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Recreational angler preferences for, and potential effort responses to, different red snapper management approaches

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Abstract

The Gulf of Mexico red snapper fishery has been caught in a spiral of more restrictive regulations and disputed management. Current management measures have failed to reduce fishing mortality, owing in part to derby style fishing. A harvest tag system could potentially better limit fishing mortality without decreasing harvest seasons. In 2019/20 we surveyed 766 recreational anglers who fish in Florida with private boats to ascertain their preferences for regulation changes, and how they would alter their fishing effort if a harvest tag was implemented. Respondents were heterogeneous in terms of their preferences for harvest tags versus current management approaches, with most respondents preferring to maintain their current effort under the existing management approach of bag, size, and season limits. Respondents who preferred harvest tags indicated that they might increase or decrease fishing effort. Our findings suggest that more stringent regulations using current management approaches will not secure angler satisfaction or reduce fishing pressure on the red snapper stock. Harvest tags, though not preferred by all respondents, may allow regulators to better manage the number of anglers in the fishery and to rebuild the stock, although implementing this program will pose some challenges.

KEYWORDS

bag limits, Gulf of Mexico, harvest tag, recreational fishery, red snapper (*Lutjanus campechanus*), rights-based management, season lengths, size limits, stated preference choice experiments

1 | INTRODUCTION

Traditional recreational fisheries harvest management regulations (size, bag, and season limits) sometimes fail to constrain exploitation of fish stocks and sustain fishing quality because they do not account for dynamic angler behavior (Cox & Walters, 2002; Lewin et al., 2006; Post et al., 2002). This may happen in regulated open access recreational fisheries, the status quo in North America (Abbott et al., 2018; Homans & Wilen, 1997).

Unconstrained effort in open access fisheries may result in a race to fish as anglers compete to harvest fish before the catch limit is met and the season closes (Abbott et al., 2018; Farmer et al., 2020). Derby style fishing behaviors may compress fishing effort within a shorter temporal window, which is expected to result in greater daily catch rates (for the fishery) and reduced satisfaction (for individual anglers) owing to congestion and limited fishing opportunities (Abbott et al., 2018; Fenichel & Abbott, 2014; Scyphers et al., 2021; Timmins & Murdock, 2007). Management agencies' response to compressed effort, derby style fishing, and greater harvest per day is often to further shorten harvest seasons (Wilen, 2006). This is expected to exacerbate the race-to-fish problem and has prompted researchers to question the efficacy of regulated open access management of recreational fisheries in which demand for harvest surpasses what is ecologically sustainable (Sadovy & Eklund, 1999).

Rights-based approaches may more effectively control recreational fishing mortality while maintaining angler satisfaction and welfare (Abbott et al., 2018; Ihde et al., 2011). Rights-based management approaches are commonly used in commercial fisheries (e.g., individual transferable quotas) to increase the sustainability and economic efficiency of the fishery by enhancing fishers' accountability and incentives to sustainably harvest fish (Arnason, 2012; Grafton et al., 2016). Rights-based management approaches could be applied to recreational fisheries (Abbott et al., 2018, 2022; Cox & Walters, 2002; Fenichel & Abbott, 2014) via harvest tags. In a harvest tag system, anglers receive a fixed quantity of tags, one of which is required for harvesting an individual fish during a specified time (e.g., 12 months)—thus obviating size, bag, and harvest season restrictions—although some spatial or temporal restrictions (e.g., for fish spawning) may apply (Johnston et al., 2007). Harvest tags may ameliorate derby-style races to fish because anglers can spread their fishing effort over time to select the most desirable times to fish. Harvest tag systems can also increase harvest controllability, reduce congestion in the fishery, and potentially lead to better catch data (Johnston et al., 2007, 2009). However, harvest tags have been discussed more frequently than they have been implemented in recreational fisheries (Arostegui et al., 2021; Jackson et al., 2016; Johnston et al., 2007, 2009; Jungers et al., 2023). Jungers et al. (2023) analyzed how anglers in the for-hire recreational red snapper fishery in the Gulf of Mexico might respond to the implementation of harvest tags, but harvest tag preferences and potential behavioral responses of private-vessel anglers have not been explored. The red snapper fishery is of substantial economic importance to both the commercial and recreational sectors, although recreational harvest management has been especially controversial recently—largely due to short harvest seasons (Scyphers et al., 2021; SEDAR, 2018, 2021).

The management history of the Gulf red snapper stock provides context relevant to potential implementation of harvest tags. The Gulf of Mexico red snapper fishery is managed by the Gulf of Mexico Fishery Management Council (GMFMC, 1999) from the Florida Keys to Texas, within the federal waters of the US Exclusive Economic Zone (EEZ). The fishery was historically heavily exploited commercially and recreationally, and in 1990, an annual catch limit (ACL) was implemented to prevent overfishing. Since 1990, the ACL was allocated 51% to the commercial sector and 49% to the recreational sector (SEDAR, 2018). In 2005, the GMFMC established a new rebuilding plan for red snapper, which reduced catch limits but did not change recreational-commercial allocation percentages (GMFMC, 2006). Since 2015, the recreational sector has been divided between private-vessel anglers (57.7%) and the for-hire fishing sector (42.3%). The private vessel fishery is a regulated open access fishery in which the number of trips (fishing effort) is not controlled, but size, bag, and harvest season limits are implemented to constrain recreational harvest to their allocation of the ACL. Recreational anglers can fish at any time but may only harvest red snapper within the harvest season, which is set annually based on projections of fishing effort and harvest, and may be closed early if the recreational allocation (combined for state and federal waters) is reached.

