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Characterizing Louisiana's Freshwater Commercial Fisheries

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CHARACTERIZING LOUISIANA'S FRESHWATER COMMERCIAL FISHERIES

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This thesis would not have been possible without the support, friendship, and help of my lab mates, Lauren Carter and Nick Haddad. I would like to thank fellow graduate students and friends Kathryn Parraga Estrada and Erin Thayer for helping with field work. I would also like to thank Tyler Martin for his unbelievable patience, support, and positivity throughout this study. Lastly, I would like to thank my family for their unending love and support and for encouraging me to follow my path.

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ABSTRACT

As an important contributor to Louisiana's economy, the commercial freshwater fisheries have been the subject of growing attention in recent years by resource managers. Compared to the marine sector, little is known about these fisheries. Anecdotally, the fisheries appear to be on the brink of collapse. Fewer young fishermen are entering the field, fish buyers and processors are closing, and market prices remain stagnant. Because of this, the fisheries lack the resources needed to perpetuate the success and sustainability for future generations. To better understand this industry, I conducted a two-part study to characterize the commercial freshwater fisheries in Louisiana. First, I used spatial analysis to understand trends of historical landings data and fishing effort from the years 2000-2016. I mapped freshwater commercial fish landings and locations of fish houses and processors across the 12 river basins in Louisiana. Secondly, I completed in-person surveys to collect data about the fishermen, including target species, gear type, and number of trips. I also assessed their opinions and attitudes about the effect of ecological factors, commercial regulations, and human interference on their fishing success, as well as their interest in learning new techniques to improve the quality of their product. Results showed that the Atchafalaya River Basin is the preferred river basin for freshwater commercial fishermen. For 17 consecutive years, the largest number of pounds of both finfish and wild crawfish were landed within the Atchafalaya River Basin. Additionally, the majority of freshwater fish dealer license holders were located in central and southeastern Louisiana, close to the Atchafalaya River Basin region. Survey results suggested that the closing of fish houses has created a bottleneck effect for fishermen who are looking for places to sell their catch. This increases competition between fishermen, floods the market, and costs the fishermen time and money. Additionally, results showed there is an overpopulation of Asian carp

(Hypophthalmichthys spp.) and alligators (*Alligator mississippiensis*), which can hinder the number of landings brought in. Catfish (*Ictaluridae* spp.) and buffalo (*Ictobius* spp.) appear to be the most sought-after finfish; however, this slightly differs by region. Overall, this thesis provides in-depth insight into the current trends, problems, and successes of Louisiana's freshwater commercial fisheries. The results herein may inform future workshops, educational material, and policy actions aimed to improve the livelihood of the fishermen and success of the fisheries.

CHAPTER 1. GENERAL INTRODUCTION

1.1. Freshwater Fisheries

Globally, inland fisheries are one of the most important natural resources. In 2017, inland capture fisheries produced approximately 11.9 million tons of fish worldwide (FAO Fish Statj., 2017). They provide a fundamental source of commerce, employment, nutrition and recreation (FAO, 2016). In developing countries, inland fisheries are the main source of food security (Youn et al., 2014) and are economically important. In developed nations where food security is less of an issue, such as the United States (U.S.), inland fisheries have shifted more towards the recreational sector, although niche commercial fisheries still exist (Beard et al., 2011). Regardless of their national prevalence, the status of inland commercial fisheries is largely unknown across the globe (Beard at al., 2011). This is likely due in part to their spatial dispersion – many landings over several thousand lakes and rivers creates difficulty in collecting regular data. In addition, inland commercial and subsistence fisheries are often perceived as having a low economic value, especially when looking at it from a per-lake or -river point of view (Beard et al., 2011).

Inland fisheries are influenced by distinctly different drivers than in marine fisheries. For instance, there are a rarely large commercial fleets of inland fishing vessels, lending itself more to small-scale fishing operations. Most of the catch landed in inland fisheries around the globe are part of subsistence fisheries, where it is consumed locally rather than exported. Additionally, as inland fisheries are more spatially fragmented, they are diverse in their ecosystems, responding differently to natural and human-based disruptions (Welcomme et al., 2010). From an ecosystem services perspective, there are several uses for the water inhabited by inland fish,

increasing competition between sectors such as fisheries, agriculture, industry, and transportation (Welcomme et al., 2010; Beard et al., 2011).

Though data is generally lacking for inland fisheries, studies have shown that with increasing industrialization, there is a shift in inland fisheries from commercial to recreational use (Cowx et al., 2010). An estimated 10 percent of the global population in industrialized countries participate in recreational fishing (Arlinghaus & Cooke, 2009), and this shift is becoming apparent in transitional nations as well (Ditton, 2008).

