ESTIMATION OF ECONOMIC VALUE OF RECREATIONAL PRIVATE AND CHARTER BOAT FISHING IN SOUTHEAST ATLANTIC AND GULF OF MEXICO USING THE MEAN/MEDIAN OF COORDINATE OF RECREATIONAL SITES

by

MOHAMMAD REZA ZAREI

(Under the Direction of Craig Elliot Landry)

ABSTRACT

Travel cost is used as an auxiliary variable for the price of non-market goods and services. A major issue with this approach is how to calculate the travel distance accurately and decrease the measurement errors. In this study, we use the mean and median of the coordinates of fishing sites in the coastal counties along the Southeast Atlantic and the Gulf of Mexico, to measure the travel distance of alternative fishing sites and compare it to the conventional method using the mid-point of county-level sites. The willingness-to-pay (WTP) of charter and private/rental boat anglers for one additional catch on a day-trip for Dolphinfish, King Mackerel, and Red Snapper is estimated by nested logit model. Our results indicate that the conventional method overestimates the WTP of charter boat anglers for Dolphinfish and King Mackerel, and underestimates the WTP of private boat anglers for these species.

INDEX WORDS: Random utility models, travel cost, recreation demand, discrete choice model, non-market valuation, single species sports fishing demand.

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DEDICATION

I dedicate this thesis work to my wife, Raha, who has always encouraged, supported, and helped me to move forward in my graduate studies and life, and made my dreams come true despite all of the challenges.

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I would also acknowledge the help and guidance of my committee members, Dr. Bergstrom, and Dr. Shonkwiler. I am honored that they accepted to be my committee members. The knowledge and experience that I achieved by studying the prior research works, and in the classes of my committee members, significantly improved my ability to conduct this research.

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CHAPTER 1

INTRODUCTION

Problem Statement

Fish have been a well-known source of protein for centuries. Depending on the availability, price, taste, shape, odor, and texture of the flesh of fish different individuals prefer different species. Commercial fishing for years played an important role to provide this healthy food along with other seafood for households. On the other hand, recreational anglers also target salt water or stream water fish (either cold or warm water). In the US (NOAA 2011), 98 percent of all finfish species were captured by the commercial sector, and only 2 percent of them were caught by recreational anglers in 2011. As can be seen in Figure 1, the recreational sector's contribution to GDP (75%) is significantly more than commercial sector's contribution (25%), despite less share of the landed harvest. From the benefit-cost standpoint, it might seem justified to allocate more resources to the recreational sector that provide higher economic value.

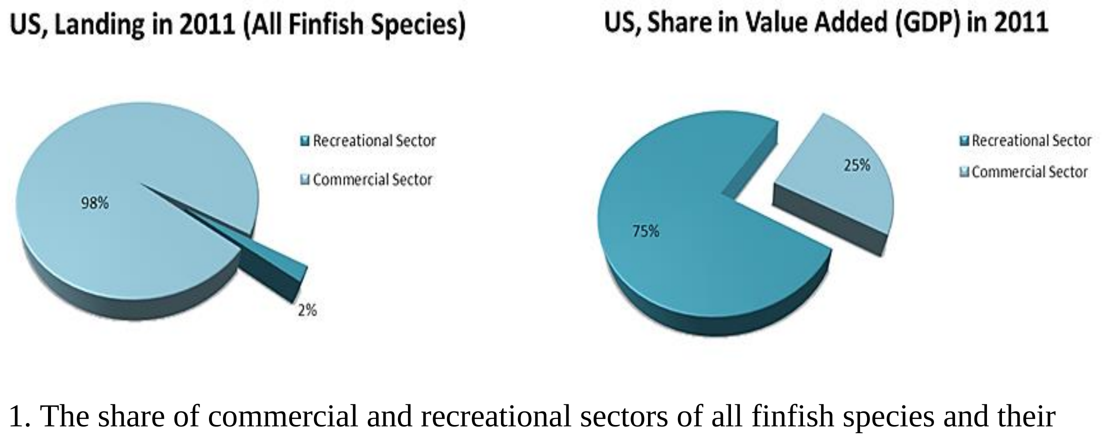

Figure 1. The share of commercial and recreational sectors of all finfish species and their contribution to GDP in 2011.

Economically and biologically sustainable levels of catch in marine fisheries require efficient and effective management strategies and policies. Fisheries managers change the allocations of the total allowable catch for the commercial and recreational sectors to protect overfished species that are appealing for recreational anglers and commercial fishermen. Top ten targeted species by recreational anglers are Striped Bass, Red Drum, Spotted Seatrout, Bluefish, Yellowfin Tuna, Red Snapper, Dolphinfish, Summer Flounder, Spanish Mackerel, and Mullets (NOAA 2011). Fishery management policies like bag limit, size limit, quota allocation, and fishery closure protect these renewable resources (Whitehead et al. 2011). The share of recreational and commercial sectors of the harvest of these species are shown in Figure 2. Commercial fishermen and recreational anglers harvest 20 percent and 80 percent of the total allowable catch of Dolphin fish, respectively. They roughly split the harvest of Red Snapper and King Mackerel. Red Drum and Striped Bass are caught mostly by recreational anglers.

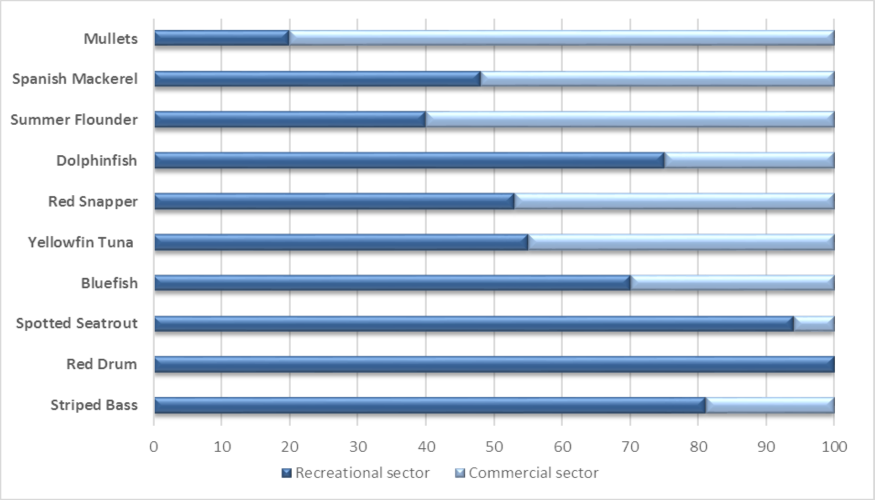

Figure 2. The share of recreational and commercial sectors of landed harvest of top ten targeted species by recreational anglers.

An efficient allocation equalizes the marginal value of catch of each species between leisure and commercial sectors (Agar and Carter 2014, Carter, Agar, and Waters 2008, Haab et al. 2012). To estimate the marginal value of catch for these species in recreational sector non-market valuation techniques, such as the discrete random utility model, are applied.

Study Area and Description of Current Services

In South East Atlantic area, including East part of Florida, Georgia, North and South Carolina states, over 48.5 million pounds of finfish were harvested by fishermen in the Commercial sector in 2011. From the 48.5 million pounds yield of the commercial industry, worth $60.2 million, including multiplier effects, resulted in $215.2 million in value-added (GDP) and supported 6,803 jobs, of which 37.5 million pounds were the harvest of species that were also appealing to recreational anglers. On the other hand, 35 million pounds were caught by recreational anglers, who spent $6.1 billion, supported 52,572 jobs and generated $3.0 billion in value-added (GDP) in 2011 (NOAA 2011). Figure 3 shows the share of commercial and recreational fishing sectors of landed harvest and their contribution to income and GDP of the US and Figure 4 illustrates the share of commercial and recreational fishing sectors of landed harvest and their contribution to income and GDP of Southeast Atlantic area, in 2011.

The catch of commercial fishermen in the Gulf of Mexico, from West Florida to Louisiana (excluding Texas), was 1.4 billion pounds and provided $186.5 million for the catch of species that were targeted by anglers. However, recreational anglers caught 74.8 million pounds, spent $9.8 billion, generated $494.0 billion in value-added (GDP), and supported 18,131 jobs. Figure 5, illustrates the share of commercial and recreational fishing sectors of landed harvest and their contribution to income and GDP of Gulf of Mexico area in 2011.

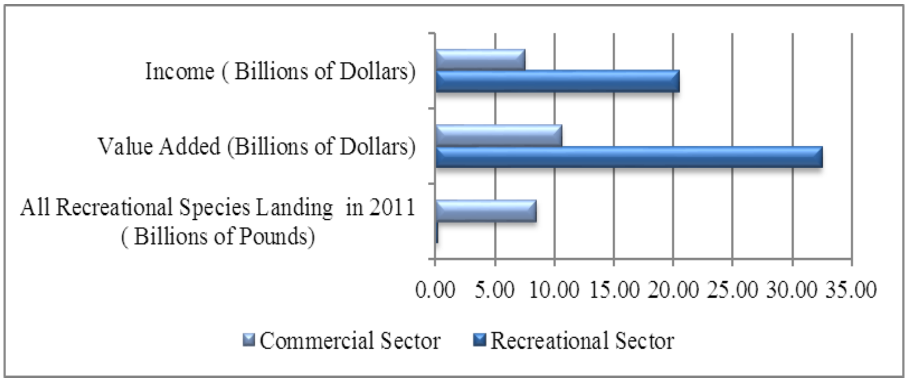

Figure 3. The share of commercial and recreational fishing sectors of landed harvest and their contribution to income and GDP of US in 2011.

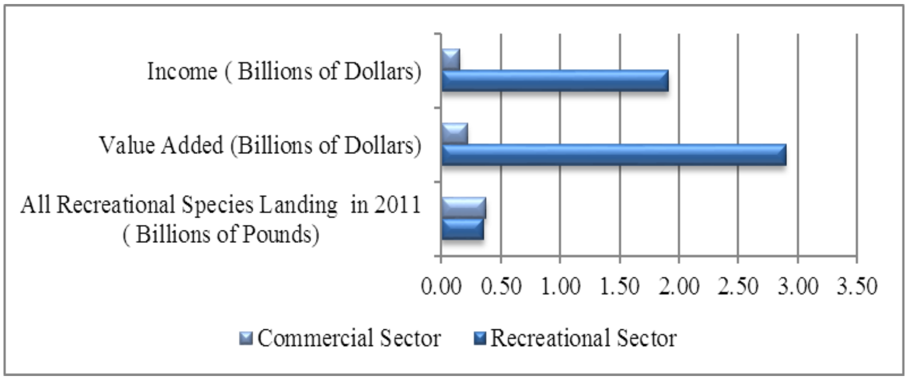

Figure 4. The share of commercial and recreational fishing sectors of landed harvest and their contribution to income and GDP of South East Atlantic area in 2011.

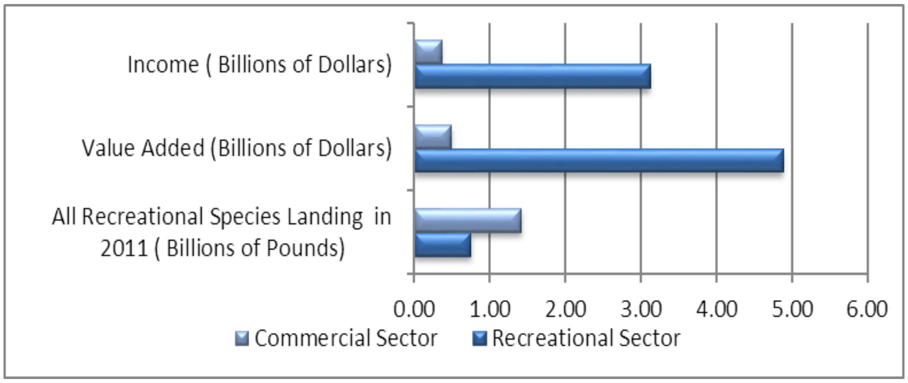

Figure 5. The share of commercial and recreational fishing sectors of the catch of finfish species, and their contribution to revenue and GDP of Gulf of Mexico area in 2011.

Specific Research Question and objectives

Random utility model is used to measure the economic value of some popular species, such as Dolphinfish, King Mackerel, Red Snapper and Grouper species (Agar and Carter 2014, Bockstael, McConnell, and Strand 1989, Carter, Agar, and Waters 2008, Gentner 2009, Haab et al. 2012). The marginal value of catch or marginal willingness to pay for an additional unit of the catch highly depends on how a researcher measures the quality of fishing sites and travel cost. Whenever a researcher has access to an intercepted dataset, measurement of travel distance between the zip code of interviewees and the recreational sites is done by using some tools like PC*Miler or Arc GIS (Desktop 2011). However, sometimes there is a lack of information for each site of interest or no historical catch rate for a specific species exists in fishing sites. Therefore, previous studies aggregated the available data over the counties to have enough observations (Whitehead, Haab, and Huang 2000, Hindsley, Landry, and Gentner 2011, Haab et al. 2012, Lovell and Carter 2014, Alvarez, 2014).

This aggregation method results in missing the actual destination. The mentioned studies have utilized the center or midpoint of each county or in some studies the closest city or zip code to a destination like a national park, river, or lake. This approach results in measurement error in calculating the distance, and consequently, the welfare measure (MWTP) might be far from the true value since the actual, recreational destination might be far from the midpoint of the county. For instance, Figure 6 shows the location of charter and private boat anglers' home zip code, intercepted sites, the midpoint of county, and mean/median of fishing sites for Dolphinfish in Carteret County, North Carolina. It can be seen that the intercepted sites and fishing locations are far from the midpoint of the county. Also, Figure 7 illustrates the distance between the midpoint and the median of coastal counties in the Gulf of Mexico and Southeast Atlantic area.

In this study, we contribute to previous studies by introducing a new method to calculate the travel cost for the alternative sites; that is utilizing the mean or median of the coordinates of available intercepted sites (NOAA - MRIP Site Register Data) for calculating the travel cost. This method addresses the issue of what the correct measure of distance for alternative sites is (Phaneuf and Smith 2005). We estimate the marginal willingness to pay of anglers for Dolphinfish, King Mackerel, and Red Snapper in South East Atlantic area and the Gulf of Mexico area. Three travel cost measures are calculated by a new STATA package (Huber and Rust 2015). The first measure is the distance from anglers' home zip code to the midpoint of the aggregated-over-county sites. The second measure uses the mean of the coordinates of fishing sites, and in the third one, the median of longitude and latitude of fishing sites in each county has been utilized. Moreover, we add a new dummy, Home County Fishing Site (HCFS), to take into account the effect of familiarity and ease of access of coastal county anglers. The final objective is to evaluate the sensitivity of the estimated marginal willingness to pay (MWTP), for one additional Dolphinfish, Red Snapper, and King Mackerel per day trip, to these measures of the alternative sites' distance.

In the next chapters of this thesis; some of the previous studies have been reviewed (Chapter 2), description of data and empirical methodology have been presented (Chapter 3), the results have been discussed (Chapter 4), and the conclusion has been provided (Chapter 5).

Figure 6. Illustration of anglers' home zip code, intercepted sites, midpoint of county, and mean/median of fishing sites in Carteret County, North Carolina for each fishing mode (Dolphinfish Model).

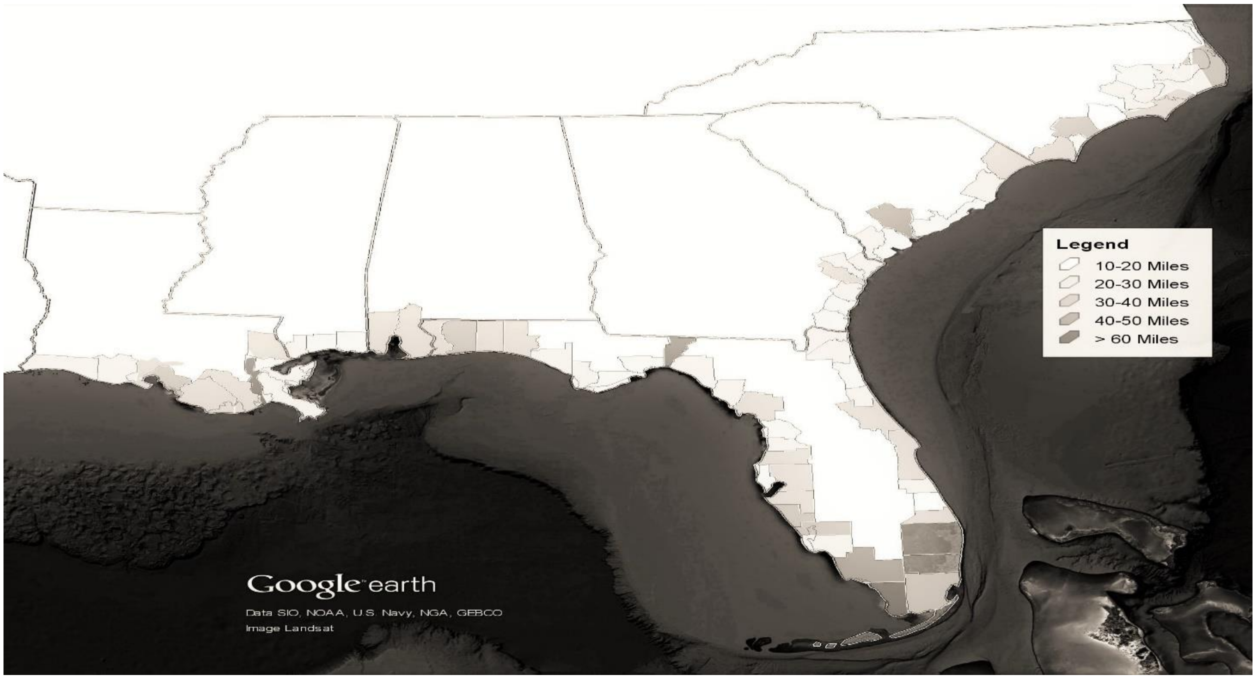

Figure 7. Illustration of the distance between the mid-point and the median of coastal counties in the Gulf of Mexico and Southeast Atlantic area.

CHAPTER 2

LITERATURE REVIEW

Background

Economic valuation of environmental good and services has been improved over the last five decades. The economic valuation techniques are used to estimate the value of climate change impacts (such as sea level rise), air pollution emissions, hazardous wastelands, and ecosystem services. Travel cost and random utility models are non-market valuation methodologies that are used for estimation of choice parameters and welfare measurements. These methods can be used to analyze the behavior and reaction of respondents to a change in law, or quality of a site (such as catch rate), or any related policy, for example, bag limits, size limits, or fishing closure in fishery management.

Contingent valuation and choice experiments are stated preference methods for estimating both a nonuse and use value of recreational sites, some particular species, or change in demand under hypothetical circumstances. These methods are practical in a situation when there is no revealed preference data, and respondents are untested with a proposed variation in quality or valuing the variations is the beyond the radius of revealed information (Whitehead, Haab, and Huang 2012). Contingent valuation has been criticized for validity and reliability of results (Venkatachalam 2004, Whitehead, Haab, and Huang 2012), which led to promising results by combining revealed and stated preference data (Whitehead et al. 2008). Choice studies provide some series of alternatives for responders in which different attributes are designed. In each choice, respondents trade off an amount of attributes with some other characteristics to maximize utility. Analysis of responses delivers the marginal value of attributes and reveals the most significant attributes (Chhun, Thorsnes, and Moller 2013).

On the other hand, in revealed preference methods, such as travel cost model and random utility models, subjects are users, and thus only use-value is estimated. By assessing the travel expenses that anglers incur, the travel cost method indirectly approximates the demand for a recreational angling activity. TCM is a standard tool for estimating a recreation site demand especially for estimating the demand for long distant visitors. Most studies are either based on aggregated data or individual data. According to the distance that people travel to reach a recreation site, aggregate data approach divides the people into groups (zonal travel cost) (Hellerstein 1991).

In the individual data approach, each visit is an observation with a trip cost. The random utility model is an applicable tool for predicting the probability of visiting a recreational site. This method considers the decision made by individuals on traveling to multiple sites with differing attributes. The simple random utility model was based on an unrealistic assumption that alternative recreation activities are independent. Nested, repeated choice, and sequential choice models were developed to tackle this problem, but they were can still be restrictive. Train developed a flexible random parameter multinomial limited dependent variable model (Train 1998, Hensher and Greene 2003). Larson and Lew (2014) assume the opportunity cost of time as a portion of wage rate does not embody per unit leisure values, and if for an individual recreation value is more than the fraction of wage then the model underestimates the value. Also, this method fails to consider the pleasure of driving, and incentive of adventuring. Other factors that should be considered are homogeneous preferences in aggregate groups, multipurpose respondent, lack of consideration of a change in technology and preference of users over time.

