An Analysis of Congestion Measures and Heterogeneous Angler Preferences In A Random Utility Model of Recreational Fishing[1]

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Abstract. The potential importance of congestion effects on the management and rationing of recreational facilities and services in the presence of heterogeneous preferences were highlighted nearly twenty-five years ago by Freeman and Haveman (1977). While there have been a number of theoretical models extending and expanding upon this work (McConnell 1988; Anderson 1993), empirical research evaluating such impacts are limited. Evidence of the potential impacts of congestion on resource usage is of obvious importance, especially for natural resource managers who understand that congestion can be an effective rationing device and because users likely differ in both their preferences for use and aversion to congestion. It is the objective of this research to compare alternative measures of congestion for explaining site choice within a random utility modeling framework. Furthermore, we investigate how these congestion measures impact site choice and per trip willingness to pay for stock enhancements when anglers are perceived to differ in their fishing objectives.

Introduction

The potential importance of congestion on the management and rationing of recreational resources in the presence of heterogeneous preferences was highlighted nearly twenty-five years ago by Freeman and Haveman (1977). In particular, it was shown that optimal pricing policy in the presence of congestion effects requires an explicit accounting of how these congestion costs are distributed across users. Yet while there have been a number of theoretical models extending and expanding upon this work, notably McConnell (1988) and Anderson (1993), empirical research evaluating such impacts are limited. Evidence of the potential impacts of congestion on resource usage is of obvious importance, especially for natural resource managers who may use congestion as a rationing device to limit use. Furthermore, because users likely differ in both their preferences for use and aversion to congestion, evidence of how such congestion effects are borne differently by different user groups may help resource managers more efficiently manage their resources. Indeed, without knowledge of the potential congestion-related impacts across heterogeneous users, resource managers can at best provide dilatory responses to emerging resource allocation problems.[1]

Unfortunately, the empirical evidence gleaned from the recreation demand literature on the potential impacts of congestion is somewhat mixed. For example, both Cicchetti and Smith (1973) and McConnell (1977) generally find a statistically significant and negative relationship between some type of consumer surplus-related estimate and various measures of congestion. Yet Deyak and Smith (1978), Berrens, Bergland, and Adams (1993), and Lin, Adams, and Berrens (1996) report positive and/or statistically insignificant relationships between congestion and a consumer surplus-type estimate. Perhaps these discrepancies may be a sign of the difficulties associated with both defining and measuring congestion. Jakus and Shaw (1997) suggest such, and in response describe four different measures of congestion -- actual, expected, anticipated, and perceived congestion – that may be used in estimating the demand for recreation. Furthermore Smith (1981: p92), who focuses specifically on the difficulties of predicting the relationship between congestion and recreation demand within a travel cost demand setting, notes that, “These difficulties arise, in part, as a result of the data generally available, the form of the …

method itself, and the nature of the congestion problem with recreational facilities." This conclusion seems easily generalized to other methodologies as well.

The objective of this research is two-fold. First, we intend to illustrate how well alternative measures of expected congestion within a random utility modeling framework succeed in helping to explain site choice decisions made by recreational anglers.[2] Operating under the assumption that an angler's expectation of congestion contributes to his/her site choice decision and furthermore, that anglers formulate their expectations about site congestion on information on aggregate visits during previous periods, we develop and test six different expected congestion measures. Using intercept data collected via on-site interviews of recreational anglers in the Roanoke River Management Area, northeastern North Carolina in 1998, our measures differ with respect to the time horizon over which expectations are formulated and whether or not there is an appreciable difference between weekend versus weekday trips. Second, we investigate whether heterogeneous user groups respond differently to these expected congestion measures. By breaking up our sample into two distinct angler types – *catch and keep* anglers and *catch and release* anglers – we compare both the coefficients on expected congestion and the per trip willingness to pay for a stock increases in the presence of congestion across these angler types.

The paper is organized as follows. Section II develops a model of site choice behavior using a random utility modeling framework that acknowledges the potential impacts of expected congestion on site choice decisions. Section III presents the specific application and data. In Section IV we present the results of the random utility model of site choice. In this section, the results of the random utility model are used to estimate a trip participation function that allows for estimation of the likely changes in congestion that may follow catch improvements from a stock enhancement. These catch improvements are then coupled with the congestion estimates to derive the willingness to pay for changes in both catch and congestion that may come about following growth in the stock of striped bass in the Roanoke River. In the last section we summarize the paper.

Before discussing our stylized model, it is interesting to note that the majority of studies modeling the impacts of congestion within the recreational demand literature have used stated preference models, as shown in Table 1. Within this literature, congestion has been measured with hypothetical increases in encounters with backpackers or horseback riders per trip (Ciccehetti and Smith, 1973), actual beach attendance per acre during a trip (McConnell, 1977), yearly wilderness users per wilderness area (Deyak and Smith, 1978), and the previous week's total angler days divided by the length of fishable water (Lin, Adams, and Berrens, 1996). Rarely, as Shaw and Jakus (1997) point out and explain, are objective measures used in a revealed preference context. Indeed, the only two studies the authors are aware of that have used a revealed preference approach and accounted for, or analyze, potential congestion impacts include Lin, Adams, and Berren (1996) and Boxall, Englin, and Rollins (2001).[3]

A Model of Congestion in a Random Utility Framework

A RUM framework for describing site-choice decisions is well established in the literature.[4] This framework assumes that for each trip occasion, the individual compares the conditional indirect utility derived from each of the site alternatives and chooses that site for which the utility realized given a fixed budget constraint is greatest. The conditional indirect utility functions for each site are specified to be a function of the price of recreating at the site, individual income designated for that choice occasion, and various site attributes. The conditional indirect utility from visiting site j in period t, for example, can be represented by

(1) $U_{ijt} = U(y - tc_{ij}, z_{jt})$

where y is available income for this choice occasion, tc_{ij} is a measure of the travel and time costs to individual i for recreating at site j, and z_j is a vector of quality characteristics associated with site j on choice occasion t.