Inland commercial fisheries in the Mississippi River date back to the mid-1800s. Though inconsistent over the years, there are statistical data describing landings of freshwater fish species for commercial use as early as 1894. Common species caught in the upper Mississippi River were catfish (Ictaluridae), buffalofish (Ictobius), freshwater drum (*Aplodinotus grunniens)*, sturgeon (Acipenseridae), paddlefish (Polyodontidae), and common carp (*Cyprinus carpio*) (Carlander, 1954) (Fig.1.1.). In the late 1800s and early 1900s, commercial fishing in the Mississippi River was a lucrative endeavor. There was a higher demand for local inland fish species likely because of the lack of access to ice to keep fish fresh for transport. Practicing commercial fishermen during that time entered the industry because there was a good return on investment. Becoming a fisherman was a low-cost venture, there was no bureaucracy, and the fishing operations were small (Carlander, 1954).

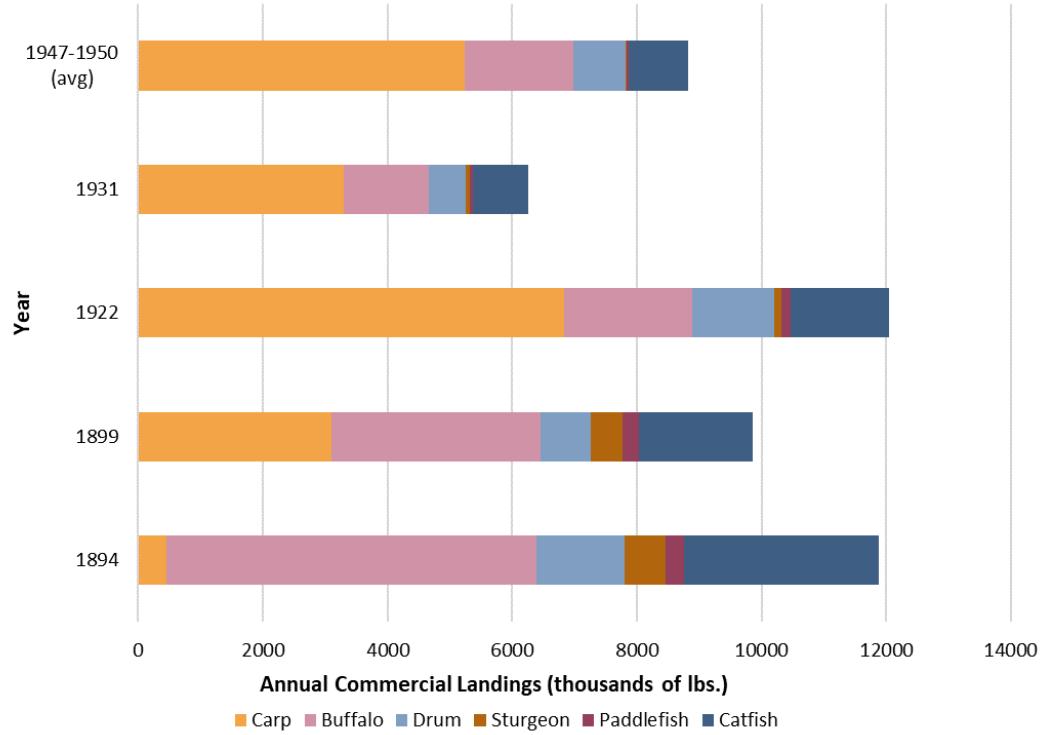

Fig. 1.1. Annual commercial landings in thousands of lbs. of carp, buffalo, drum, sturgeon, paddlefish, and catfish in the upper Mississippi River for certain years between 1894 and 1950. Source: Carlander, 1954.

In the early 1900s, the change started from participation in inland commercial fishing to sport fishing. Since then, commercial fishing has been in direct competition with the sportfishing sector, leading to the historic creation of rules that have deliberately hurt the success of the commercial industry (Cooke & Murchie, 2015). Even in 1946, a rule from the Florida Game and Fresh Water Fish Commission prohibited the sale of any freshwater game fish and prevented the use of many common types of commercial fishing gear in favor of the recreational fishery (Dequine, 1950). This change was in part instigated by the invention and subsequent accessibility of refrigeration. It was easier to ship marine-caught fish across the country, giving consumers more options for their seafood (Carlander, 1954). Further, the fragmentation of freshwater landing ports was a disadvantage to the sector. Small amounts of fish were landed throughout the Mississippi River rather than all of the catch coming in through one or two ports,

like the marine sector. This prevented the inland fishermen from being able to provide adequate quantities of fish to restaurants, retailers or wholesalers. During this time there was also a shift of consumer preferences from fish to beef, pork, and poultry, creating a decline for commercial fish in general (Cooke and Murchie, 2015).

