VALUING CHANGES IN ENVIRONMENTAL ATTRIBUTES WITH DISCRETE CHOICE MODELS: AN APPLICATION TO SPORTFISHING IN THE EAST COAST OF U.S.A.

Sebastián Valdés De F.*
Kenneth E. McConnell**

ABSTRACT

Consumer decisions regarding quality or attribute differentiated goods, involve a discrete or qualitative choice regarding an exhaustive set of mutually exclusive alternatives determined by preferences over the attributes that characterize the alternatives, not over the alternatives themselves. From the standpoint of the researcher, in any choice occasion, some of the determinants of preferences will be unobserved, like taste variations and/or perceptions of quality for example, giving rise to a random utility model of choice.

This type of models is well suited to study choices among environmental goods that are differentiated by their quality attributes, and allows us to investigate the value of changes in these attributes.

The present paper has three purposes. First, we want to show the potential of discrete choice models to study consumers behavioral changes when economic or environmental policies affect the attributes of natural resources. Second, we show how to use the results of such models to measure the welfare effects associated to these policies in order to conduct benefit-cost analysis. Third, we show a way to incorporate demand changes, caused by the policies, in order to obtain complete welfare measures.

SINTESIS

Las decisiones de los consumidores entre bienes diferenciados por calidad o atributos suponen una elección cualitativa discreta entre un conjunto exhaustivo de alternativas mutuamente excluyentes determinadas por preferencias acerca de los atributos que caracterizan a la alternativa, no en relación a las alternativas en sí. Desde el punto de vista del investigador, en cualquier situación de selección, algunos de los determinantes de las preferencias no serán observadas, como, por ejemplo, variaciones en los gustos y/o percepciones de calidad, originando un modelo de utilidad aletatoria de selección.

Este tipo de modelos se adapta muy bien para estudiar selecciones entre bienes ambientales que están diferenciados por sus atributos de calidad y nos permite investigar el valor de los cambios en estos atributos.

Este trabajo tiene tres finalidades. Primero, queremos mostrar el potencial de los modelos de selección discretos para estudiar los cambios de comportamiento de los consumidores cuando las políticas económicas o ambientales afectan a los atributos de los recursos naturales. Segundo, estudiamos como usar los resultados de esos modelos para medir los efectos de bienestar asociados a estas políticas a fin de realizar análisis de costo beneficio. Tercero, mostramos una forma para incorporar los cambios en la demanda originados por las políticas, a fin de obtener mediciones de bienestar completas.

* **Department of Economics, Universidad de Chile.**
** **Department of Agricultural and Resource Economics, University of Maryland.**

VALUING CHANGES IN ENVIRONMENTAL ATTRIBUTES WITH DISCRETE CHOICE MODELS: AN APPLICATION TO SPORTFISHING IN THE EAST COAST OF U.S.A.*

Sebastián Valdés De F.
Kenneth E. McConnell

1. INTRODUCTION

There are many instances where empirical economic decisions involve choices among discrete alternatives. Decisions on labor force participation, occupation, educational level, marital status, family size, residential and work location, travel mode are good examples. The common aspect among these decisions is that in any choice occasion, the person that makes the choice has two or more exclusive courses of action among which to choose from a finite set of alternatives. This description of a choice situation also applies to choices among quality or attribute differentiated goods, such as brands of commodity purchases and environmental goods.

Discrete or qualitative choice models are used to analyze situations in which decision makers are faced with a finite and exhaustive set of mutually exclusive alternatives, as in the cases presented above. The consumer has preferences over the attributes that characterize the alternatives, not over the alternatives themselves, such that the demand for a good is actually a demand for the bundle of attributes assembled under that alternative. On the other hand, each decision maker has its own characteristics that define which alternative will be chosen. From the standpoint of the researcher, in any choice occasion, some of these characteristic will be unobserved, like taste variations and/or perceptions of quality for example, introducing a random element in the decision. The result is a probabilistic theory of choice which has a lot in common with models of judgment developed in the psychometric literature (Thurstone, 1927; Luce, 1972; Tversky, 1972), and generalized by McFadden into the random utility model (1975). These discrete choice models calculate the probability that a decision maker will choose a particular alternative from the set of alternatives, given data observed by the researcher.

* *Estudios de Economía*, publicación del Departamento de Economía de la Facultad de Ciencias Económicas y Administrativas de la Universidad de Chile, Vol. 23 N°1, junio 1996.

This type of models is well suited to study choices among environmental goods that are differentiated by their quality attributes, and allows us to investigate the value of changes in these attributes. Differences in these attributes among the available alternatives determine different levels of utility obtainable from each alternative. It is the comparison among the levels of utility provided by each alternative that will determine the choice.

Apart from the correct treatment of variables with a discrete nature, discrete choice models study individuals decisions' based on comparisons among substitutable alternatives, which itself is an advantage over travel cost models where substitution effects are difficult to incorporate.

In what follows we present a model of the choice of fishing destination by anglers practicing sport fishing in the Chesapeake Bay area. Four sites in Delaware, eight sites in Maryland, and eight sites in Virginia are the destinations considered in this study (see the Appendix for site definitions). One model of the choice of site and fishing type is estimated for each state. The decision is modeled in a sequential fashion where the individual first chooses the mode and species combination he or she wants to practice and then chooses where to do so. Changes in sites' attributes translate into changes in the relative utilities of the alternatives, which cause changes in destination and fishing type choices.

In the same manner, changes in attributes will cause adjustments in the number of fishing trips taken during a season. To incorporate this effect in the derivation of welfare measures, a demand for fishing trips is also estimated for each state and appended to the destination and fishing type model.

The present paper has three purposes. First, we want to show the potential of discrete choice models to study consumers' behavioral changes when economic or environmental policies affect the attributes of natural resources. Second, we show how to use the results of such models to measure the welfare effects associated to these policies in order to conduct benefit-cost analysis. Third, we show a way to incorporate demand changes, caused by the policies, in order to obtain complete welfare measures.