Recreational red snapper fishing regulations have generally become more restrictive with reductions in bag limits (from seven to two fish) and increased minimum size limits (from 13 to 16 in.), in addition to decreased season lengths (Abbott et al., 2018). Unfortunately, shorter federal seasons promoted effort compression and increased the pounds of fish landed per open federal day six-fold since the implementation of the rebuilding plan (Farmer et al., 2020; Powers & Anson, 2016). From 2004 to 2017, the recreational ACL was exceeded 10 times, and each time the ACL is exceeded, the subsequent year's ACL must be decreased. This culminated in a three-day federal water recreational fishing season in 2017. Frustrated recreational anglers successfully lobbied the Secretary of Commerce to disregard the best available scientific information and to extend the recreational season in federal waters by an additional 39 days. This eventually resulted in the GMFMC passing Amendment 50 in April 2019 (GMFMC, 2019). Amendment 50 came into effect in February 2020 and allowed individual states to set their own catch limits, size limits, and harvest seasons, though the aggregate harvest still must not exceed the ACL. While harvest seasons from 2020 onwards have been longer than the shortest precedent (a 3-day season) and have exceeded 3 weeks (in Florida), seasons appear to be much shorter than recreational anglers desire and still constrain harvest to a small proportion of the year. Gulf of Mexico red snapper spawning stocks remain very low, indicating that increasing harvest season limits would likely result in the ACL being exceeded. The strong preference anglers have for retaining (i.e., harvesting) red snapper (Jungers et al., 2023; Scyphers et al., 2021), as opposed to catching and releasing snapper exacerbates management challenges.

These trends in the Gulf of Mexico recreational red snapper fishery suggest that current management regulations (season length, bag and size limits) may be inadequate to sustain reef fish populations and maximize benefits to anglers (Johnston et al., 2007, 2009; Jungers et al., 2023; Sutinen & Johnston, 2003). Accordingly, we surveyed recreational anglers who fish using private vessels to ascertain both their (1) preferences for and (2) potential effort responses to changes in current recreational red snapper management approaches versus implementing a harvest tag system. Examining anglers' preferences for fisheries management and how anglers may respond to alternative management approaches or regulatory changes is important to balance angler satisfaction and long-term sustainability of fish populations (Arlinghaus et al., 2019; Beardmore et al., 2013; Birdsong et al., 2021; Carruthers et al., 2019). Anglers typically support regulatory measures that do not limit their fishing opportunities and allow them to maximize their catch (Arostegui et al., 2021). Consistent with the existing literature, we predicted that anglers would prefer longer seasons, shorter on-water travel distances, and larger bag limits (i.e., higher retention), catch rates, and sizes of fish. In this manuscript, catch refers to the total amount of fish caught (including discarded fish), and retention only refers to kept fish. In general, longer on-water travel distances decrease angler satisfaction (Beardmore et al., 2013; Matsumura et al., 2019; Post et al., 2008), while higher catch rates and larger fish increase angler satisfaction (Beardmore et al., 2015; Birdsong et al., 2021; Heermann et al., 2013; Hunt, 2005; Hunt et al., 2019; Wilde & Pope, 2004). However, recreational anglers may be heterogeneous in their preferences for management options (Johnston et al., 2010; Ward et al., 2013), meaning that management actions may satisfy only a subset of anglers. We predicted that some private-vessel anglers would recognize the potential benefits of a harvest tag system over the current management approach. Finally, we predicted that private-vessel anglers would alter the number of trips they would take to target red snapper (i.e., effort) based on their preferred management approach, but we had no predictions about the directionality of that effort change. Anglers might increase derby fishing under current management approaches or reduce effort owing to dissatisfaction with their fishing experience. Alternatively, anglers might increase or decrease effort under a harvest tag system, depending on how frequently they prefer to fish over the year. Our study complements recent research on the for-hire sector within the recreational red snapper fishery in the Gulf of Mexico (Abbott et al., 2018; Abbott & Willard, 2017; Jungers et al., 2023).

2 | METHODS

2.1 | Sampling and data collection

We designed and implemented stated preference discrete choice experiment (SPCE) surveys to elicit recreational red snapper anglers' preferences for management of the red snapper fishery and how anglers would respond to different management regulations and trip options, specifically focusing on anglers with private vessels. We collected data using an online questionnaire from December 2019 to January 2020, which accidentally overlapped with changes in the Gulf of Mexico red snapper fishery. We focused on recreational anglers with Florida fishing licenses because their contact details were publicly available under the Florida's Government-in-the-Sunshine Law (§ 286, Fla. Stat., 1967).

We obtained contact information for all individuals holding a Florida Gulf of Mexico Reef Fish permit ($n = 86{,}590$) because recreational fishing licenses in Florida do not specify the species targeted. This permit is legally required for anglers targeting reef fish in waters adjacent to Florida's Gulf of Mexico coastline, but the permit is free and may have been obtained by people who did not target reef fish or red snapper. We administered the questionnaire using the University of Florida's Qualtrics license. After initial implementation of the survey, we sent four follow-up reminder emails to individuals who had not responded to the survey approximately every 2 weeks. At the close of data collection, we mailed a short, reduced survey to a random sample of 6000 non-respondents to test for non-response bias.

2.2 | Survey design

We initially asked survey respondents to indicate which fish they had targeted in the Gulf of Mexico in the past 24 months, namely: red snapper; other reef fish (e.g., gray snapper *Lutjanus griseus*, gag grouper *Mycteroperca microleptis*, greater amberjack *Seriola dumerili*, and gray triggerfish *Balistes capriscus*); inshore fish (e.g., red fish, spotted seatrout *Cynoscion nebulosus*); pelagic fish (e.g., king mackerel *Scomberomorus cavalla*, tuna, cobia *Rachycentron canadum*); and other fish. We elicited details of respondents' red snapper fishing over the past 12 months, specifically: (1) how many trips respondents had taken to fish for red snapper; (2) how many red snapper respondents caught and/or released; (3) the average size of red snapper caught; (4) the weight of the largest red snapper caught; (5) whether respondents typically launched from the Florida panhandle or peninsula Florida when targeting red snapper; (6) the average distance offshore that respondents traveled to start harvesting red snapper; and (7) the average distance traveled and hours spent on water to target red snapper. We also collected information on respondents' demographics (i.e., sex, age, and household income).