Under the discrete choice RUM framework, it is assumed that the individual chooses a single option among N mutually exclusive alternatives, and that a site choice decision can be represented by both a systematic and unobservable component. Specifically, upon selecting site j on choice occasion t, we model individual i's decision as

(2) $U_{ijt} = V(y - tc_{ij}, z_{jt}) + \varepsilon_{ijt}$

where y, tc, and z are defined above. V is the systematic component of the indirect utility function and ε is a random component known to the individual but unobserved by the researcher. Individual i will choose site j on choice occasion t when

(3) $V(y - tc_{ij}, z_{jt}) + \varepsilon_{ijt} > V(y - tc_{ik}, z_{kt}) + \varepsilon_{ikt}$ for all $j \neq k$

Now let us add more information to the characteristics, z_j, of each site. Assume the application is recreational fishing and that the utility of any particular fishing trip is impacted by what the anglers catch, c, and the amount of congestion anglers' experience (McConnell 1988), q. That is, z = (c,q) and

(4) $dU/dc > 0$ and $dU/dq < 0$

As is well noted in the literature (Bockstael, McConnell and Strand 1989; McConnell 1988), decisions about site choice and/or demand and quality characteristics are ex ante. Indeed, as Deyak and Smith (pp78-9) state, "…It is individual's anticipations which are relevant to his decision to participate and not what is realized after the fact," and thus call for greater attention "…on the formation of anticipations regarding the experiences a recreationist believes he will have in particular activities at given sites."

Following this convention, we define q^e_{jt} and c^e_{jt} as the expected congestion and expected catch at site j at time period t and assume the same relationships hold for the expectations of both catch and congestion as represented in equation (4) for actual catch and congestion. Given that these ex ante measures contribute to site choice behavior, we can model the probability of agent i choosing site j over any other site k at time t, π_{jt}, as

(5) $\pi_{jt} = \text{Prob}\,[\varepsilon_{kt} - \varepsilon_{jt} < V(y - tc_{jt}, q^e_{jt}, c^e_{jt}) - V(y - tc_{kt}, q^e_{kt}, c^e_{kt})] \quad \forall\, j \neq k$

As shown in Ben-Akiva and Lerman (1985), if the ε's are distributed i.i.d. type I extreme value, then the probability that agent i visits site j at time t can be represented by the following logistic:

(6) $\pi_{jt} = \exp V_{jt}(.) \,/\, \sum_m \exp V_{mt}(.)$

If we assume a linear specification for $V_{jt} + \varepsilon_{jt}$ and take its expectation, Hanemann (1982) has shown that the benefits of an improvement in one of the variables in Z can be estimated as:

(7) $$CV_{it} = \frac{1}{\beta}\left\{\ln\left[\sum_{j=1}^{J} \exp\ V_j^1\right] - \ln\left[\sum_{j=1}^{J} \exp\ V_j^0\right]\right\}$$

Where β is the marginal utility of income, V^0 and V^1 represent both the conditional indirect utility before and after the quality change in Z, and J is the site choice set confronting angler i at time t.

While equations (1) through (7) are relatively straightforward and well-accepted, within the revealed preference literature there is limited knowledge of the impacts of congestion on site choice decisions and, furthermore, the effects of congestion on the compensating variation measures, CV, for changes in other quality characteristics or access price. For instance, consider the following explicit linear representation of the conditional indirect utility function:

(8) $$V_{ijt} + \varepsilon_{ijt} = \beta tc_{ij} + \delta c^e_{jt} + \lambda q^e_{jt} + \varepsilon_{ijt}$$

While there has been considerable work on investigating various representations of expected catch (McConnell, Strand, and Blake-Hedges 1995), there is a lack of work on representing expected congestion in revealed preference models. Since the character of revealed preference models often limits the researcher to using "objective" proxies for expected catch, surveying the literature provides little guidance in what measure to use. In theory, it can be seen that the researchers choice of proxy will influence site choice decisions and, subsequently, any welfare measure of a potential environmental improvement. In practice, though, the implications of any particular choice are an empirical issue that has yet to be investigated. Thus along with evaluating how heterogeneous angler types may respond differently to increases in congestion, we also investigate, empirically, a variety of expected congestion measures. In the following analysis, we test a variety of congestion measures that are intended to mimic the relevant time horizons over which anglers formulate their expectations concerning congestion. Additionally, whether these expectations are formulated acknowledging potential differences between weekdays versus weekend congestion is analyzed as well.

Application and Data

Roanoke River Striped Bass Fishery

The annual spring run of striped bass up the Roanoke River in North Carolina typically begins with their movement out of the Albemarle Sound and up the Roanoke in early March, reaching their spawning grounds near the North Carolina-Virginia border in late May. This annual run supports two distinct recreational fisheries. At the beginning of the migration up river, the North Carolina Wildlife Resources Commission (NCWRC) opens the river for striped bass harvest. In 1998, the open season began on March 14. During this season, anglers were permitted to catch and keep up to three striped bass per day. Each year, based on population estimates, a total allowable harvest (in weight) is declared prior to the start of the open season. Once this allowable harvest has been removed, the open season is closed. Following the closure, anglers are still permitted to catch striped bass, but must return all catch to the water. In 1998, the Albemarle Sound/Roanoke River striped bass population was estimated to be quite healthy, and as a result an unusually large allowable catch of 62,000 pounds was declared for the open season, which lasted until April 29. Significant catches of striped bass (up to 200 fish per angler per trip) continued until early June.

During the period of the striped bass run, the majority of anglers on the Roanoke River are specifically targeting striped bass.[5] However, the characteristics of these anglers differ greatly between the open (“catch-and-keep”) season and the closed (“catch-and-release”) season (Table 2). As might be expected, the open season is characterized by a predominance of anglers that want to keep their fish for consumption. These anglers tend to have lower incomes than their closed season counterparts, travel shorter distances to the fishing sites, and have fewer trip expenditures on bait, tackle and guide services. Because these anglers differ in their personal characteristics and motivations for fishing, we might expect their trip utility functions to differ as well.

Data

For the empirical component of this study, we use intercept data collected by the North Carolina Wildlife Resources Commission, Division of Inland Fisheries via on-site interviews of recreational anglers in the Roanoke River Management Area, northeastern North Carolina during the period March 1, 1998- May 26, 1998. Supplementary surveys were distributed to anglers at 10 different boat ramps on the Roanoke River.[6] Information was collected about aspects of the angler's current fishing trip such as mode of fishing, target species, and quantity and type of fish both caught and kept, and caught and released. Trip expenditures, as well as angler characteristics such as county of residence, age, gender, and fishing experience were collected as well. Table 2 provides descriptive statistics.

