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Bioeconomics of Florida Recreational Fisheries to Estimate Willingness to Pay for Bag and Size Limits of Spotted Seatrout

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Abstract: This research focuses on the economic component of a bioeconomic model for spotted seatrout in the recreational fisheries on Florida's west coast. A survey was designed to assess how anglers, who caught or targeted spotted seatrout on Florida's west coast, valued combined changes in the existing bag limit and size limit. The biological component of the stated preference model deemed such change necessary to ensure a sustainable stock. The biological model provides an economic constraint and results in the treatment of the bag and size limits as a composite good in which separate utilities cannot be measured for each component of the composite good. The stated preference choice method (SPCM) was used to estimate the change in economic value by boat mode of access (e.g., charter boat and private boat). The models also controlled for length of trip (full day versus half-day) for charter boat trips and for type of day (weekend or weekday) for both boat modes of access. Since those who accessed the fishery by private boat had a lower probability of achieving the bag limit/size limit, a model was run to predict the probability of achieving the bag limit/size limit and the probability was interacted with the bag limit/size limit choice. This yielded a positive willingness to pay for the bag limit/size limit combination that was sustainable. Estimated values per person per day for changing the bag limit/size limits to a sustainable level were USD 20.24 for the charter boat mode and USD 32.54 for the private boat mode. Aggregating this to a total value change using a five-year annual average (2012–2016) of total days of fishing for spotted seatrout on Florida's West Coast yielded an estimate of USD 147.9 million per year for charter boat anglers. The total annual value was about USD 3.4 million, while for private boat anglers the annual value was about USD 144.5 million.

Keywords: economic value; stated preference choice method; Florida's west coast; recreational fishing; spotted seatrout; bioeconomic model; bag limit; size limit; composite goods; charter boat; private boat

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1. Introduction

Spotted seatrout (*Cynoscion nebulosus*) have historically suffered from overconsumption. This study seeks to integrate biological and economic modeling to determine the value recreational fishers give to changes to bag and size limits that would support a more sustainable fishery. The objective of this study is to develop a bioeconomic model of spotted seatrout for recreational fishing on Florida's west coast to determine the value of improving size and bag limitations of spotted seatrout. The key to a valid stated preference survey is realistic scenarios and requires integrating biological information with economic information.

Using biological data to determine sustainable levels of catch (size and quantity), anglers' willingness to pay for spotted seatrout to attain the new hypothetical sustainable market was estimated. Although multiple species are targeted by recreational anglers off the west coast of Florida, efforts to design a survey for multiple species at once proved too complicated for this study given survey budget constraints. Since spotted seatrout was the top species either caught or targeted by anglers on Florida's west coast (MRIP, 2004–2015), spotted seatrout was selected for the study. Further, shore-mode fishing for spotted seatrout on Florida's west coast was very uncommon; therefore, the focus of this study was on the charter and private boat modes of access.

To make this approach for spotted seatrout relevant to policy/management, the focus was on how recreational anglers on Florida's west coast value changes in the bag limit and size limits. The integration of the biological information is critical here in evaluating a range of bag limit/size limit combinations that result in sustainable stock levels. This provides an important constraint to economic valuation in that sustainable catch is determined jointly with the bag limit/size limit combinations for spotted seatrout. Economically, the bag limit/size limit is treated as a composite good in which separate utilities/values cannot be measured for the components [1]. Bag limit/size limit combinations that are not sustainable are not policy/management relevant.

There are two possible economic outcomes from changes in bag limit/size limit combinations. A change in the bag limit/size limit could increase anglers' willingness to pay and it could increase the amount of fishing effort. The first is an economic efficiency criterion used in benefit–cost analysis and is the change in the non-market economic value or consumer's surplus (i.e., the economic value received by anglers over and above what they spend to undertake the activity). The second would result in market economic effects measured as increased spending and associated economic impact/contributions to the economy measured as increased output, value added (gross regional product), and income, tax revenues and employment, including multiplier effects.

In a bioeconomic model, the increase in effort could have a feedback effect changing the bag limit/size limit combinations that are sustainable. Therefore, both hypotheses were tested to determine whether a change in bag limit/size limits combinations would change willingness to pay and/or effort. In addition, if the change, when scaled up to population estimates, changes the sustainability of the bag limit/size limit, i.e., it is not policy/management-relevant to evaluate bag limit/size limits that are not sustainable.

2. Methods and Materials

2.1. Fishery Sustainability Evaluation and Management Options

Evaluation of spotted seatrout sustainability status for various size limit and bag limit regulations was conducted using length-based stock assessment procedures [2]. A numerical cohort-structured population model was parameterized using empirical information from life history demographic studies and the recreational fishery. The population model was then used to compute sustainability benchmarks for different size and bag limit management scenarios.

Spotted seatrout life-history parameters for the von Bertalanffy length–age growth function, allometric weight–length relationship, maximum lifespan, and length-at-sexual maturity were obtained from life-history studies [3,4]. Seatrout catch, effort, and size composition were obtained from NOAA's Marine Recreational Information Program (MRIP). Total instantaneous mortality rate $\left(\hat{Z}\right)$ n the exploited phase of the population was estimated using the length-based model of Ehrhardt and Ault (1992) [5],

$$\left[\frac{L_\infty - L_\lambda}{L_\infty - L_c}\right]^{\frac{\hat{Z}(t)}{K}} = \frac{\hat{Z}(t)\left(L_c - \bar{L}(t)\right) + K\left(L_\infty - \bar{L}(t)\right)}{\hat{Z}(t)\left(L_\lambda - \bar{L}(t)\right) + K\left(L_\infty - \bar{L}(t)\right)} \quad (1)$$

where L_c is length at first capture, L_λ is average length at the oldest age a_λ, $\bar{L}(t)$ is the average length in the exploited phase (i.e., between L_c and L_λ) at time t (i.e., year), and K and L_∞ are parameters of the von Bertalanffy growth equation. Average length $\bar{L}$ and the associated standard error were estimated from the MRIP survey data following Ault et al. (2019) [2]. Natural mortality rate M was estimated from maximum lifespan (Alagaraja 1984).

The stochastic procedures of Ault et al. (2019) were used to create probability distributions for Z, M, and fishing mortality rate F (i.e., $F = Z - M$) [2,6]. A calibration check for the numerical population model compared model-predicted length frequencies in the exploited phase with observed length frequencies from the MRIP survey.