2. THE DATA

The observations come from a subsample of anglers interviewed about their fishing activities in sites along Atlantic Coast states. The survey was commissioned by the University of Maryland as part of a cooperative agreement with different agencies of the government of the USA (EPA, NOAA and NMFS) to measure the economic value of East Coast Sport fishing. The surveys recorded data on the number of trips taken during a period of two months (from hereon a wave) to fishing destinations within a set of 69 aggregated sites along the East Coast (the sites were aggregated at the county level). The species group targeted and fishing mode, were also recorded. The species groups are aggregates of 25 species regularly sought at sites in Atlantic coast states: big game fish, small game fish, flat fish and bottom fish. Fishing from a party/charter boat, or a private/rental boat, or from the shore are the three fishing mode alternatives. Non-seekers were assigned the small game catch rates since, presumably, they were expecting to catch the most abundant species at the site which normally are small fish. To restrict the study to a similar population the data only includes anglers who took trips of a maximum duration of one day, assuming that the only objective of the trip was fishing.

The four aggregated species groups (big game, small game, flat fish and bottom fish) plus a non-targeting group (seeking a particular species), and the three fishing modes (party/charter, private/rental and shore) define a set of fifteen species/mode combinations available for each angler. Big game fishing from the shore was not considered plausible and, hence, eliminated. Also, not all 69 sites were considered plausible alternatives for one-day fishing trips, hence, a smaller set was defined for each angler according to the distance from his or her residence to the sites, and to the shore. Even though the surveys covered the states of New York through Florida, only sites in the Chesapeake Bay area in the states of Delaware, Maryland and Virginia are considered in this study. Otherwise, the number of observations becomes intractable from the point of view of estimation. Also, the potential substitutability among sites within these states make the application of this modeling approach specially appropriate. The data was reduced further by randomly choosing six sites from the original site sets plus the chosen site as alternative destinations. Only those anglers that had at least seven alternatives in the original set of sites were considered. Table 1 shows the final number of observations used in this application.

TABLE 1

FINAL SAMPLE

State	Wave 2 (Feb-Mar)	Wave 3 (Apr-May)	Wave 4 (Jun-Jul)	Wave 5 (Aug-Sep)	Wave 6 (Oct-Nov)	Total
Delaware	40	78	122	77	30	347
Maryland	24	104	136	71	5	340
Virginia	17	117	146	106	15	401

3. THE TRIP ALLOCATION DECISION

Visitors to each state are assumed to allocate their fishing trips among multiple substitutable sites. The decision is modeled in the familiar multidimensional random utility maximization (RUM) framework (see McFadden,1975 and Ben-Akiva and

Lerman, 1985). This model has been applied successfully in recreation studies where substitutability often characterizes choices (Bockstael, Hanemann and Strand, 1986; McConnell et al., 1992).

The RUM considers each choice occasion independent of previous ones. On each choice occasion the angler is assumed to have a trip allocation decision consisting of a species and fishing mode choice, and a destination choice. The angler decides sequentially; first, he/she decides what kind of fishing to practice among all the species/mode combinations available (species and modes have been combined), and second, conditional on the species/mode choice, he/she decides which site to visit. For the choice of how many trips to take in a season, a demand for trips will be appended to the allocation decision. The site and species/mode decisions are described below.

The choice of species/mode combination is determined by the alternative with the highest level of (indirect) utility

$$V_{m^*} = Max(V_m \mid m = 1,\ldots, M), \tag{3.1}$$

where V denotes indirect utility, and m = 1,..,M denotes the set of species/mode combinations available. If $V_{m^*} > V_m$,$\forall$ m$\neq$m* (m=1,...,M-1), then he/she chooses to practice species/mode combination m*.

Finally, there is the choice of which site to visit given the species/mode combination chosen. Again, the angler ranks the utilities of the available sites and chooses the one with the highest. The total utility of practicing the best expected fishing alternative at the best expected site can be written as

$$V_{j^*, m^*} = Max\{Max(V_{jm} \mid m = 1, \ldots, M) \mid j = 1, \ldots, J\}, \tag{3.2}$$

where j = 1,..., J denotes the set of available sites. If $V_{j^*m^*} > V_{jm^*}$ $\forall$ j$\neq$j*, the angler decides that he/she will practice the chosen type of fishing m* at site j*.

A simple representation of the indirect utility function of an angler is

$$V(s, z, \epsilon) = V_{jm} = \beta s_{jm} + \gamma z_m + \epsilon jm, \tag{3.3}$$

where s_{jm} is a vector of attributes for the m^{th} species/mode combination at site j, z_m is a vector of variables that affect only the species/mode choice, β and γ are vectors of coefficients to be estimated, and ϵ_{jm} is a vector of unobserved attributes that are considered random by the researcher.

Domencich and McFadden (1975) developed a nested multinomial logit that can handle this choice structure. Assume that the errors, ϵ_{jm}, have a generalized extreme value distribution, then, the probability of choosing site j, conditioned on the choice of species/mode m, is

$$P(j/m) = \frac{\exp[\beta s_{jm} \,/\, (1 - \sigma)]}{\sum_{j=1}^{J} \exp[\beta s_{jm} \,/\, (1-\sigma)]}, \qquad (3.4)$$

and the probability of choosing species/mode combination m is given by

$$P(m) = \frac{\exp[\gamma z_m + (1 - \sigma) I_m]}{\sum_{m=1}^{M} \exp[\gamma z_m + (1-\sigma) I_m]}$$

where I_m is a variable that summarizes the attractiveness of practicing species/mode m at the alternatives sites. It "..is an attempt to describe the utility of the best alternative in a subset of choices as a summary of the value of that subset to an individual." (Ben-Akiva and Lerman, 1985). It is also called the "inclusive value", and is defined as

$$I(m) = \ln\{\sum_{j=1}^{J} \exp[\beta s_{jm} \,/\, (1-\sigma)]\}, \qquad (3.6)$$

The coefficient σ, measures the similarities of the alternatives in the choice set. If $\sigma = 0$, the model reduces to a simple multinomial logit with JxM alternatives. If $\sigma = 1$, there is only one relevant choice, the species/mode choice; all the sites available for the practice of each type of fishing are perfect substitutes, and it does not matter where the angler goes fishing, only what kind of fishing he/she wants to practice.

