Sensitivity of angler benefit estimates from a model of recreational demand to the definition of the substitute sites considered by the angler

Brad Gentner

NMFS Office of Science and Technology
Fisheries Statistics and Economics Division
1315 East West Highway
Silver Spring, Maryland 20910

Email address: brad.genter@noaa.gov

Abstract—Fishery managers are mandated to understand the effects that environmental damage, fishery regulations, and habitat improvement projects have on the net benefits that recreational anglers derive from their sport. Since 1994, the National Marine Fisheries Service (NMFS) has worked to develop a consistent method for estimating net benefits through site choice models of recreational trip demand. In estimating net benefits with these models, there is a tradeoff between computational efficiency and angler behavior in reality. This article examines this tradeoff by considering the sensitivity of angler-welfare estimates for an increase in striped bass (*Morone saxatalis*) angling quality across choice sets with five travel distance cut-offs and compares those estimates to a model with an unrestricted choice set. This article shows that 95% confidence intervals for welfare estimates of an increase in the striped bass catch and keep rate overlap for all distance-based choice sets specified here.

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Recreational angling is the second most popular outdoor sport nationwide when measured by number of participants. In 2004, 10.2 million anglers took 73.8 million recreational trips in the United States, exclusive of Alaska, Hawaii, and Texas (NMFS[1]). In addition to participation, anglers spend $20.4 billion dollars annually on trip-related and durable expenditures to pursue saltwater gamefish (Gentner et al., 2001), producing $30.5 billion in economic impacts and supporting nearly 350,000 jobs (Steinback et. al, 2004). Recreational fishing is an economically important activity and the National Marine Fisheries Service (NMFS) is mandated by law to examine changes in net benefits to anglers after the impact of environmental damage (oil spills, algal blooms, etc.), fishery regulations (bag limits, size limits, seasonal closures), and habitat improvement projects (damn removal, water quality improvements, etc.). Calculation of net benefits involves an examination of angler behavior when they make choices about taking recreational fishing trips.

Modeling angler trip demand involves observing anglers making recreation site choices and using a site choice model to estimate a recreational trip demand function. Site-choice models are typically estimated by using a random utility model (RUM). RUMs are used to estimate net benefits by looking at the cost of traveling to the site that anglers selected and comparing that cost to the cost of traveling to other sites in their choice set (set of sites considered by the angler). Without any other information about the site, these models allow one to estimate the net benefits of access to that site which can be used to examine closures due to environmental damages or regulation. If site-quality information is available, such as catch rates or other measures of environmental quality, the net benefits of those ecosystem services can be estimated as well.

Since 1994, it has been the goal of the NMFS to develop a consistent method for estimating recreational site-choice models to increase the speed and efficiency of meeting legal mandates. To this end, NMFS has sponsored a good deal of research into RUMs of recreational site choice to value site closures and angling quality (the quality of the angling experience as measured by catch and keep rates) (Haab and Hicks, 1999, Jones and Lupi, 1999, Parsons et. al, 1999). From this, and other work, the composition of an individual's choice set can impact net benefit estimates, giving rise to several difficulties when modeling angler net benefits. First, NMFS's RUM models concentrate on only single day trips, because it is difficult to disentangle the value of angling for anglers on trips that have

[1] NMFS (National Marine Fisheries Service). 2006. Fisheries Statistics and Economics Division. Marine Recreational Fisheries Statistical Survey Real Time Data Queries. Website: http://www.st.nmfs.gov/st1/recreational/database/queries/index.html (accessed on 13 August 2006).

multiple purposes. Because focus is strictly on single day trips, it would be incorrect to include sites in an angler's choice set if those sites are "too far" for the angler to consider when choosing a site for a single day trip. Second, a large number of sites in each individual's choice set can be computationally costly, particularly when a nested choice structure is appropriate, and increase the time it takes to bring policy analyses to the table. This problem may indicate that there is a tradeoff between computational efficiency and angler behavior in reality; a balance that will be examined here.

