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Abstract

Recognition of the benefits to society supported by estuary ecosystem functions and services, and threats to these benefits posed by human activities, has led to various public programs to restore and protect estuaries and the federal, state and local levels. As available budgets shrink, program administrators and public elected officials struggle to allocate limited restoration and protection funds to the highest priority areas. Economic benefit and cost information can provide useful inputs into this decision-making process by quantifying estuary restoration and protection benefits and costs in commensurate terms. In this paper, a combined actual and intended travel behavior model is described that can be applied to estimate the recreational fishing benefits of estuary restoration and protection. The model was estimated for recreational fishing in the Lower Atchafalaya River Basin estuary along the Gulf of Mexico, Louisiana, U.S.A. coast. Changes in freshwater flows into this estuary may affect redfish and speckled trout game fish populations. The model indicates that changes in catch rates of these two species would have a relatively minor affect on annual fishing trips per angler. However, because total effects may be large when effects per angler are aggregated across total anglers, resource management agencies should consider these changes in recreation benefits when evaluating projects that influence the ecology of coastal estuaries, fish populations and catch rates. Moreover, in other coastal areas or situations, the responsiveness of angling trips to changes in catch rates may vary because of differences in user populations, environmental conditions, fish populations and fishing experiences.

Key Words: Coastal estuary management, ecosystem services, game fish populations, angler catch rates, fishing trip changes, fishing benefits

Estuary Management and Recreational Fishing Benefits

Introduction and Problem Statement

Estuaries are defined as partially enclosed transition zones between freshwater riverine and saltwater ocean ecosystems where freshwater from inland rivers mixes with saltwater from oceans. In coastal areas, a particular estuary may be known commonly as a bay, inlet, sound, harbor or lagoon. The natural mixing of freshwater and saltwater in an estuary creates an ecologically rich ecosystem that provides unique habitat for a wide diversity of marine life. This marine life provides many nonconsumptive and consumptive values to people including nature observation and photography, and commercial and recreational fishing (NOAA, 2002; U.S. EPA, 2003).

In many coastal estuaries throughout the United States and world, human activities are affecting the natural balance of salt and other chemicals in estuaries resulting in changes in ecosystem functions and services. For example, changes in the chemical composition of estuaries due to municipal and industrial wastewater emissions and chemical run-off from farms, golf courses and residential subdivisions impact the natural habitat functions of estuaries often with negative impacts on fish and wildlife populations. The salt content of estuaries is also sensitive to increases or decreases in freshwater inflow resulting from changes in inland river system management.   Changes in the delicate mix and balance of freshwater and saltwater in coastal estuaries may also impact natural habitat functions resulting in increases in some fish and wildlife species and decreases in others (NOAA, 2002; U.S. EPA, 2001; U.S. EPA, 2003).

Recognition of the benefits to society supported by estuary ecosystem functions and services, and the threats to these benefits posed by human activities, has led to various public efforts to protect estuaries. In the United States, one of the core objectives of the federal Coastal Zone Management Act of 1971 is to foster coordinated efforts at the federal, state and local government levels to protect coastal estuaries and wetlands (Hershman et al., 1999). The mission of the National Estuary Program initiated under 1987 amendments to the federal Clean Water Act is to "restore and protect America's nationally significant estuaries" (U.S. EPA, 2003). The federal Estuary Restoration Act of 2000 has the goal of restoring one million acres of estuary habitat by 2010 (NOAA, 2002). In addition to these federal acts and programs, many state and local governments are actively involved in efforts to protect and restore coastal estuaries.

Implementation of federal, state and local government programs to restore and protect estuaries involves considerable expenses. Program administrators and elected public officials in charge of budgets may request or demand an answer to the following question, "What are the economic benefits of estuary restoration and protection, and how do these benefits compare to the economic costs"? As available budgets shrink, this question may be asked more frequently as program administrators and public elected officials struggle to allocate limited funds to the highest priority areas; for example, the highest valued estuaries in their county, state or nation.

The economic costs of estuary restoration and protection including land acquisition costs, civil and environmental engineering costs, and public management and administrative costs are often relatively straightforward to estimate. The economic benefits of estuary restoration and protection, however, are typically much more difficult to quantify as illustrated by the recent estuary valuation study conducted by Johnston et al, 2002 as part of the National Estuary Program. In the Johnston et al, 2002 study, several valuation methodologies were applied to estimate the economic benefits of the Peconic Estuary System along the New York Atlantic Ocean coast including a travel cost model similar to the one presented in this paper. The travel cost model presented in this paper was estimated for a coastal estuary in a different region of the United States, the Louisiana Gulf of Mexico coast. Our model also used combined actual and intended behavior data to estimate catch elasticities for specific game fish species, redfish and speckled trout. The models and results provided by this study and the Johnston et al, 2002 study provide consistent and complementary information useful for evaluating estuary restoration and protection from regional and national perspectives.

