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Louisiana Southern Flounder: Commercial and Recreational Trends

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LOUISIANA SOUTHERN FLOUNDER: COMMERCIAL AND RECREATIONAL TRENDS

A Thesis
Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfilment of the
requirements for the degree of
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in
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by
David R. Smith
B.S., Auburn University, 2014
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Abstract

Southern Flounder (*Paralichthys lethostigma*) is a coastal flatfish species that supports recreational and commercial fisheries throughout Louisiana. The recreational and commercial sectors of the Southern Flounder fishery in Louisiana both lack current information that profiles the fishery’s ability to meet stakeholder interest. This project characterized the Louisiana Southern Flounder fishery through an evaluation of fishery-dependent data and a survey of coastal Louisiana anglers.

Fishery-dependent data was gathered to characterize the recreational and commercial Southern Flounder fisheries in Louisiana. This study had three objectives for this evaluation: 1) modeling landings data to evaluate any trends, 2) examine the seasonality of landings, and 3) assess synchrony between regions and sectors of the fishery. A significant decline was apparent for Southern Flounder landings in the recreational fishery, while a less substantial decline was observed in the commercial fishery. Seasonality is shifting in the recreational fishery. Synchrony evaluations revealed moderate to strong positive correlations for intra-sector comparisons.

The decline in the Southern Flounder fishery has prompted a reevaluation of Southern Flounder harvest regulations in Louisiana. To characterize attitudes and values toward specific regulation strategies in this fishery, we developed and executed a survey of coastal recreational anglers in Louisiana. There were two objectives for the survey: 1) determining the total travel cost value that the current Southern Flounder fishery in Louisiana provides, and 2) characterizing how effort alters in coastal Louisiana angling under a range of Southern Flounder regulation scenarios. Survey results indicated that the current Southern Flounder fishery in Louisiana provides a total travel cost value of $126.2 million and that the effort of coastal anglers in Louisiana is not significantly affected by regulations in the Southern Flounder fishery.
Chapter 1. Fishery-Dependent Analysis of Louisiana Southern Flounder

1.1. Introduction

Southern Flounder (*Paralichthys lethostigma*) is a coastal flatfish species found throughout the Gulf of Mexico and U.S. Southeast Atlantic. Southern Flounder holds importance in coastal Louisiana, where it provides economic value to a diverse group of both commercial and recreational stakeholders. Southern Flounder are popular among recreational anglers due to the accessibility of fishing sites where Southern Flounder are found and the high food quality of their flesh (Gulf States Marine Fisheries Commission 2015). In Louisiana, the commercial fishery for Southern Flounder has historically been a bycatch fishery, where most of the fish harvested come from non-directed effort within the commercial shrimp fishery (West et al. 2020, Adkins et al. 1998). The value of Louisiana Southern Flounder within the commercial sector has declined tremendously since the early 1990s due to regulatory changes; however, the supplementary value of commercial landings is still significant. Despite the demonstrated value across different fisheries, the recreational and commercial sectors both lack current information that profiles harvest rates, economic values, and concentration of interest within the Southern Flounder fishery. A thorough evaluation is warranted to characterize this fishery and identify the stock’s potential to meet stakeholder interest.

1.1.1. Fishery-Dependent Data

Information about wild capture fisheries typically comes from either fishery-dependent or fishery-independent sources. Fishery-dependent data is information obtained directly from fishing activities that reports on the volume and composition of landings, in addition to other related information, such as the location and effort of fishing. Although fishery-dependent data can be extremely valuable, there are significant limitations to this information. While some
aspects of sampling can be held random (e.g., site location, hours sampled), the behavior of anglers and commercial fishers does not occur randomly. Commercial and recreational fishers seek large concentrations of fish and typically expend their effort spatially and temporally by the likelihood of obtaining desirable catches. In addition, fishers can be selective toward sizes, year-classes, or sexes of fish that further biases statistics derived from this data (Murie et al. 2013). Information resulting from catch data alone can only be used to monitor production within the recreational and commercial fishery and in many cases may not directly correspond to the abundance of a fish stock (Hilborn and Walters 2013). For example, increased catch rates may reflect an increase in stock abundance or a rise in fishing effort (Murie et al. 2013). To account for these limitations, fishery-independent data is collected alongside fishery-dependent data using a systematic survey design that keeps spatial, temporal, and effort elements consistent to gather unbiased abundance data.

Keeping these limitations in mind, fishery-dependent data is still very important, as addressing the stock status of a species requires information pertaining to fishing mortality (i.e., harvest, bycatch, discard mortality). Determining the level of removal from a population often comes directly from fishery-dependent data. Fishery-dependent data may also be used to estimate population abundance, mortality, recruitment, growth, and other vital characteristics of populations (Murie et al. 2013). For example, commercial catch data provided an extended time series and wide spatial coverage that was used to indicate essential fish habitats for elasmobranch species within the western Mediterranean Sea (Pennino 2016). With appropriate sampling schemes, fishery-dependent data can provide information that is used to ensure long-term production of the resource coupled with the economic benefit a fishery can provide.
Fishery-dependent data can be further separated into recreational and commercial data, both providing significant details for the characterization of a fishery. In general, commercial fishery data focuses on two components: attributes of the fishery and catch. The attributes of the fishery are the operation of fishing units (e.g., fishers, vessels, gear types) that harvest the catch and expend fishing effort. The catch is the fish captured by these operations, typically reported in terms of volume (weight; Murie et al. 2013). It is important to note that the terms catch, and landings are not interchangeable. Catch refers to the amount of fish captured, whereas landings refer to the portion of the catch retained and harvested (Murie et al. 2013). Commercial information is gathered through the implementation of monitoring programs that either census the landings or directly sample the catch. Most commercial fishers in the United States must report landings data through state-run census programs where aspects of fishing trips such as volume caught, species composition of landings, gear used, effort expended, area fished, and value of commercially sold species must be reported. Supplementary to this approach, direct sampling of the catch can occur through port or observer sampling. Data gathered through these sampling schemes can gather more specific aspects of landings such as length compositions, age compositions, and sex ratios.

Landings in recreational fisheries can rival those of commercial fisheries, resulting in comparable economic and ecological outcomes to the resource (Coleman 2004). Harvest data trends indicate that recreational fishery landings have increased in magnitude over the last several decades in the U.S., deserving increased attention by fishery managers to these removals (Cooke and Cowx 2006, Ihde 2011). Recreational information is collected through the process of creel surveys where information is directly collected from anglers, often in the form of intercept surveys. A creel survey involves sampling anglers and harvested fish to estimate the amount of
angling activity and harvest of species (Jones and Pollock 2013). Methods of contacting an angling population are typically conducted through access point surveys, household surveys, or complemented surveys.

Access point survey methods involve directly interviewing anglers in person during or after their fishing activities. An advantage of access point surveys is that recall biases are minimized as questions typically pertain to a trip that was recently completed. Additionally, samplers have the direct opportunity to identify fish species and gather specimens from recreational landings (Jones and Pollock 2013). Disadvantages of access point methods relative to household surveys are that the cost per interview can be high, it may be difficult to scale results to the whole population, and there are logistical problems of contacting a representative sample of anglers over large areas. A form of access point method that is typically used to estimate marine recreational catches is the dockside intercept technique in which a sampler is stationed at an access point (i.e., pier, boat ramp, beach) and anglers are contacted, typically at the end of their trip. Information collected from these surveys can have a high cost per interview, but the information collected is typically of high quality (Pollack et al. 1994).

Household surveys require a sample to be pulled from a sampling frame such as telephone directories, fishing license registries, or boat registries (Lyle et al. 2002). Once a sample is chosen, either a telephone or mail survey will be conducted to gather information on past fishing trips. The advantages of this method are that data can be related to an entire population and the cost per interview is low for these types of surveys (Jones and Pollock 2013). Sampling in this manner has a variety of biases; for example, not all anglers have boat registrations or fishing licenses. Another concern is that data is self-reported and can contain
errors resulting from willful deception, recall bias, prestige bias, or lack of knowledge (National Research Council 2006).

Some of the disadvantages encountered with each individual survey approach can be overcome through the implementation of a complemented survey where essentially two sampling populations exist (Jones and Pollock 2013). For instance, an access point survey for catch can be combined with a household survey for effort. This approach has been used in all the different marine recreational monitoring programs that have existed in Louisiana including: Marine Recreation Fisheries Statistics Survey (MRFSS), Marine Recreational Information Program (MRIP), and the Louisiana Department of Wildlife and Fisheries (LDWF) LA Creel Program.

1.1.2. Fishery-Dependent Data in Louisiana

Recreational fishery-dependent data is currently collected in Louisiana through the LDWF LA Creel Program. The LA Creel Program survey is a complemented survey design with a dockside intercept survey at access points that is used to estimate harvest rates per trip or catch per unit effort (CPUE), combined with an electronic household survey that estimates total effort as the number of angler trips. Total landings are estimated through the product of effort and CPUE collected through these two methods. During the access point survey, information is collected on number of species harvested, area of fishing effort, and other trip specific details (Louisiana Department of Wildlife and Fisheries 2016a). Angler effort surveys are drawn from a sample frame of license holders and information is gathered on the location and amount of fishing trips to develop effort estimates. For the purposes of this study, LA Creel Program data was evaluated in landings by the number of Southern Flounder estimated to have been harvested by recreational anglers and effort by the number of inshore fishing trips that were estimated to occur.
While coastal creel surveys have been conducted in Louisiana since 1982, the methods which this data was collected have varied greatly. From 2009 to 2013 MRIP, under the National Oceanic and Atmospheric Administration (NOAA), collected coastal recreational angling data in Louisiana. From 1982 to 2008 the MRFSS, also under NOAA, collected coastal recreational angling data in Louisiana. As these programs collected data under a different format than the LA Creel Program, comparisons of these data types are difficult to conclude. West and Zhang (2018) completed a calibration of landings under the two previous programs so data before 2014 can be reasonably compared to current LA Creel Program data. While this hindcast of data is useful for comparison, the data was available in annual form and is not regionally segmented. As the LA Creel Program data provides landings on a much finer scale based regionally and temporally, analysis of fishery-dependent data for this study remained heavily focused on the LA Creel Program period (2014 to present).

In Louisiana, fishery-dependent data is collected for the commercial sector through the LDWF Trip Ticket Program. Under Louisiana law, all commercial seafood landed in Louisiana waters must have a record of the transaction at the first point of sales, called a trip ticket (Isaacs 2020). The Trip Ticket Program has officially been collecting commercial landings data in Louisiana since January 2000. The information gathered from trip tickets contains the following: identifying information about the fisher, vessel, and dealer; the area fished; species landed; quantity; and dockside value. For the purposes of this study, Trip Ticket Program data was extracted for flounder landings volume, value, trip count (the number of commercial fishing trips that landed flounder) and fisher count (the number of commercial fishers that landed flounder).

It is important to note that due to multiple flatfish species having the same economic value in the marketplace (Gulf States Marine Fisheries Commission 2015), the Trip Ticket Program does
not differentiate between flounder species and documents all flatfish landings as “flounder.” Southern Flounder are known to be the dominate flatfish species in coastal Louisiana (Gulf States Marine Fisheries Commission 2015). Over the past 20 years, a flatfish species other than Southern Flounder has not been identified by coastal recreational creel surveys in Louisiana (West et al. 2020). Using ‘flounder’ landings as a metric for Southern Flounder abundance was applied in this analysis as this is a measure that has been repeated within previous evaluations of the Louisiana Southern Flounder fishery (West et al. 2020, Gulf States Marine Fisheries Commission 2015, Adkins 1998).

Under confidentiality standards of the LDWF Trip Ticket Program, commercial data for individual commercial fishers and dealers remains unreported by the program. This information is only provided through an aggregate summary of landings by multiple dealers. If there are not multiple dealers or fishers available for the level of resolution within a data request, this information is marked confidential and is not available for analysis. For the purposes of this study, two data requests were made based on two resolutions. The resolutions requested were under a monthly resolution separating landings by basin and under an annual resolution that included statewide data (Figure 1.1). The annual resolution for this data was available for all years in the aggregate form, therefore no data was left unreported under the confidentiality standards with this resolution. While a portion of each year’s data is unavailable for analysis when separated under a monthly, basin resolution; this resolution of data was important for this study to determine the seasonal and regional patterns of commercial flounder landings.

The LA Creel Program segments its data regionally into 5 regions based upon LDWF Coastal Study Areas (CSAs; Figure 1.2). The LDWF Trip Ticket Program divides its regional data at a finer basis by the basin in which commercial fishing occurred. To compare the two data sets,
commercial data was reduced regionally to CSA based upon which CSA most of the basin falls in. From this point forward CSA1 will be referred to as Pontchartrain CSA, CSA3 will be referred to as Barataria CSA, CSA5 will be referred to as Terrebonne CSA, CSA6 will be referred to as Vermilion CSA, and CSA7 will be referred to as Calcasieu CSA.

In addition to regional separation, LA Creel data for effort and landings are divided by trip type. Trip type is separated into four categories: private inshore, private offshore, charter inshore, and charter offshore. As the number of Southern Flounder landings that occur offshore account for an insignificant portion of total Southern Flounder landings, only inshore landings and effort...
were accounted for in this analysis. Furthermore, charter and private landings were aggregated and assessed together within this study.

1.2. Methods

As noted above, Louisiana has a lot of fishery-dependent data that is collected on a variety of spatial and temporal scales. Using this information, this project characterized the Southern Flounder fishery through an analysis of both commercial (LDWF Trip Ticket Program) and recreational (LDWF LA Creel Program) data. Cursory evaluations occurred in both sectors through a depiction of landings within each CSA to display the visual patterns of Southern Flounder landings before getting into the project objectives. Since data available at the finest temporal and spatial scale comes from the LA Creel Program, which began gathering data in 2014, there was a focus on evaluating data from the years 2014 to 2019. Landings data were analyzed through three main objectives for both commercial and recreational sectors of the fishery. These objectives are:

1) Document landings trends of Southern Flounder in fishery-dependent data,
2) Evaluate and document the seasonal trends in Southern Flounder landings, and

3) Test for synchrony of spatiotemporal patterns within Southern Flounder landings.

### 1.2.1. Modeling Southern Flounder Landings

Generalized additive models (GAMs) were applied to evaluate the effects of temporal factors on landings of Southern Flounder in Louisiana. GAMs were applied in this study as these models are capable of portraying non-linear and complex relationships between response and explanatory variables (Wood 2006). In addition, GAMs provide easily interpreted visualizations of these complex relationships. Within GAMs, the relationship between response variables and explanatory variables is described by smooth terms. The use of $f$ in each model denotes the isotropic smoothing term. For each smoothing term a regression spline structure is specified. With the smoothing term $f_{\text{trend}}$, thin plate and cubic regression splines were introduced and compared. Akaike information criterion (AIC) values were assessed for each regression spline. AIC values were minimized under the thin plate regression spline; therefore, this spline structure was applied to the model. Under the $f_{\text{season}}$ smoothing term, a cyclic cubic regression spline structure was applied so that there was no discontinuity between the end points of the splines applied to seasonal effects. Essentially, the cyclic spline structure connects the data collected in the beginning of the year to data collected in the end of the year as seasonally, these periods have close to the same effect.

The GAM used to evaluate recreational landings is displayed in Equation 1.1.

$$L_{ij} = \beta_0 + f_{\text{trend}}(T_i) + f_{\text{season}}(S_i) + \ln(E_{ij}) + \varepsilon$$  \hspace{1cm} (Eq. 1.1)

In this model, the term $L_{ij}$ refers to the estimated number of Southern Flounder landed for each corresponding week and year, $i$, within each CSA, $j$. The term $\beta_0$ refers to the intercept for each model. The term $T_i$ refers to time in the corresponding week and year that landings were estimated. As landings of the Southern Flounder fishery are known to be highly seasonal (Gulf
States Marine Fisheries Commission 2015), a seasonal effect was added to these models to account for the intra-annual fluctuations. The term $S_i$ refers to the seasonal effect in the ordinal date of the year that landings were estimated. The term $E_{ij}$ refers to effort as the number of trips estimated to occur for each corresponding week and year, $i$, within each CSA, $j$. $E_{ij}$ is applied as an offset within the model that adjusts for the differential effort over each corresponding week and year, $i$, within each CSA, $j$. The natural log ($ln$) of $E_{ij}$ is applied within the offset of this model to account for the log link that is applied within these models. The term $\varepsilon$ refers to the corresponding error for each model.

Effort was modelled in a GAM to depict how this response has varied over time and seasonally throughout the year for each CSA (Equation 1.2).

$$E_{ij} = \beta_0 + f_{trend}(T_i) + f_{season}(S_i) + \varepsilon \quad \text{(Eq. 1.2)}$$

The term $E_{ij}$ refers to effort as the number of trips estimated to occur for each corresponding week and year, $i$, within each CSA, $j$. The term $\beta_0$ refers to the intercept for each model. The term $T_i$ refers to time in the corresponding week and year that effort was estimated. The term $S_i$ refers to the seasonal effect in the ordinal date of the year that effort was estimated. The term $\varepsilon$ refers to the corresponding error for each model.

Due to the amount of data unavailable for analysis under the confidentiality agreement within the LDWF Trip Ticket Program, models displaying commercial data were not run using data collected at the finest level (month). Excluding October to December, monthly data is typically absent from evaluation due to landings data unavailable in the aggregate form. Due to this absence of data, models applied to the commercial dataset were run on the annual level for each CSA. Additionally, reported landings of flounder that did not capture at least 50% of the total landings of flounder for that year were left out of this analysis (Figure 1.1). The years 2011
and 2012 were not used in this model for this reason. The GAM used for commercial landings is displayed in Equation 1.3.

\[ L_{ij} = \beta_0 + f_{trend}(T_i) + \varepsilon \]  
\textbf{(Eq. 1.3)}

The term \( L_{ij} \) refers to the estimated volume of flounder landed, in pounds, for each corresponding year, \( i \), within each CSA, \( j \). The term \( \beta_0 \) refers to the intercept for each model. The term \( T_i \) refers to the corresponding year that data was collected. The term \( \varepsilon \) refers to the error associated with each model.

Recreational hindcast data (West and Zhang 2018) collected at the annual level was modeled to depict the annual trend in recreational landings (Equation 1.4).

\[ L_i = \beta_0 + f_{trend}(T_i) + \varepsilon \]  
\textbf{(Eq. 1.4)}

Within this model, the term \( L_i \) refers to the estimated number of Southern Flounder landed each corresponding year, \( i \). The term \( \beta_0 \) refers to the intercept for each model. The term \( T_i \) refers to the corresponding year that data was collected. The term \( \varepsilon \) refers to the error associated with each model.

In addition to the regional application for each specific CSA, a statewide estimate for all of Louisiana was modelled using a hierarchical approach with GAMs (Pedersen et al. 2019). Data from all five CSAs are applied to this hierarchical approach to generate a global term that displays the status of statewide landings throughout Louisiana while penalizing the effects of each CSA to remain close to the global term so that regional fluctuations in landings are accounted for consistently.

Equation 1.5 displays the notation for the hierarchical GAM applied to commercial flounder data and Equation 1.6 displays the notation for the hierarchical GAM applied to recreational Southern Flounder data.
The terms within Equation 1.5 correspond to the same terms within Equation 1.3. The terms within Equation 1.6 correspond to the same terms within Equation 1.1. The difference between Equation 1.1 and 1.3 and Equation 1.5 and 1.6 is that data is applied to the hierarchical GAM for all CSAs and within these models, a smoothing term \( f_{re}(j) \) runs a factor associated with each specific CSA, \( j \), as a random effect within each model.

All statistical analyses were performed with R programming (R Core Team 2020). Within R, GAMs were built using the package \textit{mgcv} (Wood 2006). The method applied to each model was a restricted maximum likelihood (REML) as this is the method that is strongly recommended while using GAMs (Wood 2011). The number of basis functions used within each smoothing term, specified as \( k \), was set at the default of 10 within \textit{mgcv}. To determine if the value of \( k \) needed to be adapted to the structure of the data, the value of \( k' \) (effectively 1 minus the number of basis functions) was compared to the effective degrees freedom (EDF). When \( k' \) was well below the value of EDF, the \( k \) value was determined to stay at the default. If EDF was approaching the \( k' \) value (separation less than two units apart), then the value of \( k \) was increased by an additional 10 units until \( k' \) no longer approached the value of EDF.

To determine the family (distribution) used within each GAM, data was checked for overdispersion through an analysis of the variance of landings data in comparison with the mean landings value. If overdispersion was detected, models were run using the negative binomial family as this family is capable of handling overdispersal through a dispersion parameter. This family was also chosen for analysis as it is appropriate for handling many zeros within datasets. Within each CSA, were many zeros for Southern Flounder weekly landings.
A zero-inflated model was explored for this large number of zeros. These models are unable to run within the mgcv package, so functions within the gamlss package (Rigby and Stasinopoulos 2005) were used for this part of the evaluation. Under the zero-inflated negative binomial family, model output was nearly identical for the trend and seasonal effect smoothed terms in comparison to output under the negative binomial family. Due to these model similarities, to remain within the functionality of the mgcv package, a negative binomial family was used for analysis of all data that exhibited overdispersion.