There is literature on the specification of choice sets based on many factors including distance. Parsons and Hauber (1998) estimated a freshwater recreational angler site choice model and found that there is little difference in the magnitude of welfare effects as one reduces the spatial scope of choice sets until a threshold of 1.6 hours one-way travel time is reached. This spatial scope translates into 32 mile and 80 mile distance thresholds, if one assumes a 20 mile per hour (mph) urban travel speed and a 50 mph highway travel speed, respectively. Below that threshold, welfare estimates inflate as the constraint tightens. Whitehead and Haab (1999) estimated a site choice model using a range of choice sets constructed with distance and site-quality metrics. They found that there is very little difference in the trip cost coefficients across distance-based choice sets that eliminate between 13% and 82% of the available sites. Hicks and Strand (2000) found that because the probability of choosing a site depends on the choice set, the likelihood function is also dependent on the choice set. If the choice set is incorrect, biased parameter estimates could be a consequence. The welfare estimates derived in the "Materials and methods" section below explicitly include the choice set and demonstrate this interaction.

This analysis will examine the sensitivity of welfare estimates in a RUM model of recreational demand across six distance-based definitions of site choice. This analysis will focus on a single species, striped bass (*Morone saxatalis*), from a single mode (the private rental boat mode) to avoid a nested choice structure. A simulation approach will be used to derive confidence intervals around these estimates in order to examine the significance of any differences found and to expand the literature that has previously been focused on only on the magnitude of the differences in welfare estimates.

Materials and methods

An angler chooses a fishing site from the set of all alternative sites if the utility of visiting that site is greater than the utility of visiting any other site in the global choice set. Denoting the set of all alternatives faced by any angler by $S = \{1, \ldots, N\}$ as the choice set, the indirect utility of visiting site j is

$$U_j(q_j, y-p_j, \varepsilon_j) = V_j(q_j, y-p_j) + \varepsilon_j, \tag{1}$$

where U_j = an individuals utility;
V_j = the deterministic portion of utility;
y = income;
p = the cost of angling at site j;
q = a vector of characteristics of site j; and
ε_j = the unobservable portion of indirect utility.

In the RUM framework, an angler will choose site j from S if

$$V_j(q_j, y-p_j) + \varepsilon_j \geq V_k(q_k, y-p_k) + \varepsilon_k, j \in S, \forall k \in S, \tag{2}$$

where the indirect utility of visiting site j is greater than the indirect utility of visiting site k for all k in the global choice set, S.

The random portion of the random utility model stems from the unobservable portion of indirect utility, captured here in the error term ε_j. If this error term is assumed to be distributed in a type-I extreme value distribution, the above site choice framework can be modeled with the conditional logit model. Maddala (1983) has provided a complete derivation of the conditional logit model. Within this framework, the probability that i visits site j is given by

$$P_i(j) = P(j \mid j \in S) = \frac{e^{V_j(q_j, y-p_j)}}{\sum_{k \in S} e^{V_k(q, y-p_k)}}. \tag{3}$$

Up to this point it has been assumed that each angler faces the same choice set, S. This is not a necessary assumption and can be generalized to represent the possibility that i faces a choice set S_i that is a subset of the global choice set S. In this case the indirect utility comparison becomes

$$\begin{aligned} &V_j(q_j, y-p_j) + \varepsilon_j \geq V_k(q_k, y-p_k) \\ &+\varepsilon_k, j \in S, \forall K \in S_i, \quad {}_i \subset S \end{aligned} \tag{4}$$

and the probability that angler i chooses site j becomes

$$P_i(j) = \frac{e^{V_j(q_j, y-p_j)}}{\sum_{k \in {}_i} e^{V_k(q, y-p_k)}}. \tag{5}$$

Because the goal of the present study is to examine the sensitivity of welfare estimates of a quality change to the specification of choice sets, it is necessary to show how the choice set enters the calculation of compensating variation (CV), or the level of income required to keep the angler at the same level of expected utility after the quality change. The following expression for CV is taken from the work of Bockstael et al. (1991), who examined the value of quality improvements in the demand for recreation, where β_y is the travel cost parameter.

$$CV = \frac{\ln\left(\sum_{k \in {}_i} e^{v_k(q_k^1, p)}\right) - \ln \ln\left(\sum_{k \in {}_i} e^{v_k(q_k^0, p)}\right)}{\beta_y} \tag{6}$$

The summation of the indirect utilities is across the choice set facing each individual, S_i, and not the global choice set, S.