The timing of the survey corresponded with the annual run of striped bass up the Roanoke River from the Albemarle Sound. Focusing on only those anglers targeting striped bass, we estimated an indirect trip utility function separately for the open and closed striped bass seasons. In doing so we employed the common assumption that the indirect utility function is linear in access costs. Access costs are measured as direct travel costs plus the opportunity cost of travel time.[7] The quality of each site is measured using site-specific characteristics, which include estimates of both the expected catch, in numbers and weight of striped bass and other species, and expected congestion. The predictions of expected catch and weight are generated using separate catch models for the individual species, and will be described in more detail below, as will our various measures of expected congestion.[8]

The following function describes the conditional indirect utility from a recreational fishing trip to site *i* for angler *k*, and is estimated separately for anglers in the open and closed seasons: [9]

$$(9) \qquad V_{ik} = \alpha_1(\textit{travel cost}_{ik}) + \alpha_2(\textit{expected catch striped bass}_{ik}) + \alpha_3(\textit{expected total weight striped bass}_{ik}) + \alpha_4(\textit{expected catch other species}_{ik}) + \alpha_5(\textit{expected congestion}_{ik}) + \alpha_6(\textit{capacity}_i) + \alpha_7(\textit{public}_i)$$

where: $\textit{travel cost}_{ik}$ = (.30) (round-trip distance in miles to site *i* by angler *k*) + (.67)(hourlywage)(hours driving time); $\textit{expected congestion}_i$ = expected number of boats per day at the site; $\textit{capacity}_i$ = the number of boat trailer parking spaces at the ramp; $public_i$ = 1 if the ramp is a public access ramp and = 0 otherwise (private ramp). The derivations of both expected catch and weight are outlined below and are followed by a description of the expected congestion measures.

Modeling Expectations of Catch and Weight as a Poisson Process

Because the random utility model examines site choices prior to the realization of site quality, the proper specifications for attributes that influence site choice are reflections of the angler's expectations of site quality. We hypothesize that anglers make site choice decisions based on different types of expectations. Anglers may be concerned with total numbers of fish caught or total weight of catch (having a large amount of fish for consumption or catching larger fish). We model site choice as a function of expected quality over all sites in the choice set and thus require information on expectations of quality at sites that were not visited. To model the site choice decision, a proxy for these expectations is formed. Past studies have used the historical average catch rate at each site as the expected catch rate for that site.[10] While this allows the expected catch rate to vary across sites, it does not allow catch to vary across anglers. It may be more accurate to assume that individual characteristics such as fishing experience, age, familiarity with the site, and type of gear will all likely influence expected catch so that different anglers will have different expectations about different aspects of catch. By modeling actual catch and weight as a function of these variables, we will form a reasonable proxy for the expectations we hypothesize to drive site choice.

We assume that anglers have expectations about the number of fish that they will catch and the total weight of their catch. Actual catch (in numbers) must take on integer values ≥ 0, hence we can model expected catch per trip with a Poisson specification.[11] Using the intercept data, we estimate both the numbers of striped bass and the total weight of striped bass caught[12] as a function of the variables we hypothesize to influence expected catch:

(10) $Q^a = \exp[\beta_0 + \beta_1(\text{site 2}) + \beta_2(\text{site 3}) + \beta_3(\text{site 4}) + \beta_4(\text{site 5}) + \beta_5(\text{site 6}) + \beta_6(\text{site 7}) + \beta_7(\text{site 8}) + \beta_8(\text{site 9}) + \beta_9(\text{hours fished}) + \beta_{10}(\text{boat length}) + \beta_{11}(\text{horse power}) + \beta_{12}(\text{number of trips on Roanoke in past 12 months}) + \beta_{13}(\text{charter}) + \beta_{14}(\text{live bait}) + \beta_{15}(\text{cut bait}) + \beta_{16}(\text{artificial bait}) + \beta_{17}(\text{years of fishing experience}) + \beta_{18}(\text{season})]$

Q^a is the actual number or actual total weight of species *a*. The site variables are dummy variables equal to 1 if the angler was fishing at that site, and equal zero otherwise.[13] "Hours fished" is an instrument constructed via OLS using all of the independent variables in the catch model, plus angler age and a dummy variable for employment status.[14] "Boat length," "horsepower," "past fishing trips," and "years of fishing experience" are survey values reported by the angler. "Charter" is a dummy variable equal to one if the angler reported paying for charter services and zero otherwise. The bait variables are also dummy variables based on reported bait used by the angler.[15] "Season" is a dummy variable for open striped bass season. With this setup, we can estimate (10) for total numbers caught and total weight for striped bass as well as for total numbers of other species caught. These two catch equations (in numbers), and a total weight equation can serve to generate predictions of fishing quality for the sub-sample of single-day striped bass anglers to be used in equation (9).

The results from the Poisson regressions are given in Table 3. The coefficients can be interpreted as logarithmic elasticities. That is, each coefficient indicates the percentage change in expected catch or weight per trip given a one-unit change in the independent variable. The signs of the estimated coefficients are generally as expected. The site dummy variables are generally significant, indicating that location plays an important role in determining catch. It also appears that our angler experience variables (i.e., number of Roanoke fishing trips in the past twelve months and number of fishing years) are fairly good indicators of expected catch. The coefficient on the season variable is generally negative and significant suggesting that anglers catch fewer (and smaller) fish during the open season. This is due, most likely, to the harvest season opening just as striped bass begin their upriver migration when catch rates may be relatively low. Also, the smaller male fish migrate earlier in the spring than the larger males and females that comprise most of the harvest in the latter part of the season.[16]

Deriving Various Measures of Expected Congestion

An angler's expectations of future congestion, which will influence site choice, is likely to be a function of congestion realized during the angler's past experiences. The NCWRC survey data includes an estimate of the total number of boats at the ramp on each day of the season.[17] Recognizing that this *realized* congestion may or may not reflect the angler's pre-trip expectation of congestion, we form a proxy for expected congestion using an average of actual congestion realized over different periods prior to the angler's trip.[18]

Individual anglers participate in fishing trips for different reasons, including catching fish for pleasure or for consumption, to enjoy a peaceful outdoor experience, or for multiple purposes. Aggregate visits can therefore affect individual angler utility in several ways; hence the effect of crowding on angler utility may be positive or negative and may or may not be linear. For example, to the extent that other anglers possess information about fishing quality at a particular site, expected congestion may in fact serve to reveal expectations of site quality that are not captured by the individual angler's own knowledge or experiences.[19] Furthermore, aggregate visits may serve to affect utility (in either a positive or negative fashion) only when certain threshold levels of crowding have been reached.