We presented respondents with different options (size limits, bag limits, season lengths, and harvest tags) for managing the red snapper fishery, and asked them to indicate whether they supported these management options (strongly oppose = −2, oppose = −1, neutral = 0, support = 1, and strongly support = 2). We informed respondents that under current size limits, anglers could only legally keep red snapper that are ≥16 in. in length. However, two alternatives were to allow anglers to keep red snapper that are 14–24 in. in size (a slot limit) or to implement a harvest tag system. A slot limit for red snapper was proposed to the GMFMC to increase catch, extend season lengths, and reduce mortality of larger red snapper (Farmer et al., 2014; Garner et al., 2020). We explained that under a harvest tag system, anglers could keep any size of red snapper, but they may only harvest 10 red snapper each year (i.e., no size limit, bag limit, or closed season). In addition to the current bag limit of two red snapper/person/trip, we presented respondents with a bag limit of one red snapper/person/trip (but a longer season), four red snapper/person/trip (but a shorter season), or 10 harvest tags (no size limit, no bag limit, and no closed season). In addition to the current recreational season length of ∼25 days/year (which we noted did not apply to for-hire vessels), we presented respondents with a season of 15 days/year (but a higher bag limit), a season of 40 days/year (but a lower bag limit), or 10 harvest tags. From 2011 to 2016, the federal red snapper season ranged from 9 to 48 days (Farmer et al., 2020; Jungers et al., 2023), and we selected the alternative season lengths based on this range.

We then presented respondents with SPCEs to mimic the reality of fisheries management. Specifically, we presented respondents with three alternative management options for the recreational red snapper fishery and asked respondents which option they preferred. Respondents could also elect to reject all management options and to ‘opt-out’ of the recreational red snapper fishery by not fishing for red snapper, although they could still target other species. If respondents chose one of the management options, we asked them whether they would alter the number of trips they take to target red snapper (increase, decrease, or stay the same) under that management approach. We asked respondents “How confident are you that your responses to [the stated preference] questions accurately reflect how you would fish under different management alternatives?”, and we excluded respondents who stated that they were not at all confident in their responses from our analysis. We asked respondents who chose the opt-out option why they would not choose to fish for red snapper. Response options included: (1) I do not like any of the management options; (2) I do not trust how the government is managing the red snapper fishery; (3) I object to government management of the red snapper fishery; (4) I prefer to

TABLE 1 Attributes and attribute-levels for stated preference choice experiments (SPCEs) pertaining to recreational red snapper management in the Gulf of Mexico adjacent to Florida, USA.

Attributes	Levels
SPCE1	
Size limit	16″ minimum; 14–24″ harvest slot limit
Red snapper bag limit	1, 2, or 4 red snapper/person/trip
Season length	15, 30, or 45 days
On-water travel distance (panhandle Florida)	10, 20, 30 miles
On-water travel distance (peninsula Florida)	30, 40, 50 miles
SPCE2	
Management regulation	Current management[a], harvest tag (10 tags/year)
Average size of catch[b]	14″, 18″, 22″ or 26″
Catch rate for 16″ red snapper per trip[c]	1/vessel/trip, 1/angler/trip, 2/angler/trip, 4/angler/trip
On-water travel distance (panhandle Florida)	10, 20, 30 miles
On-water travel distance (peninsula Florida)	30, 40, 50 miles

Note: We generated two questionnaire versions (SPCE1 and SPCE2) that differed in attributes and levels.
[a]The current management approach for red snapper, that is, a bag limit of two fish/person/trip, a minimum size limit of 16″, and a season length of 25 days, which is approximately in line with past seasons.
[b]The total length of individual red snapper caught.
[c]Catch rates refer to catch per unit of effort, which is often expressed on a per trip or per hour basis.

FIGURE 1 Examples of choice-scenarios presented to respondents.

Choice Experiment 1

	Alternative 1	Alternative 2	Alternative 3
Size limit	14-24" slot	16" minimum	16" minimum
Bag limit	1 fish	4 fish	2 fish
Season length	30 days	30 days	15 days
Distance from shore	30 miles	10 miles	20 miles

Which management option would you prefer?

- Alternative 1
- Alternative 2
- Alternative 3
- I would not choose to fish for red snapper

Choice Experiment 2

	Alternative 1	Alternative 2	Alternative 3
Management approach	Harvest tag	Status quo	Status quo
Average catch size	18"	22"	18"
Catch rate	4 per fisher	1 per fisher	1 per boat
Distance from shore	20 miles	10 miles	20 miles

Which management option would you prefer?

- Alternative 1
- Alternative 2
- Alternative 3
- I would not choose to fish for red snapper

fish for other types of fish; and (5) I do not anticipate fishing for red snapper in the future. We considered the answer "I object to government management of the red snapper fishery" as a protest response and excluded individuals that selected this option.

We designed two questionnaires that differed in the SPCE attributes and levels, and respondents randomly received one of the two questionnaire versions (Table 1; Figure 1). The SPCEs presented in questionnaire version 1 (SPCE1) focused on traditional management options (size limits, bag limits, and season length), while also presenting respondents with the distance from shore they should expect to travel before catching a red snapper that is at least 14 in. in size. We included distance traveled on water in the SPCEs as a proxy for the cost to anglers with private vessels of harvesting red snapper. Distance traveled increases fuel usage (a major component of trip cost for offshore fishing) and the physical and psychological discomfort of anglers, owing to rougher water and greater risks (e.g., from storms) when traveling farther from port. Respondents who usually launched from the Florida panhandle were presented with offshore travel distances of 10, 20, or 30 miles. Respondents who launched from peninsula Florida were presented with distances of 30, 40, or 50 miles. These distances were based on the expert opinion of Florida Fish and Wildlife Conservation Commission biologists and managers. The SPCEs in the second questionnaire version (SPCE2) presented respondents with the choice between the harvest tag system and the current management system (i.e., a bag limit of two fish/person/trip, a minimum size limit of 16″, and a season length of 25 days), in addition to the average size of red snapper that respondents would expect to catch, the catch rate per trip, and offshore travel distances. We informed respondents that the harvest tag option "allows fishermen to fish all year long, but their take-home catch would be restricted to 10 fish". The choice of 10 tags was based on feedback from fisheries managers and biologists and recreational red snapper anglers, who confirmed that this was the appropriate number of tags and was in line with the number of snapper that anglers would be expected to harvest over a year. Catch rates and sizes were based on recent information from the National Marine Fisheries Marine Recreational Information

Program database (http://st.nmfs.noaa.gov/recreational-fisheries/access-data/data-downloads/index). Unfortunately, our survey was implemented after Amendment 50 passed and when exempted fishing permits were available. This meant that the management options we presented in the survey were more restrictive than the management approaches being implemented by the Gulf states at the time.

