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Lifting the goliath grouper harvest ban: Angler perspectives and willingness to pay

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ABSTRACT

Despite uncertainties surrounding the protected Atlantic goliath grouper's stock size and resilience, fishery managers are under pressure to end the harvest moratorium in place since 1990. The present study sought to measure the proportion of anglers interested in reopening the goliath grouper fishery and to identify key reasons for this interest. We also present an estimate of the amount that anglers would be willing to pay for a goliath grouper harvest tag (the right sold to an angler to harvest one goliath grouper). A survey was mailed to a random sample of Florida (USA) residents with a recreational fishing license. Approximately half of the respondents agreed that the goliath grouper should now be open to recreational take. A probit analysis indicated that the best predictor for the opinion the fishery should be open is the belief that there are "too many goliath grouper." Also, more anglers agreed than disagreed that goliath grouper are eating "all the fish on the reef," a belief that was related to anglers personally viewing goliath grouper depredation. The mean willingness to pay for a goliath grouper harvest tag was estimated to be between $34 and $79. This information can be used to estimate the potential revenues available from a hypothetical tag system and can be compared with the economic value of goliath grouper in non-consumptive uses such as recreational diving.

1. Introduction

After decades of heavy fishing in US waters, the Atlantic goliath grouper spawning stock biomass declined to about 5% of virgin levels, which prompted a harvest moratorium in 1990 (Porch et al., 2006). A 2006 evaluation by the National Marine Fisheries Service (NMFS) suggested that the moratorium had successfully increased adult abundance to about 30% of virgin levels (but see McClenachan, 2009 for discussion about the appropriate baseline), which led to the grouper's removal from the NMFS species of concern list (NMFS, 2006). Nevertheless, high uncertainty remains among fishery managers as to the goliath grouper's stock size and age class structure (Cass-Calay and Schmidt, 2009) and the species is still considered critically endangered throughout its range (IUCN, 2014).

Despite the uncertainty surrounding stock size and resilience to fishing, fishery managers are revisiting the goliath grouper harvest moratorium. Some anglers have voiced concerns that goliath grouper are damaging the reef fish community, that there are too many of them, and that recreational take should be allowed (Frias-Torres, 2013; GS pers obs). Further, anglers report viewing depredation events (goliath grouper taking angler's hooked fish), which serves to increase angler annoyance and reinforces angler perceptions that goliath grouper are major consumers of other reef fishes. Koenig et al. (2011) contended that angler misconceptions about the goliath grouper reflect the "poor job" the scientific and management community has done communicating to the public. In general, the majority of information about angler perceptions regarding goliath grouper is anecdotal and empirical verification is lacking. A previous email-based survey of goliath grouper stakeholders found a majority of recreational Florida anglers have interest in harvesting the species, but suggested additional in-depth research of each stakeholder group to better understand their perceptions (Lorenzen et al., 2013). Without proper insight into Florida recreational angler perceptions, management is unable to place the demand for the reopening of the goliath grouper fishery into the appropriate context or to foresee the likely effects of future management decisions.

Though some anglers are pressuring for protection to be lifted, there is still uncertainty surrounding how representative these vocal anglers are of Florida recreational anglers, what influences their beliefs, or how much they are willing to pay to harvest a fish. The present study sought to answer two questions about Florida

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recreational anglers with respect to the goliath grouper using a 17-question mail survey distributed to a random sample of 1000 Florida residents with recreational fishing licenses: (1) What proportion of anglers favor reopening the fishery and why?; and (2) How much are anglers willing to pay to harvest a goliath grouper? To answer these questions, we used a modeling approach to examine which variables are the best indicators of angler beliefs about reopening the fishery, and used the contingent valuation methodology (CVM) to calculate measures of mean willingness to pay for the right to harvest goliath grouper. We also examined how willingness to pay for the harvest tag varies among subgroups of Florida anglers. Results from the present study may afford fishery managers a context in which to place the vocal Florida anglers pressuring policymakers to reopen the fishery. Further, results may allow for comparison with future estimates of non-consumptive use value of goliath grouper.

2. Methods

2.1. Survey

A survey to quantify angler perspectives was designed (for full survey and results, see Appendices) following the recommendations of the "tailored design method" outlined by Dillman (2007). Because the survey was intended for anglers who fish recreationally in Florida, the sample frame was based on individuals that were licensed saltwater anglers. State saltwater license-holder information (containing names, addresses, license types, demographics, etc.) was obtained from the Florida Fish and Wildlife Conservation Commission (FWC) in July 2012, which comprised 1,011,562 individual licenses and associated data. The sample frame was restricted to resident 1-y, 5-y, or lifetime saltwater fishing license types [omitted license types included snook and lobster endorsements (duplicative), non-resident licenses, charter licenses (as the survey questions were designed for individual anglers), and comprehensive license types less likely to be regular saltwater anglers (hunting/freshwater/saltwater combinations)]. Individuals younger than 18 y of age (minors) also were removed from the list. After this process, the sample frame was reduced down to 475,091 individuals, from which a random sample of 1000 individuals was drawn using a simple random selection.

The sample was randomly ordered, numbered, and individuals were assigned to bins of 100 (e.g., 1–100, 101–200, etc.) for assignment to 10 versions of the survey with 10 unique dollar amounts for the willingness-to-pay dichotomous choice component of the study (see willingness to pay section below). Each individual's survey was printed with a unique identifying number, and individual surveys were matched with the corresponding mailing address label to ensure that each survey was sent to the appropriate individual, but also to ensure that the survey results were kept anonymous to anyone without access to the secured database.