Table 5 provides descriptions of the various proxies for expected congestion that we estimate with the available data. In effect, we vary the time horizon over which an angler's expectations of congestion are formulated. Our measures include the current day's average congestion (CONG), the previous week's average congestion (PWA), the previous two-week's average congestion (PTWA), and the previous four-week's average congestion (PFWA). Notice that these measures are also calculated with and without differentiating between weekday and weekend trips. And while the data essentially limit us to evaluating "expected" congestion measures and their potential influence on site choice decisions, such an evaluation will allow us investigate how different measures of the intra-seasonal variation in congestion may influence site choice.

Given these congestion measures are calculated for both catch and keep anglers and catch and release anglers, our data will allow us to compare the effect of expected congestion on site choice and trip utility across heterogeneous angler types. Our data set consists of anglers who are surveyed during both the open season for striped bass fishing (catch-and-keep is permitted) and the closed season (catch and keep not permitted), and also contains responses to a survey question regarding trip purpose. Two comparisons are then performed. First, the parameter estimates on the expected congestion measures are compared across angler type. Second, we compare the per trip willingness to pay for a hypothetical increase in catch in the presence of congestion.

Results

Table 6 and 7 present the site choice logit results for catch and keep and catch and release anglers, respectively. The Poisson coefficients in Table 3 are used to generate proxies for expected catch and total weight of striped bass, and expected catch of other species for each angler at each site for single-day fishing trips in our sample. These values, along with the other site quality characteristics noted above, were used to estimate the per-trip indirect utility function described in equation (9). Assuming both linear and nonlinear (quadratic) congestion effects yields ten alternative specifications.

A comparison of these two models reveals some similarities. First, the travel cost variable is of its expected negative sign and statistically significant for each trial. The coefficient on site capacity is both positive and statistically significant for both types of anglers, possibly suggesting that larger ramps are more likely to be visited by both types of anglers. The coefficient on the public access dummy variable is negative for both types of anglers, but only significantly different than zero for the catch and keep anglers. This may suggest that catch and keep anglers have a preference for private ramps or are in some way averse to public access ramps.

As a general result, the coefficient on expected numbers of striped bass is positive and significant for the catch and release anglers (exceptions are when it is negative and not statistically significant). In contrast, this coefficient is negative and statistically insignificant for the catch and keep anglers. For the expected weight variable, though, more consistency is suggested across angler type. That is, the coefficient on weight of striped bass is positive for both types of anglers. Such results are not surprising. In each model, we control for both the total number and total weight of striped bass caught. In the catch and keep model, and given a potentially binding three-bag limit per day, anglers are likely to be more concerned with the size of the fish they catch rather than the number of fish they catch. Larger fish contribute to the utility of the catch-and-keep anglers most likely because these anglers are primarily concerned with catching fish for consumption. Thus catching more fish for a given total weight may detract from utility. Alternatively, in the catch and release model, the greater are the number of fish, while controlling for weight, the greater is the utility of the catch and release angler. Also, greater weight for a given number of fish adds to utility. These anglers therefore seem to derive utility from both increases in the weight and quantity of the catch. Finally, the negative sign on numbers of other fish caught is not surprising. Given that all the anglers in our data set are specifically targeting striped bass, catching a non-target species uses time and gear and may be regarded as a nuisance.

With respect to the congestion coefficients, the sign and statistical significance varies quite dramatically, both across and within angler type depending on specification. Focusing on the catch and keep anglers (Table 6), we see that when congestion is modeled in a linear fashion, the coefficient is generally positive and statistically significant. Yet when we assume a nonlinear specification, the coefficient on the quadratic term is negative and statistically significant. These results may suggest that while initial increases in aggregate visits can serve as an indicator for site quality, continued increases beyond a threshold may detract from utility. With respect to choice of weekend versus weekday congestion coefficients, there does not appear to be any statistically significant difference between the models where we break up the expected congestion terms into weekday and weekend measures or lump them together. In general, likelihood ratio tests reject the null hypothesis that the congestion coefficients in the nonlinear models are jointly not statistically different from zero.

Interpretations of the congestion results for the release anglers are not as straightforward. When the congestion variable is constructed as realized congestion or average congestion over the past week and enters the utility function linearly, its coefficient is negative, quite small, and generally statistically insignificant. While not shown on this table, taking the average over a longer time period (two or four weeks) causes these linear coefficients to become positive and statistically significant, while the expected catch quality coefficient becomes negative. When the quadratic specification for congestion is used, the coefficients on the linear and quadratic terms reverse sign as the time horizon for the assumed formulation of the expected congestion measures moves from one week to two weeks. Note that when actual congestion is used, the linear congestion term is positive while the squared term is negative. Similar results appear when congestion is averaged over two or four weeks. Yet when the expected congestion measure is formed using only the past week's visits, the coefficient on the linear term is negative while the squared term's coefficient is positive. An interpretation of the nonlinear specification using the previous week's average congestion might be that while initial levels of congestion are a deterrent for these anglers, the impact of further increases in site visits ceases to detract from site utility. Again, there appears to be no information gained from accounting for whether the anglers base their expectations of congestion on weekday versus weekend measures. Finally, similar to the catch and keep models, the likelihood ratio tests of the null hypothesis that the dual congestion coefficients are jointly zero is generally rejected at the 1% level.

While a comparison across Tables 6 and 7 suggest that these angler types react and/or are impacted differently by congestion, it may be useful to illustrate the potential welfare implications of associated with these differences. Traditionally, estimates of angler willingness to pay for particular management changes, such an increases in stock, exclude any potential congestion effects. However, policies that increase catch or weight are likely to induce more trips, which would serve to increase aggregate visits and congestion (McConnell 1988; Anderson 1993). As shown above, the implications of these results may vary across angler type. For the catch and keep anglers, the probability of visiting any particular site is likely to increase given it has a reputation as a popular site. Conversely, given a similar increase in popularity, the probability that a catch and release angler with visit such a site is likely to decrease. To investigate the potential impacts of the congestion effects on trip demand and per trip willingness to pay following an increase in either the numbers or weight of catch, we estimate a trip participation function for each angler type. Given this function, we can evaluate the change in participation at each site that results from changing catch rates and, subsequently, feed these changes back into the RUM to account for changes in site congestion. Both changes can then be valued together.