Estimating Estuary Management Benefits: A Case Study

Estuaries along the coastal United States often represent highly managed ecosystems as freshwater flows into these estuaries are influenced by large networks of water projects that control coastal river flows into the estuaries. In these coastal areas, there is great interest in how management projects that influence the flow of freshwater into estuaries from rivers may change fish habitat, fish populations and ultimately recreational fish catch. Assessment of the effects of such projects on anglers requires information on how responsive angler use is to changes in catch.

Recreational fishing continues to be a popular activity that provides much enjoyment to people who fish. Although previous studies suggest that people engage in fishing for a variety of reasons including spending time with friends, nature appreciation, personal reflection and relaxation (Harris and Bergersen, 1985), the actual success of catching fish is a primary motivation and source of angling satisfaction. But, just how sensitive are anglers to changes in fishing success? This question was addressed in our case study conducted to measure how responsive coastal angler visitation is to changes in catch rates of specific game fish species, redfish and speckled trout. The case study area was the Lower Atchafalaya River Basin along the Louisiana, U.S.A coast.

Theoretical Demand Model

A combined travel cost and trip response demand model was specified to estimate the change in fishing trips with changes fish catch and the economic value per fishing trip. A trip response model is a type of intended behavior model (Loomis, 1993; Teasley *et al*, 1994). Intended behavior models fall under the broad classification of stated preference approaches that include contingent valuation. There are several advantages of combining actual visitation behavior data (e.g. revealed preferences) and intended visitation behavior data (e.g. stated preferences) when estimating a recreational fishing demand curve. First, management changes may result in changes in fish populations and catch rates that exceed what has been observed in the study area in the past. In such cases, observations of anglers' responses to catch rate changes that are outside of the range of actual past variations in catch rates would be unavailable. However, employing the intended behavior approach, these unobserved catch rate changes can be described to anglers in a survey and their intended change in trips in response to these changes recorded and included when estimating the recreational fishing demand curve.

Second, past changes in catch rates for the species of interest may be correlated with changes in other species catch rates making it difficult to isolate the effect of the policy change. This can be overcome in the design of the intended behavior scenarios by varying just the catch rates of the species of interest. Finally, besides varying fishing quality, the intended behavior approach can posit higher levels of travel cost to provide additional price variability, especially near the vertical axis of the demand curve, which helps to improve precision of the benefit estimates.

The format of the combined actual and intended behavior model in this study was:

(1) $TRIPS_{ij} = f\,(TC_{ij}, CATCH_{i}, INCOME_{i}, SUBSTITUTE_{i}, H_{i})$, where,

$TRIPS_{ij}$ = annual actual fishing trips by individual *i* to access site *j* with current catch combined with planned or intended fishing trips by individual *i* to access site *j* assuming given increases or decreases in expected catch or higher trip costs

TC_{ij} = actual and scenario specific round-trip travel cost for individual *i* to access site *j*

$CATCH_i$ = actual and scenario specific fish catch per trip for individual *i*

$INCOME_i$ = individual *i*'s household income

$SUBSTITUTE_i$ = distance (miles) to substitute access site

H_i = demographic and tastes and preferences variables describing individual *i*.

Trip and Catch Variables. A major objective of the demand model estimation was to measure the effects of recreational fish catch on the quantity of annual recreation fishing trips taken by current users of the study area. This relationship was estimated using a combination of data on actual or revealed trips given current actual catch of the primary target species, data on intended or stated trips given potential changes in trip cost holding current catch constant and data on intended or stated trips given potential changes in catch of the primary target species. The dependent variable in Equation (1) therefore contains four observations per respondent: one observation corresponds to actual annual trips taken at current catch; the second corresponds to intended annual trips assuming an increase in trip cost with current catch held constant; the third corresponds to intended annual trips assuming a decrease in expected catch with current trip cost held constant; and the fourth corresponds to intended annual trips assuming an increase in expected catch with current trip cost held constant.

Given the above set-up of the revealed and stated trip questions in the survey questionnaire, the fishing catch variable in Equation (1) was constructed by combining actual current catch and expected catch under alternative catch scenarios. In the data collection survey conducted for this study which is described in more detail later in the paper, anglers were presented with a scenario where catch per trip was assumed to increase by a certain percentage from current catch, and a scenario where catch per trip was assumed to decrease by a certain percentage from current catch. The assumed percentage increase or decrease in catch was multiplied by current catch to estimate expected catch under alternative catch scenarios.

For example, suppose that Respondent A's current catch of the primary target species per trip is 12 fish. In the data set for estimating Equation (1), the value for the catch variable corresponding to current trips would therefore be set equal to 12. Next, suppose the first alternative catch scenario presented a respondent with a 50% decrease in catch meaning that in this scenario expected catch would be 12 x .50=6. In the data set for estimating Equation (1), this respondent's next observation would have the value of the catch variable corresponding to the number of intended trips in the decreased catch scenario equal to 6. Finally, suppose the second alternative catch scenario presented a respondent with a 25% increase in catch meaning that in this scenario expected catch would be 12 x 1.25=15. In the data set for estimating Equation (1), the value of the catch variable for the corresponding variable would set equal to 15.