Since 1979, data have been collected on marine recreational angling during the Marine Recreational Fishery Statistics Survey (MRFSS). The MRFSS consists of two independent but complementary surveys: a field survey and a telephone survey, conducted annually in six two-month "waves." The field survey is an intercept survey of anglers conducted at fishing access sites and is designed to obtain a random sample of recreational trips for computing catch per unit of effort. Fish retained by interviewed anglers are sampled for length and weight. Fish not retained by the angler are not observed, but count data on this unobserved catch are collected. The data on harvest provide a picture of the size distribution of the kept fish from the stock. If a fishery is regulated by a minimum size limit, a catch-and-keep rate calculated from these data indicates the catchability of fish large enough to keep. As such, it is the observed rate at which anglers can catch and keep fish from a stock.

The intercept sample is stratified by state, wave, fishing mode, fishing area, catch type, and species. Specific data elements collected during the intercept survey include state, county, and zip code of angler's residence, hours fished, primary area fished, target species, gear used, and days fished in the last two and 12 months. During the intercept portion of the survey, data are collected on the length and weight of all fish species retained by the angler and the species and condition of all catch not retained by the angler. Upon completion of the base MRFSS, anglers in the Northeast (NE) (Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, and Virginia) were asked to complete a short add-on questionnaire in 2000. This questionnaire provided information on whether or not the trip was a single-day or longer trip and, if it was a multiple-day trip, whether fishing was the primary purpose of the trip. Data were also collected on the angler's saltwater fishing experience (in number of years), boat ownership (whether owned or not), and whether or not the individual took time off without pay to take the fishing trip. If the individuals responded in the affirmative to the later, they were asked the number of hours in their work week and their personal income. The survey instrument is available at the NMFS web site (NMFS[2]).

In order to reduce the complexity of the modeling effort, the angler's choice to fish rather than participate in some other recreational activity, the angler's choice to fish in a private or rental boat mode, and the angler's decision regarding a species target are exogenous to the model. Because the area fished is not documented in the MRFSS, a fishing site is defined as the point of fishing access. As mentioned previously, the treatment of all substitute sites can be quite costly from a data standpoint for a number of reasons. Because thousands of individual sites in the North East (NE) region are recognized in the MRFSS, estimation can be a lengthy process, particularly with nested models. In addition, not all species are sampled in all survey waves at all sites in all modes; therefore the calculation of historic catch rates at the individual site level results in many empty cells. To speed estimation and to fill some of these empty cells, all sites within a coastal county were aggregated into one site that represented that county. Across the NE, there are roughly 63 coastal counties, and therefore 63 sites. In order to examine whether this aggregation strategy induces any bias into the estimation of the conditional logit model, a variable (m) was created that represents the number of MRFSS sites aggregated into each new site. The rule that a county equals a site was not strictly followed in all cases. Some geographically diverse counties (i.e., those counties with both ocean frontage and bay frontage) were separated into two sites because of the different opportunities provided by these different types of water.

Both the historic five-year average catch rate (catch rate) and catch-and-keep rate (KRATE) were calculated for the boat mode for each wave and site combination. KRATE measures the catchability of a striped bass large enough to keep, incorporating the five-year average probability of catching a striped bass large enough to keep. The distinction between the catch rate and KRATE is particularly important for striped bass because this species is heavily regulated. Historic KRATE was used in the model because it represents the portion of the catch that an angler would be able to keep, not just the increase in overall catch. It is also the measure of angler quality used in the Whitehead and Haab (1999) study. Even after the site aggregation, some counties did not contain enough data points on striped bass catch from the boat mode over the 5-year period.