To perform the following evaluation, we limit our analysis to the site choice specifications represented in columns G and E of tables 6 and 7, respectively. While none of the goodness of fit tests suggested one specification dominates another, the individual coefficients associated with these two specifications were of the expected signs and statistically significant, with the exceptions of catch (in numbers) for the catch and keep anglers and publicly owned ramp for the catch and release anglers. None of these latter two variables were statistically significant in these respective models.

Trip Participation and Per Trip Willingness to Pay

In order to properly value improvements in catch or weight, we must couple the catch/weight improvements with increases in congestion and value both changes simultaneously. Towards this end, we estimate the changes in trips that are likely to come about from changing catch rates. Following Bockstael, Hanmeann, and Kling (1987), we estimate a participation function for our sample of single-day anglers using a regression of the form:[20]

(11) $T_k = g(\mathbf{s}_k, I_k, \varepsilon)$

where T_k = the number of trips taken per year by angler k, $\mathbf{s}_k$ = a vector of individual characteristics, I_k = the inclusive value computed from the site choice model, and ε = a random error term.[21] The following function was estimated for both samples of anglers:

(12) $T^0_k = \beta_0 + \beta_1 I^0_k + \beta_2 (income_k) + \beta_3 (age_k) + \varepsilon_k$

where the left-hand side variable is the number of reported trips to the Roanoke in the past 12 months. The estimates of pre- and post-change participation can then be used to derive an annual willingness-to-pay measure as:

(13) $\text{Annual } CV_k = [(T_k^1 \cdot I_k^1) - (T_k^0 \cdot I_k^0)] / \beta$

where T_k^1 = the predicted number of trips by angler *k* following the improvement, T_k^0 = the number of trips before the improvement, I_k^1 = the inclusive value following the improvement, I_k^0 = the inclusive value before the improvement, and β = the coefficient on travel cost from the site choice model.

The function in (12) is used to estimate the percentage increase in trips that follows from hypothetical changes in catch and weight. Using the estimated site probabilities from the random utility model (9), we distribute the new trips across the sites thereby leading to an increase in our expected congestion measure for each site. We then calculate per trip values for both the change in catch/weight and the accompanying change in congestion using the measure in (7). While there have been recent stock improvements that have impacted both the number and weight of striped bass caught, the actual magnitudes are not known. For illustrative purposes, then, we simply examine a twenty-five percent increase in catch for the release anglers and a twenty-five percent increase in weight for the keep anglers.

Tables 8 and 9 present the regression results from the participation function as well as the per trip willingness to pay estimates for the catch improvements both with and without the accompanying change in congestion. For both types of anglers, the coefficients on the inclusive value and income terms are of the expected sign, while only the inclusive value coefficient is strongly statistically significant. We have no prior expectations on the age variable, and as shown, it is negative and statistically insignificant.

Feeding the increase in trips from the stock enhancement and the accompanying changes in congestion at each of the sites back into the site choice model, we see that the per trip willingness to pay by the catch and keep anglers is larger than the value for the catch improvement alone. This is direct result of the specific signs and magnitudes of the coefficients on the nonlinear congestion term. Since the linear coefficient is positive and larger than the negative squared coefficient, overlooking the potential impacts of congestion leads to an underestimate of the per trip willingness to pay. We observe just the opposite effect for the catch and release anglers. That is, because the linear coefficient is negative while the squared term is positive, overlooking these nonlinear congestion effects leads to an overestimate of the per trip willingness to pay for the stock enhancement. Hence if positive stock growth results in improved quality of catch, we can assume that both types of anglers will initially increase visits. It is this increase in aggregate trips that will impact angler types differently. Such an increase in aggregate trips may reinforce the relative attractiveness of one site versus another for the catch and keep anglers yet detract from the overall expected utility of a trip for the catch and release anglers.

Conclusions

The purpose of this paper was to develop and test various expected congestion measures that may influence site choice decisions within a revealed preference framework. Our congestion measures are derived from data on the average number of fishing parties per day at various boat ramps during the striped bass fishing season in the Roanoke River, North Carolina. A variety of expected congestion measures are developed that differ with respect to the time horizon with which we assume anglers might base their site choice decisions upon, and whether or not anglers differentiate between weekend or weekday congestion. We also test whether heterogeneous angler types respond differently to changes in expected congestion that may result from improved quality of catch.

Our results suggest a clear difference in the trip utility functions for different types of anglers that frequent the Roanoke River during striped bass season. While the anglers are targeting the same species, and generally using similar fishing methods, the preferences of these anglers for different aspects of trip quality seem quite different. Consequently, these heterogeneous preferences are likely to affect the incidence of welfare gains from a stock improvement. For instance, our results suggest that anglers participating in the catch-and-release fishery appear to be more averse to congestion than their catch and keep counterparts. Assuming a nonlinear congestion specification, increases in expected congestion decrease the probability that a catch and release angler will visit a particular site, yet the utility-related congestion impacts are likely to diminish with each additional visitor. Conversely, catch and keep anglers seem to respond positively to increases in expected congestion, perhaps suggesting that increases in past aggregate visits serves as an indication of quality. Yet, within the nonlinear specification, there does seem to be a threshold after which additional increases in aggregates visits likely detract from site utility. There did not seem to be any strong indication for any particular time horizon over which either of the angler types formulate their expectations of congestion. Furthermore, differentiating between weekday versus weekend expected congestion did not seem to add any significant explanatory power.