1.2.2. Seasonality

Traditionally, the seasonality of Southern Flounder landings for both recreational and commercial fisheries has been defined by the fall migration, in which periods of high landings are documented from October to December. These catches coincide with the spawning migration that Southern Flounder make while moving from inshore estuaries to offshore spawning grounds (Gulf States Marine Fisheries Commission 2015). There is some anecdotal evidence for an additional peak in Southern Flounder landings during the spring when this species putatively reenters the estuaries. As this spring migration has not been characterized in any systematic exploration of fishery-dependent data, this study compared seasonal landings peaks in the spring and fall. This part of the evaluation has been restricted to the recreational side of the fishery as monthly data is very limited for the commercial sector outside of October to December.

This study defined the magnitude of each seasonal migration within each CSA and then determined if these landings periods differed significantly. Spring and fall peak landings were defined by separating the year into two halves and selecting the top eight weekly landings periods within each half of the year. This study chose eight weekly periods as there is an average of 7.75 weeks within each half-year that landings exceed the mean weekly value for that half-
year within each CSA. Weekly landings periods were defined by landings per unit effort (LPUE; Equation 1.7).

\[ LPUE_{ij} = \frac{L_{ij}}{E_{ij}} \]  

(Eq. 1.7)

The term \( LPUE_{ij} \) refers to LPUE values for each corresponding week and year, \( i \), within each CSA, \( j \). The term \( L_{ij} \) refers to the estimated number of Southern Flounder landed for each corresponding week and year, \( i \), within each CSA, \( j \). The term \( E_{ij} \) refers to effort as the number of trips estimated to occur for each corresponding week and year, \( i \), within each CSA, \( j \). The spring migration strength was calculated by taking the top eight LPUE values in the first half of the year that occurred from January 1 to June 30. The fall migration strength was calculated by taking the top eight LPUE values in the second half of the year that occurred from July 1 to December 31. To evaluate if the spring and fall migrations differed significantly, two-sided \( t \)-tests were run between the two samples and significance was determined at \( \alpha = 0.05 \).

Mean values for the fall and spring migration peaks were subtracted to give annual difference value (Equation 1.8).

\[ D_{ij} = LPUE_{fij} - LPUE_{sij} \]  

(Eq. 1.8)

The term \( D_{ij} \) refers to the yearly difference value between mean values for each corresponding year, \( i \), within each CSA, \( j \). The term \( LPUE_{fij} \) refers to the mean value of fall LPUE for each corresponding year, \( i \), within each CSA, \( j \). The term \( LPUE_{sij} \) refers to the mean value of spring LPUE for each corresponding year, \( i \), within each CSA, \( j \).

For commercial landings, seasonality was determined through the analysis of monthly data. While much of the data is not available due to the confidentiality agreements of the Trip Ticket Program, it can be assumed under most circumstances that the landings that occurred in months that do not have an aggregation large enough to be reported are of reduced volume when
compared to the months that do have an aggregation of data that is reported under the monthly by basin resolution.

1.2.3. Synchrony

To quantify the similarity of temporal patterns in Southern Flounder landings both regionally and by sector (commercial and recreational) synchrony between unique time series characterizing these regions and sectors was quantified through the calculation of Pearson’s correlation coefficients (Gouhier and Guichard 2014). With this calculation, a coefficient of 1 indicates a perfect positive relationship while a coefficient of -1 indicates a perfect negative relationship. A coefficient of 0 indicates that no relationship is present. Using the package Hmisc (Harrell 2020), correlation coefficients were calculated.

As the finest level of resolution for commercial landings is at the monthly level, recreational landings were aggregated to this level so that comparisons could be made. Monthly time series were produced for each CSA. Each recreational time series was an accumulation of monthly landings in the number of fish estimated to have been caught each month by the LDWF LA Creel Program within each CSA. Each commercial time series was an accumulation of monthly landings in the volume in pounds of flounder landed by commercial fishers determined by the LDWF Trip Ticket Program within each CSA. To determine if relationships existed between specific regions and statewide data, a monthly time series was produced that aggregated data from all CSAs to produce a statewide index for recreational and commercial data. Data from 2014 to 2019 was used in this analysis, making each monthly time series 72 periods long. With 6 total time series within each sector \((n = 12)\), 66 unique correlation coefficients were calculated between each time series.
1.3. Results

1.3.1. Commercial and Recreational Landings

Monthly recreational landings of Southern Flounder typically peaked in the fall during October and November of most years (Figure 1.3). Depending on the year, there was an additional springtime increase in landings for the recreational fishery that occurred in April and May. The year 2016 displayed the strongest recreational springtime peak where landings in May amounted to the highest monthly landings for that year. Commercially, springtime landings are not apparent as the flounder fishery is strongly dependent upon the fall months (Figure 1.4). November is apparently the strongest month for commercial landings of flounder as this month held the largest volume of commercial flounder landings for any month of the year during 18 of the 20 years analyzed.

Annual Southern Flounder recreational landings are dominated in Louisiana by the Calcasieu CSA (Figure 1.5). The dominance of Calcasieu CSA is one that is additionally present in the commercial fishery (Figure 1.6), though not as strong in the early 2000s as compared to the present commercial fishery. Within the recreational fishery, at least 55% of the annual Southern Flounder landings are estimated to come from the Calcasieu CSA in every year that the LA Creel Program has collected data. Within the commercial fishery, the dominance of Calcasieu CSA did not exceed 40% of the total annual reported landings from the years 2000 to 2005. Landings in Calcasieu CSA were still robust during this time period, however there were also much higher flounder landings among other CSAs. More recently, Calcasieu CSA has trended toward dominating the commercial catch as it has exceeded 75% of the total reported landings (on a monthly, basin resolution) every year from 2013 to 2019.

Annual recreational landings of Southern Flounder have seen a sharp decrease over the last three years, as landings from 2017 to 2019 are all approaching levels that are below 50% of
the 20-year mean (Figure 1.7). While flounder landings in the commercial fishery are presently not as strong as they were during the late 2000s (Figure 1.8), the decline here is not as pronounced as the recreational fishery.

1.3.2. Modeling Southern Flounder Landings

Within the recreational GAMs, the smoothed term for trend was significant ($p < 0.001$) within all CSAs, except for the Vermilion CSA (Table 1.1). Significant smooth terms indicate that an explanatory variable applied to a model has a significant effect on your response variable (Wood 2006). Significant relationships are typically denoted when areas of the partial effect plot that do not overlap the zero-effect line by the smooth curve and error bars. All recreational GAMs with significant smoothed terms for trend display a smooth curve that begins declining approximately at the end of 2016. After this decline, the partial effect plot for trend displays a smooth curve that is below or has error bars touching the zero-effect line (Figures 1.9–1.13).

An additional recreational model is displayed in the hierarchical GAM (Equation 1.6) that applies data from all CSAs to generate a global term for the recreational Southern Flounder fishery in Louisiana. Within this hierarchical GAM, the smoothed term for trend was significant ($p < 0.001$). The partial effect plot for the hierarchical GAM (Figure 1.14) exhibits a smooth curve for trend that follows nearly the exact pattern described for the recreational GAMs for each individual CSA that displayed a significant smoothed term for trend.
Figure 1.3. LA Creel Monthly Recreational Landings. Louisiana monthly recreational landings in the number of Southern Flounder landed per month as determined by LDWF LA Creel Program. Increased levels of landings are denoted with darker shades of blue.

Figure 1.4. Trip Ticket Monthly Commercial Landings. Louisiana monthly commercial landings in the volume of flounder landed per month as determined by LDWF Trip Ticket Program. Data provided on a monthly, basin resolution. Increased levels of landings are denoted with darker shades of red.
Figure 1.5. LA Creel Annual Recreational Landings. Annual recreational landings for each CSA in the number of Southern Flounder landed per year as determined by LDWF LA Creel Program.

Figure 1.6. Trip Ticket Annual Commercial Landings, Monthly Resolution. Annual commercial landings for each CSA in the volume of flounder landed per year as determined by LDWF Trip Ticket Program. Data provided on a monthly, basin resolution.
Figure 1.7. LA Creel Hindcast Annual Recreational Landings. Annual recreational landings in the number of Southern Flounder landed per year as determined by LDWF LA Creel Program from 2014–2019 and MRIP from 2009–2013 and MRFSS from 2000–2008. Data collected before 2014 has been hindcast to match LA Creel Program calculations (West and Zhang 2018).

Figure 1.8. Trip Ticket Annual Commercial Landings, Annual Resolution. Annual commercial landings in the volume of flounder landed per year as determined by LDWF Trip Ticket Program. Data requested on an annual, statewide resolution.
Table 1.1. GAM Smooth Term Significance. \( p \)-values for all smoothed terms within each GAM run within this study. Associated output of each model is displayed in the listed figures. Significant smoothed terms (\( \alpha = 0.05 \)) are presented in boldface.

<table>
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<th>Sector</th>
<th>Figure</th>
<th>Region</th>
<th>Equation</th>
<th>Smoothed Term</th>
<th>( p )-value</th>
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Response plots for recreational GAMs display the prediction that the trend and seasonal effect smoothed terms exhibit in relation to the response variable (Southern Flounder landings) for each weekly period (Figures 1.9–1.13). Within the recreational GAM response plots, data does not fluctuate in a smooth pattern like a typical GAM, as the addition of an offset displays landings responses in relation to the differential effort applied to the inshore fishery for each weekly period within each specific CSA (Figure 1.16). When viewing the response plots for the recreational GAMs, there is a distinct declining pattern in the fishery that can be seen by separating the years 2014, 2015, and 2016 from 2017, 2018, and 2019. In reviewing the response plots, fall landings peaks are noticeably larger and occur over a greater period for the former three years when compared to the later three years within each CSA. This is including Vermilion CSA that did not display a significant smoothed term for trend. This pattern of decline, beginning in 2017, is repeated within the annual recreational GAM (Equation 1.4; Figure 1.15) that applied LA Creel Program and hindcast recreational data for all of Louisiana. Within the annual recreational GAM, the smoothed term for trend was significant ($p < 0.001$).

Effort GAMs (Equation 1.2) were applied to each CSA with smoothed terms for trend and seasonal effect. Effort GAMs for Barataria, Vermilion, and Calcasieu CSA all displayed significant smoothed terms for trend (Table 1.1). Effort GAMs for each CSA displayed a significant smoothed term ($p < 0.001$) for seasonal effect. The combination of these two smoothed terms is displayed in response plots (Figure 1.16) with a peak for each year in the late spring from May to June. This peak is followed by another smaller increase in the fall during October. Each CSA’s partial effect plot for effort (excluding Pontchartrain) displayed a smoothed curve for seasonal effect with error bars touching the zero-effect line during the fall peak, while the late spring peak displayed smooth curves that indicated a period with smooth
curves and error bars above the zero-effect line. These response plots reflect that Barataria is the strongest CSA in terms of effort and Vermilion is noticeably the weakest CSA in terms of effort.

Commercial GAMs (Equation 1.3; Figure 1.17) display a significant effect for the trend smoothed term in the Pontchartrain, Barataria, and Vermilion CSAs (Table 1.1). Within commercial GAMs for Pontchartrain and Barataria the trend displays a decline where a negative effect is presented by a smooth curve and error bars fully below the zero-effect line from 2015 to 2019. The commercial GAM for Vermilion displays a decline as well, however the error bars of the smooth curve touch the zero-effect line for every year from 2000 to 2019. An additional commercial model is displayed in the hierarchical GAM (Equation 1.5) that applies data from all CSAs to generate a global term for the commercial flounder fishery in Louisiana. Within this hierarchical GAM, the smoothed term for trend was significant ($p = 0.043$). The partial effect plot for the commercial hierarchical GAM (Figure 1.17) exhibits a smooth curve that displays a decline; however, the error bars of the smooth curve are touching zero-effect line for every year from 2002 to 2019.

1.3.3. Seasonality
The smoothed term for seasonal effect within each GAM for Equation 1.1 can be used as an indication of the periods of the year that have elevated landings of Southern Flounder. All models for the recreational fishery (Equation 1.1) had a significant smoothed term ($p < 0.001$) for seasonal effect except for Terrebonne CSA (Table 1.1). The hierarchical recreational GAM (Equation 1.6) had a significant smoothed term ($p < 0.001$) for seasonal effect. The models with significant smoothed terms for seasonal effect display a partial effect plot that show a smooth curve and error bars above the zero-effect line for the entire month of October and November within each recreational model that displayed a significant smoothed term for seasonal effect.
Figure 1.9. Recreational Pontchartrain CSA GAM. Landings estimated by the LDWF LA Creel Program. Shaded area represents two standard errors above and below the estimate of the smooth curve and response plot. a) Partial effect plot for the $f(trend(T_i))$ smoothed term. b) Partial effect plot for the $f(season(S_i))$ smoothed term. c) Response plot for weekly Southern Flounder landings.

Figure 1.10. Recreational Barataria CSA GAM. Landings estimated by the LDWF LA Creel Program. Shaded area represents two standard errors above and below the estimate of the smooth curve and response plot. a) Partial effect plot for the $f(trend(T_i))$ smoothed term. b) Partial effect plot for the $f(season(S_i))$ smoothed term. c) Response plot for weekly Southern Flounder landings.
Figure 1.11. Recreational Terrebonne CSA GAM. Landings estimated by the LDWF LA Creel Program. Shaded area represents two standard errors above and below the estimate of the smooth curve and response plot. a) Partial effect plot for the $f_{\text{trend}}(T_i)$ smoothed term. b) Partial effect plot for the $f_{\text{season}}(S_i)$ smoothed term. c) Response plot for weekly Southern Flounder landings.

Figure 1.12. Recreational Vermilion CSA GAM. Landings estimated by the LDWF LA Creel Program. Shaded area represents two standard errors above and below the estimate of the smooth curve and response plot. a) Partial effect plot for the $f_{\text{trend}}(T_i)$ smoothed term. b) Partial effect plot for the $f_{\text{season}}(S_i)$ smoothed term. c) Response plot for weekly Southern Flounder landings.
Figure 1.13. Recreational Calcasieu CSA GAM. Landings estimated by the LDWF LA Creel Program. Shaded area represents two standard errors above and below the estimate of the smooth curve and response plot. a) Partial effect plot for the \( f_{\text{trend}}(T_i) \) smoothed term. b) Partial effect plot for the \( f_{\text{season}}(S_i) \) smoothed term. c) Response plot for weekly Southern Flounder landings.

Figure 1.14. Hierarchical Recreational GAM. Global term from Model 6 for recreational landings throughout Louisiana. Shaded area represents two standard errors above and below the estimate of the smooth curve. a) Partial effect plots for the \( f_{\text{trend}}(T_i) \) smoothed term within Model 6 for weekly recreational data. b) Partial effect plot for the \( f_{\text{season}}(S_i) \) smoothed term.

Figure 1.15. LA Creel Hindcast Recreational GAM. Partial effect plot for the \( f_{\text{trend}}(T_i) \) smoothed term within Model 4 for annual recreational data. Shaded area represents two standard errors above and below the estimate of the smooth curve.
Figure 1.16. Recreational Effort GAM Response Plots. Effort is measured in the estimated number of trips to have been taken each week for the recreational inshore fishery within each CSA by the LDWF LA Creel Program. Shaded area represents two standard errors above and below the estimate of the response plot. a) Response plot for Pontchartrain CSA. b) Response plot for Barataria CSA. c) Response plot for Terrebonne CSA. d) Response plot for Vermilion CSA. e) Response plot for Calcasieu CSA.
Figure 1.17. Commercial GAM Partial Effect Plots. Partial effect plots for the $f_{trend}(T_i)$ smoothed term within Model 3 and Model 5 for commercial annual landings within each CSA. Shaded area represents two standard errors above and below the estimate of the smooth curve. a) Partial effect plot for Pontchartrain CSA. b) Partial effect plot for Barataria CSA. c) Partial effect plot for Terrebonne CSA. d) Partial effect plot for Vermilion CSA. e) Partial effect plot for Calcasieu CSA. f) Global term from Model 5 for commercial landings throughout Louisiana. Partial effect plot for the $f_{trend}(T_i)$ smoothed term.
Among the six years that migration strengths were compared in this study, each CSA displayed variability in significance when the spring and fall landings were statistically compared (Figure 1.18–1.23). For the six years analyzed, every CSA displayed at least two years with migration strengths that were not significantly different, and some CSAs displayed up to four years that were not significantly different.

The differences between these seasonal landings periods appears to be changing. The trend line for difference values between seasonal migration peaks in the fall and spring is declining for every CSA and overall statewide, indicating that these landings periods are becoming more similar (Figure 1.24). Trend lines for mean fall landings periods exhibit a declining trend in all CSAs and statewide over the last six years while mean spring landings periods have remained relatively stable over that same time period (Figure 1.25).

1.3.4. Synchrony

Intra-sector comparison of landings series produced strong to moderate positive correlations within both the recreational and commercial sectors (Figure 1.26). On the commercial side, the comparison between commercial Pontchartrain and commercial Vermilion held the lowest Pearson correlation coefficient at 0.23. All other relationships within the commercial sector held Pearson correlation coefficients of at least 0.37. The strongest relationship among commercial time series was between commercial statewide and commercial Calcasieu with a coefficient that rounded to 1, a nearly perfectly positive correlation. On the recreational side, the comparison between recreational Terrebonne and recreational Vermilion held the lowest coefficient with a value of 0.20. All other relationships within the recreational sector had coefficients of at least 0.29. The strongest relationship among recreational time series was between recreational statewide and recreational Calcasieu with a coefficient of 0.98.
Figure 1.18. Pontchartrain CSA Seasonal LPUE. Boxplots displays the top eight weekly LPUE values in the first half (Spring) and the second half (Fall) of the year for recreational Southern Flounder landings. The $p$-value of a two-sided $t$-test between the Spring and Fall LPUE values is indicated at the top of each year plot. Blue boxes indicate years with significant differences while grey boxes indicate years without significant differences ($\alpha = 0.05$). Axes are scaled freely to depict the variability within each year.

Figure 1.19. Barataria CSA Seasonal LPUE. Boxplots displays the top eight weekly LPUE values in the first half (Spring) and the second half (Fall) of the year for recreational Southern Flounder landings. The $p$-value of a two-sided $t$-test between the Spring and Fall LPUE values is indicated at the top of each year plot. Blue boxes indicate years with significant differences while grey boxes indicate years without significant differences ($\alpha = 0.05$). Axes are scaled freely to depict the variability within each year.
Figure 1.20. Terrebonne CSA Seasonal LPUE. Boxplots displays the top eight weekly LPUE values in the first half (Spring) and the second half (Fall) of the year for recreational Southern Flounder landings. The $p$-value of a two-sided $t$-test between the Spring and Fall LPUE values is indicated at the top of each year plot. Blue boxes indicate years with significant differences while grey boxes indicate years without significant differences ($\alpha = 0.05$). Axes are scaled freely to depict the variability within each year.

Figure 1.21. Vermilion CSA Seasonal LPUE. Boxplots displays the top eight weekly LPUE values in the first half (Spring) and the second half (Fall) of the year for recreational Southern Flounder landings. The $p$-value of a two-sided $t$-test between the Spring and Fall LPUE values is indicated at the top of each year plot. Blue boxes indicate years with significant differences while grey boxes indicate years without significant differences ($\alpha = 0.05$). Axes are scaled freely to depict the variability within each year.
Figure 1.22. Calcasieu CSA Seasonal LPUE. Boxplots displays the top eight weekly LPUE values in the first half (Spring) and the second half (Fall) of the year for recreational Southern Flounder landings. The $p$-value of a two-sided $t$-test between the Spring and Fall LPUE values is indicated at the top of each year plot. Blue boxes indicate years with significant differences while grey boxes indicate years without significant differences ($\alpha = 0.05$). Axes are scaled freely to depict the variability within each year.

Figure 1.23. Statewide Seasonal LPUE. Boxplots displays the top eight weekly LPUE values in the first half (Spring) and the second half (Fall) of the year for recreational Southern Flounder landings. The $p$-value of a two-sided $t$-test between the Spring and Fall LPUE values is indicated at the top of each year plot. Blue boxes indicate years with significant differences while grey boxes indicate years without significant differences ($\alpha = 0.05$). Axes are scaled freely to depict the variability within each year.
Figure 1.24. Seasonal LPUE Difference Plots. Seasonal LPUE differences where mean LPUE for Fall landings are subtracted by mean LPUE values for Spring landings. Lines depict the linear trend in difference values by year. Axes are scaled freely to depict regional variability.
Figure 1.25. Seasonal LPUE Mean Plots. Each data point displays the mean value of the top eight weekly LPUE values in the first half (Spring) and the second half (Fall) of the year. Error bars indicate the 90% confidence intervals around mean values. Lines depict the linear trend in mean LPUE value by year. Axes are scaled freely to depict regional variability. a) Seasonal plot for Pontchartrain CSA. b) Seasonal plot for Barataria CSA. c) Seasonal plot for Terrebonne CSA. d) Seasonal plot for Vermilion CSA. e) Seasonal plot for Calcasieu CSA. f) Seasonal plot for statewide data.
Figure 1.26. Louisiana Synchrony Heatmap. Correlation matrix for monthly landings within the commercial and recreational flounder fisheries in Louisiana for each CSA and statewide. The number indicated in each box is the Pearson correlation coefficient between the two monthly datasets that intersect. Data for both sectors is from the years 2014 to 2019.
The temporal trends within the commercial sectors were not strongly positively correlated with the temporal trends of the recreational sectors when Pearson correlation coefficients were measured for the same CSA. The Pearson correlation coefficient for Pontchartrain, Barataria, Terrebonne, and Vermilion CSAs when commercial and recreational sectors were compared ranged from -0.08 to 0.17. The Pearson correlation coefficient for Calcasieu CSA when commercial and recreational sectors were compared was moderately positive with a value of 0.51. The relationship between statewide estimates was also moderately positive with a Pearson correlation coefficient of 0.48.