We generated a *D*-efficient design for the SPCEs using the R package "choiceDes" (Horne, 2018), which allowed us to estimate regression parameters efficiently while reducing the cognitive burden for respondents. Each questionnaire version consisted of 24 blocks of questions with three SPCE questions per block (Tables S1–S4). Respondents were randomly assigned one of the 24 blocks. We pretested the survey with four experts (fisheries biologists, social scientists) and four anglers who routinely fished for red snapper in the Gulf of Mexico waters adjacent to Florida. The University of Florida Institutional Review Board reviewed and approved our study (IRB 201901429).

2.3 | Data analysis

We used STATA (v 17.0) and R (v 4.1.2) software to conduct all statistical analyses. We hypothesized that anglers' preferences for different management options were correlated, and hence represented latent constructs. Accordingly, we used exploratory factor analysis (Watkins, 2021) to determine whether ordinal survey items that measured respondents' a priori support for bag limits, size limits, season lengths, and harvest tags could be combined to generate composite variables (e.g., support for the four different management options). Exploratory factor analysis is a data reduction technique that assumes that correlations (covariance) between observed variables (i.e., responses to socio-psychological questions) can be explained by a smaller number of latent variables (i.e., factors; Watkins, 2022). Factors are unobservable variables that influence more than one observed measure (Watkins, 2021). We deemed exploratory factor analysis to be appropriate if the Kaiser–Meyer–Olkin measure of sampling adequacy ≥0.7, Barlett's test of sphericity (to test if variables are independently distributed) was significant ($p \leq .05$), and the determinant value ≥0.00001 (Leech et al., 2007; Watkins, 2018). We assumed that survey items that loaded onto a factor could be combined to measure a single construct if Cronbach's alpha ≥0.7 (George & Mallery, 2003), the eigenvalue for that factor ≥1, and the factor loadings for the items ≥0.3 (Leech et al., 2007). We generated constructs (e.g., attitudes towards harvest tags) through linear combinations of the variables that loaded onto retained factors.

We used random parameters logistic (RPL) regression (mixed logit) models to analyze the SPCE data (McFadden & Train, 2000; Train, 2009). Random parameters logistic models are based on the random utility model (RUM) framework, which assumes that individuals make choices that maximize their utility (or satisfaction). According to the RUM framework, respondent *i*'s utility from red snapper management option *j* (U_{ij}) is modeled as

$$U_{ij} = V_{ij} + \varepsilon_{ij} = X_{ij}\beta + \varepsilon_{ij}$$

where V_{ij} is the systematic (observed) component of the utility function, ε_{ij} is a random error, X_{ij} is a matrix of explanatory variables (including the attributes of the red snapper management option), and β is a vector of estimated coefficients (Train, 2009). For SPCE1, V_{ij} took the form:

$$V_{ij} = \beta_0 + \beta_1 \text{Size}_{ij} + \beta_2 \text{Bag}_{ij} + \beta_3 \text{Season}_{ij} + \beta_4 \text{Distance}_{ij}$$

where β_0 is the opt-out dummy (or alternative specific constant) associated with exiting the recreational red snapper fishery, Size_{ij} is the size limit (effects coded as ≥16 in. = −1, slot limit of 14–24 in. = 1), Bag_{ij} is the bag limit (1, 2, and 4 red snapper/person/trip), Season_{ij} is the season length (15, 30, and 45 days), and Distance_{ij} is the offshore travel distance to catch a red snapper (10, 20, 30, 40, and 50 miles) associated with management option *j*. For SPCE2, V_{ij} took the form:

$$V_{ij} = \beta_0 + \beta_1 \text{Management}_{ij} + \beta_2 \text{Catch}_{ij} + \beta_3 \text{Rate}_{ij} + \beta_4 \text{Distance}_{ij}$$

where Management_{ij} is the management approach (effects coded as current management approach = −1, harvest tag = 1), Catch_{ij} is the average catch size (14, 18, 22, and 26 in.), and Rate_{ij} is the catch rate (1/vessel/trip = 1, 1/angler/trip = 3, 2/angler/trip = 6, 4/angler/trip = 12) associated with management option *j*.

The probability that respondent *i* chooses management option *j* from *J* alternatives is

$$\text{Prob}(U_{ij} > U_{ik}) = \text{Prob}(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}) \; \forall j \neq k; j,k \in J.$$

Assuming that ε_{ij} is independently and identically distributed with an extreme value type I distribution, then the probability of respondent *i* selecting management option *j* is given by:

$$\text{Prob}_{ij} = \frac{e^{X_{ij}\beta}}{\sum_{k=1}^{J} e^{X_{ik}\beta}}$$

The above multinomial logistic (MNL) function makes three limiting and unrealistic assumptions, namely: (1) homogeneity of preferences across individuals; (2) independence of irrelevant alternatives; and (3) no correlation of unobserved factors over time (Carlsson et al., 2003).

Accordingly, we estimated RPL models, which relax the unrealistic assumption of preference homogeneity across individuals. The RPL model captures preference heterogeneity by no longer assuming that β are fixed across respondents:

$$\text{Prob}_{ij} = \frac{e^{X_{ij}\beta_i}}{\sum_{k=1}^{J} e^{X_{ik}\beta_i}}$$

Here, β_i represents a matrix of coefficients. The RPL model generates both mean and standard deviation coefficients for the opt-out dummy and the attributes of recreational red snapper management. If the standard deviation coefficient is significantly different from zero then individuals are heterogeneous in their preferences for a management attribute (Train, 2009). We assumed that the beta coefficients for all attributes were uncorrelated and normally distributed (Hunt et al., 2005; Jungers et al., 2023). We used 50 Halton draws for the models presented in this paper after confirming that increasing the number of draws to 1000 did not alter our findings.

We further tested for sources of preference heterogeneity by interacting respondents' demographic characteristics, fishing behaviors, and support for or opposition to different aspects of red snapper management with the opt-out dummy and attributes of the different management options. We included these interaction terms as non-random covariates in the RPL models. We then selected best-fit models based on the stepwise procedure (forward entry and backward removal; Derksen & Keselman, 1992) and the minimum Akaike Information Criteria (AIC; Burnham & Anderson, 2004). We considered a coefficient statistically significant if $p \leq 0.05$.