Travel Cost (Price) Variable. The travel cost (or price) variable, TC_{ij}, was calculated using a standard travel cost method distance-to-cost conversion that accounts for both out-of-pocket expenses and the opportunity cost of time (Loomis and Walsh, 1997, Chapter 9; U.S. Water Resources Council, 1983). The distance-to-cost conversion formula was:

(2) $TC_{ij} = [(2 \text{ x } DISTANCE_{ij} \text{ x } \$PERMILE)/GROUP+(2 \text{ x } TIME_{ij} \text{ x } (WAGE_i/3))]$,

where,

TC_{ij} = travel cost to site *j* for individual *i* per trip

$DISTANCE_{ij}$ = one-way distance individual *i* traveled from home to access site *j*

$PERMILE = cost per mile in dollars of operating a motor vehicle

$TIME_{ij}$ = one-way travel time to access site *j* for individual *i*

$WAGE_i$ = effective household wage rate per hour for individual *i*

GROUP = individual *i*'s group size per trip.

Because of limited access for bank fishing, most anglers in the study area fish by boats launched from boat access sites. To account for higher costs of driving a vehicle pulling a trailer and boat, the 1999 (last year of data collection) cost per mile allowance set by the U.S. Internal Revenue Service (IRS), $.315 per mile, was used as the estimate of $PERMILE in Equation (2).

The variable $WAGE_i$ in Equation (2) was estimated by dividing household income for individual *i* by assumed work hours in a calendar year (2000 hours), and then dividing this result by the number of workers in a household. Dividing $WAGE_i$ by three provides a standard estimate of the opportunity cost of travel time (Loomis and Walsh, 1997, Chapter 9).

Substitute Variable. In the survey questionnaire, respondents were asked if they would travel to another access site if for some reason the spot where they fished on the day of the interview were not available. If a respondent responded in the affirmative, he or she was asked to report the distance in miles to this new access site. This distance provides a measure of the cost of substitute fishing opportunities. For these respondents, the $SUBSTITUTE_i$ variable in Equation (1) was set equal to the distance in miles from the respondent's home to the new access site. If a respondent stated that he or she would go to a different spot in the bay using the same access site, the $SUBSTITUTE_i$ variable in Equation (1) was set equal to the distance in miles from the respondent's home to the original access site. In this latter case, the economic interpretation of the substitute variable coding is that the cost of substitute recreational opportunities for a particular respondent is essentially the same as the original recreational opportunities (since they would use the same access point, but fish in a different part of the bay).

Income (Budget) Constraint Variable. The income variable in Equation (1), $INCOME_i$, is individual *i*'s reported household income. Household income serves as a total budget constraint to the amount of goods and services an individual can consume, including annual fishing trips. The general theoretical expectation is that as income increases, consumption of goods and activities will increase unless the good or service is an inferior commodity.

Demographic and Taste and Preference Variables. Demographic and tastes and preference variables describing individual *i*, represented by H_i in Equation (1), can influence recreation trip behavior in a variety of ways. In general, variables in H_i measure an individual's strength of preferences for recreational trips and attributes of these trips (e.g., catch). For the estimation of Equation (1), the following variables were selected to represent H_i.

The amount of leisure time available to a person represents an overall time constraint influencing annual fishing trips. As the amount of leisure time increases, a person can allocate more time to recreational activities including fishing trips. For Equation (1), whether or not a respondent is retired was used as a proxy for total leisure time. This variable was expected to be positively related to preferences for fishing and therefore annual fishing trips taken by a person.

Individual anglers combine their skills, experience, time, travel and equipment to "produce" recreational trips (Bockstael and McConnell, 1981). For Equation (1), total years of fishing experience was used to measure accumulated fishing skills and experience contributing to an individual's ability to "produce" fishing trips with desired quantity and quality attributes. Because a person with more total years of fishing experience is likely to be a better "producer" of fishing trips, this variable was expected to increase preferences for fishing and therefore be positively related to annual fishing trips.

Strength of preferences for fishing may also be indicated by an individual's age. Preferences for fishing and other types of recreation may increase or decrease as a person ages. Hence, the expected relationship between age and number of annual fishing trips taken by an individual is ambiguous (e.g., the relationship could be positive or negative for different individuals and groups).

Years of education is another general measure of strength of preferences that was used in the estimation of Equation (1). As with age, the relationship between education and recreational behavior is difficult to predict *a priori*. As a person obtains more years of formal education, preferences for certain types of outdoor recreation may increase or decrease. Thus, the expected relationship between years of education and annual fishing trips taken by an individual is ambiguous (e.g., could be positive or negative for different individuals).