The population model was further calibrated to match the annual recreational fishery catch for spotted seatrout by adjusting annual recruitment to the population. The calibrated model was then used to compute the spawning potential ratio (SPR), a management benchmark of stock reproductive capacity [7], defined as the ratio of spawning stock biomass (SSB) at the current fishing mortality rate F and size and bag limits relative to that of an unexploited stock ($F = 0$).

$$\mathrm{SPR} = \frac{\mathrm{SSB}_{\mathrm{exploited}}}{\mathrm{SSB}_{F=0}} \tag{2}$$

A minimum range for SPR used by fishery management councils and commissions for population sustainability is 30–40% [2]. Alternative management options for size and bag limits for spotted seatrout were designed to satisfy this minimum criterion for SPR.

2.2. Development of Fishery Management Options

Spotted seatrout length composition data from the recreational fishery prior to implementation of size and bag limits (1987–1989) were used to estimate average length $\underline{L}$ and total mortality rate Z. This enabled estimation of fishing mortality rate F for unconstrained size and bag limits (Table 1), and subsequent parameterization of the numerical seatrout population model. Model estimates of SPR were 3% for the pre-regulation period and 20% for the current management regime comprising a slot size limit of 381 to 508 mm (15 to 20 in) and a bag limit of 4 fish per person (Table 1). In both cases, SPR was below the accepted level (≈35%) considered to be sustainable. The model was then used to identify two alternative size and bag limit scenarios that achieved SPR $\geq$ 35%. Scenario #1 increased the lower bound of the current slot limit from 381 mm (15 in) to 432 mm (17 in), and increased the bag limit from the current 4 fish per person to 7 fish per person. Scenario #2 increased the minimum size limit to 559 mm (22 in) with no upper bound and increased the bag limit to 5 fish per person.

The results of this analysis provided the policy change tested in the stated preference model. The new policy would provide a bag limit of 7 fish per harvester per day on the west coast of Florida, where the size of the fish is greater than 17 inches, but less than 20 inches. One of the 7 fish could be greater than 20 inches. These changes are discussed further in the choice attribute section below.

2.3. Survey Design and Implementation

2.3.1. Choice of Economic Methodology

Researchers followed the methodological approach of Carter and Liese (2017) using the stated preference choice method (SPCM) [8]. The SPCM has become a popular method when evaluating people's willingness to pay for different attributes of a good or service [9]. A different demand for and value of a good or service or change in a good or service is based on a bundle of attributes. Here, the bundle consists of the mode of access (e.g., charter boat or private boat), length of trip (e.g., half-day or full-day for charter boat trips), type of day (e.g., weekday or weekend), the bag limit/size limit, and price or cost of the trip. For the bag limit/size limit, the current bag limit/size limit (which is not sustainable according to the biological model component) and a new bag limit/size limit combination (which is sustainable) were evaluated. Price or cost of the trip was specified based on Liese and Carter (2017) with the cost for private boats for fuel, bait, and ice [8]. The cost for charter boats was the charter boat fee (excluding tip).

Table 1. Fishery analysis and development of alternative management scenarios for achieving acceptable stock sustainability status: (A) pre-regulation (1987–1989) estimates of instantaneous mortality rates for parameterizing the spotted seatrout numerical simulation model; and (B) numerical model estimates of average length in the exploited phase ($\underline{L}$) and spawning potential ratio (SPR) for various size and bag limit management regimes. An SPR $\geq$ 35% was considered a satisfactory sustainability status.

(A) Mortality Estimates

Description	Parameter	Estimate
Total Mortality	Z	0.8433
Natural Mortality	M	0.1577
Fishing Mortality	F	0.6856

(B) Analysis of Fishery Size and Bag Limit Options

Management Regime	Size Limits (in)		Bag Limit	Average Length (in)	SPR (%)	Sustainability Status
	Lower	Upper				
Pre-Regulation, 1987–1989	None [1]	None	None	377 mm (14.8)	3.0	Unsatisfactory
Current	381 mm (15)	508 mm (20)	4	424 mm (16.7)	20.0	Unsatisfactory
Alternative Scenario #1	432 mm (17)	508 mm (20)	7	561 mm (22.1)	35.4	Satisfactory
Alternative Scenario #2	559 mm (22)	None	5	592 mm (23.3)	35.2	Satisfactory

[1] Although not regulated, length at first capture L_c was 310 mm (12.2 in), estimated from length composition data.

For the bag limit/size limit combinations, it would have been preferable to have several alternatives to evaluate. However, the combinations that were sustainable were not very different. Since the budget did not allow for extensive focus group work and pre-tests to see if anglers would have different values for these alternatives, one sustainable alternative was chosen to evaluate based on consultation with the research team. For the prices or cost, researchers used a range of prices for private boats and charter boats (half-day and full-day) from Liese and Carter (2017) [8].

Bag Limit/Size Limit Combinations. The key policy/management variable was the bag limit/size limit. Only two levels were used for both the charter boat and private boat modes, the current regulations and a new alternative.

Existing Regulation:

Bag limit

Northwest Zone: 5 per harvester per day;

Southwest Zone: 4 per harvester per day.

A map of the zones was included in the survey online questionnaire.

Size Limit

More than 15 inches and less than 20 inches total length (may possess one over 20 inches included in the bag limit).

New Regulation:

Bag Limit

West coast of Florida: 7 per harvester per day.

Size Limit

More than 17 inches and less than 20 inches total length (may possess one over 20 inches included in bag limit).

It was determined in the biological component of the model that the existing regulations were not sustainable; the new proposed regulation was determined to be sustainable (Table 1 [2]). The distinction between zones is eliminated in the new proposed regulation and the minimum size limit is increased by two inches. A dummy variable was created for model estimation where 1 = new regulation and 0 = existing regulation.