The Great Lakes region and the Mississippi River are the largest commercial fishing areas within the U.S., but these fisheries are quickly dwindling. As the U.S. continues to increase the importation of seafood, local freshwater fish are becoming less relevant. Imported seafood is often less expensive and easier to get as they are frequently sold at larger grocery chains. Local seafood usually requires a trip to a local retail store and may have higher prices. Additionally, many wild-caught commercial fish are now competing with the aquaculture industry. Preference for aquacultured fish is increasing as they are reared in a controlled environment and can be produced in bulk (Bjørndal and Guillen, 2016).

1.2. Louisiana Inland Commercial Fisheries

Anecdotally, Louisiana inland commercial fisheries began to decline in the early to mid-1900s, but historic data of freshwater fish value do not reflect that sentiment. According to inland commercial fisheries values data (NMFS, 2018), the price-per-pound for the top three consistently commercially valuable finfish groups for Louisiana (buffalo, catfishes, and gar) steadily increased from 1950 until about 1965 (Fig. 1.2.). After 1965, the price-per-pound began to decline intermittently until a sharp decrease around 1990. There are many plausible explanations for this decline, one being under exploitation of inland fishes, which may relate back to the increase of sport fishing and decrease in commercial fishing. In the 1970's, awareness of pollution and anthropogenic impacts on the environment began to increase, and the United States passed policies such as the Clean Water Act (EPA, 2019) that limited the amount

of pollutants that can enter waterways. As scientific studies followed this policy, consumers became aware of the threat of PCBs, chlordane, DDT, and dieldrin that were bioaccumulating in the tissues of common commercial species of the Mississippi River (e.g. channel catfish), and consumption advisories were put in place (Rostad et al., 1994). This likely impacted their decision to purchase and eat freshwater fish (Lauber et al., 2017).