Certain people with strong preferences for outdoor recreation may be in category of "outdoor recreation enthusiasts". People in this "enthusiast" category are characterized by a high commitment to spending time outdoors engaged in recreational activities. For estimation of Equation (1), the degree of enthusiasm for outdoor recreation in general was measured by annual days of all types of outdoor recreation and whether or not a respondent is a member of a sportsmen's organization. Both of these variables were expected to be positively related to the annual number of fishing trips taken by an individual.

Interest and involvement in environmental issues may also be an indicator of strength of preferences for fishing. For Equation (1), a respondent's level of interest and involvement in environmental issues was measured by whether or not the respondent is a member of an environmental organization. Members of environmental organizations are likely to have strong interests in natural resource management issues, but may or may not have strong preferences for particular outdoor activities such as fishing. The relationship between membership in an environmental organization and number of annual fishing trips taken by an individual is therefore ambiguous (e.g., could be positive or negative for certain individuals).

Interest in natural resource management issues and familiarity in particular with water diversion projects in the study area was measured by a respondent's knowledge of U.S. Army Corps of Engineers flood control projects in the Lower Atchafalaya River Basin. As a person spends more time fishing in the study area, he or she is likely to become more aware and concerned about resource management in the area. Knowledge of flood control projects in the Lower Atchafalya River Basin was therefore expected to be positively correlated with annual fishing trips taken by an individual.

Issues Related to Dependent Variable Distribution. There are several econometric issues worth discussing related to the distribution of the dependent variable in Equation (1),

$TRIPS_{ij}$. Two of these issues are truncation and(or) censoring of the dependent variable. As described in more detail in the next section, data for estimating Equation (1) was collected from current recreational users only. Hence, nonusers are not represented in the data set used to estimate Equation (1); econometrically speaking, nonusers have been *truncated* from the data set (Fletcher et al, 1990; Madalla, 1983, Chapter 6).

When estimating a demand function such as Equation (1), econometricians typically assume that the dependent variable is normally distributed. In the case of the model estimated here, the assumption of normality for $TRIPS_{ij}$ would technically imply that the range of annual trips is from minus to plus infinity. Of course, the data set used to estimate Equation (1) only includes nonnegative observations of trips. Because part of the statistical range of variation in the dependent variable is omitted from the data set used to estimate Equation (1), the data set econometrically speaking is *censored* (Fletcher et al, 1990; Madalla, 1983, Chapter 6).

Whether or not truncation is a problem for estimation and application of a demand function depends upon the population to which the estimation results (e.g., estimated economic value) will be applied. Because nonusers are not included in the data set used to estimate Equation (1), the estimation results are only representative of current users. Thus, the estimation results from this truncated sample can only be applied to the population of current users. As long as the estimation results are only applied to the population of current users, there is no econometric problem.

Censoring presents a potential econometric problem, regardless of the population to which to estimation results will be applied. Because a portion of the range of the statistical normal distribution of the dependent variable in Equation (1) is omitted, ordinary least squares (OLS) regression estimates of Equation (1) coefficients are biased

(Fletcher et al, 1990; Madalla, 1983, Chapter 6). The severity of the bias depends on how much of the statistical distribution of $TRIPS_{ij}$, as predicted by Equation (1), would actually fall in the negative range. If the number of negative trips that the estimated demand model predicts is small, the potential bias caused by censoring is also small, and vice-versa. If the estimated demand function predicts a large number of negative trips, econometric estimation techniques other the OLS that correct for censoring should be used. In the case of demand functions such as Equation (1), however, application of econometric techniques to correct for significant suspected censoring problems would be very data-intensive requiring observations on both current users and nonusers (Fletcher et al, 1990).

Potential econometric problems may also arise that are related to the integer nature of the dependent variable in Equation (1). Because people cannot logically take fractional trips, $TRIPS_{ij}$ in Equation (1) is distributed technically as an integer variable. That is, in the data set used to estimate Equation (1), observations of $TRIPS_{ij}$ are reported and recorded only as whole numbers.

Reporting and recording the dependent variable only as whole numbers is a potential econometric problem if the resulting fractional predicted values are a problem for the users. The extent of the problem depends on the range of distribution of the dependent variable. When the range of distribution of $TRIPS_{ij}$ is very small; for example, from zero to ten trips, the problem can be more acute. If the range of distribution of $TRIPS_{ij}$ is relatively large, say zero to 50, 100 or even 200 trips, then econometric problems likely would be negligible and best ignored. For this reason, it is common practice to apply OLS to estimate empirical demand functions for commodities that technically are distributed as integer values, but have a wide range of distribution (e.g., loaves of bread, apples, clothing items).

