The use of sampling weights in regression models of recreational fishing-site choices

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Abstract—Improved methods for estimating saltwater recreational fishing catch and effort have been developed by the NOAA National Marine Fisheries Service. Sampling weights that account for a complex sample design in surveys of anglers are now available with NMFS catch and effort estimates. Previously, estimates of the economic value to anglers (known as the "willingness to pay") for additional fish caught that were based on angler surveys did not typically account for the underlying complex sample design. In this study, a recreational-demand model was used for analysis of fishing site choices in the Gulf of Mexico in 2009 among private-boat anglers who target groupers (*Epinephelus* spp., *Hyporthodus* spp., or *Mycteroperca* spp.) or red snapper (*Lutjanus campechanus*). Different versions of the model were developed with and without accounting for the complex sample design. Results between the unweighted version and weighted versions of the model varied in estimates of catch between sites and the value anglers place on being able to catch and keep additional fish.

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In 2012, the NOAA National Marine Fisheries Service (NMFS) released a new method for estimation of recreational fishing catch and effort based on data obtained from its Access Point Angler Intercept Survey (APAIS) of saltwater anglers. Previous methods of estimation of catch and fishing effort from this intercept [interview] survey were subject to a number of different potential biases as pointed out by the National Research Council of the National Academies (NRC, 2006). In particular, the earlier estimation methods did not account for the complex sample design of the intercept survey and instead simple random sampling was assumed. The new method of estimating catch and effort uses specially calculated weights and variance adjustments (Breidt et al.[1]).

The APAIS sampling weights incorporate information from a separate survey, the NMFS Coastal Household Telephone Survey (CHTS), that is used to estimate fishing effort by coastal residents by state, wave (defined as a consecutive 2-month period), and fishing mode (private boat and shore). Data from the APAIS on the proportion of angler effort from coastal residents to angler effort from noncoastal and out-of-state residents are used to scale the level of angler effort from coastal residents up to an unbiased estimate of total effort for all anglers, both coastal and noncoastal. For example, 85% of private boat trips that targeted groupers and red snapper in the Gulf of Mexico in 2009 were taken by residents of coastal counties. Inclusion of the APAIS sampling weights in recreational site-choice demand models will ensure that results correctly reflect the true proportion of trips that come from coastal residents compared with trips from noncoastal residents. This inclusion is important because the costs associated with traveling between an angler's home and different fishing sites used in the demand models will vary on the basis of proximity to the coast.

A number of recreational site-choice demand models have been developed with the APAIS data (e.g., Whitehead and Haab, 2000; Gentner, 2007; Haab et al., 2012). These mod-

[1] Breidt, F. J., H.-L. Lai., J. D. Opsomer, and D. A. Van Voorhees. 2012. A report of the MRIP sampling and estimation project: improved estimation methods for the Access Point Angler Intercept Survey component of the Marine Recreational Fishery Statistics Survey. [Available from Fisheries Statistics Division, Natl. Mar. Fish. Serv., NOAA, Silver Spring, MD, and from http://www.countmyfish.noaa.gov/projects/downloads/Final%20Report%20of%20New%20Estimation_Method_for_MRFSS_Data-01242012.pdf.]

els examine how anglers make choices about which fishing sites to visit on the basis of the costs of travel to a site and the qualities of a site. For models of recreational fishing, site quality is typically measured by the average harvest rate per angler at a site. The parameters of site-choice models are used to estimate economic values associated with recreational fishing. However, failure to account for the complex sampling design of the NMFS APAIS survey could result in biased demand-model parameters. It is important to have unbiased model parameters to obtain accurate estimates of benefits and costs and to ensure that policy recommendations are not misleading.

The APAIS data are collected by using a stratified, multistage survey design with stratification that is based on intercept site, time of year, and other variables. Therefore, the proportion of anglers interviewed at each intercept site may reflect sampling allocations and not necessarily reflect angler preferences or the *demand* for one site over another. This problem of demand estimation is commonly referred to as *endogenous stratification*. Another issue with demand estimation can arise when using APAIS data because more avid users tend to be overrepresented in intercept surveys. This problem, referred to as *avidity bias*, can cause demand-model parameters to be influenced more heavily by avid users. Hindsley et al. (2011), using simulated data sets, found evidence of both endogenous stratification and avidity bias. However, their analysis was performed before the new NMFS estimation methods were available. The sampling information made available through the updated estimation methods can be used to generate sampling weights to correct for endogenous stratification in recreational site-choice demand models developed with data from the APAIS.