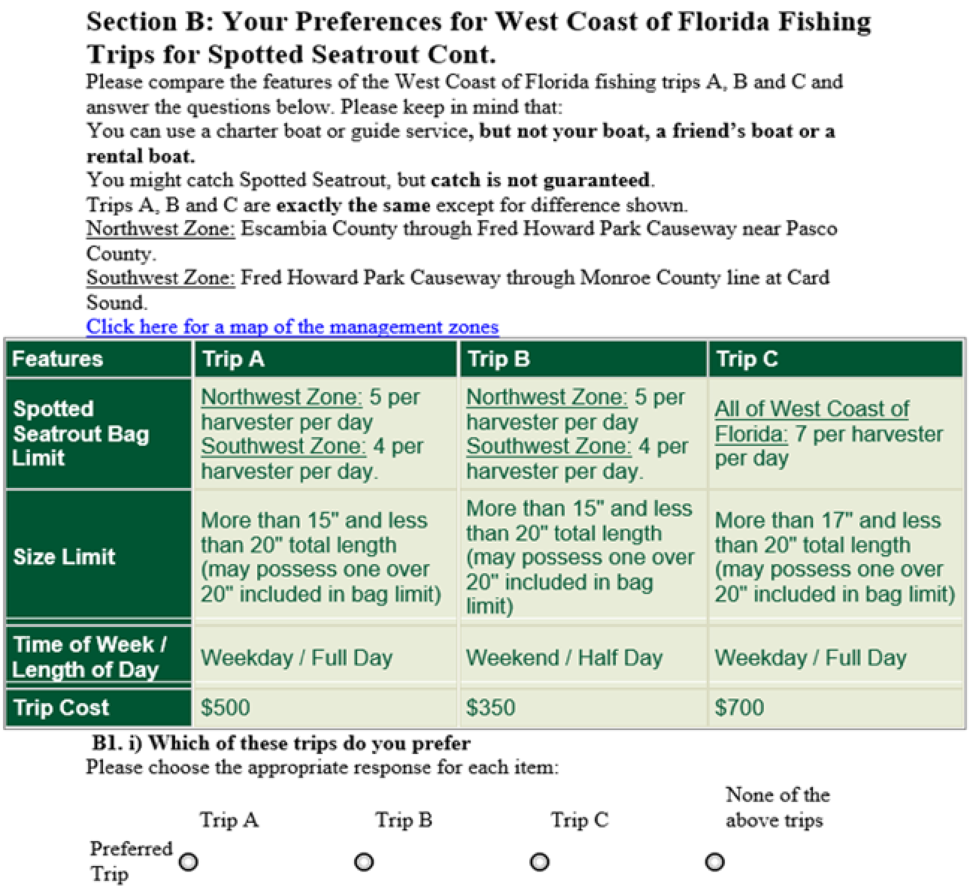
Time of Week. In Liese and Carter (2017), time of week was found to be a significant factor in willingness to pay [8]. Time of week was specified as a weekday or a weekend day. Time of week would seem to serve as a proxy for crowdedness as Liese and Carter (2017) found that weekdays were more valuable than weekend days [8]. A dummy variable was created for time of week where weekday = 1 and weekend = 0.

Length of Day. Liese and Carter (2017) also found that length of day was important, especially for charter boat anglers [8]. Charter boats offer half-day and full-day trips and prices are scaled to the length of trip. A dummy variable was created for length of trip with 1 = full-day and 0 = half-day for charter boats only.

Price (Trip Cost). Prices were from Liese and Carter (2017) and represented trip cost [8]. Prices were different for charter and private boat modes and within charter boat mode for half-day and full-day trips. The charter boat prices were defined as the cost of the charter boat/guide fee (not including tip) and covered everyone aboard. The private boat prices were defined as your share of the costs of boat fuel, bait, and ice.

Charter Boat—Half-Day (USD 250, USD 350, USD 500);
Charter Boat—Full-Day (USD 350, USD 500, USD 700);
Private Boat (USD 25, USD 50, USD 70).

Figure 1 shows an example question that charter boat users may have received. Figure 2 shows an example contingent choice questions that private/rental boat fisher may have received.



Section B: Your Preferences for West Coast of Florida Fishing Trips for Spotted Seatrout Cont.

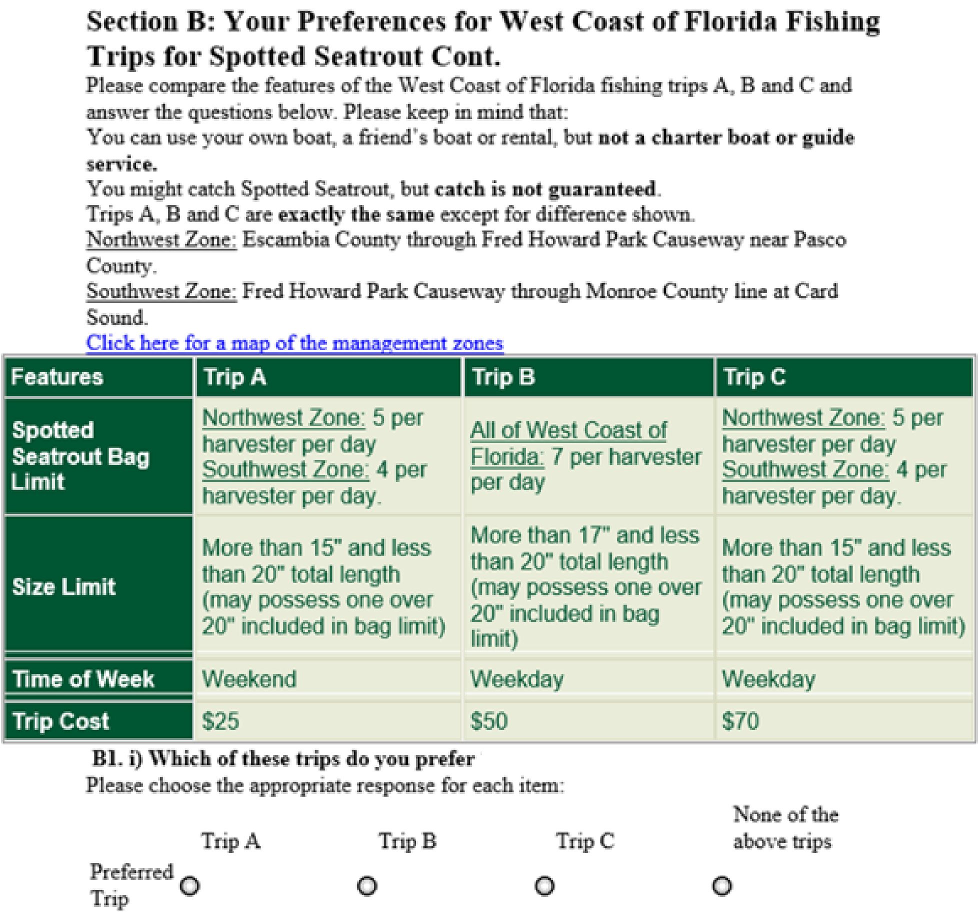
Please compare the features of the West Coast of Florida fishing trips A, B and C and answer the questions below. Please keep in mind that:
You can use a charter boat or guide service, **but not your boat, a friend's boat or a rental boat.**
You might catch Spotted Seatrout, but **catch is not guaranteed**.
Trips A, B and C are **exactly the same** except for difference shown.
Northwest Zone: Escambia County through Fred Howard Park Causeway near Pasco County.
Southwest Zone: Fred Howard Park Causeway through Monroe County line at Card Sound.
Click here for a map of the management zones

