NOAA Technical Memorandum NMFS-SEFSC-465

Analysis of Contingent Valuation Data from the 1997-98 Southeast Economic Add-on Survey Data

by:

John C. Whitehead
Department of Economics
Brewster Building
East Carolina University
Greenville, NC 27858
whiteheadj@mail.ecu.edu

Timothy C. Haab
Department of Agricultural, Environmental and Development Economics
2120 Fyffe Road
The Ohio State University
Columbus, OH 43210
haab.1@osu.eduay 2001

September 2001

Final Report for Contract No. 40WCNA005806

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

NOAA Technical Memorandum NMFS-SEFC-465

Analysis of Contingent Valuation Data from the 1997-98 Southeast Economic Add-on Survey Data

John C. Whitehead and
Timothy C. Haab

U.S. Department of Commerce
Donald L. Evans, Secretary

National Oceanic and Atmospheric Administration
Scott B. Gudes, Acting Under Secretary for Oceans and Atmosphere

National Marine Fisheries Service
William T. Hogarth, Assistant Administrator for Fisheries

Notice

The National Marine Fisheries Service (NMFS) does not approve, recommend or endorse any proprietary product or proprietary material mentioned in this publication. No reference shall be made to NMFS, nor to this publication furnished by NMFS, in any advertising or sales promotion which would indicate or imply that NMFS approves, recommends or endorses any proprietary product or proprietary material mentioned herein, or which has as its purpose an intent to cause directly or indirectly the advertised product to be used or purchased because of this NMFS publication.

This report should be cited as follows:

John C. Whitehead and Timothy C. Haab, 2001. Analysis of Contingent Valuation Data from the 1997-98 Southeast Economic Add-on Survey Data. Final Report for Contract No. 40WCNA005806. NOAA Technical Memorandum NMFS-SEFSC-465, 70 p.

Copies may be obtained by writing:

National Technical Information Services
5258 Port Royal Road
Springfield, VA 22161
(800) 553-6847 or (703) 605-6000
http://www.ntis.gov/numbers.htm

Acknowledgement

The authors would like to thank Stephen Holiman for his contributions to this report.

Executive Summary

The purpose of this report is to estimate the value of avoiding reductions in bag limits for king mackerel, red snapper and gag in the southeastern United States. The data used are from the 1997 Marine Recreational Fishery Statistical Survey (MRFSS) and the Add-On MRFSS Economic Study (AMES). During 1997-98 over 10,000 telephone follow-up interviews were conducted with MRFSS intercept respondents who agreed to be interviewed. These surveys elicit information on willingness to pay for permits that avoid reductions in bag limits, questions related to reasons for an unwillingness to pay, and contingent behavior from past and future regulations. The contingent valuation method allows the determinants of willingness to pay to be estimated by regression analysis. Through regression analysis the marginal value of one-fish reductions in bag limits are estimated for king mackerel and red snapper.

We develop theoretical and econometric models of willingness to pay. We develop theoretical definitions of willingness to pay to avoid bag limits in order to develop hypotheses about the magnitude of willingness to pay bids and specify the empirical willingness to pay models. We define the option price as the willingness to pay under demand uncertainty. The demand uncertainty arises from the species targeting decision. The key component of this model is the inclusion of the probability of participation, or targeting decision, as an independent variable in empirical willingness to pay models.

We present a general econometric specification of the willingness to pay for changes in bag limits. The model depends on the number of willingness to pay questions offered to each individual. The primary econometric model employed is the Tobit which allows for censoring at zero willingness to pay. We also consider the Heckman sample selection model and the double hurdle model.

The willingness to pay data is summarized by frequencies and a variety of univariate statistics. We find that more than 70% of the willingness to pay values are zero. Most zero willingness to pay respondents answer in this way because they do not target king mackerel, red snapper, or gag. We also define potential protest bids as those zero willingness to pay values which are provided because the respondent considers the special permit unfair or does not agree with it. Given another type of policy, these respondents might have a positive willingness to pay. We also identify potential outliers. These are respondents who are willing to pay greater than $100 for the permit.

We estimate Tobit, Heckman, and double hurdle models of willingness to pay for avoidance of reductions in king mackerel, red snapper, and gag bag limits. The Tobit model statistically dominates the Heckman and double hurdle models. We find that the king mackerel and red snapper willingness to pay values are valid measures of economic value. Willingness to pay increases with the magnitude of the bag change and with the probability

that the respondent would target the species. These results conform to economic theory. The gag willingness to pay values are not valid measures of economic value.

In comparisons of the models employing the full and trimmed (deleting protests and outliers) samples, in general, the trimmed data leads to smaller coefficient estimates. For king mackerel, income is a determinant of willingness to pay for the full sample but not for the trimmed sample. For red snapper, the probability of participation is a determinant of willingness to pay for the trimmed sample but not for the full sample. Since theory can not guide the selection of the sample and neither dominates the other statistically, we focus on the full sample because it is not subject to potentially ad-hoc decisions about protests and outliers.

Based on the theoretical model we expect willingness to pay to increase with the hypothetical change in the bag

limit. However, the pattern of willingness to pay estimates does not conform to expectations, especially for red snapper. In this case, willingness to pay for a 5-fish bag change is less than willingness to pay for the 2-fish and 3-fish bag change. In the empirical models we find a related "zero bag" effect for both king mackerel and red snapper. Willingness to pay increases with the size of the bag change until the maximum bag change. Respondents who are given a scenario in which the future legal bag limit is zero fish, but are then told that they can purchase a permit to legally catch the current number of legal fish, are willing to pay zero dollars.

We estimate the marginal effects and 95% confidence intervals of the coefficient on the bag change on willingness to pay. The marginal effect is the willingness to pay for avoiding a one-fish reduction in the bag limit. The full data king mackerel marginal effects are $2, $5, $4, $4, $4, $3, $0 and $3 for anglers intercepted in Alabama, Florida (East Coast), Florida (West Coast), Georgia, Louisiana, Mississippi, North and South Carolina. The full data red snapper marginal effects are $0, $2, $1 and $2 for anglers intercepted in Alabama, Florida (West Coast), Louisiana and Mississippi. However, none of the differences are statistically significant. In general, the trimmed data leads to lower estimates of the value of a one-fish reduction in the bag limit.

We extend these results with two additional sets of models. We estimate bivariate Tobit willingness to pay models for king mackerel and red snapper in which the correlation across willingness to pay questions is accounted for. The bivariate Tobit is an improvement over the independent Tobit models. The king mackerel willingness to pay to avoid a one-fish bag change from the bivariate Tobit are substantially smaller than those from the independent Tobit models. The red snapper willingness to pay estimates are of the same magnitude as from the independent Tobit.

We also estimate joint targeting and willingness to pay models for red snapper and king mackerel in which the correlation across these two decisions is accounted for. In this bivariate model, the probit model for participation and the Tobit model for willingness to pay are estimated jointly. We find that the participation and willingness to pay decisions are correlated for the king mackerel sample. We find some minor differences in option price estimates between the independent and joint models. We find that the participation and willingness to pay decisions are not correlated for the red snapper sample.

Table of Contents

List of Tables

Chapter 1
Introduction

The purpose of this report is to estimate the value of avoiding reductions in bag limits for king mackerel (*Scomberomorus cavalla*), red snapper (*Lutjanus campechanus*) and gag (*Mycteroperca microlepis*) in the southeastern United States. The data used are from the 1997 Marine Recreational Fishery Statistical Survey (MRFSS) and the Add-On MRFSS Economic Study (AMES). The AMES data consists of three parts, the Intercept Survey, the Add-On Economic Intercept Survey, and the Add-On Telephone Follow-Up to the Intercept Survey. The telephone follow-up contains a series of contingent valuation method (CVM) questions that directly elicit the willingness to pay for reductions in bag limits for red snapper, king mackerel and gag.

During 1997-98 over 10,000 telephone follow-up interviews were conducted with MRFSS intercept respondents who agreed to be interviewed. These surveys elicit information on willingness to pay for permits that avoid reductions in bag limits, questions related to reasons for an unwillingness to pay, and contingent behavior from past and future regulations. The CVM allows the determinants of willingness to pay to be estimated by regression analysis. Economic theory guides the empirical analysis. Through regression analysis the marginal value of one-fish to three-fish reductions in bag limits will be estimated for king mackerel and one-fish to five-fish reductions for red snapper and gag.

The AMES telephone survey includes a series of CVM questions concerning red snapper, king mackerel, and gag. Each angler provides 2 or 3 willingness to pay bids. South Atlantic anglers provide one bid (king mackerel), Gulf coast anglers provide two bids (king mackerel and red snapper) and Gulf coast Florida anglers provide 3 bids. The red snapper and king mackerel willingness to pay question is open-ended:

> "The current bag limit for [red snapper/king mackerel] is [STLIMIT] fish per day. It may be necessary in the future to reduce the bag limit to [VER_RS/VER_KM] fish. Suppose you could purchase a special annual permit that would allow you to keep [STLIMIT] fish per day while all anglers who did not purchase the permit would only be allowed to keep [VER_RS/VER_KM] fish per day. The [VER_RS/VER_KM] fish bag limit would be your daily limit for the year. How much would you be willing to pay for this special permit?"

For red snapper the variable STLIMIT is equal to 5 and the variable VER_RS varies from 0 to 4. Only Gulf coast anglers are asked about red snapper. South Atlantic and Florida anglers are asked a similar open-ended question about gag. For king mackerel the variable STLIMIT is equal to 3 for anglers that were intercepted in Georgia, North Carolina, and South Carolina and 2 for anglers intercepted in Florida, Mississippi, Alabama, and Louisiana. The variable VER_KM is randomly assigned and can take on values of 0, 1, and 2 for anglers intercepted in states with a bag limit of 3 and 0 and 1 for anglers intercepted in states with a bag limit of 2.

The willingness to pay question for gag is also open-ended:

> "Another type of special permit might apply for gag. If it was necessary in the future to reduce the number of gag kept under the aggregate grouper bag limit to [LIMIT], how much would you pay to purchase a special annual permit that would allow all of your five fish to be gag?"

The LIMIT variable ranges from 0 to 4.

The Report

In the rest of this report we present theoretical and econometric models of willingness to pay and describe the data and results. The purpose of Chapter 2 is to develop theoretical definitions of willingness to pay to avoid bag limits in order to develop hypotheses about the magnitude of willingness to pay bids and specify the empirical willingness to pay models. We define the option price as the willingness to pay under demand uncertainty. The demand uncertainty arises from the species targeting decision.

In Chapter 3 we present a detailed summary of the willingness to pay data. It is summarized by frequencies and a variety of univariate statistics. We consider reasons for zero willingness to pay values, reactions to zero bag limits, protest bids and outliers. We also summarize the construction of avidity weights, data imputation for missing values, and the independent variables.

In Chapter 4 we present a general econometric specification of the willingness to pay for changes in bag limits. The model depends on the number of willingness to pay questions offered to each individual. The primary econometric model employed is the Tobit which allows for censoring at zero willingness to pay. We also consider the Heckman sample selection model and the double hurdle model.

In Chapter 5 we present Tobit, Heckman, and double hurdle models of option price (i.e., willingness to pay under uncertainty) for avoidance of reductions in king mackerel, red snapper, and gag bag limits. We estimate the marginal effects and 95% confidence intervals of the coefficient on the bag change independent variable on the option price. The marginal effect is the option price of avoiding a one-fish reduction in the bag limit.

In Chapter 6 we estimate joint willingness to pay models for king mackerel and red snapper in which the correlation across willingness to pay questions is accounted for. We also

estimate joint targeting and willingness to pay models for red snapper and king mackerel in which the correlation across these two decisions is accounted for.

In Chapter 7 we present a summary and conclusions. We also present an policy illustration in order to demonstrate how these results might be used.

Chapter 2
Theoretical Model

Estimation of the contingent valuation data will be guided by economic theory. The purpose of this chapter is to develop theoretical definitions of willingness to pay to avoid bag limits, use these definitions to develop hypotheses about the magnitude of willingness to pay bids and specify the empirical willingness to pay models.

The Model

The utility of the angler depends on species specific fishing trips and catch (including harvest and catch and release) rates

2.1 $$U = u(X, Q, R)$$

where U is utility, u(.) is the utility function, X is a vector of recreational fishing trips, $X = [X_{ij}]$, where i = 1, … , N species, j = 1, … , J sites, $Q = [Q_{ij}]$ is a vector of i, j per trip harvest rates, $R = [R_{ij}]$ is a vector of i, j per trip catch and release rates. Utility is increasing in trips, harvest per trip, and catch and release per trip.

The per trip catch rates depends on inputs in a household production function

2.2 $$\begin{aligned} Q_{ij} &= q_{ij}(k, \ell, h_{ij} \mid b_{ij}, d) + \varepsilon_q \\ R_{ij} &= r_{ij}(k, \ell, h_{ij} \mid d) + \varepsilon_r \end{aligned}$$

where $q_{ij}(.)$ is the expected harvest rate, $r_{ij}(.)$ is the expected catch and release rate, ε_q and ε_r are mean zero random error terms, k is a vector of capital inputs including a boat and other gear, ℓ is a vector of labor inputs including time spent fishing, h_{ij} is the species stock (which could be measured as the historic harvest rate) of species i at site j. The harvest rate is conditioned on constraints and technology. The harvest constraint is b_{ij}, the daily bag limit of species i at site j, and d is a set of preference and technology variables including fishing experience. Catch and release does not depend on the bag limit. The trip harvest and catch and release is increasing in capital and labor inputs and species stock. Hereafter, the subscripts i, j and all arguments other than the bag limit will be dropped for notational simplicity except when needed.

While actual harvest, Q is an integer variable (e.g., Q = 0, 1, 2, ...), expected harvest, q, is a continuous variable. Therefore, the marginal effect of a reduction in the bag limit on harvest is positive or equal to zero

2.3 $$\frac{\partial q}{\partial b} \begin{cases} = 0 & \text{if } q < \hat{b} \\ > 0 & \text{if } q \geq \hat{b} \end{cases}$$

where $\hat{b}$ is the reduced bag limit. For those "expert" anglers who tend to harvest and keep their daily limit, $q \geq \hat{b}$, a decrease in the bag limit will decrease harvest. For those "non-expert" anglers who tend to harvest less than the reduced daily bag limit, $q < \hat{b}$, a decrease in the bag limit will not decrease harvest. For these anglers, the daily bag limit is non-binding and will not affect their fishing trips.

Substitution of the household production functions into the utility function yields

2.4 $$U = u(X, q(b), r)$$

with all arguments other than the bag limit suppressed for simplicity. Anglers are constrained by the fishing budget, y = p'X, where p is a vector of i, j travel costs, $p = [p_{ij}]$. Note that the targeting of different species will have little effect on travel costs, which primarily depends on distance from the angler's residence to the fishing site. Maximization of angler utility subject to the budget constraint yields the indirect utility function

2.5 $$v(p, q(b), r, y) = \max\ U(X, q(b), r) \quad s.t.\ y = p'X$$

where v(.) is the indirect utility function which is decreasing in p, and increasing in q, r, and y. The marginal utility of a change in the bag limit is equal to the marginal utility of harvest multiplied by the marginal effect of the bag limit on harvest

2.6 $$\frac{\partial v}{\partial b} = \frac{\partial v}{\partial q}\frac{\partial q}{\partial b}$$

It is easily seen that the bag limit only affects the utility of expert anglers for whom the marginal effect of the bag limit is positive. For non-expert anglers the bag limit constraint is non-binding and a decrease in the bag limit yields no less utility. Similarly, increases in the bag limit will not be binding and will have no effect on non-expert angler utility.