The goal of our analysis was to compare the estimates of parameters and economic value that result from the use of a typical NMFS recreational site-choice demand model with and without the newly available sampling weights designed to correct for endogenous stratification. We used a model of fishing site choices among private-boat anglers in the Gulf of Mexico who target groupers (*Epinephelus* spp., *Hyporthodus* spp., or *Mycteroperca* spp.) or red snapper (*Lutjanus campechanus*). Following Kuriyama et al. (2013), we focus on the correction for endogenous stratification and do not attempt to correct for potential avidity bias. More details on avidity bias and how to correct for it are given in Thomson (1991) and Hindsley et al. (2011).

Materials and methods

Model specification and estimation of angler willingness to pay

The standard recreational discrete choice model that uses APAIS data has the angler choosing a preferred fishing site on any given occasion when a choice can be made (e.g., day). Following Whitehead and Habb (2000) and Gentner (2007), we limited the options available to each angler to trips at locations within a 300-mi (483 km) round trip from an angler's residence. We also assumed that the angler had already decided to fish from a private boat and had decided which species to target so that the primary choice was where to launch the boat. In our model, this choice is made by comparing the benefits or *utility* available from each potential launch site against the costs of getting to each site. The indirect utility, U_j, of going to site j for angler i can be written as

$$U_{ji} = v_{ji}\,(q_j,\, m_i - c_{ji}) + \varepsilon_{ji}, \tag{1}$$

where m_i = income; and

for angler i at site j:

v_{ij} = the observable portion of utility;
c_{ij} = the trip cost;
q_j = a vector of attributes that defines the quality of fishing and other site features; and
ε_{ij} = the error term that represents the unobserved (to the analyst) portion of utility.

The observable portion of utility, such as travel costs and site characteristics (harvest rates for a site) or other site amenities (such as those at a marina), is based on those attributes that can be observed and measured by the analyst. The unobserved portion includes information on characteristics of the site or angler that are unavailable to the analyst, for example, the presence of a tackle shop near a site or the number of years of experience an angler has at a given site.

Under the assumptions of the random utility model (McFadden, 1974), an angler will choose the site that provides the greatest level of utility:

$$V_{ij}\,(q_j,\, m_i - c_{ij}) + \varepsilon_{ij} \geq V_{is}(q_s,\, m_i - c_{is}) + \varepsilon_{is} \quad \forall\, j \neq s, \tag{2}$$

where V = the utility function; and
j = a member of s recreation sites.

Assuming that the observed portion of utility is linear, $V_{ij}\,(q_j,\, m_i - c_{ij}) = \beta_q q_j + \beta_c c_{ij}$, and the unobserved portions of utility, ε_j, have a type-I extreme value distribution, the probability that angler i chooses site j can be estimated with a standard conditional logit model:

$$P_{ij} = P(y_i = j) = \frac{\exp(\beta_q q_j + \beta_c c_{ij})}{\sum_{s=1}^{J} \exp(\beta_q q_j + \beta_c c_{ij})}, \tag{3}$$

where y_i = the choice made by angler I; and
β_q and β_c are parameters to be estimated.

The parameters of the conditional logit model are typically estimated through the use of maximum likelihood with the following log-likelihood expression:

$$LL(\beta) = \sum_{i=1}^{N} \sum_{j=1}^{J} d_{ij} \log P_{ij}, \tag{4}$$

where N = the number of anglers in a sample; and

d_{ij} = 1 if angler i chooses site j and 0 otherwise.

We will refer to Equation 4 as the *unweighted estimator* because this specification is based on the assumption that the anglers are selected to be interviewed by simple random sampling. Manski and Lerman (1977) suggested a way to weight the conditional logit estimator by using information on the estimated population proportion of anglers observed at each of the j sites. The log likelihood of the weighted exogenous sampling maximum likelihood (WESML) estimator is

$$LL(\beta) = \sum_{i=1}^{N} \sum_{j=1}^{J} \frac{Q_j}{H_j} d_{ij} \log P_{ij}, \quad (5)$$

where Q_j and H_j are the population and sample proportions at site j.

Note that the variance matrix of the estimated parameters must also be corrected to reflect the nonrandom nature of the data (Lerman and Manski, 1981).

The estimated parameters of the conditional logit model can be used to determine an angler's willingness to pay (WTP) for changes in site characteristics or for the loss or addition of a site (Haab and McConnell, 2002). The most common measure used in the NMFS recreational site-choice demand models with the APAIS data is the value of a one-unit change in harvest rate. If we define one element of q, say q_1, as the harvest rate, then the average angler WTP for a one-unit change in this attribute is given by

$$WTP(q_1) = \frac{\beta_{q_1}}{\beta_c}. \quad (6)$$

We calculated confidence intervals for this nonlinear combination of parameters using the method of Krinsky and Robb (1986) with 1000 random draws from the multivariate normal distribution defined by the estimated mean parameter vector β and its related estimated covariance matrix. The mean marginal WTP by anglers is given by the mean of the simulated WTP vector calculated by evaluating expression 5 with the 1000 parameter draws. Similarly, the upper and lower 95% confidence intervals are given by the 5^{th} and 95^{th} quantile of the simulated WTP vector. The unweighted conditional logit and the WESML versions of the model and WTP confidence intervals were estimated with the software NLogit[2], vers. 5 (Econometric Software, Plainview, NY).