We also used a multinomial logistic regression model to explore how respondents would change their fishing effort under current management approaches versus a harvest tag system. The multinomial logistic regression is a logistic regression that allows probabilities for more than two categorical responses to be estimated (Fox, 2015). We created five models in which we regressed effort response (if respondents would increase, decrease, or maintain the same number of trips to target red snapper) against the management option (current management approach vs. harvest tag) and various combinations of catch size, catch rate, and on-water travel distance. We first estimated the full model (model 1) that included the management option, catch size, catch rate, and on-water travel distance. We then interacted the management option with one additional attribute, namely: catch size (model 2); catch rate (model 3); and on-water travel distance (model 4). Finally, we estimated the regression with the management option and no interactions (model 5). We treated the management option as a Bernoulli variable and the catch size, catch rate, and on-water distances as continuous variables. Coefficients in the multinomial logistic regression are expressed as natural log odds ratios of a given response type (increase or decrease fishing trips) to the reference category (stay the same number of trips to target red snapper).

3 | RESULTS

We received responses from 1079 anglers, of whom 766 indicated that they were recreational red snapper anglers, and 660 completed the survey (61% completion rate). On average, respondents were 45–55 years old and their annual household income was \$100,000–\$199,999 (Table S5). Most respondents were male (94.0%). In total, 427 respondents (55.7%) launched from panhandle Florida when targeting red snapper. Respondents' median on-water travel distance to start fishing for red snapper was 21–30 miles, although 35.7% of respondents traveled >30 miles offshore to fish for snapper. Most respondents (85.8%) used their own vessels or fished from the vessels of family members or friends. Respondents took a median of four trips to fish for red snapper, caught a median of 12 red snapper, and released a median of 20 red snapper in the past 12 months (Table S6). The median size of the red snapper respondents caught and/or released was 20 in. in length and 10 lbs in weight. Only 16 respondents (2.1%) stated that the average size of red snapper was less than the minimum slot limit of 14 in., and 82.1% of respondents indicated that the average red snapper met current size limits of ≥16 in. Respondents traveled a median of 63 miles on water during their red snapper fishing trips and spent a median of 8 h fishing. Given that respondents estimated that vessels traveled a median of 2 miles per gallon of fuel, this suggests that over 30 gallons of fuel are required per fishing trip. During the time of this survey, fuel cost \$2.60/gallon, that is, fuel costs for each trip were approximately \$81.90 (median of 63 miles).

On average, respondents were supportive of a minimum size limit of 16 in. for red snapper (median = support) but were neutral about a 14–24 in. slot limit (Figure 2, Table S7). On average, anglers opposed a smaller bag limit of one snapper/person/trip with a longer fishing season (median = oppose) and a larger bag limit of four snapper/person/trip with a shorter fishing season (median = oppose), but neither supported nor opposed

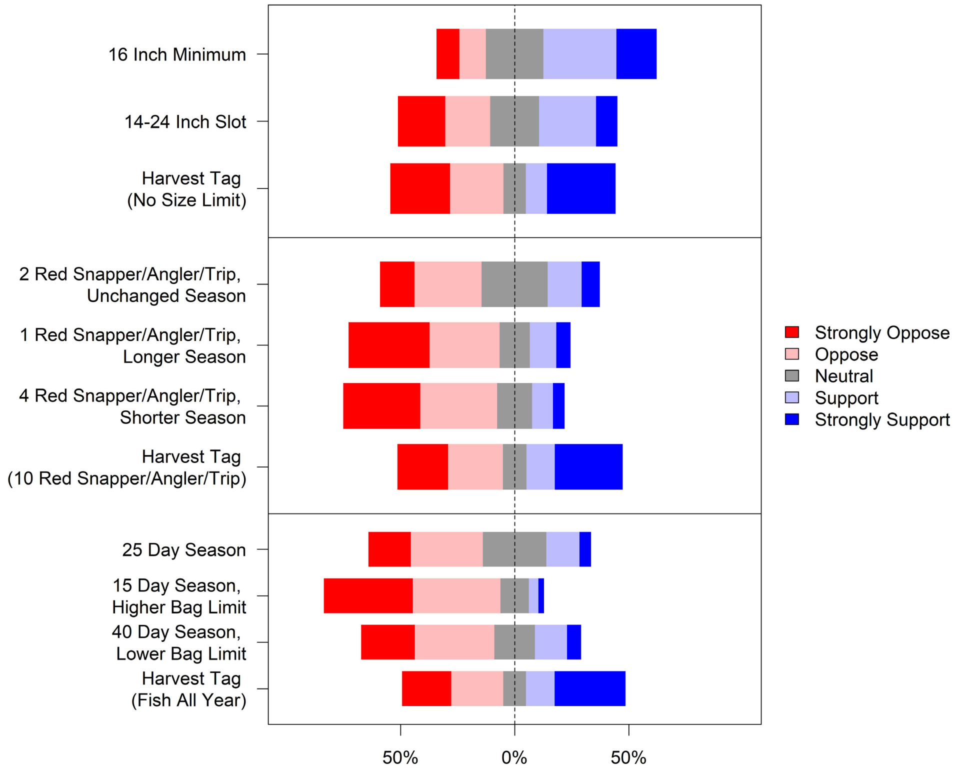

FIGURE 2 Visual representation of the distribution of the responses to different options for managing the red snapper fishery, including various size limits, bag limits, season lengths, and a harvest tag option. The harvest tag option includes no size limit and season length and 10 red snapper/angler/year. "Strongly oppose" = red, "oppose" = light red, "neutral" = gray, "support" = light blue, and "strongly support" = blue ($n = 766$).

the current bag limit of two snapper/person/trip and an unchanged fishing season (median = neutral). On average, respondents opposed all season lengths (25 days, 15 days with a higher bag limit, 40 days with a lower bag limit; median = oppose). When presented with a harvest tag system rather than bag or size limits and season lengths, most respondents opposed or were neutral about the harvest tag. Respondents opposed the harvest tag because they believed anglers would not comply with the harvest tag limits ($n = 175$, 22.8%), it would restrict how many fish they could harvest ($n = 115$, 15.0%), it might lead to the red snapper fishery being overharvested ($n = 85$, 11.1%) or for other reasons (e.g., commercial sector does not have similar restrictions, $n = 63$, 8.2%).