Features	Trip A	Trip B	Trip C
Spotted Seatrout Bag Limit	Northwest Zone: 5 per harvester per day Southwest Zone: 4 per harvester per day.	Northwest Zone: 5 per harvester per day Southwest Zone: 4 per harvester per day.	All of West Coast of Florida: 7 per harvester per day
Size Limit	More than 15" and less than 20" total length (may possess one over 20" included in bag limit)	More than 15" and less than 20" total length (may possess one over 20" included in bag limit)	More than 17" and less than 20" total length (may possess one over 20" included in bag limit)
Time of Week / Length of Day	Weekday / Full Day	Weekend / Half Day	Weekday / Full Day
Trip Cost	$500	$350	$700

B1. i) Which of these trips do you prefer
Please choose the appropriate response for each item:

	Trip A	Trip B	Trip C	None of the above trips
Preferred Trip	○	○	○	○

Figure 1. Sample charter boat choice questionnaire.



Section B: Your Preferences for West Coast of Florida Fishing Trips for Spotted Seatrout Cont.

Please compare the features of the West Coast of Florida fishing trips A, B and C and answer the questions below. Please keep in mind that:
You can use your own boat, a friend's boat or rental, but **not a charter boat or guide service.**
You might catch Spotted Seatrout, but **catch is not guaranteed**.
Trips A, B and C are **exactly the same** except for difference shown.
Northwest Zone: Escambia County through Fred Howard Park Causeway near Pasco County.
Southwest Zone: Fred Howard Park Causeway through Monroe County line at Card Sound.
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Features	Trip A	Trip B	Trip C
Spotted Seatrout Bag Limit	Northwest Zone: 5 per harvester per day Southwest Zone: 4 per harvester per day.	All of West Coast of Florida: 7 per harvester per day	Northwest Zone: 5 per harvester per day Southwest Zone: 4 per harvester per day.
Size Limit	More than 15" and less than 20" total length (may possess one over 20" included in bag limit)	More than 17" and less than 20" total length (may possess one over 20" included in bag limit)	More than 15" and less than 20" total length (may possess one over 20" included in bag limit)
Time of Week	Weekend	Weekday	Weekday
Trip Cost	$25	$50	$70

B1. i) Which of these trips do you prefer
Please choose the appropriate response for each item:

	Trip A	Trip B	Trip C	None of the above trips
Preferred Trip	○	○	○	○

Figure 2. Sample private boat choice questionnaire.

2.3.2. Experimental Design

Before designing a survey questionnaire, implementation of the SPCM requires an experimental design. In most applications, a full factorial is not possible since all possible combinations of attributes and their levels is larger than can be presented to survey respondents. Methods have been developed and are detailed (in Louviere, Hensher, and Swait 2000) for designing partial factorials that allow for estimating the marginal effects of attribute levels that can be extrapolated across all possible combinations in a full factorial [9]. Marginal effects here are the main effects of independent variables (e.g., bag limit/size limit combinations, type day, length of trip and price) on the dependent variable (willingness to pay or number of additional days of fishing). The fractional factorial optimal design allows for estimation of the main effects. Interaction effects are ignored. It has been found that the main effects account for most of the variation and there is little loss in not including interaction effects (Louviere, Hensher, and Swait 2000).

Separate designs were developed for anglers who caught or targeted spotted seatrout via the private boat mode of access and the charter boat mode of access since the scales of prices and attributes were slightly different.

For the charter boat mode, there were four total attributes, three attributes with two levels, and one attribute (price) with six levels (3 prices for half-day trips and 3 prices for full-day trips). In addition, each choice set included the decision to not take a trip. Therefore, there was a possible combination of 48 alternatives.

For the private boat mode, there were three total attributes, two attributes with two levels and one attribute (price) with three levels. In addition, each choice set included the decision to not take a trip. Therefore, there was a possible combination of 16 alternatives. The macros in SAS version 9.4 and (Johnston et al. 2007) were used to determine the optimal design [10,11]. The optimal designs yielded orthogonal (attributes uncorrelated) and balanced (equal numbers of each attribute levels) designs. For charter boats, the optimal design required specification of 32 alternatives using 16 choice sets, with each choice set including two alternatives. Given the length of the survey and potential respondent fatigue, the number of choices was limited to a maximum of six per respondent. Therefore, three versions of the survey were designed. Version 1 included six choices and Version 2 and 3 included five choices.

For the private boat mode, the optimal design required specification of 24 alternatives using 12 choice sets, with each choice set including two alternatives. Given the length of the survey, the number of choices was limited to six per respondent. Therefore, two versions of the survey were designed each with six choices per respondent.

2.3.3. Sample Sizes Required for Statistical Efficiency

In Orme (1998), the following formula is found for determining the minimum sample size required for a given design [12]:

$$N = 500 \times \mathrm{NLEV}/(\mathrm{NALT} \times \mathrm{NREP}) \tag{3}$$

where

N = minimum sample size required;
NLEV = the largest number of levels in any attribute (here, 6 for the number of prices for charter and 3 for private boat);
NALT = number of alternatives per choice set (not including the no trip choice; here, 2);
NREP = number of choice sets per respondent (here, 6 for Version 1 for charter boat and Versions 1 and 2 for private boat, and 5 for Versions 2 and 3 for charter boat).

Therefore, minimum sample sizes required for statistical efficiency were 111 and 84, respectively, for charter boat and private boat. As will be discussed in the survey results, a sample size of 137 was achieved for the charter boat and 882 for the private boat; thus, both sample sizes met the minimum requirement for statistical efficiency.

2.3.4. Survey Sample Design

The first task in sampling is choosing the sampling frame so one can design a sample that may be extrapolated from sample to population. The optimal sampling frame for this study would have been the MRIP intercept survey where anglers are surveyed at access points by mode of access along Florida’s west coast and catch is identified by species which are counted and measured. Anglers are also asked about the number discarded (not kept) by species. Sampling efficiency and thus sampling costs would be minimal using this method, since anglers who caught or targeted spotted seatrout could be selected for inclusion in the sample. However, due to logistical and privacy concerns, the researchers were not able to piggyback onto the MRIP survey. Therefore, the National Saltwater Angler Registry (NSAR) was used to identify permit holders with residency in Hillsborough and Pinellas Counties along Florida’s gulf coast as the sampling frame.