The simulated WTP vectors can also be used to formally test whether the mean WTP estimates generated by the weighted versions of the model are significantly different from the mean WTP estimates produced with the unweighted version of the model. We use the method of convolutions suggested by Poe et al. (2005) to test the null hypothesis that the estimates of mean unweighted WTP and mean weighted WTP are equal against the alternative that the unweighted estimate is larger than the weighted estimate. The calculations with the method of convolutions were performed with the mded package for R, vers. 3.0.0 (R Core Team, 2013).

Sources and description of data

Data with which to estimate the conditional logit demand models came from a sample of private-boat anglers who were interviewed in 2009 as part of the APAIS in the Gulf of Mexico. The APAIS is a stratified, multistage, cluster-sample survey of angler trips designed to obtain estimates of mean catch per angler fishing day by species type and angler effort for each state, wave (2-month period), fishing mode (private boat, for-hire boat, and shore), and area fished (inland, state waters, and federal waters). The sample frame is based on the number of days at coastal fishing sites (site-days) that are accessible to the general public. Before 2011, simple random sampling was assumed during estimation procedures for estimates of mean catch and total effort, although the data were collected through the use of a complex sample design. The APAIS sampling weights were designed to incorporate the complex sample design and nonrandom nature of the sample (Breidt et al.[1]). Available as part of the APAIS data sets, these weights were calibrated by the NMFS Marine Recreational Information Program so that they summed to total estimated angler effort by year, wave, state subregion, fishing mode, and area fished. This calibration was based on estimates of total angler effort from data from the APAIS and CHTS, both of which are part of the NMFS Marine Recreational Information Program. The CHTS is a random-digit-dial telephone survey of households stratified by coastal counties to obtain the number of private boat and shore trips made by each member of a household in a 2-month period. Summation of the weightings within or across strata can then provide an estimate of total fishing effort by those same strata or combinations of strata (Foster[3]).

We selected APAIS trips by anglers who launched from sites along the coasts of western Florida, Alabama, Mississippi, and Louisiana and who reported targeting (by hook and line) red snapper or any of the following species of groupers: rock hind (*Epinephelus adscensionis*), speckled hind (*E. drummondhayi*), red hind (*E. guttatus*), red grouper (*E. morio*), yellowedge grouper (*Hyporthodus. flavolimbatus*), misty grouper (*H. mystacinus*), Warsaw grouper (*H. nigritus*), snowy grouper (*H. niveatus*), black grouper (*Mycteroperca bonaci*), yellowmouth grouper (*M. interstitialis*), gag (*M. microlepis*), scamp (*M. phenax*), tiger grouper (*M. tigris*), and yellowfin grouper (*M. venenosa*). Anglers who indicated they targeted any type of grouper also were

[2] Mention of trade names or commercial companies is for identification purposes only and does not imply endorsement by the National Marine Fisheries Service, NOAA.

[3] Foster, J. 2013. Personal commun. Office of Science and Technology, Natl. Mar. Fish. Serv., NOAA, Silver Spring, MD 20910.

Table 1

Average unweighted (UW) and weighted (W) harvest rates per angler trip for groupers (*Epinephelus* spp., *Hyporthodus* spp., or *Mycteroperca* spp.) and red snapper (*Lutjanus campechanus*) were calculated for 28 fishing zones, which represented a coastal county along the Gulf of Mexico where fishing for these species occurred in 2009. Data are from the National Marine Fisheries Service's Access Point Angler Intercept Survey in west Florida, Alabama, Mississippi, and Louisiana for anglers fishing from private boats. This table also shows the number of individual sites within each zone where fishing occurred for groupers and red snapper. The proportion of angler trips by zone is shown for the sample (H_j) data. Survey weights were used first to estimate the total number of trips at the population level by zone and then to calculate by zone the proportion of trips evaluated at the mean population level (Q_j) and the lower and upper limits of the 95% confidence interval around the mean. No value in a cell signifies that the zone had no predicted trips in the lower-limit scenario and, therefore, data for that zone were not used.