The Marshallian demand function for site and species specific trips is found by Roy's identity

2.7 $$-\frac{\frac{\partial v}{\partial p}}{\frac{\partial v}{\partial y}} = x(p, q(b), r, y)$$

The demand for trips is decreasing in the own-travel costs, and increasing in harvest of the target species, catch and release of the target species, and the fishing budget. Trips are increasing in cross-travel costs for substitute sites. Harvest and catch and release of other species may have positive or negative effects on species specific trips depending on substitution and complementarity relationships between species.

Assuming the bag limit is constant across sites, the effect of a bag limit on species specifc trips is

2.8 $$\frac{\partial x}{\partial b} = \frac{\partial x}{\partial q}\frac{\partial q}{\partial b}$$

where $\frac{\partial x}{\partial q} > 0$ is the marginal effect of harvest on trips. Since the marginal effect of the bag limit on harvest,

$\frac{\partial q}{\partial b}$, is equal to zero for non-expert anglers and greater than zero for expert anglers, the marginal effect of the bag limit on trips is greater than or equal to zero, $\frac{\partial x}{\partial b} \geq 0$. The marginal effect of the bag limit on trips is equal to zero for non-expert anglers and equal to the marginal effect of harvest on trips for expert anglers.

Willingness to Pay from Trip Behavior

The willingness to pay to avoid a reduction in the bag limit can be defined using demand theory. The willingness to pay for trips is the consumer surplus of site and species specific trips

2.9 $$CS_{ij} = \int_{p}^{\overline{p}} x_{ij}(.)dp$$

where CS_{ij} is the consumer surplus and $\overline{p}$ is the choke price. The effect of the change in the bag limit on the willingness to pay for trips is equal to zero for non-expert anglers. The effect of the change in the bag limit on the willingness to pay for trips for expert anglers is the change in the consumer surplus of site and species specific trips

2.10 $$\Delta CS_{ij} = \int_{p}^{\overline{p}} \int_{q(\overline{b})}^{q(\hat{b})} x_{ij}(.)dpdq$$

where $\overline{b}$ is the current catch rate and ΔCS_{ij} is the change in consumer surplus.

The effect of a bag limit on consumer surplus for expert anglers also depends on the utility functions of heterogeneous anglers and other fishing behaviors. Anglers who receive no utility from catch and release, $\frac{\partial v}{\partial r} = 0$, and who are willing to substitute secondary species for the target species, will target other species at the same or other sites when faced with a reduction in the bag limit for the target species. If the marginal utility of the secondary species (species 2) is less than the marginal utility of the target species (species 1), $\frac{\partial v}{\partial q_1} > \frac{\partial v}{\partial q_2}$, the number of trips targeting species 1 will fall and $\Delta CS_{ij} > 0$. However, if the species are perfect substitutes, the reduction in the bag limit on species 1 will have no effect on species 1 trips. In this case $\Delta CS_{ij} = 0$.

Expert anglers who gain utility from catch and release of the target species will increase their catch and release per trip with a decrease in the daily bag limit. If the marginal utility of harvest of the secondary species is greater than the marginal utility of catch and release of the target species, $\frac{\partial v}{\partial q_2} > \frac{\partial v}{\partial r_1}$, then species specific trips will fall and $\Delta CS_{ij} > 0$. If the marginal utility of catch and release and the marginal utility of harvest of the target species are equal, $\frac{\partial v}{\partial q_1} = \frac{\partial v}{\partial r_1}$, these behaviors are perfect substitutes. The reduction in the bag limit on species 1 will have no effect on species 1 trips and $\Delta CS_{ij} = 0$.

Finally, species specific trips will increase if the goal of the expert angler is to maximize the aggregate harvest of the targeted species. In this case the angler will substitute trips for harvest per trip when the bag limit is reduced. For example, if an expert angler takes 4 king mackerel trips and harvests 3 fish per trip a reduction in the bag limit to 2 fish per trip might prompt an increase in trips. The angler who wants 12 fish in the freezer will take an additional 2 trips for a total of 6 king mackerel trips. In this case the willingness to pay to avoid the bag limit reduction will be greater than or equal to the increased trip expenditures.

Willingness to Pay from Contingent Valuation

Willingness to pay to avoid the bag limit reduction can also be defined directly through the properties of the indirect utility function. Dividing the marginal utility of harvest, $\frac{\partial v}{\partial q}$, by the marginal utility of income, $\frac{\partial v}{\partial y}$, yields

2.11
$$mWTP_q = \frac{\frac{\partial v}{\partial q}}{\frac{\partial v}{\partial y}}$$

where $mWTP_q$ is the marginal willingness to pay for additional harvest. Likewise, for reductions in q, $mWTP_q$ is the willingness to pay to avoid decreases in harvest.

The value of a change in the bag limit is equal to the marginal utility of a change in the bag limit divided by the marginal utility of income

2.12
$$mWTP_b = \frac{\frac{\partial v}{\partial q}\frac{\partial q}{\partial b}}{\frac{\partial v}{\partial y}}$$

where $mWTP_b$ is the marginal willingness to pay for a change in the bag limit. After rearranging, it can be seen that the marginal willingness to pay for a change in the bag limit is equal to the marginal willingness to pay for a change in the harvest multiplied by the marginal effect of the bag limit on catch

2.13
$$mWTP_b = \left(\frac{\frac{\partial v}{\partial q}}{\frac{\partial v}{\partial y}}\right)\frac{\partial q}{\partial b} = mWTP_q\frac{\partial q}{\partial b}$$

Therefore, on average, the marginal willingness to pay of a change in the bag limit is less than the marginal willingness to pay of a change in harvest. For non-expert anglers, $\frac{\partial q}{\partial b} = 0$, and $mWTP_b$ is equal to zero. For expert anglers, $\frac{\partial q}{\partial b} \geq 0$, and the marginal value of the bag limit is equal to the marginal value of harvest.

The willingness to pay values defined are for use values. Non-use values are also feasible. For example, in the case of a recreational quota[1], the willingness to pay of both expert and non-expert anglers might contain positive value due to a stock effect. With a quota, a limited number of permits will be sold per year. Purchase of a permit to harvest, say, 3 fish when expected harvest is less than 3 fish is rational if this leads to increased recruitment and increased future catch. These anglers have a conservation value. Due to data limitations, these subtle effects will be difficult to determine, except as a residual called conservation value below.

Also, the purchase of a permit by one angler may be perceived as increasing their chance of harvest since the difference between the bag limit and expected harvest is fish that cannot be legally caught. In this case, the purchase of the permit may be perceived as an increase in the expected harvest so that it is greater than the bag limit.

The value of avoiding a non-marginal reduction in the bag limit can be defined by comparing utility functions

2.14 $$v(p,q(\bar{b}),y - WTP_b) = v(p,q(\hat{b}),y)$$

where WTP_b is the willingness to pay for a non-marginal change, $\bar{b}$ is the current bag limit and $\hat{b}$ is the new bag limit, $\bar{b} > \hat{b}$. For the non-expert angler, $q(\bar{b}) \leq q(\hat{b})$, and $WTP_b = 0$ unless conservation value is positive. For expert anglers, $q(\bar{b}) > q(\hat{b})$, and $WTP_b > 0$. However, with zero conservation value and under the special conditions discussed in the previous section, WTP_b can be equal to zero even for expert anglers.

Willingness to Pay under Uncertainty

The definitions of willingness to pay from the previous two sections are most appropriate for anglers who currently target the species (i.e., participants). For all other anglers (i.e., non-participants) it is inappropriate. An extension of this model that allows definition of willingness to pay for current non-participants incorporates demand uncertainty.

Suppose there is uncertainty about species participation (whether a species of fish will be targeted) due to uncertainty about tastes and preferences. Let π_i be the probability that the species i will be targeted and $(1 - \pi_i)$ is the probability that species i will not be targeted. The probability of participation is a function of tastes and preferences and the expected harvest rates, $\pi_i(q(b), d)$. The effect of expected harvest on participation is positive. Since the effect of the bag limit on harvest is greater than or equal to zero, the effect of the bag limit on participation is greater than or equal to zero. Given data limitations, however, we assume the effect is zero.

---

[1]For example the recreational quota for king mackerel is 7.21 million and 6.3 million pounds per year in the Gulf of Mexico and South Atlantic, respectively.

The expected indirect utility with the current bag limit is

2.15 $$E[\bar{v}] = \pi_i v(p, q(\bar{b}), y) + (1 - \pi_i) v(p, q(\bar{b}), y)$$

The expected indirect utility with the restricted bag limit is

2.16 $$E[\hat{v}] = \pi_i v(p, q(\hat{b}), y) + (1 - \pi_i) v(p, q(\hat{b}), y)$$

The economic value of avoiding the reduction in the current bag limit is

2.17 $$\begin{gathered} \pi_i v(p, q(\bar{b}), y - OP) + (1 - \pi_i) v(p, q(\bar{b}), y - OP) = \\ \pi_i v(p, q(\hat{b}), y) + (1 - \pi_i) v(p, q(\hat{b}), y) \end{gathered}$$

where OP is the option price. The option price is the ex-ante maximum amount of money an angler would be willing to pay to avoid the reduction in the bag limit given demand uncertainty.

For anglers who are certain they will not participate in the fishery (non-participants) the demand probability is equal to zero and

2.18 $$v(\bar{p}, q(\bar{b}), y - OP) = v(\bar{p}, q(\hat{b}), y)$$

For non-participants the option price is equal to zero since $q(\bar{b}) = q(\hat{b}) = 0$ unless the angler has conservation value.

For non-expert target anglers, $q(\bar{b}) = q(\hat{b})$ and rearranging 2.15 yields

2.19 $$\begin{gathered} \pi_i \left(v(p, q(\bar{b}), y - OP) - v(p, q(\hat{b}), y) \right) = \\ (1 - \pi_i) \left(v(p, q(\hat{b}), y) - v(p, q(\bar{b}), y - OP) \right) \end{gathered}$$

If $OP > 0$, the left hand side of equation 2.17 is negative and the right hand side is positive. Therefore, the option price must be equal to zero for non-expert anglers except with positive conservation value.

An Ideal Approach

An ideal approach to the estimation of the willingness to pay for reductions in bag limits would incorporate household production, revealed trip behavior, and contingent valuation models. Household production models would be used to differentiate between expert and non-expert anglers which could help explain the magnitude of willingness to pay. Willingness to pay from revealed behavior and contingent valuation models would be compared for testing the validity of both estimates.

The determination of expert and non-expert anglers could be determined empirically with a household production model. These data are available with the MRFSS but close inspection of the target and catch data indicates that few anglers targeted king mackerel, red snapper, or gag on their intercepted trip. Also for those anglers who did target these species, the harvest and catch and release rates are without sufficient variation for modeling.

The willingness to pay to avoid a reduction in the bag limit could be estimated with the traditional travel cost approach and revealed behavior data. The traditional travel cost approach estimates recreation demand functions with the number of fishing trips (or fishing days) as the dependent variable and travel costs, income, quality, and other relevant factors as the independent variables. The AMES data includes the number of site and species specific trips and harvest and catch and release rates per trip (available from the intercepted trip). However, these data are needed for at least two time periods -- before and after the bag limit reduction -- in order to estimate the value of bag limit changes with the traditional travel cost model. While the AMES data contains sufficient information for a limited number of anglers (only those who target the species), this information is not available for several time periods since the bag limits for these species are constant during 1997.[2] Therefore the CVM is the preferred approach for estimating the willingness to pay for avoiding bag limit reductions with the AMES data.

The CVM allows estimation of the option price. The extent of demand uncertainty can be assessed through the estimates of the effect of the probability of species participation on option price. The definitions of willingness to pay using revealed behavior and contingent valuation data suggests several reasons why option prices for bag limit reductions might be zero. Option price will be zero for non-expert anglers. For expert anglers, if the target and secondary species are perfect substitutes or if the catch and release and harvest of the target species are perfect substitutes, the option price to avoid the bag limit reduction will be zero. Option price will be zero for anglers who do not target the species.

An empirical specification

Solving equation 2.15 for the option price, OP, yields

2.20 $$OP = OP\left(p, q(\bar{b}), q(\hat{b}), y, \pi_i \mid d\right)$$

where d is a vector of taste and preference variables. A linear approximation of the option price function is

2.21 $$OP = \alpha_0 + \alpha_1 p + \alpha_2 q(\bar{b}) + \alpha_3 q(\hat{b}) + \alpha_4 y + \alpha_5 \pi_{i1} + \alpha_6 d + \mu$$

where the α's are coefficients and μ is a mean zero error term. With the linear approximation the marginal effect of each of the independent variables is constant. Since very few anglers actually caught king mackerel, red snapper, or gag on their intercepted trip, measures of expected catch rates will be of poor quality. Absent good measures of the expected harvest with different bag limits the bag limits themselves will be used to proxy for the expected harvest measures. With this assumption, $\bar{b} - \hat{b} > 0$ by construction, and the linear approximation of the option price function is

2.22 $$OP = \alpha_0 + \alpha_1 p + \alpha_2 \bar{b} + \alpha_3 \hat{b} + \alpha_4 y + \alpha_5 \pi_i + \alpha_6 d + \mu$$

[2]Note that MRFSS data contains revealed behavior data suitable for estimation of random utility (site-selection) models. Estimation of the value of Gulf of Mexico red snapper bag limit changes is feasible because the bag limits has varied from 4 to 7 during the 1990s.

with expected signs of $\alpha_1 < 0$, $\alpha_2 > 0$, $\alpha_3 < 0$, $\alpha_4 > 0$, and $\alpha_5 > 0$. If the current bag limit is constant across all anglers (e.g., red snapper, gag) then the current bag limit term is included in the constant term. Alternatively, we construct a bag change variable which yields the more parsimonious option price model

2.23 $$OP = \beta_0 + \beta_1 p + \beta_2(\bar{b} - \hat{b}) + \beta_3 y + \beta_4 \pi_i + \beta_5 d + \mu$$

where $(\bar{b} - \hat{b})$ is the bag change variable and $\beta_2 > 0$. Equation (2.23) is also appropriate if the marginal effects of changes in the current bag limit and new bag limit are equal, $\alpha_2 = \alpha_3$. Measures for the variables are described in next chapter.

Chapter 3
The AMES Data

In this chapter we present a summary of the AMES data. The willingness to pay data is summarized by frequencies and by a variety of univariate statistics. We consider reasons for zero willingness to pay values, reactions to zero bag limits, and outliers. We also summarize the construction of avidity weights, data imputation for missing values, and the independent variables.