From a management perspective, insight into the impact of changes in current stock levels or management practices on different user groups may be prove useful. Since 1987, strict harvest controls on striped bass in the Roanoke and proper management of flows during the spawning season have resulted in successive years of good reproduction. Consequently, the Albemarle Sound/Roanoke River striped bass stock has gown and, in 1997, was declared recovered to historical population levels by the Atlantic States Marine Fisheries Commission (J.W. Kornegay, N.C. Wildlife Resources Commission, personal communication). We can assume that as stocks continue to grow, both catch rates and congestion will increase, and hence anglers that are more averse to congestion than the average may decrease visits. Those who are relatively indifferent to congestion, but who have high preferences for catch, may increase visits.[22] The extent of the welfare effects from these changes in use will depend on the relative value that anglers place on catch, landings, and congestion. For a given increase in fish stock, our results suggest that overlooking the potential impacts of congestion on angler site choice and trip demand will likely overestimate the catch and release anglers' per trip willingness to pay for this stock increase yet underestimate of the catch and keeps anglers' per trip willingness to pay.

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TABLE 1. Congestion measures in the empirical literature

STUDY	OBJECTIVE	METHOD	MEASURE OF CONGESTION
Cicchetti and Smith (1973)	Estimate impact of congestion on the benefits from wilderness experiences	Stated preference method	Average number of trail encounters; number of nights of camp encounters
McConnell (1977)	Estimate benefit functions for beach recreation accounting for congestion effects	Stated preference method	Hourly beach attendance per acre of beach
Deyak and Smith (1978)	Investigate congestion effects on both participation in (and quantity of) remote camping	Household production model	Total use per acre of National Forest Wilderness and Primitive Areas by state in year of survey
Lin, Adams, and Berrens (1996)	Investigate welfare effects of alternative salmon allocation policies	Revealed preference method	Total angler days in previous week divided by length of fishable water at site
Jakus and Shaw[23] (1997)	Compare congestion measures from stated vs. revealed preference models	Stated preference method	Perceptions of adequate parking spaces; encounters on trails and roads
Boxall, Englin, and Rollins (2000)	Estimate welfare impacts of congestion on wilderness experience	Stated and revealed methods	Number of groups encountered during canoe trip

TABLE 2. Descriptive Statistics

	CATCH-AND-RELEASE ANGLERS (N=146)				CATCH-AND-KEEP ANGLERS (N=213)			
Variable	Mean *	Std Dev	Min	Max	Mean *	Std Dev	Min	Max
MILES	87.32	58.92	1	260	52.47	48.18	1	300
TRIP HRS	5.85	2.34	0	12	5.22	2.24	1	12.5
BOAT LENGTH	15.88	3.71	0	22	16.16	2.76	0	28
MOTOR HP	65.88	45.45	0	200	59.46	39.70	0	225
PAST TRIPS	4.77	8.68	0	75	4.23	5.58	0	50
FUTURE TRIPS	5.30	9.01	0	50	9.32	12.50	0	100
USE CHARTER	0.13	0.34	0	1	0.02	0.15	0	1
ANGLER AGE	41.55	13.04	19	81	42.16	13.13	11	82
FISHING YRS	30.01	14.75	0	68	31.23	13.32	2	70
COMPLETE HS	0.99	0.08	0	1	0.96	0.19	0	1
INCOME	67162.5	48899.1	0	380000	57875.6	31423.2	0	185000

* Means of (0,1) variables should be interpreted as the % of respondents answering in the affirmative

TABLE 3. Results of Poisson regressions for expected catch

Variable	Numbers of Striped Bass	Weight of Striped Bass	Numbers of Other Species
Site 2	-0.192***	-0.327***	0.983***
	(0.050)	(0.032)	(0.252)
Site 3	-0.772***	-0.710***	0.256
	(0.085)	(0.051)	(0.379)
Site 4	-0.713***	-0.711***	2.387***
	(0.053)	(0.031)	(0.148)
Site 5	-0.871***	-0.882***	-0.550
	(0.054)	(0.033)	(0.497)
Site 6	-2.95718***	-3.547***	-13.252
	(0.252313)	(0.175)	(151.409)
Site 7	-2.248***	2.688***	3.555***
	(0.195)	(0.119)	(0.246)
Site 8	-0.465***	-0.656***	2.576***
	(0.046)	(0.029)	(0.111)
Site 9	0.663***	0.393***	0.533
	(0.051)	(0.031)	(0.351)
Hours Fished	0.030***	0.069***	-0.218***
	(0.011)	(0.006)	(0.064)
Boat Length	-0.017***	-0.017***	0.163***
	(0.003)	(0.001)	(0.023)

Variable	Numbers of Striped Bass	Weight of Striped Bass	Numbers of Other Species
Horsepower	0.005***	0.005***	-0.001
	(0.0004)	(0.0002)	(0.002)
Past Roanoke Trips	0.0207***	0.026***	-0.0005
	(0.002)	(0.0009)	(0.005)
Charter	0.369***	0.328***	-0.829***
	(0.025)	(0.014)	(0.281)
Live Bait	-0.022	-0.0003	-1.490***
	(0.029)	(0.016)	(0.210)
Cut Bait	-0.194***	-0.140***	-2.350***
	(0.044)	(0.026)	(0.224)
Artificial Bait	-0.139***	-0.049***	-0.563***
	(0.020)	(0.011)	(0.103)
Years of Fishing	0.009***	0.008***	0.002
	(0.001)	(0.0006)	(0.005)
Season	-0.478***	-0.650***	-0.884***
	(0.018)	(0.010)	(0.080)
Constant	3.204***	4.055***	-0.323
	(0.079)	(0.045)	(0.527)
Pseudo R-squared	0.218	0.272	0.481

*,**,*** indicates statistical significance at the 10%, 5%, and 1% levels, respectively.