		Harvest rate				Proportion of trips			
		Groupers		Red snapper			Population (Q_j)		
Zone	Number of sites	UW	W	UW	W	Sample (H_j)	Mean	Lower limit	Upper limit
1	7	0.150	0.043	1.155	1.003	0.025	0.020	0.036	0.016
2	3	0.708	0.763	1.000	0.898	0.046	0.038	0.046	0.035
3	9	0.732	0.668	1.273	1.219	0.023	0.050	–	0.068
4	2	0.532	0.527	0.010	0.010	0.002	0.004	–	0.006
5	5	0.433	0.411	0.010	0.010	0.058	0.040	0.048	0.037
6	7	0.059	0.049	0.010	0.010	0.033	0.054	0.047	0.053
7	4	0.563	0.533	0.333	0.333	0.003	0.003	–	0.005
8	11	0.403	0.408	1.380	1.601	0.074	0.072	0.059	0.071
9	11	1.119	1.098	1.310	1.495	0.036	0.059	–	0.071
10	3	0.864	0.956	1.086	1.181	0.007	0.003	–	0.005
11	3	0.246	0.222	0.010	0.010	0.085	0.053	0.060	0.049
12	9	0.148	0.262	0.010	0.010	0.104	0.091	0.137	0.078
13	7	0.254	0.165	0.010	0.010	0.006	0.007	–	0.010
14	3	1.027	1.435	0.010	0.010	0.003	0.002	–	0.003
15	7	0.193	0.212	0.010	0.010	0.034	0.034	0.011	0.037
16	5	0.208	0.303	1.153	1.188	0.030	0.039	0.022	0.041
17	4	0.384	0.318	0.010	0.010	0.042	0.033	0.045	0.029
18	19	0.344	0.337	1.500	1.643	0.187	0.188	0.351	0.148
19	3	0.182	0.193	1.262	1.689	0.026	0.056	–	0.084
20	6	0.551	0.499	1.402	1.402	0.067	0.058	0.044	0.058
21	5	1.143	1.054	0.010	0.010	0.002	0.001	–	0.002
22	5	0.786	0.749	0.010	0.010	0.031	0.043	0.041	0.042
23	3	0.010	0.010	1.020	1.045	0.022	0.018	0.021	0.017
24	3	0.010	0.010	1.707	1.381	0.002	0.001	–	0.001
25	3	1.400	1.039	1.749	1.867	0.018	0.018	–	0.023
26	2	0.010	0.010	2.931	3.412	0.008	0.006	–	0.007
27	4	0.010	0.010	0.200	0.170	0.006	0.002	0.006	0.001
28	5	0.010	0.010	0.512	0.520	0.017	0.009	0.026	0.005

included. Anglers from Texas were not included because Texas does not participate in the Marine Recreational Information Program. Following standard practice (e.g., Gentner, 2007; Haab et al., 2012), we grouped together the intercept sites, where anglers were interviewed, within the same coastal county and then redefined the site chosen by the angler in terms of a coastal county, or *zone*. Across the 4 states in our sample, 160 APAIS intercept sites had data for private-boat trips for groupers or red snapper. We aggregated these 160 sites into 28 zones (Table 1). To address potential biases with aggregation of differing numbers of sites in each zone, a variable for the natural logarithm of the number of sites in that zone was included in the vector, q, of attributes (Parsons and Needleman, 1992). Figures 1 and 2 were created with the maps, ggplot2, and GISTools packages for R, vers. 3.0.0 (R Core Team, 2013).

The mean population-level frequency of trips in each zone in 2009 (and the 95% confidence interval) was estimated with the Surveyfreq procedure in SAS, vers. 9.3 (SAS Institute, Cary, NC) by using the APAIS weightings, stratum, and cluster information. The mean, lower confidence limit, and upper confidence limit of the population proportions (Q_j) were divided