Recreation Demand Models

The idea of recreation demand model using travel cost was introduced by Harold Hotelling (Hotelling 1947). One of the first travel cost studies used zonal data for lake recreational activities conducted by (Burt and Brewer 1971). The Random utility model (RUM) was first introduced for the public transportation choice models (McFadden 1974, 1978). One of the first application of random utility model for recreation demand was conducted by (Hanemann 1978, 1984, 1985). Other variants of recreation demand include single site model and Kuhn-Tucker system of demand equations (Binkley and Hanemann 1978, Wales and Woodland 1983, Bockstael, Hanemann, and Strand 1986).

Recreation demand models are utilized to analyze the demand for sports fishing, beach recreation, hunting, salt-water fishing, hiking, wilderness use, rock climbing, wildlife viewing, skiing, cross country, and so on (Phaneuf and Smith 2005). Recreation demand models estimate the value that individuals obtain from a recreational activity and the impact of various factors on their decision. For example, recreational angling data is used to estimate demand for sports fishing and measure the value that people are willing to pay or incur to have some specific kind of fish instead of spending their budget and recreational time on other commodities and services that provide less utility (Brownstone and Train 1998). The value associated with the change of quality of fishing sites can be measured by willingness to pay (WTP) as the theoretically appropriate welfare measure for public policy evaluation. WTP represents what an individual is willing to give up income for access to and use of a resource or commodity (Brookshire, Ives, and Schulze 1976, Bergstrom and Randall 2010).

Random Utility Model

The application of random utility model (RUM) (McFadden 1974, 1978) for the estimation of the economic value of recreational fishing is based on the assumption that anglers choose the recreational destination that provides greater satisfaction or utility, and as a result highest net economic value (Haab et al. 2012). In this model, the implicit cost of travel to a recreational site is used as a proxy for the time and money that anglers spend to visit a recreational site. Angler k chooses the site j if the utility from this site is greater than the utility from all substitute sites:

$$\mathrm{U_{ji}} > \mathrm{U_{hi}} \ \text{ for h} \neq \text{j and h} = 1, .. \mathrm{J} \qquad (1)$$

where:

U_{ji} = utility of visiting site j for angler i;

U_{hi} = utility of visiting a substitute site h for angler i; and

J = the total number of available sites in the angler's choice set.

In the RUM the probability of selecting a particular site is a function of the site attributes, catch rates, and the travel costs to the site:

$$\mathrm{Prob_{(j)}} = \mathrm{f}\,(\text{Catch rate}, \text{Site} - \text{specific characteristics}, \text{travel cost}) \qquad (2)$$

The RUM model, each angler's utility has a deterministic component (v_j) and a random element (ε_j) in that is not observable by the researcher:

$$\mathrm{U_{ji}} = \mathrm{v_{ji}} + \varepsilon_j \qquad (3)$$

where:

U_{ji} = utility of visiting site j for angler (i);

v_{ji} = the observable component of utility; and

ε_j = the random, or unobservable component.

Anglers choose the fishing mode, targeted species, and fishing sites that provide the highest utility for them (Haab et al. 2012). Lower cost and higher quality provide greater service for angler:

$$U_{i,j} = V\,(y_i - c_{i,j}\,, q_{i,j}) + \varepsilon_{i,j} \tag{4}$$

Where y is the budget for the trip; c is the travel cost plus opportunity cost, and q is a measure of the quality of the site. Assuming that the error terms are Type-I extreme value, conditional logit model estimates the probability of the chosen site as:

$$\text{Prob (j)} = \frac{e^{v_j}}{\sum_{h=1}^{J} e^{v_h}} \tag{5}$$

A major problem of conditional logit is the assumption of Independence of Irrelevant Alternatives (IIA) (Ben-Akiva and Lerman 1985). IIA property implies that the relative probability of choosing between recreational sites remain constant even if a perfect substitute is introduced (Haab and McConnell 2002). Therefore, nested logit model which relaxes IIA property across nests, but keep it within nests, is more appropriate in some instances (Petrin and Train 2003). In a nested logit, having one upper-level nest and a lower level nest, an angler chooses among M species-mode nests, $m = 1 \ldots M$. In each nest there are J_M sites, $j = 1 \ldots J_M$. If the error term is distributed as a generalized extreme value, the probability of selecting a species and location in the nested logit model is given by:

$$\text{Prob (j, m)} = \frac{e^{v_{jm}/\theta_m}\left[\sum_{l=1}^{J_m} e^{v_{lm}/\theta_m}\right]^{\theta_m - 1}}{\sum_{m=1}^{M}\left[\sum_{j=1}^{J_m} e^{v_{lm}/\theta_m}\right]^{\theta_m}} \tag{6}$$

In Equation (6), the product of the utility from choosing nest m and site j, and the summation of the all the utilities of each nest's sites, is divided by utility of all site and nests (Whitehead

2013). The similarity of locations in each nest is measured by dissimilarity parameter, $0 \leq \theta \leq 1$. If the dissimilarity parameter (θ) is equal to one, nested logit and conditional logit results are the same (Haab et al. 2012).

Addressing Econometric Problems

Hellerstein and Mendelsohn (1993) derive the relationship between site choice and aggregate demand for recreation trips. They point out that there is no theoretical base for count data and present the restricted choice model and the repeated discrete choice model for count data in welfare analysis. They define the Poisson distribution for nonnegative integer numbers which is a single parameter distribution (λ), and the estimation of a Poisson model by revealed preference data on demand for example trips to a recreational site gives coefficient estimates which can be used to compute the values of $\lambda = \exp(XB)$. They conclude that when count data models for estimating trip demand are utilized, expectation of consumer surplus can be computed by integrating under the expected value of demand. Moreover, assuming that demand at any given price follows Poisson distribution, yields the equality of λ to expected value of demand.

The repeated discrete choice model can be used to represent count models as well. This method assumes that an individual makes a binary choice at every repeated interval to consume or not. That is, an angler can choose to go on a fishing trip or to engage in some other activities. Moreover, they conclude that taking the integral of the price over λ (P, Y) (Poisson parameter that is a function of price and income) is a consistent approximation of the compensating variation. Also, when the price goes to infinity expected value of consumer surplus is equal to $E[CE] = \lambda/B_P$ like restricted choice model. Haab and McConnell (1996) introduce a random error term into the traditional count model demand function and derive a better measure for expected consumer surplus. Shonkwiler and Shaw (1996) suggest Double-Hurdle Poisson model and derive a zero-modified Poisson model.

The travel cost method is utilized to value stocked Steelhead in Ohio tributaries around Lake Erie (Kelch et al. 2006). They use a steelhead angler intercept survey in fall, winter, and spring of 2002–2003. The number of trips, angler experience, hours of fishing per trip, and type of tackle are the explanatory variables that positively relate to the catch rate. The estimated value that participated anglers were willing to pay for steelhead angling experience ranged from $36 to $46 per trip. This study provides information on attitude and fishing behavior of steelhead anglers in Ohio. The information provided about the benefits of a fishery in coastal areas is very critical for making policy on stocking, public access, and water quality that improve angling. This study is an example of using intercept survey data. They faced two common statistical biases, truncation at zero trips and endogenous stratification, in their study. The latter happens because the people who responded were more avid anglers than the entire population of steelhead fishers. To address these problems, they applied the Haab and Mc-Connell (2002) correction.

Another study, Hindsley, Landry, and Gentner (2011) addressed avidity bias and endogenous stratification of onsite sampling in a discrete choice context. Not addressing these biases results in overestimated willingness to pay of anglers for improvement in quality. They combine Weighted Exogenous Stratification Maximum Likelihood estimation and propensity score estimation to attenuate these biases. The log-likelihood function of WESML estimation, which is a pseudo maximum likelihood approach, is given by

$$\mathrm{LL}(\beta) = \sum_{s=1}^{S} \sum_{x} \sum_{j} \mathrm{n}(j, x|s)\ \mathrm{w}(j, x, s) \ln \mathrm{P}(j|x, \beta), \tag{7}$$

In this function, the angler population is segmented into strata $(s = 1, \dots, S)$, $n(j, x|s)$ is the number of observations in stratum s with observed variables (j, x), $w(j, x, s)$ is the weight, and $P(j|x, \beta)$ is the conditional probability that individual i chooses site j conditional on site attributes x and model parameters β. The weight $w(j, x, s)$ is an inverse probability weight (IPW) and is given by:

$$w(j, x, s) = Q_s(j, x)/H_s\,(j, x) \qquad (8)$$

Where, $Q_s(j, x)$ is the joint probability of site choice and attributes within given strata for the population, and $H_s(j, x)$ is the joint probability of site choice and attributes within given strata for the sample. They found that propensity score based weights are a useful method in tackling biases in estimation. However, the variance of estimated parameters and willing to pay are higher.

Kuriyama, Hilger, and Hanemann (2013) study the issue of using datasets that are primarily designed for resource management in recreational demand models. Since these data sets are not generated by random sampling, estimation can address the problem by using some weight based on the provided information of sampling effort. Blaine et al. (2015) examine the four top causes of the sensitivity of consumer surplus estimates in Travel Cost Method (TCM). In other words, they studied four issues in the application of TCM to estimate consumer surplus associated with recreational use of an environmental amenity. The comparison of Poisson and negative binomial estimation, endogenous stratification, and elimination of outliers using truncation of the data set as cases of sensitivity have been addressed in the travel cost model studies. However, the fourth issue that they addressed, the potential effect of the interaction between income and travel cost on recreation demand, has not been scrutinized.

They compared the four factors by analyzing the impact of each of them on regression parameters and consumer surplus estimates. Their results showed that truncation effect on parameters estimated from Poisson model was considerable. Entering an income-travel cost interaction parameter in Poisson and negative binomial models results in a more conservative estimate of consumer surplus, but the difference was not meaningful and produced a larger confidence interval.

The results of Blaine et al. (2015) indicate that the application of Englin's correction, income-travel cost interaction, and the truncation modified models of Poisson and the Negative Binomial are the most cautious estimates of consumer surplus, and there was no statistical difference between estimates of Poisson and the negative binomial models. Also, use of income-travel cost interaction term indicated that for travelers, for whom the cost of travel is small, traveling is an inferior good and for others that incur high expenses traveling is an ordinary good.

Assessing Opportunity Cost of Time

Conventionally, travelers' opportunity costs of time have been calculated as some function of wage rate (McConnell and Strand 1981). Some studies just consider a fixed value like minimum wage (Smith and Kaoru 1990, Parsons and Hauber 1998, Hindsley, Landry, and Gentner 2011), whereas other used one-third of individual wage rate per hour (Phaneuf, Kling, and Herriges 2000, Eom and Larson 2006, Landry and Liu 2009, Kuriyama, Hanemann, and Hilger 2010, Alvarez et al. 2014). This approach has been controversial in the literature (Smith, Desvousges, and McGivney 1983, Feather and Shaw 1999, Bockstael, Strand, and Hanemann 1987).

In a more generic model Shonkwiler and Englin hypothesize that the true opportunity cost for an individual is unobservable. They estimated a latent variable on travel time, converted distance to money (double distance/a dollar value per mile) travel cost, and wage loss (Englin and Shonkwiler 1995b). They assumed the error term is independent of travel demand and used factor analysis to estimate travel cost. By applying this approach, a researcher can use other factors such as demographic characteristics that might have an effect on travel cost in the estimation of the trip cost. However, the estimate of opportunity cost in this method is almost one-third of wage rate. Another approach is to use a shadow wage by asking some question of respondents regarding their ability to work for additional hours or if they can choose their working hours (Feather and Shaw 1999). This method is also roughly consistent with conventional approach since the shadow values are consistent with market wage rate.

In a recent study (McKean, Johnson, and Taylor 2012), authors claim that although most studies use the traditional approach, it is based more on convention than strong theoretical foundation. In traditional models, wage rates are exogenous, and wage rate is adjusted downward for labor market imperfections. The full price of a recreation trip is the sum of out-of-pocket travel cost (TC) and the time required for a journey (t) valued at the opportunity cost of time which is the wage rate (W) adjusted downward for labor market imperfections (k). In a traditional TCM (Equation (9)) $(\mathrm{TC} + \mathrm{kW\tau})$ is full price, $(\mathrm{I} + \mathrm{kWF})$ is the consumer’s annual total income, S includes all other demand shift variables), free time valued at the wage rate adjusted for underemployment caused by labor market imperfections (F).

$$Q_a = trips\ per\ year = a_0 + a_1(TC + kWt) + a_2(I + kWF) + \sum a_i S_i \tag{9}$$

This quasi-neoclassical construct ignores the distinction between the long-run labor market and household investment decisions, and short-run consumption decisions. They suggest a two-step decision model with an endogenous time value. This method, contrary to the traditional model, does not equilibrate in a short run and considers the decisions that are made in the short term and long term separately. In this model, the opportunity cost of time is endogenous and is based on the assumption that a consumer at step one considers the long-run trade-off between labor and leisure and in step two, allocates the rest of time and income to the other individual goods.

Larson and Lew (2013) develop the rationale behind utilizing a wage fraction as the opportunity cost of travel time under the assumption of labor market equilibrium and disequilibrium. Under the prior assumptions, an individual maximizes utility by choosing labor supply h (free choice of work hours). The derived opportunity cost of time $\mathrm{P_r}$ is presented by

$$\mathrm{P_r} = \mathrm{w} + \frac{\mathrm{U_h}}{\lambda} - \frac{\mathrm{U_{T_r}}}{\lambda} \tag{10}$$

Where the opportunity cost of time is equal to the summation of wage (w) and the difference in marginal monetized utility/disutility of working ($\frac{\mathrm{U_h}}{\lambda}$) and recreation travel ($\frac{\mathrm{U_{T_r}}}{\lambda}$). When an individual prefers to work $\frac{\mathrm{U_h}}{\lambda}$ is greater than zero, his or her opportunity cost of recreation travel is higher, and whenever an individual prefers recreational visit his/her opportunity cost is lower. Assuming that the marginal values of work time ($\mathrm{d_1}$) and recreation travel ($\mathrm{d_2}$) are constant, recreation travel can be given by:

$$\mathrm{P_r} = \mathrm{w} \cdot \left(1 + \frac{\mathrm{d_1}}{\mathrm{w}} - \frac{\mathrm{d_2}}{\mathrm{w}}\right) = \mathrm{k} \cdot \mathrm{w} \tag{11}$$

Where K is the wage fraction [k =$\left(1 + \frac{\mathrm{d_1}}{\mathrm{w}} - \frac{\mathrm{d_2}}{\mathrm{w}}\right)$]. Under the assumption of labor market disequilibrium, workers have a work hour constraint. That is, workers have to work less than or more than the amount that they would like to, or even be out of labor market. Opportunity cost is presented by:

$$P_r = \mathrm{k} \cdot \mathrm{w} + \mathrm{u} \tag{12}$$

In which, u is a zero-centered random error equal to marginal value of working $\frac{\varphi_\mathrm{h}}{\lambda}$. The marginal value of working is less than zero for over employed workers, more than zero for underemployed workers. For unemployed people, it can be either greater or less than zero. Random error stands for unobservable factors when there no information about the labor market of respondents. They presented an individual-specific version for opportunity cost function in which k_i and u_i vary randomly in the population.

$$P_{r,i} = k_i \cdot w_i + u_i \tag{13}$$

Where, k_i is a function of demographics or other explanatory variables. Considering that the random wage fraction k_i is summation of the mean wage fraction and a random error, the opportunity cost function takes the following construction:

$$k_i = \bar{k} + \vartheta_i \tag{14}$$

$$P_{r,i} = \bar{k} \cdot w_i + \epsilon_i \tag{15}$$

In Equation 14 and 15, $\bar{k}$ is the mean wage fraction, ϑ_i is a zero-centered error, and $\epsilon_i = w_i \cdot \vartheta_i + u_i$.

All in all, whenever the assumption is that the marginal utility of working and the marginal utility of recreation travel vary among the respondents in a sample, the noisy wage fraction method takes the value of the mean wage fraction. However, it is not easy to have a dataset without missing values for labor market variable, whether the respondent is employed or not, wage rate, income and other critical variables for considering the mentioned methods, even after a perfect survey design. Therefore, the traditional estimation for opportunity cost is often the only available approach for applied researchers.

Defining Recreation Sites

An angler can choose a destination like a river, stream, lake, beach, or ocean, then choose a specific species to target or vice versa. The assumptions used to define the choice process are vital. Whether an angler targets a species or just goes fishing with no specific target in mind can critically affect the model results and welfare measures. For example, Parsons and Hauber (1998) address the issue of how spatial boundaries in the choice set can influence the welfare measure of the random utility model. This study argues that defining all sites that take 45 minutes, one hour or four hours one way can dramatically change the number of places in a discrete choice random utility model. They estimate a nested logit, in which the first level is the different sites in a spatial boundary and the second level is the choice amongst three species. Three factors including species abundance, species preference, and water quality are considered as independent variables affecting conditional utility. The results of their study show that there is no significant change in welfare estimate in a model with spatial boundaries of one way one hour with the model of four hours one way.

In another study, Whitehead and Haab (1999) investigate the effect of distance on welfare measure of Southeast marine recreational fishing for small game, big game, flat, and bottom species. They considered four categories of distance for defining the choice set: 180, 240, 300, and 360 miles. Their results also show that spatial boundaries do not affect the welfare measures. However, some studies argue that the distance can have an impact on the intention of respondents. For instance, recreationists that travel past a particular threshold may not be making a single purpose trip. Therefore, some spatial boundaries need to be set to control the issue of multipurpose trips (Gentner 2009, Haab et al. 2012).

In the studies of fishery management in Southeast Atlantic and The Gulf of Mexico, it is conventional to eliminate (Parsons and Needelman 1992) or aggregate sites (Lupi and Feather 1998) to address computational power issues and lack of data on catch rates. Whitehead and Haab (1999) use catch rates to eliminate the unimportant or unproductive sites from the choice set. Some studies aggregate based on a historical catch over the county (Whitehead, Haab, and Huang 2000, Hindsley, Landry, and Gentner 2011, Haab et al. 2012, Lovell and Carter 2014). Alvarez et al. (2014) extend the aggregation of the catch of all species of fish over the states of North Carolina, South Carolina, West Florida, East Florida, Northeast Florida, Alabama, Mississipi, and Louisiana to estimate the loss of recreational fishing caused by Deepwater Horizon oil spill.

Impact of Fish Species

In studies of catch and release fisheries mostly stated and revealed preference data are used. Wallmo and Gentner (2008) hypothesize that fish species has a significant effect on release decision. Using a binary discrete choice model, they examine the role of species type, angler characteristics, and demographic variables in the individual release decision. The study indicates that prediction of the future catch and release decisions needs comprehensive information about the angler population.

The comparison of stated data with revealed data shows that stated preference data can be considered as a useful tool to predict what anglers do in a real situation in 74% of the cases. More importantly, their results indicate that fish species is a significant factor affecting the release decision of anglers in the stated preference model and model prediction success.

Finally, personal and situational characteristics of anglers such as conservation ethic, enjoyment of catch-and-release fishing, supporting limits on the catch, and dependency on the fish as a food source were significant in explaining release behavior.

Most of the saltwater fishing studies consider species aggregations like big game, small game, flat, or bottom (Bockstael, McConnell, and Strand 1989, Navrud and Mungatana 1994, Whitehead and Haab 1999, Hicks et al. 1999, Whitehead, Haab, and Huang 2000). Gentner (2009) studies the allocation of Red Grouper in the Gulf of Mexico. Haab et al. (2012) estimate species-specific demand models for Dolphinfish, Red Snapper, Spanish Mackerel and Red Drum using 2000 Marine Recreational Fisheries Statistics Survey (MRFSS) data. They point out that the MRFSS data has a limitation for few species-specific recreation demand models and conclude that recreational values in single-species models are better than multiple-species models.