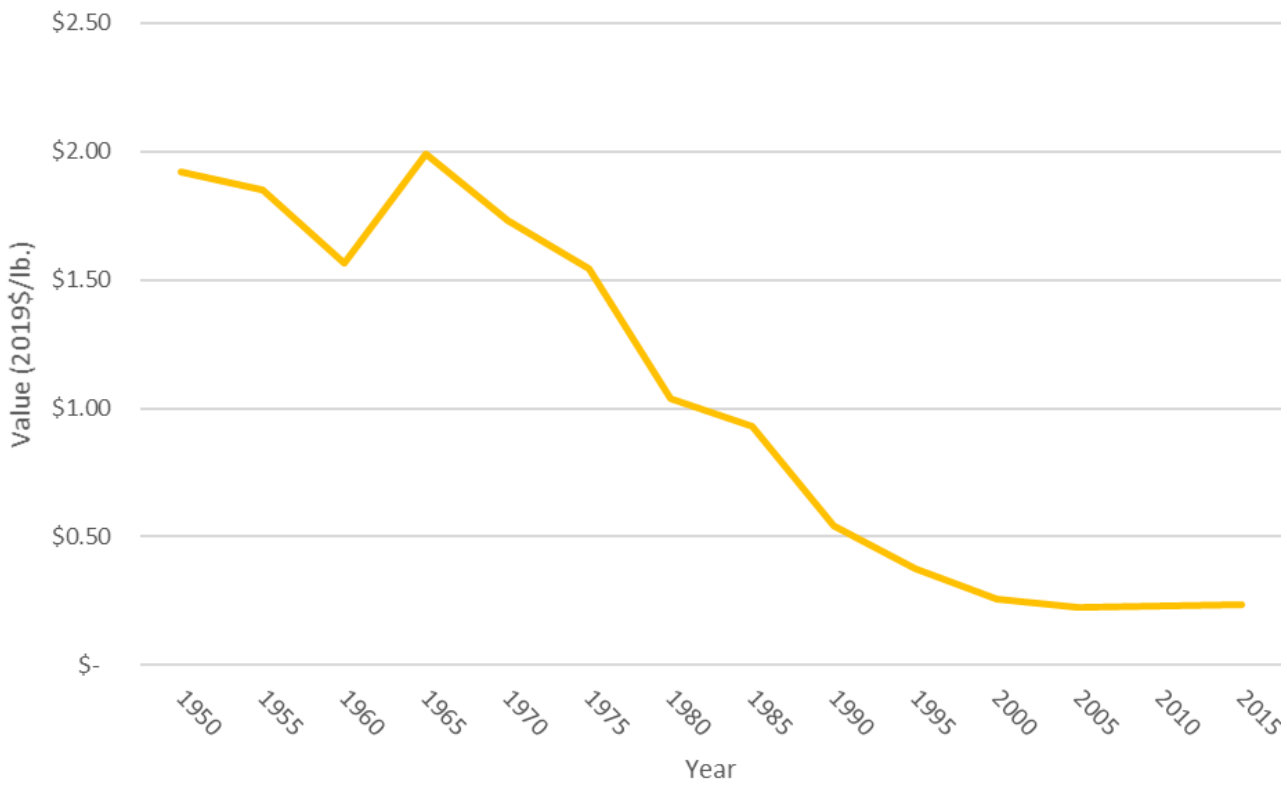

Fig. 1.2. Average price per lb. over time for freshwater commercial fish in Louisiana – adjusted to 2019 dollars for inflation. Source: National Marine Fisheries Service Annual Landings Tool, 2018.

Currently, Louisiana has some of the most robust marine and inland commercial fisheries in the U.S. Both sectors are economically valuable, with inland commercial fisheries valued at over $17 million dollars in 2016. Despite this, fisheries interests in Louisiana have overwhelmingly resided in the marine industry. With the relative lack of focus on inland fisheries, the industry has remained stagnant with little to no overall change in landings and a sharp decrease in value (LDWF, 2017; NMFS, 2018). Consequently, as fishermen approach retirement age, there are few younger fishermen entering the field likely due to the expensive startup and maintenance costs (Cooke & Murchie, 2015).

Most of the known data about this fishery come from a 2011 survey conducted by the Louisiana Department of Wildlife and Fisheries (LDWF). The survey attempted to understand basic information about the fishery and fishermen. In total, there were about 592 licensed inland commercial fishermen who reported landings in 2011. This is less than the total number of freshwater commercial fishing licenses purchased in 2011, however many license holders do not actually land commercial catch. Geographically, approximately 25% of the fishermen resided in central coastal Louisiana, primarily Iberia, St. Mary, Terrebonne, and Vermilion parishes while 42% resided in southeastern Louisiana. About 17% lived in the upper Atchafalaya River Basin (ARB), while only 10% were from northern Louisiana. Finally, approximately 4% of inland commercial fishermen lived in southwestern Louisiana. Similarly, the Atchafalaya River was the most fished water body reported in the survey. Most landings occurred in the ARB, which is central to the highest populated areas of commercial fishermen residences (LDWF Office of Fisheries, 2013). On average, in 2011, inland commercial fishermen took 106 fishing trips over the course of the year. Hoop nets and trot lines were the primary gear types used for finfish, with an average of 25 hoop nets set per trip and 85 trot lines set per trip. Crawfish traps were the

primary gear used for crawfishing, with an average of 362 traps per trip (LDWF Office of Fisheries, 2013).

Within this survey, the average age of freshwater commercial fishermen was 50.7 yrs. of age, ranging from 18 yrs. to 79 yrs., suggesting that this is an aging industry (LDWF Office of Fisheries, 2013). Despite this, in 2011 the inland commercial fishery brought in approximately $16.1 million for 22.5 million pounds of landings, proving its relevance in the Louisiana economy (Louisiana State University Agricultural Center, 2012).

1.2.1. Fisheries Data Collection

Currently, there is only one program set to collect fishery-dependent data on the inland commercial fisheries in Louisiana. The Trip Ticket Program, managed by LDWF, began in the year 1999. The Trip Ticket Program compiles data for each fishing trip taken where freshwater fish were landed and sold commercially. Initially, the trip ticket program included only freshwater fish species, but beginning on August 1, 2016, frog and turtle landings were reported on trip tickets as well (LDWF Pers. Comm., 2019). As landings are sold to wholesale or retail seafood dealers, the dealers must collect specific information about the fisherman and their trip, including area fished, gear used, type of species landed, and number of landings on an LDWF designed data sheet (LDWF, 2015). Subsequently, the seafood dealers then input the monetary value for which the landings were sold. Monthly, the dealers will send these data back to LDWF who keep a database of trip data. The public has access to Trip Ticket data upon request. At present, there are no consistent measures in Louisiana to collect fishery-independent data for important freshwater commercial species.

1.2.2. Focus Species

According to 17 years of Trip Ticket Data (1999-2016), the most economically important freshwater species in Louisiana is wild crawfish (*Procambarus clarkii* and *Procambarus zonangulus*). In 2016, crawfish landings alone accounted for $12.6 million of the freshwater landings, which is about 70% of the total value for freshwater landings for that year. This trend remains consistent throughout the 17 years.