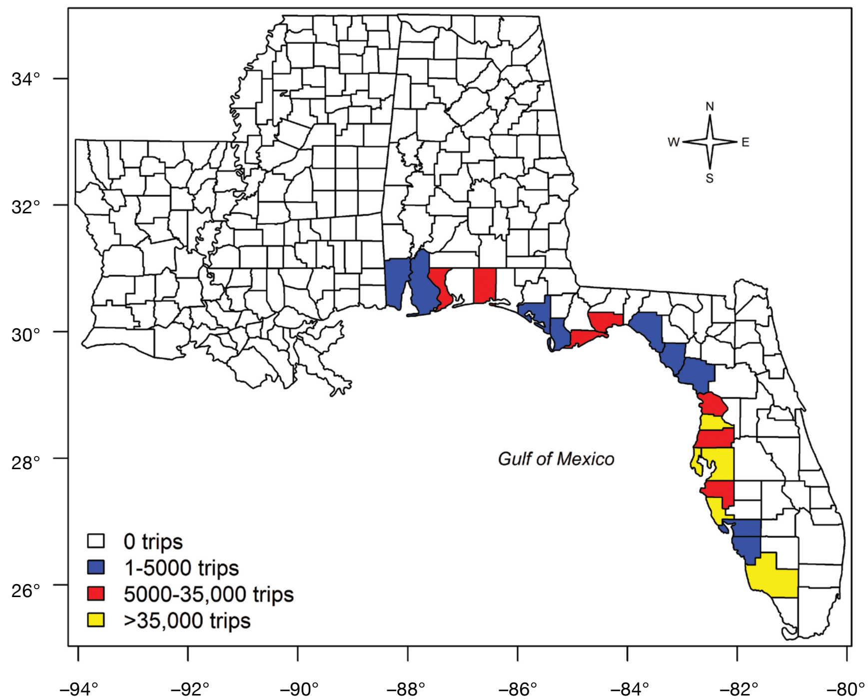

Figure 1

The number of angler fishing trips, by state, that targeted groupers (*Epinephelus* spp., *Hyporthodus* spp., or *Mycteroperca* spp.) from private boats in the Gulf of Mexico in 2009. Data are from the National Marine Fisheries Service's Access Point Angler Intercept Survey. Trips are distributed across coastal counties in Florida, Alabama, Mississippi, and Louisiana according to locations of intercept sites on shore where anglers were interviewed for the survey.

by the sample proportions (H_j) to construct 3 versions of the weights for the WESML estimator (Table 1). On the basis of the lower limit of the population proportion, 12 of the 28 zones had no predicted trips in the scenario; these zones were left out of the model in the lower-limit scenario. In other words, whereas the other models were estimated with 28 zones, the lower-limit WESML model was estimated with 16 zones.

We used APAIS catch data to calculate the unweighted and weighted average harvest rates for groupers and red snapper for each of the 28 zones over the 5 years (2004–08) that preceded our sample period of 2009 (Table 1). Average harvest rates were calculated with the Surveymeans procedure in SAS. These targeted harvest rates represent the number of fish caught and kept per angler on a targeted trip and are used as a proxy for fishing quality in the vector, q, of attributes in the demand model. We also considered including the catch rates for other snappers (as a group) into the model as did Haab et al. (2012). However, there were very few target trips for offshore varieties of snappers in the APAIS data set (gray snapper [*Lutjanus griseus*] was excluded because it is primarily an inshore species). Zones with historically high targeted harvest rates for groupers and red snapper should be preferred by anglers targeting these species. Note that the unweighted conditional logit demand model was based on the unweighted harvest rates, whereas the WESML demand models were based on the weighted harvest rates. Our goal was to compare estimated parameters and angler WTP between a typical demand model that does not use any APAIS weight information and typical demand models that do use this information.

Travel cost, c, to each zone was calculated as the round-trip distance in miles, from the centroid of the angler's zip code of residence to the centroid of the first zip code in the zone, multiplied by the cost per mile. The distances were calculated with PC*Miler, vers. 23 (ALK Technologies, Princeton, NJ). We used \$0.59 as the cost per mile on the basis of the standard business mileage rate for 2009 from the Internal Revenue Service (IRS[4]), adjusted to 2012 dollars using the Consumer Price Index (CPI Inflation Calculator, Bureau of Labor Statistics, http://www.bls.gov/data/inflation_calculator.htm).

We did not include the opportunity cost of time in the model because information on angler income or whether or not the angler took time off from work to fish was not collected in the 2009 APAIS. Gentner (2007) notes that relatively few (e.g., <4% in 2000) anglers reported having foregone income when asked to be part of the APAIS.

Results

In 2009, anglers who targeted primarily groupers took trips from central and southwestern Florida (Fig. 1). Anglers in Louisiana and Mississippi targeted red snapper more often than groupers (Fig. 2). In the Florida panhandle area and in Alabama, anglers tended to target both species, but the proportion of trips during which groupers were targeted there was less than the proportion of trips in other areas of Florida. In the models, 990 observations were available for use; 725 trips during which anglers targeted groupers and 265

[4] IRS (Internal Revenue Service). 2008. IRS announces 2009 standard mileage rates. IRS News Release IR-2008-131, 24 November. [Available from http://www.irs.gov/uac/IRS-Announces-2009-Standard-Mileage-Rates.]