Factor analysis (Cronbach's alpha = 0.94, eigenvalue = 2.45) indicated that the three ordinal items that measured respondents' level of support for a harvest tag system as opposed to size, bag and season limits could be combined to generate a single composite variable, 'harvest tag support' (median = 1.84, -0.44 ± 4.08; Table S8). The remaining ordinal items did not load onto single factors, likely because the management options represented distinct types of control rules. Thus, we included these individual ordinal items pertaining to bag and size limits and season lengths as effects-coded variables in the regression models (range of −2 to 2). We created non-random interaction variables for inclusion in the RPL models by interacting (1) the opt-out variable with respondents' socio-demographic characteristics and fishing behaviors, and (2) attributes of the management options presented (harvest tag, size and bag limits, season length, and on-water travel distance) with respondents' support for these attribute levels (Table S9).

3.1 | Respondents' preferences for alternative variations on current red snapper management approaches (SPCE1)

Respondents were heterogeneous in their preferences for continuing to fish for red snapper versus not fishing for red snapper (statistically significant standard deviation coefficient for the opt-out; Table 2). On average, respondents preferred a minimum size limit of 16 in. for red snapper over a 14–24 in. slot (negative mean coefficient), although they demonstrated heterogeneity in their preferences. Respondents were also heterogeneous in their preferences for bag limits, but most respondents preferred higher bag limits. Respondents preferred longer season lengths (positive mean coefficients), although the strength of their preferences for season length varied. Respondents who were presented with their preferred size and bag limits and season lengths derived greater satisfaction from red snapper management. Taking preference heterogeneity into account, respondents preferred to travel less distance offshore to catch snapper, although respondents who travel longer distances to target red snapper derived less disutility from on-water travel

TABLE 2 Random parameters logistic (RPL) regression models that measured respondents' preferences for recreational red snapper management regulations that included size and bag limits and a season length, Florida, USA, 2019–2020 ($n = 381$).

	RPL model						RPL model with interaction variables					
	Mean coefficient			Standard deviation coefficient			Mean coefficient			Standard deviation coefficient		
	β	S.E.	*p*	*β*	S.E.	*p*	*β*	S.E.	*p*	*β*	S.E.	*p*
Opt-out	−1.487	0.692		4.348	0.831	≤0.05	−1.970	1.577		3.401	0.572	≤0.05
Size limit[a]	−0.482	0.074	≤0.05	0.712	0.139	≤0.05	−0.504	0.079	≤0.05	0.695	0.134	≤0.05
Bag limit[b]	0.712	0.070	≤0.05	0.719	0.094	≤0.05	0.915	0.087	≤0.05	0.701	0.012	≤0.05
Season length[c]	0.076	0.008	≤0.05	0.058	0.013	≤0.05	0.080	0.008	≤0.05	0.055	0.010	≤0.05
Distance[d]	−0.038	0.009	≤0.05	0.082	0.015	≤0.05	−0.122	0.026	≤0.05	0.073	0.016	≤0.05
Opt-out × travel distance							−0.027	0.050				
Opt-out × age							0.028	0.024				
Size × size preference[e]							0.244	0.079	≤0.05			
Bag × bag preference[f]							0.192	0.029	≤0.05			
Season × season preference[g]							0.012	0.002	≤0.05			
Distance × travel distance[h]							0.004	0.001	≤0.05			
AIC/n	0.520						0.490					
McFaddens *R*[b]	0.117						0.102					
Log likelihood	−1203.47						−1039.90					

[a]Effects coded as minimum size of 16 in. = −1, slot limit of 14–24 in. = 1.
[b]Continuous variable coded as 1, 2, or 4 red snapper/person/trip.
[c]Continuous variable coded as 15, 30, or 45 days.
[d]Continuous variable coded as 10, 20, 30, 40, or 50 miles depending on whether the respondent launched from panhandle or peninsula Florida to catch red snapper.
[e]The attributes for size limit (16″ minimum vs. 14–24″ harvest slot) that respondents selected in the choice experiments were interacted with respondents' support for or opposition to various size limits (effects coded as strongly oppose = −2 to strongly support = 2).
[f]The attributes for bag limit (1, 2, or 4 red snapper/person/trip) that respondents selected in the choice experiments were interacted with respondents' support for or opposition to various bag limits (effects coded as strongly oppose = −2 to strongly support = 2).
[g]The attributes for season length (15, 40, and 45 days) that respondents selected in the choice experiments were interacted with the support for or opposition to various season lengths (effects coded as strongly oppose = −2 to strongly support = 2).
[h]The attributes for on-water distance (10, 20, 30, 40, and 50 miles) that respondents selected in the choice experiments were interacted respondents' estimated travel distance to target red snapper.

(positive interaction between distance that the respondent travels on water to target red snapper and the distance presented in the choice experiment).

3.2 | Respondents' preferences for a harvest tag system versus current management (SPCE2)

Respondents preferred to continue fishing for red snapper rather than exiting the red snapper fishery (negative mean coefficient for the opt-out; Table 3), although the strength of their preferences varied (statistically significant standard deviation coefficient). Older respondents and respondents who launched from the panhandle were more likely to exit the recreational red snapper fishery (positive interaction terms). Although, on average, respondents were indifferent between current management of the recreational red snapper fishery and harvest tags (mean coefficient was not statistically different from zero), a subset of respondents preferred the harvest tag (i.e., respondents demonstrated preference heterogeneity). Respondents who were supportive of harvest tags preferred a harvest tag system to the current management of bag and size limits combined with a fishing season. Respondents preferred higher catch rates, even taking preference heterogeneity into account. Respondents showed heterogeneity in their preferences for catch size. Although we found heterogeneity in preferences for on water travel distances, the relative magnitude of the mean and standard deviation coefficients suggest that most respondents preferred to travel less distance to catch red snapper.

TABLE 3 Random parameters logistic (RPL) regression models that measured respondents' preferences for recreational red snapper management regulations that included management option (harvest tag vs. current management), catch size, and a catch rate.