Willingness to Pay Frequency Distribution

The frequency distribution of the king mackerel willingness to pay data reveals a preponderance (74%) of zero values (n = 9783, Table 3-1). No other value was given by more than 5.9% of the responses. Willingness to pay responses that accumulated more than 100 values are $2 (2.6%), $5 (5%), $10 (5.9%), $15 (1.8%), $20 (3%), $25 (2.5%), and $50 (1.4%). Several other values accumulated greater than 10 but less than 100 responses, including $100 (.5%), but none generated more than 55 responses. Twenty-two responses are greater than $100.

The frequency distribution of the red snapper (n = 4598, Table 3-2) and gag (n = 3344, Table 3-3) willingness to pay data reveal a similar pattern. Seventy-three percent of the red snapper willingness to pay values are zero. Common values are $2 (2%), $5 (2.7%), $10 (6.1%), $20 (3.5%), and $25 (2.1%). Ten values are greater than $100. Eighty-six percent of the gag willingness to pay values are equal to zero. Other common values are $2 (2.1%), $5 (3%), $10 (2.7%), $20 (1.1%), and $25 (1.2%). There are three values greater than $100.

Zero Willingness to Pay and Protests

Respondents who gave a zero willingness to pay value were asked why they would not be willing to pay anything (Table 3-4). The most common response for all species being "doesn't fish for [species]." Fifty-seven percent of zero willingness to pay respondents do not fish for king mackerel, 53% do not fish for red snapper, and 80% do not fish for gag.

A large number of respondents "don't agree with special permit idea" or consider it "unfair." Fourteen and one-half percent of king mackerel respondents, 13.5% of red snapper respondents, and 5% of gag respondents answered in this way. These respondents could be considered as "protest" respondents. A protest respondent is one who has a positive true willingness to pay value for the permit but chooses not to participate in the hypothetical scenario and responds with a zero willingness to pay amount. One reason is the rejection of the contingent valuation scenario itself, in this case disbelief or uncertainty about the permit system.

Another potential protest response is "you don't want to pay any more to fish than you do now." This response suggests that respondents, who may have a positive willingness to pay value, are engaging in strategic behavior by trying to influence the aggregate willingness to pay value downward so that the special permit policy will not be enforced. Six percent, 7% and 4% of the king mackerel, red snapper, and gag respondents gave this answer.

Other results from Table 3-4 suggest that the zero willingness to pay values are true zeros and not protests. Many anglers practice catch and release for king mackerel (6.2%), red snapper (6.4%) and gag (3%). Other responses yielded fewer than 3% of the answers.

In Table 3-5 we summarize the response to the question eliciting the behavioral reaction (the RXN variable) of anglers when faced with a zero bag limit for king mackerel. Over eighty percent of respondents who do not "generally target" king mackerel would keep fishing if there were a zero bag limit for king mackerel.[3] The dominant reason is that they seldom fish for king mackerel. One-half of respondents who do generally target king mackerel would keep fishing if there were a zero bag limit. Almost one-half of these practice catch and release while 20% seldom target king mackerel.

---

[3]An angler who generally targets the species is one who provided the species as one of their top four targeted species in the telephone follow-up interview (GENTAR).

Almost eighty percent of respondents who do not generally target red snapper would keep fishing if there were a zero bag limit (Table 3-6). The dominant reason is that they seldom fish for the species. Only 38% of respondents who generally target red snapper would keep fishing if there were a zero bag limit. Thirty-two percent of red snapper anglers would stop fishing for red snapper and fish for other species.

Over eighty percent of respondents who do not generally target gag would keep fishing if there were a zero bag limit (Table 3-7) with the dominant reason being that they seldom fish for the species. Sixteen out of twenty-nine anglers who generally target gag would keep fishing if there were a zero bag limit.

Outliers

An analysis of potential outliers is presented in Table 3-8. An outlier is one who engages in strategic behavior by overstating willingness to pay in order to influence the aggregate willingness to pay amount. Outliers are defined as "unreasonably" large values that will have a significant effect on the mean. Outliers are flagged as the willingness to pay values greater than $100. Admittedly, this cutoff is somewhat arbitrary. However, the $100 upper bound is beyond the 99th percentile of the frequency distribution. Also, $100 is the highest willingness to pay amount for which responses congregate. The potential outliers are presented by willingness to pay amount along with whether they generally target the species, the size of the bag limit change (BAGCHG), the number of fishing trips during the 2-month wave (TRIPS), whether they think they would catch the bag limit (SUCEXP, which is only asked for anglers who generally target the species), their income (INCOME) and their reaction to the zero bag limit (RXN).

There is little reason to believe that most of the potential outliers are not true outliers. Most of the willingness to pay values greater than $100 are stated by those who do not generally target the species. In addition, for king mackerel, more than one-half of those who do not target indicate that they do not fish for king mackerel (RXN=1). Of the three anglers who generally target king mackerel, one indicates that they would keep fishing because the bag limit does not matter (RXN=3). The $500 angler who targets king mackerel indicates he would stop fishing if faced with the bag limit reduction. But, he does not expect to catch the bag limit (SUCEXP=0). The angler who is willing to pay $1000 indicates that he would stop fishing if faced with the bag change. But, this angler faces a potential bag reduction of only one-fish.

Three of the ten red snapper (RS) willingness to pay respondents generally target red snapper. The first is willing to pay $150, faces a bag change of 4 fish per trip, took 1 five day trip during the 2-month wave, and expects to catch the current bag limit. The second is willing to pay $250, faces a bag change of 3 fish per trip, took 4 trips during the 2-month wave, expects to catch the current bag limit and would stop fishing altogether if the bag limit is reduced. Further inspection reveals that each of the four trips were targeting red snapper and the angler does not generally target any other species. This angler presents the strongest case that true willingness to pay is greater than $100. The third red snapper targeting angler is willing to pay $1000, faces a bag change of 2 fish per trip, expects to catch the current bag limit and indicates an "other" reaction to the zero bag limit (the variable RXN_RS_O is missing). But, the $1000 represents an implausibly high percentage of the angler's annual income (more than 3%). Finally, none of the gag (G) potential outliers generally target the species.

Willingness to Pay Summary Statistics

In Table 3-9 we present a summary of the willingness to pay values by state and wave of the intercept interview and by the version of the survey. The bag change variable ($\bar{b} - \hat{b}$ in Chapter 2) is constructed as

3.1 $$\text{Bag Change} = \text{STLIMIT - VER\_KM}$$

for king mackerel,

3.2 $$\text{Bag Change} = 5 - \text{VER\_RS}$$

for red snapper and

3.3 $$\text{Bag Change} = 5 - \text{LIMIT}$$

for gag. The willingness to pay for the king mackerel permit is highest in Georgia, North Carolina and South Carolina. Willingness to pay for the red snapper permit is highest in Alabama and Mississippi. The mean differences across state are statistically significant at the p=.01 level according to the nonparametric Kruskal-Wallis test.

Willingness to pay for the king mackerel permit is over $5 during waves 3 and 4 (1997) and falls below $5 during the other waves. Willingness to pay for the red snapper permit is over $8 during wave 4, almost $6 during wave 2, $5 during wave 3 and below $4 during the other waves. Willingness to pay for the gag permit is over $4.50 during wave 4, about $1 less during wave 2, and below $3 during the other waves.

Willingness to pay for the king mackerel permit is $4.40 to avoid a 1-fish bag change, $4.96 to avoid a 2-fish bag change, and $5.91 to avoid a 3-fish bag change (south Atlantic anglers only). These differences are statistically significant at the .01 level. Willingness to pay for the red snapper permit is $2.65, $5.17, $4.91, $8.60, and $4.76 for the 1-fish, 2-fish, 3-fish, 4-fish, and 5-fish bag change. These differences are statistically significant at the .01 level. Willingness to pay for the gag permit is $2.17, $4.32, $2.22, $1.69, and $2.69 for the 1-fish, 2-fish, 3-fish, 4-fish, and 5-fish bag change. These differences are not statistically significant.

We expect willingness to pay to increase with the bag change. For example, willingness to pay for a 2-fish bag change should be greater than willingness to pay for a 1-fish bag change. The pattern of willingness to pay estimates does not conform to expectations, especially for red snapper. In this case, willingness to pay for a 5-fish bag change is less than willingness to pay for the 2-fish and 3-fish bag change. We address this issue further in Chapter 5.

We do not present higher moments of the willingness to pay distribution due to its non-normal distribution. Willingness to pay means and standard errors estimated from the Tobit model are presented in later chapters. See Holiman (2000a, 2000b) for a summary of the red snapper and Gulf king mackerel willingness to pay estimates by intercepted mode and bag change version. Both of these reports contain estimates of the mean and standard deviation using a Weibull distribution.

Weighting, Data Imputation, and the Independent Variables

Weights are constructed to correct for avidity bias in the AMES data. Avidity bias will exist if the participants in the telephone follow-up to the intercept interview are more intense anglers (i.e., fish more days throughout the year). To test for avidity bias we first compare the number of days fished throughout the year, as measured from the intercept survey (FFDAYS12), for those who did and did not participate in the telephone survey. The number of days fished by those who did not participate in the telephone survey is 29.11 (n=46,361). For those who did participate in the telephone survey the number of days is 36.91 (n=9348). The difference in the days is statistically significant (t=13.43).

Since FFDAYS12 contains a number of missing values, we impute data for these missing values so that weights may be constructed for each respondent who reports a willingness to pay value. The logic of data imputation is that the efficiency loss from dropping an observation with a valid dependent variable (e.g., willingness to pay) exceeds the efficiency

loss from including an observation with measurement error in a variable (e.g., measurement error in the weight based on predicted fishing days).

The predicted value for days fished is based on a regression model with days fished during the past 2 months (FFDAYS2) conditioned on the fishing mode and wave of the survey. The model is

3.4 $$\begin{aligned} FFDAYS12 = {} & 0.98\ (2.98) + 4.53{*}FFDAYS2\ (328.14) + 8.00{*}MODE2\ (23.38) \\ & + 3.23{*}MODE3\ (9.12) - 0.55{*}WAVE3\ (-1.75) \\ & - 4.15{*}WAVE4\ (-13.02) - 3.52{*}WAVE5\ (-10.88) \end{aligned}$$

$R^2 = .68$, n = 55,656 (t-statistics in parentheses)

This model finds that anglers annually fish about 4.53 times more days than the number of days fished during the past two months, private/rental boat (MODE2) and shore (MODE3) anglers fish 8 and 3.23 more days than charter boat anglers, and anglers intercepted during waves 3, 4, and 5 spend .55, 4.15, and 3.52 fewer days fishing than those intercepted during waves 1, 2, and 6.

When predicting FFDAYS12 for those with missing values of FFDAYS2 we use the predicted FFDAYS2. Predicted FFDAYS2 is from a regression model with the lone regressor being the days fished during the past two months reported from the AMES (TRIPS). The model is

3.5 $$FFDAYS2 = 2.40\ (23.00) + 0.62*TRIPS\ (67.22)$$

$$R^2 = .33,\ n = 9234 \text{ (t-statistics in parentheses)}$$

This model finds that the number of two month days fished is equal to 2.4 plus 62% of the number of days fished from the AMES. For those missing the predicted FFDAYS2 variable, due to a missing TRIPS variable, we use the average predicted value of FFDAYS2 (mean=6.75).

With imputed FFDAYS12 included in the sample, the number of days fished by those who did not participate in the telephone survey is 29.33 (n=47,559). For those who did participate in the telephone survey the number of days is 36.68 (n=10,758). The difference in the days is statistically significant (t=14.04). The similarity of these values to data without imputation indicates that the imputation procedure does not bias the FFDAYS12 variable. Therefore, we proceed with construction of the weights based on FFDAYS12 with imputed values for those missing.

In Table 3-10 anglers are grouped into ten days fished categories (0 days fished, 1 days fished, 2 to 3 days fished, etc.). These categories were determined based on the frequency distribution of days fished. The objective was to create ten categories in which the differences in the number of anglers in each group was minimized. After some experimentation, the categories in Table 3-10 achieved this goal.

The weight is equal to the percentage of the respondents in the intercept sample but not in the telephone sample (AMES=0) divided by the percentage of respondents in the telephone sample (AMES=1). The weights are greater than one for days fished less than or equal to 13 and less than one for days fished greater than 13. This indicates that those who fish more days will be treated as a lower percentage of the weighted AMES sample. When the weights are applied the average number of days fished in the AMES sample is 29.57 (n=10,758) which is not significantly different from the number of days fished by those who did not participate in the telephone survey from above.

When the overall sample weight (WT) is used for the king mackerel, red snapper, and gag sub-samples the sum of the weights does not equal the sample size due to missing observations. The use of weights that do not sum to equal the sample size may lead to bias in coefficient estimates. Therefore, we create separate weights for the sub-samples by scaling the weights. The individual sub-sample weights (WT_S, where S = KM, RS, G) are scaled by multiplying the unscaled weight (WT) by the sample size (n_S) and dividing by the sum of the unscaled weights for the sample size ($\sum WT$). For example, for king mackerel this formula is

3.6 $$WT_{KM} = WT \times \frac{n_{KM}}{\sum_{n_{KM}} WT}$$

where n_{KM}= 9783 and $\sum WT$=9708.44. The scaling factor is equal to 1.00768. When the scaling factor is applied, $\sum WT_{KM} = n_{KM}$.

An unweighted and weighted summary of the independent variables and those contained in the demographic vector (Chapter 2) for the empirical analysis is presented in Table 3-11. The variables include gender (GENDER = 1 if male), race (WHITE = 1), fishing experience (YRSFISH and its square: YRSFISHSQ), if the angler owns a boat (BOATOWN), travel expenses (TRAVEXP) on the intercepted trip, income (INCOME), and if the angler has ever seen an enforcement officer (ENFORCE=1).

For all variables except income a small percentage of cases contain missing values. Again, we apply data imputation techniques to generate a rectangular data set since the efficiency loss from dropping an observation with a valid dependent variable (e.g., willingness to pay) is expected to exceed the efficiency loss from including an observation with measurement error in a variable. If the angler's gender is missing the observation is assigned the mode (GENDER=1, n=4). Fourteen and 38 anglers are assigned the mode boat ownership (BOATOWN=1) and enforcement (ENFORCE=1) values. If the number of years fishing or travel expenditures are missing, the observation is assigned the rounded mean (YRSFISH=21, n=305; TRAVEXP=$43, n=201). More than 40% of the sample contains missing income values. These were replaced with predictions from a regression model (see Haab, Whitehead, and McConnell, 2000).

The unweighted and weighted means and standard deviations appear in Table 3-11. Most (88%) of the sample is male and white (91%). The average fishing experience is 21 years. More than one-half of the sample owns a boat. The weighted average travel expenditure is $51. Weighted average annual income in $49 thousand. More than two-thirds of respondents have seen an enforcement officer.

Fishing mode and state of intercept dummy variables are also included. Fifty-six percent of the sample fished from a private/rental boat on their intercepted trip while 30% fished from the shore. The remaining 14% of the anglers fished from a charter boat. Sixteen percent of the anglers were intercepted on the Atlantic coast of Florida while 37% were intercepted on the Gulf coast. Seventeen and 11 percent of the anglers are from North Carolina and Louisiana. South Carolina and Georgia account for 11% of the anglers while Alabama and Mississippi account for the remaining 7%.