Measuring the Quality of Recreation Site

Measuring the quality of recreational sites has been discussed in the literature. An average number of caught fish at each site, mean catch per angler by species group, total catch rate, and total species biomass are some of the measures that previous studies have applied (McConnell, Strand, and Blake-Hedges 1995, Melstrom et al. 2015). Other studies use the expected catch at each site for each species as a measure of the quality of fishing sites. McConnell, Strand, and Blake-Hedges (1995) estimate Poisson models for predicting the catch rate at each site for the small game group using historical catch rate, the natural logarithm of hours fished and years of fishing as the explanatory variables. Whitehead and Haab (1999) regressed catch and keep rate per day trip on two monthly waves dummies; historical catch rate; a dummy variable for boat ownership; and years of fishing for small game, big game, flat fish, and bottom fish species to predict the catch rate for each angler at each fishing site. Gentner (2009) uses the 2006 MRFSS data and estimates a Negative Binomial model to predict the catch rate of Gag and Red Grouper. In his model, historical catch rate, the number of fishing trips in the last two months, and dummy variables for charter mode and two-monthly wave (Sep & Oct) were explanatory variables.

Haab et al. (2012) use five-year average historical catch and keep rate per day for King Mackerel, Spanish Mackerel, Small game group, Red Snapper, Dolphinfish, Big game group, and grouper group for each fishing mode (charter boat, Private/rental boat, and shore) and wave for each site. Lovell and Carter (2014) also used the five-year average historical catch and kept rate per day (2004-2008) to estimate the economic value of Red Snapper in the Gulf of Mexico. Prediction of the expected catch and keep rate for a specific species requires a rich dataset. For the MRFSS data, and its new version MRIP data (provided by Marine Recreational Information Program), there are a significant amount of missing values for single species.

Welfare Measurement

In analyzing welfare measures a utility function is specified:

$$v_{ni}(y - c_{ni}, q_{ni}) = a(y - c_{ni}) + \beta' q_{ni} = -ac_{ni} + \beta' q_{ni} \qquad (16)$$

Where y is budget, a is the marginal utility of income, c_{ni} is travel cost to sites, and q_{ni} is the quality of site. $a \cdot y$ has been dropped since it is a constant term and has no effect on utility (Haab et al. 2012). Product of the natural log of the summation of the nest site choice services measure the inclusive value, IV in nested logit:

$$IV(c,q;a,\beta) = ln\left(\sum_{m=1}^{M}\left[\sum_{j=1}^{J_m} e^{(-ac_{mj}+\beta\prime q_{mj})/\theta}\right]^{\theta}\right) \tag{17}$$

welfare change from a change in the quality of the site is (Hanemann 1996):

$$WTP = \frac{IV(c,q;a,\beta) - IV(c,q+\Delta q;a,\beta)}{a} \tag{18}$$

Where WTP is the appropriate measure of welfare (compensation variation). Haab and McConnell (2002) show that the WTP, compensation variation, for a quality change can be measured as:

$$CV = WTP(\Delta q|nj) = \frac{\beta_q \Delta q}{a} \tag{19}$$

The total value of a change in catch rate is measured as (Carter, Agar, and Waters 2008):

$$\mathrm{TEV=N*X*WTP} \tag{20}$$

where: TEV = total economic value; N = the number of anglers; X = the number of trips of each angler; and WTP = value of money that each angler is willing to pay for quality improvement of a fishing trip.

Policy Applications

Policy applications of travel cost and random utility models can be categorized for resource management (Whitehead et al. 2011, Carter, Agar, and Waters 2008, Whitehead 2013), damage assessment (Desvousges, Smith, and McGivney 1983, Poor and Breece 2006, Alvarez et al. 2014) and project evaluations (Loomis 2002, Brown et al. 2009). Random utility models have mostly used for some regional evaluations or site specific policies. For instance, the effects of acid rain on recreational fishing (Morey and Shaw 1990) and losses of recreational fisheries as a result of Deepwater Horizon oil spill in the Gulf of Mexico (Alvarez et al. 2014). Most relevant policies to fishery management are imposing quota allocation, size limit, bag limit, site closure, and harvest moratorium to avoid overfishing of some endangered species (Whitehead et al. 2011, Shideler et al. 2015).

Poor and Breece (2006) study the reaction of charter boat anglers to a change in water quality and estimate welfare measures for charter fishing participants by a contingent behavior model. They use a truncated Poisson model modified for endogenous stratification and realized that charter fishers have a significant role in improving the local market economy, and they also are more willing to pay more for fishing when the water quality is higher. A joint revealed and stated preference model for measuring the cost of bag limits that anglers on charter boats are willing to pay was conducted by Whitehead et al. (2011). Marginal cost and marginal willingness to pay were considered as increased fee and willingness to pay for charter trips, respectively. In the choice model, *y* was the number of charter boat trips and *x* was a vector of Independent variables. Revealed and stated preference models are given by:

$$y_r = a_r + \beta_r' x_r + \varepsilon_r \tag{21}$$

$$y_s = a_s + \beta_s' x_s + \varepsilon_s \tag{22}$$

Where a and β are coefficients, ε is the error term, and r, s stands for revealed and stated preference data. The estimated willingness to pay of each angler per trip was $273. Also, they estimated that anglers were willing to pay $10 to avoid a one-fish reduction in the snapper-grouper bag limit. Anglers would be willing to pay $80 to prevent the decrease of the snapper-grouper bag limit from 15 to 7 fish.

Pascoe et al. (2014) address the claims of commercial and recreational fishers regarding the substantial loss in economic benefit due to loss of fishing ground as a result of increases in the area of Moreton Bay Marine Park from 0.5 to 16 percent of Bay area. The commercial sector was compensated, but recreational sector was not. They use the travel cost method to estimate the effect of Marine Park rezoning on the recreational sector. They follow all conventional methods and show that the recreational fishing benefit increased with a confidence interval of 1.3 million to 2.5 million a year. They justify their result by stating that commercial and recreational sector did not compete for the same space. The business sector was more interested in prawns, crabs, and Moreton Bay Bugs while recreational sector focused mostly on finfish species. So more finfish would be caught with removing the trawl fishing efforts in the commercial sector, and more benefit goes to recreational sector compare to any loss from the increase in the area of no-take zones.

Measurement of Travel Cost

Travel cost is an auxiliary variable for the price of non-market goods and services (Champ, Boyle, and Brown 2012). The cost of a recreational trip can be categorized by travel cost, access fee, equipment cost, and time cost. Operating cost per mile for an average sedan car is 14.72 cents in 2016, provided by American Automobile Association. Some equipment cost in recreational fishing is a rod, bait, tackle, boat cost, to say a few. If an angler has a boat or rent a boat, the cost of using the boat or rent should be imputed, and if an angler uses a charter boat, the cost is a fee.

In most studies, the cost of equipment is ignored or keep the same in the sample, for example, all anglers that use rod are kept (Agar and Carter 2014, Gentner 2009, Haab et al. 2012, Whitehead 2013). Time cost usually considered as a fraction of wage rate. For the respondents that have a fixed hours of work (40-48 hours) and cannot trade off the time of leisure and work like retired, or unemployed people, annual income is divided by 2000-2080 to get the wage rate per hour. The general formula for calculation of travel cost is given by(Champ, Boyle, and Brown 2012):

$$p_i = \left\{ \left(\gamma \cdot \left(\frac{y_i}{2040} \right) \cdot t_i \right) + (c_i \cdot d_i) \right\} + fee_i + other_i \qquad (23)$$

In which, t is travel time, y is annual income, γ is a constant number equal to one-third, c is cost per mile, fee is site access fee, other is for other fees such as charter fee or rental fee.

CHAPTER 3

METHODS AND DATA ANALYSIS

Data Description and Methodology

We use the Marine Recreational Information Program (MRIP) catch and effort intercept data (South Atlantic and Gulf of Mexico intercept data[1]). The NMFS[2] uses MRFSS[3] to gather information of anglers characteristics, the number of trips and caught fish. MRIP data is the new version of MRFSS and have advantages such as sampling during all 24 hours; interviewer does not have permission to change the assigned site, and better stratification weights are available. Also, NMFS created a registered site dataset (NOAA) that provides the attributes of the fishing sites in coastal counties. However, endogenous stratification, and avidity bias, due to nature of the on-site survey, are the issue of using MRIP data. Hindsley, Landry, and Gentner (2011) address this issue by using two empirical methods in a conditional logit model, and pointed out that neglecting these features of data may result in overestimated WTP. In this study, our focus is on a with-in sample comparison of estimated measures of welfare (WTP), and in this context our evaluations are valid. However, for policy applications, our estimates should be corrected for avidity bias.

The 2009 MRIP data is used with a focus on private/rental boat anglers and for-hire boat anglers (party/charter). In the 2009 MRIP data, there are 45,658 anglers interviewed from North

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[1] Texas does not participate in Marine Recreational Information Program
[2] National Marine Fisheries Service
[3] Marin Recreational Fisheries Statistics Survey

Carolina to Louisiana (Figure 8 shows the study area). Thirty-eight percent of these anglers have missing values for targeted species. We kept the anglers who used hook-and-line (less than one percent of anglers use other gears of fishing). Dolphinfish, King Mackerel, Red Snapper (Figure 9) are important species for fishery management (Haab et al. 2012). Therefore, only anglers that have a primary target species are used in Dolphinfish, King Mackerel, and Red Snapper datasets (Table 1). Five years average historical catch rate (per day trip) for each (two-month) wave, fishing mode (private/rental boat and charter boat), and targetted species per site, is the measure of the quality of the site for King Mackerel, Dolphinfish, and Red Snapper. We exclude all of the anglers that live more than 200 miles from the nearest site to control for multipurpose trips. Distance from anglers' home zip code to the intercepted fishing sites and the alternative county level sites are calculated with Open Street Map Data using the Open Source Routing Machine (OSRM) (Huber and Rust 2015).

We use the mean or median of the coordinates of available intercepted sites (NOAA - MRIP Site Register Data) for calculating the travel distance to the alternative county level sites. We calculate three travel distance measures. The first one, conventional approach, is the distance from anglers' home zip code to the midpoint of county-level sites (Method 1). The second and third measures use the mean (Method 2) and median (Method 3) of the coordinates of fishing locations in each county level site, respectively. Round trip distance valued at \$0.59 cost per mile according to standard business mileage rate for 2009 per mile).Travel time (t) is measured by dividing the travel distance by an assumed 40 miles per hour for travel (Haab, Hicks, and Whitehead 2005). Travel costs (TC) are calculated by

$$\mathrm{TC} = ((2 * \mathrm{Distance}) * 0.59) + (1/3 * (\mathrm{MHHI}/2000) * \mathrm{t}) \tag{24}$$

In which, MHHI is the median of household income in each county.

We add an average charter boat fee $130 (adjusted by the price index for 2009) to the travel cost of charter boat anglers (Haab et al. 2012). The natural log of the number of fishing locations in each county is also included in the models to mitigate site aggregation bias (Parsons and Needelman 1992).

For the purpose of this study, which measures the changes in economic value that a change in conditions of a single species causes, assuming that each angler chooses mode of fishing (private boat, and party/charter), targeted species and a recreation site, we develop species-specific models for Dolphinfish, King Mackerel, and Red Snapper. Moreover, we evaluate the sensitivity of the estimated marginal willingness to pay (MWTP), for one additional Dolphinfish, King Mackerel, or Red Snapper, to the measures of travel cost. Furthermore, we use a dummy, Home County Fishing Site (HCFS), for chosen sites as a proxy for other factors such as home county bias, or private boat dock that are not accounted in the survey. HCFS is equal to one if an angler chooses his/her home county and it is equal to zero, otherwise.

Dolphinfish and aggregate big game species group[4] (substitute for Dolphinfish) are the targeted species in the Dolphinfish model. There are 1055 and 516 anglers that target Dolphinfish and Big game species, respectively, in the Dolphinfish model. In this model, we focus on the Dolphinfish and big game boat trips in the southeast Atlantic area. Trips taken from Monroe County (the Gulf of Mexico area) are also included, which result in 22 county level fishing sites. Some county/species alternative have missing values, which results in 60 alternatives.

Anglers choose among two fishing modes and two targets. There are four mode/species alternatives in the model (Figure 10). In the charter mode alternatives: 8% (n = 127) of all

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[4] Atlantic Tarpon, Billfish Family, Black fin Tuna, Cobia, Little Tunny, Requiem Shark, Sailfish, Sea Bass Family, Swordfish, Tripletail, Tuna Genus, Unidentified (Sharks), Wahoo, and Yellowfin Tuna

anglers target Dolphinfish and choose among seven county-level sites, and 9% (n = 138) target big game and choose among ten county-level sites. In the private/rental boat alternatives: 59% (n = 928) of all anglers target Dolphinfish and choose among 18 fishing sites, 24% (n = 856) target big game and choose among 25 sites. Overall 1571 trips and 60 alternatives result in 94,260 cases.

In total, seventy-six percent of trips take place in Florida, 1% in Georgia, 20% in North Carolina, and 3% in South Carolina (Figure 11). The location of home zip code, intercepted sites, the midpoint of each county, and mean/median of fishing sites in North Carolina, the east coastline of Florida, and south of Florida for each fishing mode are shown in Figure 12, Figure 13, and Figure 14, respectively.

There are three targeted species in King Mackerel model, including King Mackerel (n=834), Spanish Mackerel (the first substitute target (n=704)), and a grouped small game species[5] (the second substitute target (n=1275)). There are 48 county level fishing sites from North Carolina to Louisiana. There are missing values for some county/species alternatives, which results in 151 alternatives (Figure 15).

Charter boat and private boat anglers target one of the three targets. There are six mode/species alternatives in the model (Figure 15). Using charter boat mode, 2.66% (n = 75) of all anglers target King Mackerel and choose among 15 county-level sites, 1.67% (n = 47) target small game and choose among nine county-level sites, and 0.57% (n=16) target Spanish Mackerel and choose among six county-level sites. Using private/rental boat mode, 27% (n =

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[5] Atlantic Croaker, Blue Runner, Bluefish, Bonefish, Cobia, Common Snook, Drum Family, Florida Pompano, Great Barracuda, Greater Amberjack, Gulf Flounder, Gulf Killifish, Irish Pompano, Jack Family, Kingfish Genus, Ladyfish, Largemouth Bass, Left eye Flounder Genus, Little Tunny, Mackerel Family, Mackerel Genus, Permit, Sand Seatrout, Sea Bass Family, Seatrout Genus, Sheepshead, Southern Kingfish, Spot, Striped Bass, Tarpon Family, Unidentified Catfishes, and Weakfish

759) of all anglers target King Mackerel and choose among 32 fishing sites, 43% (n = 1228) target small game and choose among 46 sites, and 24% (n=688) target Spanish Mackerel and choose among 48 sites. Overall 2813 trips and 151 alternatives result in 424,763 cases.

In total, fifty-four percent of trips take place in Florida, 3.77% in Alabama, 0.46% in Georgia, 0.39 % in Louisiana, 2.31% in Mississippi, 36.12% in North Carolina, and 2.56% in South Carolina (Figure 16). The location of home zip code, intercepted sites, the midpoint of each county, and mean/median of fishing sites in North Carolina, South Carolina, Georgia east coastline of Florida, South Florida, the west coastline of Florida, Alabama, Mississippi and Louisiana for each fishing mode are shown in Figure 24.

There are also three targeted species in Red Snapper model, including Red Snapper (n=207), Grouper species group[6] (the first substitute target (n=429)), and other Snapper species group[7] (the second substitute target (n=435)). In this model, we only focus on the private/rental boat trips that target Red Snapper, Grouper, and other Snappers in the Gulf of Mexico area. There are 27 level fishing sites from Louisiana to the West Coastline of Florida. There are missing values for some county/species alternatives, which results in 60 alternatives (Figure 25). Private boat anglers choose among three targets. Nineteen percent of all anglers target Red Snapper and choose among 12 sites, forty percent target Grouper species and choose among 22 sites, and forty-one percent target other Snappers and choose among 26 sites. In total, eighty-five percent of trips take place in Florida, 7.7% in Alabama, 5.6% in Louisiana, and 2.71% in Mississippi (Figure 26). The location of home zip code, intercepted sites, the midpoint of each

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[6] Grouper Genus, Goliath Grouper, Red Hind, Red Grouper, Misty Grouper, Grouper Genus, Yellow mouth Grouper, Warsaw Grouper, Gulf Grouper, Broomtail Grouper

[7] Amberjack Genus, Snapper Genus Atlantic Spadefish, Black Sea Bass, Black Fin Snapper, Mutton Snapper, Lane Snapper, Crevalle Jack, Gray Snapper, Gray Triggerfish, Vermilion Snapper, Snapper Family, Silver Seatrout, Yellowtail Snapper

county, and mean/median of fishing sites in the west coastline of Florida, Alabama, Mississippi, and Louisiana for each fishing mode are shown in Figure 27 and Figure 28, respectively. More information about the frequency of the county-level fishing sites in each state is provided in the appendix.

Empirical Model

We perform a full information maximum-likelihood estimation using nested logit compatible with RUM Stata[8] package (Heiss 2002). We regress the chosen mode/species/site alternative on travel cost, the square root of five-year historical catch and keep rate and the natural logarithm of the number of fishing sites in each county-level site. Three travel cost (TC) measures using the mid-point of the county (Method 1), mean of sites' coordinates (Method 2), and the median of sites' coordinates (Method 3) are used for Dolphinfish, King Mackerel, and Spanish Mackerel models.

We also estimate the mentioned models by adding the dummy HCFS to each model to study its impact on the welfare measures (WTP). We take 5000 random draws of the coefficients of each model from an asymptotic multivariate normal distribution of the parameter estimates using the (Krinsky and Robb 1986, 1990) procedure to compare the accuracy of estimated WTP using each method.

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[8] StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP

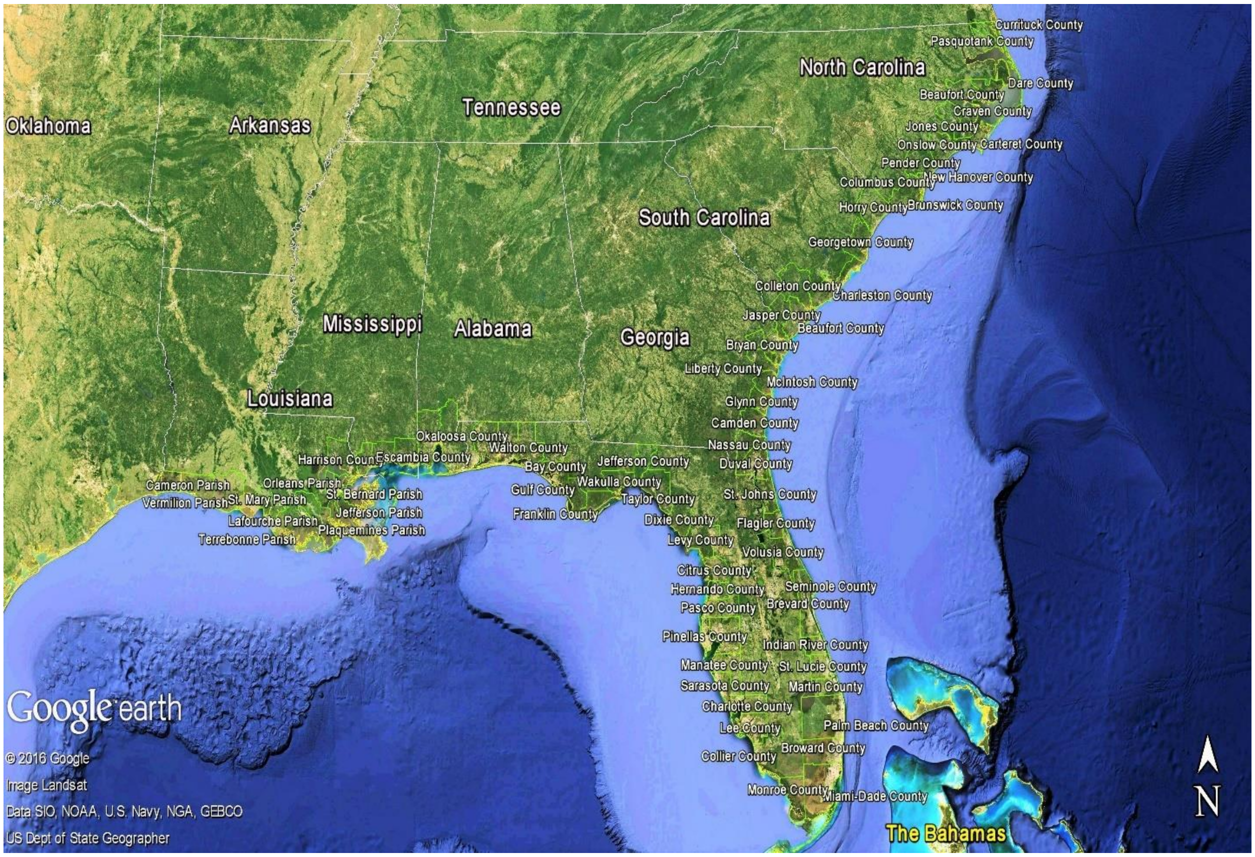

Figure 8. Study area from Louisiana to North Carolina.