The survey was accompanied by a letter of explanation and informed consent, and with contact information for questions. Funding limitations precluded the use of a pre-paid cash incentive with each mailing to increase response rate. Although research has shown that a lottery prize has minimal effects compared to no prize (control) or pre-paid cash incentives (Dillman, 2007), the letter of explanation communicated that all participants would be included in a raffle for a prize at the end of the study period, per previous angler studies (e.g., Larkin et al., 2010 and references therein).

The first wave of mailings was sent in May 2013. As responses were received, the sample list was adjusted to account for individuals who had responded or letters that were returned as undeliverable. If an expired forwarded address was listed on a returned envelope, the address for the individual was updated for future mailings. A second wave of mailings was prepared and sent (July 2013) to those who had not yet responded.

2.2. Survey error and analysis

Sampling error was derived following Dillman (2007). A mail survey was chosen over an email survey because less than half of licensed anglers in Florida provided an email address. Also, using standard mail avoids the potential bias in the subsample of individuals willing to disclose an email address to a government agency. One of us (GSS) conducted a survey pilot study in February 2013 at a local fishing club located in Hollywood, Florida. The results of the pilot study were used to improve the survey design.

We used a Lagrange Multipiler test to evaluate nonresponse error (Whitehead et al., 1993; Fisher, 1996; Marra and Radice, 2011) using the R package "SemiParBIVProbit" (Marra et al., 2013). The Lagrange Multiplier test is used to test the null hypothesis that there is no sample selection error present (Marra et al., 2013). Demographic data provided as part of the Florida saltwater fishing license database outlined above were used in the model, including age, sex, ethnicity, license type, and Florida region. We supplemented these data with the political affiliation of each angler as listed in public records (using http://www.politicalstrategies.com/VoterSearch.aspx).

All categorical and ordinal responses were coded to numerical values, and were coded as binomial values for models. If an angler provided a range (e.g., for number of fishing trips per month), the midpoint for that range was used. Response refusals for income and education were replaced with the mean values of the valid observations so that other survey responses were not lost in analyses (Whitehead et al., 1993). All means are reported with standard errors, and statistical significance was declared at $P < 0.05$. Statistical analyses were conducted using the R Environment for Statistical Computing (R Core Team, 2012).

2.3. Survey questions

2.3.1. Perceptions of goliath grouper abundance changes over time

To gauge the perceptions of goliath grouper abundance changes over time, anglers were asked to estimate encounter rates for three points in time: 2012 (survey read "last year"), 2008 (survey read "five years ago"), and when an angler first started fishing (calculated as 2013 minus reported number of years fishing). We binned these reported encounter rates into six groups: pre-1980 (pre-heavy exploitation), 1980–1989 (the years of heavy exploitation leading up to the moratorium), 1990–1999 (the first decade of the moratorium), 2000–2007 (the second decade of the moratorium), 2008–2009 (five years ago binned with individuals who began fishing within this time), and 2010–2012 (last year binned with individuals who began fishing within this time). For each of these time periods, we calculated the probability per trip that anglers would encounter a goliath grouper. This was accomplished by summing the medians of the frequency ranges anglers reported to have encountered goliath grouper (e.g., 10–25% of trips = 17.5%), which was divided by the sum of the total number of fishing trips anglers in that time period indicated they took per month. We then truncated the data at 1993 to aid in comparison to the Reef Environmental Education Foundation (REEF) database (which was also calculated as percent of total dive trips), a citizen-science diving survey effort that has been cited as the best available index of abundance for the goliath grouper in Florida (see Koenig et al., 2011).

2.3.2. Belief about reopening the fishery

We used a probit model to estimate the probability that an angler would agree that the fishery should be reopened to harvest.

We used a stepwise model selection method using Akaike information criterion (AIC; package MASS in R; Venables and Ripley, 2002) to find the model that best fit the data, then used the final model to estimate an angler's probability of agreeing that the fishery should be open. The variables considered in the model included: age, gender, ethnicity, education, political affiliation, region fished, license type, years fishing, fishing trips per month, and the various beliefs regarding goliath grouper.

2.3.3. Willingness to pay for a goliath grouper harvest tag

We used a dichotomous choice contingent valuation question to estimate the potential value of goliath grouper harvest tags. Each angler answered "yes" or "no" to the following question with randomly varying harvest tag costs ($1, $5, $10, $20, $50, $100, $200, $500, $1000, or $2000):

> "Right now, it is illegal to possess (for example, remove from water to take a picture) or harvest (keep) a goliath grouper. Suppose the fish population was considered healthy and Florida Fish and Wildlife Commission was selling tags that would permit you to possess or harvest a goliath grouper, would you be willing to pay $X.XX (in addition to your annual fishing license fee) to obtain a tag?"

Using this information from all respondents, we applied the Turnbull method to estimate the lower bound for the mean willingness to pay for a goliath grouper harvest tag (Haab and McConnel, 1997). The lowest value an angler was assumed to be willing to pay for a goliath grouper harvest tag was $0.00, as the price for a tag for harvest cannot be a negative value. To estimate the upper bound, one must know the highest price an angler would pay for a tag, otherwise any upper bound estimate will be arbitrary (Haab and McConnel, 1997). It cannot be said with confidence what constitutes the highest amount an individual would be willing to pay. Because some anglers were willing to pay $500, but none were willing to pay greater (see Results for more information), in an effort to make a conservative and reliable upper bound estimate, we used $501 as the maximum willingness to pay for a tag in all nonparametric measures that required an upper bound; we used the Paasche method (Boman et al., 1999) for estimating the upper bound of the mean and the Kristrom method (Kristrom, 1990) for the intermediate mean value, both of which use similar methods to that of the Turnbull method for computing estimates based on CVM response data.

We hypothesized that the most influential factor affecting whether anglers would be willing to pay for a goliath grouper harvest tag would be the belief that the fishery should be open now. Thus, we used a probit model to investigate the effect of this belief on willingness to pay for a harvest tag.