Chapter 4
Econometric Considerations of the Willingness to Pay and Option Price Models

In this chapter we present econometric option price models. The primary model employed is the Tobit which allows for censoring at zero willingness to pay. We also consider the Heckman sample selection model and the double hurdle model.

A Random-Effects Specification

As a point of departure for implementation of the option price model described in Chapter 2, consider a general specification of the willingness to pay for changes in bag limits. The modeling of the willingness to pay for changes in bag-limits will depend on the number of questions (species) offered to each individual. Because the survey design differs by geographic region, the formulation of the econometric models in this chapter will focus on the generic case of an individual i, facing j different willingness to pay questions. As special cases of this model, individuals can face any subset of the j questions.

Suppose the willingness to pay for individual i and species j can be written in general form as

4.1 $$WTP_{ij}=f(x_i,z_{ij},\mu_{ij})$$

where z_{ij} represents a vector of individual specific characteristics that vary across species including the change in bag-limits, and whether the individual targets that particular species (i.e., assume that the targeting decision is known with certainty thereby eliminating the complications introduced by the option pricing model) and x_i represent a vector of individual specific characteristics that vary across individuals but are constant across species (e.g., income, experience). The error term μ_{ij} contains both individual specific and individual-species specific components such that

4.2 $$\mu_{ij}=u_i+v_{ij}$$

The error terms u_i and v_{ij} are assumed to be independently distributed normal random variables with mean zero and respective standard errors σ_u and σ_v. In other words, the responses to the three willingness to pay questions are assumed to be correlated through an individual specific error term that carries across responses. For a specific individual (i) and species (j), μ_{ij} is distributed normally with mean zero and variance $\sigma_v^2+\sigma_u^2$.

For ease in exposition, suppose the system of WTP functions can be written as a linear in parameters function with additively separable error term such that

4.3 $$WTP_{ij}=\beta_{xj}x_i+\beta_{zj}z_{ij}+\mu_{ij}$$

where β_{xj} represents a vector of equation specific parameters conformable with x, and likewise, β_{zj} is a vector of equation specific parameters conformable with z; i=1, ... , N; j=1, ... , J. Given the composite structure, the error terms μ_{ij} for a given individual (i) are jointly distributed with mean zero and J x J variance-covariance matrix (Ω) equal to

4.4 $$\Omega = \sigma_v^2 I_J + \sigma_u^2 W_J$$

where I_J represents a J-dimensional identity matrix and W_J is a square J-dimensional matrix of ones. For a given individual, the on-diagonal elements of the variance-covariance matrix are: $E(\mu_{ij}^2) = \sigma_v^2 + \sigma_u^2$, and the off-diagonal elements are: $E(\mu_{ij}\mu_{ik}) = \sigma_u^2$. If there is no individual specific error term that carries across species then σ_u=0 and the variance covariance-matrix simply becomes

4.5 $$\Omega = \sigma_v^2 I_J$$

In this case, the error terms can be viewed as independently and identically distributed random variables with no across equation correlation. If in addition, there are no across equation parameter restrictions (that is, all parameters are equation specific) then the J WTP equations can be modeled independently and there is no statistical gain to modeling the responses to the three WTP questions jointly. If across equation correlation exists or there are a priori reasons to believe some subset of the parameters do not vary across equations, then joint estimation of the system of three WTP responses is necessary.

Standard panel data estimation routines readily handle the estimation structure set forth above. Random effects panel data models can be estimated on the three WTP responses for each individual with or without cross-equation parameter restriction imposed. Fixed-effects across species groups can be introduced through equation specific dummy variables. Parameter estimates can be allowed to vary across equations by introducing interaction terms between independent variables and the fixed-effect equation specific dummy variables. Tests of parameter restrictions across equations can be performed by comparing the models estimated with across equations restrictions to more general specifications that allow for full variation across all equations and all independent variables. Standard Lagrangian Multiplier (LM) tests or Likelihood Ratio (LR) tests can be used. Tests for independence of the error terms across equations can be performed by comparing the panel data estimators to independent estimation on each equation.

The panel data formulation derived here assumes that WTP is fully observable for all equations, and that all observations are generated by the same underlying data generating process. Also, the above formulation assumes that the error term and consequently WTP is unbounded and therefore has an infinite support (both positive and negative). For reasons to be discussed subsequently, this may not be the case for the current application. As such, it is necessary to consider alternatives to the general formulation presented above for the analysis of the WTP responses to changes in bag-limits.

Modeling Zero and Non-negative Willingness to Pay

Two immediate concerns arise with the previous derivation of a model for WTP: 1) WTP for the prevention of a reduction in bag-limits can not be negative. The good being valued is the status quo. It is inconceivable that a respondent would have a negative WTP to maintain the status quo relative to a more restrictive situation (tighter bag-limits), and 2) The open-ended format for the valuation questions leads to a large number of respondents reporting zero WTP. As will be discussed below, these zero WTP responses often have plausible justifications, but the continuous dependent variable model proposed in the previous section is unlikely to predict the large number of zero WTP's observed in the sample. For these reasons (and others to be discussed), it is necessary to consider models that go beyond the simple continuous dependant variable panel model proposed in the previous section.

What can lead to zero WTP?

Zero WTP is a problem that has confounded researchers in contingent valuation for a number of years. Plausible explanations for the large number of zero responses observed in open-ended CV studies exist, but successfully modeling the underlying behavior processes has proven elusive. In the present case, zero WTP responses can occur for a number of reasons. The following list is meant to illustrate some of the possible justifications for zero WTP to prevent the reduction in bag-limits, but this list is by no means exhaustive. Most of the reasons defined here are discussed more formally in Chapter 2.

Non-expert Anglers: As defined here, a non-expert angler is an angler that does not typically catch the reduced bag-limit of a particular species. Holding everything else constant, such an angler is expected to respond that WTP to prevent the reduction in bag-limit is zero because the reduced bag-limit is not a binding constraint and the angler is no worse off than under the status quo bag-limit.

Perfect Substitution Between Species: If an angler can perfectly substitute between species and the angler is not an expert for all species then a reduction in the bag-limit for one species will not decrease the utility of the angler. WTP to prevent the reduction will be zero.

Perfect Substitution between 'Catch and Release' and Harvest: Similarly if there is perfect substitutability between 'catch and release' and harvesting, then the reduced bag-limit will have no negative utility effects on the angler.

Non-participation with No Conservation Motives: If the angler does not participate in the fishery for which the bag-limit is proposed, there will be no reduction in utility due to the bag-limit and WTP will be zero. Note that we must assume no conservation motives on the part of the non-participant angler to ensure zero WTP.

A Single Equation Framework

To begin the discussion of models that allow for zero WTP, first assume that there is no error correlation between the WTP decision for different species, and that the structural form of WTP is independent across species. As noted above, these are the two conditions required for independent estimation of the WTP equations for each species. These conditions will be relaxed in later sections. With these assumptions, this section will focus on the estimation of a single species WTP function with zeros.

The Tobit Model: The simplest method for accounting for a large number of zero observations for a continuous dependent variable, and no negative observations is to suppose that WTP is censored from below at zero. That is, suppose true willingness to pay (WTP*) for a given species and individual i can be written as

4.6
$$WTP_i^* = \beta_x x_i + \beta_z z_i + v_i$$

However, to the researcher, WTP* is unobservable over its full range. Instead, if WTP* is less than or equal to zero, observed WTP is zero, otherwise, observed WTP=WTP*. That is, true WTP is only observed if it is greater than or equal to zero. Otherwise, the observed value for WTP is zero. This does not necessarily mean that true WTP for these censored observations is equal to zero, but the true WTP is unobservable over the non-positive range and instead only a zero is observed. Note that assuming an unbounded latent WTP conflicts with the assumption that anglers can not be made worse off by provision of the status quo. Despite this shortcoming, the censored dependent variable model provides a valuable starting point for the discussion of more realistic models.

The censored dependent variable model is often referred to as the Tobit model. The Tobit model assumes a one-stage decision rule such that all observations are generated by the same underlying data generating process. The probability of observing a zero observation is equal to the probability that WTP* is less than or equal to zero. Assuming that the error term (v) is normally distributed with mean zero and constant variance (σ), this probability becomes

4.7 $$P(WTP^* \leq 0) = \Phi(-\frac{\beta_x x + \beta_z z}{\sigma})$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function. The probability of observing a positive WTP is simply the probability of observing WTP*

4.8 $$P(WTP*) = \frac{1}{\sigma}\phi(\frac{WTP^* - \beta_x x + \beta_z z}{\sigma})$$

Defining an indicator variable $I_{>0} = 1$ if the respondent has a positive WTP and $I_{>0} = 0$ if the respondent has a zero WTP, the Tobit likelihood function can be written as

4.9 $$L(\beta) = \prod_{i=1}^{N} P(WTP=0)^{1-I_{>0}} P(WTP*)^{I_{>0}}$$

As stated previously, the Tobit model assumes that the zero WTP responses are driven by the same data generating process as the positive WTP responses. In fact, underlying the Tobit model is the assumption that WTP can actually be negative; but, as researchers we can not observe the negative range of true WTP. In addition, the Tobit model assumes the same structural model generates the zero observations and the positive WTP values. The multiple possible explanations for zero WTP discussed in the previous section lend evidence that a more general econometric model may be warranted.

The Heckman Two-Stage Model: To alleviate the restrictive assumptions of the Tobit single-stage model, suppose decisions are instead made in two-stages: First whether to pay anything, and then conditional on being WTP something, how much to pay. The first stage of this model can be thought to explain the zero WTP values versus the positive WTP values, but not the magnitude of the positive WTP values. Conditional on clearing the zero-WTP hurdle, we can then view the observed positive WTP values as a truncated-at-zero sample. A positive WTP observation is a function of a set of exogenous variables (x_1) but is also conditioned on the factors that determine the zero WTP observations (x_2). To remain consistent with previous sections, we define x_1 as the composite matrix: $x_1 = (x,z)$. It is important to note that x_1 and x_2 can contain none, some, or all of the same variables. In this Heckman two-stage formulation, the factors that determine zero observations can differ from those determining the positive observations. The stochastic link between the two decisions is an individual specific error that carries across the two stages (u). In addition, there are stage specific errors (v_1 and v_2) that are specific to either the zero WTP decision or the positive WTP decision but are uncorrelated.

More formally, the decision of whether reported WTP (WTP^R) will be greater than zero is based on an unobservable continuous dependent variable (y*) such that $WTP^R=0$ if $y^* \leq 0$ and $WTP^R>0$ if $y^*>0$.

Define y* as a linear in parameters function of x_1, the individual specific error (u) and the first-stage specific error (v_1) such that

4.10 $$y^* = \beta_{x_1} x_1 + u + v_1$$

The probability that reported WTP will be greater than zero is consequently equal to the probability that y*>0. Assuming u and v_1 are normally distributed with respective variances: σ_u^2 and $\sigma_{v_1}^2$ the probability of a zero reported WTP can be written

4.11 $$P(WTP^R = 0) = P(y^* \leq 0) = \Phi(-\frac{\beta_{x_1} x_1}{\sigma_u + \sigma_{v_1}}$$

If the zero-WTP hurdle is cleared then reported WTP is equal to true WTP (WTP*). True WTP is a linear function of x_2, the individual specific error (u), and the second-stage specific error (v_2)

4.12 $$WTP^* = \beta_{x_2} x_2 + u + v_2$$

Observation of WTP* is conditional on clearing the zero WTP hurdle. The expected value of WTP* conditional on y*>0 can now be written

4.13 $$E(WTP* | y*>0) = \beta_{x_2} x_2 + E(u + v_2 | u + v_1 > -\beta_{x_1} x_1)$$

The conditional error expectation on the RHS of the above equation can be shown to be (Greene, 2000, 926-931)

4.14 $$E(u + v_2 | u + v_1 > -\beta_{x_1} x_1) = (\sigma_u)(\sigma_u + \sigma_{v_2}) \frac{\phi(\frac{\beta_{x_1} x_1}{\sigma_u + \sigma_{v_1}})}{\Phi(\frac{\beta_{x_1} x_1}{\sigma_u + \sigma_{v_1}})}$$

Consistent estimates of $\beta_{x_1} / (\sigma_u + \sigma_{v_1})$ can be found from a first-stage probit model explaining zero versus non-zero WTP. These first stage probit estimates can be used to calculate the inverse Mill's ratio

4.15 $$\lambda\left(\frac{\beta_{x_1}x_1}{\sigma_u+\sigma_{v_1}}\right)=\frac{\phi\left(\frac{\beta_{x_1}x_1}{\sigma_u+\sigma_{v_1}}\right)}{\Phi\left(\frac{\beta_{x_1}x_1}{\sigma_u+\sigma_{v_1}}\right)}$$

A second-stage ordinary least squares model which includes x_2 and $\lambda(\cdot)$ can then be used to correct the truncated positive WTP responses for sample selection bias. The parameter estimate on the inverse Mill's ratio β_λ provides a consistent estimate of $(\sigma_u)(\sigma_u+\sigma_{v_2})$. Note that individual estimates of the three error variances are not identifiable in the Heckman specification.

The Heckman two-stage model offers a more general treatment of WTP responses than the Tobit model because it allows for different sets of explanatory variables to affect the zero observations versus the positive observations. However, the Heckman model is still restrictive because it assumes that all zero observations are generated by the same structural form of the model. Problems occur if the two-stage behavioral process underlying the WTP decision allows for zero WTP responses in the second stage (the Heckman model does not allow for this possibility). The Heckman model assumes the two-stages are zero/non-zero and then conditional on non-zero how much greater than zero?

Double-Hurdle Models:

Suppose instead, respondents first make the decision of market participation versus non-particpation and then conditional on participation how much to pay (which could potentially include zero). For example, if an angler is a non-conservationist non-expert for a particular species, they will have zero WTP for preventing reductions in bag-limits for that species. However, an expert angler for that species does not necesarily have positive WTP. It is conceivable that participants in the market for a species can still have zero WTP for the prevention of reductions in bag-limits. The Heckman model does not allow for the possibility of zero WTP in the second stage.

The aforementioned drawback to the Heckman model for the current application opens the possibility for a three-stage decision process: Market-participation versus non-participation, zero WTP versus positive WTP, and how much to pay? The three-stage decision can be modeled as a combination of the Tobit and Heckman. The resulting model is referred to as a double-hurdle model. The basic formulation is as follows: true WTP (WTP*) is a Tobit model as modeled previously. However, true WTP is only observed if the respondent is a market participant. So, conditional on the decision to participate in the market, the respondent then faces a second hurdle of zero versus non-zero WTP. This decision is modeled in a Tobit framework. This procedure can be generalized to a three-stage Heckman procedure in which the three decisions are determined by different structural models but an individual specific error carries across the three decisions.

The three sets of models described in this section apply to single equation situations only. In the current case, each survey participant is offered multiple CV questions. At the very least it is expected that individual specific unobservable preferences will carry across the multiple questions. To address the multiple questions in a single equation setting it must be the case that question responses are independent across questions. If independence is violated, multiple equation solutions must be pursued. However, simultaneous modeling of multiple decisions drastically increases the computation and estimation complexity.