QuanTech, which has had prior experience in implementing the MRIP survey in the Atlantic and Gulf of Mexico, was hired to conduct the survey. The Florida license/permit registration file from NOAA Fisheries was provided to QuanTech. QuanTech then designed a survey to be implemented via the internet to achieve our experimental design sample size requirements. The Florida license/permit registration file contains names, addresses, and sometimes emails for all anglers that fished in Florida. A major task for QuanTech was determining the probability that a license/permit registration holder would have fished for spotted seatrout on Florida’s west coast during the past year. This was called the ‘eligibility rate’. It was estimated to be 38.7%.

The survey was done in two stages. In stage 1, emails were sent out to those with emails and postcards were sent out to those without an email address to invite anglers to take the internet survey. QuanTech then designed the online survey. Two screener questions were used to determine eligibility. Question 1 was: “Have you targeted or caught spotted seatrout on the west coast of Florida in the last 12 months while fishing on a boat (private/rental or charter/guide)?" Question 2 then asked: "Was your most recent trip on the west coast of Florida, where you targeted or caught spotted seatrout, on a private or charter/guide boat?". This was used to select which version of the surveys to assign. However, initial results were indicating a low number of charter boat assignments so the second question was changed to: "Have you taken a trip, within the past 12 months, on a charter/guide boat where you targeted or caught spotted seatrout?" If they answered yes, they were given the charter boat survey; if they answered no, a private boat mode survey was administered.

A sample of 60,000 was selected from the NSAR files for permit holders 16 years and older with a valid permit between 18 July 2016 and 18 July 2017. The survey was conducted August–October 2017. An eligible weighted response rate was 6.1%. A total of 1019 surveys were completed, 137 charter boat and 882 private boat. Although the response rate was low, the sample sizes exceeded the sample size requirements of the optimal design (Table 2).

Table 2. Number of completed surveys.

Mode	Version	Number Completed	Optimal Design Sample Size Requirement
Charter	1	52	37
Charter	2	41	37
Charter	3	44	37
Private	1	429	84
Private	2	453	84
Total		1019	279

3. Results

3.1. Economic Modeling

The number of independent variables used varied by mode of access (i.e., charter boat and private boat). Differences in variables relevant to each model were noted and differences in levels for different attributes (i.e., price) were detailed. Socioeconomic variables such as income, age, race/ethnicity or gender were not included in the estimated models. The choice attributes were described first, followed by additional variables tested in the logistic regressions.

For the private boat mode, bag limit/size limit did not yield usable results since in the private boat model anglers had higher value for the existing regulation, which is not sustainable. This will be discussed in the model results section. MRIP data from 2004 to 2016 were used to determine the success rates; i.e., the percentage of anglers that achieved the bag limit/size limit. The MRIP data were weighted by geographic area (e.g., northwest, NW, and southwest, SW) since the existing bag limits were different for each zone. The success rates by mode and geographical zone were variable across years. For 2004–2016, the average success rates for the charter boat—full-day were 18.21% in the NW and 9.66% in the SW, 5.83% in the NW and 1.4% in the SW for charter boat—half-day, and 2.3% in the NW and 1.42% for the SW for private/rental boats. For 2012–2016 (a five-year annual average often recommended for use in policy/management analysis of regulations), the success rates were 14.2% in the NW and 2.58% in the SW for charter—full-day, 5.78% in the NW and 1.33% in the SW for charter—half-day, and 1.48% in the NW and 0.77% in the SW for private/rental boats. Private/rental boat anglers generally have the lowest success rate and their success rates significantly declined from 2004 to 2016 (Table 3).

It is possible that for private/rental boat anglers, the success rate was so low that the perception of achieving the higher bag limit/size limit combination would be low and the movement to the new regulation would be undervalued. Therefore, a variable was created to account for the low probability of achieving the bag limit/size limit. A dummy variable to differentiate those who targeted spotted seatrout was also created where 1 = targeted spotted seatrout and 0 = did not target spotted seatrout.

Table 3. Probability of attaining bag limit for spotted seatrout west coast of Florida 2004–2016 [1].

	Private/Rental Boats		Charter Boat—Full-Day		Charter Boat—Half-Day	
	Geozone [2]		Geozone [2]		Geozone [2]	
Year	**North (%)**	**South (%)**	**North (%)**	**South (%)**	**North (%)**	**South (%)**
2004	2.73	2.75	12.94	7.04	1.11	2.00
2005	4.81	2.70	26.67	6.98	16.13	9.52
2006	3.60	2.19	7.69	0.00	0.00	0.00
2007	2.53	1.38	15.69	35.71	0.00	0.00
2008	1.01	1.57	33.33	26.09	15.38	0.00
2009	3.32	2.09	36.84	9.52	0.00	0.00
2010	1.25	0.64	11.11	10.71	14.29	0.00
2011	3.28	1.35	21.43	16.67	0.00	0.00
2012	2.99	1.39	14.29	4.17	12.50	4.25
2013	1.52	0.70	12.50	0.00	9.09	0.00
2014	1.01	0.67	11.76	4.88	3.85	1.01
2015	1.03	0.59	14.81	0.00	0.00	1.37
2016	0.85	0.49	17.65	3.85	3.45	0.00
2004–2016 Average	2.30	1.42	18.21	9.66	5.83	1.40
2012–2016 Average	1.48	0.77	14.20	2.58	5.78	1.33

[1]. Success rate is the percentage of those that caught or targeted spotted seatrout that achieved the bag limit.
[2]. Geozone: North = Northwest Zone, Escambia County through Fred Howard Park Causeway near Pasco County and South = Southwest Zone, Fred Howard Park Causeway through Monroe County line at Card Sound. Source: Marine Recreational Fishing Information Program.

Since the researchers were unable to link the MRIP intercept survey where the catch was recorded to the data collected in this effort, the success in achieving the bag limit/size limit combination of each sampled angler was not available. To construct a variable on the probability of achieving the bag limit/size limit combination, the MRIP intercept survey data from 2004 to 2016 were used to run a logistic regression equation to predict the probability of achieving the bag limit/size limit combination for private/rental boat anglers.

Model for predicting success rate by private/rental boat anglers

$$P = a + B1 \times \text{Local\_res} + B2 \times \text{fishdays\_12\_mo} + B3 \times \text{year} \tag{4}$$

where P = predicted probability of a private/rental boat angler achieving the bag limit/size limit combination in the current regulation.