Catfishes (Ictaluridae) are a significant group for the inland commercial fishery as well. As the only species group with reported landings across all basins in most years, catfishes made up about 16% of the total value of the fishery in 2016. However, recent regulation changes in the catfish processing industry may threaten the prevalence of catfish entering the commercial industry. According to a new federal rule, any business that engages in the processing of any fish under the order "Siluriformes" (catfishes) must now be inspected by the Food and Safety Inspection Service (FSIS), a branch under the U.S. Department of Agriculture (Mandatory Inspection of Fish Rule, 2015). Under the new regulation, catfish processors are only able to process catfish during normal weekday hours when an inspector is available. No processing is allowed on weekends or holidays unless processors pay an inspection agent to be present. Further, catfish may not be processed on the same surface as any other species, which had been a common practice in multi-species fish houses. Subsequently, the switch to new inspection standards often leads to a need for facility upgrades, a costly endeavor that has resulted in the closure of some catfish processing facilities. As catfish are one of the most landed species groups in Louisiana, these regulations have severely hurt the processing capabilities of fish houses and have prevented commercial fishermen from landing larger amounts of catfish.

The rest of the fishery is split up among garfishes, carp, and shad, along with bowfin and buffalo. Together, these species comprised about 14% of the value of commercial landings in 2016**.** Amphibians and reptiles such as frogs, turtles, and alligators are considered freshwater fisheries in Louisiana as well, however they were only required on trip tickets beginning August 1, 2016.

1.3. Fishery Dependent Surveys

Whereas the fishery includes the fish, the habitat, and the stakeholders, fisheries management is more about managing the users of the resource, as they affect all components of the fishery (McMullin and Pert, 2010; Hunt and Grado, 2010; Fulton et al., 2011). In addition to having an in-depth understanding of catch and effort, life history traits, and fish population trends, managers must understand the attitudes and behaviors of the fishermen who participate in the fishery, whether recreationally or commercially. Surveys, interviews, and questionnaires are common tools used to collect fishery-dependent and human dimensions data within a specific industry. While commercial fishing surveys are minimal and do not often make it into peer-reviewed literature, the sportfishing sector commonly uses these tools for data collection. Creel-intercept surveys are the most widely used tools for estimating angler effort and catch for recreational fisheries (Ditton & Hunt, 2001), while mail-in or telephone surveys are more for assessing angler attitudes, characteristics, and opinions. Although these two types of surveys are often separated, it is possible to include angler attitudes, beliefs, and opinions within a creel survey if it meets the objectives of the survey (Pollock et al., 1994).

Survey nonresponse has been increasing both internationally and within the United States. This is likely due to refusal to respond. The increase in refusals is often attributed to the phenomenon called “survey fatigue” – an overexposure to the survey process (Porter et al.,

2004). Survey length is also a factor in survey fatigue – longer surveys are less frequently completed. Because of this, collecting human dimensions data is becoming more difficult as it increases in importance.

In-person surveys often yield greater response rates, likely due to the interpersonal connection between interviewer and respondent (Ditton & Hunt, 2001). However, lengthening the creel-survey can result in frustration or survey-fatigue with the respondents, so it is necessary to keep the surveys as succinct as possible while still collecting the desired information. Mixed-mode surveying, usually a combination of telephone, email, or mail-in surveys, are another approach when trying to increase response rates (Wallen et al., 2016).

In-person intercept interviews in the inland commercial fishing sector could provide some important insight into the fishery. Demographics, target species vs. landed species, and fishing locations are some examples of simple data that is lacking for the Louisiana inland commercial fisheries. As is seen with the sportfishing sector, surveys are used continually to assess the status of the industry as well as the attitudes of the anglers. These data are then taken into consideration by fisheries managers when making regulatory decisions about the fishery.

1.4. Significance of research

There are very few peer-reviewed publications assessing freshwater commercial fisheries anywhere in the U.S. (Cooke & Murchie, 2015). Without basic ecological, economic, and social data describing the fisheries, there are likely opportunities for growth that have not been identified.

With a decreasing commercial value and a lack of newcomers, the Louisiana inland commercial fisheries are threatened with a severe decline in productivity. Secondary to the sportfishing sector, this fishery has been overshadowed and a lesser management priority.

Though not as directly lucrative as the marine commercial fisheries in Louisiana, the inland fisheries still contribute millions of dollars per year to the local economy and provides employment for many, including fishermen, fish buyers, and fish processors. Understanding the status of these fisheries may lead to management actions and educational opportunities to promote progress.

1.5. Goals and Objectives

Characterizing the inland commercial fisheries in Louisiana is the first step to increasing its relevance within Louisiana's seafood economy. Therefore, the overarching goal for this research was to identify opportunities for fishermen in terms of economic growth, management, and access to ensure the survival of the industry. Specifically, I completed two objectives to address these goals.