3. Results

Of the 1000 mailed surveys, 124 were returned as undeliverable. Of the 876 delivered surveys, 164 were completed and returned for analysis (7.65% survey error at 95% confidence). The age distribution of responders differed significantly from the sample frame [sample frame: 42.8 (SE 0.44) y; responders 44.7 (1.08) y; Kolmogorov-Smirnov test: $D = 0.1171$, $P < 0.05$], the license types for the responders differed significantly from the sample frame (Chi-square test: $\chi^2 = 183.5753$, df = 4, $P < 0.001$; Table 1), and the ethnicity of responders differed significantly from the sample frame (Chi-square test: $\chi^2 = 9.9806$, df = 1, $P < 0.01$) (Table 1). However, a binomial probit response model (Table 2) indicated that only ethnicity (white vs nonwhite) and license type (annual license vs multi-year license) were significant factors in propensity to respond to the survey (all P-values < 0.05). The Lagrange Multiplier test results indicated that the propensity to respond to the survey would not significantly affect the additional analyses.

Table 1
Summary of responder and non-responder demographics obtained from the Florida Fish and Wildlife Conservation Commission Saltwater Angler License Database. Sample includes deliverable mailings only.

	Sample ($n = 876$)	Responders ($n = 164$)
Age (mean yrs)	42.8 (SE 0.44)	44.66 (SE 1.08)
Gender		
Female	241 (27.7%)	48 (29.3%)
Male	629 (72.3%)	116 (70.7%)
Ethnicity		
Whites	746 (85.7%)	154 (93.9%)
Non-whites	124 (14.3%)	10 (6.1%)
License type		
1 year	675 (77.6%)	112 (68.3%)
5 year	186 (21.4%)	48 (29.3%)
Lifetime (13–64)	9 (1.0%)	4 (2.4%)
Region		
Florida Keys	29 (3.3%)	3 (1.8%)
Northeast Florida	134 (15.4%)	23 (14.0%)
Northwest Florida	236 (27.1%)	40 (24.4%)
Southeast Florida	271 (31.2%)	49 (29.9%)
Southwest Florida	200 (23.0%)	49 (29.9%)

3.1. Florida saltwater recreational anglers

The number of years a responding recreational Florida angler has been fishing ranged from 1 to 63 y, with a mean of 24.91 (SE 1.18) y. The reported number of saltwater fishing trips a recreational Florida angler took per month ranged from 0.8 to 20, with a mean of 3.23 (SE 0.29) trips mo^{-1}. Just over half of the anglers reported they had an undergraduate degree or higher ($n = 88$, Table 3, Appendix 1). Furthermore, most recreational Florida anglers earned higher than the median Florida income level of $47,827 (http://quickfacts.census.gov/qfd/states/12000.html), with approximately 65% reporting earnings > $50,000 ($n = 107$), and 29% reporting > $100,000 per year ($n = 48$; Appendix 1). The majority of anglers (89%) reported to have no association with a fishing organization ($n = 146$), with approximately 10% of anglers indicating membership ($n = 17$) (Appendix 1). About 11.5% of anglers were not listed in the public records political database, suggesting they were not registered voters. About 47% are registered Republicans and 26% were registered Democrats, with about 16% identified as "other or no affiliation."

Of the 164 survey responses, 154 anglers (93.9%) were familiar with the goliath grouper and were directed to continue the entire survey (those unfamiliar with goliath grouper were asked to skip all goliath grouper-related questions). Of the anglers familiar with the goliath grouper, about 94% ($n = 144$) indicated that they had not participated in targeted catch-and-release fishing of goliath grouper in

Table 2
Results of a probit model for survey response/nonresponse. For modeling purposes, factors were simplified to binomial logical expressions (e.g., regions northeast, northwest, southeast, southwest, the Keys simplified to the logical South Florida = True/False). Significant factors are in bold.

Coefficients	Estimate	SE	z value	P
(Intercept)	−1.3967	0.2912	−4.796	**<0.0001**
Age	0.0044	0.0039	1.106	0.2686
Female				
Male	−0.0597	0.1111	-0.537	0.5912
Nonwhite				
White	0.5714	0.1762	3.243	**0.0012**
Multi-year license				
Annual license	−0.2777	0.1170	−2.373	**0.0177**
North Florida				
South Florida	0.1262	0.1027	1.229	0.2192

Table 3
Summary of (A) demographics and (B) beliefs of anglers who favored opening the goliath grouper (GG) fishery vs anglers with no opinion or who opposed a fishery (pooled).

Variables	All anglers ($n = 164$)	Open fishery ($n = 80$)	Other beliefs pooled ($n = 74$)
(A) Angler demographics			
Age	45	44	46
Gender	71% male	76% male	69% male
Ethnicity	94% white	94% white	95% white
Region fished	71% in south Florida	73% in south Florida	69% in south Florida
Education	56% college educated	47% college educated	62% college educated
Political affiliation	47% Republican	39% Republican	53% Republican
License type	68% annual licenses	64% annual licenses	71% annual licenses
Years fishing	25 y	27 y	25 y
Trips per month	3.2 trips mo^{-1}	4.1 trips mo^{-1}	2.6 trips mo^{-1}
(B) Angler beliefs			
Target GG	7%	6%	7%
Reported depredation	37%	63%	18%
GG is eating reef fish	32%	51%	15%
There are too many GG	42%	77%	11%
GG is properly managed	18%	15%	19%

the last year; about 6% ($n = 10$) reported to have targeted the species (Table 3, Appendix 2).

Supplementary material related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.fishres.2014.07.009.