Whitehead and Haab (1999) replaced missing catch rates using the catch rate from the nearest neighboring site in some cases and with zero values, in other cases depending more or less on mode. Hicks et al. (1999) recognized this approach to be *ad hoc* and estimated his model using both nearest neighbor and zero value assignment, another *ad hoc* approach, and found that the treatment of missing values did not significantly affect the welfare estimates. He concluded that the zero assignment is perhaps less arbitrary because the empty cells actually convey information. That is, if there are no observations of average catch within a particular wave+mode+site+species combination, the site is not very productive over that combination. As a result, zero assignment requires less judgment by the researcher; therefore that is the approach used here.

Estimating any demand equation requires a price variable. Because recreational fishing experiences are not openly traded in markets, travel cost (both the actual cost of travel plus the opportunity cost of time) is

[2] NMFS (National Marine Fisheries Service). 2006. Fisheries Statistics and Economics Division. Survey Instruments. Website: http://www.st.nmfs.gov/st1/econ/surveys/survey_timeline.html (accessed on 13 August 2006).

used as the price. Round-trip travel cost (*ttc*) is calculated as the following;

$$ttc = (\ 0.33 \times distance \times 2) + \left(\frac{(distance \times 2)}{40} + hrsf \right) \times lost\_income \times w, \qquad (7)$$

where *distance* = the one-way distance from the anglers home zip code to the zip code, or latitude/longitude, of the intercept site.

This distance is multiplied by the Federal Travel Regulations reimbursement rate for private transportation ($0.33) and includes both the fixed and variable costs of operating an automobile. The variable *lost_income* is a dummy that takes the value of 1.0 if the individual did take time off work without pay to go fishing. If the individual lost income, their wage rate (w) is multiplied by the travel time plus the time on site (*hrsf*) and this amount is added to the travel cost (40 miles per hour is used as the average travel speed). Therefore, the opportunity cost of onsite time and travel time is only included if an individual took time off work to participate in fishing on a given day. If the individual is not losing income for the trip, his travel cost is simply round-trip distance multiplied by the fixed and variable costs of operating an automobile. As is typical for these MRFSS data sets, very few anglers (3.34%) report having foregone income to take the trip. To account for the opportunity cost of time for those anglers not losing income, travel time is used as a measure of time cost for those individuals. In order not to double count those that lost income taking a trip, the expression for travel time (*tt*) is

$$tt = \left(\frac{(distance \times 2)}{40} \right) (1 - lost\_income)\,. \qquad (8)$$

Keeping only those anglers that have targeted or caught striped bass from the boat mode on a single day trip leaves 3630 usable observations.

With an aggregation strategy in place and the variables defined, the estimation of the conditional logit model follows. As a reminder, the choice of whether or not to take a fishing trip, which mode to fish in, and what species to pursue are made outside of this model. The angler then chooses the site that maximizes indirect utility from his or her set of substitutes. Every model carries a set of implicit assumptions. Angler behavior within this model is defined on a trip-by-trip basis and the angler is not allowed to modify the number of trips taken each season. Therefore, each choice is independent of the next, and unobservable utility, ε_j, is independent of any other trips. Additionally, the MRFSS intercept survey is assumed to approximate a random sample of trips. The author acknowledges these contentions with choice-based sampling in the MRFSS data, and this is an area of research that this author and NMFS scientists continue to explore.