1.5.1 Objective 1.

I mapped and analyzed historic freshwater commercial fisheries data to visualize trends or changes across basins through time. I focused the maps on each species group, including all commercially landed finfish, crawfish, and reptiles and amphibians as data were available. The maps are delimited by river basin (Fig. 1.3.). River basins provide a larger geographic area to discuss sensitive data, such as economics and demographics, without revealing private information of the fishermen. When delimited by parish, sometimes there were fewer than three fishermen in that area. In this case, their data would be confidential to protect the privacy of these fishermen. When using larger areas, such as river basins, this issue is mostly avoided.

The maps contain data such as freshwater dealer locations, freshwater landings (lbs.) in total per basin, freshwater landings by species per basin, value (in dollars) of landings per basin, number of trips per basin, and gear types used per basin. I used density analysis to produce

choropleth maps and time-series that help visualize the various fishing activities in each basin over time. The maps serve as a visual representation of the industry and will provide a bird's eye perspective to help resource managers understand the flow of activity across the state.

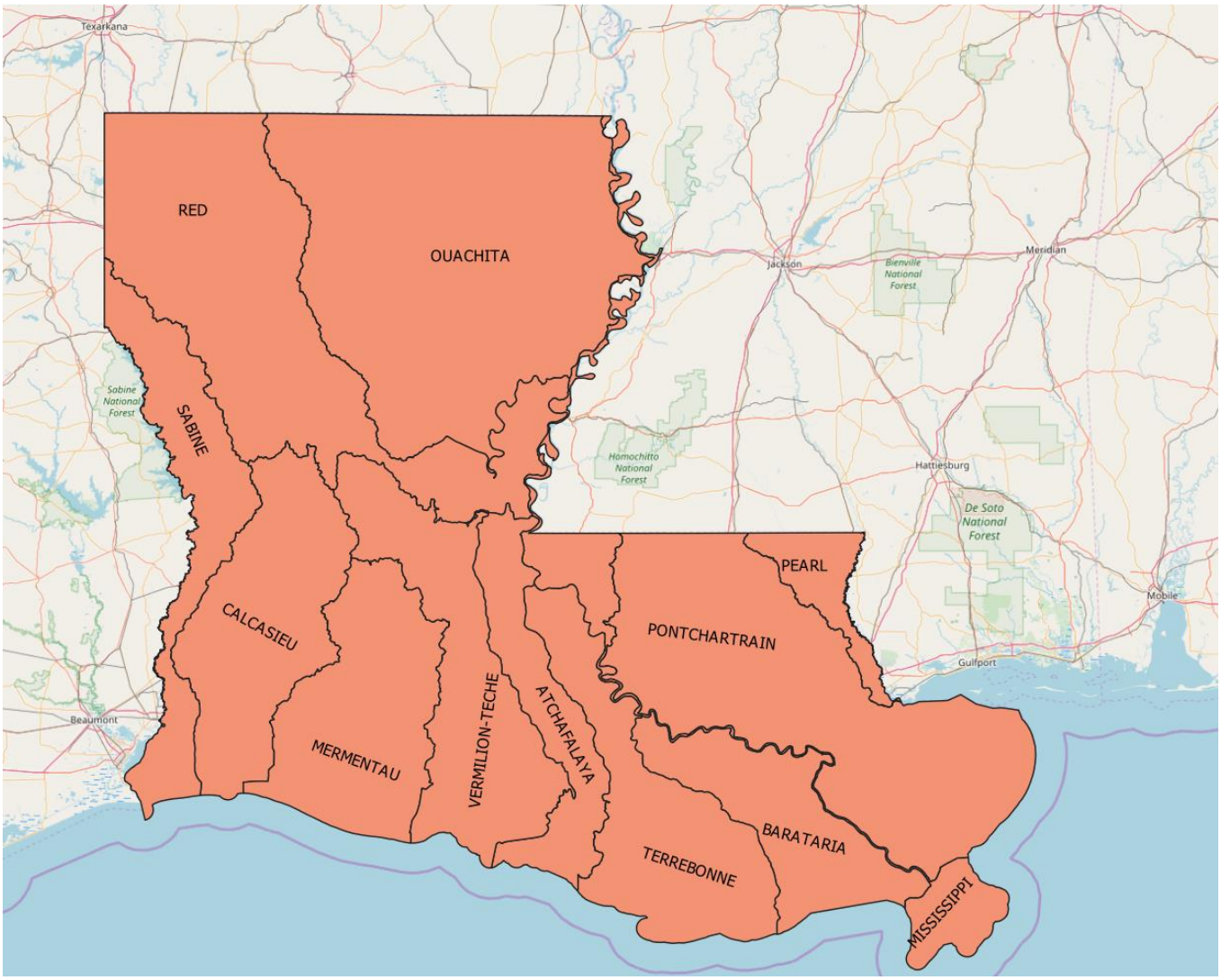

Fig. 1.3. A map of Louisiana's 12 river basins. Source: Louisiana Department of Environmental Quality.