3.2. Goliath grouper perceptions

3.2.1. Goliath grouper abundance

Since 1993, the percent of recreational angler trips where goliath grouper were reported present has been increasing (see Fig. 1 for more details). This is consistent with the trend of goliath grouper sightings on dive trips reported in the REEF database. Anglers were asked to indicate whether they agreed or disagreed with the statement, "Goliath grouper populations need to be controlled. There are too many of them." About 45% of survey respondents agreed with the statement ($n = 68$) and 21% of survey respondents disagreed with the statement ($n = 32$). Anglers who favored opening the fishery to recreational take were much more likely to believe there are too many goliath grouper (Table 3). The belief that there were too many goliath grouper was not related to the number of years an individual had been fishing (Spearman's rank correlation: $\rho = 0.07$, $P > 0.05$).

3.2.2. Depredation by goliath grouper

When asked how frequently goliath grouper engaged in depredation, about 40% ($n = 61$) reported that it had occurred last year (2012), but about 53% ($n = 82$) stated that it did not occur (Fig. 2). About 12% ($n = 19$) of anglers reported that it occurred on more than half of all saltwater fishing trips (Appendix 2).

Anglers were asked to indicate whether they agreed or disagreed with the statement, "Goliath grouper are eating all the fish on the reef." About 32% of survey respondents agreed with the statement ($n = 53$) and 18% of survey respondents disagreed with the statement ($n = 29$) (Table 3, Appendix 2). Anglers who favored opening the fishery were more likely to believe the goliath grouper are eating all the reef fish (Table 3). There was a significant relationship between the belief that goliath grouper are eating all the reef fish and the reported frequency that goliath grouper eats an angler-hooked fish (Spearman's rank correlation: $\rho = 0.35$, $P < 0.01$).

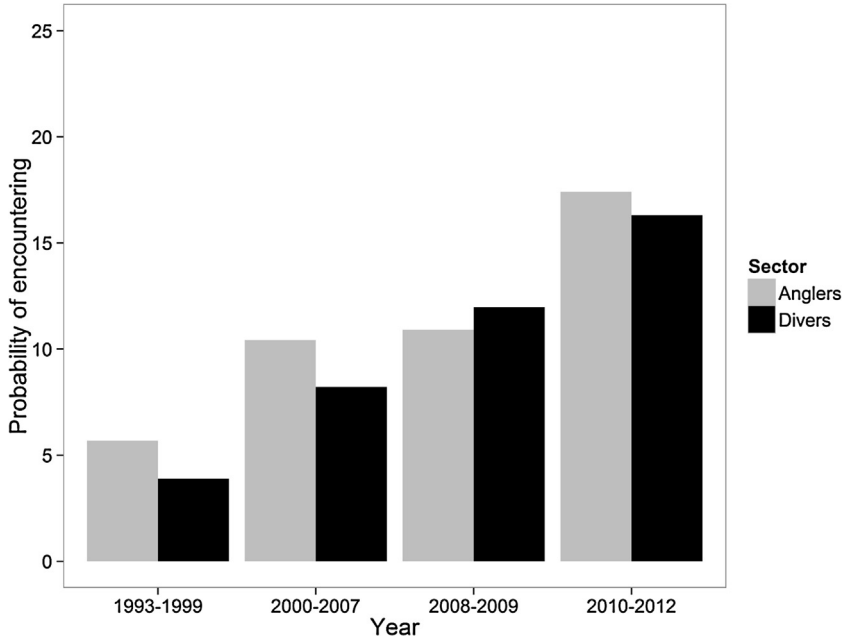

Fig. 1. Estimated probability of anglers encountering goliath grouper in Florida (per angling trip, gray) compared with the Reef Environmental Education Foundation diver-based reports of encounters (per dive trip, black), which has been touted as the best available index of abundance for goliath grouper (Koenig et al., 2011).