Local_res = region of residence 1 = west coast of Florida resident, 2 = east coast of Florida resident and 3 = non-resident of Florida. A dummy variable was then constructed, where 1 = west coast of Florida resident and 0 = not a resident of west coast of Florida.

Year = year of survey.

It was hypothesized that the predicted probabilities would vary by place of residence, fishing intensity, and year. Place of residence was a proxy for knowledge assuming that those who lived on the west coast of Florida would have the most knowledge of the area, holding other factors constant. The intensity of fishing served as a proxy for experience as measured by the number of annual days spent saltwater fishing in Florida. Finally, the year was included to adjust for stock effects due to environmental or other factors. Equations were run with unweighted and weighted data using PROC Logistic in SAS Version 9.4 and NLOGIT Version 5 for checking SAS results and obtaining additional statistics on model performance such as pseudo R-square.

The results for the model found similar results for weighted and unweighted data (Table 4). Those with more experience (fishdays_12_mo) had a higher probability of achieving the bag limit/size limit combination. An unexpected result was obtained for those who were residents of the west coast of Florida. Researchers hypothesized that west coast residents would have more knowledge of the west coast fishery and therefore a higher probability of catching the bag limit, but results found this not to be true with local residents having a lower probability of achieving the bag limit/size limit. Year gave the expected negative sign as the probability of success declined over time.

Table 4. Weights used for logistic equations.

Year	Geography	Private Boat	Charter Full-Day	Charter Half-Day
2004	North	0.376	0.545	0.351
2004	South	0.624	0.455	0.649
2005	North	0.445	0.511	0.425
2005	South	0.555	0.489	0.575
2006	North	0.521	0.531	0.238
2006	South	0.479	0.469	0.762
2007	North	0.509	0.785	0.325
2007	South	0.491	0.215	0.675
2008	North	0.436	0.511	0.394
2008	South	0.564	0.489	0.606
2009	North	0.429	0.475	0.355
2009	South	0.571	0.525	0.645
2010	North	0.339	0.491	0.255
2010	South	0.661	0.509	0.746
2011	North	0.407	0.539	0.183
2011	South	0.593	0.462	0.817
2012	North	0.385	0.422	0.258
2012	South	0.615	0.578	0.742
2013	North	0.345	0.410	0.220
2013	South	0.655	0.590	0.780
2014	North	0.334	0.293	0.208
2014	South	0.666	0.707	0.792
2015	North	0.396	0.365	0.180
2015	South	0.604	0.635	0.820
2016	North	0.367	0.395	0.299
2016	South	0.633	0.605	0.701

As will be shown below in the private boat analysis of economic value, the predicted probabilities for private/rental boats were used in the valuation analysis. To predict the probabilities of achieving the bag limit/size limit for those who accessed the fishery from private/rental boats, a separate model was estimated using geographic weights.

Weighted private/rental boat success rate equation

$$\mathrm{LN}\ (p/1-p) = 242.9 - 0.6752 \times \mathrm{local\_res} + 0.00370 \times \mathrm{fishdays\_12\_mo} - 0.1228 \times \mathrm{year} \tag{5}$$

where LN $(p/1-p)$ is the natural logarithm of the odds ratio.

Solving the equation for P:

$P = 1/(1 + e^x)$, where x = log of the odds ratio.

All the explanatory variables were statistically significant for the weighted equation. The percentage of correct predictions was 65%. Pseudo R-square was 0.03, which is relatively low for time series data.

3.2. Protest Bids

A protest bid analysis was also conducted for the charter and private rental boat samples. The first step was to identify how many respondents answered 'none' to which of the trips they preferred. In the charter sample, 12 respondents answered none to all the choice questions, and 124 respondents answered none to all the choice questions they responded to in the private/rental sample.

Secondly, those who had selected none to all the chosen questions they answered may have had either a true selection in that they preferred none of the options presented or they may have been protesting the questions. To identify true protest bids, several follow-up questions were asked about why they did not choose a trip. The reasons included:

1. Costs too high;
2. Do not think fishery managers will use results from this study;
3. Do not believe the bag limit/size limit combinations are sustainable for spotted seatrout;
4. Against all government regulations of the fisheries;
5. Other.

If a respondent selected 2, 3, or 4 from the above list, then the respondent was identified as a protestor. Based upon this analysis, there were no protestors in the charter sample and 11 protesters in the private/rental boat sample. (Many of the 'other' responses included people giving alternative options they would have preferred to have seen or indicated that they engaged in catch and release activities. Neither of these would qualify as a protestor).

3.3. Charter Boat Analysis

For this analysis, two models were run, the conditional logit model and random parameters model using STATA SE Version 14. The random parameters model was estimated to account for the Hausman–McFadden Independence of Irrelevant Alternatives (IIA) to test for the assumption of independence of irrelevant alternatives [13]. However, when the conditional logit does not pass the IIA assumption, it should not be of much concern, as the alternatives "can plausibly be assumed to be distinct and weighted independently in the eyes of each decision maker" [14].

As the survey was developed to present respondents with distinct scenarios to choose from, it is reasonable to accept the conditional logit specification. When considering other model specification, one of the benefits of the random parameters model is it allows for heterogeneity and addresses the independence of identically distributed random variables violation of constant variance for the observed portion of the variance [9]. For the random parameters model, the normal error structure was assumed. Price was a fixed factor while all other variables were random. Only three variables for the charter boat model (baglim, weekday, and full-day) that were treated as random had a significant coefficient on their standard deviations (SDs). This means that for these variables there was significant heterogeneity among charter boat anglers for these attributes.

Applied work like the analysis used here for the conditional logit model can be found in several previous papers [15–17] and for the RP model [16–18]. The math behind each of the model specifications may be found in Louviere, Hensher, and Swait (2000) [9]. STATA Version 14 was used to estimate all three models [19]. However, the basic premise behind the models is below.

$$P(j|\mu_i) = \left[\exp\left(\alpha_{ji} + \theta_j z_i + \varphi_i f_{ji} + \beta_{ji} x_{ji}\right)\right] / \left[\left(J \sum j = 1\right) \exp\left(\alpha_{ji} + \theta_j z_i + \varphi_i f_{ji} + \beta_{ji} x_{ji}\right)\right] \tag{6}$$

where

α_{ji} is a fixed or random alternative-specific constant associated with $j = 1, \ldots J$ alternatives and $i = 1, \ldots, I$ individuals and $\alpha_j = 0$;
φ_j is a vector of non-random parameters;
β_{ji} is a parameter vector that is randomly distributed across individuals; μ_i is a component of the β_{ji} vector (see below);
z_i is a vector of individual-specific characteristics (e.g., personal income);
f_{ji} is a vector of individual-specific and alterative specific attributes;
x_{ji} is a vector of individual-specific and alterative specific attributes;
μ_i is the individual-specific random disturbance of unobserved heterogeneity.