1.5.2. Objective 2.

I conducted informal conversations with LDWF and fish buyers and processors to obtain a better understanding of the freshwater commercial fishing industry in different locations around the state. Following these conversations, I presented a formal survey to practicing freshwater commercial fishermen to assess their current attitudes, beliefs, and ideas about the status quo of the industry and potential improvements.

The survey was organized into six constructs (Johnson & Morgan, 2016) including a mix of open-ended and close-ended survey items (Dillman et al., 2009). Most of the survey included general open answer questions about the respondents' fishing activity – fishing area, target species, and number of trips per year. The survey also included items addressing the respondents' attitudes about ecological, commercial, and anthropogenic factors affecting the fisheries. The survey included basic demographic items as well. I aimed to primarily survey commercial fishermen who target finfish, however I did include crawfish harvesters when able. I kept the survey concise, about 15 minutes long, while allowing extra time for the respondent to relay any additional thoughts, opinions, or concerns they wanted to express.

CHAPTER 2. STATEWIDE ANALYSIS OF FRESHWATER COMMERCIAL FISHERIES LANDINGS, 1999-2016

2.1. Introduction

Inland commercial fisheries in the Mississippi River date back to the mid-1800s. Though inconsistent over the years, there are statistical data describing landings of freshwater fish species for commercial use as early as 1894. Common species caught in the upper Mississippi River were catfish, buffalofish, freshwater drum, sturgeon, paddlefish, and common carp (Fig. 2.1.) (Carlander, 1954). In the late 1800s and early 1900s, commercial fishing in the Mississippi river was a lucrative endeavor. There was a higher demand for local inland fish species likely because of the lack of access to ice to keep fish fresh for transport. Practicing commercial fishermen during that time entered the industry because there was a good return on investment. Becoming a fisherman was a low-cost venture, there was no bureaucracy, and the fishing operations were small (Carlander, 1954).

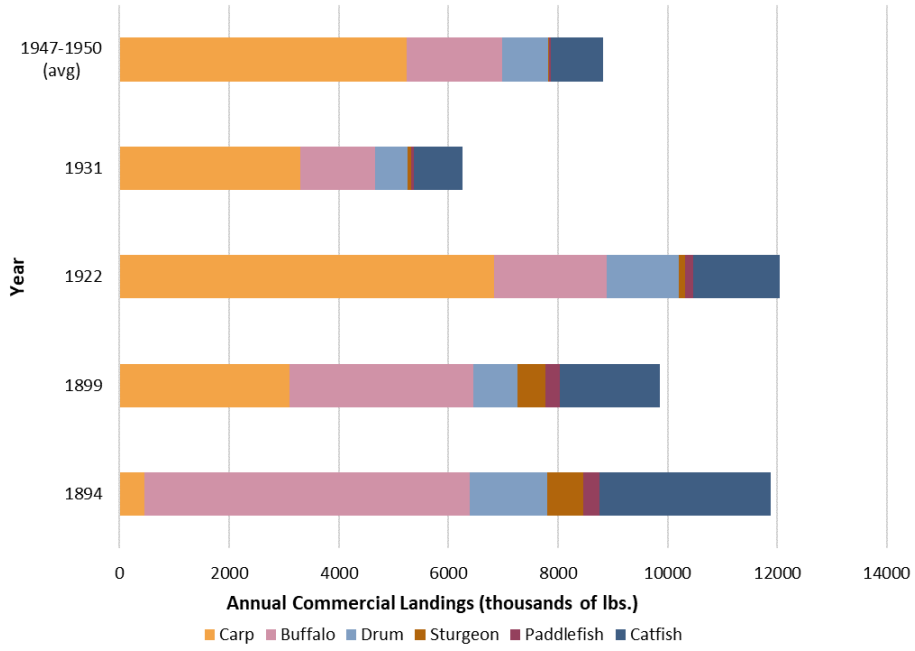

Fig. 2.1. Annual commercial landings in thousands of lbs. of carp, buffalo, drum, sturgeon, paddlefish, and catfish in the upper Mississippi River for certain years between 1894 and 1950. Source: Carlander, 1954.

In the early 1900s, the change started from participation in inland commercial fishing to sport fishing. This change was instigated by the invention and subsequent accessibility of refrigeration. It was easier to ship marine-caught fish across the country, giving consumers more options for their seafood (Carlander, 1954). Further, the fragmentation of freshwater landing ports was a disadvantage to the sector. Small quantities of fish were landed throughout the Mississippi River rather than all of the catch coming in through one or two ports, like the marine sector. This prevented the inland fishermen from being able to provide adequate amounts of fish to restaurants, retailers or wholesalers. During this time there was also a shift of consumer preferences from fish to beef, pork, and poultry, creating a decline for commercial fish in general (Cooke and Murchie, 2015).