1.4. Discussion

1.4.1. Regional Comparisons of Southern Flounder Landings

The regional resolution of CSAs within the data provided the opportunity to characterize the unique spatial variability that exists for the Southern Flounder fishery in Louisiana. For example, the Calcasieu CSA dominates Southern Flounder landings for both sectors of the fishery. The dominance of this region can be seen by the strong correlation coefficient that each of these sectors demonstrate in the synchrony analysis when this CSA is compared to statewide estimates. The strong correlations for the years 2014 to 2019 demonstrate that in both sectors the statewide landings of Southern Flounder are driven by landings that occur in the Calcasieu CSA for this time period.

Terrebonne CSA provides another differing quality in comparison to the other CSAs as this is the only CSA that did not display a smoothed term of significance for seasonal effect within the recreational GAM. The Terrebonne CSA also displayed low correlated values when inter-sector comparisons were made. When looking at correlation coefficients between commercial Terrebonne and all recreational CSAs, the Pearson correlation coefficients ranged
from -0.08 to 0.01. Furthermore, recreational Terrebonne also displayed weak correlation coefficients among inter-sector comparisons that ranged from -0.08 to 0.17. A more thorough evaluation of habitat, bay morphology, and climate patterns may be warranted to determine why these CSAs provides different signals in the seasonality and intensities of landings.

It is consistently apparent that there is an abundance of similarities among the CSAs compared within this study. The smoothed curve for time displays a pattern that is nearly duplicated in partial effect plots for three of the five CSAs in the recreational sector. Within Pontchartrain, Barataria, and Terrebonne CSAs, a partial effect plot displays a rise in landings, followed by a sharp drop all around the year 2016, then another rise around the end of 2018, with a repeated falling trend for 2019. This is the exact shape that the smoothed term for trend displays in the hierarchical GAM. The similarities of the smoothed term for seasonal effects is also apparent within all CSAs except Terrebonne. The response plots for effort also point toward similarities among the CSAs. Within Pontchartrain, Barataria, Terrebonne, and Calcasieu CSA there is a significant peak in the number of trips taken during the late spring (May to June) with a somewhat smaller (excluding Pontchartrain) peak in the fall (October). This is indicative of a typically increased importance placed by anglers in fishing during the late spring over the fall within each CSA in coastal Louisiana.

1.4.2. Seasonality of Southern Flounder Landings

This study detected strong evidence that the seasonality of this fishery is changing. The seasonal LPUE difference values show that in recent years these difference values are declining as the disparity between landings periods for Southern Flounder is growing smaller. Every CSA displayed a downward trend in difference values with year, suggesting the emergence of a spring fishery that is comparable to the fall fishery. In the most recent year of collected data, 2019, there
were no significant differences displayed in spring and fall migration strengths for any CSA. As peak landings periods are moving closer together, what appears to be occurring is that the fall periods are falling while the spring periods are remaining relatively stable.

It should be noted that the strengths of springtime landings periods do coincide with a peak in effort during the early spring. While effort is accounted for within each LPUE value, it is important to note that this effort value accounts for every coastal angler that may be targeting a variety of species. While an additional increase in effort is noticed in the fall around the Southern Flounder peak landing months, this increase in effort is insignificant when compared to the spring peak (except for the Pontchartrain CSA). An understanding of this fluctuation in effort is important to note when discussing these seasonal patterns.

While the seasonality of commercial landings was not evaluated within the GAMs applied in this study, the visual display of landings by month show that the fall is tremendously important to this sector of the flounder fishery. Commercial landings of Southern Flounder are driven by the shrimp fishery in Louisiana (West et al. 2020, Gulf States Marine Fisheries Commission 2015). The timing of spring Southern Flounder landings in the commercial fishery not aligning with spring landings in the recreational fishery may be driven by the timing of the Louisiana shrimp season. There are two inshore seasons for the shrimp fishery in Louisiana for Brown Shrimp and White Shrimp. The Brown Shrimp season generally runs from mid-May to July and the White Shrimp season generally runs from mid-August to mid-December (Louisiana Department of Wildlife and Fisheries 2016b). While the White Shrimp season overlaps the peak migration period for Southern Flounder in the fall, the Brown Shrimp season is likely occurring after the peak spring migration for Southern Flounder.
1.4.3. A Fishery Trending Downward

The display of a declining fishery is incredibly apparent when reviewing the response plots for each CSA in the recreational sector. While only displaying data from a six-year time series, the decline that has occurred over the last three years is one that is apparent in every CSA for the recreational side of the fishery. The GAM for annual recreational hindcast data displays a decline that further confirms this pattern in the fishery with the context of a 20-year time series.

While the commercial fishery is one that is also displaying a decline when analyzed within the hierarchical GAM, it is important to note that the scale of this decline is on a much different level from the recreational fishery. The commercial landings for Calcasieu CSA, the region that drives statewide landings patterns in the current era, do not appear to sharply decline over this time period and has even shown some indications of increasing in landings magnitude. Conversely, there have been noted declines within Pontchartrain, Barataria, and to a lesser extent Vermilion CSAs that drive this global term to produce a downward trend.

It should be noted that there has also been a strong decrease in effort within the commercial flounder fishery over the time period analyzed in the number of fishers and trips that are reporting landing flounder, so a decline in landings would naturally fall this progression. In 2000, 716 fishers took a total of 3,368 commercial fishing trips that reported commercial flounder landings compared to 2019 where 162 fishers took 654 trips that reported commercial flounder landings. This reduction in effort in the flounder fishery is driven by a concurrent decline in effort within the shrimp fishery over the past 20 years (Isaacs 2020).

Looking forward with management, it is apparent that Louisiana is dealing with a declining fishery for Southern Flounder when it comes to fishery-dependent data, particularly within the recreational fishery. Furthermore, fishery-independent data confirms that this decline
is not only occurring within the commercial and recreational sectors (Erickson unpublished data). As new management options may be warranted to recover the declining fishery, this provided the perfect opportunity to gauge the preferences and values that anglers may hold for specific regulation scenarios within the Southern Flounder fishery.
2.1. Introduction

While the exact cause of the decline presented by Louisiana’s Southern Flounder fishery is unknown, this decline has induced a reevaluation of harvest regulations used to manage this fishery (West et al. 2020). The continued abundance of fish stocks relies upon the policies put in place by regulatory agencies to limit harvest. Some of the more popular tools that managers use to regulate exploitation include placing minimum sizes, limiting the creel (daily bag limit), placing seasonal limitations upon allowable harvest, and in extreme cases, completely closing fisheries (Van Poorten et al. 2013, Whitehead et al. 2011a, Hubert and Quist 2010). In the Gulf of Mexico, each individual state is responsible for setting Southern Flounder regulations within state waters (Gulf States Marine Fisheries Commission 2015). This has led to a variety of regulation strategies employed throughout these states (Table 2.1). Among Gulf-states, Louisiana has the fewest regulations regarding Southern Flounder—with no minimum size restriction, no seasonal limitations, and a creel of 10 fish. While the need for new regulations in Louisiana may

Table 2.1. Gulf of Mexico Southern Flounder Regulations.

<table>
<thead>
<tr>
<th>State</th>
<th>Minimum Size</th>
<th>Creel</th>
<th>Seasonal Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>14”</td>
<td>5 fish per day</td>
<td>No harvest during the month of November</td>
</tr>
<tr>
<td>Florida</td>
<td>12”</td>
<td>10 fish per day</td>
<td>No seasonal limitations</td>
</tr>
<tr>
<td>Louisiana</td>
<td>No minimum size</td>
<td>10 fish per day</td>
<td>No seasonal limitations</td>
</tr>
<tr>
<td>Mississippi</td>
<td>12”</td>
<td>10 fish per day</td>
<td>No seasonal limitations</td>
</tr>
<tr>
<td>Texas</td>
<td>14”</td>
<td>5 fish per day</td>
<td>Creel is reduced to 2 fish per day from November 1 to December 15</td>
</tr>
</tbody>
</table>
be biologically warranted, it is important that the behavior and attitudes of Louisiana recreational anglers is addressed to assess the viability of new regulatory strategies.

An advantage of considering stakeholder preferences in management decisions is the degree to which it can promote support of management decisions. If attitudes and preferences of stakeholders are ignored, placing new limits upon a fishery will often lead to management failure (Knuth et al. 2013, Arlinghaus et al. 2007). While a regulation may be biologically sound, management success is reliant upon the behavior of anglers. Whether regulations are supported or opposed is dependent upon how an angler’s fishing experiences will be altered (Wilde and Ditton 1999). Thus, the need exists to identify angler support for current and proposed regulation scenarios to ensure that successful management takes place.

In addition to stakeholder support, it is equally important that the economic considerations are evaluated before the restructuring of regulations within a fishery occurs (Liese and Carter 2017). The economic impact that new regulations would impart upon the Southern Flounder fishery in Louisiana is difficult to determine as no valuation of the current Southern Flounder fishery exists. By employing a survey of coastal anglers in Louisiana, this project provides an economic value for the current Southern Flounder fishery, as well as delivers an estimation of how that value will change under a variety of proposed regulatory actions.

2.1.1. Nonmarket Valuation

Nonmarket valuation is an economic technique used to provide a value for environmental goods and services that are not traded in traditional markets (Segerson 2017). This technique can provide a dollar value to environmental amenities based upon the choices that individuals make. Nonmarket valuation methods are based on the principle that when a set of choices is confronted, individuals make the choice that most aligns with their preferences (Segerson 2017). Through
obtaining information on the public’s preferences over alternative outcomes, nonmarket valuation seeks to quantify the values that individuals assign to environmental goods and services.

The field of nonmarket valuation can be separated into the categories of stated preference (SP) and revealed preference (RP). SP methods reach values by surveying individuals and inferring value from hypothetical responses, while RP methods estimate value through the observation of actual behavior that is linked to environmental goods (e.g., counting the number of fishing trips conducted at a site; Segerson 2017).

Both approaches provide their own strengths and weaknesses in the types of information that these methods measure. SP approaches have the strength of flexibility where hypothetical scenarios can be created that mirror situations created by a new policy (Whitehead et al. 2011a). Since new policies often lie outside the realm of observed behavior, stated preference methods are often preferred to gain policy relevant information that can be useful in analyzing potential behavior fluctuations (Phaneuf and Smith, 2005). The hypothetical nature that SP methods rely on can also be viewed as a weakness of this approach. SP methods are prone to hypothetical bias, where respondents may be placed in unfamiliar situations which can lead to inconsequential responses due to the hypothetical nature of the scenario (Penn and Hu 2018, Whitehead et al. 2008). It is often argued that RP data is more reliable than SP data as RP approaches are based on real choices that are made in connection to perceived costs and benefits (Whitehead et al. 2011b). A weakness of RP approaches is the reliance on historical data, leading to an inability to predict outcomes outside of the realm of observed behavior. As the strengths of RP data are the weaknesses of SP data, and vice versa, these approaches can be used together as compliments to reach a nonmarket valuation of an environmental good or service (Whitehead et al. 2011b).
A common RP method is the travel cost method (TCM), which uses travel time, expenditures, and the opportunity cost of time as a proxy for the price that recreators are willing to pay for the site’s nonmarket services. The TCM is effective in estimating benefits associated with recreational activities with the realization that travel time and costs incurred to get to a recreation site are the major costs of participation in outdoor recreation (Whitehead et al. 2008). The number of trips and the sites visited reveal an individual’s willingness to pay for recreational activities. From this data, the economic value of an activity can be calculated that shows how users will visit a site in relation to the costs of travel (Parsons 2017).

Since there are no existing data that can be used to describe how anglers might respond to changes in Southern Flounder regulations, stated preference data are necessary to develop estimates of the benefits and costs of alternative regulation scenarios (Whitehead et al. 2011a). Through the construction of proposed scenarios, SP methods can be used to measure the value of environmental resources through a variety of approaches. The contingent valuation (CV) method is a SP approach that is conducted to directly elicit values for nonmarket goods and services (Boyle 2017). Factors such as what the policy will deliver, method of provision, and cost are specified for the specific policy change to deliver a final estimate of what the public is willing to pay for specific nonmarket goods and services (Navrud 2001). Choice experiments (CE) are another common SP approach that is used to estimate utility associated with a non-market good or service based upon the choice an individual selects from a choice set with various attributes such as trip success, trip cost, or a specific management scenario (Cha and Melstrom 2018). The premise behind these models is that individuals will receive utility from a given alternative depending upon a set of observable features (Holmes et al. 2017). This technique is commonly
used to evaluate fishing regulations as it can provide insight into how anglers view their recreational activity is affected by possible management options (Oh and Ditton 2006).

Another SP approach that is commonly used to evaluate potential responses to hypothetical scenarios is the contingent behavior (CB) method. Under CB, respondents are asked to state their intended behaviors given a proposed change in the nonmarket good or service, such as a policy that may result in a change in recreational opportunities (Grijalva et al. 2002). To estimate values associated with CB responses, this approach is commonly paired with RP approaches such as the TCM, which can provide an estimated value of an observed behavior and compare this to hypothetical behavior under proposed scenarios (Deely 2019). Combining the two methods allows for the elicitation of information that lie outside the realm of observed data. This information can be used to indicate how proposed policy ultimately leads to a shift in behaviors that affect the economic value of a recreational activity.

2.1.2. Nonmarket Valuation Approaches in Fisheries

Within fisheries research, RP approaches are used to model angler preferences from analyzing actual behavior to produce recreation values (Whitehead et al. 2011a). These recreation values are produced through an enumeration of past trips over a selected time period while also producing travel cost estimates for each trip. The TCM is the RP approach that is classically used to value angling experiences (Pollack et al. 1994).

The variety of SP methods used in fisheries is much more diverse. Within SP approaches for fisheries research, two types of hypothetical situations are typically presented to reveal values held by anglers. Those situations typically include either 1) an environmental change (e.g. water quality increase, catch rate improvement) or 2) the introduction of specific regulations (e.g. creel decrease). There is a large amount of literature that has been used to value environmental
changes in fisheries. Gilig et al. (2003) used data from the Gulf of Mexico Red Snapper fishery to estimate the value of catch rates using a combination of CV and TCM approaches. Poor and Breece (2006) applied a CB model to estimate the welfare of charter fishing participants associated with water quality improvements in the Chesapeake Bay. Cantrell et al. (2004) used a CV approach to indicate how catch rates and demographic information (e.g. income, occupation, employment status) are important determinants for how the Pacific Threadfin fishery is valued.

While the effects of a specific policy may lead to an improvement in environmental quality (e.g. catch rates), applying these changes directly to policy changes is difficult as this approach provides unreliable estimation of individual’s preferences. Applying a SP approach that directly elicits hypothetical behavior in relation to regulation scenarios is preferred because of these limitations (Whitehead et al. 2011a). There is an equally large amount of literature that has been used to value specific regulation changes. Cha and Melstrom (2018) applied a CE to model the effects of catch-and-release regulations on location choice and participation within the Oklahoma Paddlefish fishery. Carter and Liese (2017) used a CE to evaluate how anglers value catch rates for popular Gulf of Mexico fish species in relation to whether a fish is kept or released due to the size of a creel.

The potential use of a CE was explored in this study; however, it was decided to apply CB for this study as it allows the direct elicitation of effort information in relation to hypothetical regulation scenarios. Furthermore, this study’s objectives were interested in eliciting information based on changes in effort in relation to policy rather than changes within other payment vehicles (e.g. fishing license prices, charter fees). The ability to gather effort information in a direct manner that could be linked to the TCM presented CB as the preferred method for this study.
Within fisheries, the first application of CB with a combined RP approach was applied by Englin and Cameron (1996) with their evaluation of changing prices for recreational fishing demand. This study was the first to display how CB can be used to extend revealed preference data, particularly with policy related changes in a fishery. Since then, several other studies within the scope of fisheries have applied CB and combined this data with RP methods. Alberini et al. (2007) used CB to examine the effects of increased catch rates in the number of trips respondents would take per year within Italy’s Lagoon of Venice recreational fishery. Prayaga et al. (2010) also used this method to explore how specific site conditions and increasing the probability of catching a desired fish species would affect the behavior of recreational anglers within Australia’s Capricorn Coast. Within both the Prayaga et al. (2010) and Alberini et al. (2007) studies, the effects of altered fishing trip conditions did not lead to significant changes in angling participation. Deely et al. (2019) surveyed anglers fishing within an Irish freshwater fishery to explore the effects of increased size and quantity of fish caught during trips on angler participation. The results of the Deely study revealed that an increase to both quantity and size of fish related to significant increases in angler participation.

Each of the CB methods mentioned above pertain to examples of surveys that used environmental factors such as catch rates as a proxy for direct regulatory effects on the fishery. Only one other study was found that applies direct regulatory change within a CB approach in Whitehead et al. (2011a). This study used CB to explore how anglers would react in the number of trips taken in response to an increase in charter fees and a decrease in Red Snapper, Grouper, and King Mackerel creel limits. Willingness to pay (WTP) per trip in relation to a creel reduction was measured in this study through an analysis of the price respondents were willing to pay for charter fishing trips with specific creel limits. The approach this study took is comparable to CB
approach applied in the Whitehead et al. (2011a) study, however this study applied the TCM to calculate welfare estimates on a per trip basis for recreational coastal angling in Louisiana.

2.1.3. Survey Approaches in Louisiana Fisheries

Few SP approaches have been used to value coastal Louisiana recreational fisheries; however, there are many examples of these methods applied to the valuation of coastal wetlands within Louisiana (Petrolia et al. 2014, Petrolia and Kim 2011, Landry et al. 2011). Moreover, while the characterization of expenditures and participation in Louisiana recreational fisheries within the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior, U.S. Fish and Wildlife Service 2011) has occurred as recently as 2011, few explicit applications of RP approaches have been used to characterize coastal Louisiana recreational fisheries. The following will characterize the most recent applications of survey approaches used to characterize coastal Louisiana fisheries.

Louisiana Department of Wildlife and Fisheries (2018) conducted a survey of recreational fishing license holders to determine the level of support and opposition to a potential reduction in the creel for Spotted Seatrout from 25 to 15 fish statewide. While this study did not seek to conduct a valuation of the fishery, it obtained data that indicated the support or opposition that respondents held toward a regulatory change in the Spotted Seatrout fishery that is important to consider within an approach used for valuing regulations. Bergstrom et al. (2004) conducted a combined travel cost and trip response demand model to estimate changes in angling related to catch rates of popular coastal fisheries in the Lower Atchafalaya River Basin along the Louisiana coast. Within this study, SP and RP approaches were combined to estimate a recreational fishing demand curve.
RP survey approaches used in Louisiana fisheries include Alvarez et al. (2014), where a RP approach was developed to value quality changes in the Gulf of Mexico fisheries to examine the effects of the Deepwater Horizon oil spill on recreational anglers and value the loss of resources. Wang et al. (2019) applied a random utility model to portray the variation of welfare losses associated with the potential closure of three major fishing locations on the Louisiana coast to understand preferences in Louisiana for surf and marsh fishing locations. The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation has been conducted every five years, since 1955, and is one of the longest running recreation surveys in the United States. The survey collects information on the number of anglers, how often they take angling trips, and how much they spend on their activities throughout the United States (U.S. Department of the Interior, U.S. Fish and Wildlife Service 2011).

2.2. Methods

2.2.1. Survey Structure

The development of a survey was conducted to meet the primary objectives of this study, which are:

1) Determine a value for the current Southern Flounder fishery in Louisiana, and

2) Characterize the management preferences and values of coastal Louisiana anglers for a range of possible regulatory action within the Southern Flounder fishery in Louisiana.

All survey design, participation, and communication were completed using Qualtrics survey software. Additionally, Louisiana State University Institutional Review Board (LSU IRB) reviewed my survey application (IRB#E11895) and determined that LSU IRB approval was not needed. This study received exempt status due to no manipulation of, nor intervention with human subjects included within this survey.
While the primary objectives of this survey revolved around Southern Flounder, the survey was framed to gather information that characterized all important Louisiana coastal fisheries for several reasons. First, the population of anglers taking coastal fishing trips while targeting Southern Flounder as the primary species is already documented by the LA Creel Program and amounts to a small percentage when compared to other species. From 2016 to 2018, less than 2.5% of Louisiana coastal anglers reported targeting Southern Flounder as the primary species during coastal fishing trips (LA Creel unpublished data). A survey framed around Southern Flounder would likely generate little interest from the coastal Louisiana angling population that this study worked to characterize. To keep the attention of respondents, the survey was framed as broadly as possible. Furthermore, Louisiana Department of Wildlife and Fisheries (LDWF) has stated a goal of enumerating expenditures and frequency of trips involved with coastal Louisiana fishing. For these reasons, the survey was applied to gather information on Red Drum (*Sciaenops ocellatus*) and Spotted Seatrout (*Cynoscion nebulosus*), the two major coastal fisheries in Louisiana, alongside Southern Flounder.