Another potential problem related to the distribution of $TRIPS_{ij}$ is overrepresentation of high annual trip users. In the case of on-site interviews as conducted for this study, high annual trip users may have had a higher probability of being interviewed because they are out in the study area during the interviewing period more often than low annual trip users. If this was in fact the case, the distribution of $TRIPS_{ij}$ in Equation (1) may be skewed towards high annual trip users, rather than normally distributed with relatively equal numbers of high and low annual trip users. Therefore in our statistical analysis we checked for each of the potential problems with OLS to determine whether this was a serious problem for our data set or not.

Empirical Estimation Approach and Results

Data Collection. The study area was composed of an approximately 1,965 square mile area of the Lower Atchafalalya River Basin along the Gulf of Mexico coast of Louisiana. Major water bodies in the study area are Terrebone Marsh, Atchafalaya Bay, Four League Bay, East and West Cote Blance Bays, Weeks Bay and Vermilion Bay. The study area is extensively used for saltwater recreational fishing with redfish and speckled trout being two of the most popular game species sought by anglers.

An on-site, personal interview survey of saltwater anglers was conducted in the study area to collect data needed to estimate the trip response model. 12 boat access interview sites were selected to represent geographic dispersion (major coastal access locations across the 100-mile wide study area), different intensity of use levels (low, moderate and high) and different ownership (public and private).

Weekday and weekend interview days were scheduled for each boat access site from July, 1998 through June 1999 during each of the following four quarters: July through September, 1998; October through December, 1998; January through March, 1999; and April through June 1999). A total of 24 survey dates and days were randomly selected for each quarter giving a grand total of 96 survey dates and days for the 12-month period.

On the assigned sampling days at each boat access site, trained interviewers from the Louisiana State University Population Data Center Survey Research Laboratory administered personal interviews with anglers. In the case of inclement weather unsuitable for fishing, contingency days were randomly selected to take the place of the original designated sampling days. A total of 726 interviews were completed with the following distribution across the four quarters: July-September, 1998 (204); October-December, 1998 (198); January-March, 1999 (165); and April-June, 1999 (159). More detail on the study area, sampling and survey procedures are provided in URS/Dames& Moore and Greeley-Polhemus Group, 2001.

Estimation Results. With the potential problems discussed above related to the distribution of $TRIPS_{ij}$ in mind, Equation (1) was initially estimated with OLS regression. Assuming that the estimation results will only be applied to the population of current users, truncation of nonusers from the sample does not hinder the application of OLS. The estimated model also predicted fewer than 10 negative trips (out of 1164 observations). Thus, censoring also did not appear to be a problem with respect to application of OLS. The empirical distribution of $TRIPS_{ij}$ in the sample is from zero to about 200 trips. Given this wide distribution, acting as if the dependent variable is continuously distributed including fractional numbers appears reasonable.

Analysis of the empirical distribution of $TRIPS_{ij}$ indicated that the sample distribution was skewed slightly towards high annual trip users. This skewness was attributable primarily to a small number of users (fewer than 6) with very high annual trips (greater than 100). However, the mean number of trips for the sample appears reasonable and is in line with previous studies of similar angler populations (Bergstrom *et al*, 1990).

Equation (1) was estimated using OLS applied to alternative functional forms. Alternative functional forms estimated included: linear (linear dependent and independent variables); log-linear (logged dependent variable and linear independent variables); linear-log (linear dependent variable and logged continuous independent variables; and log-log (logged dependent variable and logged continuous independent variables). Statistical tests indicated the presence of heteroskedasticity in the OLS results. Heteroskedasticity means that the regression model error variance is not constant as required by OLS to be efficient. The models were therefore re-estimated using a

Generalized Least Squares (GLS) regression procedure that corrected for heteroskedasticity.

The GLS procedure used the variables for total annual recreation days and flood control project knowledge to correct for heteroskedasticity. In correcting for heteroskedasticity, the GLS procedure weighted observations by the inverse of the estimated standard deviation of each observation. This procedure provided a correction for the slight skewness towards high use anglers observed in the sample. Condition number tests indicated no major problems with multicollinearity in the GLS estimation results. Multicollinearity refers to combined correlation between the regression model independent variables. In addition, analysis of simple correlation coefficients between independent variables indicated relatively small correlation between sets of independent variables, including socioeconomic variables such as age, income and education that in some data sets may be found to be highly correlated.

With respect to the substitute variable, a very high proportion of the sample respondents stated that if the primary spot where they fished on the day of the interview was not available for some reason, they would go to a different spot in the bay from the same access site. Hence, for most of the respondents the price of substitute fishing opportunities was about the same as primary trip cost. As a result, there was high correlation between the trip cost and substitute variables in Equation (1). It was therefore necessary to drop the substitute variable from the final equation. The sensitivity of the magnitude and sign of remaining variables to dropping the substitute variable was very low. Thus, omitted variable bias does not appear to be a concern.

In the modeling process, separate catch variables for redfish and speckled trout were tested. Statistical tests indicated that the catch coefficient estimates for these two species were not statistically different. Redfish and speckled trout catch were therefore combined into one primary catch per trip variable for the final estimated demand function.