Variables in the deterministic portion of indirect utility include travel cost (*ttc*), travel time (*tt*), log of the number of MRFSS intercept sites aggregated into the county site used in the model (m), and historic KRATE per trip for striped bass at site j (q_j). Indirect utility is

$$\beta_c tt_{\ ij} + \beta_q q_j + \beta_t t_{\ ij} + \beta_m \ln(m_j) + \varepsilon_j . \qquad (9)$$

With this expression for indirect utility, the probability that angler i selects site j is

$$P_i(j) = \frac{e^{\beta_c tt_{\ ij} + \beta_q q_j + \beta_t t_{\ ij} + \beta_m \ln(m_j)}}{\sum_{k \in \ i} e^{\beta_c tt_{\ ik} + \beta_q q_k + \beta_t t_{\ ik} + \beta_m \ln(m_k)}} \qquad (10)$$

and the expression for the change in compensating variation for a change in the historic catch and keep rate, after assuming a constant marginal utility of income, is the following:

$$\frac{1}{\beta_c} \left(\begin{array}{l} \ln\left(\sum_{j \in S_i} \beta_c tt_{\ ij} + \beta_q q_j^0 + \beta_t t_{\ ij} + \beta_m \ln(m_j) \right) \\ -\ln\left(\sum_{j \in S_i} \beta_c tt_{\ ij} + \beta_q q_j^1 + \beta_t t_{\ ij} + \beta_m \ln(m_j) + \varepsilon_j \right) \end{array} \right), \qquad (11)$$

where q^0 = the historic KRATE; and
q^1 = the KRATE after the environmental or policy change.

Table 1 provides descriptive statistics for all the variables to be used in the analysis and some angler-specific attributes in order to give the reader some background on these anglers. Throughout the range of this data collection, the bag limit for striped bass is two fish per day. On average, anglers catch far less than the limit. In fact, the base catch rate for anglers targeting or catching striped bass from the boat mode is less than one fish per trip. What is readily apparent is that there are some irrational anglers in this group, at least concerning travel time. The maximum travel time translates into a 798 mile one-way travel distance, which does not seem feasible for a one-day trip. Even after eliminating those anglers that admit to taking an "overnight" trip, there are obviously anglers that are away from home longer than 24 hours. One explanation is that these anglers live in the local area seasonally and have given the zip code of their permanent address, which is used to calculate travel distance. Another explanation arising from the author's experience in the field is that some of these anglers drive incredibly long distances and fish for 24 or more hours. They do not consider their trip to be an overnight trip because they are not staying in a hotel even though their round trip travel distance indicates that they were away from home for more than 24 hours. There were only 3 individuals in the data set with one-way travel distances greater than 500 miles and the results were not sensitive to leaving these outliers in the model. As a result they remain in the data set. Other statistics of note include the variable that

Table 1

Descriptive statistics for selected variables describing angler and trip characteristics from the only data set used in this study from the 2000 Marine Recreational Fisheries Statistical Survey economic add-on survey conducted in Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, and Virginia.

Variable	Mean	Standard deviation	Minimum	Maximum
Used in model				
Travel cost (*ttc*) (US$)	30.39	38.36	0.0	778.73
Travel time (*tt*) (hours)	1.99	2.15	0.0	39.93
Aggregation variable (m) (number of sites)	43.85	37.88	5.0	138.00
Catch-and-keep rate (q)	0.19	0.40	0.0	2.00
One-way travel distance (*distance*) (miles0miles)	41.54	43.13	0.1	798
Not used in model				
Boat ownership (%)	0.73	0.44	0.0	1.00
Hours fished	4.20	1.88	0.5	22.00
Years fished	23.61	14.76	0.0	70.00
Catch rate (no. of fish)	0.89	1.64	0.0	10.67

looks at the aggregation of sites. On average there are almost 44 MRFSS intercept sites aggregated into the definition of a "site" used in the present study and a maximum of 138 sites and a minimum of five sites in a county. On average, anglers spend 4.2 hours on the water and 73% own the boat they are fishing from. Finally, this is a fairly experienced group, with an average of almost 24 years of saltwater fishing experience.