A Discussion of Multiple-Equation Models

Random Effects Tobit: The simplest version of a multiple-equation model that accounts for a mass of zero WTP responses is the random effects Tobit. Recall the random effects panel formulation of the multiple CV questions

4.16 $$WTP_{ij}^{*} = \beta_{xj}x_{i} + \beta_{zj}z_{ij} + \mu_{ij}$$

Suppose we introduce two complications to this standard random effects model: 1) WTP_{ij}^{*} is unobserved. Reported WTP (WTP_{ij}^{R}) is the maximum of zero and WTP_{ij}^{*} . This is the Tobit formulation. 2) $\mu_{ij} = u_{i} + v_{ij}$. That is, the error term is the sum of an individual-specific component and an individual-equation-specific component. By assuming normal distributions for the error components, the joint censored distribution of observed WTP can be derived. Parameter estimates can be obtained using standard maximum likelihood procedures. Statistical analysis in the random effects Tobit is difficult as the standard errors on parameter estimates must be corrected for the across equation correlation in the error terms. The random effects Tobit suffers from problems similar to those of the single-equation Tobit in explaining zero observations. The model assumes that the same data generating process underlies both the zero and positive observations. While recognizing the problem in a multiple-equation framework is straightforward, multiple equation single and double-hurdle models have proven difficult to derive and estimate in the literature.

Chapter 5
Tobit, Heckman and Double Hurdle Model Results

In this chapter we develop empirical option price models maintaining the assumption of independence across equations. We present Tobit, Heckman, and double hurdle models of option price (i.e., willingness to pay under uncertainty) for avoidance of reductions in king mackerel, red snapper, and gag bag limits. Finally, we estimate the marginal effects and 95% confidence intervals for the value of avoiding a one-fish reduction in the bag limit. The samples used are the south Atlantic and Gulf states for king mackerel, the Gulf states for red snapper, and Florida for gag.

Empirical Results

We implement the willingness to pay empirical models using SAS software. The Tobit model employs PROC LIFEREG with the normal distribution. The Heckman model is implemented with a probit model (PROC PROBIT) to estimate the probability of a positive willingness to pay followed by an ordinary least squares regression (PROC REG) on the positive willingness to pay values with the inverse Mill's ratio as a regressor. Both the Tobit and Heckman models also include the predicted probability of participation (i.e., probability of targeting the species) as a regressor and are, therefore, explicitly both option price models. The double hurdle model employs a combination of the probit participation model and a Tobit model on the participants. Conceptually, the second stage Tobit is a willingness to pay model after the uncertainty about participation has been resolved (as specified by the participation model). All models are estimated with two sets of data. The first is the full data including all willingness to pay values. The trimmed data excludes protest and outlier willingness to pay values.

Participation Models

Of the cases with non-missing willingness to pay values, 6.9%, 4.4%, and 1.1% of the AMES anglers generally target (GENTAR) king mackerel, red snapper, and gag, respectively. The empirical models estimating the factors that influence species participation are presented in Table 5-1. We attempted numerous specifications of these models in an attempt to identify the most influential determinants of participation. Other variables were included but were found to be statistically insignificant predictors of participation.

The king mackerel model contains a number of variables that influence participation. Men, whites, and boat owners are more likely to target king mackerel. King mackerel participation is increasing with fishing experience (at a decreasing rate) and income. Private/rental boat and shore anglers are less likely to target king mackerel, relative to charter boat anglers. Anglers in the Carolinas and Alabama are more likely while anglers in Georgia and Louisiana are less likely to target king mackerel, relative to those on the Gulf coast of Florida.

Few variables predict participation in the red snapper and gag fisheries. Boat owners and private/rental boat and shore anglers are less likely to target red snapper. Anglers who spent more money for travel on their intercepted trip are less likely to target red snapper. Alabama, Mississippi, and Louisiana anglers are more likely to target red snapper. The only variables which predict gag fishing is experience (at a diminishing rate) and the dummy variable for the east coast of Florida.

The predicted probability of participation (PROB) is used as an independent variable in the option price empirical models. The average probability of participation is 6.7%, 4.6%, and 1% for king mackerel, red snapper, and gag. The minimum probability of participation is 0% (after rounding) for each species. The maximum probability of participation is 35%, 41%, and 14% for king mackerel, red snapper, and gag.

Zero Bag Limit Effect

In preliminary Tobit models of willingness to pay we found that the willingness to pay amounts vary in the expected direction with the bag limit version of the permit, as expected. However, when the zero fish bag limit version is controlled for separately (e.g., ZERO = 1 if ver_km = 0, 0 otherwise) the magnitude of the bag change coefficient increases substantially and the zero bag dummy variable coefficient is negative and of similar magnitude to the bag change coefficient. This result suggests that the willingness to pay for the permit is equal to zero when the bag limit is zero.

Further investigation of these responses indicates there is no relationship between the protest zero responses and those who received the zero bag limit version. Therefore, this "zero willingness to pay to avoid a zero bag limit" effect is due to something other than protest responses. One explanation of this result is that anglers prefer not to harvest the species if it is so stressed that a zero bag limit is recommended. This suggests a conservation ethic among AMES anglers. If a species is stressed, anglers will choose a substitute species to target until the stock of the stressed species has improved to a healthy size.

In the models that follow we include the ZERO version dummy variable. In the king mackerel and red snapper models the coefficient is usually negative and statistically significant. The coefficient is typically not significantly different from zero in the gag models.

King Mackerel

The king mackerel Tobit option price models are presented in Table 5-2. With the full data the willingness to pay for the king mackerel permit is increasing in the size of the proposed change in the bag limit (BAGCHG). For example, if the reduction in the bag is one fish willingness to pay to avoid this bag reduction is lower than if the reduction in the bag is two or more fish. The magnitude of the BAGCHG coefficient, 8.87, is related to the marginal value of the bag change. The marginal value of the bag change is equal to the regression coefficient multiplied by the probability that the respondent will state a positive willingness to pay value. Therefore, the Tobit coefficient is always greater than the marginal value of the bag change.

Other results from the king mackerel model are that willingness to pay increases with the probability that the angler will target the species and income. Both results are as predicted and lend credibility to the willingness to pay data. Boat owners are less likely to be willing to pay.

The trimmed data Tobit model obtains different results from the full data model. The bag change coefficient is again positive and statistically different from zero. However, its magnitude is less than 50% of its full data counterpart. This indicates that after trimming protests and outliers, the willingness to pay to avoid the bag change is lower. The only other statistically significant coefficient is for the probability of targeting the species.

The Heckman results are presented in Table 5-3. The probit model for positive willingness to pay finds that boat owners are less likely to give a positive willingness to pay in the full sample. In both full and trimmed samples, the probability of a positive willingness to pay value is higher with higher income. Results from the second-stage models indicates that willingness to pay increases as the proposed bag change increases. Similarly to the Tobit model, the magnitude of the bag change coefficient is higher with the full data. In the full data model, the inverse mills ratio is negative and statistically significant indicating that sample selection bias will result if the zero willingness to pay values are excluded from the regression model. The participation probability is a determinant of willingness to pay only in the trimmed data. In both models, only 1% of the variation in willingness to pay is explained by the independent variables. These results suggests that little confidence should be placed in the Heckman model.

In general, the double hurdle model results are similar to the Tobit and Heckman models (Table 5-4). Willingness to pay increases with the bag change and income. However, the magnitude of the bag change coefficient is much larger when compared to the Tobit model coefficients in Table 5-2. This indicates that the sub-sample of anglers who target king mackerel are willing to pay more to avoid a reduction in the bag limit, relative to the full sample.

Red Snapper and Gag

The red snapper Tobit models follow a similar pattern as the king mackerel models (Table 5-5). The coefficient on the bag change variable is positive and statistically significant and is larger in magnitude with the full data relative to the trimmed data. The probability of targeting red snapper is not a statistically significant determinant of willingness to pay using the full data. However, the coefficient on this variable is statistically significant when using the trimmed data. In both models willingness to pay is increasing in income and lower for boat owners.

The results from the Heckman models for the red snapper data are not impressive (Table 5-6). The determinants of a positive willingness to pay value are the boat ownership and income variables. In the second stage regression model, the bag change variable is positive and statistically significant (again, the magnitude of the coefficient is higher in the full data). In the trimmed data model willingness to pay increases with the probability that red snapper will be targeted and if the angler had ever seen an enforcement officer. The F-value from the full data model indicate that the overall regression model is not statistically significant. The R-squared values from the trimmed data model indicates that only 2% of the variation in willingness to pay is explained by the independent variables.

The red snapper double hurdle model also does not perform particularly well (Table 5-7). With the full data, the bag change coefficient is not statistically different from zero. The only variables which do have statistically significant coefficients are travel expenditures and income. With the trimmed data, the coefficient on the bag change variable is only marginally statistically significant. Also, the travel expenditures and boat ownership coefficients are statistically significant.

Each of the gag regression models are plagued by coefficients on the bag change variables that are of the opposite sign from what is expected. In the Tobit model, income has a negative effect on willingness to pay (Table 5-8). In the Heckman models, the probability of a positive willingness to pay value decreases with income and increases for Florida Gulf coast anglers (Table 5-9). None of the determinants of a positive willingness to pay value have statistically significant coefficients. Given that very few anglers target gag, the double hurdle models also have no statistically significant determinants of willingness to pay (Table 5-10).

State Effects

We next incorporate variables which capture potential geographic differences in the value of avoiding the bag limits. Each state dummy variable is interacted with the bag change coefficient and included in the king mackerel and red snapper Tobit models. In the king mackerel full data model, all of the coefficients on the interaction variables are statistically significant except for the Louisiana interaction (Table 5-11). With the trimmed data, the Alabama and Louisiana interaction coefficients are not statistically significant. All of the other results are similar to the more parsimonious Tobit models (Table 5-2) except the coefficient on the enforcement variable becomes marginally significant with the full data. A comparison of the log-likelihood function values of the parsimonious models and the models with interaction terms indicates that the models with the interaction terms are improvements.

The red snapper models with interaction terms show similar improvement (Table 5-12). In the full data model the Alabama interaction coefficient is not statistically different from zero. In the trimmed data model the Alabama interaction term is marginally significant. Again, all other results are similar when compared to the more parsimonious models (Table 5-5) except that the coefficient on the enforcement variable becomes marginally significant in the trimmed data model.

Option Price Estimates

The marginal effect of the bag change on the willingness to pay is the value of avoiding a one fish reduction in the bag limit. The marginal effects of the bag change from the Tobit and the double hurdle models are calculated as the coefficient on the bag change variable scaled by the mean of the standard normal cumulative distribution function (Greene, 1997; p. 963)

5.1 $$\frac{\partial E(OP)}{\partial BAGCHG} = \beta_1 \Phi\left(\frac{\beta' X}{\sigma}\right)$$

where β_1 is the Tobit coefficient on the BAGCHG variable. The marginal effects from the Heckman model is simply the ordinary least squares regression coefficient. For each of the models the 95% confidence intervals are constructed from the standard errors of the regression coefficient. The standard errors from the Tobit and double hurdle models are also scaled by the mean of the standard normal cumulative distribution function.

The mean option price and 95% confidence interval estimates from the Tobit, Heckman, and double hurdle models from Tables 5-2 to 5-10 are presented in Table 5-13. Several patterns emerge. First, the king mackerel option prices are greater than the red snapper and gag estimates. Second, all but one of the double hurdle model option price estimates are not statistically different from zero since the 95% confidence intervals overlap with zero. Third, the option price estimates from the full data are larger than those from the trimmed data models. Fourth, the gag option price estimates are all negative, reflecting the wrong signed coefficient on the gag change variable.

The estimates of the willingness to pay to avoid a one fish bag limit decrease estimates from the Tobit models of Table 5-11 and 5-12 vary across state and species (Table 5-14). However, none of the differences in option price are statistically significant at p=.05. The option price is not significantly different from zero for anglers who were intercepted in Alabama (trimmed data only) and Louisiana for king mackerel. The king mackerel option price estimates are 18% to 144% greater than when the value is constrained to be equal across states as in Table 5-13. The full data king mackerel option price is (with rounding) $2, $5, $4, $4, $4, $3, and $3 in Alabama, Florida (East Coast), Florida (West Coast), Georgia, Mississippi, North and South Carolina. The trimmed data king mackerel option price is $2, $2, $1, $1, $1 and $1 in Florida (East Coast), Florida (West Coast), Georgia, Mississippi, North and South Carolina.

The red snapper estimates are only slightly different from the constrained estimates (Table 5-13). The full data red snapper option price is $2, $1 and $2 for Florida (West Coast), Louisiana and Mississippi. The trimmed data red snapper option price is less than $1 in Florida (West Coast), Louisiana and Mississippi. None of the differences in option price are statistically significant at p=.05. The option price is not significantly different from zero for anglers who were intercepted in Alabama.

Chapter 6
Bivariate Tobit Model Results

To demonstrate the potential models that can be estimated on the AMES contingent valuation data, two additional sets of models were estimated: (a) joint willingness to pay models and (b) joint participation/willingness to pay models. The additional complications added by these models require specific programming of tailored likelihood functions. The models estimated were programmed in Gauss.

Joint Willingness to Pay Models

Chapter 3 discusses the Random Effects Tobit model. As a generalization of that model, we estimate a bivariate Tobit model on the king mackerel and red snapper WTP responses. Due to missing values and that the red snapper WTP question only applied in Gulf States, the joint sample size is 4,447 responses. The bivariate Tobit model is specified as

$$
\begin{gathered}
WTP^*_{KM} = X_{KM}B_{KM} + \varepsilon_{KM} \\
WTP_{KM} = Max(0, WTP^*_{KM}) \quad 6.1 \\
WTP^*_{RS} = X_{RS}B_{RS} + \varepsilon_{RS} \\
WTP_{RS} = Max(0, WTP^*_{RS}) \\
\varepsilon_{KM}, \varepsilon_{RS} \sim N(0, 0, \sigma_{KM}, \sigma_{RS}, \rho)
\end{gathered}
$$

where WTP_{KM} and WTP_{RS} represent observed willingness to pay. The correlation coefficient represents the across response correlation between the two willingness to pay questions. Nested within the bivariate Tobit model is the random effects Tobit in which the species specific parameter vectors and error variances are restricted to be equal, but the covariance (and consequently the correlation coefficient) is non-zero. Tables 6-1 and 6-2 presents the parameter estimates and standard errors of the bivariate Tobit and random effects Tobit models. The specifications for the bivariate Tobits are identical to those in Tables 5-12 and 5-13 with the following exceptions:

1. Because the joint sample focuses on Gulf states, only Gulf state bag limit change interactions are possible.

2. The zero bag limit variable is eliminated from the king mackerel equation. Because only one version of the bag limit change was offered in the Gulf states for king mackerel, the zero bag limit variable is collinear with the bag-limit change variables.

3. The bivariate Tobit routine in LIMDEP proved unreliable in this application. The bivariate Tobit likelihood function was programmed instead in GAUSS. Olsen's reparameterization of the Tobit likelihood function was implemented in which each parameter is normalized by the standard error of the appropriate error term. In addition, the standard errors were reparameterized such that $\eta = \ln(\frac{1}{\sigma})$.