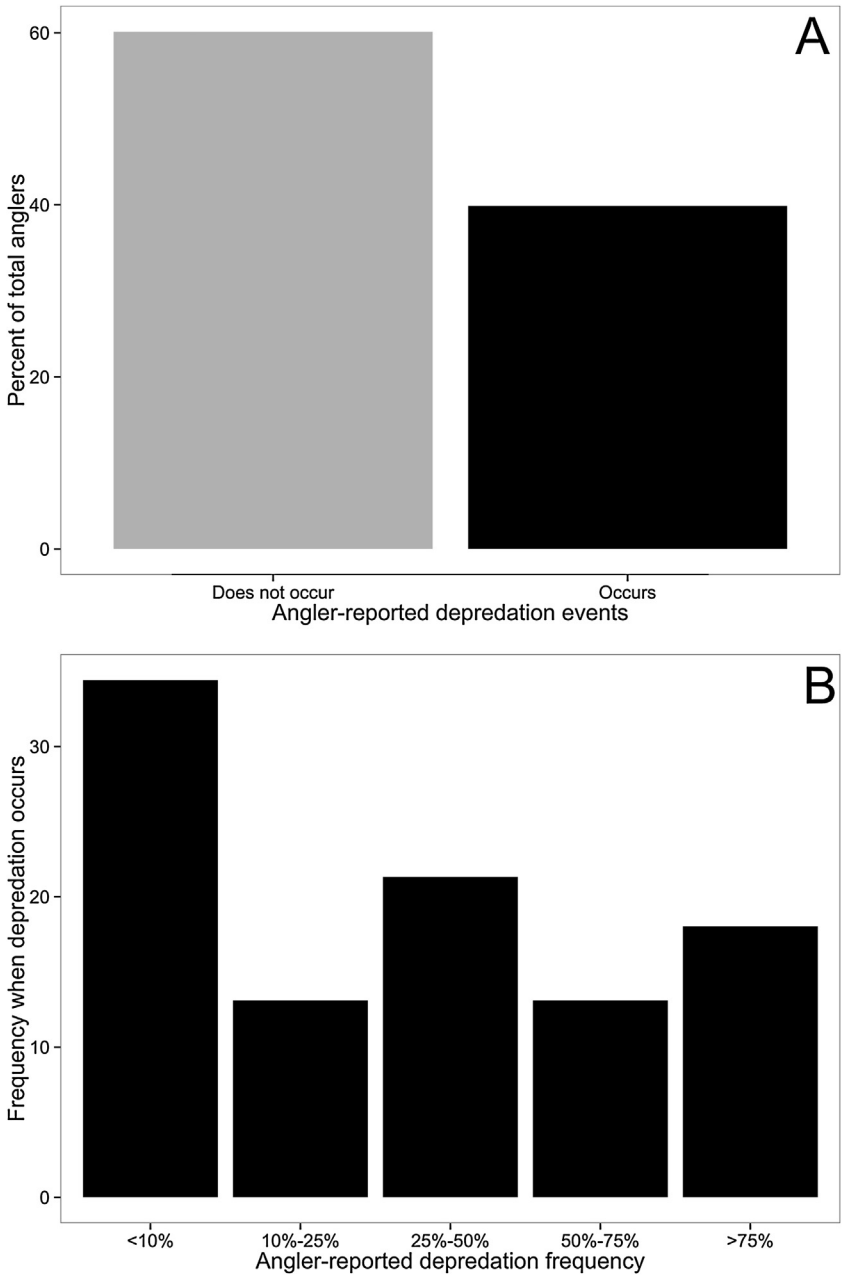

Fig. 2. Frequency of trips that anglers reported a goliath grouper ate a fish they were targeting in 2012. (A) Percentage of anglers that claimed to have seen depredation by goliath grouper, and (B) percentage of anglers that indicated varying levels of the frequency of depredation by goliath grouper when it occured on fishing trips.

3.2.3. A goliath grouper fishery

The survey stated that scientists are uncertain if goliath grouper can presently withstand harvest pressure. Within this context, anglers were asked to rate how much they favor or oppose the idea of opening the goliath grouper to recreational fishing. Approximately 25% indicated they had no opinion (Appendix 2); however, a slight majority (about 52%, $n = 80$) were in favor of opening the goliath grouper to recreational take, with 27.3% (the most-selected response) indicating they were strongly in favor. Only about 22% of survey respondents ($n = 34$) reported they opposed the opening of a recreational fishery (Appendix 2). A summary of the two subgroups' differences (open fishery vs other beliefs pooled) is provided in Table 3.

The initial model results suggested that there were only two significant model terms correlated with the belief the fishery should be open: the number of trips one takes per month ($P < 0.05$) and the belief that there are too many goliath grouper ($P < 0.0001$) (Table 4). The stepwise AIC model selection procedure removed all but the two significant model terms. Results of the final, best-fit probit model indicated that there was a positive relationship between number of trips anglers took per month and desire for the fishery to be open ($P < 0.0001$), and an even stronger relationship with regard to the belief that there were too many goliath grouper ($P < 0.0001$) (Table 4). Survey respondents who believed that there were too many goliath grouper had a high probability of believing the fishery should be open, independent of how many trips that angler took per month, while individuals who did not believe there were too many goliath grouper had an increasing likelihood of believing the fishery should be open as the number of trips the angler took per month increases (Fig. 3).

Table 4
Results of a probit model for (A) willingness to pay for a harvest tag and the stepwise model selection results for belief the goliath grouper (GG) fishery should be open with (B) the beginning model with all parameters and (C) the final model selected for best fit. For modeling purposes, factors were simplified to binomial logical expressions (e.g., for the statement that the fishery should be open: strongly agree and somewhat agree became "true," all other answers became "false"). Significant model terms have bolded *P*-values.

Coefficients	Estimate	SE	*z* value	*P*
(A) Willingness to pay for a harvest tag				
(Intercept)	−2.1243	0.1110	−19.134	**<0.0001**
Open fishery (belief)	2.1375	0.2195	9.737	**<0.0001**
Tag amount	−0.0022	0.0006	−3.331	**0.0008**
College attendance	0.9877	0.2248	4.395	**<0.0001**
(B) Initial model: belief that the goliath grouper fishery should be open				
(Intercept)	−0.606	0.811	−0.748	0.455
Age	−0.007	0.010	−0.636	0.525
Gender	0.081	0.299	0.269	0.788
Ethnicity	−0.524	0.547	−0.958	0.338
Location	0.018	0.295	0.062	0.951
Education	−0.118	0.271	−0.437	0.662
Political affiliation	−0.074	0.276	−0.269	0.788
License type	0.076	0.312	0.245	0.806
Years fishing	0.010	0.010	0.974	0.330
Trips per month	0.090	0.041	2.196	**0.028**
GG is properly managed	−0.050	0.341	−0.146	0.884
Reported depredation	0.593	0.323	1.838	0.066
GG is eating reef fish	−0.702	0.450	−1.560	0.119
There are too many GG	2.225	0.423	5.267	**<0.0001**
Target GG	−0.600	0.555	−1.082	0.279
(C) Final model: belief that the goliath grouper fishery should be open				
(Intercept)	−1.07	0.20	−5.37	**<0.0001**
Trips per month	0.09	0.04	2.60	**0.009**
There are too many GG	1.95	0.26	7.63	**<0.0001**

3.3. Willingness to pay for a goliath grouper harvest tag in a theoretical healthy fishery

The dichotomous choice nonparametric estimators suggested that the lower bound of respondents' willingness to pay was approximately $33.74 (SE $0.91). The median price (value range that includes 50% of angler willingness to pay) was between $20.00 and $50.00. The Paasche estimator indicated that the upper bound for the willingness to pay was $122.64 (SE $2.17), and the Kristrom intermediate mean willingness to pay for a harvest tag was around $78.56 (SE $0.92). No respondent in the present study was willing to pay $1000 or $2000, though some anglers did indicate they were willing to pay $500 (4 out of 13), suggesting that some individuals would be willing to pay much higher than the estimated mean.