TABLE 4. Roanoke River Angler Intercept Site Characteristics

Site	Location	Capacity	Public	Average Congestion Keep Season	Average Congestion Release Season
1	Weldon (WRC) Halifax County	100	Yes	141.43	142.39
2	Edward's Ferry (WRC) Halifax County	75	Yes	42.217	15.79
3	Hamilton (WRC) Martin County	50	Yes	18.13	8.65
4	Williamston (WRC), Martin County	50	Yes	28.09	11.86
5	River's Edge Martin County	50	No	30.42	10.51
6	Pulp Mill Landing Martin County	25	Yes	5.75	12.82
7	Conaby Creek (WRC) Washington County	50	Yes	13.71	18.68
8	Highway 45 (WRC) Washington County	75	Yes	40.98	25.98
9	Sans Souci (WRC) Bertie County	10	Yes	18.57	25.04

TABLE 5. Roanoke River Angler Expected Congestion Measures

Congestion Measure	Description
CONG	Actual number of boats visiting the ramp on the day of the angler's trip (realized congestion).
PWA	Average number of boats visiting the ramp over the week prior to the angler's trip.
PTWA	Average number of boats visiting the ramp over the two weeks prior to the angler's trip.
PFWA	Average number of boats visiting the ramp over the four weeks prior to the angler's trip.
SPWA	Average number of boats visiting the ramp over the 5 weekdays prior to the angler's trip if the angler took a weekday trip and over the past weekend if the angler took a weekend trip.
SPTWA	Average number of boats visiting the ramp over the 10 weekdays prior to the angler's trip if the angler took a weekday trip and over the past two weekends if the angler took a weekend trip.
SPFWA	Average number of boats visiting the ramp over the 20 weekdays prior to the angler's trip if the angler took a weekday trip and over the past four weekends if the angler took a weekend trip.

TABLE 6. Utility function coefficients for catch and keep anglers (n = 213)

VARIABLE	COEFFICIENT (STANDARD ERRORS)										
	A	B	C	D	E	F	G	H	I	J	K
cost	-0.051***	-0.046***	-0.049***	-0.048***	-0.050***	-0.049***	-0.049***	-0.051***	-0.05***	-0.053***	-0.052***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
cbass	-0.133	-0.048	-0.055	-0.065	-0.045	-0.097	-0.040	-0.016	-0.008	-0.011	0.019
	(0.085)	(0.097)	(0.11)	(0.093)	(0.1001)	(0.092)	(0.094)	(0.1)	(0.094)	(0.096)	(0.093)
wbass	0.034***	0.016	0.022	0.020	0.022	0.027**	0.023*	0.023*	0.020	0.025*	0.020
	(0.012)	(0.014)	(0.015)	(0.014)	(0.014)	(0.013)	(0.013)	(0.014)	(0.013)	(0.014)	(0.013)
cother	-0.059	-0.074*	-0.104**	-0.079*	-0.116**	-0.081*	-0.111**	-0.129***	-0.116**	-0.142***	-0.123***
	(0044)	(0.045)	(0.048)	(0.045)	(0.046)	(0.044)	(0.046)	(0.047)	(0.047)	(0.049)	(0.048)
pubown	-3.178***	-2.72***	-2.511***	-2.78***	-2.41***	-2.8***	-2.484***	-2.344***	-2.45***	-2.26***	-2.39***
	(0.359)	(0.365)	(0.014)	(0.366)	(0.377)	(0.368)	(0.375)	(0.379)	(0.376)	(0.377)	(0.379)
cap	0.044***	0.025**	0.017	0.031**	0.023*	0.035***	0.027**	0.02	0.023*	0.018	0.023*
	(0.011)	(0.013)	(0.014)	(0.012)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)	(0.013)	(0.012)
cong		0.008***	0.033***								
		(0.002)	(0.006)								
cong2			-0.00007***								
			(0.00001)								
pwa				0.009***	0.028***						
				(0.002)	(0.007)						
pwa2					-0.0001***						
					(0.00002)						
spwa						0.01***	0.033***				
						(0.003)	(0.008)				
spwa2							-0.0001***				
							(0.00003)				
ptwa								0.0568***			
								(0.0103)			
ptwa2								-0.00024***			
								(0.00005)			
sptwa									0.042***		
									(0.01)		
sptwa2									-0.0002***		
									(0.00006)		
pfwa										0.078***	
										(0.015)	
Pfwa2										-0.0005***	
										(0.0001)	
spfwa											0.064***
											(0.016)
spfwa2											-0.0004***
											(0.0001)
Adj. R2	0.43	0.47	0.50	0.45	0.48	0.45	0.46	0.48	0.46	0.48	0.46

*, **, *** ~ statistically significant at the 10%, 5%, and 1% level, respectively

TABLE 7. Utility function coefficients for catch and release anglers (n = 146)

VARIABLE	COEFFICIENT (STANDARD ERROR)										
	A	B	C	D	E	F	G	H	I	J	K
Cost	-0.0375*** (0.006)	-0.038*** (0.006)	-0.0272*** (0.009)	-0.037*** (0.006)	-0.037*** (0.006)	-0.038*** (0.006)	-0.038*** (0.006)	-0.038*** (0.006)	-0.039*** (0.006)	-0.021** (0.009)	-0.023*** (0.008)
cbass	0.0246** (0.01)	0.0306*** (0.011)	-0.0155 (0.0117)	0.026** (0.011)	0.032*** (0.011)	0.027** (0.011)	0.031*** (0.011)	-0.007 (0.013)	-0.003 (0.013)	-0.035** (0.017)	-0.041*** (0.015)
wbass	0.0005*** (0.0002)	0.0006*** (0.0002)	0.0004** (0.0002)	0.0005*** (0.004)	0.0006*** (0.0002)	0.0005*** (0.0002)	0.0006*** (0.0002)	0.0002 (0.0002)	0.0002 (0.0002)	0.0002 (0.0002)	0.0003 (0.0002)
cother	-0.0172 (0.0127)	-0.0217* (0.0132)	-0.0518*** (0.016)	-0.0184 (0.0133)	-0.025* (0.014)	-0.020 (0.0.013)	-0.023* (0.014)	-0.006 (0.023)	-0.007 (0.012)	-0.013 (0.012)	-0.014 (0.014)
pubown	-0.6333 (0.557)	-0.721 (0.559)	1.319 (0.830)	-0.661 (0.561)	-0.826 (0.564)	-0.702 (0.557)	-0.80 (0.558)	0.352 (0.660)	0.078 (0.611)	2.246*** (0.810)	2.35*** (0.809)
cap	0.0529*** (0.0063)	0.0632*** (0.0084)	-0.002 (0.013)	0.055*** (0.009)	0.071*** (0.013)	0.059*** (0.009)	0.069*** (0.011)	-0.013 (0.019)	-0.002 (0.015)	-0.091*** (0.029)	-0.108*** (0.026)
cong		-0.0042* (0.002)	0.1462*** (0.0268)								
cong2			-0.0005*** (0.0001)								
pwa				-0.001 (0.002)	-0.014* (0.008)						
pwa2					0.00003* (0.00002)						
spwa						-0.002 (0.002)	-0.012* (0.007)				
spwa2							0.00003 (0.00002)				
ptwa								0.064*** (0.022)			
ptwa2								-0.0002** (0.0001)			
sptwa									0.043*** (0.013)		
sptwa2									-0.0001** (0.00004)		
pfwa										0.091* (0.048)	
pfwa2										-0.0001 (0.0002)	
spfwa											0.150*** (0.031)
spfwa2											-0.0004*** (0.0001)
Adjusted R2	0.62	0.63	0.64	0.62	0.63	0.62	0.63	0.65	0.65	0.77	0.76