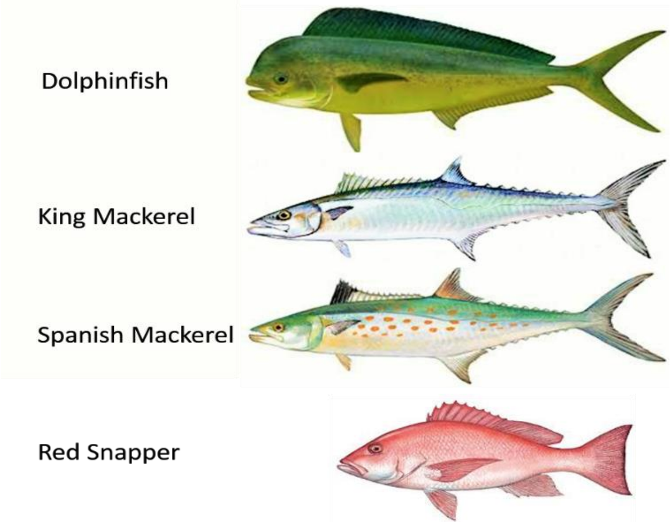

Figure 9. Targeted species by anglers in this study: Dolphinfish, King Mackerel, Spanish Mackerel, and Red Snapper.

Table 1. Data sets used for nested logit models

Dataset	Single Species		Species Groups		Fishing Mode	Number of Sites	Number of Alternatives
1	Dolphinfish (n=1055)		Big game (n=516)		Private Boat/ Charter Boat	22	60
2	King Mackerel (n=834)	Spanish Mackerel (n=704)	Small game (n=1275)		Private Boat/ Charter Boat	48	151
3	Red Snapper (n=207)		Snappers (n=435)	Groupers (n=429)	Private Boat	27	60

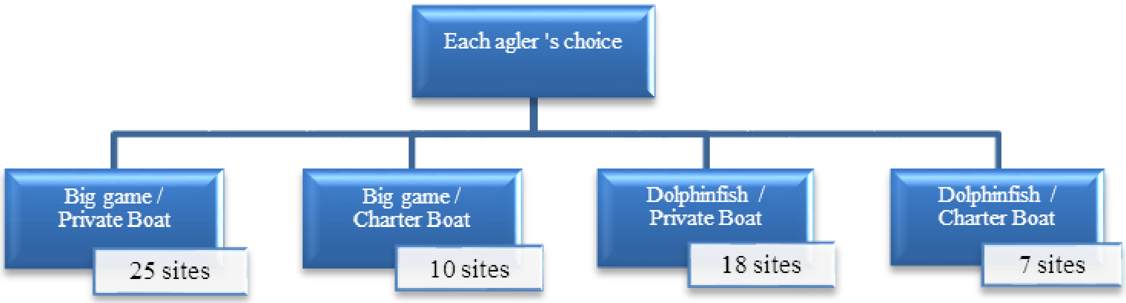

Figure 10. Structure of nests for Dolphinfish model.

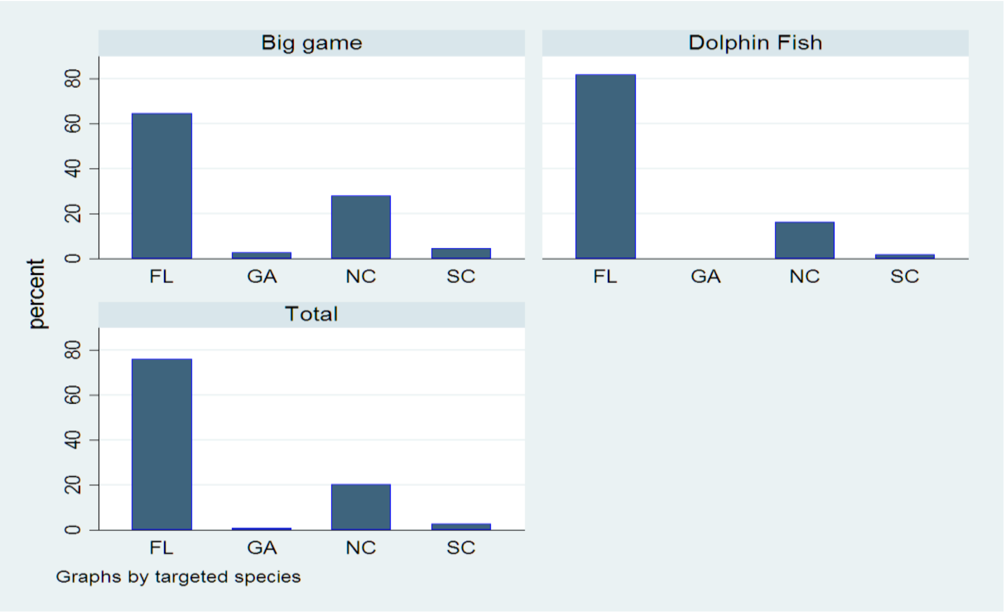

Figure 11. The proportion of anglers targeted Dolphinfish and Big game, in each state.

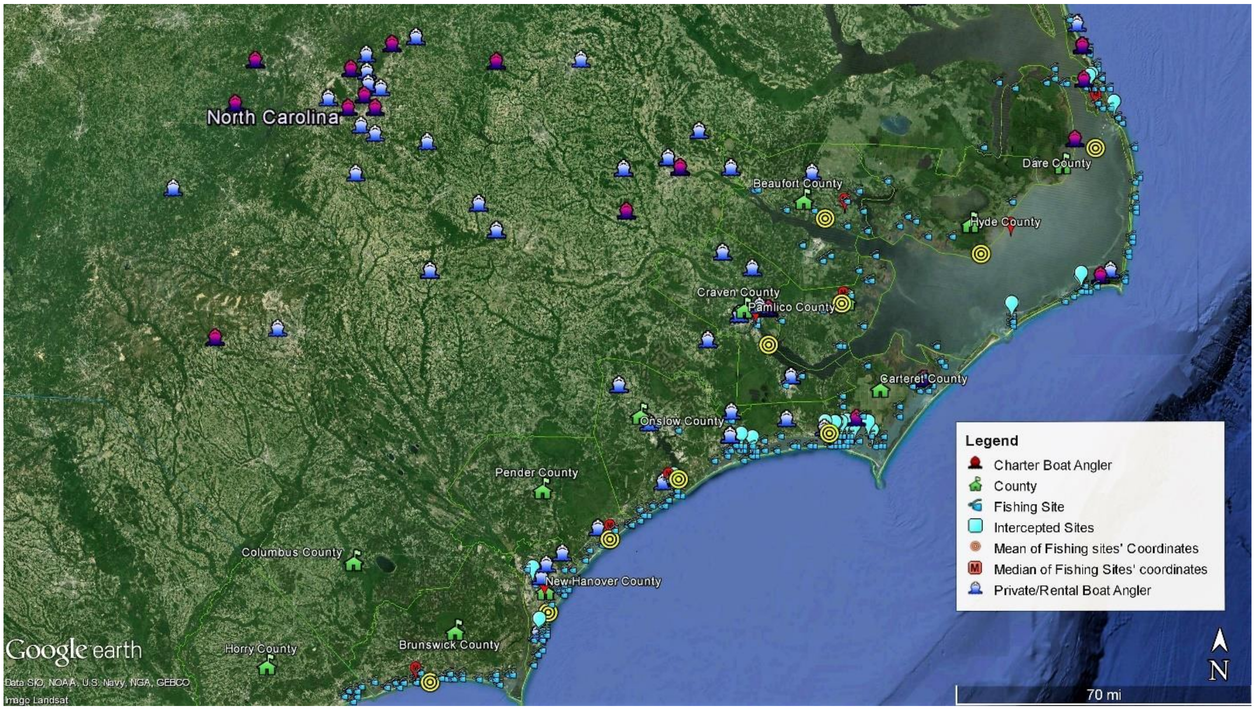

Figure 12. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in North Carolina for each fishing mode (Dolphinfish Model).

Figure 13. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites on the east coast of Florida for each fishing mode (Dolphinfish Model).

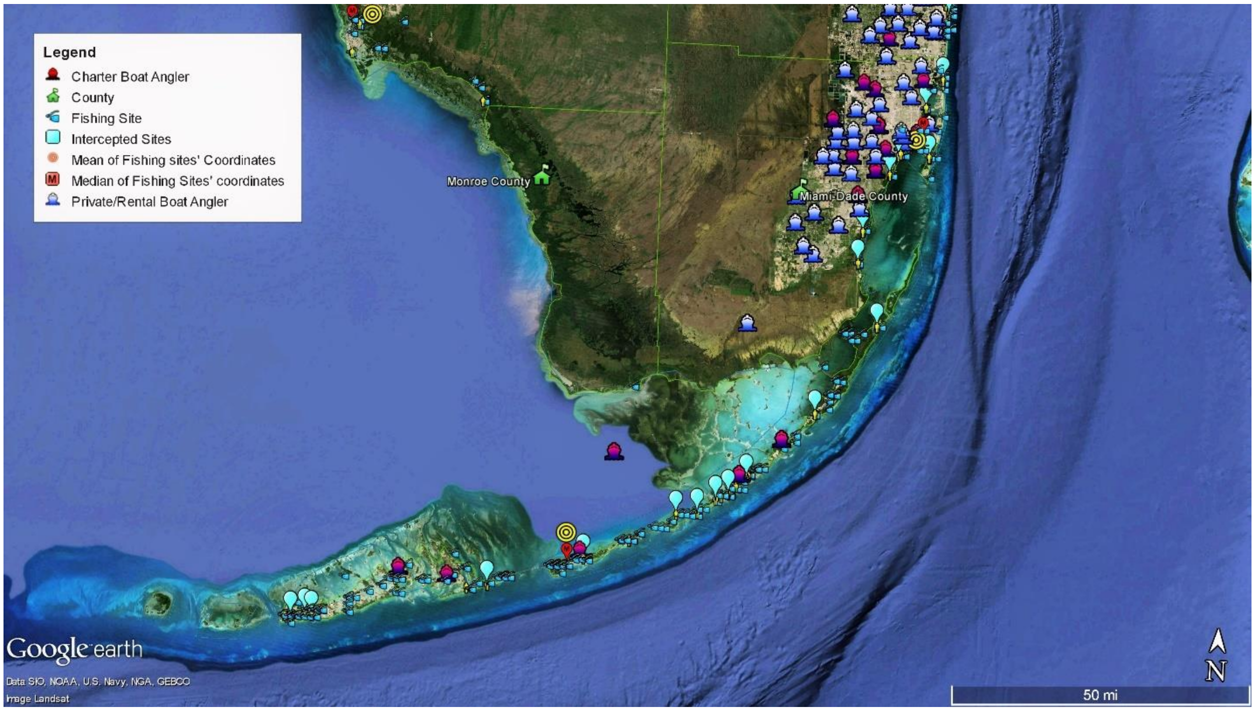

Figure 14. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in the south of Florida for each fishing mode (Dolphinfish Model).

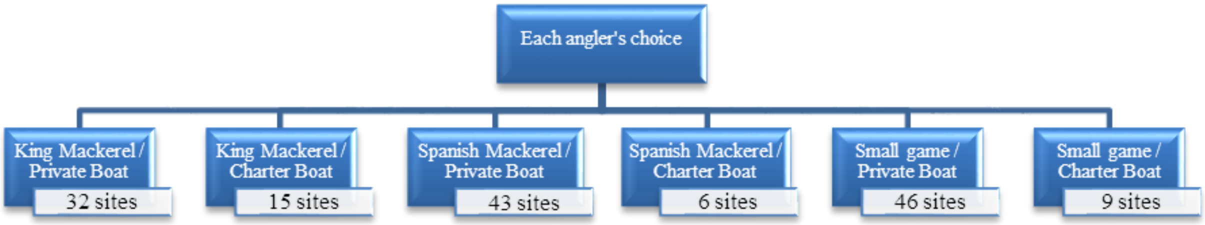

Figure 15. Structure of nests for King Mackerel model.

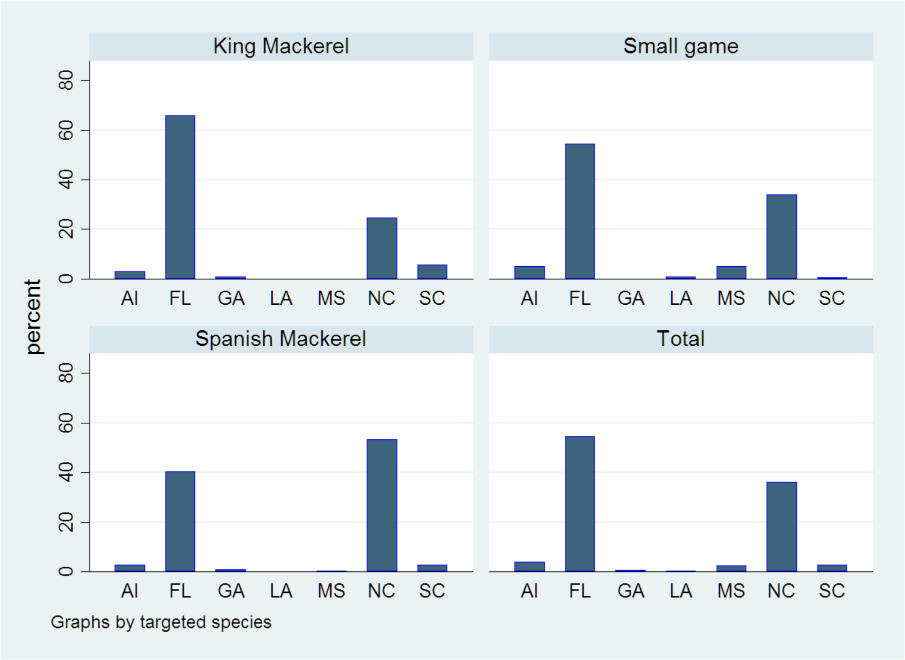

Figure 16. The proportion of anglers targeted King Mackerel, Spanish Mackerel, and Small game in each state.

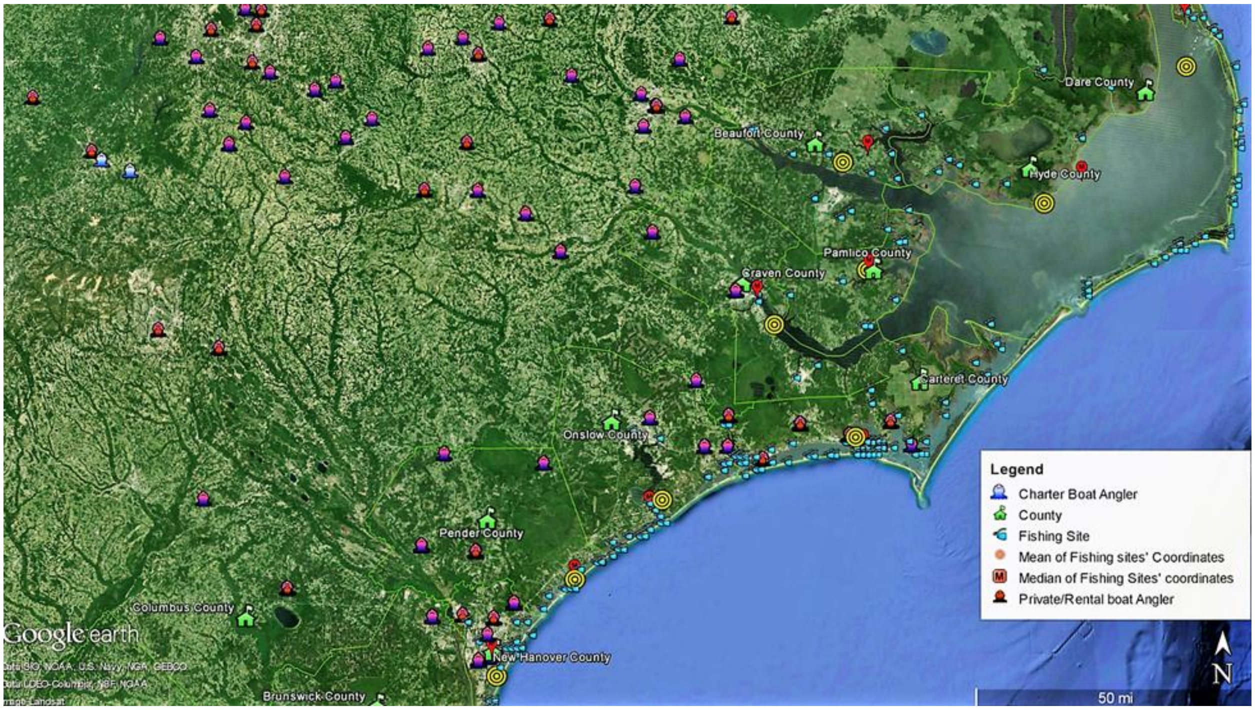

Figure 17. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in North Carolina for each fishing mode (King Mackerel Model).

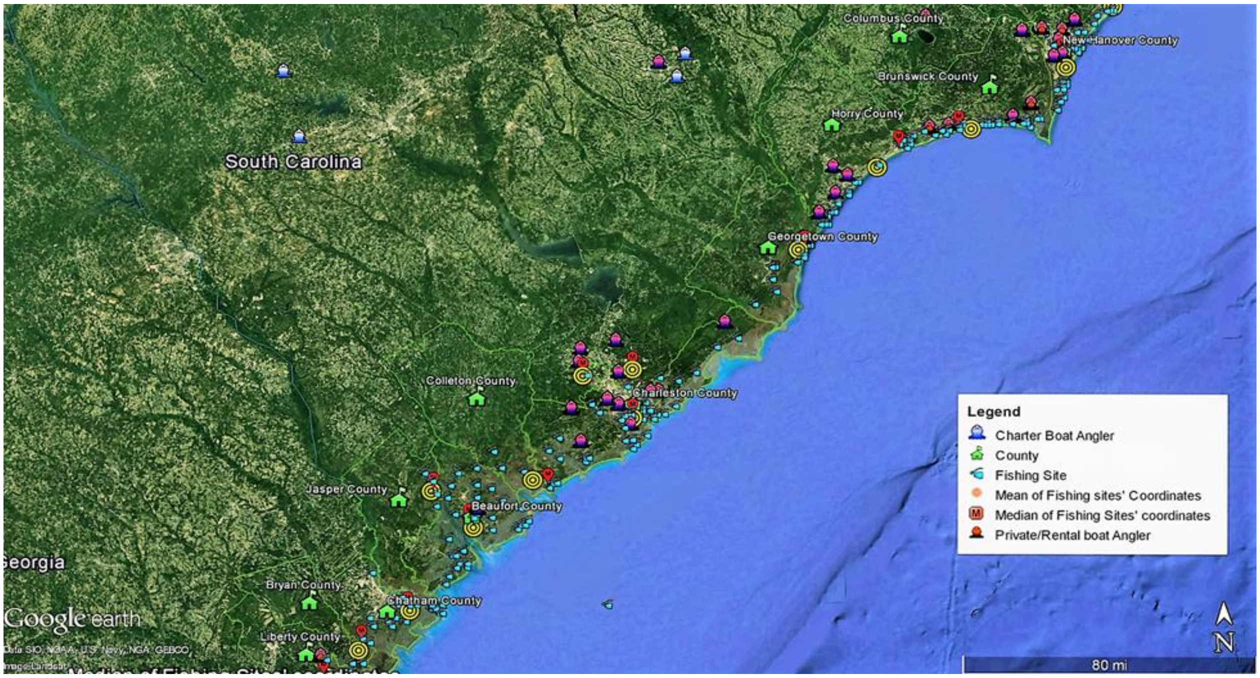

Figure 18. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in South Carolina for each fishing mode (King Mackerel Model).