Results of the probit model indicated that survey respondents who believed the fishery should be open were much more likely to be willing to pay for a tag (Table 4, Fig. 4). Though college attendance was a significant term in the model, it did not affect the overall pattern that those who desired the fishery to be open had a higher willingness to pay for the theoretical tag in a potential fishery (data not shown).

4. Discussion

The present study attempted to quantify angler beliefs concerning goliath grouper, a species protected from harvest in US waters since 1990. We estimate that approximately half (95%CI: 44–60%) of licensed Florida recreational anglers believed that goliath grouper should be open to recreational take. Although many anglers did not hold strong opinions, the belief that there are too many goliath grouper and that their populations need to be thinned was the strongest predictor of the belief the fishery should be open. However, the belief that the fishery should be open was not significantly related to age, ethnicity, experience, political affiliation, education, or geographic region, suggesting this is an issue that cannot easily be defined by demographics.

4.1. Goliath grouper perceptions

4.1.1. A goliath grouper fishery

Relatively is little known about how much goliath grouper could be safely harvested. The most recent stock assessment suggested that the allowed take would be relatively small if the fishery were

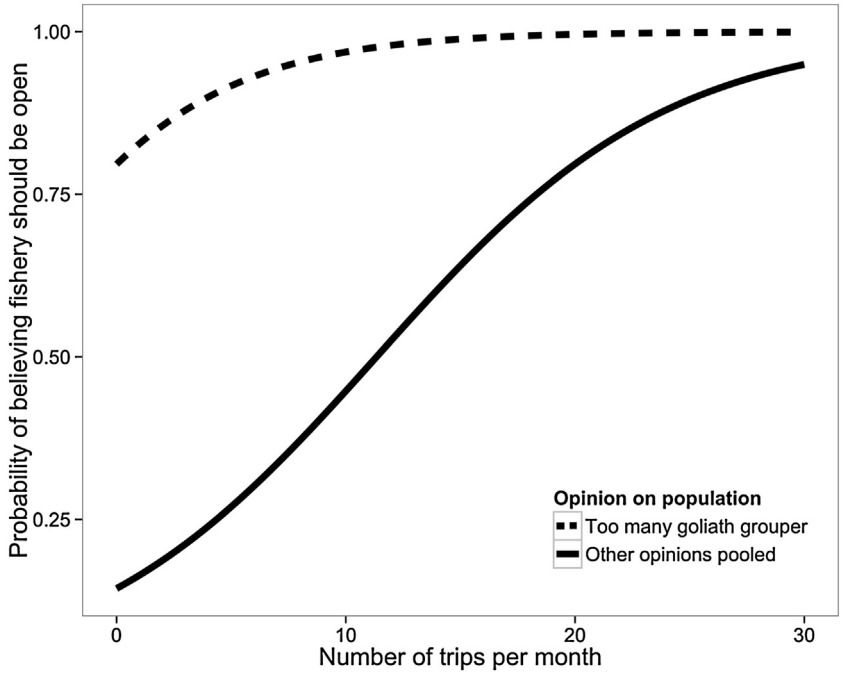

Fig. 3. Probit model result for recreational Florida angler propensity to believe the goliath grouper fishery should be open right now as a function of number of trips an angler took per month. Dashed line indicates model results for anglers who believe there were too many goliath grouper (those who strongly believed and somewhat believed pooled), and solid line indicates model results for other anglers pooled (those who were indifferent and those who had differing levels of disagreement).

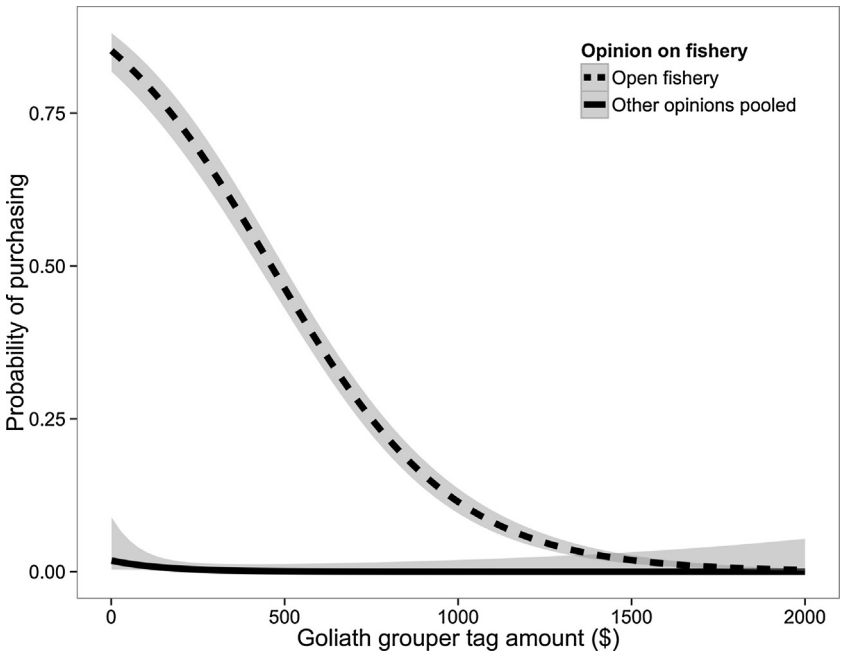

Fig. 4. Probit model result for recreational Florida angler willingness to pay for a goliath grouper harvest tag as a function of tag amount. Dashed line indicates model results for anglers who believed the fishery should be open (those who strongly believed and somewhat believed pooled), and solid line indicates model results for other anglers pooled (those who were indifferent and those who had differing levels of opposition). Gray shading represents 95% confidence intervals.

reopened (SEDAR 23, 2011). Approximately half of our sample of licensed Florida recreational anglers were in favor of opening the goliath grouper fishery now, even in the face of scientific uncertainty; the remaining sample of anglers were split between having no opinion and having some degree of opposition. Despite our best efforts to rule out nonresponse bias, we note our estimate might still be biased due to sample selection issues. However, our findings are consistent with the findings of a previous survey of Florida recreational anglers that found that Florida recreational anglers (on average) disagreed with the present closure and agreed with opening a regulated fishery (Lorenzen et al., 2013). More research is necessary to confirm the actual share of all licensed Florida saltwater anglers that would like to open the goliath grouper fishery.