The nested logit model is estimated in two stages[1]. The first stage models the choice of site conditional on the species/mode choice, and the second stage models the species/mode choice. Seven site alternatives were considered for the choice of site and fourteen species/mode combinations for the choice of fishing type.

The log likelihood function is

[1] It is reasonable to think that the three choices may be made simultaneously in each choice occasion and every destination/species/mode combination be an alternative, in which case the model reduces to a multinomial logit. However, the results show that $\sigma \neq 0$ and hence, such a structure would violate the Independence of Irrelevant Alternatives assumption. The sequence of the choices was selected after previous studies with this same data showed that it seems to describe reasonably well the choices made by anglers (see McConnell et al. 1992).

$$L = \sum_{i=1}^{N} \sum_{j=1}^{J} \sum_{m=1}^{M} y_{ijm} \ln[P_i\,(j/m)\; P_i\,(m)]$$

$$= \sum_{i=1}^{N} \sum_{j=1}^{J} \sum_{m=1}^{M} y_{ijm} \ln[P_i\,(j/m)] + \sum_{i=1}^{N} \sum_{j=1}^{J} \sum_{m=1}^{M} y_{ijm} \ln[P_i\,(m)] \quad (3.7)$$

$$= \sum_{i=1}^{N} \sum_{j=1}^{J} y_{ij} \ln[P_i\,(j/m)] + \sum_{i=1}^{N} \sum_{m=1}^{M} y_{im} \ln[P_i\,(m)]$$

where N is the number of visitors to the state, J = 1, ... , 7 denote the number of sites available in the angler's alternatives set, M = 1, ... , 14 denotes the alternative species/mode combinations or fishing types available at each site. The probabilities, $P_i\,(j\,|\,m)$ and $P_i\,(m)$, were defined in equations (3.4) and (3.5), y_{ij} is an indicator that takes the value 1 if site j is chosen, 0 otherwise, and y_{im} is an indicator that takes the value 1 if site m is chosen, 0 otherwise. The first term of the RHS of equation (3.7), corresponds to the conditional site choice, and the second term corresponds to the species/mode choice. Maximizing the likelihood function in (3.7) simultaneously gives estimates that are consistent and asymptotically efficient, but it is computationally burdensome.

This model can be more easily estimated in sequence[2]. First, we estimate the conditional multinomial logit of the site choice. This gives estimates of $\beta/(1\text{-}\sigma)$. Then we estimate the species/mode choice, which gives us estimates of γ and σ, with which β can be identified (see Ben-Akiva and Lerman, 1985).

The same specification was used in the three states. A simple general model for the utility of a fishing trip to state *s* is

$$V_s(\text{site } j,\ \text{species/mode } m) = f(TCOST_{jm},\ TTIME_j,\ \ln(M_j),\ SQRCR_{jm},\ IBOAT_{jm},\ BT_m), \quad (3.8)$$

where s = 1, ... , 3, denotes states NJ, DE, MD, VA and NC, and the variables are as defined in Table 2.

The square root of the historical catch rate average, $SQRCR_{jm}$ is used as an indicator of site quality, and it varies according to site and species/mode combination. The travel cost variable, $TCOST_{j,m}$, includes an average cost for boat modes. The variable $\ln(M_j)$, is included to eliminate the potential bias caused by the aggregation of sites into counties or groups of counties. The more sites within a county, the higher the probability that someone may choose that county. Including

[2] The resulting estimates less efficient compared to the full information estimation. However, Limdep corrects the asymptotic var-cov matrix to give asymptotically efficient estimates, following McFadden's recommendation (McFadden, 1981).

this variable captures the degree of aggregation of elemental alternatives (sites) into an aggregate alternative (county) (Ben-Akiva and Lerman, 1985). The variable $IBOAT_{jm}$ is included to capture the potential different behavior of anglers who own a boat. The variable BT_m is a dummy that takes the value 1 if the angler owns a boat and the species/mode alternative includes the private/rental mode.

TABLE 2

RUM VARIABLE DEFINITIONS

TCOST:	Travel Cost	=	$0.20 x distance + wage x time x interior + mode cost.
	distance	:	round-trip distance from home to site (Hiways and Biways files).
	wage	:	self-reported; if not, as predicted in UM study.
	interior	:	dummy taking value 1 if individual can work flexible hours, 0 otherwise.
	time	:	ound-trip travel time from home to site, self reported; if not as predicted in UM study.
TTIME:	Travel time	=	time x (1- interior).
	time	:	same as above.
	1 - interior	=	dummy taking value 1 if individual cannot work flexible hours, 0 otherwise.
M:	Size variable	:	This variable corresponds to the number of interview locations in the NMFS intercept survey for the UM study site definition.
SQRCR		:	Square root of catch rate. This is calculated over the 1980-90 historical average number of fish caught per hour, reported at the site (this data is collected by NMFS through their annual survey). It varies with species, mode and wave. The square root allows for a decreasing marginal utility in catch.
IBOAT		:	Boat ownership at the site. A dummy taking the value 1 if the angler owns a boat and it is moored at the site, 0 otherwise.
BT		:	Boat ownership for private/rental mode. A dummy taking the value 1 if the angler owns a boat and the species/mode combination includes private/rental mode.

Therefore, the conditional probability of choosing site j (eqn. 3.4) can be rewritten as

$$P(j/m) = \frac{\exp[(\beta_1 TCOST_{jm} + \beta_2\, TTIME_j + \beta_3 \ln(M_j) + \beta_4\, IBOAT_j + \beta_5\, SQRCR_{jm}) \,/\, (1-\sigma)]}{\sum_{j=1}^{J} \exp[(\beta_1 TCOST_{jm} + B_2 TTIME_j + B_3 \ln(m_j) + B_4 IBOAT_j + B_5 SQRCR_{jm} \,/\, (1-\sigma))]} \qquad (3.9)$$

and the species/mode combination choice probability in (eqn. 3.5) is

$$P(m) = \frac{\exp[(\gamma BT_m + (1 - \sigma)I_m]}{\sum_{j=1}^{J}\exp[(\gamma BT_m + (1 - \sigma)I_m]} \tag{3.10}$$

The results of the estimation are presented in Table 3.