The final portion of this analysis yet to be discussed is the definition of distance-based choice sets. Haab and Hicks (1997) and Parsons and Hauber (1998) found that welfare estimates change little beyond a certain threshold. Up to a point, limiting an angler's choice set by using a distance-based metric only increases the realism of the choice that anglers consider in reality. Hicks et al. (1999) used such a designation in their analyses. Both included all sites within 150 miles, if the angler lived within 30 miles of the site selected, and all sites within 400 miles otherwise. The extreme rational limit for a one-day trip is probably 400 miles one-way. That distance translates into a 10 hour or 6 hour and 40 minute one-way travel time at 40 and 60 miles per hour, respectively. Whitehead and Haab (1999) used definitions of distance-based choice sets that ranged from 180 miles one-way to 360 miles one-way (3–6 hours one-way at 60 miles per hour), realizing that the 360 mile cut-off is likely not very realistic. These definitions probably drive the small difference in parameters across specifications, because eliminating sites outside of what anglers are really considering should have little effect (Whitehead and Haab, 1999).

To examine the definition of choice sets, this study examined much smaller cut-offs than those found in the previous literature that focused on saltwater angling. The cut-offs included the following: a full unrestricted choice set, and 300-, 250-, 200-, 150-, and 100-mile distance cut-offs. Initially, a 50-mile one-way distance cut-off was included, but, because of the site aggregation strategy used, the only substitutes left in the choice set at the 50-mile cut-off were closer than the site that was chosen, for most anglers. If it is possible to estimate the model on an individual site basis, it would be possible to run smaller distance cutoffs without encountering this problem. In order not to also drop observations when applying these cut-offs, if an individual was observed to make a choice outside of the cut-off, that observation is retained. If all substitute sites for that individual are also outside of the cut-off, the next nearest site is included in that angler's choice set. Therefore, anglers have at least one substitute left in their choice set, no matter how restrictive the cut-off becomes. The average number of sites in each choice set is 63, 37.2, 30.5, 23.3, 16.9, and 10.6 for the six choice sets, from least restrictive to most restrictive, respectively. In percentage terms, these restrictions on the choice set eliminate between 40% and 93% of the available sites.

Estimation of the confidence intervals around these welfare estimates is calculated by taking 1000 random draws from a multivariate normal distribution parameterized by the vector of estimated parameters and their covariance matrix. Sorting these draws from highest to lowest and removing the upper and lower 2.5% and 5%, respectively, construct 95% and 90% confidence intervals (Krinsky and Robb, 1986).

Results

Table 2 contains the parameter estimates and standard errors of the six conditional logit models. All six models strongly reject the hypothesis that the coefficients are simultaneously equal to zero. Also, all coefficients in all models are statistically significant at the 99% level or better. In general, anglers prefer sites that are closer to home, both in terms of the cost of driving and the time cost (travel time multiplied by the individual's

Table 2

Parameter estimates for the six distance-based conditional logit models (standard errors in parantheses).

Variable	Full	300-mile	250-mile	200-mile	150-mile	100-mile
	Choice set					
Travel cost (*ttc*)	0.06242	–0.06240	–0.06232	–0.06176	–0.05827	–0.04150
(US$)	–(0.00573)	(0.00573)	(0.00575)	(0.00582)	(0.00606)	(0.00682)
Travel time (*tt*)	–0.23226	–0.23154	–0.23216	–0.23771	–0.27057	–0.36472
(hours)	(0.07753)	(0.07759)	(0.07782)	(0.07873)	(0.08186)	(0.09201)
Log of aggregation variable (*m*)	0.68125	0.68220	0.68262	0.68293	0.68187	0.67143
(no. of sites)	(0.02482)	(0.02483)	(0.02484)	(0.02484)	(0.02484)	(0.02479)
Catch-and-keep rate (*q*)	0.67653	0.67535	0.67584	0.67506	0.66885	0.65325
(no. of fish)	(0.03792)	(0.03794)	(0.03795)	(0.03795)	(0.03794)	(0.03820)
LR[1]	17,245.31	13,192.55	11,695.28	9695.16	7350.95	3891.39
R[2]	0.573	0.507	0.523	0.430	0.364	0.236

[1] Value of the likelihood ratio (LR) statistic testing the hypothesis that all betas = 0.