A subset or all of α_{ji} alternative-specific constants and the parameters in the β_{ji} vector can be randomly distributed across individuals, such that for each random parameter, a new parameter, call it ρ_{ki}, can be defined as a function of characteristics of individuals and other attributes which are choice invariant ([9], p. 199).

In both models, price was negative and significant. Additionally, in both models all of the bag limit/size, weekday, and full-day variables were positive. However, only the full-day variable was statistically significant in both models. The bag limit/size and weekday were only significant in the conditional logit model (Table 5). The random parameters model for charter boat anglers did not produce a statistically significant coefficient on the bag limit/size limit. Two explanations are plausible for the random parameters results: first, the endowment effect, and second, the low success rate in achieving the bag limits/size limit combinations on Florida's west coast for spotted seatrout, both of which are discussed in further detail in the private/rental boat section.

Table 5. Charter boat conditional logit model results.

Variable	Coefficient	Robust Standard Error	z	$p > \lvert z \rvert$	95% Confidence Interval	
					Low	High
baglim	0.431	0.195	2.210	0.027	0.048	0.814
weekday	0.854	0.140	6.110	0.000	0.580	1.129
full-day	0.811	0.254	3.190	0.001	0.313	1.309
price	−0.007	0.001	−9.260	0.000	−0.006	−0.009

Observations: 1941. Wald Chi-Square: 121.54. Pseudo Log Likelihood: −15,766.07. Pseudo R^2: 17. Adjusted Pseudo R^2: 15.

The positive relationship for the bag limit/size limit means that respondents were willing to pay more for the new regulation; a bag limit of 7 fish per day between 17 and 20 inches long. Respondents were also willing to pay more for a weekday charter trip as opposed to a weekend charter trip and they were also willing to pay more for a full-day trip versus a half-day trip. In the conditional logit model, where all variable estimates were significant, the most influential variable to affect their decision to choose an option was whether the trip was a weekday, followed by whether the trip was a full or half day.

Another possible behavioral response to a change in the bag limit/size limit combinations is a change in the number of days fishing. The survey choice questions were followed by a question asking the respondent for the choice they made, would they have changed the number of days they fished during the past 12 months on Florida's west coast. Theoretically, it is possible that willingness to pay per day could increase but days of fishing (effort) could decline, remain the same or increase. The analysis on change of days was conducted using a negative binomial count data model, but the model produced no statistically significant results; consequently, there would be no change in days of fishing in response to the new bag limit/size limit combination.

3.4. Private Boat Analysis

The initial models estimated (conditional logit and random parameters) for private/rental boat anglers produced a negative coefficient on the bag limit/size limit, which suggests that private/rental boat anglers value the existing bag limit/size limit higher than the proposed alternative. This suggests that a more restrictive policy would decrease the user's utility, resulting in an economic loss to anglers. One explanation for this result is there may be an 'endowment effect' caused by an individual's attachment to a good [20–22]. Experimental work by these authors and others (e.g., List, 2003; 2004) using everyday goods such as coffee mugs, chocolate bars, and sports cards do indeed find evidence of an endowment effect. Milon (2005) found this for reducing the bag limits for spiny lobster in the Florida Keys [23].

A second possible explanation is the low success rate in achieving the bag limits/size limit combinations on Florida's west coast for spotted seatrout. One hypothesis is that accounting for this low probability of achieving the current bag limit/size limit would result in a positive increase in the willingness to pay for the new sustainable levels of the bag limit/size limit. This hypothesis was tested by interacting the predicted probabilities of achieving the bag limit/size limit combination and with a dummy variable for whether private/rental boat anglers targeted spotted seatrout. The results supported this hypothesis (Table 6). Given the random parameters model failed to yield a statistically significant coefficient on the price variable, the conditional logit model was used to estimate marginal willingness to pay.

Table 6. Private/rental boat conditional logit model results.

Variable	Coefficient	Robust Standard Error	z	$p > \|z\|$	95% Confidence Interval	
					Low	High
Baglim_prob	0.2056	0.0221	−9.31	0.000	0.1623	0.2489
weekday	−0.1580	0.0890	−1.78	0.075	−0.3320	0.0158
price	−0.0025	0.0006	−3.80	0.000	−0.0012	−0.0038

Observations: 13,665. Wald Chi-Square: 110.07 Prob > chi2 = 0.000 Pseudo Log Likelihood: 0 Pseudo R^2: 056 Log Pseudo Likelihood: −154,291.13.

As with the charter boat mode, the researchers also tested whether there would be a change in the number of fishing days for the choices made and found no statistically significant results. Therefore, there were no expected changes in days of fishing from the change in bag limits/size limits.

3.5. Marginal Willingness to Pay

For the estimated models, the marginal willingness to pay (MWTP) can be calculated for each attribute to assess relative importance. MWTP here is the change in value at movement from the 'zero' level of the condition to the 'one' level of the condition. The formula for MWTP is the attribute's coefficient divided by the negative of the price coefficient [9,24]. The results for the conditional logit model are in Table 7 below.

Table 7. Willingness to pay of charter boat anglers.

Variable	Marginal Value	Lower Bound	Upper Bound
Bag Limit/Size Limit	USD 60.72	USD 5.33	USD 136.67
Weekday	USD 120.29	USD 64.44	USD 188.17
Full-Day	USD 114.17	USD 34.78	USD 218.17

In this research, willingness to pay is a useful metric that quantifies the change in utility for a change in the quality of an attribute. This estimate can be used to both quantify the change in benefit and the change in net benefits when the cost of a proposed management action is known. Further, understanding the value that various user groups have for the same resource helps to inform discussions and to understand how benefits (or costs if activity is restricted) accrue to various users as the result of a policy change or management action.

Charter boat anglers were willing to pay about USD 61 using the conditional logit for the new regulation. Charter boat anglers also placed a premium on fishing during the weekday versus the weekend. Based upon the conditional logit estimates, they were willing to pay about USD 120 more for a weekday versus the weekend and USD 114 more for a full-day trip versus a half-day trip.

Private/rental boat anglers were willing to pay about USD 81 using the conditional logit for the new regulation. Private/rental boat anglers were willing to pay less for weekdays versus weekend days (Table 8). These results contrast with those for charter boat anglers. The results might be explained by the opportunity cost of time for private/rental boat anglers. Fishing on a weekday may require taking a day off from work and either giving up pay or using a vacation day.