TABLE 3

ESTIMATION RESULTS OF THE NESTED LOGIT

	Individual States			Pooled Samples		
Conditional Site Choice	**DE**	**MD**	**VA**	**DEMD**	**DEVA**	**MDVA**
TCOST	-0.029	-0.028	-0.025	-0.029	-0.027	-0.026
	(-6.22)	(-7.38)	(-5.99)	(-9.59)	(-8.39)	(-9.36)
TTIME	-0.117	-0.214	-0.492	-0.175	-0.296	-0.338
	(-1.87)[a]	(-3.70)	(-7.09)	(-4.13)	(-6.56)	(-7.76)
LOGM	0.103	0.584	0.532	0.296	0.263	0.536
	(1.55)[b]	(6.39)	(5.24)	(5.55)	(4.63)	(8.11)
IBOAT	2.308	2.727	1.354	2.505	1.836	2.300
	(4.31)	(5.11)	(1.84)[a]	(6.66)	(4.33)	(5.45)
SQRCR	0.292	0.188	0.738	0.261	0.413	0.409
	(5.49)	(2.48)	(7.92)	(6.03)	(8.50)	(6.61)
Chi-squared (slope = 0) $_{(5 df)}$	251.2	413.4	552.3	-	-	-
1st Stage Log-L	-623.58	-540.52	-471.10	-1174.3	-1119.2	-1028.2
Species/Mode Choice						
INCLUSIVE	0.457	0.274	0.211	0.345	0.389	0.275
VALUE	(6.00)	(4.49)	(4.70)	(7.35)	(8.03)	(6.60)
BT	1.027	1.175	0.967	1.119	1.436	1.439
	(2.05)	(2.93)	(2.31)	(3.75)	(3.05)	(3.72)
Chi-squared (slope=0) $_{(2 df)}$	67.6	39.1	38.9	-	-	-
2nd Stage Log-L	-953.69	-965.39	-965.45	-1922.7	-1915.7	-1930.4
Total Log-L (1st Stage Log-L + 2nd Stage Log-L)	-1577.27	-1505.91	-1436.55	-3097.0	-3034.9	-2958.6
No. Observations	347	340	401	687	748	741

Note: Asymptotic t-statistics in parenthesis. Unless otherwise noted, all coefficients are different from zero at the 5% level.

[a] Significant at 10% level.

[b] Not significantly ≠0. The Chi-squared test corresponds to a model with just a constant. Two-tailed $\chi^2(5, 2.5\%) = 11.07$, $\chi^2(2, 2.5\%) = 5.99$.

All the estimated coefficients have the expected sign and most of them are significantly different from zero at the 5% level (31 in a total of 35). Three pooled models were also estimated with the same specifications described above, one for each pair of states. The results will be used later in testing the similarity of the models across states.

4. THE DEMAND FOR TRIPS

To incorporate potential changes in visitation due to the effects of a policy that changes the conditions of the activity, a demand for trips is appended to the trip allocation decision. Following Bockstael, Hanemann and Kling (1986), the inclusive value of the trip allocation decision (IV in section 3) is used as an index that summarizes the maximum utility attainable from that choice among all the possible substitutable alternatives, along with other socio-economic variables that determine the number of trips choice. The inclusive value is a measure of consumer surplus that captures the qualities and costs of all available sites. Hausman, Leonard and McFadden (1992), and more recently the McConnell et al. (1992), have successfully used this approach.

The general form of the two months trips demand is

$$T = f(IV, v) \tag{4.1}$$

where T denotes the number of trips taken during the last two months, IV is the inclusive value, and v is a vector of individuals' characteristics.

The data on trips is a discrete variable which in many cases is a small integer (the typical case of count data); hence, the trips distribution is assumed to follow a Poisson process where

$$P(t=T) = \frac{\lambda^T \exp[-\lambda]}{T!} \tag{4.2}$$

is the probability that an angler takes T trips during the two-month period.

Since the sample is of visitors, which correspond to anglers who had previously taken at least one trip, the distribution is truncated from below at zero trips. Hence, the conditional probabilities that enter the likelihood function are given by

$$P(t=T|t>0) = \frac{\lambda^T \exp[-\lambda] / T!}{P(t>0)}, \qquad \text{for } t = 1, 2, 3, \ldots \tag{4.3}$$

The most common formulation for the conditional mean of T is

$$\lambda = exp[g\ (IV,\ v;\ \alpha)] \tag{4.4}$$

where g is a linear function of v and IV, and α is a vector of parameters to be estimated. It is specified as

$$\lambda = exp[\alpha_0 + \alpha_1\ IV + \alpha_2\ WINTER + \alpha_3\ YMED + \alpha_4 YHIGH + \alpha_5\ IBOAT + \alpha_6\ EXP] \tag{4.5}$$

where $\alpha_0,\ldots,\ \alpha_6$ are the parameters to be estimated, and the variables are defined as:

IV = inclusive value at initial situation (IV^0).

WINTER = 1 if the anglers took the trips in waves 2 or 6 (February-March, November-December), 0 otherwise.

IBOAT = 1 if the angler owns a boat, 0 otherwise.

EXP : is a continuous variable that represents the sport fishing experience of the angler. It is defined as the number of years practicing sport fishing.

YHIGH = 1 if the angler's income is higher than $60,000 a year, 0 otherwise.

YMED = 1 if the angler's income is between $15,000 and $59,999 a year, 0 otherwise.

The variable IV is a measure of the expected maximum utility of taking a trip, and through it, changes in fishing conditions translate into trip demand changes; larger catch rates increase IV, banning a species as well as banning access to a site decrease the value of IV. An increase (decrease) in IV increases (decreases) the demand for trips. On the other hand, we would expect fewer trips to be taken when it is cold in the Mid-Atlantic states. The dummies for income represent the effect of moving to a higher income bracket. Being in a higher income bracket may mean a higher opportunity cost of time, and hence fewer, one day trips would be taken (conceivably the number of longer trips would increase). Also, the angler might choose other recreational activities when he or she moves to a higher income bracket. Owning a boat could be an indication of fishing avidity, and therefore we would expect a positive effect on the demand for trips. Also, a more experienced angler can be expected to take more trips than a less experienced one. The results from the truncated Poisson estimation are presented in Table 4. Three pooled models were estimated for the Poisson demands as well, to investigate the similarity of the demand models across states.