[2] McFadden's psuedo R^2.

wage rate). Additionally, anglers prefer sites that offer the possibility of catching and keeping more striped bass. Finally, with regard to the number of MRFSS sites aggregated into a site as defined in this study, anglers preferred to visit counties that contain more sites. Table 3 gives the mean CV for a one-fish increase in the catch-and-keep rate. A one-fish increase in the catch-and-keep rate is equivalent to the net benefits of an improvement in angling quality large enough to increase the keep rate by one fish or a regulation that allows increasing keep rates. A quality change significant enough to change KRATE by one fish would be unrealistic in the short term, considering the striped bass stock size distribution inferred from the catch rate and KRATE estimates (Table 1). Because KRATE incorporates the five-year average probability of catching a striped bass large enough to keep, this one-fish increase in KRATE models an angler's willingness to pay for a one-fish increase in the bag limit or an angler's willingness to pay for a special license allowing the retention of one striped bass more than the current two-fish limit.

This result supports Parson and Hauber's (1998) and Whitehead and Haab's (1999) results that there is indeed little difference in the definition of choice sets with the use of a distance metric. To examine the significance of the difference in welfare estimates, and not just the magnitude, 95% confidence intervals were calculated around each welfare measure (Krinsky and Robb, 1986). In fact, the mean of the smallest choice set is almost entirely contained within the 95% confidence interval of the next smallest choice set, and the entire lower bound for the smallest choice set is contained in the next smallest choice set. This is demonstrated graphically in Figure 1. From Figure 1, however, it appears that as the choice sets are truncated past the 150-mile threshold, welfare estimates rise—a similar result to that of Parson and Hauber (1998). Unfortunately, the aggregation strategy necessary when using the MRFSS data precludes an examination of a distance-based cut-off as small as that used in Parsons and Hauber's study (1998).

Table 3

Mean increase in angler benefits, measured by compensating variation (with 95% and 90% confidence intervals [CIs], for a one-fish increase in the catch-and-keep rate by distance-based choice set).

Choice set	Mean increase	95% CI		90% CI	
		Upper	Lower	Upper	Lower
Full	$10.84	$13.56	$8.89	$13.05	$9.15
300-mile	$10.82	$13.57	$8.86	$13.04	$9.13
250-mile	$10.84	$13.61	$8.90	$13.29	$9.18
200-mile	$10.93	$13.79	$8.95	$13.30	$9.23
150-mile	$11.48	$14.73	$9.28	$14.22	$9.57
100-mile	$15.74	$23.57	$11.65	$22.05	$12.23

Conclusions

In general, as choice sets are restricted, the coefficient on cost goes up, its absolute value goes down, and its standard error goes up, but only slightly, until the point is reached where the aggregation strategy begins to impose an artificial restriction on the choice set with this data set. It would be interesting to examine the effect of the aggregation strategy by using the individual MRFSS intercept sites. It is possible that using average catch-and-keep rates calculated over a longer time series would result in far fewer empty cells, which are the main hurdle to using the individual MRFSS sites.

Mean one-way travel distance in the data set is 41.5 miles (Table 1). All of the choice sets at and above the 150 mile cut-off have an almost equal proportion of sites in the choice set and sites chosen at the cut-off point. That is, the percentage of substitutes within the cut-off and the percentage of sites chosen within the cut-off are equal (near 99% for both) for the full, 300-, 250-, and 200-mile choice sets. At the 150 mile cut-off this equality begins to fail and the percentage of chosen sites inside the cut-off fall to 98% and 94% for the 150- and 100-mile cut-offs, respectively. This fall is being driven partially by the aggregation strategy. Although this result has not been examined by the author, it is likely that the average distance for an angler to travel outside his county of residence is somewhere between 100 and 150 miles. Again, if the historic catch rate could be calculated to examine individual MRFSS sites, this aggregation restriction could be examined to determine the overall sensitivity of welfare estimates to the designation of distance-based choice sets.