	RPL model						RPL model with interaction variables					
	Mean coefficient			Standard deviation coefficient			Mean coefficient			Standard deviation coefficient		
	β	S.E.	*p*	*β*	S.E.	*p*	*β*	S.E.	*p*	*β*	S.E.	*p*
Opt-out	−3.804	0.640	≤0.05	3.803	0.479	≤0.05	−12.663	2.887	≤0.05	3.075	0.682	≤0.05
Management[a]	0.019	0.068		0.770	0.120	≤0.05	0.118	0.078		0.719	0.134	≤0.05
Catch size[b]	−0.003	0.013		0.055	0.024		−0.017	0.015		0.095	0.025	≤0.05
Catch rate[c]	0.222	0.018	≤0.05	0.113	0.030	≤.05	0.250	0.023	≤0.05	0.133	0.032	≤0.05
Distance[d]	−0.054	0.008	≤0.05	0.064	0.011	≤0.05	−0.060	0.010	≤0.05	0.089	0.013	≤0.05
Opt-out × trip							−0.141	0.079				
Opt-out × launch							2.519	0.939	≤0.05			
Opt-out × total distance							0.017	0.010				
Opt-out × age							0.095	0.035	≤0.05			
Opt-out × income							1.517	0.731				
Management × harvest tag support[e]							0.121	0.021	≤0.05			
AIC/*N*	0.554						0.533					
McFaddens *R*[b]	0.096						0.101					
Log likelihood	−1333.42						−1079.57					

Note: This choice experiment surveyed respondents in Florida, USA, 2019–2020 ($n = 385$).
[a]Effects coded as current management = −1, harvest tag = 1.
[b]Continuous variable coded as 14, 18, 22, and 26 in. (total length) of individual red snapper caught.
[c]Continuous variable coded as 1/boat/trip = 1, 1/angler/trip = 3, 2/angler/trip = 6, 4/angler/trip = 12.
[d]Continuous variable coded as 10, 20, 30, 40, or 50 miles depending on whether the respondent launched from panhandle or peninsula Florida to catch red snapper.
[e]The attributes for management option (current management vs. harvest tag) that respondents selected in the choice experiments were interacted with the composite variable that measured respondents' support for or opposition to the harvest tag option.

3.3 | Respondents' effort response to a harvest tag system versus current management

The model with the best fit (minimum AIC) only included the management attribute (current management approach vs. harvest tag; Table S10). The odds ratio of choosing the harvest tag option and decreasing the number of trips was 1.279 and the odds ratio of choosing the harvest tag option and increasing the number of trips was 1.239 (Table S10). Respondents preferred to keep their effort response (i.e., the number of trips) the same if they chose the current management approach and they would either increase or decrease their effort response if they chose the harvest tag option.

3.4 | Non-respondent follow-up surveys

We received non-respondent follow-up surveys from 711 anglers, of whom 319 non-respondents (44.9%) indicated that they fished for red snapper. We found a significant difference between respondent and non-respondent red snapper anglers in terms of the amount of red snapper trips they took in the past 12 month, with non-respondents taking fewer trips than respondents ($p < 0.001$). Non-respondents fished for red snapper an average of two times in the past 12 months (2.93 ± 3.39 trips, range of 0–25 trips). We also found a significant difference between respondent and non-respondent anglers in terms of their use of for-hire vessels. Most non-respondent red snapper anglers ($n = 212$, 66.5%) always used for-hire vessels to target red snapper, whereas only 21 individuals (6.6%) never used for-hire vessels ($\chi^2 = 43.402$, $p < 0.001$). We found no significant difference between respondents and non-respondent red snapper anglers in terms of fish they targeted in the Gulf of Mexico (inshore species: $\chi^2 = 1.808$, $p = 0.178$; pelagic species: $\chi^2 = 1.953$, $p = 0.162$; other reef fish: $\chi^2 = 0.121$, $p = 0.728$).

Only 110 non-respondents (15.5%) indicated that they had received the survey but had not responded to it. Non-respondents primarily stated that they had not responded to the survey because they had not received the survey (e.g., it was redirected to their spam folder, $n = 279$, 39.2%), and they do not fish for red snapper in the Gulf of Mexico ($n = 167$, 23.5%). Less than 8% of non-respondents indicated that they chose not to respond to the survey because they didn't believe their responses would impact red snapper management ($n = 55$, 7.7%), they considered the survey biased ($n = 15$, 2.1%), or recreational red snapper management was unimportant to them ($n = 5$, 0.7%). Our analysis suggests that survey respondents comprised individuals who target red snapper more frequently and do not purchase fishing trips on for-hire vessels.

3.5 | Limitations

There are four limitations to our study. First, we asked respondents their intended behaviors and we did not measure actual behaviors in response to changes in red snapper management. Second, we did not survey anglers who use for-hire vessels, and thus we have not captured their preferences for different management options (but see recent analysis by Jungers et al., 2023). Third, we did not test for policy consequentiality in our choice experiments, that is, whether respondents believed that their survey responses would impact policy design and implementation (Liu et al., 2020). Finally, we did not test for scale heterogeneity (i.e., differences in scale across choice tasks or respondents; Hess et al., 2009).

4 | DISCUSSION

More restrictive regulations and alternative management approaches (i.e., rights-based systems or regional management) are typically used to control harvest rates and alleviate derby fishing, while also seeking to enhance the satisfaction of a heterogenous angler population (Arostegui et al., 2021; Johnston et al., 2007). Consistent with the larger literature on fisheries management, we found that most recreational red snapper anglers in this study preferred less restrictive regulations with reduced size limits, higher retention (i.e., larger bag limits), and longer seasons, increased catch rates (Beardmore et al., 2015; Birdsong et al., 2021; Heermann et al., 2013; Hunt, 2005; Hunt et al., 2019; Wilde & Pope, 2004), and shorter on-water travel distances (Beardmore et al., 2013; Matsumura et al., 2019; Post et al., 2008). We also found that participants in the recreational red snapper fishery are generally White males aged less than 65 years who have the opportunities (e.g., leisure time, sufficient physical health and strength) and resources (e.g., private vessels) to engage in saltwater angling, likely owing to their high incomes (Floyd et al., 2006; Lee et al., 2016). Our finding that older anglers may exit the recreational red snapper fishery is consistent with national statistics that show that only 12% of the population aged 65 years or older engages in freshwater and/or saltwater angling (U.S. Department of the Interior, U.S. Fish and Wildlife Service, 2022), which may be attributable to the fact that this demographic no longer has the physical capacity to fish or may prioritize other leisure activities. Our results suggest that recreational anglers with private vessels would prefer to have the option to catch and retain larger fish and not to be constrained by regulatory requirements to release fish (e.g., because fish do not meet size limits; Arostegui et al., 2021; Carter & Liese, 2012). This preference was likely reinforced by the fact that most respondents (82.1%) were catching red snapper ≥16 in., and respondents released ∼20 fish compared to the ∼12 fish they kept (within 1 year).