TABLE 4

ESTIMATION RESULTS OF THE POISSON MODEL FOR TRIPS DEMAND

Coefficient	Individual States DE	MD	VA	Pooled Samples DEMD	DEVA	MDVA
CONSTANT	1.319 (12.59)	0.566 (3.29)	0.771 (4.58)	1.682 (25.49)	1.562 (26.46)	0.696 (6.49)
IV	0.156 (5.21)	0.265 (7.70)	0.168 (6.23)	0.021 (1.63)	0.042 (4.70)	0.200 (11.18)
WINTER	-0.156 (-3.79)	-0.464 (-4.40)	-0.398 (-4.44)	-0.223 (-4.54)	-0.257 (-5.42)	-0.428 (-6.36)
YMED	-0.089 (-1.75)	-0.427 (-7.22)	0.023 (0.45)[b]	-0.253 (-6.57)	-0.054 (-1.50)	-0.156 (-4.04)
YHIGH	-0.317 (-3.56)	-0.211 (-2.68)	-0.381 (-4.54)	-0.188 (-3.28)	-0.404 (-6.68)	-0.230 (-4.11)
IBOAT	0.162 (3.74)	0.186 (3.80)	0.366 (8.90)	0.238 (7.56)	0.313 (10.82)	0.279 (9.12)
EXP	0.007 (4.84)	0.007 (4.23)	0.001 (0.82)[b]	0.008 (7.43)	0.005 (4.55)	0.004 (4.00)
Chi-squared(slope=0) (6 df)	111.4	198.8	237.4	-	-	-
Log-Likelihood	-1548.4	-1321.5	-1736.4	-2937.4	-3329.1	-3103.0
No. Observations	347	340	401	687	748	741
Mean Trips	6.66	5.95	6.75	-	-	-

Note: Asymptotic t-statistics in parenthesis. Unless otherwise noted, all coefficients are different from zero at the 5% level.
[a] Significant at 10% level.
[b] Not significantly ≠0.

The signs of the inclusive value variable (IV) are as expected and significantly different from zero. The seasonal variable, WINTER, has a negative effect on trips demand in the three states. In general, the dummies for income brackets also behaved as expected for DE and MD. Increases in income above $15,000 affect negatively the demand for trips. Boat ownership has a significantly positive effect, and fishing experience has a significant effect in DE and MD. However, it seems that different variables explain the demand for trips in VA. EXP has no significant effect, and YMED has the opposite sign. Therefore, VA's demand for trips was reestimated in order to achieve a better specification for benefit estimation (see Table 5).

TABLE 5

REESTIMATED TRIPS DEMAND MODEL FOR VA

Variable	VA
CONSTANT	0.793
	(4.92)
IV	0.168
	(6.22)
WINTER	-0.394
	(-4.42)
YHIGH	-0.396
	(-5.52)
IBOAT	0.306
	(8.92)
EXP*IBOAT	0.002
	(1.94)
Chi-squared(slope=0) (6 df)	239.0
Log Likelihood	-1735.6

Note: Asymptotic t-statistics in parenthesis. Unless otherwise noted all coefficients are significant at 5% level.

5. A DIFFERENT MODEL FOR EACH STATE

An important issue that has to be addressed before continuing with welfare estimation, is related with the need to estimate a separate model for each state. Since all the sites belong to the same area, maybe one model could explain fishing decisions in all three states. However, substitution possibilities vary among states in terms of species/mode combinations. Also the morphological characteristics of bay and ocean sites among the three sites are different. These differences may induce different kinds of anglers to visit each state.

Likelihood ratio tests for equality in models' parameters show that both models are different among states. Therefore, anglers' preferences vary across states and separate estimation is justified in order to get accurate benefit measures. Table 3 shows the results of the nested logit for individual states and pooled samples. The results of the Poisson models of trips demand for individual states and pooled samples are shown in Table 4. The null Hypothesis of equality in parameter estimates among states can be written as

$$Ho: \hat{\delta}_{s,1} = \hat{\delta}_{r\neq s,1};\ \hat{\delta}_{s,2} = \hat{\delta}_{r\neq s,2};\ \ldots;\ \hat{\delta}_{s,k} = \hat{\delta}_{r\neq s,k} \qquad (5.1)$$

where the subscripts denote state s and state $r \neq s$, and k is the number of parameters. The likelihood test for (5.1) is given by (Ben-Akiva and Lerman, 1985)

$$X^2 = -2\left[L_R(\hat{\delta}) - \sum_{ss=s,r\neq s} L_{ss}(\hat{\delta}_{ss})\right] \qquad (5.2)$$

where $L_R(\hat{\delta})$ is the total value of the log likelihood function of the restricted model estimated on pooled data from state s, and state $r \neq s$, with a single vector of coefficients $\hat{\delta}$. $L_{ss}(\hat{\delta}_{ss})$, are the total values of the log likelihood functions of the individual state model. The statistic χ^2 is asymptotically distributed chi-squared with degrees of freedom equal to the number of restrictions $k_{ss} + k_{ps} - k$, where $k_{ss} = k_{ps} = k$. The same testing procedure is used in both trips allocation decision (nested logit), and number of trips decision.

In Table 6 the values of the likelihood ratio tests between two states for the nested logit model and the Poisson demand models are presented. All the values are significantly larger than the critical value of the Chi-squared distribution, even at the $\alpha = 1\%$ significance level. Hence, the hypothesis in (5.1) of equality among states' parameters is easily rejected in all cases. The coefficients of both models (nested logit and Poisson) differ significantly between states[3].

[3] Ben-Akiva and Lerman (1985), and more recently Swait and Louviere (1993), have emphasized that in comparing coefficients between market segments (in this case states), attention must be paid to the implications of the scale parameter of any multinomial logit specification. Recall that the extreme value distribution has the form

$$F(\epsilon) = \exp[-\exp[-\mu(\epsilon-\eta)]],$$

where μ is a scale parameter and η is a location parameter. The latter is always assumed equal to zero, but μ, is carried on into the specification of the model multiplying the components of the utility function. It cannot be identified, and is normally assumed equal to one. But, when comparing models among samples, we have also to recall that the variance of a ϵ is $\pi^2/6\mu^2$, and hence that μ is inversely proportional to the variance of the random utility components.