In conclusion, when estimating the net benefits of quality changes for recreational anglers with the MRFSS data, it matters little how restrictive the choice sets become with a distance metric, as long as the researcher does not ask more of the aggregation strategy than it can provide. This result quantifies the significance of the difference in welfare estimates across aggregation strategies and indicates the strengths and the weaknesses of a nationwide data set on marine angling in estimating net benefits and thus makes policy analysis quicker and easier.

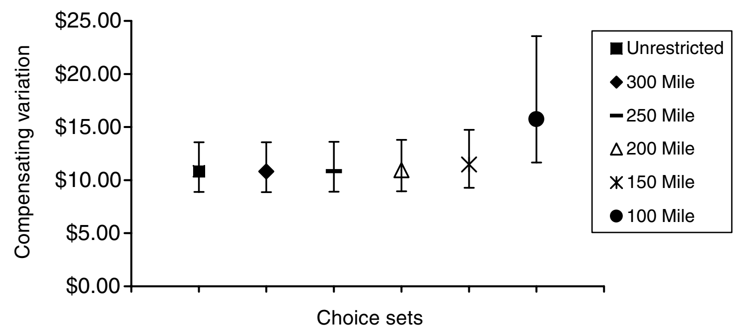

Figure 1

Mean benefits as measured by compensating variation (with 95% confidence intervals) for a one-fish increase in the catch-and-keep rate by distance-based choice set.

Literature cited

Bockstael, N. E., K. E. McConnell, and I. E. Strand.
1991. Recreation. *In* Measuring the demand for environmental quality (J. Braden, and C. Kolstad, eds.), 227–268 p. North-Holland Publs., Amsterdam, The Netherlands.

Gentner, B. J., S. Steinback, and M. Price.
2001. Marine angler expenditures in the Pacific coast region, 2000. NOAA Tech. Memo. NMFS-F/SPO-49, 66 p.

Haab, T., and R. Hicks.
1997. Accounting for choice set endogeneity in random utility models of site choice. J. Environ. Econ. Manage. 34:127–47.

Haab, T., and R. Hicks.
1999. Choice set considerations in models of recreation demand. Mar. Res. Econ. 14:271–281.

Hicks, R., A. B. Gautam, D. VanVoorhees, M. Osborn, and B. Gentner.
1999. *Thalassorama*: an introduction to the NMFS marine recreational fisheries statistical survey with an emphasis on economic valuation. Mar. Res. Econ. 14:375–385.

Hicks, R., and I. E. Strand.
2000. The extent of information: Its relevance for random utility models. Land Econ. 76:374–385.

Jones, C. A., and F. Lupi.
1999. The effects of modeling substitute activities on recreational benefit estimates. Mar. Res. Econ. 14:357–374.

Krinsky, I., and A. L. Robb.
1986. On approximating the statistical properties of elasticities. Rev. Econ. Stats. 68:715–719

Maddala, G. S.
1983. Limited dependent and qualitative variables in econometrics, 401 p. Economic Soc. Monographs. Cambridge Univ. Press, New York, NY.

Parsons, G. R., D. M. Massey, and T. Tomasi.
1999. Familiar and favorite sites in a random utility model of beach recreation. Mar. Res. Econ. 14:299–315.

Parsons, G. R., and A. B. Hauber.
1998. Spatial boundaries and choice set definition in a random utility model of recreation demand. Land Econ. 74:32–48.

Steinback, S., B. Gentner, and J. Castle.
2004. Economic impacts of marine recreational angling in the United States. U.S. Dep. Commer., NOAA Prof. Pap. NMFS 2, 169 p.

Whitehead, J. C., and T. C. Haab.
1999. Distance and catch based choice sets. Mar. Res. Econ. 14:283–299.