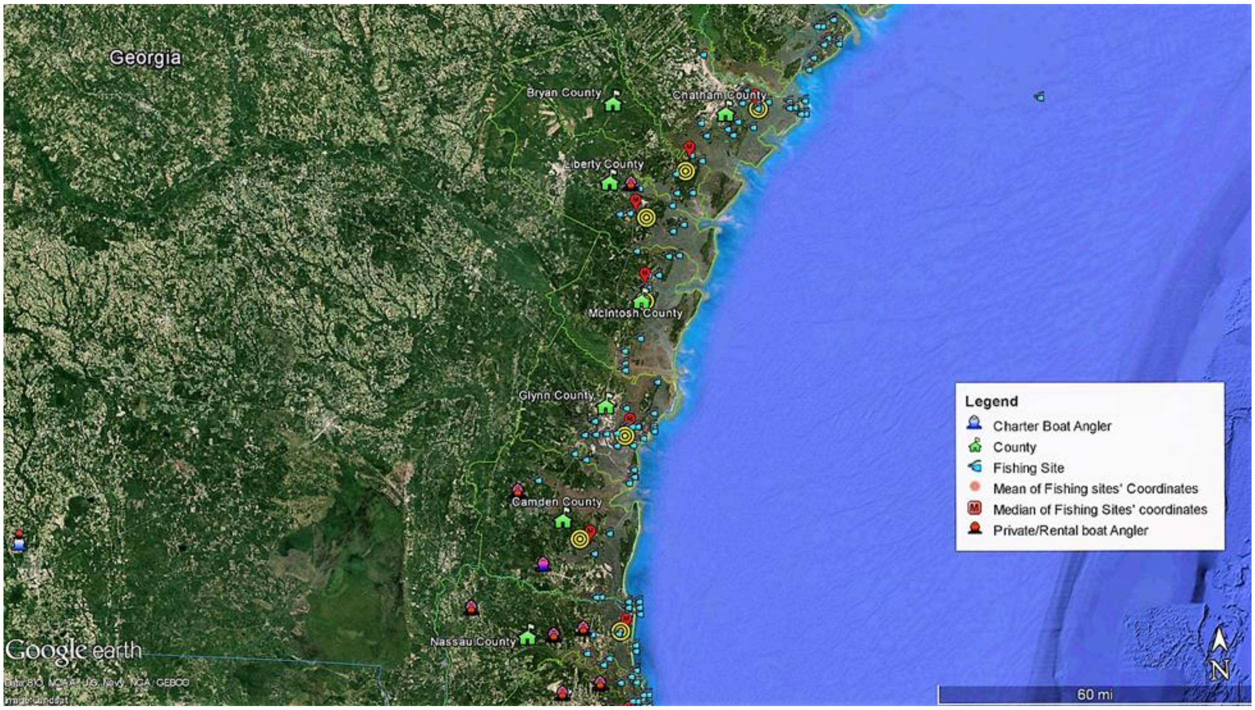

Figure 19. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in Georgia for each fishing mode (King Mackerel Model).

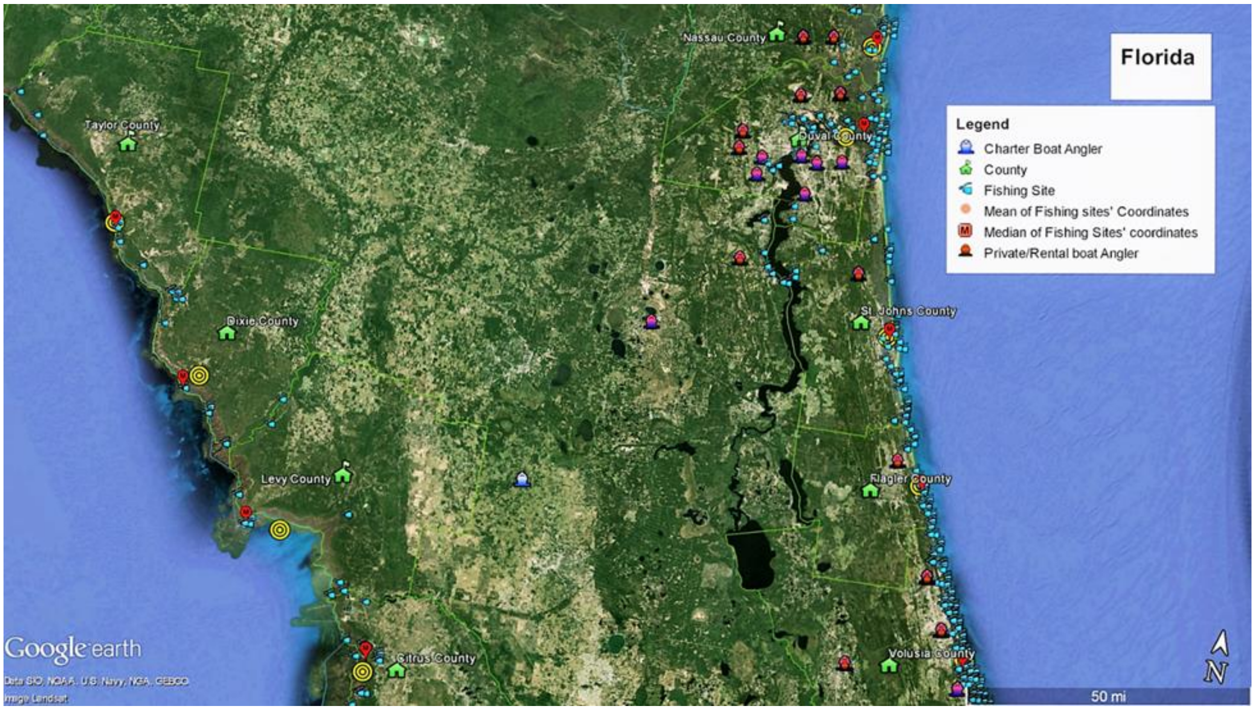

Figure 20. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in east of Florida for each fishing mode (King Mackerel Model).

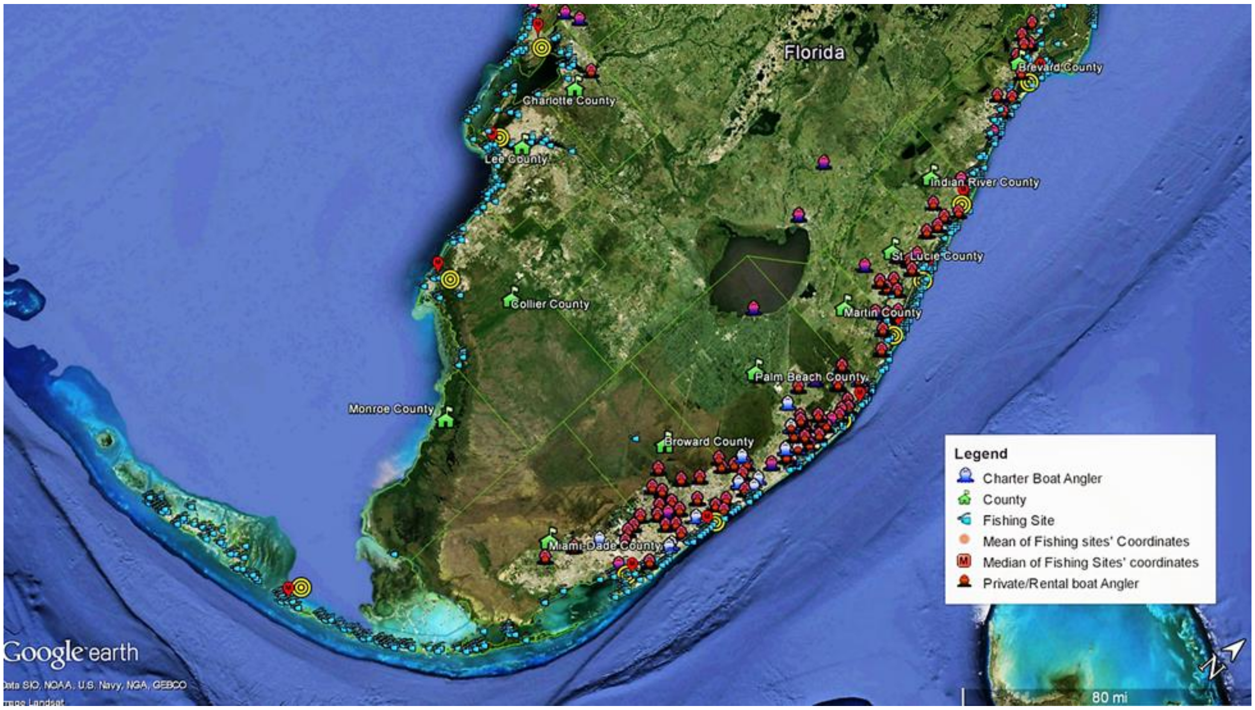

Figure 21. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in south of Florida for each fishing mode (King Mackerel Model).

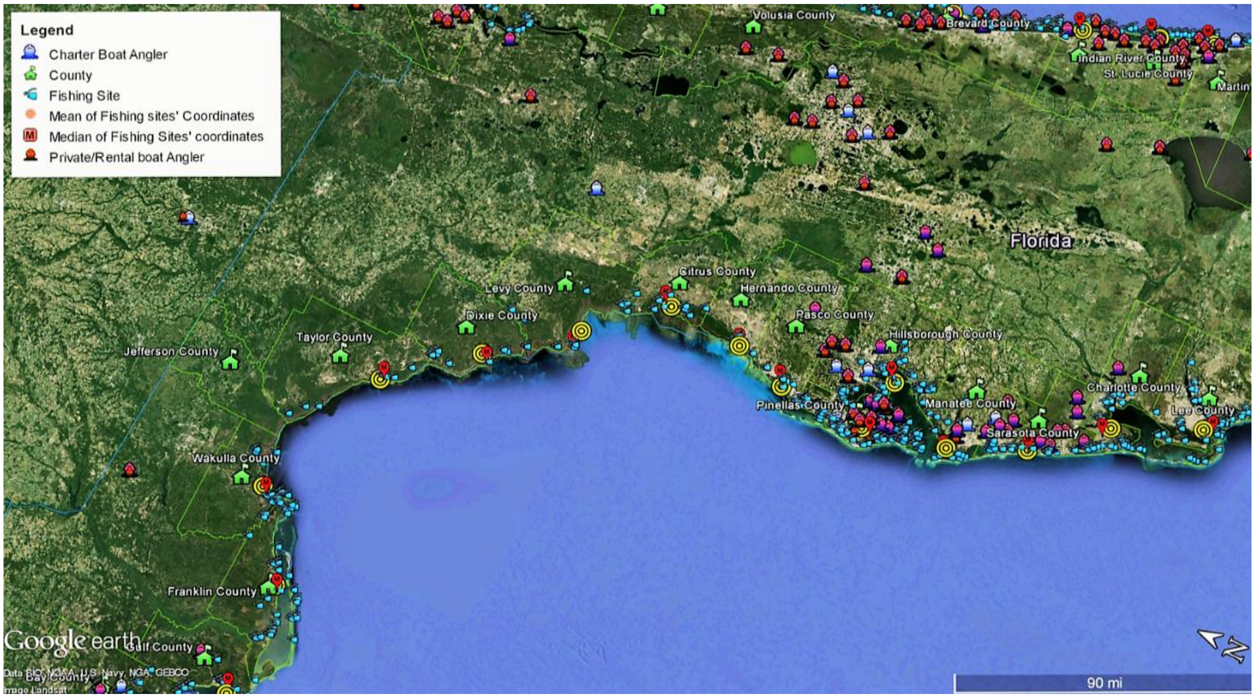

Figure 22. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in northwest of Florida for each fishing mode (King Mackerel Model).

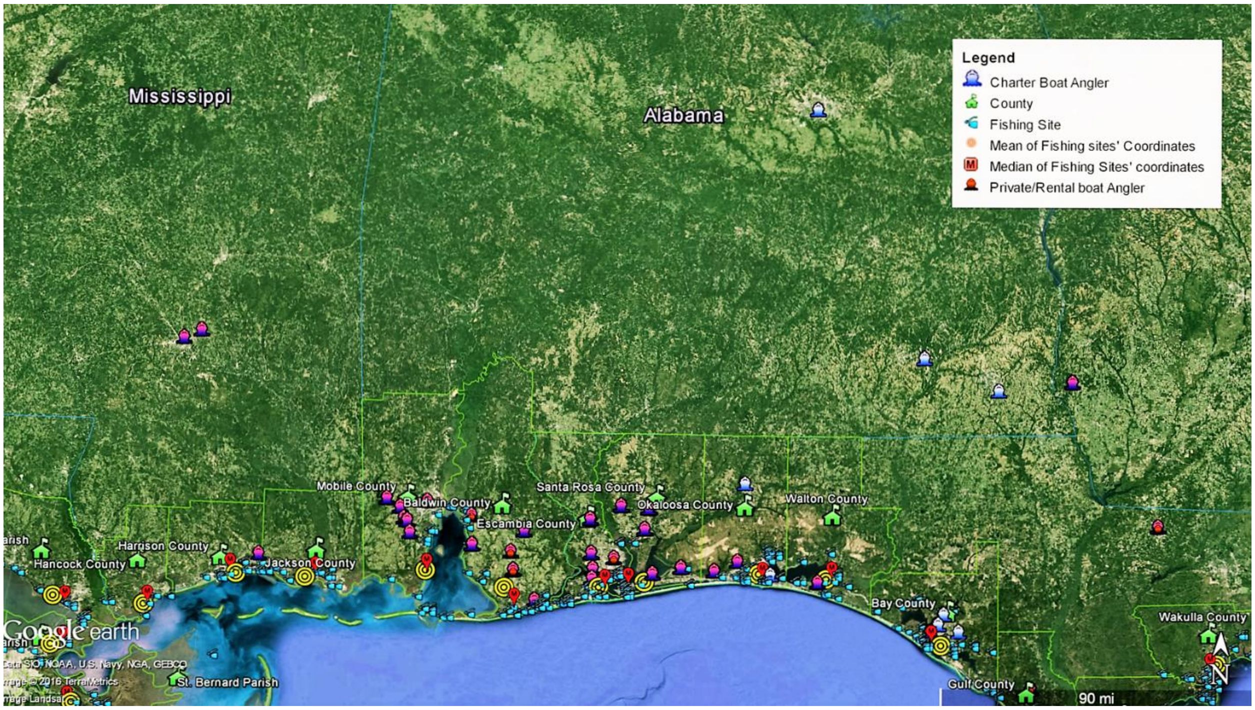

Figure 23. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in Alabama for each fishing mode (King Mackerel Model).

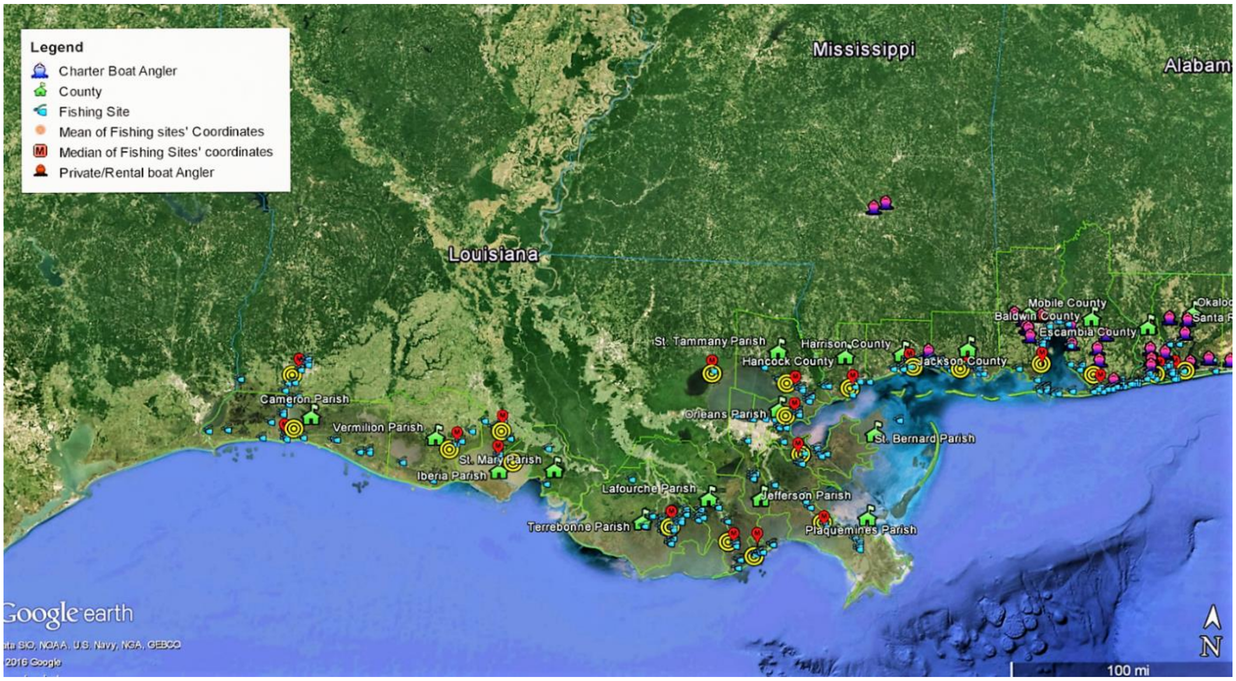

Figure 24. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in Mississippi and Louisiana for each fishing mode (King Mackerel Model).

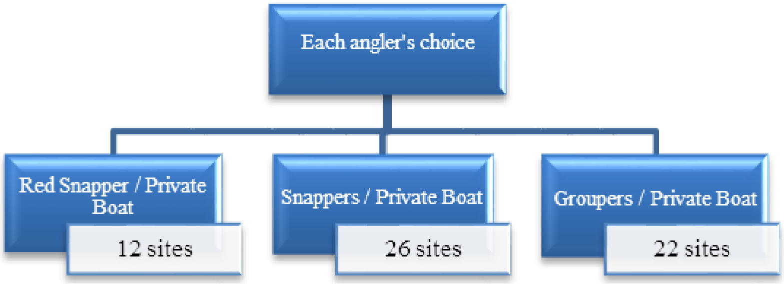

Figure 25. Structure of nests for Red Snapper model.

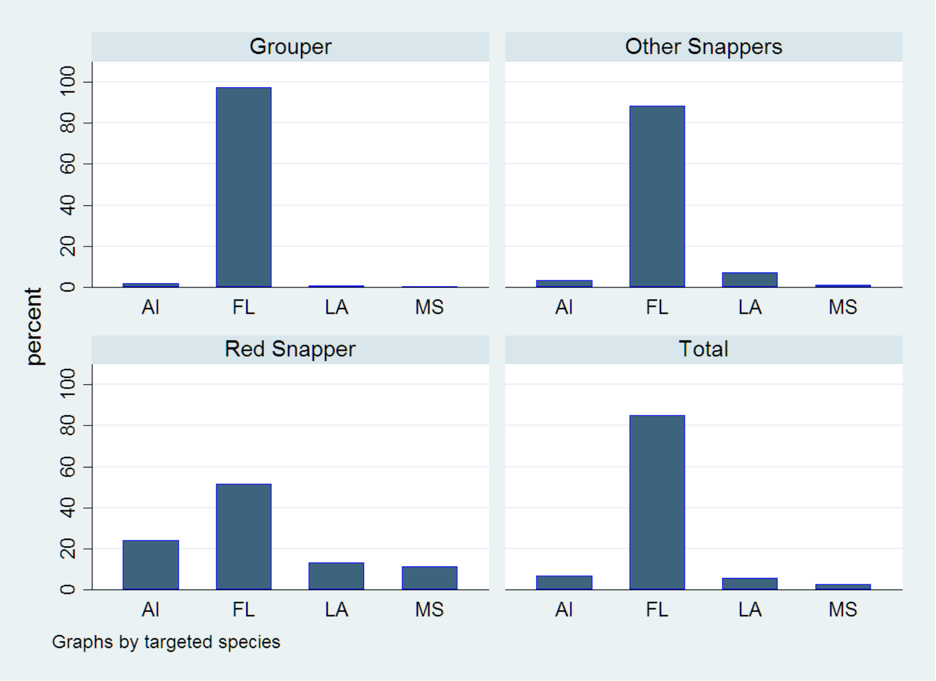

Figure 26. The proportion of anglers targeted Red Snapper, Groupers, and other Snappers in each state.