Assuming that μ is equal to a constant within a sample has no impact in the analysis, but assuming that it is constant among samples (in the pool model) is equivalent to assuming homoscedastic random utilities among samples, which might not be true. This may lead us to reject the hypothesis (5.1) when the two samples have different scales, and not necessarilly because the coefficients are different. These authors have suggested some tests that can be used to identify this heteroscedasticity problem.

However, in this study the differences between the estimated coefficients reported in Table 3 do not seem to come only from differences in the scale parameters. If the coefficients were equal, we would observe a degree of proportionality given by μ $(\mu_1\beta_{11}/\mu_2\beta_{21} = \mu_1\beta_{12}/\mu_2\beta_{22} = \ldots = \mu_1\beta_{1k}/\mu_2\beta_{2k} = \mu_1/\mu_2)$ between the vectors of estimated coefficients, that we do not observe here. Hence, the risk that the likelihood ratio tests in (5.2) could be rejecting hypothesis (5.1) mistakenly is fairly low. If the hypothesis is rejected, and we do not observe any proportionality between ratios of coefficients, then the coefficients are different independently of differences in the scale parameters.

TABLE 6

LIKELIHOOD RATIO TESTS FOR EQUALITY OF ESTIMATED COEFFICIENTS

	Nested Logit Model			Poison Demand Model		
State (Site)	DE	MD	VA	DE	MD	VA
DE		27.64	42.2		112.0	63.9
MD			32.28			135.0

Critical Values: χ^2 (7, 5%) = 12.02, χ^2 (7, 2.5%) = 14.07.

6. WELFARE MEASUREMENT

With the results obtained above we can estimate the value of the effects of changes in the attributes of the alternatives or the alternatives set. Small and Rosen (1981) and Hanemann (1982) have derived the formulas for the standard compensated and equivalent variation measures in the random utility case.

For the RUM model, maximum indirect utility (defined in equation (3.3)) is a random variable from the perspective of the researcher, as individual preferences are only partly observable; therefore, when evaluating welfare effects we focus on the mean of the distribution of the maximum utility attained by the angler, E{V(s, z, ϵ)} = V(s, z). Assuming no income effects, for the nested logit model, CV and EV take the form

$$CV=EV=\frac{1}{\Sigma_1}\left[\ln\left(\sum_{j=1}^{J}\left[\sum_{m=1}^{M}\exp[V^{\circ}_{jm}/(1-\sigma)]\right]^{1-\sigma}\right)-\ln\left(\sum_{j=1}^{J}\left[\sum_{m=1}^{M}\exp[V^{1}jm/(1-\sigma)]\right]^{1-\sigma}\right)\right] \quad (6.1)$$

or

$$CV = EV = \frac{1}{B_1}[IV^{\circ}-IV^{1}] \quad (6.2)$$

$IV^t = \sum_{j=1}^{J}\left[\sum_{m=1}^{M}\exp[V^{tjm} / (1-\sigma)]\right]^{1-\sigma}$ where , t=0,1 denotes the situation before (t=0) and after (t=1) the policy is implemented, and where β_1 is the marginal utility of income. The expression IV^t is the maximum expected utility in situation t. With the estimated coefficients, $\hat{B}$, $\hat{\gamma}$ and $\hat{\sigma}$, and the values of the explanatory variables in s and z before and after the policy, per-trip benefit estimates can be obtained through equation (5.2).

This measure corresponds to a per-trip benefit estimate under the assumption that the number of trips remains constant, unaffected by the policy. However, as Morey has shown, when the characteristics of a commodity change the value individuals attach to it depends on the quantity of the commodity they consume (Morey, 1992). Therefore, welfare change per-angler should be calculated as the difference between the total (expected maximum) utility after the policy change, which is the maximum expected utility of a trip after the policy change times the number of trips taken after the policy change, and the total utility in the initial situation, which is the expected maximum utility of a trip times the number of trips initially taken. A monetary measure of this change is

$$w(x, z; \delta) = (T^1\, IV^1 - T^0\, IV^0)/\beta_1 \tag{6.3}$$

where β_1 is the marginal utility of income (the coefficient of the travel cost estimated in the nested logit model), T^0 and T^1 are the number of trips estimated through eqn. (4.5) under the original situation before the policy (with IV^0) and after the policy (with IV^1), and IV^0 and IV^1 are the inclusive values of equation (5.2). The angler's characteristics included as explanatory variables in the trip allocation and the trips demand models are denoted by $x = (s,v)$, z is the vector of sites' characteristics, and $\delta = (\beta, \gamma, \sigma, \alpha)$ are the coefficients of the nested logit and the Poisson demand models.

Aggregate benefits for public goods (i.e., recreational resources) are calculated by summing benefits per-user over all users, which requires unavailable census data that would account for every user. Instead, a measure of central tendency can be used to calculate aggregated benefits in each state. The most commonly used measure of central tendency is the sample mean. Hence, aggregated benefits are

$$W_s = N_s\, \bar{w} \tag{6.4}$$

where the bar denotes the mean of the estimated benefits across the sample of anglers in the state, N is the number of users, and the subscript refers to state s.[4]

Three policies are evaluated. The first is a 10 percent, increase in catch rates in all sites, under all species/mode combinations. The second is a ban on flat fish fishing in all sites, under all modes. The last policy is a ban on fishing activities at

[4] Given that per-angler benefits refer to benefits to the representative angler, a weighted average seems appropriate here because anglers that take more trips would presumably have a higher valuation. However, this issue may only be relevant for benefit transfers in the case of a direct transfer, where the distribution of trips and values may differ among sites. In this study, however, the conclusions regarding the performance of the direct transfer approach were not altered by comparing weighted averages instead of simple averages.

a specific site in each state, which was chosen randomly among the sites available in each state (Table 7).