4. Only full-data models are estimated.

Likelihood ratio tests overwhelmingly rejected the hypothesis of no correlation between WTP responses. The likelihood ratio test is performed by comparing twice the difference in the log-likelihood function value between independent Tobits and the bivariate Tobit. Restricting the correlation coefficent to be zero in the bivariate Tobit is equivalent to running independent Tobits on the two WTP responses. The likelihood ratio test statistic is distributed chi-squared with 1 degree of freedom. For the present case, the likelihood-ratio test statistic for zero correlation is 662.14. The 95% critical value for the test is 3.84.

As noted above, nested within the bivariate Tobit is the random effects Tobit model. Table 6-2 reports two specifications of the random effects model. In Random Effects Tobit 1 we (a) restrict the error variance to be equal across WTP questions but allow for correlation between responses and (b) allow for species specific effects for variables that differ across WTP questions (state specific bag-limits, participation probabilities, and zero bag-limits).

Random Effects Tobit 2 still restricts the error variance to be equal across WTP questions but allows for species specific coefficients for all explanatory variables. A likelihood ratio test fails to find a significant difference between Random Effects Tobit 1 and Random Effects Tobit 2 implying that variables that do not vary across WTP questions have similar effects on WTP in a random effects framework. However, comparing the Random Effects Tobit 2 to the more general bivariate Tobit, the restriction of equal variance across WTP questions is rejected (likelihood ratio test statistic=81.82, 95% critical value with 1 restriction = 3.84). We therefore choose the general bivariate Tobit as our preferred specification and the remainder of this discussion will focus on the bivariate Tobit specification of the WTP responses.

Survey design and implementation problems lead to difficulty in measuring the option price for changes in bag limits for king mackerel with the bivariate Tobit model. As noted above, only one version of the king mackerel bag-limit change question was asked in the Gulf states. This leads to collinearity between the bag-limit change variables and the zero-bag limit dummy variable. As such, the zero-bag limit dummy variable can not be included in the king mackerel analysis. It is expected that the zero bag-limit variable will have a negative effect on option price. Because the zero-bag limit variable and the bag-limit change variables are correlated, it is expected that the bag-limit change variable will pick up the effect of the omission of the zero-bag limit variable. This effect manifests itself in small and negative coefficients on the state-specific king mackerel bag-change variables. As noted in previous sections, the option price for the Tobit model is the bag-change coefficient scaled by the probability of a non-zero response. If the coefficient on bag-change is negative then the option price will also be negative. Table 6-3 gives the average king mackerel and red snapper option prices from the bivariate Tobit models.

The king mackerel option prices for the bivariate Tobit are substantially smaller than those for the independent Tobit models (Tables 5-11 and 5-12). The Alabama and Louisiana estimates are negative as dictated by the negative bag-change coefficients. The red snapper estimates are of the same magnitude as the independent Tobit. Given the necessary restriction in sample size to estimate the bivariate Tobit, and the collinearity problem caused by the zero-bag limit dummy variable, we recommend against using the bivariate Tobit results for policy analysis in this case.

Joint WTP/Participation Models

The joint participation/willingness to pay models estimate the species participation model and Tobit willingness to pay model simultaneously. The probability of participation for king mackerel and red snapper are modeled as in Table 5-1. The Tobit specification for each species is the same as in Tables 5-11 and 5-12. For the joint model, the probability of participation from the participation model directly enters the Tobit WTP function and is simultaneously estimated with the parameters of the Tobit model. In addition, the unobservable error terms from the participation and willingness to pay models are assumed to be correlated. Formally, the joint participation/willingness to pay model is

$$Participation = X_P \beta_P + \varepsilon_P$$
$$WTP^* = X_W \beta_W + P(Participation)\beta_{PW} + \varepsilon_W$$

where Participation represents a continuous unobservable participation variable measured by GENTAR. The participation variable is only observable as an index function for values of Participation greater than or equal to zero. Assuming the participation error, ε_P, is normally distributed with mean zero and unknown standard deviation, σ_P, the probability of observing participation greater than or equal to zero is

$$P(Participation \geq 0) = \Phi(X_P \beta_P)$$

where the parameter vector is now understood to be normalized by the unknown standard deviation.

An additional complication arises because WTP is not fully observable. WTP* represents the underlying unobservable WTP function, but WTP is only observable if WTP*≥0. Otherwise, WTP=0. Finally, the decision to participate and the WTP decision are generated by correlated unobservable decision processes. In other words, the errors for the two decisions are assumed to be correlated. This correlation is introduced by assuming that the two errors are generated by a bivariate normal distribution. Each error has a marginal normal distribution with mean zero and unknown (and possibly unequal) variance. Correlation is introduced through a correlation coefficient that will be estimated jointly with the other parameters. The full participation/willingness to pay model is

$$\begin{aligned}
&WTP = X_W \beta_W + \Phi(X_P \beta_P) + \varepsilon_W \text{ ; if WTP*} > 0 \\
&WTP = 0 \text{ ; otherwise} \\
&P = 1 \text{ ; if Participation } \geq 0 \\
&P = 0 \text{ ; otherwise} \\
&\varepsilon_P, \varepsilon_W \sim N(0,0,\sigma_P,\sigma_W,\rho)
\end{aligned}$$

Four possible observational combinations between participation and WTP exist. There are summarized as: (a) participation and WTP>0, (b) participation and WTP=0, (c) nonparticipation and WTP>0, and (d) nonparticipation and WTP=0. The probability of each occurrence yields the contribution to the likelihood function for each observation.

Tables 6-4 and 6-5 present the parameter estimates for the joint participation/willingness to pay models on the full king mackerel and red snapper samples. Also reported are the estimates of the independent participation and willingness to pay models (with correlation between errors restricted to be zero). The parameter estimates should be interpreted as the normalized parameter estimates. The first finding is that the decision of WTP and participation for the king mackerel sample are correlated. The significant correlation coefficient for the king mackerel sample indicates that modeling the decisions jointly should enhance the statistical efficiency of the parameter estimates.

The same can not be said for the red snapper sample. The correlation coefficient can not be distinguished from zero at a reasonable confidence level. Given this lack of correlation, it is not surprising that independent Tobit and probit models perform similar to the joint model. The remainder focuses on the king mackerel sample.

Table 6-6 reports the option prices to avoid a one fish bag decrease for the king mackerel sample. The values are reported for the independent probit/Tobit specification of the model, and the joint probit/Tobit model. The endogeneity of the probability of participation leads to biased estimates of the option prices for the independent models. The joint model accounts for this endogeneity by jointly allowing for correlation between the decisions. As Table 6-6 shows, accounting for this endogenity leads to different point estimates for the option price than does the independent specification.

It should be noted that the option prices for the independent probit/Tobit model differ slightly from those in

Table 5-14 because of possible differences in algorithms and convergence criteria across estimation packages. Further, although the errors are assumed independent, the joint estimation of the parameters within the same maximization routine may cause slight differences. While standard errors are not directly calculated for the option prices in Table 6-6 (the joint estimation routine results in standard errors for functions of parameters that are not directly comparable with other methods used in this report), it is worth noting that the point estimates for the option prices for the joint model all fall within the 95% confidence intervals defined for the independent Tobit estimates in Table 5-14.

Chapter 7
Conclusions

The purpose of this report is to estimate the value of avoiding reductions in bag limits for king mackerel, red snapper and gag in the southeastern United States using the AMES data. The AMES contains a series of CVM questions that directly elicit the willingness to pay for reductions in bag limits for red snapper, king mackerel and gag. We presented theoretical and econometric models of willingness to pay.

We theoretically defined the option price as the willingness to pay under demand uncertainty where the uncertainty arises from the species targeting decision. Several theoretical reasons for zero willingness to pay are described. The primary econometric model employed is the Tobit which allows for censoring at zero willingness to pay. We also consider the Heckman sample selection model and the double hurdle model. We find that the Tobit model is statistically superior to the other models.

Several results emerge from our empirical analysis. First, we find that the king mackerel and red snapper willingness to pay values are valid measures of economic value. Willingness to pay increases with the magnitude of the bag change. This result confirms the theoretical prediction that "more is better." The marginal effect of the bag change coefficient is the value of avoiding a one-fish reduction in the bag limit. Willingness to pay also increases with the probability that the respondent would target the species. In addition to confirming that the option price specification is appropriate, this result conforms to economic theory. The gag willingness to pay values are not valid measures of economic value. In particular, willingness to pay decreases with increases in the bag change.

Second, we found a "zero bag" effect. In the king mackerel and red snapper models, willingness to pay increases with the size of the bag change until the maximum bag change. Respondents who are given a scenario in which the future legal bag limit is zero fish and are then told that they can purchase a permit to legally catch the current number of legal fish (e.g., three or two for king mackerel, five for red snapper) are willing to pay zero dollars. We speculate that these zero willingness to pay values are protest bids. In other words, respondents do not believe the scenario and respond accordingly.

We extended the basic Tobit estimates with two additional sets of models. First, we estimated the bivariate Tobit willingness to pay models for king mackerel and red snapper. The bivariate Tobit is an improvement over the independent Tobit models. The king mackerel option prices for the bivariate Tobit are substantially smaller than those for the independent Tobit models. The red snapper estimates are of the same magnitude as the independent Tobit. We recommend against using the bivariate Tobit results for policy analysis since only the Gulf of Mexico anglers are included.

Next, we estimate the bivariate probit and Tobit models in which the participation and willingness to pay decisions are estimated jointly. We find that the participation and willingness to pay decisions are correlated for the king mackerel sample. We find some differences in option price estimates between the independent and joint models. But the point estimates from the joint model fall within the 95% confidence intervals for the independent models. For red snapper, the correlation coefficient is not different from zero.

The willingness to pay estimates in this report could be used for policy analysis. The annual value of avoiding a one-fish reduction in the king mackerel bag limit ranges from $1.54 to $4.79 across state. The value of avoiding a one-fish reduction in the red snapper bag limit ranges from $.44 to $1.90 across state. These estimates could be aggregated across the number of anglers in each state to estimate the aggregate value of avoiding a one-fish reduction in the bag limit. These aggregate estimates could then be compared to the value of reduced bag limits to determine the efficiency of bag limits.

For example, aggregating the Florida (East Coast) value ($4.79) by 1.11 million Florida Atlantic coastal resident anglers in 1997 (personal communication, Stephen Holiman, 2001) yields an aggregate value of $5.32 million. This indicates that all Florida Atlantic coastal resident anglers would be willing to pay $5.32 million to avoid the one-fish reduction in the king mackerel bag limit. Aggregating the Florida (West Coast) value of avoiding a one-fish reduction in the red snapper bag limit ($1.90) by 1.25 million Florida Gulf coastal resident anglers in 1997 yields an aggregate value of $2.38 million.

References

Greene, William H. 2000. Econometric Analysis: Fourth Edition, Prentice Hall.

Haab, Timothy C., John C. Whitehead, and Ted McConnell. 2000. "The Economic Value of Marine Recreational Fishing in the Southeast United States, 1997 Southeast Economic Data Analysis," Final Report for Contract No. 40WCNF802079, National Marine Fisheries Service, Southeast Regional Office, 9721 Executive Center Drive N, St. Petersburg, FL.

Holiman, SG. 2000a. "Summary Information for the Gulf of Mexico Red Snapper Recreational Fishery," SERO-ECON-00-18, Fisheries Economics Office, National Marine Fisheries Service, St. Petersburg, FL.

Holiman, SG. 2000b. "2000 Economic Summary of the Gulf of Mexico Coastal Migratory Pelagics Recreational Fishery," SERO-ECON-00-12, Fisheries Economics Office, National Marine Fisheries Service, St. Petersburg, FL.

Table 3-1. Willingness to Pay for King Mackerel Permit

WTP_KM	Frequency	Percent
0	7227	73.87
1	44	0.45
2	254	2.60
3	55	0.56
4	12	0.12
5	492	5.03
6	14	0.14
7	19	0.19
8	28	0.29
9	6	0.06
10	573	5.86
11	4	0.04
12	31	0.32
13	6	0.06
14	7	0.07
15	179	1.83
16	2	0.02
17	2	0.02
20	294	3.01
23	1	0.01
24	1	0.01
25	243	2.48
28	1	0.01
30	47	0.48
35	8	0.08
40	18	0.18
45	2	0.02
50	133	1.36
55	1	0.01
60	2	0.02
65	1	0.01
75	4	0.04
80	1	0.01
85	1	0.01
100	48	0.49
150	5	0.05
200	6	0.06
250	1	0.01
300	2	0.02
400	1	0.01
500	5	0.05
550	1	0.01
1000	1	0.01

Table 3-2. Willingness to Pay for Red Snapper Permit

WTP_RS	Frequency	Percent	WTP_RS	Frequency	Percent
0	3343	72.64	210	1	0.02
1	26	0.56	250	2	0.04
2	123	2.67	251	1	0.02
3	29	0.63	1000	1	0.02
4	8	0.17	2000	1	0.02
5	218	4.74			
6	6	0.13			
7	11	0.24			
8	10	0.22			
10	281	6.11			
11	3	0.07			
12	22	0.48			
13	7	0.15			
14	11	0.24			
15	80	1.74			
16	3	0.07			
17	3	0.07			
18	1	0.02			
20	160	3.48			
21	8	0.17			
22	2	0.04			
23	2	0.04			
24	1	0.02			
25	96	2.09			
26	3	0.07			
30	37	0.80			
31	1	0.02			
32	1	0.02			
35	6	0.13			
40	5	0.11			
45	1	0.02			
50	43	0.93			
52	1	0.02			
54	2	0.04			
55	1	0.02			
60	2	0.04			
65	1	0.02			
66	1	0.02			
70	1	0.02			
75	3	0.07			
100	25	0.54			
110	1	0.02			
150	1	0.02			
200	2	0.04			

Table 3-3. Willingness to Pay for Gag Permit

WTP_G	Frequency	Percent
0	2776	85.57
1	11	0.34
2	68	2.10
3	7	0.22
4	4	0.12
5	97	2.99
6	1	0.03
7	3	0.09
8	17	0.52
10	89	2.74
12	6	0.18
14	4	0.12
15	29	0.89
20	36	1.11
21	2	0.06
24	1	0.03
25	39	1.20
30	8	0.25
35	3	0.09
40	1	0.03
50	22	0.68
65	1	0.03
75	2	0.06
80	1	0.03
100	13	0.40
185	1	0.03
200	1	0.03
1250	1	0.03

Table 3-4. Why Wouldn't You Pay Any Money?