Through close work with the Socioeconomic Research and Development Section of LDWF, the survey sample population was gathered from Louisiana license holders who acquired any of the several licenses that grant recreational saltwater fishing privileges from the two years prior to survey execution (from June 1, 2017 through May 31, 2018 and June 1, 2018 through November 13, 2019). The licenses that grant these privileges include resident saltwater licenses, resident hook and line licenses, senior hunt and fish licenses, Sportsman’s Paradise licenses, student saltwater fishing licenses, military fishing licenses, and disability fishing licenses. The population of Louisiana license holders with saltwater privileges in 2019 was 373,120 anglers. A random sample was drawn from this population using the Cochran method (Sugden et al. 2000)
to gather 10,000 email addresses connected to recreational fishing licenses with saltwater privileges to form the sample population.

A copy of the full survey employed appears in Appendix B. The survey contained five distinct sections that included: 1) avidity characterization, 2) effort characterization, 3) typical trip description, 4) Southern Flounder regulations, and 5) demographics. The avidity characterization section included questions that asked what types natural resource recreation trips they participated in and their self-reported angling ability. The effort characterization section included questions that asked the number of coastal angling trips taken over the past 12 months, where these trips were located, and what species were targeted during these trips. The typical trip description section included questions that asked the average distance traveled, the average time spent fishing, and the average expenditures spent, all during typical coastal angling fishing trips. The Southern Flounder regulations section included the CB section of the survey where the survey presented various regulation scenarios and elicited the number of expected fishing trips under those scenarios. The demographics section included questions that identified personal information about the respondent including income, employment status, age, race, and gender.

The survey opened with a cover letter that described the reasons for conducting this survey without fully implying that the survey was focused on Southern Flounder regulations. This survey indicated that it was looking to measure the economic activity surrounding coastal angling and that this study wanted to allow anglers the opportunity to provide information that represented their preferences for specific fishing regulations. This was followed by a Frequently Asked Questions section and a consent agreement that participants were required to answer before moving to the next section. Those that agreed to the consent agreement were routed to the
next section of the survey while those that did not agree to the consent agreement were routed to
the end of the survey.

The avidity characterization section had three questions that asked whether respondents
had participated in an activity over the past 12 months. The questions began broadly with
participation in outdoor recreation, then narrowed to participation in Louisiana fishing, and
finally to participation in coastal Louisiana fishing. This section ended with two ratings of
angling ability including identifying whether they rated their angling ability as beginner,
intermediate, advanced, or expert and a question that identified the average number of fishing
trips that respondents had conducted over the last five years.

The effort characterization section began by identifying the total number of trips that the
angler took for the primary purpose of coastal angling in Louisiana over the last 12 months. If
respondents answered that they took zero coastal angling trips, they were routed to the Southern
Flounder regulations section. If respondents answered that they took at least one trip they were
routed to a map displayed the five Coastal Study Areas (CSAs) that LDWF regionally divides its
fisheries research. Respondents were asked to select the CSAs that they had conducted coastal
angling trips in. For each CSA selected, respondents were asked how many of the trips were
taken while primarily targeting either Red Drum, Spotted Seatrout, Southern Flounder, or any
other species (categorized as “other”). Primarily targeted species were defined as the species
which respondents are most interested in catching during a fishing trip. If multiple species are
targeted during a trip, the respondent was asked to identify the species with the most time spent
targeting as the primarily targeted species for that trip.

The survey was formatted to characterize trips in this manner to match the format that is
applied to the LA Creel Program survey (Louisiana Department of Wildlife and Fisheries
The question was framed so that the sum of total trips taken targeting each species would amount to the total trips taken for the primary purpose of coastal angling. Each respondent was reminded of the number of coastal angling trips that they had answered in the previous question within the header of this question. Out of 802 responses to this section of the survey, 437 indicated taking a sum of trips in the species-specific section that was not equal to the number of primary purpose trips indicated by the question eliciting this information. To account for this mismatch, a section for multispecies trips was created. Multispecies trips were estimated for each species category when a respondent indicated taking a sum of total trips that surpassed the number indicated for coastal angling trips in Louisiana. As multispecies trips could possibly include several different combinations of each fish species, an upper bound was estimated for each individual species in the multispecies trip category. Responses were removed that indicated taking trip numbers for a single species that surpassed the total trip numbers indicated for coastal angling. This section had a question that also asked the mode of access used during fishing trips. This question was separated into private or rental boat; shore, surf, pier, or marsh by foot; and guide or charter. The final question of this section asked whether the respondent was satisfied with coastal fishing experiences using a five-point Likert-scale that ranged from not at all satisfied to extremely satisfied.

The typical trip description section of the survey included the main travel cost identifiers for TCM calculations. The average time that anglers spent fishing during a typical trip, from arrival to departure from a fishing access point was identified for a typical coastal angling trip. The road mileage travelled was indicated for the average one-way mileage traveled by vehicle from residence to fishing access point for a typical coastal angling trip. The expenditure section elicited the average amount spent on 11 categories of expenditure during a typical coastal
angling trip. The categories for expenditures were listed as boat fuel/oil, boat rental, hotel/motel, camping/recreational vehicle hookup, guide/charter fees, boat ramp/pier access fees, ice, live bait (live minnow, live shrimp, etc.), dead bait (cut-bait, frozen shrimp, etc.), terminal tackle (hooks, weights, lures, etc.), and an “other” section that included any trip expenditure not specified.

The Southern Flounder section began with asking the level of interest in catching Southern Flounder in Louisiana with a five-point Likert-scale ranging from strongly uninterested to strongly interested. The next question asked if over the last five years respondents had noticed a change in fishing quality for Southern Flounder in Louisiana with responses including: “yes, it has declined;” “no, it has not changed;” “yes, it has improved;” and “I don’t know.” The next few questions were all related to current Southern Flounder regulations in Louisiana starting with asking whether the respondent was familiar with Southern Flounder regulations in Louisiana. If the respondent answered yes to this question, then respondents were tested on the creel, minimum size, and seasonal limitations of Southern Flounder in Louisiana to see if they were truly familiar with Southern Flounder regulations.

The next section began the CB section of the survey. Respondents were presented with the current regulations for Southern Flounder in Louisiana and asked to indicate their level of support for the current regulations in Louisiana with a five-point Likert-scale ranging from strongly oppose to strongly support. The question then asked what their expected effort for the next 12 months would be for total coastal angling trips in Louisiana if Southern Flounder regulations remain unchanged. This was followed by a question asking what their expected effort for the next 12 months would be for Southern Flounder specific trips in Louisiana if Southern Flounder regulations remain unchanged.
After gathering information that was used to develop a status quo estimate related to Louisiana Southern Flounder regulations, this survey presented respondents with a short preamble that described the current state of Southern Flounder in Louisiana. This included a graphical representation of LA Creel data indicating the decline over the past two years and bullet points that described the decline in both fishery-dependent and -independent data for Southern Flounder. The following section was directly related to specific regulation scenarios.

The regulation scenarios that were displayed in the survey are indicated in Table 2.2. In Table 2.2, Regulation Scenario refers to the name that each regulation scenario will be referred to from this point forward. There were two types of regulation scenarios selected. Either Southern Flounder regulations were applied that are already in place for other Gulf-states or a regulation scenario was presented that changes one of the primary regulatory tools that fishery managers have at their disposal in creel and seasonal applications. Since the Mississippi Florida regulation scenario already includes a regulation scenario that only altered the minimum size of the Southern Flounder fishery, the exploration of this regulatory tool was not investigated further. With the regulation scenarios that changed one of the regulatory tools, this survey included two scenarios that held a more restrictive approach than current Louisiana regulations and one scenario that held a less restrictive approach than current Louisiana regulations.

This survey did not show every regulation scenario to each respondent in the CB section. This section was segmented as this study wanted to gauge responses from respondents on a variety of regulation scenarios while also maintaining attention and reducing survey fatigue. This
survey displayed three of the six regulation scenarios to each respondent. Regulation scenarios were randomly and evenly selected so that responses were gathered at an approximately even rate among each scenario and ordered effects would not occur.

This survey elicited the exact same information that was gathered in the status quo section of the CB section for each regulation scenario. Respondents were presented with a specific regulation scenario for Southern Flounder and asked to indicate their level of support for the proposed management scenario with a five-point Likert-scale ranging from strongly oppose to strongly support. The question then asked what their expected effort for the next 12 months would be for coastal angling trips in Louisiana if the Southern Flounder regulations presented
were adapted in Louisiana. This was followed by a question asking what their expected effort for the next 12 months would be for Southern Flounder specific trips in Louisiana if the regulations presented were adapted in Louisiana.

The final section was the demographics section which asked a variety of personally identifying information questions. The survey began this section with asking respondents to indicate their gender. The next question asked respondents to indicate their race or ethnicity. This question was followed by asking what employment status best describes you. This was followed by a question of what level of education best describes the highest level that you have completed. This was followed by asking respondents to elicit their age, home ZIP Code, and annual individual income. Every multiple-choice question for this section had an option for “prefer not to answer”.

2.2.2. Travel Cost Calculations

The total travel cost value of coastal angling was calculated for each respondent through information gathered in the typical trip characterization section of the survey. Equation 2.1 displays the way the travel cost value of coastal angling was calculated

\[ TC_i = F_{Vi} + E_{Xi} + OC_i \]  
\( (Eq. 2.1) \)

The term \( TC_i \) refers to the travel cost value for each angling trip for each respondent, \( i \). The term \( F_{Vi} \) refers to the operational cost of vehicle travel for the average coastal angling trip for each respondent, \( i \). The term \( E_{Xi} \) refers to the total dollar value of all expenditures for each respondent, \( i \). The term \( OC_i \) refers to the opportunity cost of time for each respondent, \( i \).

\[ F_{Vi} = M_i \times 0.2444 \times 2 \]  
\( (Eq. 2.2) \)

Equation 2.2 displays the way the operational cost of vehicle travel for the average coastal angling trip was calculated. The term \( M_i \) is the average one-way vehicle mileage travelled
to complete a coastal fishing trip, for each respondent, \( i \). The number 0.2444 represents the dollar value of the 2019 American Automobile Association operating cost per mile for a half-ton, crew-cab pickup (AAA Association Communication 2019). The equation is multiplied by two to represent the driving mileage to the site and back from the site.

\[
E_{xi} = Fb_i + R_i + H_i + C_i + A_i + G_i + I_i + Bl_i + Bd_i + Ta_i + O_i
\]  
(Eq. 2.3)

Equation 2.3 displays the calculation for total cost of expenditures. The term \( Fb_i \) refers to the dollar value of expenditures spent on boat fuel and oil for the average coastal angling trip for each respondent, \( i \). The term \( R_i \) refers to the dollar value of expenditures spent on boat rentals for the average coastal angling trip for each respondent, \( i \). The term \( H_i \) refers to the dollar value of expenditures spent on hotel lodging for the average coastal angling trip for each respondent, \( i \). The term \( C_i \) refers to the dollar value of expenditures spent on camping for the average coastal angling trip for each respondent, \( i \). The term \( A_i \) refers to the dollar value of expenditures spent on access fees at boat ramps or piers for the average coastal angling trip for each respondent, \( i \). The term \( G_i \) refers to the dollar value of expenditures spent on guided or chartered trips for the average coastal angling trip for each respondent, \( i \). The term \( I_i \) refers to the dollar value of expenditures spent on ice for the average coastal angling trip for each respondent, \( i \). The term \( Bl_i \) refers to the dollar value of expenditures spent on live bait for the average coastal angling trip for each respondent, \( i \). The term \( Bd_i \) refers to the dollar value of expenditures spent on dead bait for the average coastal angling trip for each respondent, \( i \). The term \( Ta_i \) refers to the dollar value of expenditures spent on terminal tackle for the average coastal angling trip for each respondent, \( i \). The term \( O_i \) refers to the dollar value of expenditures spent on any other expenditures for the average coastal angling trip for each respondent, \( i \). Outliers were identified as any expenditure
value greater than three standard deviations from the mean within each category. Outliers were
discarded from analysis.

\[ OC_i = h_i \times W_i \times \text{Fraction} \]  \hspace{1cm} (Eq. 2.4)

Equation 2.4 displays the way opportunity cost (OC) of time was calculated. The term \( h_i \) refers to the hours spent fishing during an average coastal fishing trip for each respondent, \( i \). The term \( W_i \) refers to the wages that the respondent, \( i \), indicated in the demographic section of the survey. There was an encountered gap in the data as many respondents declined to provide income data within the survey. To account for this gap, the mean value for income in the survey was applied to respondents that did not provide income information. When calculating the opportunity cost of time for each respondent, it is common practice to use a fraction of the respondent’s wage (Parsons 2017, English et al. 2015). This study used 0.25 and 0.33 within the term \textit{Fraction} as these are both commonly used in travel cost analyses. This study chose two fractions to test for sensitivity within the travel cost calculations.

\[ TC_{\text{total}} = TC\bar{x} \times TRIPS\bar{x} \times 0.762 \times \text{Population} \]  \hspace{1cm} (Eq. 2.5)

The total travel cost value for coastal angling was calculated through Equation 2.5. From the \( TC_i \) data, a mean value per respondent was calculated to apply to the valuation estimates and reported as the term \( TC\bar{x} \). The term \( TRIPS\bar{x} \) refers to the average number of trips that respondents of the survey indicated taking for the primary purpose of coastal angling. It is understood that everyone that has saltwater privileges in Louisiana does not go fishing in coastal waters. The fraction 0.762 is the proportion of respondents that indicated that they had participated in coastal angling over the last 12 months. This fraction was applied to the total population and represents the proportion of anglers with saltwater privileges that use these privileges in the coastal environment. The term \textit{Population} refers to the total number of anglers that had saltwater
privileges in Louisiana for the year 2019. 90% confidence intervals were calculated for the $TC\bar{x}$ and $TRIPS\bar{x}$ term to place an upper and lower bound on the estimated value of coastal angling in Louisiana. These intervals were calculated using the number of respondents that produced usable travel cost and trip responses in this survey and the standard deviations within those travel cost and trip responses.

$$TC_{ij} = TC\bar{x} \times TRIPS\bar{x}_{ij} \times P_j \times 0.762 \times Population$$  \hspace{1cm} (Eq. 2.6)

The total travel cost value for individual coastal fisheries was calculated for four individual species within each individual CSA and statewide for all of Louisiana. Each individual fishery was calculated using Equation 2.6. The term $TC_{ij}$ refers to the total travel cost value for each fish species, $f$, within each region, $j$. The term $TRIPS\bar{x}_{ij}$ refers to the average number of trips that were indicated to have taken for each fish species, $f$, within each region, $j$. There were six regions referred to including one region for data within each of the five CSAs and one region including statewide data. The term $P_j$ indicates the proportion of total coastal angling trips taken within each CSA. For statewide data, $P_j$ has a value of one. There were four fish species referred to including Southern Flounder, Red Drum, Spotted Seatrout, and an “other” category for any other coastal species. 90% confidence intervals were calculated for the $TC\bar{x}$ and $TRIPS\bar{x}_{ij}$ terms to place an upper and lower bound on the estimated value of coastal angling for each individual coastal fishery in Louisiana. These intervals were calculated using the number of respondents that produced usable travel cost and trip responses in this survey and the standard deviations within those travel cost and trip responses.

### 2.2.3 Contingent Behavior Calculations

For data gathered within the CB section of the survey, two terms were generated in the number of trips estimated under the status quo for the next 12 months and the number of trips estimated
under each individual regulation scenario for the next 12 months. The term $BASE_{TRIPS_{rfi}}$ refers to the number of coastal angling trips that each respondent indicated taking over the next 12 months under the status quo regulations, for a corresponding regulation scenario, $r$, for each targeted category, $f$, for each individual, $i$. The targeted category $f$ for this term was either for Southern Flounder or all coastal species. The term $REG_{TRIPS_{rfi}}$ refers to the number of coastal angling trips that each respondent indicated taking over the next 12 months under a specific regulation scenario, $r$, for each targeted category, $f$, for each individual, $i$.

The change from status quo to specific regulation scenario was calculated for each regulation using Equation 2.7.

$$TRIPS\Delta_{rfi} = REG_{TRIPS_{rfi}} - BASE_{TRIPS_{rfi}}$$  \hspace{1cm} (Eq. 2.7)

The term $TRIPS\Delta_{rfi}$ refers to the trip change from status quo to a specific regulation, $r$, for each targeted category, $f$, for each individual, $i$. The mean value for each regulation scenario was calculated to provide the term $TRIPS\Delta \bar{\epsilon}_{rf}$ which refers to the average change for each regulation scenario, $r$, for each targeted category, $f$. Protest responses were identified as values of $TRIPS\Delta_{rfi}$ that were more than three standard deviations from $TRIPS\Delta \bar{\epsilon}_{rf}$ value and were subsequently removed from analysis. Two-sided paired $t$-tests were conducted between the $BASE_{TRIPS_{rfi}}$ and $REG_{TRIPS_{rfi}}$ values for each regulation scenario to determine if values were significantly different where $\alpha = 0.05$.

$$TRIPS_{rfi} = \beta_0 + \beta_1 BASE_{rf} + \beta_2 Policy + \delta_3(BASE_{rf} \times Policy) + \epsilon$$  \hspace{1cm} (Eq. 2.8)

Additionally, a difference-in-difference (DiD) regression was run using Equation 2.8. The DiD framework is classically used to adjust treatment effects within a heterogeneous population, where the test and control cohorts differ greatly (Zhou et al. 2016). The randomization technique applied to this section of the survey split the respondents into separate
cohorts. Differences in a variety of categories were checked to be significantly different from each cohort using two-sided t-tests. While demographic characteristics (age, gender, education, income) were not found to be significantly different ($\alpha = 0.05$) between groups, the number of $REGTRIPS_{rfi}$ that each group indicated taking for coastal fishing trips were found to be significantly different among four regulatory categories (Table 2.3). As these significant differences indicated that the randomization led to different cohorts answering this section, a DiD approach was applied when evaluating the differences between regulation scenarios and the status quo. The term $TRIPS_{rfi}$ refers to the number of trips that were indicated to occur (both $REGTRIPS_{rfi}$ or $BASETRIPS_{rfi}$) for a specific regulation scenario, $r$, for a targeted category, $f$, for each individual, $i$. The term $\beta_0$ refers to the intercept. The term $BASE_{rf}$ refers to a vector of independent dummy variables for each regulation scenario, $r$, and targeted category, $f$, where 1 is coded for $TRIPS_{rfi}$ that are connected to a specific regulation scenario and 0 is coded for all regulation scenarios that are not connected to the $TRIPS_{rfi}$ term. The term $Policy$ refers to a vector of independent dummy variables for whether the $TRIPS_{rfi}$ was for $REGTRIPS_{rfi}$ (coded as 1) or for $BASETRIPS_{rfi}$ (coded as 0). The term $\varepsilon$ refers to the associated error within the model.

Table 2.3. REGTRIPS Significance. $p$-values of two-sided $t$-tests between the $REGTRIPS_{rfi}$ values for coastal fishing trips among each regulatory option. Significant differences, where $\alpha = 0.05$, are marked in boldface. Regulation scenarios are shaded in grey.

<table>
<thead>
<tr>
<th>Regulation Scenario</th>
<th>Mississippi Florida</th>
<th>Florida</th>
<th>Season Added</th>
<th>Creel Reduction</th>
<th>Texas</th>
<th>Alabama</th>
<th>Creel Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mississippi Florida</td>
<td>1.00</td>
<td>0.83</td>
<td>0.20</td>
<td>0.08</td>
<td>0.28</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>Season Added</td>
<td>0.83</td>
<td>1.00</td>
<td>0.17</td>
<td>0.08</td>
<td>0.24</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td>Creel Reduction</td>
<td>0.20</td>
<td>0.17</td>
<td>1.00</td>
<td>0.52</td>
<td>0.80</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Texas</td>
<td>0.08</td>
<td>0.08</td>
<td>0.52</td>
<td>1.00</td>
<td>0.38</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Alabama</td>
<td>0.28</td>
<td>0.24</td>
<td>0.80</td>
<td>0.38</td>
<td>1.00</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Creel Increase</td>
<td>0.29</td>
<td>0.49</td>
<td>0.02</td>
<td>0.01</td>
<td>0.04</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>
The components of TCM calculations were combined with CB calculations to generate an estimate for the $TRIPS\Delta \bar{x}_{sf}$ dollar value of each regulation scenario, $r$, and each targeted category, $f$. The estimated value change in Southern Flounder trips was calculated, but the value changes that are represented by Southern Flounder trip changes need to be viewed with caution as a respondent can indicate changing the number of Southern Flounder trips and while taking the same number of coastal angling trips while redistributing their targets toward other fish species. With this consideration, the real change in economic value that a regulation scenario will impact on Louisiana coastal fisheries comes from the changes in coastal angling trips.

$$VALUE_{sf} = TRIPS\Delta \bar{x}_{sf} \times TC\bar{x} \times 0.762 \times Population \times P_{sf} \quad (Eq. \ 2.9)$$

The calculations for regulatory value are displayed in Equation 2.9. The term $VALUE_{sf}$ refers to the value for each regulatory change, $r$, for each targeted category, $f$. The term $TRIPS\Delta \bar{x}_{sf}$ refers to the average change in trips from the status quo for each regulatory change, $r$, for each targeted category, $f$. The fraction 0.762 is the proportion of respondents that indicated that they had participated in coastal angling over the last 12 months. The term $Population$ refers to the total number of anglers that had saltwater privileges in Louisiana for the year 2019. The term $P_{sf}$ refers to the proportion of usable responses within the full number of respondents that answered the CB section of the survey for each regulatory change, $r$, for each targeted category, $f$. Most respondents only answered the multiple-choice Likert-scale question asking for their level of support or opposition for the regulation scenario and left the section that indicated how many trips they would take under the regulation scenario blank. With the understanding that Southern Flounder are typically a species that is incidentally targeted during coastal fishing trips, this study understands that the regulations for Southern Flounder are not likely to have consequential effects for many anglers. The proportion of respondents that answered the trip
portion of the CB section represents the proportion of anglers that will alter their fishing behavior based on a specific regulation scenario. 90% Confidence intervals were calculated for the $TRIPS\Delta \bar{x}_{rf}$ and $TC\bar{x}$ value to give an upper and lower bound to the $VALUE_{rf}$ term. These intervals were calculated using the number of respondents that produced usable travel cost and trip responses in this survey and the standard deviations within those travel cost and trip responses.