TABLE 7

SITES BANNED FROM SITES CHOICE SET

State	Eliminated Site Name	Number
Delaware	New Castle	21
Maryland	Calvert	26
Virginia	Isle of Wight/Suffolk/Surry	35

7. THE EFFECT ON VISITATION

Table 8 shows descriptive statistics for the number of trips under each of the three policies implemented estimated trough equation (4.5). The effect of the policies is fairly small in terms of visitation. An 10 percent increase in catch rates, which could be associated with a generalized improvement in water quality in the state that translates in more abundance of all species, induced a very small increase in the demand for trips in all three states. On the other hand, a ban on flat fish fishing in all sites in a state had a greater impact on visitation. On average, if flat fish is not available, trips demand would fall between 0.2 to 0.4 trips per angler during the season. Finally, prohibiting sport fishing at one site in each state has a negligible 0.1 trips per angler reduction in demand. In general, the small impact of the policies over the demand for trips can be explained by the availability of substitute species groups and sites in each state. The small impact of an improvement in the success rate of a fishing hour can be explained by a change in fishing strategy. If an angler is catching more fish per hour then he or she will probably take the same number of trips but make them shorter.

TABLE 8

DESCRIPTIVE STATISTICS ESTIMATED VISITATION

Policy	Visits to State					
	DE		MD		VA	
	Mean	SDev.	Mean	SDev.	Mean	SDev.
Initial No. trips	6.8	1.5	6.1	2.0	6.8	2.0
No. of trips after increase in Catch Rates	6.8	1.5	6.1	1.7	6.9	2.0
No. of trips after a ban on flat fish fishing	6.5	1.5	5.7	1.8	6.6	1.9
No. of trips after a ban in site k	6.7	1.5	6.0	2.0	6.7	1.9

8. THE EFFECT OVER ANGLERS WELFARE

To value the effects of the policies, we estimate per-angler welfare changes through equation (5.3). In order to avoid the effects of extreme values to which the mean of a variable is very sensitive, we have calculated a 5 percent-trimmed mean of the estimated benefits for each state. It is calculated by ranking the estimated benefits in ascending order, and calculating the mean for every 5 percent of the sample except for the top and bottom 5 percent. With this procedure we have formed a sort of 90 percent interval of variation for the mean of the estimated benefits, that shows the variability of the welfare effects along the sample. Table 9 shows the estimated benefits of the three policies.

TABLE 9

DESCRIPTIVE STATISTICS ESTIMATED TOTAL BENEFITS

Policy	Measure	Fishing in State DE 5%-trimmed mean	MD 5%-trimmed mean	VA 5%-trimmed mean
Increase in Catch Rates	L_b	8.7	4.1	26.7
	Mean	19.7	9.7	71.1
	S.Dev	8.7	4.6	35.7
	U_b	31.2	16.1	132.3
Ban on Flat Fish	L_b	-94.6	-95.8	-53.6
	Mean	-164.0	-175.8	-113.9
	S.Dev	51.3	66.1	48.7
	U_b	-21.55	-261.6	-196.1
Ban on Site k	L_b	-5.4	-1.7	-2.3
	Mean	-27.8	-25.6	-74.1
	S.Dev	59.5	166.5	91.2
	U_b	-44.6	-38.9	-245.6

Notes: L_b and U_b denote the lower and upper bounds for the 5%-trimmed mean.

As is expected, a catch rate increase does cause an improvement in anglers' welfare, having positive estimated benefits per angler, though they vary considerably among states ranging from $9.7 in Maryland to $71.1 in Virginia. This considerable variability is consistent with the fact that the models have shown to be quite different among states. On the other hand, as is also expected, the two policies that presumably would have a negative effect on angler's welfare do indeed imply negative benefits or costs to anglers. However, a policy that would ban flat fish fishing in the state would imply a much higher cost to anglers than a policy prohibiting access to one of the alternative sites. If we consider that the number of substitutable sites is considerably larger than the number of substitutable species groups/fishing mode combinations in each state, this difference in valuation does not seem so far fetched.

9. FINAL COMMENTS

Discrete choice models provide a very different structure to model recreation demand, compared to the traditional continuous travel cost models for example, and a means to investigate the value of the resources used in recreation activities. Its structure focuses attention on the choice among substitutes alternatives, in our case, sites and fishing types, for every recreational fishing trip, which is precisely the weakness of travel cost models. It has been used often to value changes in sites' characteristics because those characteristics are instrumental in determining the allocation of the trips among sites and fishing possibilities.

However, research is still needed to develop in this kind of models the capacity to explain the total number of trips an individual decides to take during a season. As equation (5.3) above shows, to be able to calculate a complete welfare measure we need not only the value of a trip, but also the number of trips taken by the individual after and before the change under evaluation. The Poisson demand model appended to the nested logit model constitutes a partial solution to this weakness. It is an almost utility theoretically consistent solution (although Hausman, Leonard and McFadden (1992) consider it completely consistent) because it uses the results of the allocation model (the inclusive value of the nested logit) as a price index for a composite commodity, trips, in estimating the demand for trips. However, it is not derived from the same utility maximization process from which the nested logit is, hence, it is only a partial solution. Morey, and Parsons and Needelman have made advances in the direction of a totally consistent solution, but it becomes too cumbersome when the number of trips is large.

This technique, however, gives us the opportunity to estimate some of the benefits that different environmental policies may impose on society, and compare them to the costs of those policies. It has been used successfully in the valuation of recreational fisheries in the United States (Hanemann, McConnell and others). If fishing opportunities are improved by environmental policies like pollution controls, then the benefits of such improvements should be compared with the costs of pollution controls. If on the other hand, the use of a resource is curtailed by an environmental accident for example, as it was the case with the Exxon Valdez oil spill, part of the damages of such an accident can be measured by the loss of consumer surplus imposed on the users of the resource (see Hausman et al., 1992).

Transportation economics (Domencich and McFadden, 1975; Ben-Akiva and Lerman, 1985), product differentiation (Anderson, de Palma and Thisse, 1992), and marketing (Swait and Louviere, 1993) have also been fertile grounds for the application of discrete choice models.

REFERENCES

ANDERSON, S.P., A. DE PALMA, and J-F. THISSE (1992): *Discrete Choice Theory of Product Differentiation*. The MIT Press, Cambridge, Mass.