The linear-log functional form was superior to other functional forms based on goodness-of-fit diagnostics including statistical significance of independent variable coefficients, consistency of independent variable coefficient signs with conceptual expectations, and R-Square. The linear-log model was therefore selected for final presentation and application. GLS estimation results for the linear-log functional form of Equation (1) are shown in Table (1).

Most of the demand function coefficient estimates reported in Table (1) are statistically significant with the expected sign. The sign on the coefficient for the natural log of cost per person per trip (the trip "price" variable) is statistically significant at the .01 level and negative. Thus, the demand function is downward-sloping as would be expected from economic theory.

Fish catch is an indicator of the quality of fishing trips and is expected to be positively related to annual trips. Thus, the positive and statistically significant at the .01 level coefficient associated with the catch variable for redfish and speckled trout reported in Table (1) is consistent with conceptual expectations. The coefficient associated with the catch variable for all other fish was not statistically significant.

The monetary budget constraint represented by the natural log of household income is statistically significant at the .01 level and positive. This result suggests that fishing trips to the study area are in the nature of normal economic commodities with a positive income effect. A positive income effect implies that consumption of a commodity increases as household income increases.

Fishing participants also face an overall leisure time constraint. Whether or not an individual is retired was used as a proxy for the amount of leisure time available to a fishing participant. The sign on the coefficient for the retirement indicator variable in Table (1) was not statistically significant.

The coefficient on the natural log of total years of fishing experience was positive and statistically significant at the .01 level. The positive sign suggests that as an individual gains more total years of fishing experience, annual fishing trips taken by the individual increase. This result was consistent with the expectation that more experienced anglers would be better "producers" of fishing trips with higher frequency of participation.

Education and age may be general indicators of strength of preferences for fishing in the study area. The age coefficient was not statistically significant. The education coefficient has a negative sign and is significant at the .01 level. Thus, it appears that respondents with more years in school take fewer annual fishing trips to the study area.

The coefficient on the indicator variable for membership in a sportmen's organization was positive and statistically significant at the .01 level. This positive sign indicates that sportmen's organization members take more annual fishing trips than users who do not belong to such groups. This result is consistent with the expectation that members of sportmen's organizations have strong preferences for outdoor activities such as fishing. The coefficient associated with the variable indicating whether or not a person is a member of an environmental organization was not statistically significant.

It was hypothesized that people who take more fishing trips to the study area are likely to more knowledgeable and concerned about U.S. Army Corps of Engineers flood control projects. Thus, it was expected that knowledge of flood control projects would be positively related to annual fishing trips. As shown in Table (1), the coefficient associated with the variable indicating whether or not a respondent was knowledgeable of flood control projects was statistically significant at the .05 level with a positive sign as expected.

Calculation of Catch Elasticity. One of the primary objectives of the demand function modeling was to measure the responsiveness of annual fishing trips taken by users of the study area to changes in the number of fish caught per trip. This responsiveness can be measured using catch elasticity defined as the total percentage change in trips resulting from a one-percent change in catch. A general equation for catch elasticity is:

(3) $CE = (dTRIPS/dCATCH)x(CATCH/TRIPS)$, where

CE = catch elasticity
TRIPS = quantity of fishing trips
CATCH = catch per trip.

In Equation (3), the term (dTRIPS/dCATCH) is the partial derivative of Equation (1) with respect to catch. For the linear-log estimation of Equation (1), this partial derivative is equal to (b_2/CATCH) where b_2 equals the estimated coefficient on the catch variable. Substituting (b_2/CATCH) into Equation (3) gives the catch elasticity formula for the linear-log estimation of Equation (1):

(4) $CE = (b_2/CATCH)x(CATCH/TRIPS)$.

Equation (4) simplifies to:

(5) $CE = (b_2/TRIPS)$.

Equation (5) defines catch elasticity at a given point on the demand function for fishing trips; i.e., at a given level of fishing trips. To calculate average catch elasticity, average annual trips per individual is entered into Equation (5) along with the estimated catch coefficient value from Table 1. The estimated catch coefficient value for redfish and speckled trout from Table 1 is 1.268. Mean trips per individual predicted by the estimated demand function are equal to 16.06. Average catch elasticity calculated using Equation (5) would therefore be equal to .079.

The catch elasticity estimate of .079 implies that for the user who takes an average number of annual fishing trips to the study area (e.g., the typical or average user), a one- percent increase in catch per trip would induce him or her to take .079% more trips per year. The catch elasticity estimate suggests that the responsiveness of fishing trips taken to Atchafalaya Bay by current anglers to incremental changes in fish catch is relatively low. This low responsiveness may be explained partly by the fact that the average catch of Atchafalaya Bay current anglers is already quite high. Hence, small increases (or decreases) in catch from this high average catch rate may not have large impacts on the quality of recreation trips and therefore recreation trip behavior.