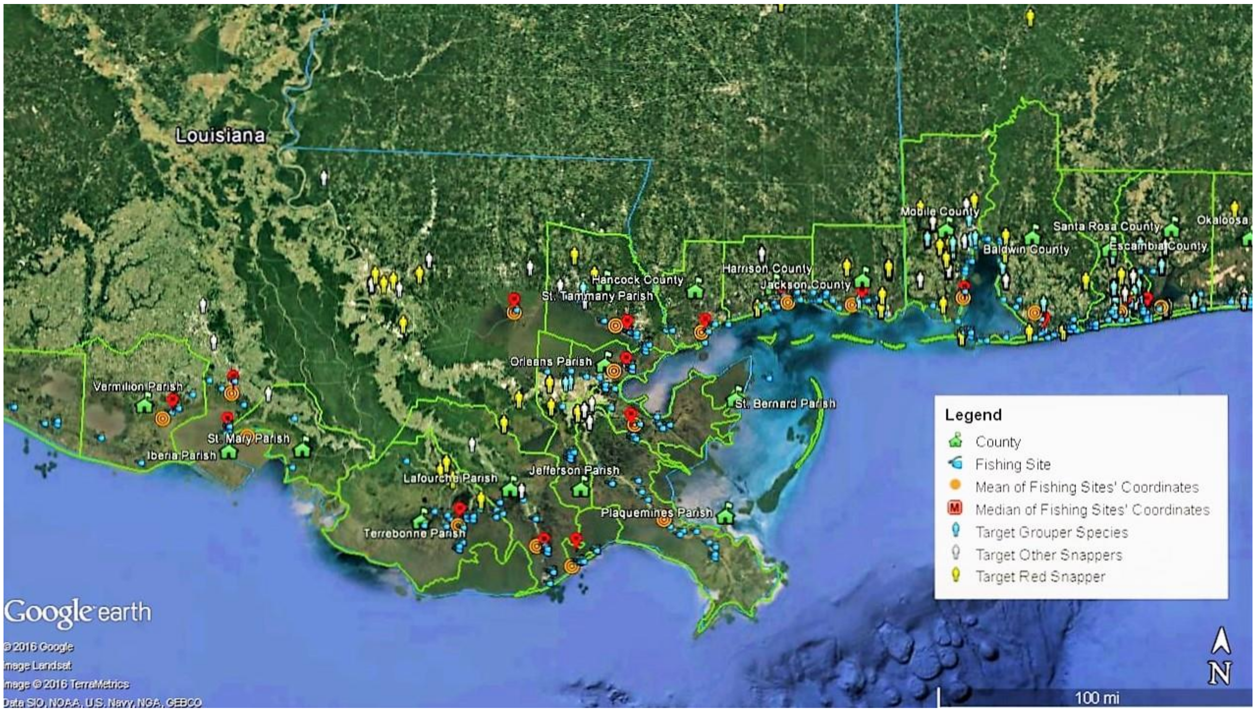

Figure 27. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in Louisiana (Red Snapper Model).

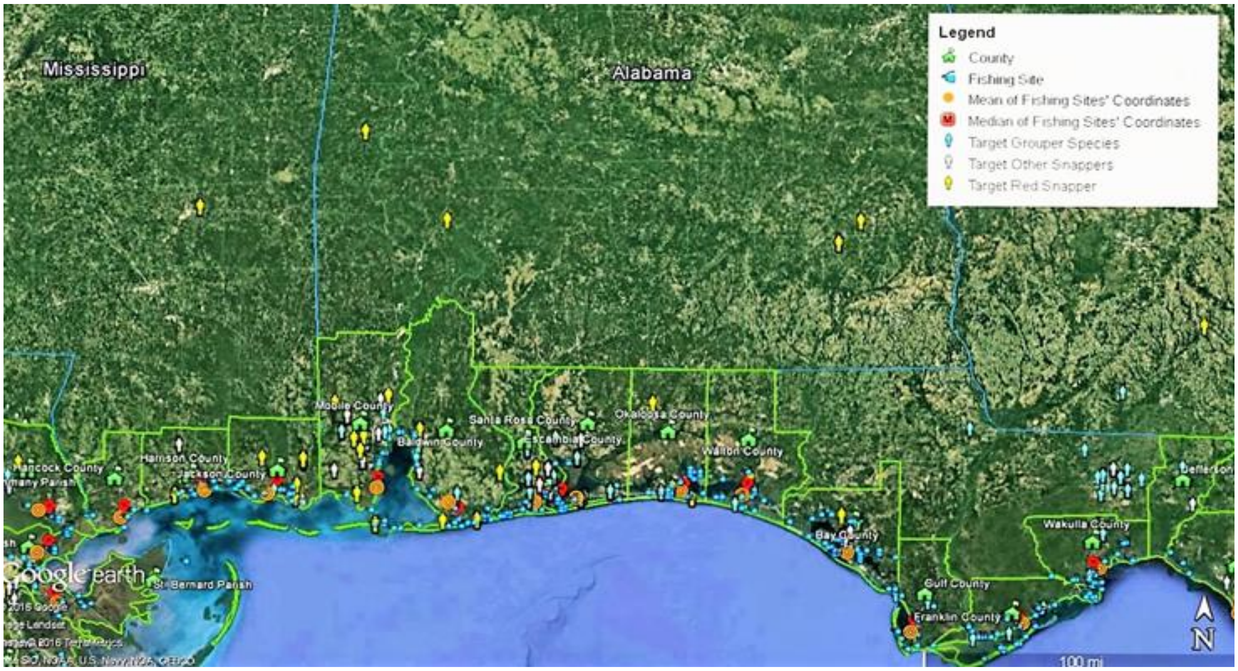

Figure 28. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in Mississippi and Alabama (Red Snapper Model).

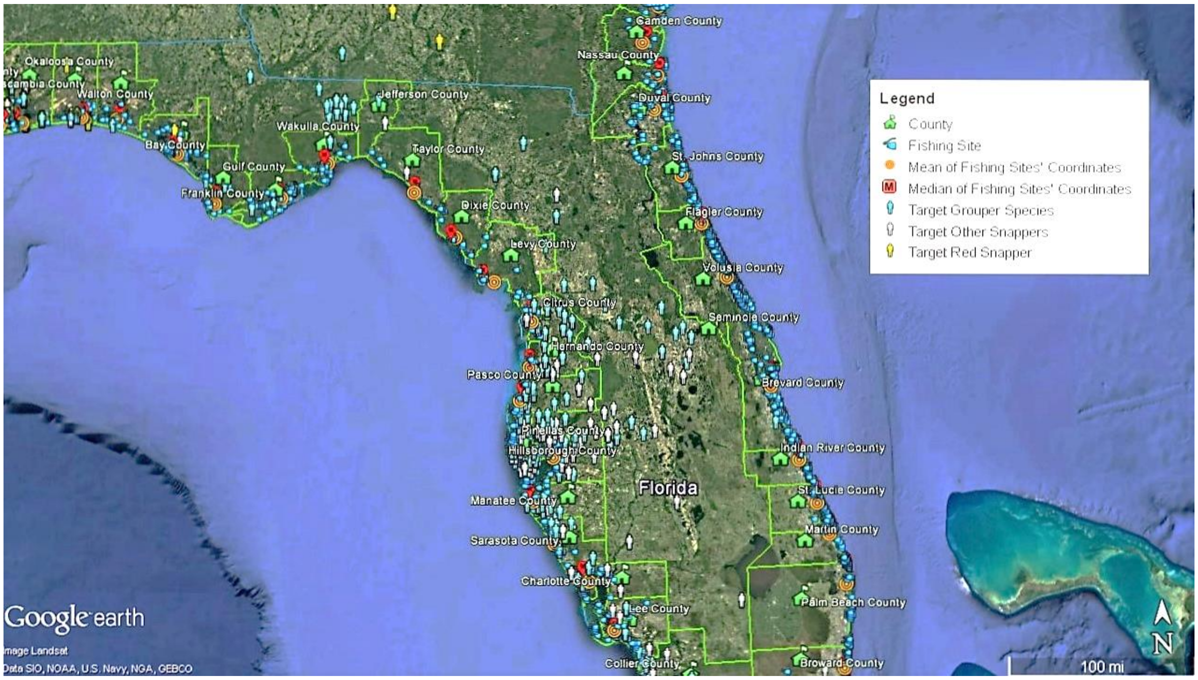

Figure 29. Illustration of anglers' home zip code, intercepted sites, midpoint of each county, and mean/median of fishing sites in Florida (Red Snapper Model).

CHAPTER 4

RESULTS AND DISCUSSION

Empirical Results

We present the nested logit results for Dolphinfish model in Table 4 (the description and summary statistics of variables in Dolphinfish, King Mackerel, and Red Snapper models are provided in Table 2 and Table 3, respectively). All parameters are significantly different from zero in the method 1 (conventional approach). Travel cost sign is negative indicating that the probability that an angler chooses a site is negatively related to cost. The positive sign of catch rate is consistent with theory except for big game private boat anglers that might be as a result of heterogeneity in big game species and offshore cost factors like fuel fee that are not included in travel cost for private anglers.

The dissimilarity parameters are statistically different from one, which indicates that the nesting structure is appropriate. The value of travel cost coefficient increases from -0.0340 in the conventional approach to -0.0231 and -0.0189 in method two (TC (Mean of Sites' Coordinates)) and three (TC (Median of Sites' Coordinates)), respectively. However, the impact of quality of site coefficients on the probability of choosing site decreases and catch rate of dolphin/charter is not significant in method three. It is necessary to mention that each coefficient is normalized by an undefined scale parameter, so it is difficult to discern whether these changes in the value of coefficients are as a result of using suggested methods or scale that is changing. Nevertheless, WTP is not affected since it is scale free (ratio of parameters). Estimation results for Dolphinfish

Model including Home County Fishing Site are shown in Table 5. The likelihood ratio test indicates this model is a better fit for the data. It can be seen that catch rate of dolphin/charter is not significant in method two and three. This shows that travel cost impact on the likelihood of choosing a site is more important for charter boat anglers that target Dolphinfish. Welfare Measures (WTP) for Dolphinfish model are presented in Table 6. It clearly seems that the conventional approach overestimates the marginal value of willingness to pay for one additional catch of Dolphinfish on a day-trip. Welfare measures (WTP) for Dolphinfish model including dummy Home County Fishing Site are even lower for charter boat anglers but increases from \$16.6 to \$19.7 for private boat anglers that target Dolphinfish (Table 7). Also, conventional approach underestimates the value of WTP for private anglers that target Dolphinfish (WTP using the median of sites' coordinates (method 3) is \$23.2).

In the King Mackerel Model, all variables are significant, and the signs of all coefficients are consistent with theory. Application of the nested logit is appropriate. The value of travel cost parameter increases from -0.0561 (conventional approach) to -0.0312 and -0.0356 using method two and three, respectively (Table 8). Model with dummy Home County Fishing Site (results are shown in Table 9) made no significant impact on WTP of charter boat anglers but estimated WTP of private boat anglers is higher (Table 11). Our results indicate that using the mid-point of alternative county-level sites (conventional approach) in King Mackerel model overestimates the willingness to pay of charter boat anglers and underestimate the willingness to pay of private boat anglers for one additional catch on day-trip (Table 10 and Table 11).

The results of nested logit model for Red Snapper model are presented in Table 12. It can be seen that the likelihood of choosing a site is positively related to the quality of the site and negatively related to the cost of trips. The value of the travel cost parameter in the conventional model decreases from -0.0252 to -0.0289 (method 2) and -0.0314 (method 3). However, the value of catch rate coefficients increases. In Table 13, the willingness to pay of private boat anglers for one additional Red Snapper on day-trip is $49.0, $39.4, and $37.6 using method one, two, and three, respectively. In the Red Snapper model that includes the dummy Home County Fishing Site (Table 13), travel cost value has a decreasing trend from -0.0178 (method 1) to -0.0245 (method 3). The WTP are lower in the model that have HCFS (Table 15), which indicate that estimated WTP are overestimated if the attributes of coastal county anglers are ignored. Nevertheless, the estimated welfare measures (WTP) in the conventional approach are overestimated compared to our introduced methods.

The results show that the estimated welfare measures using mean and median of fishing sites' coordinates provide more conservative estimations compare to the conventional approach. Failure to adopt this approach results in an overestimation of WTP of charter boat anglers, and underestimation of WTP of private boat anglers that target Dolphin fish, and King Mackerel.

The WTP of private boat angler in the west coastline of Florida, Alabama, Mississippi, and Louisiana for grouper and other Snappers are not significantly different. However, the conventional approach overestimates the WTP of anglers that target Red Snapper. The estimated WTP for Red Snapper in the model without dummy Home County Fishing Site are $32.2, $27.6, and $26.1 using method one, two, and three, respectively. However, in the model with HCFS, these estimates are significantly higher ($49.0, $39.4, and $37.6). The reason for these higher values is that HCFS address the anglers that choose a county-level site since they live there and also take into account the fact that some coastal county anglers might not choose their home county-level sites as a fishing destination. This may happen in the small counties or for anglers that live near the border of two or three counties. There are some factors like availability of tackle shop, area to clean and wash the catch, availability of a place to keep their private boat or some discount for the rental fee for members, and some other factor that may attract an angler to go to a fishing site that is located in a neighboring county. These variables do not exist in the county-level sites. Therefore, we applied the proxy HCFC to take into account these unavailable factors.

Limitations and Future Research Needs

This study and similar studies have a lack of information regarding the area of fishing offshore, and fishing activity in all coastal counties for important species. The travel cost and opportunity costs are based on the assumptions of the researcher. There are other appealing big game species for anglers, but there is not enough data to estimate models for them. The five-year historical catch rate is not available for all fishing sites. This study does not address avidity bias and endogenous stratification of data.

Table 2. Description of variables

Variables	Description
Ln (Number of sites)	Natural logarithm of number of fishing sites in each aggregated over county site
TC (Mid-Point of County)	Travel cost measure using distance from anglers' home zip code to intercepted sites and the mid-point of alternative county-level sites
TC (Mean of Sites' Coord)	Travel cost measure using distance from anglers' home zip code to intercepted sites and the Mean of fishing sites' coordinates in the alternative county-level sites
TC (Median of Sites' Coord)	Travel cost measure using distance from anglers' home zip code to intercepted sites and the Median of fishing sites' coordinates in the alternative county-level sites
Home County Fishing Site	Dummy=1 If the chosen county-level site is the home county of angler Dummy=0 otherwise
	Square root of five-year historical catch and keep rate of one-day fishing for:
Dolphin-Charter-5YHCK^0.5	Dolphinfish and charter boat fishing mode
Dolphin-Private-5YHCK^0.5	Dolphinfish and private/rental boat fishing mode
Biggame-Charter-5YHCK^0.5	Big game species and charter boat fishing mode
Biggame-Private-5YHCK^0.5	Big game species and private/rental boat fishing mode
KMackerel-Charter-5YHCK^0.5	King Mackerel and charter boat fishing mode
KMackerel-Private-5YHCK^0.5	King Mackerel and private/rental boat fishing mode
Smallgame-Charter-5YHCK^0.5	Small game species and charter boat fishing mode
Smallgame-Private-5YHCK^0.5	Small game species and private/rental boat fishing mode
SMackerel-Charter-5YHCK^0.5	Spanish Mackerel and charter boat fishing mode
SMackerel-Private-5YHCK^0.5	Spanish Mackerel and private/rental boat fishing mode
Grouper-Private-5YHCK^0.5	Grouper and private/rental boat fishing mode
Osnappers-Private-5YHCK^0.5	Other Snapper species and private/rental boat fishing mode
Red_Snapper-Private-5YHCK^0.5	Red Snapper and private/rental boat fishing mode

Table 3. Summary statistics of variables in Dolphinfish, King Mackerel, and Red Snapper models

Dolphinfish model

Variable	Obs	Mean	Std. Dev.	Min	Max
Dolphin-Charter-5YHCK	1,571	.1388741	.6006067	0	10.2
Dolphin-Private-5YHCK	1,571	.5931553	.8930606	0	4.0
Biggame-Charter-5YHCK	1,571	.275672	1.249378	0	7.70
Biggame-Private-5YHCK	1,571	.1447688	.6362162	0	4.87
Ln (Number of sites)	1,571	3.101072	.543443	1.609438	4.0
Home County Fishing Site	1,571	.6193507	.4857011	0	1
TC (Mid-Point of County)	94,260	700.8868	501.8509	.300836	2017.64
TC (Mean of Sites' Coord)	94,260	702.3076	501.6813	0	2177.39
TC (Median of Sites' Coord)	94,260	701.565	500.4335	0	2179.02

King Mackerel model

Variable	Obs	Mean	Std. Dev.	Min	Max
KMackerel-Charter-5YHCK	2,813	.0354307	.2865779	0	4.32
KMackerel-Private-5YHCK	2,813	.1885951	.405902	0	1.73
Smallgame-Charter-5YHCK	2,813	.0456779	.5148337	0	7.35
Smallgame-Private-5YHCK	2,813	.335974	.5937105	0	4.81
SMackerel-Charter-5YHCK	2,813	.0156196	.3126323	0	10.82
SMackerel-Private-5YHCK	2,813	.4818847	1.025867	0	3.13
Ln (Number of sites)	2,813	3.004191	.6427962	0	4.0
Home County Fishing Site	2,813	.5883399	.4922217	0	1
TC (Mid-Point of County)	424,763	753.093	433.572	0	048.88
TC (Mean of Sites' Coord)	424,763	756.809	433.365	.43	021.06
TC (Median of Sites' Coord)	424,763	757.562	433.486	0	2025.90

Red Snapper Model

Variable	Obs	Mean	Std. Dev.	Min	Max
Grouper-Private-5YHCK	1,266	.280	.5497527	0	2.86
Osnappers-Private-5YHCK	1,266	.332	.658254	0	2.48
Red Snapper-Private-5YHCK	1,266	.208	.5423177	0	2.21
Ln (Number of sites)	1,266	2.618	.6760592	1.38	4.00
Home County Fishing Site	1,266	.639	.480245	0	1
TC (Mid-Point of County)	107,610	555.719	365.309	0	1846.67
TC (Mean of Sites' Coord)	107,610	564.169	371.586	1.20	1888.4
TC (Median of Sites' Coord)	107,610	565.304	372.013	1.20	1889.86

Table 4. Nested logit model for Dolphinfish

	Method 1		Model 2		Method 3	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Ln (Number of sites)	1.0432***	(0.0807)	0.7680***	(0.0739)	0.6450***	(0.0647)
Dolphin-Charter-5YHCK^0.5	0.9695***	(0.1252)	0.3444**	(0.1182)	0.1952	(0.1043)
Dolphin-Private-5YHCK^0.5	0.5638***	(0.0575)	0.3018***	(0.0478)	0.2600***	(0.0439)
Biggame-Charter-5YHCK^0.5	1.4798***	(0.1223)	0.7122***	(0.1158)	0.4663***	(0.1092)
Biggame-Private-5YHCK^0.5	-0.3826***	(0.0932)	-0.4822***	(0.0823)	-0.4720***	(0.0742)
TC (Mid-Point of County)	-0.0340***	(0.0019)				
TC (Mean of Sites' Coord)			-0.0231***	(0.0017)		
TC (Median of Sites' Coord)					-0.0189***	(0.0015)
IV parameters:						
Dolphinfish/Charter Boat	2.2042***	(0.2022)	1.3872***	(0.1605)	1.0691***	(0.1299)
Dolphinfish/Private Boat	0.8094***	(0.0555)	0.5460***	(0.0463)	0.4652***	(0.0411)
Big game/Charter Boat	3.3289***	(0.2963)	2.2878***	(0.2949)	1.6868***	(0.2569)
Big game/Private Boat	0.8404***	(0.0553)	0.6275***	(0.0538)	0.5292***	(0.0472)
Log likelihood	-2603.5496		-2791.7752		-2834.0911	
N. of cases	94260		94260		94260	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5. Nested logit model for Dolphinfish (HCFS is included)