	WTP_KM		WTP_RS		WTP_G	
	Freq	Percent	Freq	Percent	Freq	Percent
Doesn't fish for king mackerel/red snapper/gag	4103	56.8	1340	52.5	2225	80.15
You practice catch and release	451	6.2	164	6.4	84	3.03
You don't usually catch the current limit	110	1.5	60	2.4	20	0.72
Limits do not restrict your catch	82	1.1	26	1	11	0.40
The lower limit is sufficient/don't fish for them often enough	348	4.8	172	6.7	37	1.33
You don't want to pay any more to fish than you do now	448	6.2	181	7.1	119	4.29
You don't know how much the change is worth to you	58	0.8	24	0.9	13	0.47
Don't Know	60	0.8	24	0.9	14	0.50
Refused	31	0.4	18	0.7	1	0.04
You don't understand how the permit would work	29	0.4	14	0.5	5	0.18
Other	360	5	155	6.1	79	2.85
Don't agree with special permit idea/"unfair"	1048	14.5	345	13.5	150	5.40
Don't believe in restrictions/regulations	99	1.4	28	1.1	18	0.65

Table 3-5. Reaction to Zero Bag Limit for King Mackerel

		Gen_Tar = 0		Gen_Tar = 1		Total	
	RXN	Freq	Percent	Freq	Percent	Freq	Percent
Keep fishing because you don't fish for king mackerel or seldom do	1	5999	65.85	125	18.57	6124	62.60
Keep fishing for king mackerel because you practice catch and release	2	1097	12.04	160	23.77	1257	12.85
Keep fishing for king mackerel because the bag limit doesn't matter	3	348	3.82	57	8.47	405	4.14
Stop fishing for king mackerel and fish for other species	4	971	10.66	195	28.97	1166	11.92
Stop fishing altogether	5	133	1.46	47	6.98	180	1.84
Other	6	142	1.56	27	4.01	169	1.73
Fish less for king mackerel/red snapper/gag	7	236	2.59	45	6.69	281	2.87
Don't know	8	164	1.80	16	2.38	180	1.84
Refused	9	20	0.22	1	0.15	21	0.21
Totals		9110		673		9783	

Table 3-6. Reaction to Zero Bag Limit for Red Snapper

		Gen_Tar = 0		Gen_Tar = 1		Total	
	RXN	Freq	Percent	Freq	Percent	Freq	Percent
Keep fishing because you don't fish for red snapper or seldom do	1	2029	63.78	31	20.00	2060	61.75
Keep fishing for red snapper because you practice catch and release	2	364	11.44	22	14.19	386	11.57
Keep fishing for red snapper because the bag limit doesn't matter	3	123	3.87	6	3.87	129	3.87
Stop fishing for red snapper and fish for other species	4	398	12.51	50	32.26	448	13.43
Stop fishing altogether	5	72	2.26	19	12.26	91	2.73
Other	6	65	2.04	7	4.52	72	2.16
Fish less for red snapper	7	75	2.36	13	8.39	88	2.64
Don't know	8	47	1.48	7	4.52	54	1.62
Refused	9	8	0.25	0	0.00	8	0.24
Totals		3181		155		3336	

Table 3-7. Reaction to Zero Bag Limit for Gag

		Gen_Tar = 0		Gen_Tar = 1		Total	
	RXN	Freq	Percent	Freq	Percent	Freq	Percent
Keep fishing because you don't fish for gag or seldom do	1	1923	66.11	11	37.93	1934	65.83
Keep fishing for gag because you practice catch and release	2	302	10.38	2	6.90	304	10.35
Keep fishing for gag because the bag limit doesn't matter	3	157	5.40	3	10.34	160	5.45
Stop fishing for gag and fish for other species	4	268	9.21	7	24.14	275	9.36
Stop fishing altogether	5	55	1.89	2	6.90	57	1.94
Other	6	68	2.34	1	3.45	69	2.35
Fish less for gag	7	44	1.51	3	10.34	47	1.60
Don't know	8	86	2.96	0	0.00	86	2.93
Refused	9	6	0.21	0	0.00	6	0.20
Totals		2909		29		2938	

Table 3-8. Willingness to Pay Outliers

Species	WTP	GENTAR	BAGCHG	TRIPS	FFDAYS12	SUCEXP	INCOME	RXN
KM	150	0	3	4	5	.	52.5	5
KM	150	0	2	3	3	.	30	4
KM	150	0	3	7	20	.	30	3
KM	150	0	1	26	30	.	20	1
KM	150	1	1	1	5	1	112.5	3
KM	200	0	3	15	100	.	67.5	3
KM	200	0	2	10	30	.	30	3
KM	200	0	1	4	32	.	30	1
KM	200	0	1	6	12	.	30	7
KM	200	0	1	10	20	.	112.5	4
KM	200	0	2	1	15	.	52.5	2
KM	250	0	2	2	20	.	30	1
KM	300	0	2	1	0	.	52.5	1
KM	300	0	2	6	3	.	52.5	1
KM	400	0	2	1	5	.	30	1
KM	500	0	1	9	36	.	40	1
KM	500	1	2	14	30	0	200	4
KM	500	0	1	12	12	.	67.5	8
KM	500	0	2	2	7	.	20	1
KM	500	0	2	1	6	.	200	1
KM	550	0	2	1	25	.	30	1
KM	1000	1	1	3	32	0	87.5	4
RS	110	0	2	1	0	.	162.5	.
RS	150	1	4	1	5	1	112.5	.
RS	200	0	4	20	76	.	112.5	6
RS	200	0	4	1	15	.	52.5	2
RS	210	0	3	2	12	.	30	.
RS	250	0	5	12	25	.	52.5	.
RS	250	1	3	4	31	1	87.5	4
RS	251	0	3	5	120	.	40	5
RS	1000	1	2	15	150	1	30	6
RS	2000	0	4	6	20	.	40	.
G	185	0	2	25	6	.	30	3
G	200	0	2	20	32	.	112.5	.
G	1250	0	2	30	12	.	20	3

Table 3-9. Willingness to Pay by State, Wave, and Bag Change

	King Mackerel		Red Snapper		Gag	
State	Mean	N	Mean	N	Mean	N
Alabama	3.96	372	7.47	359		
Florida (E)	5.07	1728			2.88	1389
Florida (W)	4.35	3818	5.23	2845	2.57	1855
Georgia	8.03	232				
Louisiana	1.96	1155	3.91	1107		
Mississippi	4.60	291	7.26	287		
North Carolina	6.04	1443				
South Carolina	7.67	744				
Kruskal-Wallis	144.87		24.69		7.19	
Wave	Mean	N	Mean	N	Mean	N
2	4.82	1426	5.94	715	3.59	566
3	5.94	1940	5.04	846	2.94	725
4	5.52	1513	8.49	643	4.64	661
5	4.33	1977	3.99	892	0.00	362
6	3.58	1845	3.74	852	0.00	483
1	4.44	1082	5.00	650	3.42	447
Kruskal-Wallis	56.25		21.33		196.04	
Bag Change	Mean	N	Mean	N	Mean	N
1	4.40	4599	2.65	915	2.17	635
2	4.96	4385	5.17	889	4.32	687
3	5.91	799	4.91	920	2.22	699
4			8.60	913	1.69	591
5			4.76	961	2.96	632
Kruskal-Wallis	15.76		40.46		8.82	

Table 3-10. Weighting the Data

	AMES=0		AMES=1		
Days Fished	Freq	Percent	Freq	Percent	Weight
0	6164	12.96	942	8.76	1.48
1	3974	8.36	442	4.11	2.03
2-3	5292	11.13	793	7.37	1.51
4-6	4696	9.87	869	8.08	1.22
7-13	5893	12.39	1134	10.54	1.18
14-24	5081	10.68	1755	16.31	0.65
25-39	4444	9.34	1457	13.54	0.69
40-51	3961	8.33	1228	11.41	0.73
52-100	3694	7.77	918	8.53	0.91
100+	4360	9.17	1220	11.34	0.81

Table 3-11. Data Summary

Variable	Label	Unweighted		Weighted	
		Mean	Std. Dev.	Mean	Std. Dev.
GENDER	male = 1, female = 0	0.88	0.32	0.88	0.33
WHITE	white = 1, non-white = 0	0.91	0.29	0.91	0.29
YRSFISH	years fished from AMES	21.30	14.89	20.74	14.94
YRSFISHSQ	yrsfish squared	675.47	814.76	653.18	810.12
BOATOWN	if household owns boat	0.58	0.49	0.54	0.50
TRAVEXP	travel expenses	42.52	193.96	51.28	217.80
INCOME	household income	48.08	32.11	48.76	31.92
ENFORCE	=1 if ever seen an enforcement officer	0.72	0.45	0.69	0.46
MODE2	=1 if private/rental boat	0.60	0.49	0.56	0.50
MODE3	=1 if shore	0.29	0.45	0.30	0.46
NC	=1 if North Carolina	0.15	0.36	0.17	0.37
SC	=1 if South Carolina	0.08	0.26	0.08	0.27
GA	=1 if Georgia	0.02	0.15	0.03	0.17
FL_E	=1 if Florida South Atlantic	0.18	0.38	0.16	0.37
FL_W	=1 if Florida Gulf	0.39	0.49	0.37	0.48
AL	=1 if Alabama	0.04	0.19	0.04	0.20
MS	=1 if Mississippi	0.03	0.17	0.03	0.17
LA	=1 if Louisiana	0.12	0.32	0.11	0.32
Cases	10,758				

Table 5-1. Probit Participation Models

	King Mackerel		Red Snapper		Gag	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
CONSTANT	-2.147	-16.098	-1.574	-7.880	-3.579	-6.725
GENDER	0.324	4.184	0.057	0.509	0.390	1.279
WHITE	0.190	2.049	0.134	0.937	0.312	0.866
YRSFISH	0.013	2.976	-0.001	-0.115	0.055	2.670
YRSFISHSQ	-0.000	-2.628	-0.000	-0.064	-0.001	-2.574
BOATOWN	0.136	2.926	-0.182	-2.376	-0.134	-0.889
TRAVEXP	-0.000	-1.254	-0.001	-1.876	0.000	1.021
INCOME	0.003	4.247	0.001	1.295	0.002	1.102
MODE2	-0.178	-2.937	-0.546	-6.011	0.240	1.114
MODE3	-0.492	-6.998	-0.634	-5.864	0.312	1.365
NC	0.232	3.780				
SC	0.314	4.515				
GA	-0.356	-2.188				
FL_E	0.101	1.715			-0.318	-2.078
AL	0.592	7.289	0.972	10.724		
MS	-0.227	-1.548	0.666	5.692		
LA	-0.683	-6.612	0.175	1.902		
Log-L	-2262.50		-765.07		-176.13	
Cases	9783		4598		3244	

Table 5-2. King Mackerel Tobit Regression Models

	Full Data		Trimmed Data	
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-51.73	-19.25	-19.85	-15.07
BAGCHG	8.87	5.49	3.37	4.21
ZERO	-9.86	-4.67	-3.03	-2.92
PROB	58.78	3.74	52.80	6.75
TRAVEXP	0.00	1.10	0.00	0.91
INCOME	0.05	2.28	0.01	0.92
ENFORCE	1.94	1.34	0.81	1.14
BOATOWN	-4.11	-2.95	-2.09	-3.08
SCALE	48.56		22.99	
Log-L	-16474.50		-14074.07	
Cases	9783		8147	

Table 5-3. King Mackerel Heckman Regression Models

	Full Data		Trimmed Data	
Probit	Coefficient	t-value	Coefficient	t-value
CONSTANT	-0.70	-10.52	-0.66	-9.40
GENDER	0.07	1.56	0.13	2.89
WHITE	0.07	1.37	0.06	1.00
BOATOWN	-0.05	-1.74	0.01	0.20
INCOME	0.00	2.95	0.00	3.40
GULF	-0.18	-6.64	-0.19	-6.52
Log-L	-5587.62		-5008.88	
Cases	9783		8217	
OLS				
CONSTANT	71.53	2.47	7.91	0.91
BAGCHG	4.63	2.30	2.18	3.17
ZERO	-8.23	-3.21	-3.13	-3.57
PROB	9.50	0.56	10.57	1.70
ENFORCE	2.06	1.27	-0.48	-0.87
INVMILLS	-92.76	-2.15	6.13	0.46
F-value	5.768		3.80	
R^2	0.01		0.01	
Cases	2556		2486	

Table 5-4. King Mackerel Double Hurdle Regression Models

	Full Data		Trimmed Data	
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-70.11	-4.99	-62.85	-4.45
BAGCHG	18.32	2.30	15.18	1.93
ZERO	-31.60	-2.94	-27.88	-2.61
TRAVEXP	-0.03	-1.05	-0.02	-0.98
INCOME	0.20	2.15	0.17	1.81
ENFORCE	4.74	0.57	4.12	0.49
BOATOWN	2.73	0.36	5.28	0.70
SCALE	72.21		71.25	
Log-L	-1609.30		-1577.26	
Cases	673		634	

Table 5-5. Red Snapper Tobit Regression Models

	Full Data		Trimmed Data	
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-74.14	-14.83	-27.47	-13.24
BAGCHG	7.21	5.58	3.28	6.12
ZERO	-16.38	-3.72	-5.67	-3.11
PROB	29.59	1.40	31.37	3.50
TRAVEXP	0.00	0.10	0.00	0.24
INCOME	0.16	4.00	0.07	4.15
ENFORCE	3.42	1.18	1.88	1.58
BOATOWN	-10.53	-3.82	-3.43	-3.01
SCALE	66.44		27.13	
Log-L	-8454.03		-7289.75	
Cases	4598		4062	

Table 5-6. Red Snapper Heckman Regression Models

	Full Data		Trimmed Data	
Probit	Coefficient	t-value	Coefficient	t-value
CONSTANT	-0.63	-6.69	-0.56	-5.72
GENDER	0.00	0.01	0.02	0.37
WHITE	0.01	0.14	0.00	0.06
BOATOWN	-0.22	-5.33	-0.19	-4.45
INCOME	0.00	5.05	0.00	4.72
Log-L	-2686.02		-2498.77	
Cases	4598		4062	
OLS				
CONSTANT	1.84	0.05	10.64	0.92
BAGCHG	3.34	2.03	1.74	3.57
ZERO	-9.32	-1.71	-2.67	-1.65
PROB	23.15	0.89	13.70	1.79
ENFORCE	4.52	1.29	1.77	1.70
INVMILLS	5.92	0.10	-2.94	-0.16
F-value	1.34		4.18	
R2	0.0053		0.02	
Cases	1255		1245	

Table 5-7. Red Snapper Double Hurdle Regression Models

	Full Data		Trimmed Data	
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-83.12	-0.01	-18.58	-2.19
BAGCHG	9.55	0.10	4.17	1.80
ZERO	-72.61	-0.01	-17.19	-1.96
TRAVEXP	-0.39	-2.60	-0.10	-2.17
INCOME	0.24	4.10	0.04	0.62
ENFORCE	8.00	0.13	1.22	0.23
BOATOWN	-5.71	-0.18	11.94	2.25
SCALE	115.38		28.68	
Log-L	-581.79		-443.05	
Cases	202		151	

Table 5-8. Gag Tobit Regression Models

	Full Data		Trimmed Data	
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-86.29	-9.25	-32.52	-8.50
BAGCHG	-6.97	-2.88	-2.51	-2.54
ZERO	23.13	2.68	10.62	3.03
PROB	394.75	1.08	139.74	0.95
TRAVEXP	-0.01	-0.82	-0.00	-0.80
INCOME	-0.16	-2.20	-0.05	-1.65
ENFORCE	4.18	0.78	1.63	0.75
BOATOWN	5.08	1.01	1.04	0.51
SCALE	84.70		34.58	
Log-L	-3288.40		-2902.79	
Cases	3244		2972	