AMEMIYA, T. (1985): *Advanced Econometrics*. Harvard University Press Cambridge, Mass.

BEN-AKIVA, M. and S.R. LERMAN (1985): *Discrete Choice Analysis: Theory and Application to Travel Demand*. The MIT Press, Cambridge Mass. and London, England.

BOCKSTAEL, N., W.H. HANEMANN, and C.L. KLING (1986): "Estimating the Value of Water Quality Improvements in a Recreational Demand Framework" *Water Resources Research*, Vol. 23, 951-960.

BOCKSTAEL, N., W.M. HANEMANN and I.E. STRAND, Jr. (1986): "Measuring the Benefits of Water Quality Improvements Using Recreational Demand Models" Vol. 2 of *Benefit Analysis Using Indirect or Imputed Market Methods*, Report to EPA, Washington, D.C.

——————— (1991): "Recreation" in *Measuring the Demand for Environmental Quality*. Braden, J.B. and C.D. Kolstad, eds. Amsterdam: North Holland.

CARSON, R.T., W.M. HANEMANN and T. WEGGE (1987): "A Nested Logit Model of Recreational Fishing Demand in Alaska", Report prepared by Jones and Stokes Assoc. Sacramento, CA.

CRAMER, J.S. (1991): *Econometric Applications of Maximum Likelihood Methods*. Cambridge: Cambridge University Press, reprinted.

DOMENCICH, T., and D. MCFADDEN (1975): *Urban Travel Demand: A Behavioral Analysis*. Amsterdam: North Holland.

FREEMAN, A. M. III (1979): *The Benefits of Environmental Improvement: Theory and Practice*. Baltimore, MD.; The Johns Hopkins Univ. Press, Resources for the Future.

GREENE, W.H. (1993): *Econometric Analysis* 2nd. Edition, NY; Macmillan.

JUDGE, G., W.E. GRIFFITHS, R.C. HILL, H. LÜTKEPOHL and T-C. LEE (1985): *The Theory and Practice of Econometrics*, 2nd Edition, John Wiley & Sons, New York.

HANEMANN, W.M. (1982): "Applied Welfare Analysis with Qualitative Response Models". California Agricultural Experimental Station Working Paper No. 241.

HAUSMAN, J. A., and D. MCFADDEN (1984): "Specification Tests for the Multinomial Logit Model". *Econometrica* Vol. 49, 1377-1240.

HAUSMAN, J. A., G.K. LEONARD, and D. MCFADDEN (1992): "A Utility-Consistent, Combined Discrete Choice and Count Data Model: Assessing Recreational Use Losses Due to Natural Resource Damage" unpublished manuscript.

HOGG, R. V. and A. T. CRAIGG (1978): *Introduction to Mathematical Statistics Fourth Edition*, Macmillan New York.

LUCE, R.D. (1959): *Individual Choice Behavior. A Theoretical Analysis*. New York, Wiley.

MADDALA G.S. (1983): *Limited Dependent and Qualitative Variables in Econometrics*. Cambridge University Press, Cambridge.

MÄLER, K.-G. (1974): *Environmental Economics: A Theoretical Inquiry*. Baltimore, MD.; The Johns Hopkins Univ. Press, Resources for the Future.

MANSKI, C.F. (1977): "The Structure of Random Utilty Models", *Theory and Decision*, Vol. 8, 229-254.

MCCONNELL, K. E., I.E. STRAND, Jr., with S. VALDES, and Q.R. WENINGER (1992): "The Economic Value of Mid and South Atlantic Sport Ffishing", Vol. 2, University of Maryland College Park, EPA, NMFS Report.

MCFADDEN, D. (1981) "Econometric Models of Probabilistic Choice" in *Structural Analysis of Discrete Data with Econometric Applications* Manski C. F. and D. McFadden eds. Cambridge, Mass.:The MIT Press.

——— (1973): "Conditional Logit Analysis of Qualitative Choice Behavior" in *Frontiers in Econometrics* P. Zarembka, ed. New York: Academic Press.

MOREY, E.R. (1992): "What is Consumer's Surplus for a Day of Use? And What Does it Tell Us About Consumer Surplus? in Benefits Transfer: Procedures, and Research Needs, Report of the 1992 Assoc. Env. and Res. Economists Workshop. Snowbird, Utah.

MOREY, E.R, R.D. ROWE, and M. WATSON (1993): "A Repeated Nested-Logit Model of Atlantic Salmon Fishing" *Amer. Journal of Agr. Econ.* Vol. 75, 578-592.

MOREY, E.R., W.D. SHAW, and R.D. ROWE (1991): "A Discrete Choice Model of Recreational Participation, Site Choice, and Activity Valuation When Complete Trip Data Are Not Available", *Journal of Environmental Economics and Management*, Vol. 20, 181-201.

PARSONS, G.R. and M.S. NEEDELMAN (1991): "A Nested Sequential Logit Model of Recreation Demand", Working Paper No. 91-14, presented at the Annual Meetings of the European Assoc. of Env. and Res. Economists.

SMALL, K.A. and H.S. ROSEN (1981): "Applied Welfare Economics with Discrete Choice Models", *Econometrica*, Vol. 49, 105-130.

SMITH, V. K. and W.H. DESVOUSGES (1986): *Measuring Water Quality Benefits*, Norwell, MA: Kluwer Academic Publishers.

STRAND, I.E. Jr., K.E. MCCONNELL, N.E. BOCKSTAEL, and D.G. SWARTZ (1991): "Marine Recreational Fishing in the Middle South Atlantic and South Atlantic: A Descriptive Study", University of Maryland, Marine Sea Grant Program.

SWAIT, J. and J. LOUVIERE (1993): "The Role of the Scale Parameter in the Estimation and Comparison of Multinomial Logit Models", *Journal of Marketing Research*, Vol. 30, 302-314.

THURSTONE, L. (1927): "A Law of Comparative Judgement," Psychological Review, Vol. 34, 273-286.

TVERSKY, A. (1972): "Choice-by-Elimination", *Journal of Mathematical Psychology*, Vol. 9, 341-367.