	Method 1		Method 2		Method 3	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Ln (Number of sites)	1.3369***	(0.1084)	1.0278***	(0.0981)	0.9305***	(0.0915)
Dolphin-Charter-5YHCK^0.5	0.7113***	(0.1294)	0.1601	(0.1167)	0.0768	(0.1045)
Dolphin-Private-5YHCK^0.5	0.5884***	(0.0653)	0.3947***	(0.0555)	0.3817***	(0.0535)
Biggame-Charter-5YHCK^0.5	1.2653***	(0.1143)	0.5622***	(0.1075)	0.3966***	(0.1032)
Biggame-Private-5YHCK^0.5	-0.3828***	(0.1031)	-0.5075***	(0.0940)	-0.5024***	(0.0872)
Home County Fishing Site	1.5076***	(0.1631)	1.2454***	(0.1394)	1.2054***	(0.1362)
TC (Mid-Point of County)	-0.0299***	(0.0018)				
TC (Mean of Sites' Coord)			-0.0193***	(0.0015)		
TC (Median of Sites' Coord)					-0.0164***	(0.0013)
IV parameters:						
Dolphinfish/Charter Boat	2.3318***	(0.2153)	1.4679***	(0.1614)	1.2487***	(0.1406)
Dolphinfish/ Private Boat	0.9931***	(0.0709)	0.7132***	(0.0620)	0.6543***	(0.0591)
Big game/Charter Boat	3.5714***	(0.3230)	2.3764***	(0.3174)	1.9232***	(0.2960)
Big game/Private Boat	1.0790***	(0.0747)	0.8101***	(0.0682)	0.7389***	(0.0645)
Log likelihood	-2512.0042		-2678.1742		-2701.9934	
N. of cases	94260		94260		94260	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6. Welfare Measures (WTP) for Dolphinfish model

	Method 1			Method 2			Method 3		
	WTP	LL	UL	WTP	LL	UL	WTP	LL	UL
Dolphin_Charter_FYHCKEEP^0.5	28.5	22.6	34.4	14.9	5.48	23.7	10.3	-0.31	19.8
Dolphin_Private_FYHCKEEP^0.5	16.6	13.4	19.9	13.1	9.27	17.1	13.8	9.49	18.2
Biggame_Charter_FYHCKEEP^0.5	43.5	39.3	47.6	30.8	23.8	37.0	24.7	15.6	32.5
Biggame_Private_FYHCKEEP^0.5	-11.3	-16.9	-5.77	-20.9	-28.0	-14.1	-25.0	-32.7	-17.7

Table 7. Welfare Measures (WTP) for Dolphinfish model (HCFS is included)

	Method 1			Method 2			Method 3		
	WTP	LL	UL	WTP	LL	UL	WTP	LL	UL
Dolphin_Charter_FYHCKEEP^0.5	23.8	16.2	31.3	8.28	-3.45	19.6	4.67	-8.05	16.6
Dolphin_Private_FYHCKEEP^0.5	19.7	15.4	24.3	20.4	14.9	26.5	23.2	17.0	30.1
Biggame_Charter_FYHCKEEP^0.5	42.3	37.4	47.1	29.1	20.5	36.5	24.1	13.7	33.1
Biggame_Private_FYHCKEEP^0.5	-12.8	-19.9	-5.87	-26.2	-36.4	-16.6	-30.6	-41.6	-20.1

Table 8. Nested logit model for King Mackerel

	Method1		Method2		Method3	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Ln (Number of sites)	2.3814***	(0.1257)	0.9408***	(0.0753)	1.1042***	(0.0850)
KMackerel-Charter-5YHCK^0.5	2.1925***	(0.2935)	1.0945***	(0.2144)	1.3091***	(0.2353)
Smallgame-Charter-5YHCK^0.5	2.9348***	(0.1784)	1.3406***	(0.1677)	1.4827***	(0.1655)
SMackerel-Charter-5YHCK^0.5	2.3474***	(0.2442)	0.8949***	(0.2365)	1.1311***	(0.2393)
KMackerel-Private-5YHCK^0.5	0.5877***	(0.0985)	0.4323***	(0.0735)	0.4731***	(0.0776)
Smallgame-Private-5YHCK^0.5	0.8442***	(0.0878)	0.6700***	(0.0612)	0.7150***	(0.0662)
SMackerel-Private-5YHCK^0.5	0.6058***	(0.0688)	0.5022***	(0.0475)	0.5299***	(0.0513)
TC (Mid-Point of County)	-0.0561***	(0.0023)				
TC (Mean of Sites' Coord)			-0.0312***	(0.0021)		
TC (Median of Sites' Coord)					-0.0356***	(0.0022)
IV parameters:						
King Mackerel/Charter Boat	5.2423***	(0.3610)	2.3575***	(0.3008)	2.8313***	(0.3254)
Small game/Charter Boat	1.6127***	(0.0943)	0.7577***	(0.0641)	0.8788***	(0.0710)
Spanish Mackerel/Charter Boat	6.1495***	(0.3409)	3.5926***	(0.3781)	4.3745***	(0.3949)
King Mackerel/Private Boat	1.5884***	(0.0746)	0.8413***	(0.0586)	0.9523***	(0.0628)
Small game/Private Boat	7.6574***	(0.6587)	2.5911***	(0.7593)	3.5123***	(0.7315)
Spanish Mackerel/Private Boat	1.3953***	(0.0790)	0.6301***	(0.0517)	0.7300***	(0.0574)
Log likelihood	-5444.8488		-5613.0292		-5602.9822	
N. of cases	424763.0000		424763.0000		424763.0000	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9. Nested logit model for King Mackerel (HCFS is included)

	Method 1		Method 3	
	Coef.	Std. err.	Coef.	Std. err.
Ln (Number of sites)	2.9897***	(0.1643)	1.4442***	(0.1125)
KMackerel-Charter-5YHCK^0.5	1.7657***	(0.2844)	0.9507***	(0.2300)
Smallgame-Charter-5YHCK^0.5	2.4720***	(0.1681)	1.2143***	(0.1538)
SMackerel-Charter-5YHCK^0.5	1.9300***	(0.2570)	0.8527***	(0.2518)
KMackerel-Private-5YHCK^0.5	0.5850***	(0.1024)	0.5150***	(0.0819)
Smallgame-Private-5YHCK^0.5	0.8934***	(0.0908)	0.7707***	(0.0715)
SMackerel-Private-5YHCK^0.5	0.6019***	(0.0728)	0.5468***	(0.0565)
Home County Fishing Site	3.0632***	(0.1954)	1.7835***	(0.1439)
TC (Mid-Point of County)	-0.0478***	(0.0021)		
TC (Median of Sites' Coord)			-0.0299***	(0.0019)
IV parameters:				
King Mackerel/Charter Boat	5.1954***	(0.3456)	2.8829***	(0.3163)
Small game/Charter Boat	1.8729***	(0.1083)	1.0578***	(0.0839)
Spanish Mackerel/Charter Boat	6.1585***	(0.3463)	4.2206***	(0.3823)
King Mackerel/Private Boat	1.7983***	(0.0864)	1.1084***	(0.0718)
Small game/Private Boat	7.0302***	(0.6527)	3.2005***	(0.7292)
Spanish Mackerel/Private Boat	1.6454***	(0.0955)	0.9164***	(0.0735)
Log likelihood	-5132.5961		-5324.3641	
N. of cases	424763		424763	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10. Welfare Measures (WTP) for King Mackerel model

	Method 1			Method 2			Method 3		
	WTP	LL	UL	WTP	LL	UL	WTP	LL	UL
KMackerel-Charter-5YHCK^0.5	39.1	29.6	48.8	35.1	23.1	46.8	36.8	25.2	48.3
Smallgame-Charter-5YHCK^0.5	52.3	48.2	56.6	43.0	35.4	50.2	41.7	35.2	48.0
SMackerel-Charter-5YHCK^0.5	41.8	34.4	49.3	28.7	15.1	41.3	31.8	20.0	43.1
KMackerel-Private-5YHCK^0.5	10.5	7.10	14.0	13.9	9.54	18.1	13.3	9.27	17.3
Smallgame-Private-5YHCK^0.5	15.0	12.0	18.2	21.5	17.8	25.4	20.1	16.6	23.9
SMackerel-Private-5YHCK^0.5	10.8	8.44	13.2	16.1	13.4	19.0	14.9	12.3	17.7

Table 11. Welfare Measures (WTP) for King Mackerel model (HCFS is included)

	Method 1			Method 3		
	WTP	LL	UL	WTP	LL	UL
KMackerel-Charter-5YHCK^0.5	36.9	26.1	48.0	31.8	17.8	45.6
Smallgame-Charter-5YHCK^0.5	51.7	46.9	56.7	40.6	32.9	48.1
SMackerel-Charter-5YHCK^0.5	40.4	31.0	49.9	28.5	13.0	43.2
KMackerel-Private-5YHCK^0.5	12.2	8.04	16.6	17.2	12.0	22.7
Smallgame-Private-5YHCK^0.5	18.7	14.9	22.7	25.8	21.0	31.0
SMackerel-Private-5YHCK^0.5	12.6	9.61	15.6	18.3	14.5	22.4

Table 12. Nested logit outputs for Red Snapper model

	Method 1		Method 2		Method 3	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Ln (Number of sites)	0.3907***	(0.0616)	0.4717***	(0.0688)	0.5321***	(0.0765)
Grouper-Private-5YHCK^0.5	0.5933***	(0.1025)	0.6366***	(0.1081)	0.7157***	(0.1177)
Osnappers-Private-5YHCK^0.5	0.3523***	(0.0797)	0.3518***	(0.0813)	0.3854***	(0.0877)
Red_Snapper-Private-5YHCK^0.5	0.8124***	(0.1185)	0.7971***	(0.1132)	0.8193***	(0.1173)
TC (Mid-Point of County)	-0.0252***	(0.0027)				
TC (Mean of Sites' Coord)			-0.0289***	(0.0032)		
TC (Median of Sites' Coord)					-0.0314***	(0.0035)
IV parameters:						
Grouper/Private Boat	0.4863***	(0.0604)	0.4337***	(0.0553)	0.4587***	(0.0588)
Other Snappers/Private Boat	0.6163***	(0.0720)	0.5942***	(0.0718)	0.6446***	(0.0783)
Red Snapper/Private Boat	0.9284***	(0.1168)	0.8763***	(0.1110)	0.9358***	(0.1197)
Log likelihood	-1870.4991		-1730.7653		-1713.3875	
N. of cases	64260.0000		64260.0000		64260.0000	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 13. Nested logit outputs for Red Snapper model (HCFS is included)

	Method 1		Method 2		Method 3	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Ln (Number of sites)	0.5523^{***}	(0.0872)	0.5891^{***}	(0.0902)	0.6382^{***}	(0.0967)
Grouper-Private-5YHCK^0.5	0.6466^{***}	(0.1210)	0.6953^{***}	(0.1278)	0.7350^{***}	(0.1336)
Osnappers-Private-5YHCK^0.5	0.3988^{***}	(0.0993)	0.4139^{***}	(0.1023)	0.4376^{***}	(0.1070)
Red_Snapper-Private-5YHCK^0.5	0.8739^{***}	(0.1246)	0.8916^{***}	(0.1242)	0.9207^{***}	(0.1275)
Home County Fishing Site	1.4166^{***}	(0.1819)	1.1615^{***}	(0.1601)	1.2204^{***}	(0.1674)
TC (Mid-Point of County)	-0.0178^{***}	(0.0020)				
TC (Mean of Sites' Coord)			-0.0226^{***}	(0.0025)		
TC (Median of Sites' Coord)					-0.0245^{***}	(0.0027)
IV parameters:						
Grouper/Private Boat	0.6477^{***}	(0.0807)	0.6129^{***}	(0.0775)	0.6502^{***}	(0.0818)
Other Snappers/Private Boat	0.7272^{***}	(0.0838)	0.7145^{***}	(0.0845)	0.7601^{***}	(0.0894)
Red Snapper/Private Boat	0.9490^{***}	(0.1175)	0.9083^{***}	(0.1133)	0.9461^{***}	(0.1173)
Log likelihood	-1698.5432		-1620.7695		-1605.6368	
N. of cases	64260		64260		64260	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 14. Welfare Measures (WTP) for Red Snapper

	Method 1			Method 2			Method 3		
	WTP	LL	UL	WTP	LL	UL	WTP	LL	UL
Grouper-Private-5YHCK^0.5	23.5	17.5	29.6	22.0	16.8	27.3	22.8	17.6	28.0
Osnappers-Private-5YHCK^0.5	14.0	8.47	19.3	12.2	7.37	16.7	12.3	7.60	16.8
Red-Snapper-Private-5YHCK^0.5	32.2	23.5	42.8	27.6	20.5	36.2	26.1	19.1	34.6

Table 15. Welfare Measures (WTP) for Red Snapper (HCFS is included)

	Method 1			Method 2			Method3		
	WTP	LL	UL	WTP	LL	UL	WTP	LL	UL
Grouper-Private-5YHCK^0.5	36.3	24.8	48.6	30.7	21.7	40.1	30.0	21.3	39.3
Osnappers-Private-5YHCK^0.5	22.4	12.3	32.4	18.3	10.3	25.9	17.9	10.2	25.3
Red Snapper-Private-5YHCK^0.5	49.0	36.0	64.8	39.4	29.5	51.3	37.6	28.1	49.2

CHAPTER 5

CONCLUSION

The marginal value of catch depends on the quality of fishing sites and travel cost. Previous studies aggregate the available data over the counties and utilize the center or midpoint of each county or in some studies the closest city or zip code to a destination like a national park, river, or lake. This approach results in measurement error in calculating the distance, and consequently, the welfare measure (MWTP).

In this study, we contribute to previous studies by introducing a new method to calculate the travel cost for the alternative sites; that is utilizing the mean or median of the coordinates of available intercepted sites (NOAA - MRIP Site Register Data) for calculating the travel cost. We use the mean and median of the coordinates of fishing sites in the coastal counties along Southeast Atlantic and the Gulf of Mexico, to measure the travel distance of alternative fishing sites and compare it to the conventional method using the mid-point of county-level sites. We use the nested logit model to estimate, the willingness-to-pay (WTP) of charter and private/rental boat anglers for one additional catch on day-trip for Dolphinfish, King Mackerel, and Red Snapper.

We calculate three travel cost (TC) measures. The first measure is the distance from anglers' home zip code to the midpoint of the aggregated over county sites. The second measure uses the mean of the coordinates of fishing sites, and in the third one median of the altitude and latitude of fishery locations in each county is utilized. Moreover, we add a new dummy (HCFS) to take into account the effect of other preferences of coastal county anglers. We investigate the sensitivity of the estimated marginal willingness to pay (MWTP), for one additional Dolphinfish, Red Snapper, or King Mackerel per day trip, to these measures of the alternative sites' distance. Moreover, we added a dummy, HCFC, to the conventional nested logit model variables (travel cost and quality of site), as an alternative specific variable, to take into account anglers that choose a county-level site since they live there, and also the coastal county anglers that do not choose their home county site and go to other counties for fishing.

The results indicate that the conventional method overestimates the WTP of charter boat anglers for Dolphinfish and King Mackerel, and underestimates the WTP of private boat anglers for these species. The estimated welfare measures (WTP) for Dolphinfish, excluding and including HCFC, are \$16.6 and \$19.7, respectively. Utilizing the mid-point of alternative county-level sites (conventional approach) in King Mackerel model overestimates the willingness to pay of charter boat anglers and underestimates the willingness to pay of private boat anglers. The estimated WTP for Red Snapper in the model without HCFS are \$32.2, \$27.6, and \$26.1 using method one, two, and three, respectively. However, in the model with HCFS these estimates are much higher \$49.0, \$39.4, and \$37.6. However, there is no change in the descending trend from method one to three. All in all, the estimated welfare measures (WTP) in the conventional approach are overestimated compared to introduced methods.

In conclusion, this study shows that the estimated welfare measures using mean and median of fishing sites' coordinates provide more conservative estimations compare to the conventional method. Failure to adopt these approaches may cause overestimated or underestimated welfare measures depending on the dispersion of anglers across the Gulf of Mexico and Southeast Atlantic and fishing mode.

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APPENDIX

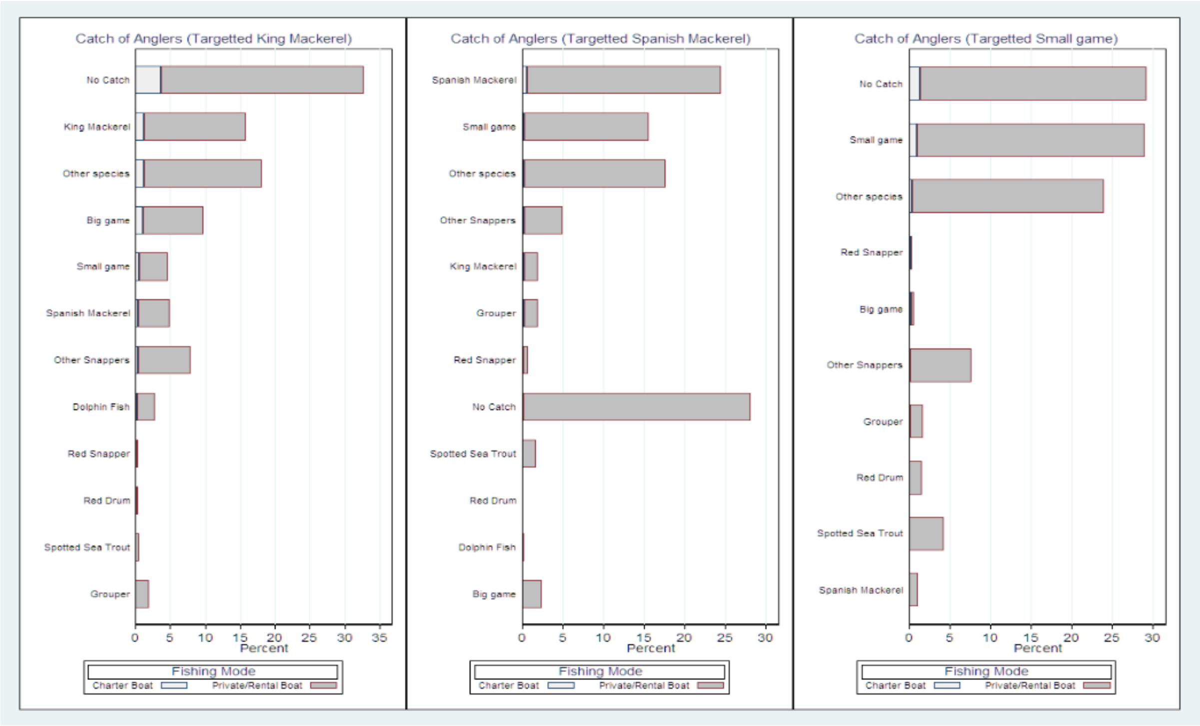

Figure 30. The catch of private/rental and charter anglers that targeted King Mackerel, Spanish Mackerel, and Small game species

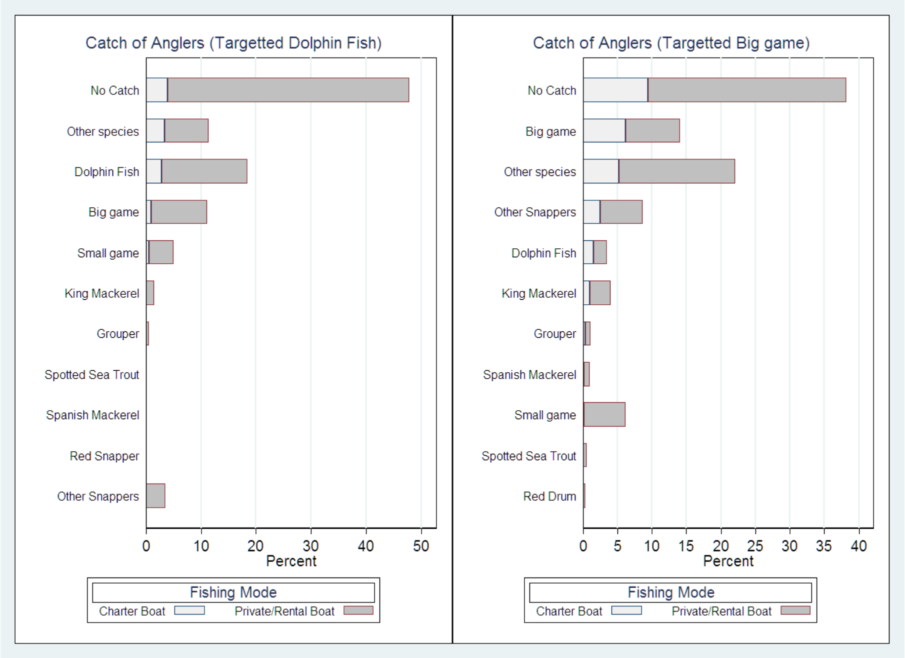

Figure 31. The catch of private/rental and charter anglers that targeted Dolphinfish and big game species