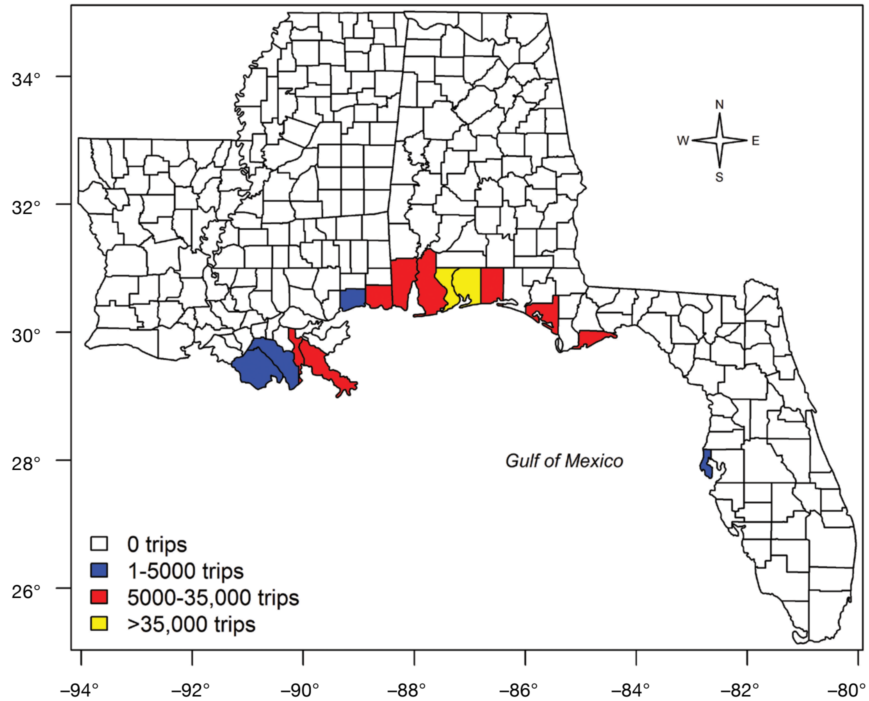

Figure 2

The number of angler fishing trips, by state, that targeted red snapper (*Lutjanus campechanus*) from private boats in the Gulf of Mexico in 2009. Data are from the National Marine Fisheries Service's Access Point Angler Intercept Survey. Trips are distributed across coastal counties in Florida, Alabama, Mississippi, and Louisiana according to locations of intercept sites on shore where anglers were interviewed for the survey.

trips during which anglers targeted red snapper (Table 2). With application of the sampling weights, these observations correspond to an estimated 716,701 trips. Anglers that targeted groupers traveled an average of 53 mi (85 km) round trip between their permanent residence and the fishing site, whereas those anglers that targeted red snapper averaged 72 mi (116 km) round trip. Anglers caught an average of 0.39 groupers per trip in the previous 5 years and an average of 1.38 red snapper per trip.

The estimation results of the site-choice model show that regardless of model version, anglers preferred sites that had lower travel costs than other sites in their choice set (Table 3). The parameter (β_c) related to the travel cost variable was statistically significant and similar in magnitude across all versions of the model. In the unweighted version of the model, the estimated travel cost parameter was –0.060, versus –0.056 for the version of the WESML model weighted with the mean site frequencies (Table 3). The results also indicate that anglers were relatively more likely to be observed fishing from zones with a relatively higher number of fishing sites. The size of the parameter for the site aggregation variable was fairly consistent between the unweighted version of the model (0.251) and the WESML model weighted with the mean site frequencies (0.242).

The results indicate that anglers preferred sites with higher average catch-and-keep rates regardless of target species. The parameter for the grouper catch rate is positive and significant across all model versions (Table 3). Compared with the grouper catch-and-keep parameter in the unweighted version of the model (b_1=0.784), the catch-and-keep parameter with the WESML version of the model with the mean site frequencies was 4% larger (b_1=0.819). For red snapper, the comparisons across versions of the model had results similar to those comparisons for groupers. The estimated parameter value for the catch-and-keep rate was statistically significant in all versions of the model. For the red snapper catch-and-keep rate, the unweighted version of the model resulted in a parameter estimate of 0.471. In contrast, as with the grouper catch-and-keep rate, the parameter estimate for the red snapper catch-and-keep rate from the WESML version of the model weighted with the mean site frequencies was higher (b_1=0.603).

For the travel cost variable, in comparison with the unweighted version of the model, weighting with the lower-limit site frequencies resulted in lower estimated parameter values whereas the use of the upper-limit site frequencies resulted in higher estimated parameter values. The same pattern was observed with the parameters of the harvest rate variables. Ultimately, however, we were interested in the net effect that sampling weights had on the estimates of mean marginal WTP for changes in harvest rates.

The mean marginal WTP for groupers varied between \$8 and \$15 and was significant in all model versions (Table 4). The mean WTP for an additional grouper estimated with the model version that used the weighted catch rates plus the correction for choice-based sampling at the mean frequencies was \$14.67, a value 12.8% higher than the estimate of \$13.01 from the unweighted version of the model. For red snapper, the mean marginal WTP varied between \$4.50 and \$13.81 across the different versions. For this species, the model that used weighted catch rates plus the correction for choice-based sampling at the mean frequencies had a WTP estimate of \$10.81. This value was 38.6% higher than the estimate of \$7.81 from the unweighted version of the model. These results indi-

Table 2

Factors that influenced an angler's choice of fishing site for groupers (*Epinephelus* spp., *Hyporthodus* spp., or *Mycteroperca* spp.) or red snapper (*Lutjanus campechanus*) targeted from private boats in the Gulf of Mexico in 2009: average round-trip distance (in miles) between an angler's permanent residence and a chosen fishing site (standard errors of the mean are presented in parentheses), average travel cost, harvest rate per angler trip (number of fish caught and kept), and average number of fishing sites in a zone (coastal county) where an angler fished. Also shown are the number of angler interviews in which anglers indicated they had targeted groupers or red snapper on the intercepted fishing trip. Data are from the National Marine Fisheries Service's Angler Access Point Intercept Survey in Louisiana, Mississippi Alabama, and west Florida in 2009.