The fish catch elasticity estimated in this study is not unusually low as compared to what one might expect from theory and past empirical studies. As noted at the beginning of this paper, anglers have many motivations for fishing besides just catching fish (e.g., being in the out of doors, being with family and friends, etc. (Harris and Bergersen, 1995). Catch elasticities for freshwater trout fishing in California averaged .456 (Cooper and Loomis, 1990). For trout fishing in Colorado, catch elasticities ranged from .23 to .43 for stream and lake fishing, respectively (Loomis and Fix, 1998). Average catch elasticity for steelhead fishing in Oregon was estimated at .524 (Loomis, 1988). Nonetheless as these empirical estimates suggest, the responsiveness of anglers in this present study is lower than in past studies.

Calculation of Net Economic Value. For national economic development (NED) analysis, the appropriate measure of economic benefits is net economic value or net benefits (U.S. Water Resources Council, 1983). In the context of this study, travel costs represent a disutility from driving to the fishing site that anglers would like to minimize or avoid if possible. Thus, to measure the net benefits derived from fishing, we must measure an angler's added value for fishing above and beyond the actual costs of a fishing trip. This added value above and beyond actual travel costs (representing disutility) is technically referred to as consumers surplus or net willingness-to-pay (hereafter, WTP).

To calculate mean WTP from the estimated demand function, mean values for all independent variables except for trip cost in Equation (1) are multiplied by the estimated coefficients for each variable from Table (1) and then summed. This summation is a composite constant term denoted by *A*. The simplified demand function for the typical or average user of the study area is then defined as:

(6) $$\text{TRIPS} = A - b_1 \ln(\text{COST}), \text{ where}$$

b_1 = estimated coefficient on the trip cost variable from Table (1).

Using Equation (6), WTP or consumers surplus at the mean number of trips per individual is calculated by the integral:

(7) $$\int_{P^m}^{P^*} [\, A - b_1 \ln(\text{COST}) \,]\, d\text{COST}.$$

The mean trip cost (P^m) associated with the estimated demand function is equal to $20.28. The choke price ($P^*$) is defined as the travel cost or price at which no person will make a trip to the study area for fishing. With the linear-log specification of the demand function, the theoretical choke price (P^*) is infinity because of the nonlinear shape of the demand function. For calculating WTP, it was therefore necessary to select a reasonable choke price. To provide for some sensitivity analysis, three trip costs were selected to serve as choke prices: the 90th, 95th and the 99th percentiles from the empirical distribution of trip costs. The 90th percentile trip cost is equal to $62.97, 95th percentile trip cost is equal to $101.88, and the 99th percentile trip cost is equal to $128.90. Table 2 shows the resulting WTP or consumer surplus estimates and their respective confidence intervals.

The closed-form solution to Equation (7) was used to calculate annual recreation benefits. With the mean trip cost as the lower limit of integration and the 90th percentile as the upper limit of integration, the integral of Equation (7) at the mean number of trips is estimated at $493.44 annually. Given the predicted mean number of trips of 16.06, mean WTP (consumers surplus) per person per trip is equal to $30.73 with a 95% confidence interval of $27.20 to $34.26. The 95th and 99 percentile mean WTP (consumers surplus) estimates were calculated correspondingly and are shown in Table 2.

The mean WTP (consumers surplus) per person per trip estimate of approximately $31 calculated with the upper limit of integration in Equation (7) at the 90th percentile compares well to a recent study that estimated mean WTP adjusted to 1999 dollars for fishing in the Barataria-Terrebonne area at about $27 per person per trip (Industrial Economics, 1996). It is also consistent with an earlier study that estimated mean WTP adjusted to 1999 dollars for wetlands-based recreation in southeastern Louisiana at approximately $32 per trip (Bergstrom *et al.*, 1990). The mean WTP estimate of approximately $31 per person per trip is also comparable to the Johnston et al, 2002 estimate of about $44 per person per trip in 1999 dollars for recreational fishing trips in the Peconic Estuary System. Although similar in magnitude, the different values for recreational fishing estimated for the Peconic Estuary System in New York and the

Atchafalaya River Basin in Louisiana suggest that recreational fishing values of estuaries may vary across different coastal regions of the United States.

The WTP estimate of approximately $31 per person per trip can be directly applied to the population of current users of the study area. For purposes of illustration, suppose 20,000 redfish and speckled trout anglers visit the estuary per year and the average angler makes 20 day trips per year. Thus, baseline redfish and speckled trout total angling trips or days would be 400,000 (20,000 x 20) with a baseline value of $12.4 million.