The gap between those that answered the CB section of the survey in full and those that left part of this section unanswered may be reconciled through the interpretation that those that did not answer this section would not have changed their behavior based on Southern Flounder regulations. To display how this assumption might affect the term $VALUE_{rf}$, an additional analysis was applied where unanswered values were substituted by the mean values that respondents indicated for that section. Under this approach, respondents that left answers blank for the number of expected trips will have answers substituted using the rounded integer value for the average number of coastal trips and Southern Flounder trips answered for $BASETRIPS_{rfi}$. Hereafter, this approach will be referred to as the blank substitution method. Using this approach, the number 12 was applied to each blank coastal trip question and the number three was applied to each blank Southern Flounder trip question. With the increase of answers indicating no change, over half of the respondents that indicated changing their trips under a regulation scenario would meet the criteria of protest responses with a $TRIPS\Delta_{rfi}$ value greater than three standard deviations from the mean. Due to this result, outliers were identified under the blank substitution method using the same measure for protest votes indicated by the approach that did not substitute for blank answers. Protest vote outliers were indicated by an absolute
value of $\text{TRIPS}_{\text{rf}_i}$ greater than ten for coastal angling trips and greater than five for Southern Flounder trips.

2.3. Results

2.3.1. Survey Summary Statistics

From the sample of 10,000 email addresses gathered from Louisiana fishing license holders with saltwater privileges 9,946 of those emails were sent, 2 email addresses failed, 556 email addresses bounced, and 31 of those email addresses were duplicates. From that sample, 1,526 respondents opened the online survey link. When respondents were presented with the consent agreement, 1,155 respondents agreed to the consent agreement and 40 did not agree to the consent agreement. Many respondents did not fully answer each section of the survey, leaving only 264 fully completed surveys with usable responses for a 2.65% completed response rate. The survey generated usable responses from 1,137 respondents for an 11.43% partial response rate. Furthermore, inferring a value for respondents that partially skipped the CB section of the survey, using the blank substitution method, the completed response rate would significantly change with an increase to a 9.55% completed response rate. 87.24% of the partial respondents were male, 94.79% were white, 73.30% had a full-time employment status, 47.88% had at least a bachelor’s degree, and 62.15% had an income that was over $80,000. The average age of the partial respondents was 51 (Figure 2.1).

2.3.2. Avidity

For the avidity portion of the survey, 97.10% of respondents indicated that they had participated in outdoor recreation in Louisiana over the last 12 months, 93.13% of respondents indicated that they had gone fishing in Louisiana over the last 12 months, and 76.23% of respondents indicated that they had gone fishing in coastal Louisiana over the last 12 months (Figure 2.2). For the self-
reported rating for angling, 6.86% of respondents categorized themselves as “beginner,” 39.89% of respondents categorized themselves as “intermediate,” 49.73% of respondents categorized themselves as “advanced,” and 6.23% of respondents categorized themselves as “expert.” For the avidity question that elicited the average number of fishing trips taken over the last five years, 3.00% of respondents indicated taking zero fishing trips and 19.20% of respondents indicated taking over 30 fishing trips.

### 2.3.3. Effort Characterization

872 respondents indicated the CSA they had conducted fishing trips in over the previous 12 months. Barataria CSA had the most reported activity with 339 respondents (38.88%) indicating taking trips in this CSA (Figure 2.3). Pontchartrain CSA was close behind with 330 respondents (37.84%) indicating taking trips in this CSA. 262 respondents (30.05%) indicated fishing in Terrebonne CSA, 189 respondents (21.67%) indicated fishing in Calcasieu CSA, and 112 respondents (12.84%) indicated fishing in Vermilion CSA.

Of the 872 respondents that indicated which CSA they had fished in, 70 respondents skipped the next section with 21 responses were discarded, making a total of 781 usable responses in this section. Red Drum trips occurred during 35.75% of the total trips in coastal Louisiana. Spotted Seatrout trips occurred during 42.94% of the total trips in coastal Louisiana. Southern Flounder trips occurred during 8.59% of the total trips in coastal Louisiana. The remaining 12.72% of trips occurred while targeting any other fish species in coastal Louisiana. Respondents indicated Spotted Seatrout as the main species of target within the three eastern CSAs (Pontchartrain, Barataria, Terrebonne) in coastal Louisiana. indicated Red Drum as the main species of target in the two western CSAs (Vermilion, Calcasieu).
Figure 2.1. Demographic Characterization. a) Race distribution (n = 863) of partial survey respondents. b) Employment status distribution (n = 880) of partial survey respondents. c) Education distribution (n = 880) of partial survey respondents. d) Income distribution (n = 745) of partial survey respondents. e) Gender distribution (n = 886) of partial survey respondents. f) Age distribution (n = 864) of partial survey respondents. Bin width = 5.
Figure 2.2. Avidity Characterization. a) Distribution of responses ($n = 1137$) to the question: Have you participated in outdoor recreation in Louisiana over the last 12 months? b) Distribution of responses ($n = 1136$) to the question: Have you gone fishing in Louisiana over the last 12 months? c) Distribution of responses ($n = 1136$) to the question: Have you gone fishing in coastal Louisiana over the last 12 months? d) Self-reported angling rating distribution ($n = 1108$). e) Distribution of responses ($n = 1099$) to the question: What is the average number of fishing trips taken over the last five year?
Calcasieu CSA saw the highest amount of Southern Flounder activity with 19.23% of the trips that occurred in this region indicated targeting Southern Flounder (Figure 2.3). This follows LA Creel estimates as over 55% of annual landings for Southern Flounder during each of the last 6 years have been estimated to occur in Calcasieu CSA (Figure 1.6). 32.08% of the total Southern Flounder trips in Louisiana were indicated to occur in Calcasieu CSA (Figure 2.4). Barataria and Pontchartrain CSAs come close to this proportion with 23.46% and 25.87% respectively. Vermilion and Terrebonne CSAs represented similar proportions of overall Southern Flounder effort with 8.41% and 10.78% of trips occurring in these CSAs respectively.

129 anglers indicated taking Southern Flounder trips, equal to 16.52% of the respondents to this section. 1,415 Southern Flounder trips were indicated to have occurred, equal to 8.59% of the total trips that respondents indicated taking in coastal Louisiana. This far exceeds the proportion of estimated trips that LA Creel estimates project to occur while targeting Southern Flounder in coastal Louisiana, which was under 2% for 2018 (LA Creel unpublished data). It is important to note that the LA Creel estimates do not account for multispecies trips, as the LA Creel survey gathers responses that require anglers to choose the species that they would most prefer to catch during their trip as their primary target species (Louisiana Department of Wildlife and Fisheries 2016a). An upper bound for multispecies trips was estimated alongside Southern Flounder trips for each respondent. With a total of 1,330 estimated multispecies Southern Flounder trips, an upper bound of 93.99% of the total Southern Flounder trips fell into this multispecies category. This left only 85 trips estimated to occur solely for the purpose of targeting Southern Flounder in coastal Louisiana. This accounts for 1.26% of total respondent trips that occurred while solely targeting one fish species, a number comparable to LA Creel
estimates. Comparatively, 51.73% and 31.92% of the total trips that occurred while solely targeting one fish species were targeting Spotted Seatrout and Red Drum respectively.

Respondents mainly took fishing trips that had access through a privately owned or rented boat with 85.19% of indicated trips occurring under this mode of access. Access by shore, surf, pier, or marsh by foot occurred for 7.91% of trips. Access through a guide or charter occurred for 6.90% of trips. Respondents were typically satisfied with their coastal fishing experiences with 57.59% of respondents indicating that they were either very satisfied or extremely satisfied with their experiences. 12.62% of respondents indicated that they were either moderately satisfied or not at all satisfied with their experiences.

2.3.4. Southern Flounder Regulations

Respondents had a high level of interest for catching Southern Flounder as 60.13% of respondents were either moderately or strongly interested in catching the species while only 12.31% of respondents indicated they were either moderately or strongly uninterested in catching the species. When asked whether they had noticed a decline in the Southern Flounder fishing quality over the last five years 57.29% of respondents answered that they were unsure if the fishing quality for Southern Flounder had changed or stayed the same. 19.67% of respondents answered that they had noticed a decline while 19.47% noted that fishing quality seems the same. When asked if respondents were familiar with Southern Flounder regulations in Louisiana, 43.85% of respondents indicated that they were familiar with the regulations. After being tested on this knowledge, 228 of the 431 respondents that answered yes could not properly identify the current Southern Flounder regulations in Louisiana. This revised the proportion of respondents that apparently know the Louisiana Southern Flounder regulations to 20.65%.
Figure 2.3. CSA Effort Characterization. 

**a**) Respondents \((n = 872)\) indicated the CSAs that trips were taken for coastal angling in Louisiana. Percentages indicate the proportion of anglers that fished in each CSA. 

**b**) Respondent distribution \((n = 284)\) for the number of trips taken while targeting each species within the Pontchartrain CSA. 

**c**) Respondent distribution \((n = 305)\) for the number of trips taken while targeting each species within the Barataria CSA. 

**d**) Respondent distribution \((n = 246)\) for the number of trips taken while targeting each species within the Terrebonne CSA. 

**e**) Respondent distribution \((n = 99)\) for the number of trips taken while targeting each species within the Vermilion CSA. 

**f**) Respondent distribution \((n = 156)\) for the number of trips taken while targeting each species within the Calcasieu CSA.
Figure 2.4. Target Species Effort Characterization. The number of respondents for each targeted species is indicated by \( n \).

- **a)** Proportional response \( (n = 557) \) of total fishing trips while targeting Red Drum for each CSA.
- **b)** Proportional response \( (n = 129) \) of total fishing trips while targeting Southern Flounder for each CSA.
- **c)** Proportional response \( (n = 598) \) of total fishing trips while targeting Spotted Seatrout for each CSA.
- **d)** Proportional response \( (n = 189) \) of total fishing trips while targeting “other” fish species for each CSA.
- **e)** Respondent distribution \( (n = 781) \) for the number of trips taken while targeting each species in each CSA.
Among the six regulation scenarios presented to respondents, the Mississippi and Florida regulation scenario received the highest score of support when coding the levels of support or opposition with scores ranging from 1 for strongly oppose to 5 for strongly support (Figure 2.6). The Mississippi Florida scenario scored even higher than the current regulations for Southern Flounder in Louisiana. The management scenario that scored the lowest level of support was the Creel Addition regulation scenario, where restrictions on Southern Flounder regulations are more relaxed than current Louisiana regulations.

2.3.5. Typical Trip

For the typical trip, respondents traveled an average of 85.72 miles to conduct a typical coastal angling trip in Louisiana. On average, respondents spend 6.16 hours angling during a typical coastal angling trip. Total expenditures averaged at $188.02 per respondent (Figure 2.5). The main expenditures indicated to occur during coastal fishing trips were for boat fuel, terminal tackle, and ice with 596, 524, and 491 out of 737 total respondents respectively (Table 2.4).

2.3.6. Travel Cost Calculations

Using the calculations indicated in Equation 2.6, travel cost estimates were calculated for each of the coastal CSAs and for total coastal Louisiana angling for Red Drum, Southern Flounder, Spotted Seatrout, and all other coastal fish species (Tables 2.5–9 and Figure 2.7). All estimates for travel cost will refer to the 0.33 OC fraction unless otherwise stated. Calculations using the 0.25 OC fraction can be found in Tables 2.5–2.9. Statewide, Spotted Seatrout generated the highest travel cost estimate with an estimated $637.6 million value for the statewide fishery. The Southern Flounder fishery produced a much lower value with an estimated $126.2 million value statewide. The Red Drum fishery produced an estimated $526.1 million statewide. All other
coastal fisheries produced an estimated $188 million value statewide. Statewide estimates for all coastal fishing trips produced an estimated $980 million in total travel cost value.

Within Pontchartrain, Barataria, and Terrebonne CSAs, Spotted Seatrout provided the highest estimated travel cost values. Within Calcasieu and Vermilion CSAs, Red Drum provided the highest estimated travel cost values. The highest travel cost estimate for Southern Flounder was produced by the Calcasieu CSA with an estimated $42.4 million value. The lowest travel cost estimate for Southern Flounder was produced by the Vermilion CSA with an estimated $7.9

Figure 2.5. Typical Trip Characterization. a) Average one-way mileage for respondents to get to a coastal angling access point during a typical coastal angling trip (n = 820). Bin width = 10. b) Average time spent fishing during a typical coastal angling trip (n = 820). c) Mean expenditures for coastal angling trips. Error bars indicate 90% confidence interval for each mean (n = 737).
million value. Southern Flounder accounted for the lowest travel cost estimates compared to the values generated for Red Drum, Spotted Seatrout, and all other coastal fisheries within every CSA except for Calcasieu CSA, where Southern Flounder accounted for a higher travel cost estimate than all other coastal fisheries.

Table 2.4. Coastal Angling Expenditures. Mean expenditures for each category and standard deviations. \( n \) indicates the number of respondents that reported expenditures for each category.

<table>
<thead>
<tr>
<th>Expenditure</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>( n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Expenditures</td>
<td>$188.02</td>
<td>$232.53</td>
<td>737</td>
</tr>
<tr>
<td>Boat Fuel</td>
<td>$58.55</td>
<td>$125.33</td>
<td>596</td>
</tr>
<tr>
<td>Charter Fees</td>
<td>$35.58</td>
<td>$124.35</td>
<td>72</td>
</tr>
<tr>
<td>Hotel</td>
<td>$22.19</td>
<td>$57.34</td>
<td>116</td>
</tr>
<tr>
<td>Terminal Tackle</td>
<td>$21.05</td>
<td>$37.52</td>
<td>524</td>
</tr>
<tr>
<td>Live Bait</td>
<td>$20.14</td>
<td>$29.23</td>
<td>412</td>
</tr>
<tr>
<td>Access Fees</td>
<td>$7.61</td>
<td>$15.43</td>
<td>384</td>
</tr>
<tr>
<td>Ice</td>
<td>$7.12</td>
<td>$9.01</td>
<td>491</td>
</tr>
<tr>
<td>Other</td>
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<td>Boat Rental</td>
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</table>
Table 2.6. Likert-Scale Support. Proportion of support and opposition for each regulation scenario presented to respondents ($n = 950$). The regulation scenario on the top (Mississippi Florida) provided the highest level of support while the regulation scenario on the bottom (Creel Addition) provided the lowest level of support.
Table 2.5. Southern Flounder Travel Cost. Travel cost calculations for the Southern Flounder fishery in Louisiana. Lower and upper bounds were calculated using 90% confidence intervals for the $TC\bar{\bar{\gamma}}$ and $TRIPS\bar{\bar{\gamma}}$ values. The $TC\bar{\bar{\gamma}}$ value for the 0.33 OC fraction is $342.26 and the $TC\bar{\bar{\gamma}}$ value for the 0.25 OC fraction is $314.87. The population of Louisiana license holders with saltwater privileges in 2019 was 373,120 anglers.

<table>
<thead>
<tr>
<th>OC Fraction</th>
<th>Region</th>
<th>TRIPS$\bar{\bar{\gamma}}$</th>
<th>$P_j$</th>
<th>Lower Bound TC Total</th>
<th>TC Total</th>
<th>Upper Bound TC Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.33</td>
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<td>1.00</td>
<td>$90.6 M</td>
<td>$126.2 M</td>
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</tr>
<tr>
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</tr>
<tr>
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<td>$13.7 M</td>
<td>$22.5 M</td>
</tr>
<tr>
<td>0.33</td>
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<td>1.20</td>
<td>0.07</td>
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<tr>
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<td>Barataria CSA</td>
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Table 2.6. Red Drum Travel Cost. Travel cost calculations for the Red Drum fishery in Louisiana. Lower and upper bounds were calculated using 90% confidence intervals for the $TC\bar{x}$ and $TRIPS\bar{x}$ values. The $TC\bar{x}$ value for the 0.33 OC fraction is $342.26 and the $TC\bar{x}$ value for the 0.25 OC fraction is $314.87. The population of Louisiana license holders with saltwater privileges in 2019 was 373,120 anglers.

<table>
<thead>
<tr>
<th>OC Fraction</th>
<th>Region</th>
<th>$TRIPS\bar{x}$</th>
<th>$P_j$</th>
<th>Lower Bound TC Total</th>
<th>TC Total</th>
<th>Upper Bound TC Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.33</td>
<td>Statewide</td>
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<td>1.00</td>
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<td>$154.8$ M</td>
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<td>$167.7$ M</td>
</tr>
<tr>
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<td>0.07</td>
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<td>$48.8$ M</td>
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<td>$77.7$ M</td>
<td>$98.4$ M</td>
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<td>0.25</td>
<td>Barataria CSA</td>
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<td>0.15</td>
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<td>$71.5$ M</td>
<td>$90.7$ M</td>
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</table>
Table 2.7. Spotted Seatrout Travel Cost. Travel cost calculations for the Spotted Seatrout fishery in Louisiana. Lower and upper bounds were calculated using 90% confidence intervals for the $TC\bar{x}$ and $TRIPS\bar{x}$ values. The $TC\bar{x}$ value for the 0.33 OC fraction is $342.26 and the $TC\bar{x}$ value for the 0.25 OC fraction is $314.87. The population of Louisiana license holders with saltwater privileges in 2019 was 373,120 anglers.

<table>
<thead>
<tr>
<th>OC Fraction</th>
<th>Region</th>
<th>$TRIPS\bar{x}$</th>
<th>$P_j$</th>
<th>Lower Bound TC Total</th>
<th>TC Total</th>
<th>Upper Bound TC Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.33</td>
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<td>1.00</td>
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<td>$25.7\ M$</td>
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<tr>
<td>0.25</td>
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<td>$176.7\ M$</td>
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<tr>
<td>0.25</td>
<td>Barataria CSA</td>
<td>7.66</td>
<td>0.29</td>
<td>$152.9\ M$</td>
<td>$201.9\ M$</td>
<td>$255.0\ M$</td>
</tr>
<tr>
<td>0.25</td>
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<td>0.24</td>
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<td>$23.6\ M$</td>
<td>$32.3\ M$</td>
</tr>
<tr>
<td>0.25</td>
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<td>0.15</td>
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<td>$68.7\ M$</td>
<td>$89.1\ M$</td>
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Table 2.8. Other Species Travel Cost. Travel cost calculations for the all other coastal fisheries in Louisiana. Lower and upper bounds were calculated using 90% confidence intervals for the $T\bar{C}$ and $TRIPS\bar{x}$ values. The $T\bar{C}$ value for the 0.33 OC fraction is $342.26 and the $T\bar{C}$ value for the 0.25 OC fraction is $314.87. The population of Louisiana license holders with saltwater privileges in 2019 was 373,120 anglers.

<table>
<thead>
<tr>
<th>OC Fraction</th>
<th>Region</th>
<th>TRIPSx̄</th>
<th>Pj</th>
<th>Lower Bound TC Total</th>
<th>TC Total</th>
<th>Upper Bound TC Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.33</td>
<td>Statewide</td>
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<td>1.00</td>
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<td>$65.7 M</td>
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<td>0.33</td>
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</tr>
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<td>$75.0 M</td>
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</tr>
<tr>
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<td>Calcasieu CSA</td>
<td>1.76</td>
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<td>$37.9 M</td>
</tr>
<tr>
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<td>1.00</td>
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<td>$49.1 M</td>
<td>$70.7 M</td>
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<tr>
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<td>0.24</td>
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<td>$48.5 M</td>
<td>$69.2 M</td>
</tr>
<tr>
<td>0.25</td>
<td>Vermilion CSA</td>
<td>1.43</td>
<td>0.07</td>
<td>$5.2 M</td>
<td>$9.4 M</td>
<td>$13.9 M</td>
</tr>
<tr>
<td>0.25</td>
<td>Calcasieu CSA</td>
<td>1.76</td>
<td>0.15</td>
<td>$13.3 M</td>
<td>$23.6 M</td>
<td>$34.9 M</td>
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Table 2.9. Coastal Louisiana Travel Cost. Travel cost calculations for the statewide coastal fisheries in Louisiana. Lower and upper bounds were calculated using 90% confidence intervals for the $TC\bar{x}$ and $TRIPS\bar{x}$ values. The $TC\bar{x}$ value for the 0.33 OC fraction is $342.26$ and the $TC\bar{x}$ value for the 0.25 OC fraction is $314.87$. The population of Louisiana license holders with saltwater privileges in 2019 was 373,120 anglers.