Our probit regression model indicated that anglers who believed that there are too many goliath grouper and that the populations need to be controlled also believe that the fishery should be open. Anglers' perceptions about the goliath grouper population has been identified as a possible example of the "shifting baselines syndrome," a phenomenon where fishers accept recent reduced abundance and size information as historical baselines, resulting in inappropriate reference points for evaluating overfishing (Frias-Torres, 2013). Interestingly, our study found no evidence of shifting baselines among anglers; there was no significant relationship between the number of years an angler has been fishing and: (1) the belief the fishery should be open, and (2) the belief that there are too many goliath grouper and their populations need to be controlled. Anglers of all experience levels, even those who had been fishing many years before the moratorium was implemented, were not more likely to support or oppose opening the fishery.

4.1.2. Goliath grouper abundance

Since the 1990 moratorium, angler-reported encounter rates have been increasing, a trend consistent with goliath grouper sightings found in the diver-reported observations of the REEF database. Further, our results are consistent with encounter rates reported in a similar survey (20–59% of anglers encountered goliath grouper in 2012 as reported in Lorenzen et al., 2013). Recent research suggests that goliath grouper populations have been increasing since the moratorium (Porch et al., 2006; Cass-Calay and Schmidt, 2009; Koenig et al., 2011). Our results suggest that anglers have indeed seen increases in goliath grouper populations over time; this fact combined with goliath grouper's continued protection has contributed to angler frustration, especially among those that consider the goliath grouper a nuisance (Koenig et al., 2011; Frias-Torres, 2013; present study). When recoveries take a long time, anglers can lose confidence in the science that drives fisheries management decisions (Steneck et al., 2013). We found that many anglers did not agree that the goliath grouper is being properly managed, and angler support is necessary for successful fishery management (see Acheson and Gardner, 2011).

4.1.3. Depredation by and diet of goliath grouper

We found that many Florida recreational anglers did not hold a strong opinion about whether goliath grouper are eating all the reef fish; this result is consistent with the Lorenzen et al. (2013) finding that only a small amount of Florida anglers viewed goliath grouper as negatively impacting the ecosystem. Further, Lorenzen et al. (2013) found only 14% of anglers in their sample perceived goliath grouper as a nuisance species, while around 50% viewed encounters as desirable. Though our questions were slightly different, approximately 40% of the anglers in our study reported they had seen depredation by goliath grouper (a behavior anglers consider a nuisance), and there was a significant relationship between the belief that goliath grouper is eating all the reef fish and an angler's personal experience witnessing a targeted fish being consumed by goliath grouper. More respondents in our study agreed with the statement that goliath grouper are eating all the fish on the reef than disagreed, even though studies indicate that crabs and crustaceans make up around 70% the goliath grouper diet (Randall, 1967; Odum and Heald, 1972; Sadovy and Eklund, 1999; Koenig et al., 2011). Indeed, Koenig et al. (2011) found a *positive* relationship between the density of goliath grouper and biological diversity of other fish species, which they indicated was additional evidence that goliath grouper are not indiscriminant predators on the reef. Frias-Torres (2013) went so far as to suggest that goliath grouper do not feed on reef fishes of angler interest. We speculate that some anglers

take this to mean that scientists do not take the angler-reported encounters seriously. It is important to note that many anglers may be confusing what a goliath grouper eats in the context of its ecological environment with what a goliath grouper will eat opportunistically. The research on effective science communication, especially related to climate change (e.g., Lewandowsky et al., 2013), is likely to be helpful in the context of the goliath grouper fishery. Importantly, the depredation issue is a different problem to be acknowledged and separated from the discussion with anglers about goliath grouper diet.

One possible explanation for (over)confidence, relative to scientific evidence, that anglers have in the belief that goliath grouper are eating their target species is psychological; anglers can witness a goliath grouper taking a fish from their lines (depredation), but are unlikely to witness a goliath grouper preying on crustaceans, unless they also scuba dive. Kahneman (2013) refers to this bias toward overconfidence is "what you see is all there is". Additionally, there exists the possibility that angler depredation events are a case of "mistaken identity," where an angler indicated goliath grouper was responsible, but did not personally witness the goliath grouper during the depredation event (i.e., another species was responsible). Additional studies would be needed to tease apart whether anglers only believe goliath grouper is responsible for depredation or personally witnessed a goliath grouper depredation event.

4.2. Willingness to pay for a goliath grouper harvest tag in a theoretical healthy fishery

According to Sadovy and Eklund (1999), standard fishery management approaches, including quotas and size limits, are not effective for larger reef species in multi-species fisheries. Harvest tags function through the assignment of a right to a specified quantity and type of harvest during a specified time period. Though still uncommon in marine recreational fisheries, harvest tags may offer many of the benefits of rights-based management and can be used to control harvest (Johnston et al., 2007). The only recreational tag program for a fish in Florida is for Florida tarpon (*Megalops atlanticus* Valenciennes in Cuvier and Valenciennes, 1847). This program does not set limits on the number of fish an individual can land annually. The tarpon is highly sought for the experience of fighting a game fish (Ault and Lou, 2013), thus the tag price is set relatively high at $50.00, effectively keeping demand for the tags well below the maximum available. While the tarpon tag program has been successful at reducing retained harvest, it has proven less effective at estimating harvest rates (Johnston et al., 2007).