Suppose a freshwater diversion project or other program would improve estuary ecosystem health and game fish populations, resulting in a 60% increase in average redfish and speckled trout catch per fishing trip. Our estimated catch elasticity indicates that this improvement in catch success would result in anglers taking, on average, approximately 5% (60 x .079) more fishing trips per year. Thus, the estuary improvement would induce redfish or speckled trout anglers to make an average of one additional angling trip per year (.05 x 20) resulting in a total of 20,000 additional angling trip per year (20,000 participants x one additional trip). The total benefits of these additional trips would be about $620,000 (20,000 trips x $31 per trip). As a shortcut, this value can also be derived by multiplying the baseline total value of $12.4 million by .05 (5%). These additional recreational fishing benefits can be directly compared to the additional costs of implementing the estuary restoration and protection program. The estimated value of $620,000 would likely be a conservative estimate of additional benefits to redfish and speckled trout anglers of the estuary improvement because it does not account for new entrants who may enter the recreational fishery because of improved estuary environmental conditions and game fish catch rates.

Policy Implications and Conclusions

Federal, state and local policy-makers and resource managers face a long list of coastal management problems with alternative solutions that share the common characteristic of being very expensive. Given limited budgets, policy and program priorities must be set and tradeoffs made. Economic benefit and cost information can provide useful inputs into this decision-making process by quantifying coastal management benefits and costs in commensurate terms (Chua, 1993; Freeman, 1995; Johnston et al, 2002; Parsons and Powell, 2001; Rein, 1999).

One of the expected outcomes of federal, state and local policies and programs to restore and protect estuaries is improvement in fish habitat and populations. In order to evaluate alternative restoration and protection programs, policy-makers and resource managers may need to translate changes in fish habitat and populations to changes in economic benefits. One pathway by which improvements in fish habitat and populations lead to economic benefits is through increases in recreational game fish catch. The methodology discussed in this paper provides a means for translating changes in fish catch to changes in economic benefits measured in dollar terms as illustrated in the Lower Atchafalya River Basin case study.

Management induced changes in freshwater flows into the Lower Atchafalya River Basin estuary would affect redfish and speckled trout species. Changes in recreational fishing benefits from this change were estimated using a combined revealed and stated preference travel cost model. Our model indicates that changes in catch rates of these two species would have a statistically significant effect on recreational fishing use and annual benefits. The responsiveness of angling trips per user to changes in catch rates as measured by the catch elasticity in our case study was relatively low. However, because total effects may be large when per user effects are aggregated across total users, resource management agencies should consider these changes in recreation benefits when evaluating restoration and protection policies and programs that influence the ecology of coastal estuaries, fish populations and catch rates. In other coastal areas or situations, the responsiveness of angling trips to changes in catch rates may vary because of differences in user populations, environmental conditions, fish populations and fishing experiences.

Additional studies of the type described in this paper are needed in other coastal areas and situations to provide comparative measures of the responsiveness of fishing trips to fishing success. The results of such studies will provide models and data that can be applied to measure the economic benefits of estuary restoration and protection actions that lead to changes in fish populations and fish catch in a variety of ecological and social settings. These economic benefit measures would provide important inputs into the evaluation of restoration and protection policies and programs at the federal, state and local government levels.

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Table 1. Modeling Results for Fishing Trip Demand Function: Lower Atchafalaya Basin Project, 1999-2000.

Dependent Variable:
Annual Recreational Trips Per Person

Explanatory Variables	Coefficient Estimate (T-value in parentheses)
Intercept	-17.820 (-1.109)
Natural Log of Cost Per Person Per Trip	- 5.405 (-9.295)**
Natural Log of Total Catch of Redfish or Speckled Trout Per Person Per Trip	1.268 (4.748)**
Natural Log of Total Catch of All Other Fish Per Person Per Trip	.140 (.609)
Natural Log of Total Years of Fishing Experience	1.774 (4.175)**
Natural Log of Age	.952 (.470)
Natural Log of Years of Education	-13.140 (-4.085)**
Natural Log of Annual Days of Outdoor Recreation	3.575 (6.400)**
Natural Log of Household Income	5.159 (3.584)**
Indicator Variable for Retirement (1=Retired)	1.696 (.881)
Indicator Variable for Member of Sportsmen's Organization (1=MEMBER)	3.471 (3.105)**
Indicator Variable for Member of Environmental Organization (1=MEMBER)	-1.280 (-.632)
Indicator Variable for Knowledge of Flood Control Projects (1=KNOWLEDGEABLE)	2.315 (2.203)*

N = 1164
R-SQUARE = .16

AVERAGE CATCH ELASTICITY FOR REDFISH AND TROUT = .079
**Significant at .01 Level
*Significant at .05 Level

Table 2. Net WTP or Consumers Surplus Estimates for Recreational Fishing in the Lower Atchafalaya River Basin			
Choke Price	Annual Net WTP	Net WTP per Trip	95% C.I.
90% $63	$493.44	$30.73	$27.20-34.26
$41.23-57.35	$791.44	$49.28	
99% $129	$948.20	$59.04	$47.27-70.84