Factor	Groupers	Red snapper
Average round-trip distance (mi)	52.61 (5.19)	72.32 (10.84)
Average travel cost (in 2009 dollars)	$26.30 (2.60)	$36.16 (5.42)
Average harvest rate	0.39 (0.03)	1.38 (0.07)
Average number of fishing sites per zone	9.86 (0.61)	6.42 (0.80)
Number of interviews (trips) in 2009 APAIS data	725	265
Estimated total number of trips	499,931	216,770

cate that weighting may matter with regard to the parameter and WTP estimates. However, on the basis of results from the method of convolutions, we cannot reject the null hypothesis that the unweighted and weighted estimates are equal at the 5% significance level. The *P*-values from testing the unweighted versus the weighted WTP estimates for groupers at the mean, lower-limit, and upper-limit estimated population weights were 0.66, 0.16, and 0.71, respectively. Similarly, the *P*-values from testing the unweighted versus the weighted WTP estimates for red snapper at the mean, lower-limit, and upper-limit estimated population weights were 0.91, 0.09, and 0.99, respectively.

Discussion

The primary aim of this research was to examine estimates of angler WTP that are derived from recreational demand models based on the APAIS data with information from the new sampling weights. We used weighted and unweighted data to estimate different versions of a model of recreational site-choice and measures of angler WTP for changes in harvest rates for groupers and red snapper in the Gulf of Mexico. The structure of the models was selected so that it would be as consistent as possible with the standard site-choice models used for policy-making at NMFS.

Depending on the weights used and species considered, the difference in estimates of angler WTP for a one unit increase in the harvest rate between the weighted versions of the site-choice model and the unweighted version of the model ranged from 13% to 77%. However, by conventional standards, none of the weighted estimates were statistically different from the corresponding unweighted estimates. Although not statically different, the variation could appear large when examining estimates across all anglers that targeted these species. Interpretation of aggregate estimates should be done with care so as not to misdirect policy recommendations. Using APAIS data for the southeastern United States in 2003–04 but different types of weights, Hindsley et al. (2011) found that weighted estimates of angler WTP were around 40% lower than unweighted estimates. Yet, they did not formally test the differences. Kuriyama et al. (2013) found that weighted estimates were around 30% lower than unweighted estimates of angler WTP for changes in harvest rates by shore anglers in California. The data used by Kuriyama et al. (2013) were similar to the APAIS data, but they used a more complicated model structure (mixed logit) and different types of weighting factors (e.g., interview effort). They did not formally test for statistically significant differences between the weighted and unweighted estimates of WTP in their shore fishing case study.

A number of studies have estimated angler WTP for groupers and red snapper in the southeastern United States. Carter and Liese (2012) estimated that anglers were willing to pay between $25 and $80 (in 2003 dollars) to keep an additional grouper, depending on how many fish they had already kept on a trip. Their comparable estimates for red snapper ranged from $20 to $62. These results are considerably higher than the estimates reported in our study (Table 4). However, the analysis by Carter and Liese (2012) was based on stated preference data, which tend to generate relatively higher WTP estimates than revealed preference data such as the data we used in our site-choice demand analysis (Johnston et al., 2006). Haab et al. (2012) pre-

Table 3

The effect of incorporating survey weights into a conditional logit model of angler site-choice is shown below for 4 different versions of the model. The unweighted version included no adjustments for survey weights. The other 3 versions incorporated weights on the basis of the ratio of the proportion of total angler trips by zone to sample proportions. Different weighted versions of the model, with mean values or the lower or upper limit of 95% confidence intervals of the total proportion of estimated trips, were used to estimate parameter values with a weighted exogenous sampling maximum likelihood function (WESML). Estimated parameters (with standard errors of the mean in parentheses) are given for the independent variables. Data used in analyses are from the National Marine Fisheries Service's Angler Access Point Intercept Survey for trips in the Gulf of Mexico in 2009 that targeted groupers (*Epinephelus* spp., *Hyporthodus* spp., or *Mycteroperca* spp.) or red snapper (*Lutjanus campechanus*).