*,**,*** ~ statistically significant at the 10%, 5%, and 1% level, respectively

TABLE 8. Participation function estimates

VARIABLE	COEFFICIENT (STANDARD ERROR)	
	Catch-and-Keep (n = 213)	Catch-and-Release (n = 146)
Intercept	4.71 (1.36)	-1.25 (2.77)
Inclusive Value	0.911 (0.165)	1.53 (0.29)
Income	0.00003 (0.00001)	0.000023 (0.000016)
Age	-0.038 (0.028)	-0.037 (0.052)

TABLE 9. Per trip willingness-to-pay for catch improvements and congestion effects
(mean and standard deviation)

	CATCH AND KEEP		CATCH AND RELEASE	
	25% increase in weight alone	25% increase in weight and congestion effect	25% increase in catch alone	25% increase in catch and congestion effect
Per trip willingness-to-pay	$8.18 (3.99)	$8.77 (4.07)	$10.94 (4.84)	$10.68 (5.39)

Endnotes

[1] Recently, the Fish and Game commission of Montana, in response to a mandate by their state legislature requiring them to find a solution to the over-crowding of anglers in the state's trout rivers, proposed a number of commercial-free zones on a few of their busiest rivers. Such an action will likely impact nonresident anglers who pay outfitters to take them fishing. Furthermore, the Commission also suggested that fishing on certain Saturdays in the summer and fall would be closed to out-of-state anglers. ("Helena Journal: Montanans Feeling Shut Out of Own Trout Rivers", New York Times, January 3, 2001).

[2] By "expected," we mean the average, similar to the mean as defined in Jakus and Shaw (1997). Clearly, this requires we assume anglers have some information on the aggregate number of trips during the previous periods. This information could be gathered through interaction with other anglers, newspaper accounts, or fishing reports.

[3] It should be noted that the focus of Lin, Adams, and Berrens (1996) was not on congestion impacts. Alternatively, the objective of Boxall, Englin, and Rollins (2001) is to evaluate the impacts of congestion, and they use both a revealed preference model to explain site choice and a stated preference model to explain how canoeists' willingness to pay differ with respect to changes in congestion.

[4] For an overview of travel cost methods and a brief history of the valuation of recreation experiences see Bockstael, McConnell, and Strand (1989), Kaoru, Smith, and Liu (1995), and Bockstael, Hanemann, and Kling (1987).

[5] Of the 598 anglers interviewed during this period, 505 (84.4 %) indicated striped bass as their primary target.

[6] One site was dropped from the data set due to lack of significant sample returned. See Table 1 for locations and characteristics of the remaining 9 sites.

[7] Travel distances are calculated to each site from the home city reported by the angler using the program Hyways/Byways. We assume explicit travel costs of $0.30 per mile. To calculate the opportunity cost of time, we multiply two-thirds of the angler's reported wage by travel time, which is calculated using the distances and an assumed average speed of 45 miles per hour.

[8] See Schuhmann (1998), McConnell, Strand, and Blake-Hedges (1995), and Kaoru, Smith and Liu (1995) for details and examples.

[9] For the estimation of utility, we focus on single-day anglers only since multi-day anglers may have a trip purpose other than fishing. As we do not have any information regarding what percent of the trip is dedicated to fishing for these anglers, we have no way of allocating the proper share of travel costs to the fishing component of their trip. Approximately 76 percent of all anglers interviewed were single-day anglers.

[10] See for example, Bockstael, McConnell, and Strand (1989), and Kaoru (1995).

[11] See McConnell, Strand, and Blake-Hedges (1995), Kaoru, Smith and Liu (1995), and Schuhmann (1998) for further discussion of the expectations issue and the Poisson application.

[12] We round total weight to the nearest whole number before estimation so that the data will conform to the restrictions of the Poisson specification.

[13] Site 1 is used as the control.

[14] We use an instrument here due to the potential endogeneity between hours of fishing and catch.

[15] A combination of baits is used as the control for these variables.

[16] Personal communication, Mr. Pete Kornegay, NCWRC, Division of Inland Fisheries.

[17] While the estimates of the number of boats at the site can be considered estimates of the number of fishing parties for each day, they do not account for the number of anglers per party or the number of hours of angling effort exerted. Our congestion estimates were

developed from instantaneous raw trailer count data that were converted into full day estimates of total anglers by expansion in accordance with past experience of characteristics of the fishery (largely angler counts in creel surveys by NCWRC).

[18] This approach is therefore similar to the common use of historical catch rates as proxies for expected catch. See, for example Bockstael, McConnell, and Strand (1989), Kaoru 1995, or Rowe, Morey, and Shaw (1985).

[19] This is similar to the idea described in Becker (1991), albeit in the context of restaurant pricing, which describes demand by an individual consumer to be positively related to quantities demanded by other consumers if crowds are an indication of quality or if consumers derive utility from competing for goods that are not available to everyone who wants them.

[20] This is one of a number of approaches to integrating site choice with number of trips data. Parsons, Jakus, and Tomasi (1999) provide a nice summary of four main approaches and illustrate how one's choice of participation function influences the resulting welfare measure. As noted in the literature, the combination site choice-participation function we employ is not derived from a single overall utility maximization problem.

[21] The inclusive value is the expected value of the maximum of the site utilities, and is a preference weighted measure of site costs and attributes represented by: $I_k = \ln \sum \exp (V_j) + .577$.

[22] Note that while larger stocks may prompt NCWRC to increase catch-and-keep bag limits, this may not be the case.

[23] Jakus and Shaw (1997) elicit from recreationists' both a perceive measure of congestion via an onsite survey and an anticipated or expected measure of congestion via a mail survey.