<table>
<thead>
<tr>
<th>OC Fraction</th>
<th>TRIPS$\bar{x}$</th>
<th>Lower Bound</th>
<th>TC Total</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
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<td>10.04</td>
<td>$0.86 B$</td>
<td>$0.98 B$</td>
<td>$1.11 B$</td>
</tr>
<tr>
<td>0.25</td>
<td>10.04</td>
<td>$0.78 B$</td>
<td>$0.90 B$</td>
<td>$1.02 B$</td>
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</tbody>
</table>

Figure 2.7. Coastal Louisiana Travel Cost. Travel cost values for each specific fish within each region in coastal Louisiana. Error bars indicate the upper and lower bounds of 90% confidence intervals for the $TC\bar{x}$ and $TRIPS\bar{x}$ values. Opportunity cost was calculated using the 0.33 fraction. The axis for statewide estimates is in billions of dollars. The axes for the CSA estimates are in millions of dollars. a) Statewide estimates of travel cost for each species and coastal Louisiana. b) Travel cost estimates for Pontchartrain CSA. c) Travel cost estimates for Barataria CSA. d) Travel cost estimates for Terrebonne CSA. e) Travel cost estimates for Vermilion CSA. f) Travel cost estimates for Calcasieu CSA.
2.3.7. Contingent Behavior Calculations

The results of paired $t$-tests between samples of $REGTRIPS_{rfi}$ and $BASETRIPS_{rfi}$ indicated that trip values between regulation scenarios and status quo were not significantly different for most regulation scenarios ($\alpha = 0.05$; Table 2.10). None of the coastal trip changes under each regulation scenario were found to have significant differences. Only one scenario of the Southern Flounder trip changes under each regulation scenario provided significant differences. The Season Added regulation scenario displayed significant differences between the regulation scenario and status quo for Southern Flounder angling trips. The number of Southern Flounder trips that the Season Added scenario changes on average per respondent from status quo to regulation scenario is a reduction of 0.19 trips per year (Table 2.15).

Within the DiD regression, a reference variable needed to be selected due to the multicollinearity of variables. The reference variable for this regression was the Creel Addition regulation scenario. The estimate for the intercept of this regression is equal to the mean $BASETRIPS_{rfi}$ value for the Creel Addition regulation scenario. Each estimate for the $\beta_1$ coefficients indicates the amount that each the mean $BASETRIPS_{rfi}$ value for a specific regulation scenario increases when compared to the Creel Addition regulation scenario. The $\beta_2$ coefficient indicates the level of change for the Creel Addition regulation scenario between $BASETRIPS_{rfi}$ and $REGTRIPS_{rfi}$. Each $\delta_3$ coefficient indicates how each regulation scenario differs in the level of change between $BASETRIPS_{rfi}$ and $REGTRIPS_{rfi}$ compared to the Creel Addition regulation scenario. Results of this regression do not indicate significance for any of the policy scenarios when the changes between status quo and regulation scenario are applied under the $\delta_3$ coefficient (Tables 2.12–13). While significance is indicated by the $\beta_1$ coefficient in the Texas regulation scenario under coastal trips, this significance does not factor the differences between the groups.
The dollar value of regulatory changes in the Southern Flounder fishery when applied to coastal angling trips ranged in estimated value changes from a reduction of $1.5 million to an addition of $3.8 million. The highest reduction in value for a regulatory change for coastal angling trips was indicated by the Texas regulation scenario and the highest increase in value was indicated by the Alabama regulation scenario. None of the changes for coastal angling trips between status quo and regulation scenario were significantly different. The error bars that 90% confidence intervals indicate for each regulation scenario are within the estimated range of a net-zero effect (Figure 2.8). The dollar value for regulatory changes when applied to Southern Flounder specific trips ranged in travel cost estimated value changes from a reduction in $4.5 million to an addition of $0.2 million. The Season Added scenario is the only estimate with 90% confidence intervals that are not within the range of net-zero effect (Figure 2.8–11).

Estimates of regulation value using the blank substitution method determined nearly identical values for dollar value changes. With the blank substitution method, estimates of dollar values for regulation change ranged from a reduction in value by $1.1 million to an addition of $3.8 million when measuring the change in coastal angling trips. For Southern Flounder trip changes, the dollar values ranged from a reduction in $4.5 million to an addition of $0.2 million. It should be noted that these methods produced very different $TRIPSΔx$ estimates. The reason for the nearly identical output is due to the relative changes in $P_{sf}$ among the two estimates. The proportion of respondents scaled out the differences in $TRIPSΔx$ values (Tables 2.15–18). The blank substitution method produced $P_{sf}$ values very close to 1 with nearly all responses marked as usable with substitution. Under the standard method, $P_{sf}$ values ranged from 0.220 to 0.265.
Table 2.10. Trip Change Significance. Mean values of \textit{REGTRIPS} and \textit{BASETRIPS}. Paired $t$-tests were run between each sample and significance ($\alpha = 0.05$) is marked in boldface.

<table>
<thead>
<tr>
<th>Trip Type</th>
<th>Regulation Scenario</th>
<th>BASETRIPS$x$</th>
<th>REGTRIPS$x$</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal</td>
<td>Mississippi Florida</td>
<td>11.70</td>
<td>11.75</td>
<td>0.48</td>
</tr>
<tr>
<td>Coastal</td>
<td>Season Added</td>
<td>11.34</td>
<td>11.37</td>
<td>0.78</td>
</tr>
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<td>Creel Reduction</td>
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<td>14.07</td>
<td>0.88</td>
</tr>
<tr>
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<td>15.68</td>
<td>15.61</td>
<td>0.63</td>
</tr>
<tr>
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<td>Alabama</td>
<td>13.44</td>
<td>13.59</td>
<td>0.40</td>
</tr>
<tr>
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<td>Creel Addition</td>
<td>10.08</td>
<td>10.22</td>
<td>0.37</td>
</tr>
<tr>
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<td>Mississippi Florida</td>
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<td>2.55</td>
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<td>Season Added</td>
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<td>2.58</td>
<td>0.02</td>
</tr>
<tr>
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<td>3.20</td>
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</tr>
<tr>
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<td>3.13</td>
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<td>Alabama</td>
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<tr>
<td>Southern Flounder</td>
<td>Creel Addition</td>
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<td>2.38</td>
<td>0.87</td>
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</table>
Table 2.11. Trip Change Significance Blank Substitution. Mean values of $\text{REGTRIPS}$ and $\text{BASETRIPS}$. Contingent behavior calculations applied the blank substitution method. Paired $t$-tests were run between each sample and significance ($\alpha = 0.05$) is marked in bold face.

<table>
<thead>
<tr>
<th>Trip Type</th>
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<th>$\text{REGTRIPS}$ $\bar{x}$</th>
<th>$p$-value</th>
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<tbody>
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<td>12.545</td>
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<td>2.803</td>
<td>2.808</td>
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Table 2.12. Coastal Angling DiD Coefficients. Model coefficients for DiD model using coastal angling trips. Creel Addition regulation scenario is the reference variable. Significance ($\alpha = 0.05$) is marked in bold face.

<table>
<thead>
<tr>
<th>Regulation Scenario</th>
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<th>Estimate</th>
<th>$p$-value</th>
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<td>1.62</td>
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<td>1.25</td>
<td>0.51</td>
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<td>Creel Reduction</td>
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<td>0.07</td>
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<td>$&lt;0.01$</td>
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<td>Mississippi Florida</td>
<td>$\delta_3$</td>
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<tr>
<td>Season Added</td>
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<td>0.97</td>
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<tr>
<td>Creel Reduction</td>
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<td>0.96</td>
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<td>1.00</td>
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<td>$\beta_2$</td>
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Table 2.13. Southern Flounder DiD Coefficients. Model coefficients for DiD model using Southern Flounder trips. Creel Addition regulation scenario is the reference variable. Significance (α = 0.05) is marked in bold face.

<table>
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<tr>
<th>Regulation Scenario</th>
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<th>Estimate</th>
<th>p-value</th>
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<tr>
<td>Texas</td>
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<td>0.99</td>
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Figure 2.8. Coastal VALUE. Dollar value of regulation changes based on the change in total coastal angling trips in Louisiana from the status quo. Error bars indicate the upper and lower bounds of 90% confidence intervals for the terms $TRIPS\Delta\bar{x}$ and $T\bar{C}\bar{x}$. Opportunity cost was calculated using the 0.33 fraction. No significant changes from the status quo were detected ($\alpha = 0.05$).

Figure 2.9. Coastal VALUE Blank Substitution. Dollar value of regulation changes based on the change in total coastal angling trips in Louisiana from the status quo Contingent behavior calculations applied the blank substitution method. Error bars indicate the upper and lower bounds of 90% confidence intervals for the terms $TRIPS\Delta\bar{x}$ and $T\bar{C}\bar{x}$. Opportunity cost was calculated using the 0.33 fraction. No significant changes from the status quo were detected ($\alpha = 0.05$).
Figure 2.10. Southern Flounder VALUE. Dollar value of regulation changes based on the change in total Southern Flounder angling trips in Louisiana from the status quo. Error bars indicate the upper and lower bounds of 90% confidence intervals for the terms $TRIPSΔx$ and $TCx$. Opportunity cost was calculated using the 0.33 fraction. Significant changes from the status quo are colored black ($α = 0.05$).

Figure 2.11. Southern Flounder VALUE Blank Substitution. Dollar value of regulation changes based on the change in total Southern Flounder angling trips in Louisiana from the status quo. Contingent behavior calculations applied the blank substitution method. Error bars indicate the upper and lower bounds of 90% confidence intervals for the terms $TRIPSΔx$ and $TCx$. Opportunity cost was calculated using the 0.33 fraction. Significant changes from the status quo are colored black ($α = 0.05$).
Table 2.14. Coastal Contingent Behavior. Mean value of differences between BASETRIPS and REGTRIPS are indicated for each regulation scenario for coastal fishing trips. Value estimates the resulting change in travel cost value. Upper and lower bounds measured by the 90% confidence intervals around each mean value. The $TC\bar{x}$ value for the 0.33 OC fraction is $342.26 and the $TC\bar{x}$ value for the 0.25 OC fraction is $314.87. The population of Louisiana license holders with saltwater privileges in 2019 was 373,120 anglers.

<table>
<thead>
<tr>
<th>OC Fraction</th>
<th>Regulation Scenario</th>
<th>TRIPSΔ$\bar{x}$</th>
<th>n</th>
<th>$P_{cf}$</th>
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<th>VALUE</th>
<th>Upper Bound VALUE</th>
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<tbody>
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<td>0.261</td>
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<td>$1.3 M</td>
<td>$4.4 M</td>
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<td>$0.8 M</td>
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</tr>
<tr>
<td>0.33</td>
<td>Creel Reduction</td>
<td>0.02</td>
<td>114</td>
<td>0.247</td>
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<td>$5.4 M</td>
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<tr>
<td>0.33</td>
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<td>102</td>
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<td>118</td>
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<td>$3.5 M</td>
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<td>0.25</td>
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Table 2.15. Southern Flounder Contingent Behavior. Mean value of differences between BASETRIPS and REGTRIPS are indicated for each regulation scenario for Southern Flounder fishing trips. Value estimates the resulting change in travel cost value. Upper and lower bounds measured by the 90% confidence intervals around each mean value. Regulations that produced significant differences between BASETRIPS and REGTRIPS are marked in boldface ($\alpha = 0.05$). The $TC\bar{x}$ value for the 0.33 OC fraction is $342.26 and the $TC\bar{x}$ value for the 0.25 OC fraction is $314.87. The population of Louisiana license holders with saltwater privileges in 2019 was 373,120 anglers.

<table>
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<tr>
<th>OC Fraction</th>
<th>Regulation Scenario</th>
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<th>VALUE</th>
<th>Upper Bound VALUE</th>
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<td>0.264</td>
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<td><strong>-$1.5$ M</strong></td>
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<td>-$2.3$ M</td>
<td>$0.7$ M</td>
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<tr>
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<td>$1.7$ M</td>
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Table 2.16. Coastal Contingent Behavior Blank Substitution. Mean value of differences between BASETRIPS and REGTRIPS are indicated for each regulation scenario for coastal angling trips. Contingent behavior calculations applied the blank substitution method. Value estimates the resulting change in travel cost value. Upper and lower bounds measured by the 90% confidence intervals around each mean value. The TC$x$ value for the 0.33 OC fraction is $342.26 and the TC$x$ value for the 0.25 OC fraction is $314.87. The population of Louisiana license holders with saltwater privileges in 2019 was 373,120 anglers.

<table>
<thead>
<tr>
<th>OC Fraction</th>
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<th>$P_{sf}$</th>
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<th>$VALUE$</th>
<th>Upper Bound VALUE</th>
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<tbody>
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<td>0.973</td>
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Table 2.17. Southern Flounder Contingent Behavior Blank Substitution. Mean value of differences between BASETRIPS and REGTRIPS are indicated for each regulation scenario for Southern Flounder trips. Contingent behavior calculations applied the blank substitution method. VALUE estimates the resulting change in travel cost value. Upper and lower bounds measured by the 90% confidence intervals around each mean value. Regulations that produced significant differences between BASETRIPS and REGTRIPS are marked in boldface ($\alpha = 0.05$). The $TC\bar{x}$ value for the 0.33 OC fraction is $342.26$ and the $TC\bar{x}$ value for the 0.25 OC fraction is $314.87$. The population of Louisiana license holders with saltwater privileges in 2019 was 373,120 anglers.

<table>
<thead>
<tr>
<th>OC Fraction</th>
<th>Regulation Scenario</th>
<th>$TRIPS\Delta\bar{x}$</th>
<th>$n$</th>
<th>$P_{rf}$</th>
<th>Lower Bound VALUE</th>
<th>VALUE</th>
<th>Upper Bound VALUE</th>
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<td>-$2.7$ M</td>
<td>-$0.2$ M</td>
<td>$2.6$ M</td>
</tr>
<tr>
<td>0.33</td>
<td>Creel Addition</td>
<td>-0.002</td>
<td>436</td>
<td>0.967</td>
<td>-$2.2$ M</td>
<td>-$0.2$ M</td>
<td>$2.1$ M</td>
</tr>
<tr>
<td>0.25</td>
<td>Mississippi Florida</td>
<td>-0.004</td>
<td>447</td>
<td>0.974</td>
<td>-$2.0$ M</td>
<td>-$0.3$ M</td>
<td>$1.5$ M</td>
</tr>
<tr>
<td>0.25</td>
<td><strong>Season Added</strong></td>
<td><strong>-0.047</strong></td>
<td>448</td>
<td>0.978</td>
<td><strong>-$6.6$ M</strong></td>
<td><strong>-$4.1$ M</strong></td>
<td><strong>-$1.3$ M</strong></td>
</tr>
<tr>
<td>0.25</td>
<td>Creel Reduction</td>
<td>-0.024</td>
<td>452</td>
<td>0.978</td>
<td>-$4.6$ M</td>
<td>-$2.1$ M</td>
<td>$0.7$ M</td>
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<tr>
<td>0.25</td>
<td>Texas</td>
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<td>457</td>
<td>0.985</td>
<td>-$1.1$ M</td>
<td>$0.2$ M</td>
<td>$1.6$ M</td>
</tr>
<tr>
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<td>Alabama</td>
<td>-0.002</td>
<td>443</td>
<td>0.971</td>
<td>-$2.5$ M</td>
<td>-$0.2$ M</td>
<td>$2.4$ M</td>
</tr>
<tr>
<td>0.25</td>
<td>Creel Addition</td>
<td>-0.002</td>
<td>436</td>
<td>0.967</td>
<td>-$2.1$ M</td>
<td>-$0.2$ M</td>
<td>$1.9$ M</td>
</tr>
</tbody>
</table>


2.4. Discussion

2.4.1. Survey Limitations

This study has many potential limitations based on survey constraints and methodologies that were not considered during survey development. An overview of the potential pitfalls that limited the scale and impact of data will be listed with the intention to display weaknesses and illuminate the course of future research.

This survey depended strongly on respondent recall over a 12-month period and this limitation in our effort characterization analysis must be noted. Within recreational demand surveys the issue of recall bias is commonly met as respondents tend to overestimate their recreational behavior (Fisher et al. 1990, Connelly and Brown 1995) and respond with answers that commonly end in a five or zero, particularly with large values (Vaske and Beaman 2006). A common issue with this data can be seen with what is referred to as *heaping*, where responses have an abundance at common numbers, typically a multiple of five (Shonkwiler and Barfield 2015). This survey data has evidence of heaping occurring as over half of the responses given for the question of how many primary purpose coastal angling trips were taken in Louisiana over the last 12 months were multiples of five. Over 97% of responses that indicated taking more than 30 trips indicated a number that was a multiple of five. The 12-month recall period utilized by this survey causes a noteworthy issue, but within survey development there was not a conceivable way considered of overcoming this issue while obtaining observational data that characterized a full year of coastal recreational angling. While this limitation exists, this was the best way of obtaining data to characterize yearly effort with only a single opportunity to survey respondents. Additionally, the typical trip section of the survey was utilized as a method to ease the constraints of recall bias while asking respondents to characterize typical behaviors and
expenditures instead of relying on respondents to recall all expenditures and behaviors over the course of a 12-month period. Within further research, segmenting data collection to shorter recall resolutions over a period of two or three surveys could significantly reduce errors associated with recall bias (Fisher et al. 1990). Additionally, the issue of heaping may be addressed through an analysis that applies a mechanism that redistributes values over an interval whose shape is related to the underlying distribution of data that is not heaped (Shonkwiler and Barfield 2015). This technique will be applied within further analyses of this data.

Within travel cost estimations, the gap between respondents that answered the income question and respondents that left this answer blank was dealt with by applying a mean value of income for non-response so that the opportunity cost of time could be calculated for those respondents. Respondents that answered this question and respondents that did not answer the question were categorized into two groups and two-sided t-tests were conducted to determine if significant differences ($\alpha = 0.05$) existed among demographic attributes. The differences between race, gender, and education among these two groups was not significant; however, employment status and age did see significantly different results. Going further with analysis it is understood that this provides a significant limitation to travel cost estimates and these estimates must be viewed with caution. Under employment status, 76.84% of respondents had a full-time employment status for those that answered the income question. This compared to 52.82% of respondents that had a full-time employment status for those that skipped the income question. One interpretation of these results would be to assume that those that answered the income question may have an income that is greater than those that skipped the income question. Under this assumption opportunity cost was overestimated for those that skipped the question giving us an inflated travel cost estimate.
The income-based approach to valuing a respondent’s leisure time has received critiques in its ability to properly value the leisure time of respondents (Lloyd-Smith et al. 2019, Feather and Shaw 1999). A constant fraction of hourly wage rate computed from self-reported income was used in this study as this is classically used within recreation demand studies (Parsons 2017, English et al. 2015). This approach can be problematic when applied to a heterogenous population as the plasticity of individual valuations of leisure time is not considered. Using an approach that applies individual-specific characteristics to reach this value may be more appropriate. Lloyd-Smith et al. (2019) compared the value of time estimates using an approach that applied individual-specific characteristics and a conventional wage-based approach to derive estimates. This study found that individual-specific values of time amounted to 90% of hourly income, significantly larger than the fractions of wage that were applied in analysis. Additionally, the correlation between the individual-specific and income-based value of time estimates were not significant, suggesting that respondents value their leisure time quite differently than traditional approaches (Lloyd-Smith et al. 2019). Any further analysis of recreation demand using an approach like the one applied in this survey should consider applying a method that accounts for the heterogeneity of respondents and derives a value of time through individual-specific characteristics.

The pseudo-panel nature of the CB section of the survey created issues with analysis as this led to different cohorts of respondents providing unequal responses for each regulation scenario. The average number of coastal angling trips was significantly different for many of the regulation scenarios leading to an inability to compare the trips taken within each scenario without further analysis. This issue attempted to be resolved by applying a DiD framework which displayed that each regulation scenario did not hold significance while accounting for
within-group differences. Splitting the sample was not ideal but given the depth of the effort characterization and typical trip sections of the survey, it was understood that displaying every regulation scenario to respondents would have led to additional issues caused by survey fatigue. Within any preference study, survey fatigue has had a long history of noted effects on survey responses (Bradley and Daly 1994, Sharp and Frankel 1983). As respondents that fully answered the CB section of the survey ranged in percentages from 22.0% to 26.5% of the total CB section respondents, survey fatigue may have already been setting in at this point of the survey. Moving forward, it may have been appropriate to select a smaller number of regulation scenarios to display to respondents. While a smaller number of regulation scenarios would limit the breadth of explored possibilities, showing these scenarios without splitting the sample would provide a more direct interpretation of this data. Tradeoffs between breadth of regulation scenarios and the effects of a split sample must be evaluated in any survey design that analyzes multiple regulation scenarios using an approach like the one applied in this survey.