		WESML		
Variable	Unweighted	Mean	Lower limit	Upper limit
Travel cost (2009 dollars)	−0.060 (0.002)	−0.056 (0.002)	−0.067 (0.003)	−0.054 (0.002)
Log of number of sites per zone	0.251 (0.099)	0.242 (0.092)	0.571 (0.142)	0.063 (0.085)
Grouper harvest rate per angler (number of fish) caught and kept)	0.784 (0.189)	0.819 (0.174)	0.543 (0.280)	0.829 (0.168)
Red snapper harvest rate per angler (number of fish caught and kept)	0.471 (0.099)	0.603 (0.091)	0.303 (0.126)	0.748 (0.088)
Log likelihood function	−914.42	−942.68	−838.64	−971.55
Number of zones in model	28	28	16	28

sented the most recent study that is most comparable to our study. Their estimates of angler WTP for red snapper and groupers calculated with APAIS data from 2000 in the Gulf of Mexico were also much higher than our estimates. On the basis of the most comparable model (conditional logit), they estimated angler WTP for an additional red snapper at $123 and for an additional grouper at $91 (in 2000 dollars). At least part of the differences in WTP estimates for groupers and red snapper between the Haab et al. (2012) study and our study likely was due to the inclusion of the for-hire mode (with higher associated travel costs) and the opportunity cost of time in their model. However, it is difficult to tell how much those inclusions contributed to the differences in the WTP estimates without a more detailed comparison of the models.

This study was based on the private-boat angler's choice across boat launch sites. However, anglers who launch from either a fixed boat slip or a boat storage facility will not regularly choose to launch from other places. Unfortunately, the APAIS data does not identify whether a boat was launched from a trailer, a slip, or a fixed dock. In the case of the APAIS data used in our study, more than 64% of the intercept sites along the Gulf of Mexico where anglers were interviewed in 2009 were only boat ramps with no associated boat slips or boat storage areas. The majority of anglers included in our study trailer their boats and, therefore, have a choice regarding what launch site they use. The potential limitation of the standard site-choice model with regard to choice of boat launch site should be explored in the context of future work, but it does not affect our results from the use of APAIS weights in our site-choice models.

Conclusions

In this study, different versions of a site-choice model for analysis of fishing site choices in the Gulf of Mexico in 2009 were estimated with recently available sampling weights from the APAIS survey in order to illustrate how site-choice models can incorporate a complex sample design and reduce potential biases in estimation. Model results indicate that the addition of sampling weights affected the estimated parameters for historic catch-and-keep rates. The difference

Table 4

The mean willingness to pay (in dollars) per angler for an additional fish caught and kept (with standard errors) estimated for groupers (*Epinephelus* spp., *Hyporthodus* spp., or *Mycteroperca* spp.) and red snapper (*Lutjanus campechanus*) and based on a conditional logit model of angler preferences for fishing sites in the Gulf of Mexico in 2009. The lower limit and upper limit of the 95% confidence intervals of mean willingness to pay also are shown. Four versions of the model were used to estimate willingness to pay. The first version did not account for survey weights (unweighted). The other versions of the model were adjusted with weights on the basis of the ratio of the proportion of total angler trips to sample proportions and with a weighted exogenous sampling maximum likelihood function (WESML). In the second version, the total population proportion of trips was evaluated at the mean, in the third version it was evaluated at the lower limit of the 95% confidence interval, and in the fourth version, it was evaluated at the upper limit of the 95% confidence interval.

Model	Mean	Standard error	Lower limit	Upper limit
Groupers				
Unweighted	$13.01	2.95	$7.22	$18.80
WESML (mean)	$14.67	2.91	$8.96	$20.39
WESML (lower limit)	$8.07	3.95	$0.33	$15.81
WESML (upper limit)	$15.32	2.89	$9.65	$20.98
Red snapper				
Unweighted	$7.81	1.61	$4.66	$10.97
WESML (mean)	$10.81	1.59	$7.68	$13.93
WESML (lower limit)	$4.51	1.84	$0.90	$8.11
WESML (upper limit)	$13.81	1.60	$10.67	$16.95

in parameter estimates translated into different WTP amounts for an additional fish caught and kept. However, the differences in angler WTP estimated between the weighted and unweighted versions of the model were not statistically different. This finding indicates that, although sampling weights can be used to correct for issues of endogenous stratification in on-site sampling and to reduce bias in parameter estimates, the bias in the related angler WTP measures may not be severe in the APAIS data used in our study. Whether this holds for other APAIS samples is an open question. For researchers who estimate recreational site-choice models with APAIS data, it is advisable to compare results produced with and without the APAIS sampling weights developed by NMFS. We have shown how to incorporate APAIS sampling weights into site-choice models using data from a popular recreational fishery in the Gulf of Mexico. The question of whether weighted or unweighted results should be used in future applications will have to be determined on a case-by-case basis.

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