Table 5-9. Gag Heckman Regression Models

	Full Data		Trimmed Data	
Probit	Coefficient	t-value	Coefficient	t-value
CONSTANT	-1.04	-7.59	-0.99	-7.16
GENDER	-0.06	-0.73	-0.05	-0.56
WHITE	-0.01	-0.13	-0.03	-0.30
BOATOWN	0.04	0.69	0.05	0.93
INCOME	-0.00	-2.00	-0.00	-2.04
GULF	0.10	1.78	0.11	1.93
Log-L	-1282.24		-1236.85	
Cases	3244		2972	
OLS				
CONSTANT	-106.86	-0.46	-57.23	-1.00
BAGCHG	-0.58	-0.18	0.64	0.70
ZERO	1.32	0.11	3.53	1.06
PROB	-228.81	-0.44	-59.90	-0.41
ENFORCE	5.36	0.75	-0.65	-0.33
INVMILLS	178.05	0.54	101.13	1.24
F-value	0.190		1.59	
R^2	0.00		0.02	
Cases	468		465	

Table 5-10. Gag Double Hurdle Regression Models

	Full Data		Trimmed Data	
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-21.85	-1.32	-27.55	-1.45
BAGCHG	6.43	1.33	7.03	1.33
ZERO	-15.43	-1.14	-18.02	-1.30
TRAVEXP	-0.12	-0.75	-0.04	-0.14
INCOME	-0.00	-0.06	0.08	0.68
ENFORCE	-6.65	-0.97	-3.50	-0.53
BOATOWN	4.29	0.62	7.16	1.09
SCALE	13.54		12.17	
Log-L	-42.47		-39.80	
Cases	35		28	

Table 5-11. King Mackerel Tobit Regression Models with State Interactions

	Full Data		Trimmed Data	
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-59.22	-12.04	-22.59	-9.36
BAGCHG*AL	10.55	2.05	2.98	1.18
BAGCHG*FL_E	21.89	4.78	8.85	3.93
BAGCHG*FL_W	18.35	4.05	7.25	3.26
BAGCHG*GA	18.19	5.43	6.90	4.13
BAGCHG*LA	7.05	1.47	1.48	0.63
BAGCHG*MS	16.79	3.26	6.27	2.49
BAGCHG*NC	12.52	4.25	4.92	3.39
BAGCHG*SC	14.85	4.92	5.51	3.71
ZERO	-18.47	-4.00	-6.38	-2.80
PROB	42.23	1.85	43.30	3.86
TRAVEXP	0.00	1.36	0.00	1.00
INCOME	0.06	2.41	0.01	1.20
ENFORCE	2.39	1.65	0.95	1.35
BOATOWN	-3.84	-2.63	-1.89	-2.66
SCALE	48.34		22.86	
Log-L	-16422.99		-14022.64	
Cases	9783		8147	

Table 5-12. Red Snapper Tobit Regression Models with State Interactions

	Full Data		Trimmed Data	
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-78.35	-15.04	-28.53	-13.28
BAGCHG*AL	1.96	0.89	1.58	1.68
BAGCHG*FL_W	8.46	6.31	3.54	6.39
BAGCHG*LA	5.42	3.67	2.86	4.70
BAGCHG*MS	8.16	4.23	4.13	5.08
ZERO	-16.21	-3.68	-5.62	-3.09
PROB	92.91	2.93	48.24	3.62
TRAVEXP	0.00	0.20	0.00	0.38
INCOME	0.14	3.48	0.06	3.83
ENFORCE	4.39	1.51	2.12	1.77
BOATOWN	-8.41	-2.98	-2.97	-2.55
SCALE	66.35		27.09	
Log-L	-8443.85		-7284.24	
Cases	4598		4062	

Table 5-13. Option Price to Avoid a One-Fish Bag Decrease

	Tobit		Heckman		Double Hurdle	
King Mackerel	Full Data	Trimmed	Full Data	Trimmed	Full Data	Trimmed
Mean	1.96	0.72	4.63	2.18	5.28	4.53
Lower 95% C.I.	1.26	0.39	0.68	0.83	0.79	-0.08
Upper 95% C.I.	2.65	1.06	8.58	3.53	9.77	9.14
Red Snapper						
Mean	1.63	0.74	3.34	1.74	2.62	1.44
Lower 95% C.I.	1.06	0.50	0.11	0.79	-1.99	-0.13
Upper 95% C.I.	2.20	0.97	6.57	2.70	7.23	3.01
Gag Grouper						
Mean	-0.91	-0.33	-0.58	0.64	1.40	1.80
Lower 95% C.I.	-1.53	-0.58	-7.09	-1.16	-0.67	-0.86
Upper 95% C.I.	-0.29	-0.08	5.92	2.44	3.47	4.46

Table 5-14. Option Price to Avoid a One-Fish Bag Decrease by State

	King Mackerel		Red Snapper	
Alabama	Full Data	Trimmed	Full Data	Trimmed
Mean	2.31	0.63	0.44	0.35
Lower 95% C.I.	0.10	-0.42	-0.53	-0.06
Upper 95% C.I.	4.51	1.68	1.41	0.77
Florida East				
Mean	4.79	1.88		
Lower 95% C.I.	2.82	0.94		
Upper 95% C.I.	6.75	2.81		
Florida West				
Mean	4.01	1.54	1.90	0.79
Lower 95% C.I.	2.07	0.61	1.31	0.55
Upper 95% C.I.	5.95	2.46	2.49	1.04
Georgia				
Mean	3.98	1.47		
Lower 95% C.I.	2.54	0.77		
Upper 95% C.I.	5.41	2.16		
Louisiana				
Mean	1.54	0.31	1.22	0.64
Lower 95% C.I.	-0.52	-0.66	0.57	0.37
Upper 95% C.I.	3.60	1.29	1.87	0.91
Mississippi				
Mean	3.67	1.33	1.83	0.93
Lower 95% C.I.	1.47	0.28	0.99	0.57
Upper 95% C.I.	5.88	2.38	2.68	1.28
North Carolina				
Mean	2.74	1.04		
Lower 95% C.I.	1.47	0.44		
Upper 95% C.I.	4.00	1.65		
South Carolina				
Mean	3.25	1.17		
Lower 95% C.I.	1.95	0.55		
Upper 95% C.I.	4.54	1.79		

Table 6-1. Bivariate Tobit Models

	King Mackerel			
	Independent Tobits		Bivariate Tobit	
	Coeff.	Stan. Err.	Coeff.	Stan. Err.
Constant/Sigma	-1.04	0.09	-0.95	0.08
Bag_al/Sigma	-0.18	0.09	-0.13	0.07
Bag_fl_w/Sigma	0.04	0.05	0.03	0.04
Bag_la/Sigma	-0.19	0.06	-0.16	0.05
Bag_ms/Sigma	0.06	0.07	0.06	0.06
(Prob*100)/Sigma	0.02	0.01	0.01	0.01
(Trav_exp/100)/Sigma	0.01	0.01	0.01	0.01
(Income/100)/Sigma	0.16	0.08	0.15	0.07
Enforce/Sigma	0.11	0.06	0.09	0.05
Boatown/Sigma	-0.06	0.05	-0.06	0.04
ln(1/sigma)	-3.86	0.00	-4.17	0.01
	Red Snapper			
	Independent Tobits		Bivariate Tobit	
	Coeff.	Stan. Err.	Coeff.	Stan. Err.
Constant/Sigma	-1.21	0.09	-1.07	0.08
Bag_al/Sigma	0.05	0.04	0.04	0.04
Bag_fl_w/Sigma	0.13	0.02	0.09	0.02
Bag_la/Sigma	0.08	0.03	0.05	0.02
Bag_ms/Sigma	0.13	0.04	0.10	0.03
Zero_Bag/Sigma	-0.29	0.08	-0.21	0.07
(Prob*100)/Sigma	0.01	0.01	0.01	0.01
(Trav_exp/100)/Sigma	0.01	0.02	0.00	0.01
(Income/100)/Sigma	0.21	0.07	0.20	0.06
Enforce/Sigma	0.08	0.06	0.07	0.05
Boatown/Sigma	-0.11	0.05	-0.11	0.05
ln(1/sigma)	-4.35	0.00	-4.46	0.00
Correlation	0.00		0.57	
Log-L	-14805.17		-14474.1	
Observations	4447		4447	

Table 6-2. Random Effects Tobit Models

	King Mackerel			
	Random Effects Tobit 1		Random Effects Tobit 2	
	Coeff.	Stan. Err.	Coeff.	Stan. Err.
Constant/Sigma	-0.95	0.07	-0.95	0.07
Bag_al/Sigma	-0.10	0.07	-0.11	0.07
Bag_fl_w/Sigma	0.04	0.03	0.04	0.03
Bag_la/Sigma	-0.15	0.04	-0.15	0.05
Bag_ms/Sigma	0.05	0.06	0.05	0.06
(Prob*100)/Sigma	0.01	0.01	0.01	0.01
(Trav_exp/100)/Sigma	0.00	0.01	0.00	0.01
(Income/100)/Sigma	0.17	0.05	0.14	0.07
Enforce/Sigma	0.08	0.04	0.08	0.05
Boatown/Sigma	-0.05	0.04	-0.06	0.04
ln(1/sigma)	-4.38	0.00	-4.38	0.00
	Red Snapper			
	Random Effects Tobit 1		Random Effects Tobit 2	
	Coeff.	Stan. Err.	Coeff.	Stan. Err.
Constant/Sigma	-1.04	0.07	-1.05	0.07
Bag_al/Sigma	0.04	0.04	0.04	0.04
Bag_fl_w/Sigma	0.09	0.02	0.09	0.02
Bag_la/Sigma	0.05	0.02	0.05	0.02
Bag_ms/Sigma	0.10	0.03	0.10	0.03
Zero_Bag/Sigma	-0.21	0.06	-0.21	0.06
(Prob*100)/Sigma	0.01	0.01	0.01	0.01
(Trav_exp/100)/Sigma	0.00	0.01	0.00	0.01
(Income/100)/Sigma	0.17	0.05	0.20	0.06
Enforce/Sigma	0.08	0.04	0.07	0.05
Boatown/Sigma	-0.11	0.04	-0.11	0.04
ln(1/sigma)	-4.38	0.00	-4.38	0.00
Correlation	0.60		0.60	
Log-L	-14515.54		-14515.01	
Observations	4447		4447	

Table 6-3. Bivariate Tobit Option Prices

	King Mackerel	Red Snapper
Alabama	-1.71	0.81
Florida_West	0.38	2.17
Louisiana	-1.77	1.28
Mississippi	0.56	2.16

Table 6-4. Joint Participation and Willingness to Pay Model

	King Mackerel			
	Independent Models		Joint Model	
	Probit Participation Model			
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-2.15	-17.90	-2.12	-19.07
GENDER	0.32	4.44	0.32	4.78
WHITE	0.19	2.15	0.21	2.52
BOATOWN	0.14	3.05	0.18	4.30
INCOME	0.25	4.29	0.23	4.22
TRAVEXP	-0.01	-1.14	-0.02	-1.44
MODE2	-0.18	-3.40	-0.18	-3.98
MODE3	-0.49	-7.88	-0.42	-7.23
AL	0.59	7.97	0.54	7.69
FL_E	0.10	1.68	0.07	1.18
GA	-0.36	-2.39	-0.25	-1.70
LA	-0.68	-7.54	-0.66	-7.25
MS	-0.23	-1.45	-0.24	-1.56
NC	0.23	4.05	0.22	4.05
SC	0.31	4.76	0.28	4.52
YRSFISH	1.30	3.00	0.72	1.98
YRSFISH2	-0.21	-2.64	-0.21	-3.04
	Tobit Willingness to Pay Model			
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-1.23	-14.01	-1.30	-14.23
BAG_AL	0.22	2.32	0.12	1.18
BAG_FLE	0.45	5.38	0.47	5.47
BAG_FLW	0.38	4.56	0.40	4.72
BAG_GA	0.38	6.54	0.41	6.79
BAG_LA	0.15	1.63	0.23	2.47
BAG_MS	0.35	3.56	0.40	3.96
BAG_NC	0.26	4.89	0.26	4.86
BAG_SC	0.31	5.68	0.29	5.19
ZERO	-0.38	-4.50	-0.40	-4.62
PROB	0.01	1.91	0.03	4.77
TRAVEXP	0.01	1.29	0.01	1.56
INCOME	0.12	2.73	0.03	0.58
ENFORCE	0.05	1.65	0.05	1.61
BOATOWN	-0.08	-2.63	-0.13	-3.85
LN(1/SIGMA)	-3.88	-1369.63	-3.88	-309.14
CORRELATION	0.00		-0.12	-2.94
LOG-L	-18685.50		-18673.30	
CASES	9783		9783	

Table 6-5. Joint Participation and Willingness to Pay Model

	Red Snapper			
	Independent Models		Joint Models	
	Probit Participation Model			
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-1.57	-8.66	-1.61	-9.21
GENDER	0.06	0.60	0.10	1.11
WHITE	0.12	0.92	0.10	0.76
BOATOWN	-0.19	-2.78	-0.17	-2.49
INCOME	0.14	1.38	0.11	1.15
TRAVEXP	-0.05	-1.45	-0.05	-1.44
MODE2	-0.53	-6.66	-0.55	-7.17
MODE3	-0.61	-6.61	-0.60	-6.80
AL	0.96	12.32	0.91	11.94
GA	0.17	1.99	0.16	1.84
LA	0.66	6.12	0.64	6.10
MS	-0.06	-0.10	0.22	0.37
YRSFISH	-0.01	-0.12	-0.11	-0.98
YRSFISH2	-0.21	-2.64	-0.21	-3.04
	Tobit Willingness to Pay Model			
	Coefficient	t-value	Coefficient	t-value
CONSTANT	-1.18	-14.44	-1.20	-14.17
BAG_AL	0.03	0.76	0.02	0.61
BAG_FLW	0.13	5.87	0.13	5.74
BAG_GA	0.08	3.37	0.08	3.31
BAG_LA	0.12	3.81	0.12	3.62
BAG_MS	-0.24	-3.30	-0.24	-3.20
ZERO	0.01	2.71	0.02	3.10
PROB	0.00	0.20	0.00	0.26
TRAVEXP	0.21	3.08	0.21	2.87
INCOME	0.07	1.38	0.07	1.45
ENFORCE	-0.12	-2.72	-0.12	-2.47
BOATOWN	-4.19	-1929.81	-4.19	-1336.52
LN(1/SIGMA)	-3.88	-1369.63	-3.88	-309.14
CORRELATION	0.00		-0.10	-1.57
LOG-L	-9249.40		-9245.30	
CASES	4598		4598	

Table 6-6. King Mackerel Option Prices: Joint Participation/WTP Model

	Tobit	Joint Model
Alabama	$2.29	$1.24
Florida East	$4.76	$4.94
Florida West	$3.99	$4.19
Georgia	$3.95	$4.31
Louisiana	$1.53	$2.38
Mississippi	$3.65	$4.17
North Carolina	$2.72	$2.74
South Carolina	$3.23	$3.03