Uncertainty in future estimates is another significant limitation that should be acknowledged within any study that estimates the future behavior of survey respondents. This is especially true within fisheries research. The environment that contains the social-ecological systems where angler behaviors are tightly linked to environmental changes is becoming increasingly unpredictable and requires dynamic and adaptive responses to a fluctuating environment (Hunt et al. 2016). Just over the past two years, unprecedented events have had immense effects on the behaviors of anglers in coastal Louisiana through the impacts of the COVID-19 pandemic and record flood levels of the Mississippi River. As the true nature of responses to any SP survey depends on stochastic events that have drastic environmental and economic impacts, measuring the consequentiality of responses is a method that should be
considered with further related research (Vossler and Watson 2012, Glenk and Colombo 2011). While this approach does not fully counteract the risk of uncertainty in responses, it would have certainly added to analysis. Applying a Likert-scale question marking the response validity from certain to uncertain (Glenk and Colombo 2011) for all responses of expected effort could have provided a measure that this analysis would have strongly benefited from. While it is impossible to go back and add this measure to the conducted survey, the estimates derived from this data must be viewed with caution, understanding that a measure evaluating consequentiality of responses was not applied.

2.4.2. Management Recommendations

In the 2020 stock assessment of Southern Flounder in Louisiana, the alarming downward trend in Southern Flounder recruitment and spawning stock biomass led the assessment to conclude that “management actions will be needed in order to recover the stock from its current depleted condition” (West et al. 2020). These are strong words that highlight the need within this fishery for regulatory change. It is important to note that the decline occurring in the Southern Flounder fishery is one that is not limited to coastal Louisiana (Erickson unpublished data, Flowers et al. 2019, Powers et al. 2018). Viewing how other state agencies have responded to this decline may provide insight that can be used to guide the decision-making process.

Just over the past 12 months, significant regulatory changes have been implemented within multiple state fisheries for Southern Flounder. Alabama Department of Conservation and Natural Resources recently moved to change their regulations from a 12-inch minimum size limit, a creel of ten fish, and no seasonal limitations to a 14-inch minimum size limit, a creel of five fish, and a season closure for the month of November beginning August 1, 2019. Texas Parks and Wildlife Department (TPWD) has decided to implement a season closure of the
commercial and recreational Southern Flounder fisheries from November 1 to December 15, 2021. Additionally, TPWD will also increase the minimum size limit for Southern Flounder from 14 inches to 15 inches beginning September 1, 2020. The scope of the decline in Southern Flounder populations extends beyond a Gulf-wide phenomenon. North Carolina Marine Fisheries Commission (NCMFC) prematurely ended the commercial and recreational Southern Flounder season on September 4, 2019 to reduce harvest in response to evidence indicating that the fishery is overfished (Flowers et al. 2019). This marked the first time that a closure has been introduced by NCMFC to the recreational Southern Flounder season.

The results of this survey can also be used to guide the decision-making process surrounding the recovery of the Louisiana Southern Flounder fishery. The key finding of this study rests in the results indicating that the number of coastal fishing trips respondents plan to take in Louisiana is not significantly affected by any of the regulation scenarios presented for the Southern Flounder fishery. Every regulation scenario’s estimate for the value change in coastal angling trips displayed 90% confidence intervals with error in the range of a net-zero effect. Within the Southern Flounder fishing trip estimates for the CB section, the only regulation scenario that displayed significant changes in respondents’ planned trips was indicated by the Season Added scenario. This management scenario applied a change in harvest during the month of November when the creel was reduced from ten to two fish.

One interpretation of survey results suggests that anglers may take less Southern Flounder trips under the Season Added regulation scenario but will redistribute their coastal angling trips while targeting another species as the number of coastal angling trips did not significantly change under the Season Added scenario. A redistribution of target species during coastal angling trips will not affect the overall economic value that coastal angling provides to
Louisiana. Additionally, it is important to note that the Texas and Alabama regulation scenarios both applied much stricter seasonal limitations than the Season Added scenario with a creel reduction from five fish to two fish during a six-week period and a season closure for the month of November respectively. Both regulation scenarios presented no significant changes in the number of Southern Flounder fishing trips expected to occur. The fact that the Alabama and Texas regulation scenarios did not present significant impacts to coastal Louisiana or Southern Flounder fishing trips indicates that applying a seasonal limitation to the Southern Flounder fishery should not be dismissed when considering possible management strategies. Considering the strong seasonality displayed when modeling fishery-dependent data for Southern Flounder, the reduction of harvest when applying a seasonal limitation to the fishery would be significant for the Louisiana Southern Flounder fishery. This action may be necessary to induce recovery for this species.

Under the Likert-scale support or oppose question, the highest level of support was given to the Mississippi Florida regulation scenario. This regulation scenario would have a 12-inch minimum size limit, a creel of ten fish, and no seasonal limitations. The modification from the current Louisiana regulations is that this regulation scenario provides the addition of a minimum size limit. While angler support is a key part of selecting a new regulatory strategy for Southern Flounder, the inherent biological capacity that a species provides is another significant consideration for management action (Johnson and Martinez 1995).

The efficacy of a minimum size limit is primarily based on the length at which maturity occurs for a fish species so that mortality risk caused by fishing is minimized prior to first reproduction (Cooke and Cowx 2006, Van Poorten et al. 2013). The length at which 50% of Louisiana Southern Flounder are expected to be mature (L_{50}) has been estimated at 13.95 inches
Using the methods highlighted by Erickson and Midway (2020), percentages of maturity were determined for specific lengths in the female Louisiana Southern Flounder population. 4.79% of female Southern Flounder were determined to be mature at 12 inches. Maturity values increased to 19.44% at 13 inches and 53.65% at 14 inches. Using $L_{50}$ as a proxy for size at maturity (Fonoura et al. 2009) indicates that applying a 14-inch minimum size compared to a 12-inch minimum size has the added benefit of a significantly greater proportion of female Southern Flounder that would become sexually mature before harvest can occur. This would suggest that setting a minimum size limit of 14 inches is a biologically defensible measure for the Southern Flounder fishery.

It appears that either the Alabama or Texas regulation scenarios present the most risk adverse scenarios for the Louisiana Southern Flounder fishery when considering a potential collapse in an already depleted fishery. Survey results suggest that the number of coastal fishing trips in Louisiana will not be significantly altered by the Texas and Alabama regulation scenarios. The support indicated for the Texas and Alabama regulation scenarios is considerably stronger than opposition under out Likert-scale support or oppose question. The need to improve recruitment levels, as spawning stock biomass is at its lowest recorded level, would indicate that setting a minimum size limit at length at maturity would be an appropriate management action for Southern Flounder. Additionally, a seasonal limitation, like those found in the Texas and Alabama regulation scenarios, would provide the harvest reduction that Southern Flounder appear to require for recovery due to the strong seasonality of recreational landings. Due to a combination of biological considerations and the results of this survey, the Alabama and Texas regulation scenarios present two potentially viable alterations within Louisiana Southern Flounder recreational regulations.
2.4.3. Future Applications

When considering the overall contribution that this study provides to natural resource management, the framework built in this study is one that has a wide range of future applications. The methodology of a combined TCM and CB survey approach used to gather preference data related to specific regulatory strategies provides managers with a useful tool that can be used to make difficult management decisions. Within fisheries, this approach has incredible potential in the context of exploring recovery options for declining stocks. Furthermore, the fact that Southern Flounder are typically an incidentally targeted fish species among coastal Louisiana anglers presented the opportunity to test this framework and fine tune this approach without the political fallout of proposing regulatory measures for a more charismatic fish species.

When Spotted Seatrout started to display a decline that warranted management action in the coastal Louisiana fishery, an opportunity was provided to apply what was learned in this study to the most desirable coastal fish species in Louisiana by this study’s estimated travel cost values. The economic importance that this fish species provides to coastal Louisiana highlights the importance that decision-makers have in finding a management strategy that is economically sound. The 2018 recreational harvest of Spotted Seatrout was the lowest observed since 1990 and female spawning stock biomass is at the lowest levels ever observed in the fishery (West et al. 2019). To preserve this valuable resource, LDWF has stated a management goal of recovering the stock by the year 2025 through a reduction in harvest of at least 20%.

There are a variety of ways to meet the goal of 20% harvest reduction using varying levels of size and creel limits. To explore the economic effects of these strategies, a survey has been developed that is currently collecting data from a sample of recreational license holders.
with saltwater privileges. This survey applied a CB approach that is evaluating a range of size and creel limits that meet the stated recovery goals to calculate the change in effort that may occur under each regulation scenario. Through a comparison of changes in effort, a determination of a regulatory strategy in the Spotted Seatrout fishery that will minimize the economic effects of this alteration can be made. The actions that LDWF has made in applying this survey approach to this management issue displays that the survey method built for this study is a viable tool for evaluating recovery strategies that reach beyond the scope of Southern Flounder and emphasizes the role that this approach can play in helping mangers find viable solutions to difficult management decisions.
Appendix A. Supplemental Figures

Figure A.1. Pontchartrain CSA Recreational Weekly Landings. Landings in the number of Southern Flounder landed per week as determined by LDWF LA Creel Program.

Figure A.2. Barataria CSA Recreational Weekly Landings. Landings in the number of Southern Flounder landed per week as determined by LDWF LA Creel Program.
Figure A.3. Terrebonne CSA Recreational Weekly Landings. Landings in the number of Southern Flounder landed per week as determined by LDWF LA Creel Program.

Figure A.4. Vermilion CSA Recreational Weekly Landings. Landings in the number of Southern Flounder landed per week as determined by LDWF LA Creel Program.
Figure A.5. Calcasieu CSA Recreational Weekly Landings. Landings in the number of Southern Flounder landed per week as determined by LDWF LA Creel Program.

Figure A.6. Statewide Recreational Weekly Landings. Landings in the number of Southern Flounder landed per week as determined by LDWF LA Creel Program.
Figure A.7. Pontchartrain CSA Recreational Monthly Landings. Landings in the number of Southern Flounder landed per month as determined by LDWF LA Creel Program.

Figure A.8. Barataria CSA Recreational Monthly Landings. Landings in the number of Southern Flounder landed per month as determined by LDWF LA Creel Program.
Figure A.9. Terrebonne CSA Recreational Monthly Landings. Landings in the number of Southern Flounder landed per month as determined by LDWF LA Creel Program.

Figure A.10. Vermilion CSA Recreational Monthly Landings. Landings in the number of Southern Flounder landed per month as determined by LDWF LA Creel Program.
Figure A.11. Calcasieu CSA Recreational Monthly Landings. Landings in the number of Southern Flounder landed per month as determined by LDWF LA Creel Program.

Figure A.12. Pontchartrain CSA Commercial Monthly Landings. Landings in the volume of flounder landed per month as determined by LDWF Trip Ticket Program.
Figure A.13. Barataria CSA Commercial Monthly Landings. Landings in the volume of flounder landed per month as determined by LDWF Trip Ticket Program.

Figure A.14. Terrebonne CSA Commercial Monthly Landings. Landings in the volume of flounder landed per month as determined by LDWF Trip Ticket Program.
Figure A.15. Vermilion CSA Commercial Monthly Landings. Landings in the volume of flounder landed per month as determined by LDWF Trip Ticket Program.

Figure A.16. Calcasieu CSA Commercial Monthly Landings. Landings in the volume of flounder landed per month as determined by LDWF Trip Ticket Program.
Appendix B. Copy of Survey

Start of Block: Cover Letter

The Economic Impact of Coastal Inshore Anglers:
Louisiana Travel Cost and Management Preference Survey

Dear Angler,

The coastal waters of Louisiana provide a major recreational activity in fishing for anglers across the country. Those involved in fishing activities support local economies throughout Louisiana. This survey sets out to provide an economic assessment for coastal inshore angling activities in Louisiana.

In addition to measuring economic activity, this survey will allow anglers the opportunity to provide information that represents their preferences for specific fishing regulations. The economic impact we are measuring is deeply connected to the actions of anglers, so an understanding of angler management preferences is a crucial part of informing potential management strategies.

Your participation in this survey will offer valuable information for decision-makers engaged in these issues. We assure you that participation in this survey is completely confidential. If you have any questions or comments regarding this survey, please direct them to David Smith at fishscience@lsu.edu.

Thank you for your time and consideration. It is only with the generous assistance of people like you that we can accomplish the goals of our research.

Sincerely,

David R. Smith
Department of Oceanography and Coastal Sciences
Louisiana State University, Room 2263,
Baton Rouge, Louisiana 70803

End of Block: Cover Letter
Start of Block: Consent Form

Louisiana Travel Cost and Management Preference Survey

This study has been approved by the LSU IRB. For questions concerning participant rights, please contact the IRB Chair, Dr. Dennis Landin, 225-578-8692, or irb@lsu.edu.

Please read the following information explaining many frequently asked questions about this survey and complete the consent agreement at the end of this section.

Why is this survey being conducted?
LSU and LDWF are assessing the economic value of coastal inshore fisheries in Louisiana through an evaluation of costs and participation. In addition to the economic assessment, we are looking to characterize angler preferences and attitudes toward specific management strategies. With these values, this survey seeks to understand how participation may change as different regulation scenarios are presented to anglers.

How will management preference information in this survey be used?
LDWF does not currently have any immediate management plans ready to be enacted following the completion of this survey. The goal of this survey is simply to collect information regarding potential management scenarios to guide the decision-making process.

Who is conducting the survey?
The survey is being conducted by researchers at LSU and LDWF. Funding for the project comes from Louisiana Sea Grant and LDWF.

Is participation voluntary?
Participation in this survey is completely voluntary. Subjects may choose not to participate at any time without penalty or loss of any benefit to which they might otherwise be entitled.

How long will it take to complete the survey?
The average time estimated to complete this survey was 10–15 minutes.

Where is this survey focused?
This survey is focused on evaluating the costs and participation of fishing activities that occur specifically within the coastal inshore environment. This area is not to be confused with the offshore marine environment. The coastal inshore environment is the tidally influenced area that is no more than 3 miles offshore of the coast. Please keep this difference in mind while answering questions about your coastal inshore fishing costs and participation.

What is meant by primarily targeted species?
In this survey, there will be several questions regarding the primarily targeted species of your fishing trip. The primarily targeted fish species is the species in which you are most interested in
catching during your trips. If multiple species are targeted during a trip, then the species with the most time spent targeting will be the primarily targeted species for that trip.

**Will survey answers remain confidential?**

*Yes.* All raw survey data will be treated as strictly confidential. Individual answers will remain unidentifiable at the individual level and will be combined at the group level before analysis occurs.

**How will the survey select participants?**

Randomly-selected Louisiana recreational fishing license-holders with saltwater privileges will receive an invitation letter by email with a link to our survey. All survey data collected over the internet will be encrypted and processed via secure web server. To participate in this study you must meet the requirements of both the inclusion and exclusion criteria.

**Who should be contacted for additional information regarding the survey?**

Because of the large number of anglers involved, email correspondence will be the preferred method of communication. Please direct all questions or comments to David Smith at fishscience@lsu.edu or Dr. Steve Midway at (225)-578-6458.

By continuing this survey, you are giving consent to participate in this study.

- ○ Yes, I give permission (1)
- ○ No, I do not give permission (0)

**End of Block: Consent Form**
Start of Block: Section 1: Avidity

*In the following section we would like to know the types of outdoor recreation activities you participate in, with a focus on fishing activities. Please answer the following multiple-choice questions so that we may understand the level of your fishing interest.*

**Section 1: Fishing Interest**

1.1 Over the past 12 months, have you participated in any outdoor recreation activities (e.g., fishing, hunting, wildlife watching, camping) in Louisiana?

- YES (1)
- NO (0)

1.2 Over the past 12 months, have you gone fishing in Louisiana (this includes freshwater and/or marine waters)?

- YES (1)
- NO (0)

1.3 Over the past 12 months, have you gone fishing within coastal inshore waters (less than 3 miles offshore) in Louisiana?

- YES (1)
- NO (0)
1.4 How would you rate yourself in terms of angling ability?

○ Beginner (1)

○ Intermediate (2)

○ Advanced (3)

○ Expert (4)

End of Block: Section 1: Avidity
Start of Block: Section 2: Effort

In the following section we would like to know the number and the types of fishing trips you took, particularly focused on coastal inshore fishing. Please answer the following questions so that we can understand your level of fishing effort.

A trip is defined as leaving your residence to participate in recreational activities. Each trip ends upon the return to your residence. Multi-day trips are to be included under the same trip number.

Section 2: Coastal Inshore Fishing Effort

2.1 Over the past five (5) years, what is the average number of fishing trips you take per year (this includes freshwater and/or marine waters)?

- 0 trips (1)
- 1–2 trips (2)
- 3–5 trips (3)
- 6–9 trips (4)
- 10–19 trips (5)
- 20–29 trips (6)
- 30+ trips (7)
2.2 How often do you fish in coastal Louisiana?

Over the past 12 months, how many trips did you take to coastal Louisiana that **included inshore fishing activities** and of those trips, how many were taken for the **primary purpose of inshore fishing**?

Inshore fishing only includes tidally influenced Louisiana waters, **no more than 3 miles offshore**. Your answer may be the same number for both questions.

<table>
<thead>
<tr>
<th></th>
<th>Trips (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All trips</strong> including coastal inshore fishing activities (2.2_1)</td>
<td></td>
</tr>
<tr>
<td>Trips taken for the <strong>primary purpose</strong> of coastal inshore fishing (2.2_2)</td>
<td></td>
</tr>
</tbody>
</table>

Page Break
2.3 Where did you fish?

You indicated taking \(2.2/ChoiceTextEntryValue/7/4\) trip(s) for the primary purpose of coastal inshore fishing in Louisiana over the last 12 months.

Referencing the map above, indicate the basin(s) in which those trips occurred. For trips spent in multiple basins, please indicate the region that the most time was spent fishing for that trip.

<table>
<thead>
<tr>
<th>Basin(s) where inshore fishing occurred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sabine/Calcasieu/Mermentau (Sabine)</td>
</tr>
<tr>
<td>Vermilion/Cote Blanche (Vermilion)</td>
</tr>
<tr>
<td>Timbalier/Terrebonne (Timbalier)</td>
</tr>
<tr>
<td>Barataria (Barataria)</td>
</tr>
<tr>
<td>Pontchartrain/South Pontchartrain</td>
</tr>
<tr>
<td>(Pontchartrain)</td>
</tr>
</tbody>
</table>
### 2.4.1 What did you fish for in the Sabine/Calcasieu/Mermentau basins?

You indicated taking {.2.2/ChoiceTextEntryValue/7/4} trip(s) for the primary purpose of coastal inshore fishing in Louisiana over the last 12 months.

Indicate the number of those trips that were spent primarily targeting the following species in the Sabine/Calcasieu/Mermentau basins. If multiple fish species were primarily targeted during the fishing trip, please indicate the species that was the primary target of the trip for the most amount of time.

<table>
<thead>
<tr>
<th>Number of trips where this fish species was primarily targeted (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Red Drum (2.4.1.1)</strong></td>
</tr>
<tr>
<td><strong>Southern Flounder (2.4.1.2)</strong></td>
</tr>
<tr>
<td><strong>Spotted Seatrout (2.4.1.3)</strong></td>
</tr>
<tr>
<td><strong>Other species (please name the most common) (2.4.1.4)</strong></td>
</tr>
</tbody>
</table>
Display This Question:

*If 2.3 = Vermilion/Cote Blanche [ Basin(s) where inshore fishing occurred ]*

2.4.2

**What did you fish for in the Vermilion/Cote Blanche basins?**

You indicated taking $\{2.2/ChoiceTextEntryValue/7/4\}$ trip(s) for the primary purpose of coastal inshore fishing in Louisiana over the last 12 months.

Indicate the number of those trips that were spent **primarily targeting the following species** in the Vermilion/Cote Blanche basins. If multiple fish species were primarily targeted during the fishing trip, please indicate the species that was the primary target of the trip for the most amount of time.

<table>
<thead>
<tr>
<th>Number of trips where this fish species was primarily targeted (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Drum (2.4.2.1)</td>
</tr>
<tr>
<td>Southern Flounder (2.4.2.2)</td>
</tr>
<tr>
<td>Spotted Seatrout (2.4.2.3)</td>
</tr>
<tr>
<td>Other species (please name the most common) (2.4.2.4)</td>
</tr>
</tbody>
</table>
Display This Question:

If 2.3 = Timbalier/Terrebonne [ Basin(s) where inshore fishing occurred ]

2.4.3 What did you fish for in the Timbalier/Terrebonne basins?

You indicated taking \(2.2/ChoiceTextEntryValue/7/4\) trip(s) for the primary purpose of coastal inshore fishing in Louisiana over the last 12 months.

Indicate the number of those trips that were spent primarily targeting the following species in the Timbalier/Terrebonne basins. If multiple fish species were primarily targeted during the fishing trip, please indicate the species that was the primary target of the trip for the most amount of time.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of trips where this fish species was primarily targeted (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Drum (2.4.3.1)</td>
<td></td>
</tr>
<tr>
<td>Southern Flounder (2.4.3.2)</td>
<td></td>
</tr>
<tr>
<td>Spotted Seatrout (2.4.3.3)</td>
<td></td>
</tr>
<tr>
<td>Other species (please name the most common) (2.4.3.4)</td>
<td></td>
</tr>
</tbody>
</table>
Display This Question:

If 2.3 = Barataria [ Basin(s) where inshore fishing occurred ]

2.4.4 What did you fish for in the Barataria basin?

You indicated taking \{2.2/ChoiceTextEntryValue/7/4\} trip(s) for the primary purpose of coastal inshore fishing in Louisiana over the last 12 months.