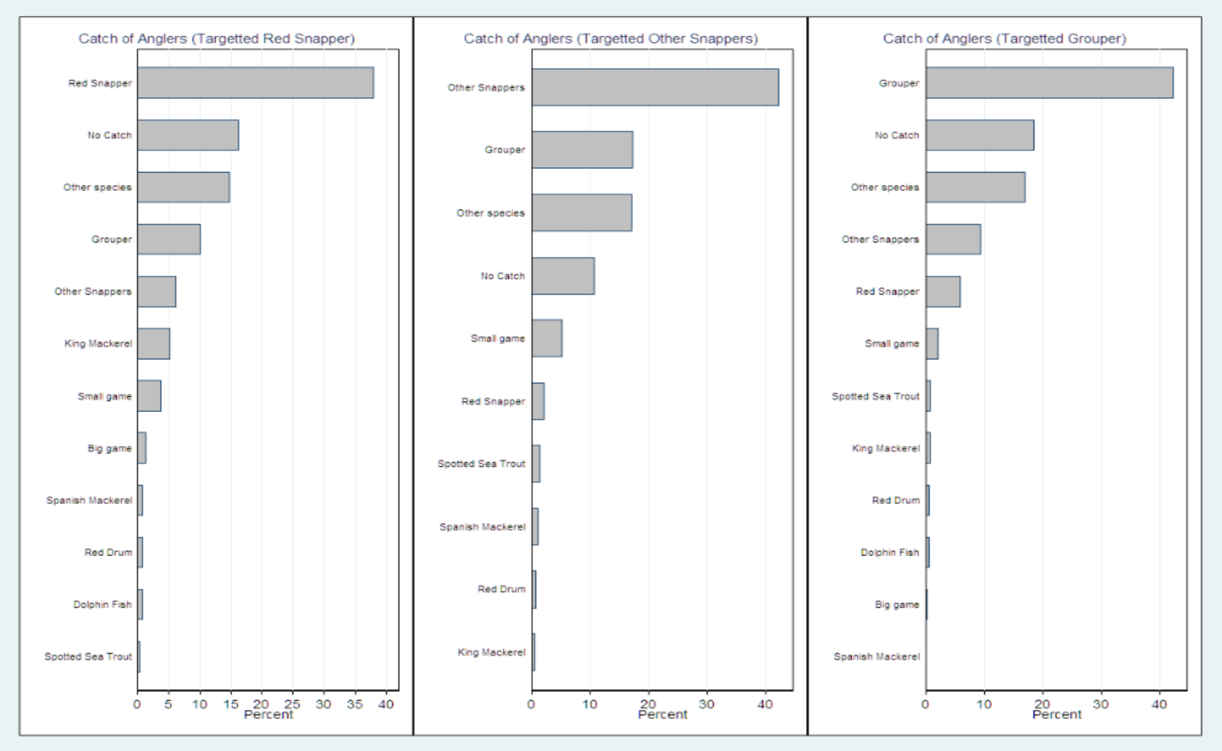

Figure 32. The catch of private/rental and charter boat anglers, (Grouper and Red Snapper model)

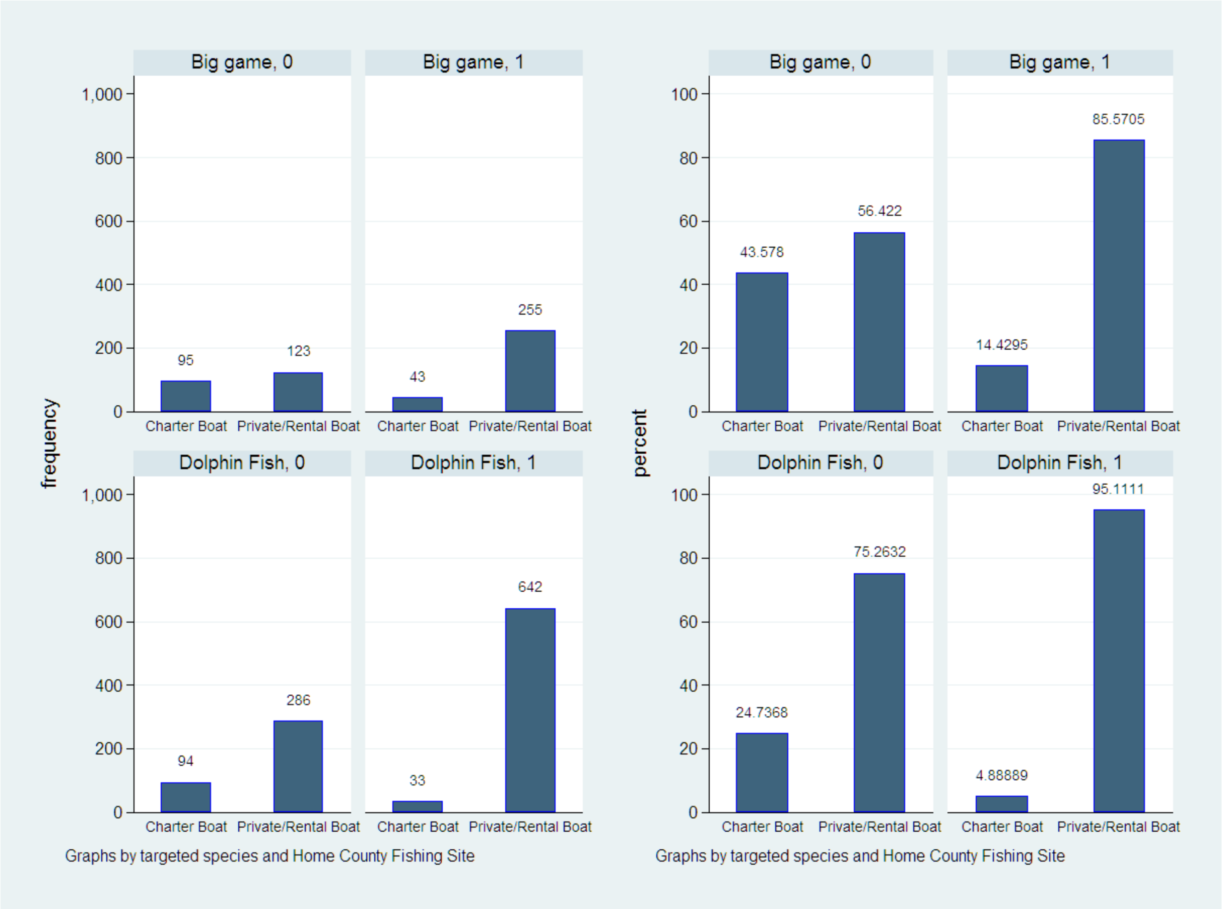

Figure 33. Frequency and percentage of charter and private/rental anglers in Dolphinfish model by targeted species and dummy Home County Fishing Site

Figure 34. Frequency and percentage of charter and private/rental anglers in King Mackerel model by targeted species and dummy Home County Fishing Site

Figure 35. Frequency and percentage of charter and private/rental anglers in Red Snapper model by targeted species and dummy Home County Fishing Site (yes choose home county as fishing site, no otherwise)

Table 16. Frequency of chosen aggregated over county sites in each state (charter boat anglers target King Mackerel)

County Name	State				Total
	FL	GA	NC	SC	
Bay	10	0	0	0	10
Brevard	3	0	0	0	3
Broward	21	0	0	0	21
Brunswick	0	0	2	0	2
Colleton	0	0	0	3	3
Dare	0	0	4	0	4
Georgetown	0	0	0	4	4
Glynn	0	2	0	0	2
Manatee	1	0	0	0	1
Miami-Dade	2	0	0	0	2
Nassau	2	0	0	0	2
Okaloosa	3	0	0	0	3
Palm Beach	8	0	0	0	8
Pinellas	9	0	0	0	9
Sarasota	1	0	0	0	1
Total	60	2	6	7	75

Table 17. Frequency of chosen aggregated over county sites in each state (charter boat anglers target small game species)

County Name	State				Total
	FL	LA	MS	NC	
Bay	6	0	0	0	6
Collier	3	0	0	0	3
Dare	0	0	0	12	12
Harrison	0	0	2	0	2
Lee	2	0	0	0	2
Manatee	3	0	0	0	3
Monroe	10	0	0	0	10
Okaloosa	6	0	0	0	6
Plaquemines	0	3	0	0	3
Total	30	3	2	12	47

Table 18. Frequency of chosen aggregated over county sites in each state (charter boat anglers target Spanish Mackerel)

County Name	**State**			**Total**
	FL	NC	SC	
Beaufort	0	0	3	3
Carteret	0	5	0	5
Georgetown	0	0	2	2
Manatee	1	0	0	1
Okaloosa	2	0	0	2
Pinellas	3	0	0	3
Total	6	5	5	16

Table 19. Frequency of chosen aggregated over county sites in each state (private/rental boat anglers target King Mackerel)

County Name	State					Total
	Al	FL	GA	NC	SC	
Baldwin	10	0	0	0	0	10
Bay	0	12	0	0	0	12
Brevard	0	21	0	0	0	21
Broward	0	51	0	0	0	51
Brunswick	0	0	0	24	0	24
Camden	0	0	3	0	0	3
Carteret	0	0	0	114	0	114
Charleston	0	0	0	0	25	25
Charlotte	0	1	0	0	0	1
Duval	0	17	0	0	0	17
Escambia	0	25	0	0	0	25
Flagler	0	1	0	0	0	1
Georgetown	0	0	0	0	15	15
Gulf	0	1	0	0	0	1
Hillsborough	0	2	0	0	0	2
Indian River	0	12	0	0	0	12
Liberty	0	0	2	0	0	2
Manatee	0	4	0	0	0	4
Martin	0	37	0	0	0	37
Miami-Dade	0	24	0	0	0	24
Mobile	14	0	0	0	0	14
Nassau	0	10	0	0	0	10
New Hanover	0	0	0	40	0	40
Okaloosa	0	4	0	0	0	4
Onslow	0	0	0	22	0	22
Palm Beach	0	132	0	0	0	132
Pinellas	0	42	0	0	0	42
Santa Rosa	0	9	0	0	0	9
Sarasota	0	26	0	0	0	26
St Johns	0	1	0	0	0	1
St Lucie	0	45	0	0	0	45
Volusia	0	13	0	0	0	13
Total	24	490	5	200	40	759

Table 20. Frequency of chosen aggregated over county sites in each state (private/Rental boat anglers target small game species)

County Name	State						Total
	Al	FL	LA	MS	NC	SC	
Baldwin	27	0	0	0	0	0	27
Bay	0	1	0	0	0	0	1
Beaufort	0	0	0	0	17	0	17
Brevard	0	21	0	0	0	0	21
Broward	0	9	0	0	0	0	9
Brunswick	0	0	0	0	11	0	11
Carteret	0	0	0	0	192	0	192
Charleston	0	0	0	0	0	3	3
Charlotte	0	17	0	0	0	0	17
Citrus	0	3	0	0	0	0	3
Clay	0	8	0	0	0	0	8
Collier	0	41	0	0	0	0	41
Craven	0	0	0	0	6	0	6
Dare	0	0	0	0	92	0	92
Dixie	0	1	0	0	0	0	1
Duval	0	6	0	0	0	0	6
Escambia	0	10	0	0	0	0	10
Georgetown	0	0	0	0	0	3	3
Hancock	0	0	0	1	0	0	1
Harrison	0	0	0	39	0	0	39
Hillsborough	0	76	0	0	0	0	76
Hyde	0	0	0	0	8	0	8
Indian River	0	24	0	0	0	0	24
Jackson	0	0	0	22	0	0	22
Lee	0	32	0	0	0	0	32
Manatee	0	31	0	0	0	0	31
Martin	0	86	0	0	0	0	86
Miami-Dade	0	59	0	0	0	0	59
Mobile	37	0	0	0	0	0	37
Monroe	0	4	0	0	0	0	4
Nassau	0	1	0	0	0	0	1
New Hanover	0	0	0	0	60	0	60
Okaloosa	0	2	0	0	0	0	2
Onslow	0	0	0	0	30	0	30
Palm Beach	0	50	0	0	0	0	50
Pamlico	0	0	0	0	4	0	4
Pasco	0	29	0	0	0	0	29
Pender	0	0	0	0	2	0	2
Pinellas	0	87	0	0	0	0	87
Plaquemines	0	0	8	0	0	0	8
Santa Rosa	0	2	0	0	0	0	2
Sarasota	0	17	0	0	0	0	17
St Johns	0	4	0	0	0	0	4
St Lucie	0	38	0	0	0	0	38
Volusia	0	4	0	0	0	0	4
Wakulla	0	3	0	0	0	0	3
Total	64	666	8	62	422	6	1,228

Table 21. Frequency of chosen aggregated over county sites in each state (private/rental boat anglers target Spanish Mackerel)

County Name	State						Total
	Al	FL	GA	MS	NC	SC	
Baldwin	3	0	0	0	0	0	3
Bay	0	11	0	0	0	0	11
Beaufort	0	0	0	0	1	0	1
Brevard	0	1	0	0	0	0	1
Brunswick	0	0	0	0	19	0	19
Bryan	0	0	4	0	0	0	4
Camden	0	0	1	0	0	0	1
Carteret	0	0	0	0	320	0	320
Charleston	0	0	0	0	0	2	2
Citrus	0	10	0	0	0	0	10
Colleton	0	0	0	0	0	1	1
Collier	0	2	0	0	0	0	2
Dare	0	0	0	0	1	0	1
Dixie	0	3	0	0	0	0	3
Duval	0	1	0	0	0	0	1
Escambia	0	8	0	0	0	0	8
Franklin	0	1	0	0	0	0	1
Georgetown	0	0	0	0	0	8	8
Gulf	0	5	0	0	0	0	5
Harrison	0	0	0	1	0	0	1
Hernando	0	8	0	0	0	0	8
Hillsborough	0	24	0	0	0	0	24
Horry	0	0	0	0	0	3	3
Hyde	0	0	0	0	2	0	2
Indian River	0	2	0	0	0	0	2
Lee	0	2	0	0	0	0	2
Liberty	0	0	1	0	0	0	1
Manatee	0	8	0	0	0	0	8
Martin	0	48	0	0	0	0	48
Miami-Dade	0	3	0	0	0	0	3
Mobile	15	0	0	0	0	0	15
New Hanover	0	0	0	0	23	0	23
Okaloosa	0	4	0	0	0	0	4
Onslow	0	0	0	0	3	0	3
Palm Beach	0	10	0	0	0	0	10
Pamlico	0	0	0	0	1	0	1
Pasco	0	8	0	0	0	0	8
Pender	0	0	0	0	1	0	1
Pinellas	0	89	0	0	0	0	89
Santa Rosa	0	5	0	0	0	0	5
Sarasota	0	14	0	0	0	0	14
St Lucie	0	6	0	0	0	0	6
Wakulla	0	5	0	0	0	0	5
Total	18	278	6	1	371	14	688

Table 22. Frequency of aggregated over county sites in each state (charter boat anglers target Big game species)

County Name	**State**				**Total**
	FL	GA	NC	SC	
Broward	6	0	0	0	6
Camden	0	7	0	0	7
Carteret	0	0	12	0	12
Dare	0	0	46	0	46
Glynn	0	1	0	0	1
Horry	0	0	0	2	2
Martin	3	0	0	0	3
Miami-Dade	11	0	0	0	11
Monroe	34	0	0	0	34
Palm Beach	16	0	0	0	16
Total	70	8	58	2	138

Table 23. Frequency of chosen aggregated over county sites in each state (charter boat anglers target Dolphinfish)

County Name	**State**			**Total**
	FL	NC	SC	
Brevard	1	0	0	1
Carteret	0	17	0	17
Charleston	0	0	5	5
Dare	0	25	0	25
Martin	11	0	0	11
Monroe	57	0	0	57
Palm Beach	11	0	0	11
Total	80	42	5	127

Table 24. Frequency of chosen aggregated over county sites in each state (private/rental boat anglers target Big game species)

County Name	**State**				**Total**
	FL	GA	NC	SC	
Beaufort	0	0	1	10	11
Brevard	36	0	0	0	36
Broward	24	0	0	0	24
Brunswick	0	0	1	0	1
Camden	0	2	0	0	2
Carteret	0	0	39	0	39
Charleston	0	0	0	10	10
Chatham	0	4	0	0	4
Dare	0	0	26	0	26
Duval	3	0	0	0	3
Georgetown	0	0	0	1	1
Hyde	0	0	8	0	8
Indian River	16	0	0	0	16
Martin	9	0	0	0	9
Miami-Dade	50	0	0	0	50
Monroe	6	0	0	0	6
Nassau	2	0	0	0	2
New Hanover	0	0	5	0	5
Onslow	0	0	2	0	2
Palm Beach	78	0	0	0	78
Pamlico	0	0	5	0	5
St Johns	9	0	0	0	9
St Lucie	6	0	0	0	6
Volusia	25	0	0	0	25
Total	264	6	87	21	378

Table 25. Frequency of chosen aggregated over county sites in each state (private/rental boat anglers target Dolphinfish)

County Name	**State**			**Total**
	FL	NC	SC	
Beaufort	0	0	1	1
Brevard	28	0	0	28
Broward	169	0	0	169
Carteret	0	62	0	62
Charleston	0	0	10	10
Dare	0	51	0	51
Georgetown	0	0	3	3
Hyde	0	2	0	2
Indian River	16	0	0	16
Martin	80	0	0	80
Miami-Dade	153	0	0	153
Monroe	7	0	0	7
New Hanover	0	6	0	6
Onslow	0	10	0	10
Palm Beach	253	0	0	253
St Johns	11	0	0	11
St Lucie	57	0	0	57
Volusia	9	0	0	9
Total	783	131	14	928

Table 26. Frequency of chosen aggregated over county sites in each state (private/rental boat anglers target Red Snapper)

County Name	**State**				**Total**
	Al	FL	LA	MS	
Baldwin	11	0	0	0	11
Bay	0	13	0	0	13
Escambia	0	53	0	0	53
Harrison	0	0	0	6	6
Jackson	0	0	0	17	17
Jefferson	0	0	11	0	11
Lafourche	0	0	2	0	2
Mobile	39	0	0	0	39
Okaloosa	0	13	0	0	13
Plaquemines	0	0	10	0	10
Santa Rosa	0	28	0	0	28
Terrebonne	0	0	4	0	4
Total	50	107	27	23	207

Table 27. Frequency of chosen aggregated over county sites in each state (private/rental boat anglers target Grouper species)

County Name	**State**				**Total**
	Al	FL	LA	MS	
Baldwin	2	0	0	0	2
Charlotte	0	2	0	0	2
Citrus	0	44	0	0	44
Collier	0	24	0	0	24
Dixie	0	5	0	0	5
Escambia	0	29	0	0	29
Franklin	0	35	0	0	35
Gulf	0	3	0	0	3
Hernando	0	63	0	0	63
Hillsborough	0	31	0	0	31
Jackson	0	0	0	1	1
Jefferson	0	0	3	0	3
Lee	0	6	0	0	6
Levy	0	3	0	0	3
Manatee	0	22	0	0	22
Mobile	5	0	0	0	5
Okaloosa	0	2	0	0	2
Pasco	0	30	0	0	30
Pinellas	0	55	0	0	55
Sarasota	0	30	0	0	30
Taylor	0	2	0	0	2
Wakulla	0	32	0	0	32
Total	7	418	3	1	429

Table 28. Frequency of chosen aggregated over county sites in each state (private/rental boat anglers target other Snapper species)

County Name	State				Total
	Al	FL	LA	MS	
Baldwin	3	0	0	0	3
Bay	0	4	0	0	4
Charlotte	0	11	0	0	11
Citrus	0	13	0	0	13
Collier	0	23	0	0	23
Escambia	0	22	0	0	22
Franklin	0	8	0	0	8
Gulf	0	1	0	0	1
Harrison	0	0	0	1	1
Hernando	0	26	0	0	26
Hillsborough	0	76	0	0	76
Jackson	0	0	0	4	4
Jefferson	0	0	18	0	18
Lee	0	10	0	0	10
Levy	0	2	0	0	2
Manatee	0	26	0	0	26
Mobile	12	0	0	0	12
Monroe	0	13	0	0	13
Okaloosa	0	2	0	0	2
Pasco	0	5	0	0	5
Pinellas	0	106	0	0	106
Plaquemines	0	0	12	0	12
Santa Rosa	0	2	0	0	2
Sarasota	0	28	0	0	28
Taylor	0	2	0	0	2
Wakulla	0	5	0	0	5
Total	15	385	30	5	435