Table 8. Willingness to pay of private/rental boat anglers.

Variable	Marginal Value	Lower Bound	Upper Bound
Bag Limit/Size Limit	USD 81.34	USD 42.71	USD 207.42
Weekday	−USD 62.66	−USD 87.37	USD 13.17

For charter boat anglers, the estimated change in value was USD 60.72 per trip. Since the variable used was the price of chartering a boat for the day, the estimate must be converted to a value per person per day to aggregate this to a total annual value. The average party size was three for charter boats, so the estimated marginal value was USD 20.24 per person per day. For private/rental boat anglers, the estimated value per trip for the new bag limit/size limit was USD 81.34 per trip. The average party size for private/rental boats was 2.5, so that yields a value per person per day of USD 32.54.

To estimate the annual increase in value, a five-year average (2012–2016) of days of fishing by mode of access for those who caught or targeted spotted seatrout on Florida's west coast (MRIP 2012–2016) was used and we multiplied the average annual days by the marginal values. Charter boat anglers recorded 167,240 person-days of fishing, while private boat anglers spent 4,440,919 days fishing for spotted seatrout. This translates into a change in total value, for the change in bag limit/size limits from the old to the new regulation, of almost USD 148 million. Charter boat anglers accounted for 3.63% of fishing days and 2.29% of the change in annual value, while private boat anglers accounted for 96.37% of fishing days and 97.71% of the change in annual value (Table 9).

Table 9. Total value of changing bag limit/size limits from existing to new regulation for spotted seatrout in Florida's west coast recreational fishery.

Mode	Five-Year Average Number of Trips [1]	Percentage of Trips	Marginal Value Per Trip [2]	Total Value Bag Limit/Size Limit Change	Percentage of Value
Charter Boat	167,240	3.63	USD 20.24	USD 3,384,938	2.29
Private Boat	4,440,919	96.37	USD 32.54	USD 144,507,504	97.71
Total	4,608,159	100.00	USD 32.09	USD 147,892,442	100.00

[1] Five-year average is for 2012–2016. Number of trips is the number of trips by all anglers that caught or targeted spotted seatrout on Florida's west coast. Since all trips were one day in length, number of trips is equivalent to person-days of effort where a person-day is one person carrying out an activity for a whole day or any part of a day. [2] Marginal value per trip is the change in value of a trip moving from the existing regulation on bag limit/size limit combination to the new proposed bag limit/size limit combination.

The estimated values for changes in the bag limit/size limit combinations for charter boat anglers relative to private/rental boat anglers would seem counter to the usual relationships since most studies find the value of charter boat trips are more valuable than private/rental boat trips. However, the total value of the trip was not being estimated. Instead, it was the change in value for a change in the bag limit/size limit that was estimated. Charter boat anglers targeting or catching spotted seatrout on Florida's west coast have been much more successful in achieving the bag limit/size limit than private/rental boat anglers. Therefore, private/rental boat anglers would be experiencing a much larger change with the new bag limit/size limit than charter boat anglers would.

A review of the literature reveals no one else has modeled the biological constraint on the bag limit/size limit combination and treated it as a composite good. The literature available estimates the marginal value of bag limits and size limits as if they were independent attributes [8,25]. For species in which the biological model determines that bag limits and size limits jointly determine stock levels that are sustainable, economic valuation must treat the bag limit/size limit as a composite good in which the separate utilities/values cannot be estimated for each component.

4. Discussion

The stated preference choice method (SPCM) can be used to evaluate different bag limit/size limit combinations that are policy/management-relevant and can be incorporated in a bioeconomic model. Integrating the biological model results on bag limits/size limits that are sustainable yields policy/management results. However, there are several limitations.

When the probability that achieving the bag limit/size limit combinations of existing regulations are not sustainable characterizes the fishery, the economic values have no policy/management relevance. For spotted seatrout on Florida's west coast, the biological component of the bioeconomic model predicts that the current regulations are not sustainable. Consequently, if policy/management remains constant (i.e., no change in the bag limit/size limit), the result will eventually lead to the tragedy of the commons where the fishery becomes overfished and more drastic actions such as closures might be required to recover to a sustainable basis.

The researchers followed the structure of the stated preference choices found in Liese and Carter (2017) [8]. However, the biological model for spotted seatrout on Florida's west coast determined that bag limit and size limits jointly determine sustainable stock levels. In this case, the bag limit/size limit combination is a composite good and separate utilities/values cannot be estimated for each component like previous studies have done. The preferred choice construction in this case would have been to make the current bag limit/size limit combination the 'status quo' alternative with emphasis to respondents that this combination was not sustainable. Those who caught or targeted spotted seatrout on Florida's west coast from private/rental boats may still have selected the status quo (due to the endowment effect), but it would have made it clear that there is no value of maintaining the status quo because it is not sustainable and therefore not policy/management-relevant.

Future Research

Use of the NSAR as a sampling frame has limitations since in most states a license is not required to fish in a charter boat. In addition, when focusing on specific species in certain geographic areas, it is inefficient to use NSAR to identify and select the appropriate sample. In these cases, the MRIP intercept survey sample is more efficient since you know the site of access, the catch, and effort, and thus the probability that anglers achieved the bag limit/size limit combination to be assessed. In addition, charter boat anglers can be recruited directly in the MRIP intercept, allowing for more complete sampling of charter boat anglers, which would also reduce redundancy across sampling initiatives.

In the SPCM design, if the biological model for a species determines that the current regulations on bag limit/size limits is unsustainable, the existing regulation should be modeled as the 'status quo' or opt out option with a zero (USD 0) value. Information describing the current regulation as unsustainable should be emphasized in a much stronger way to describe the eventual consequences of choosing this option.

Focus groups, one-on-ones and large-scale pre-tests are recommended in designing any SPCM study. This process can be used to improve understanding of how anglers think about the current regulations and the science. In addition, it is preferable to have a range of sustainable bag limit/size limit options to evaluate. However, in cases like that of spotted seatrout on Florida's west coast, there might not be much variation between options. Focus groups and one-on-ones can help determine if anglers could and would value them differently.

It is sometimes advantageous to address multiple species to capture elements of substitution and complementarity in species. Red drum and spotted seatrout are often caught on the same trip, so combining them in a SPCM design might be preferable, but it would come at the cost of complexity in design with implications for sample size and thus budget. Future research should incorporate the findings of this study to improve the utility and policy relevance of results.

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