Indicate the number of those trips that were spent **primarily targeting the following species** in the Barataria basin. If multiple fish species were primarily targeted during the fishing trip, please indicate the species that was the primary target of the trip for the most amount of time.

<table>
<thead>
<tr>
<th>Number of trips where this fish species was primarily targeted (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Drum (2.4.4.1)</td>
</tr>
<tr>
<td>Southern Flounder (2.4.4.2)</td>
</tr>
<tr>
<td>Spotted Seatrout (2.4.4.3)</td>
</tr>
<tr>
<td>Other species (please name the most common) (2.4.4.4)</td>
</tr>
</tbody>
</table>
2.4.5 What did you fish for in the Pontchartrain/South Pontchartrain basins?

You indicated taking \$2.2/ChoiceTextEntryValue/7/4\$ trip(s) for the primary purpose of coastal inshore fishing in Louisiana over the last 12 months.

Indicate the number of those trips that were spent primarily targeting the following species in the Pontchartrain/South Pontchartrain basins. If multiple fish species were primarily targeted during the fishing trip, please indicate the species that was the primary target of the trip for the most amount of time.

<table>
<thead>
<tr>
<th>Number of trips where this fish species was primarily targeted (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Drum (2.4.5.1)</td>
</tr>
<tr>
<td>Southern Flounder (2.4.5.2)</td>
</tr>
<tr>
<td>Spotted Seatrout (2.4.5.3)</td>
</tr>
<tr>
<td>Other species (please name the most common) (2.4.5.4)</td>
</tr>
</tbody>
</table>
Display This Question:

If How often do you fish in coastal Louisiana? Over the past 12 months, how many trips did you take to coastal Louisiana that included inshore fishing activities and of those trips, how many... Trips taken for the primary purpose of coastal inshore fishing - Trips Is Greater Than or Equal to 1

2.5 Mode of Access

You indicated taking trip(s) for the primary purpose of coastal inshore fishing in Louisiana over the last 12 months.

For each of those trips, indicate the primary mode of access used.

Private or rental boat : _______ (1)
Shore, surf, pier, or marsh by foot : _______ (2)
Guide or charter : _______ (3)
Total : _______

Display This Question:

If How often do you fish in coastal Louisiana? Over the past 12 months, how many trips did you take to coastal Louisiana that included inshore fishing activities and of those trips, how many... All trips including coastal inshore fishing activities - Trips Is Greater Than or Equal to 1

2.6 Overall, how satisfied are you with your coastal inshore fishing experiences in Louisiana?

- Extremely Satisfied (5)
- Very Satisfied (4)
- Satisfied (3)
- Moderately Satisfied (2)
- Not at all Satisfied (1)

End of Block: Section 2: Effort
Start of Block: Section 3: Typical Trip

Display This Question:

If How often do you fish in coastal Louisiana? Over the past 12 months, how many trips did you take to coastal Louisiana that included inshore fishing activities and of those trips, how man... All trips - All trips including coastal inshore fishing activities - Trips Is Greater Than or Equal to 1

In the following section we would like to know more about your coastal inshore fishing trips to understand some of the typical aspects of those trips. Please indicate the averages for each category presented in the following questions.

Section 3: Typical Coastal Inshore Fishing Trips
Display This Question:

If How often do you fish in coastal Louisiana? Over the past 12 months, how many trips did you take to coastal Louisiana that included inshore fishing activities and of those trips, how man... Trips taken for the primary purpose of coastal inshore fishing - Trips Is Greater Than or Equal to 1

3.1 Road Mileage

You indicated taking $\text{ChoiceTextEntryValue7/4}$ trip(s) for the primary purpose of coastal inshore fishing in Louisiana over the last 12 months.

For each of those trips, what is the \textbf{average ONE-WAY road mileage} traveled by vehicle from your residence to fishing access point(s).

- Mileage

Display This Question:

If How often do you fish in coastal Louisiana? Over the past 12 months, how many trips did you take to coastal Louisiana that included inshore fishing activities and of those trips, how man... Trips taken for the primary purpose of coastal inshore fishing - Trips Is Greater Than or Equal to 1
3.2 Hours Fished

You indicated taking $\{2.2/ChoiceTextEntryValue/7/4\}$ trip(s) for the primary purpose of coastal inshore fishing in Louisiana over the last 12 months.

For each of those trips, approximately how many hours do you spend fishing **on average PER-DAY** from arrival to your fishing access point to departure from your fishing access point?

| Hours | 0 | 1 | 3 | 4 | 5 | 6 | 8 | 9 | 10 | 11 | 13 | 14 | 15 | 16 | 18 | 19 | 20 |
|-------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|

Average hours fished per-day ()

*Display This Question:*

*If If How often do you fish in coastal Louisiana? Over the past 12 months, how many trips did you take to coastal Louisiana that included inshore fishing activities and of those trips, how man... Trips taken for the *primary purpose* of coastal inshore fishing - Trips Is Greater Than or Equal to 1*

3.3 Inshore Fishing Expenditures

You indicated taking $\{2.2/ChoiceTextEntryValue/7/4\}$ trip(s) for the primary purpose of coastal inshore fishing in Louisiana over the last 12 months.

Please estimate the **average amount** that you **personally** spent **PER-TRIP** on the following expenditures during those trips.

- Boat Fuel/Oil : _______ (1)
- Boat Rental : _______ (2)
- Hotel/Motel : _______ (3)
- Camping/RV Hookup : _______ (4)
- Restaurants : _______ (5)
- Groceries (food and beverages) : _______ (6)
- Guide/Charter Fees : _______ (7)
- Boat Ramp/Pier Access Fees : _______ (8)
- Ice : _______ (9)
Live Bait (live minnows, live shrimp, etc.): _______  (10)
Dead Bait (cut-bait, frozen shrimp, etc.): _______  (11)
Terminal Tackle (hooks, weights, lures, etc.): _______  (12)
Other trip expenditures not specified above (please list): _______  (13)
Other trip expenditures not specified above (please list): _______  (14)
Other trip expenditures not specified above (please list): _______  (15)
Total: _______

End of Block: Section 3: Typical Trip
Start of Block: Southern Flounder Knowledge

*Topic: Southern Flounder*

*In this section we would like to ask some questions regarding the Southern Flounder fishery in Louisiana. Please answer the following questions to the best of your knowledge.*

4.1 What is your level of interest in catching Southern Flounder in Louisiana?

- Strongly Interested (5)
- Moderately Interested (4)
- Neither Interested nor Uninterested (3)
- Moderately Uninterested (2)
- Strongly Uninterested (1)

4.2 Over the last five (5) years, have you noticed a change in fishing quality for Southern Flounder in Louisiana?

- I don't know (0)
- Yes, it has improved (1)
- No, it seems the same (2)
- Yes, it has grown worse (3)
4.3 Are you familiar with the regulations for Southern Flounder in Louisiana?

- YES (1)
- NO (0)

Display This Question:
If 4.3 = YES

4.4 What is the daily bag limit for Southern Flounder in Louisiana?

- I don't know (0)
- 25 fish (0)
- 15 fish (0)
- 10 fish (1)
- 5 fish (0)
- There is no bag limit for Southern Flounder in Louisiana (0)
Display This Question:

If 4.3 = YES

4.5 What is the minimum size limit for Southern Flounder in Louisiana?

○ I don't know (0)

○ 15” (0)

○ 14” (0)

○ 12” (0)

○ 10” (0)

○ There is no minimum size limit for Southern Flounder in Louisiana (1)

Display This Question:

If 4.3 = YES

4.6 What are the seasonal limitations for Southern Flounder harvest in Louisiana?

○ I don't know (0)

○ No harvest is allowed for all of Nov (0)

○ No harvest is allowed from Nov 1 to Dec 15 (0)

○ Daily bag limit is reduced to 2 fish per day for all of Nov (0)

○ Daily bag limit is reduced to 2 fish per day from Nov 1 to Dec 15 (0)

○ There are no seasonal limitations for Southern Flounder in Louisiana (1)
End of Block: Southern Flounder Knowledge

Start of Block: Status Quo

Section 4 In the following section we have presented a variety of management scenarios for Southern Flounder. We understand that Southern Flounder is not a highly targeted species in Louisiana and that regulations for this species may not affect your fishing plans. However, this section of the survey is directly focused on gaining information about how Southern Flounder regulations will affect the effort of coastal inshore anglers in Louisiana.

Please indicate your expected effort if the following management scenarios were adapted in Louisiana waters for Southern Flounder.

LDWF has no immediate plans to change the regulations for Southern Flounder in Louisiana. This section of the survey is intended to gain information that may help the decision-making process regarding these regulations in Louisiana.
Section 4: Management Preferences

The current regulations for Southern Flounder in Louisiana are listed below. Please review these rules and answer the following questions.

**Current Southern Flounder Regulations in Louisiana**

- **Minimum size limit:** No minimum size limit
- **Daily bag limit:** 10 fish per day
- **Seasonal limitations:** No seasonal limitations

4.7 Please indicate your level of support for current Southern Flounder regulations in Louisiana.

- [ ] Strongly Support (5)
- [ ] Moderately Support (4)
- [ ] Neither Support nor Oppose (3)
- [ ] Moderately Oppose (2)
- [ ] Strongly Oppose (1)
4.7 If the regulations for Southern Flounder in Louisiana remain unchanged, how would this affect your expected effort over the next 12 months for all trips with the primary purpose of inshore fishing?

More specifically, how would this affect the number of those trips taken (if any) in which Southern Flounder is the primarily targeted species?

<table>
<thead>
<tr>
<th>All Louisiana inshore fishing trips (1)</th>
<th>Louisiana inshore fishing trips primarily targeting Southern Flounder (2)</th>
</tr>
</thead>
</table>

Planned trips over the next 12 months (4.7c_1)

End of Block: Status Quo

Start of Block: Southern Flounder Assessment
Preliminary analysis of Southern Flounder abundance data has indicated a **decline in the Louisiana Southern Flounder population**.

Data collected directly from anglers through the LDWF Louisiana Recreational Creel Survey (LA Creel) estimated that **recreational landings of Southern Flounder have significantly dropped** over the past two years. In 2017 the recreational landings estimate dropped by over 50% from the previous year's estimate and in 2018 this estimate dropped by over 30% from the previous year's estimate (indicated by the graph above).

Independent surveys conducted by LDWF have also shown a **significant drop in Southern Flounder abundance** that follows the decline revealed in recreational landings estimates.

While there has been a noticeable decline in Southern Flounder abundance, the exact **cause of this decline is still uncertain**. Further evaluation is necessary to determine the reason for this decline.
Southern Flounder Management Scenario

(REMINDER) Current Southern Flounder Regulations in Louisiana

Minimum size limit: No minimum size limit
Daily bag limit: 10 fish per day
Seasonal limitations: No seasonal limitations

Please review the management scenario listed below and answer the following questions.

Proposed Southern Flounder Management Scenario
Minimum size limit: 12"
Daily bag limit: 10 fish per day
Seasonal limitations: No seasonal limitations

4.8 Please indicate your level of support for the proposed management scenario presented above.

- Strongly Support (5)
- Moderately Support (4)
- Neither Support nor Oppose (3)
- Moderately Oppose (2)
- Strongly Oppose (1)
4.8 If the management scenario listed above was adapted in Louisiana, how would this affect your expected effort over the next 12 months for all trips with the primary purpose of inshore fishing?

More specifically, how would this affect the number of those trips taken (if any) in which Southern Flounder is the primarily targeted species?

<table>
<thead>
<tr>
<th>All Louisiana inshore fishing trips (1)</th>
<th>Louisiana inshore fishing trips primarily targeting Southern Flounder (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned trips over the next 12 months (1)</td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Section 4: Management Preferences 1

Start of Block: Section 4: Management Preferences 2

Southern Flounder Management Scenario

(REMINDER) Current Southern Flounder Regulations in Louisiana

Minimum size limit: No minimum size limit
Daily bag limit: 10 fish per day
Seasonal limitations: No seasonal limitations

Please review the management scenario listed below and answer the following questions.

Proposed Southern Flounder Management Scenario

Minimum size limit: No minimum size limit
Daily bag limit: 10 fish per day
Seasonal limitations: Bag limit is reduced to 2 fish per day in Nov
4.9 Please indicate your level of support for the proposed management scenario presented above.

- Strongly Support (5)
- Moderately Support (4)
- Neither Support nor Oppose (3)
- Moderately Oppose (2)
- Strongly Oppose (1)

4.9 If the management scenario listed above was adapted in Louisiana, how would this affect your expected effort over the next 12 months for all trips with the primary purpose of inshore fishing?

More specifically, how would this affect the number of those trips taken (if any) in which Southern Flounder is the primarily targeted species?

<table>
<thead>
<tr>
<th>All Louisiana inshore fishing trips (1)</th>
<th>Louisiana inshore fishing trips primarily targeting Southern Flounder (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned trips over the next 12 months (1)</td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Section 4: Management Preferences 2
Southern Flounder Management Scenario

(REMINDER) Current Southern Flounder Regulations in Louisiana

**Minimum size limit:** No minimum size limit  
**Daily bag limit:** 10 fish per day  
**Seasonal limitations:** No seasonal limitations

*Please review the management scenario listed below and answer the following questions.*

**Proposed Southern Flounder Management Scenario**  
Minimum size limit: No minimum size limit

**Daily bag limit:** 5 fish per day  
**Seasonal limitations:** No seasonal limitations

4.10 Please indicate your level of support for the proposed management scenario presented above.

- [ ] Strongly Support (5)
- [ ] Moderately Support (4)
- [ ] Neither Support nor Oppose (3)
- [ ] Moderately Oppose (2)
- [ ] Strongly Oppose (1)
4.10 If the management scenario listed above was adapted in Louisiana, how would this affect your expected effort over the next 12 months for all trips with the primary purpose of inshore fishing?

More specifically, how would this affect the number of those trips taken (if any) in which Southern Flounder is the primarily targeted species?

<table>
<thead>
<tr>
<th>All Louisiana inshore fishing trips (1)</th>
<th>Louisiana inshore fishing trips primarily targeting Southern Flounder (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned trips over the next 12 months (1)</td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Section 4: Management Preferences 3

Start of Block: Section 4: Management Preferences 4

Southern Flounder Management Scenario

(REMINDER) Current Southern Flounder Regulations in Louisiana

Minimum size limit: No minimum size limit
Daily bag limit: 10 fish per day
Seasonal limitations: No seasonal limitations

Please review the management scenario listed below and answer the following questions.

Proposed Southern Flounder Management Scenario

Minimum size limit: 14”
Daily bag limit: 5 fish per day
Seasonal limitations: Bag limit is reduced to 2 fish per day from Nov 1 to Dec 15
4.11 Please indicate your level of support for the proposed management scenario presented above.

- Strongly Support (5)
- Moderately Support (4)
- Neither Support nor Oppose (3)
- Moderately Oppose (2)
- Strongly Oppose (1)

4.11 If the management scenario listed above was adapted in Louisiana, how would this affect your expected effort over the next 12 months for all trips with the primary purpose of inshore fishing?

More specifically, how would this affect the number of those trips taken (if any) in which Southern Flounder is the primarily targeted species?

<table>
<thead>
<tr>
<th>All Louisiana inshore fishing trips (1)</th>
<th>Louisiana inshore fishing trips primarily targeting Southern Flounder (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned trips over the next 12 months (1)</td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Section 4: Management Preferences 4
Southern Flounder Management Scenario

(REMINDER) Current Southern Flounder Regulations in Louisiana

Minimum size limit: No minimum size limit
Daily bag limit: 10 fish per day
Seasonal limitations: No seasonal limitations

Please review the management scenario listed below and answer the following questions.

Proposed Southern Flounder Management Scenario

Minimum size limit: 14"
Daily bag limit: 5 fish per day
Seasonal limitations: No harvest permitted in Nov

4.12 Please indicate your level of support for the proposed management scenario presented above.

- [ ] Strongly Support (5)
- [ ] Moderately Support (4)
- [ ] Neither Support nor Oppose (3)
- [ ] Moderately Oppose (2)
- [ ] Strongly Oppose (1)
4.12 If the management scenario listed above was adapted in Louisiana, how would this affect your expected effort over the next 12 months for all trips with the primary purpose of inshore fishing?

More specifically, how would this affect the number of those trips taken (if any) in which Southern Flounder is the primarily targeted species?

<table>
<thead>
<tr>
<th>All Louisiana inshore fishing trips (1)</th>
<th>Louisiana inshore fishing trips primarily targeting Southern Flounder (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned trips <strong>over the next 12 months</strong> (1)</td>
<td></td>
</tr>
</tbody>
</table>

**End of Block: Section 4: Management Preferences 5**

**Start of Block: Section 4: Management Preferences 6**

Southern Flounder Management Scenario

(REMINDER) Current Southern Flounder Regulations in Louisiana

**Minimum size limit:** No minimum size  
**Daily bag limit:** 10 fish per day  
**Seasonal limitations:** No seasonal limitations  

*Please review the management scenario listed below and answer the following questions.*

Proposed Southern Flounder Management Scenario

**Minimum size limit:** No minimum size  
**Daily bag limit:** 15 fish per day  
**Seasonal limitations:** No seasonal limitations
4.13 Please indicate your level of support for the proposed management scenario presented above.

- Strongly Support (5)
- Moderately Support (4)
- Neither Support nor Oppose (3)
- Moderately Oppose (2)
- Strongly Oppose (1)

4.13 If the management scenario listed above was adapted in Louisiana, how would this affect your expected effort over the next 12 months for all trips with the primary purpose of inshore fishing?

More specifically, how would this affect the number of those trips taken (if any) in which Southern Flounder is the primarily targeted species?

<table>
<thead>
<tr>
<th>All Louisiana inshore fishing trips (1)</th>
<th>Louisiana inshore fishing trips primarily targeting Southern Flounder (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned trips over the next 12 months (1)</td>
<td></td>
</tr>
</tbody>
</table>

End of Block: Section 4: Management Preferences 6
Start of Block: Section 5: Demographics

In the following section we would like to ask a few optional questions to better understand Louisiana anglers. Please answer the following questions about yourself to the best of your ability.

Section 5: Personal Information (all questions optional)

5.1 What is your gender?

- Male (1)
- Female (2)
- Prefer not to answer (0)

5.2 What race or ethnicity best describes you?

- White (1)
- Hispanic, Latino or Spanish (2)
- Black or African American (3)
- Asian (4)
- Native Hawaiian or Pacific Islander (5)
- Middle Eastern or Northern African (6)
- American Indian or Alaska Native (7)
- Other, not listed (8)
- Prefer not to answer (0)
5.3 Which employment status best describes you?

- Full-time (1)
- Part-time (2)
- Retired (3)
- Student (4)
- Homemaker (5)
- Unemployed (6)
- Prefer not to answer (0)

5.4 What level of education best describes the highest level that you have completed?

- Some grade school (1)
- Some high school (2)
- Completed high school or equivalent (3)
- Some college or community college or technical program (4)
- Bachelor's degree (college graduate) (5)
- Advanced degree (6)
- Prefer not to answer (0)
5.5 What is your age?
________________________________________________________________

5.6 What is your home ZIP Code?
________________________________________________________________

5.7 What is your approximate annual **individual** income, from all sources, before taxes?

- Under $20,000  (1)
- $20,000 to $39,999  (2)
- $40,000 to $59,999  (3)
- $60,000 to $79,999  (4)
- $80,000 to $99,999  (5)
- $100,000 to $149,999  (6)
- $150,000 to $199,999  (7)
- $200,000 or above  (8)
- Prefer not to answer  (0)

**End of Block: Section 5: Demographics**
References


Louisiana Department of Wildlife and Fisheries. (2018). Results of an online survey of Louisiana residents with recreational saltwater fishing privileges. Louisiana Department of Wildlife and Fisheries, Marine Fisheries Division, Office of Fisheries.


Vita

David R. Smith was born in Sacramento, California in 1992. He earned his Bachelor of Science in Fisheries with an emphasis in Aquatic Resource Management from Auburn University in the spring of 2014. After receiving his undergraduate degree, he pursued various fisheries management positions throughout the country working with a variety of state and federal agencies. From 2014 to 2016, he worked as a North Pacific Groundfish Observer for the National Marine Fisheries Service, living continuously aboard commercial fishing vessels operating in the Bering Sea to obtain catch data that detailed the volume and composition of commercial landings. In 2017, he worked as a Biological Science Technician for the U.S. Fish and Wildlife Service, gathering escapement data on Chinook Salmon while working from a remote field camp deep in the heart of the Kenai National Wildlife Refuge in Alaska. In 2018, he worked as a Biological Science Technician for the U.S. Geological Survey, gathering passive integrated transponder tag data to describe the abundance and migration of endangered Lost River and Shortnose Sucker populations in southern Oregon and northern California. In the fall of 2018, he joined the Transboundary Aquatic and Coastal Ecology lab at Louisiana State University and began working to characterize the commercial and recreational Southern Flounder fishery in Louisiana. He plans to earn his Master of Science in Oceanography and Coastal Sciences from Louisiana State University in December 2020.