In the present study, we used three common methods to estimate the mean value of a potential goliath grouper harvest tag using data from CVM responses. The lower bound (Turnbull) mean estimate is useful in estimating the overall minimum value of goliath grouper harvest tags in the state of Florida. The upper bound mean is considered an overstatement of the true average and it has been suggested that the intermediate measure (Kristrom) should be used as an upper range value of the true average (Russell et al., 2001). If one angler was selected at random, there is a high likelihood that he/she would be willing to pay at least $33.74 (lower bound). However, this amount assumes that there is an endless supply of goliath grouper harvest tags, that every angler wants to harvest goliath grouper, and that any individual could buy a tag without restriction. Given the present uncertain state of the goliath grouper stock status, any tag program will likely come with a maximum number of tags available.

Technical documents available from the Gulf of Mexico Fishery Management Council suggest that any potential fishery begin with a low limit of harvested goliath grouper per year (see e.g., Porch and Barbieri, 2007). One number considered was 400 tags, and multiplying that number by the lower bound and intermediate mean estimate, a goliath grouper tag program could generate somewhere between $13,496 and $31,424 per year. Value is sensitive to change in size of population (Richardson and Loomis, 2009), and if only a limited number of tags were available on the market, it is unclear how goliath grouper harvest tag willingness to pay would be affected, but the laws of supply and demand suggest it could be higher.

Additional studies are needed to examine other stakeholder groups' willingness to pay for goliath grouper to stay in the water. The dive industry has indicated growing interest in goliath grouper (Harrington et al., 2009). For example, one dive shop on the east coast of Florida reported that the divers taking part in goliath grouper dives has grown from 590 in 2010 to 1586 in 2013. Heyman et al. (2010) suggested that dive ecotourism at Nassau grouper spawning areas may represent an economically attractive alternative to fishing. More research is needed to investigate whether this also applies to goliath grouper.

4.3. Study limitations

Significant efforts were made to adhere to Dillman's (2007) "tailored design method," a survey methodology known to maximize response rate. However, we received only 164 usable surveys for our study. Although our method of testing for non-response error is supported in the literature (e.g., Whitehead et al., 1993; Fisher, 1996; Marra and Radice, 2011), there exists the possibility that several factors could have affected our results via increased/decreased participation in our study. First, *E. itajara's* common name, *goliath grouper*, was only recently proposed (in the last decade) as a replacement for the previously known common name, *jewfish*. The term *jewfish* was not used in the survey as it is not the accepted common name for the species. However, this decision may have confused anglers who have always known and referred to this species as *jewfish*. Second, resource limitations prohibited the use of all recommended tactics for maximizing response rate, such as cash incentives, hand-written addressed envelopes, or certified mailings. Our approximately 19% response rate is well below rates reported by Dillman (2007) using this methodology. Though some angler studies have been able to acquire near 100% response rates with dock-side angler interception surveys (Ferter et al., 2013), our response rate was similar to angler mail surveys conducted by the US government [e.g., 21.1% response rate for Gulf of Mexico anglers in NOAA National Saltwater Angler Survey (Brinson and Wallmo, 2013)]. Third, there is a large population of Hispanic anglers in the state of Florida, particularly in south Florida. Resource limitations prohibited the inclusion of a second survey translated into Spanish. Though the overwhelming majority of the anglers in the state's license database self-identify as white, it is unclear if the sole use of English introduced nonresponse bias. Lastly and perhaps most importantly, a survey on a single fish species is a very narrow topic, and unfamiliarity or lack of interest in the topic of one particular species may have precluded participation for many anglers while oversampling others.

The present study focused exclusively on anglers who held a resident saltwater fishing license in the state of Florida. There were license types not included in the sample frame (e.g., combination hunting and fishing licenses). It is unclear whether the opinions of anglers surveyed in the present study are representative of the opinions of anglers holding other license types.

Aside from the general debate regarding CVM (see Kling et al., 2012), there are a few caveats to the use of CVM for goliath grouper. When using CVM to value a fish species in a multi-species fishery, willingness to pay and other questions focused on one individual species can lead to potentially biased results, especially since not all anglers have experience with the species of interest (Whitehead, 2006). Further, the CVM measure was for only one goliath grouper

tag per angler, so we cannot measure the incremental value for each additional fish tag. However, given the current stock status, anglers are unlikely to encounter the opportunity to purchase multiple goliath grouper harvest tags. Lastly, we did not attempt to measure how other variables, such as size restrictions, would affect an angler's willingness to pay.

5. Conclusions

There is much uncertainty as to the extent goliath grouper population is able to withstand fishing pressure and there is little evidence, if any, to suggest that goliath grouper are responsible for other reef fish declines. Still, we found that anglers have had increasing encounter rates with goliath grouper since the implementation of the harvest moratorium, a finding consistent with results reported elsewhere. Additionally, we found that many survey respondents believe that there are now "too many" goliath grouper and they are eating all the other fish on the reef. In fact, our analyses suggested that the belief that there are too many goliath grouper drove approximately half of respondents to favor opening the fishery. The belief that the fishery should be open was not significantly related to characteristics such as geography, gender, political affiliation, education, age, or experience, suggesting this is an issue that cannot easily be defined by demographics. We found that anglers who want the fishery open are willing to pay at least $30 for a tag to harvest one goliath grouper per year. Additional research is needed to estimate the value of goliath grouper to other stakeholder groups. These findings should be considered when revisiting the present goliath grouper moratorium.

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