Despite their stated dissatisfaction with current management approaches, many respondents chose the current management system over a harvest tag system and indicated that they would neither exit the fishery nor reduce their effort under the current management approach. This suggests that current management approaches are consistent with recreational red snapper anglers' preferences for fishing experience (i.e., harvesting larger red snapper), and regulatory changes that anglers believe will undermine their fishing experience will be rejected (Koemle et al., 2024). Existing research also suggests that recreational anglers may not understand different allocation policies (e.g., harvest tags) and will default to management strategies with which they are familiar and which they believe will improve future access and harvest (Brinson & Wallmo, 2017). Respondents' preference for current management approaches was likely reinforced by the fact that we implemented the survey after Amendment 50 had passed and as harvest season limits were being changed. Nonetheless, more stringent rules regarding size and bag limits and season lengths (∼25 days/year) appear not to have constrained respondents' effort (median of four trips/season, 2.5 fish kept per trip, five fish released per trip). This suggests that derby-style fishing and pressure on the red snapper population will continue unabated even if agencies continue to make size, bag, and season length restrictions more stringent, with continued discard mortality from barotrauma as anglers discard fish to comply with bag and size limits (Curtis et al., 2015; Jungers et al., 2023).

A harvest tag program for red snapper may be useful to prevent overharvest and further angler dissatisfaction, despite the fact that anglers may initially object to harvest tags owing to the cost and inconvenience of transitioning to a new management approach (Arostegui et al., 2021; Johnston et al., 2007). Fisheries management in the Gulf of Mexico is characterized by lack of innovation and progress in attaining harvest of fish populations (Abbott & Willard, 2017), and new recreational fishing policies should be explored. A rights-based approach to managing the recreational red snapper fishery has potential to increase angler welfare and access to snapper, while decreasing regulatory discards (Abbott et al., 2018; Abbott & Willard, 2017; Jungers et al., 2023). Under a harvest tag system, anglers could spread effort across the year, which should increase angler satisfaction and safety by reducing congestion, increasing landing opportunities, and allowing anglers to fish in favorable weather conditions (Abbott et al., 2018; Fenichel & Abbott, 2014; Timmins & Murdock, 2007). We note that some respondents were supportive of and preferred harvest tags, although respondents did express concerns that harvest tags would restrict how many fish they may harvest each year and distrusted that other anglers would comply with the tag system. It is unsurprising that anglers objected to a harvest quantity of 10 red snapper per year because their average annual harvests (12 red snapper) exceeded this level. Complicating matters, recreational anglers may alter their effort in response to a tag system. Respondents indicated that they would either decrease or increase their fishing effort in response to a harvest tag, although their effort response was not influenced by catch size or catch rate, likely because anglers have observed higher catch sizes and catch rates in response to rebuilding efforts (Abbott et al., 2018; Powers & Anson, 2019). Decreased effort under a harvest tag system, even without less harvest, would still diminish fishing-related mortality, assuming discard mortality is roughly proportional to effort. If a harvest tag system increased effort, it would cause additional discard mortality, and this would need to be weighed against any other benefits from harvest tags (e.g., satisfied anglers, better harvest control). Future research is needed to assess how harvest tags might affect angler behaviors on- and off-water, in order to infer cumulative effects on fish populations and the economic value of the fishery.

Extending a harvest tag system to recreational fisheries may present some challenges, including the implementation and distribution of tags (Camp et al., 2023). The implementation of harvest tag programs for Gulf of Mexico recreational reef fisheries would require significant start-up costs and planning efforts at state and federal levels (Johnston et al., 2007). The likely mechanism for distributing harvest tags would be a market-based allocation, which would distribute a finite number of harvest tags per season. Tags could be either auctioned off directly to anglers or retailers (e.g., sporting goods stores) or allocated by a lottery to ensure equity (Johnston et al., 2007; Jungers et al., 2023). Regardless of the distribution method, reselling unused tags at the end of the season would maximize efficiency in the tag market (Johnston et al., 2007). The challenges of harvest tag systems are not trivial, but such a system is in fact the status quo for most big game hunting in North America, providing ample precedent and in some cases, existing infrastructure for implementation (Camp et al., 2023).

Our study contributes to the body of literature about the potential for rights-based management in the Gulf of Mexico, specifically for anglers with private vessels in the recreational red snapper fishery. How recreational anglers with private vessels would actually respond to harvest tags for red snapper remains to be seen. Nonetheless, under current management approaches, the disconnect between angler satisfaction and rebuilding of the red snapper population will likely persist. Anglers' dissatisfaction with the rebuilding process of the red snapper stock has already compelled states to open state waters longer than the federal seasons, negating intended effort reduction through federal season restrictions (Simmons et al., 2019), and allowing the ACL to be exceeded. Scientists and managers need to better communicate the expected benefits of management adjustments to reduce angler dissatisfaction and political opposition to red snapper management (Mora et al., 2009; Seeteram et al., 2019). However, if continued political pressure results in regional management exceeding catch limits then federally mandated harvest tags or an alternative rights-based management system may be needed to increase management control over the amount of harvest and anglers, and increase compliance with harvest limits (Johnston et al., 2007, 2009; Jungers et al., 2023).

AUTHOR CONTRIBUTIONS

L. C.: Software, Formal analysis, Visualization, Writing—original draft, Writing—reviewing & editing. E. F. P.: Conceptualization, Methodology, Validation, Investigation, Writing—reviewing & editing, Funding acquisition. R. N. M. A.: Conceptualization, Methodology, Writing—reviewing & editing, Funding acquisition. E. V. C.: Conceptualization, Methodology, Validation, Writing—reviewing & editing, Supervision, Funding acquisition.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Deidentified data that support the findings of this study are available on Zenodo at https://doi.org/10.5281/zenodo.11123839.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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