Anecdotally inland commercial fisheries began to decline in the early to mid-1900s, but historic data of freshwater fish value do not reflect that sentiment. According to inland commercial fisheries values data (NMFS, 2018), the price-per-pound for the top three consistently commercially valuable finfish groups for Louisiana (buffalo, catfishes, and gar) steadily increased from 1950 until about 1965 (Fig. 2.2.). After 1965, the price-per-pound began to decline intermittently until a sharp decrease around 1990. There are many plausible explanations for this decline, one being under exploitation of inland fishes, which may relate back to the increase of sport fishing and decrease in commercial fishing. In the 1970's, awareness of pollution and anthropogenic impacts on the environment began to increase, and the United States passed policies such as the Clean Water Act (U.S. EPA, 2018) that limited the amount of pollutants that can enter waterways. As scientific studies followed this policy, consumers became aware of the threat of PCBs, chlordane, DDT, and dieldrin that were bioaccumulating in the tissues of common commercial species of the Mississippi River (e.g.

channel catfish), and consumption advisories were put in place (Rostad et al., 1994). This likely impacted their decision to purchase and eat freshwater fish.

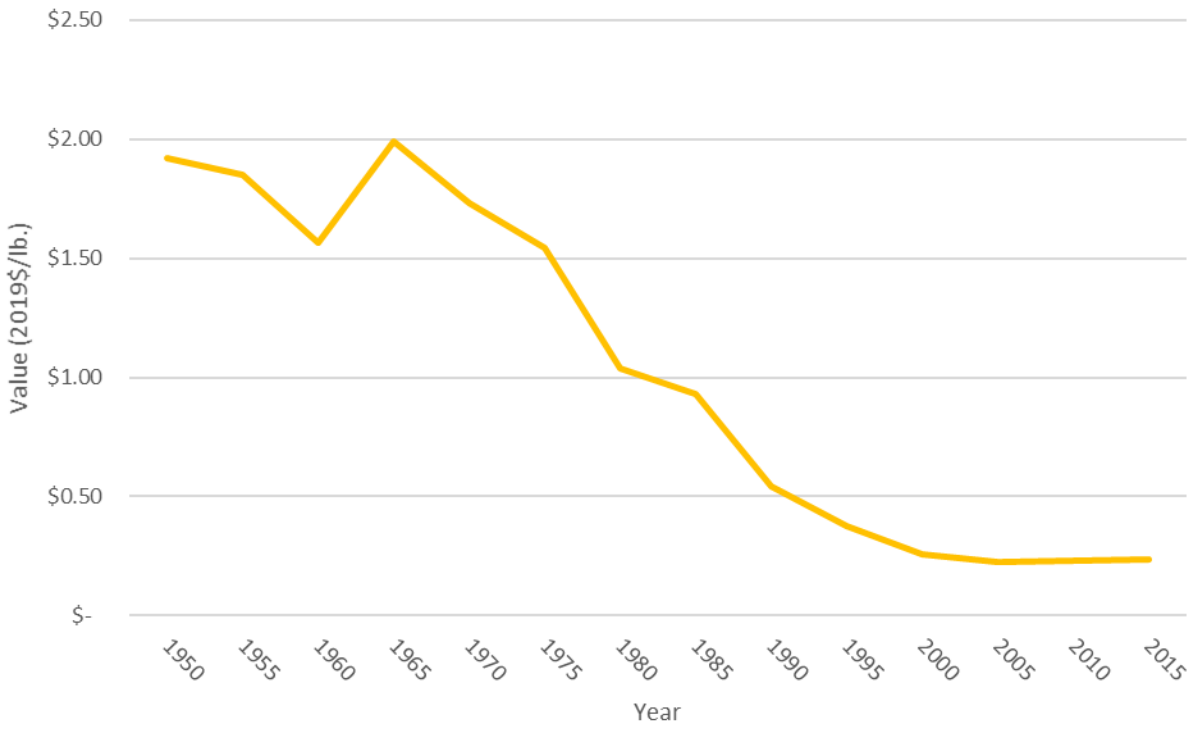

Fig. 2.2. Average price per lb. over time for freshwater commercial fish in Louisiana – adjusted to 2019 dollars for inflation. Source: National Marine Fisheries Service Annual Landings Tool.

The lack of focus on freshwater commercial fisheries coincides with data deficiencies for common commercial species, except for harvest data collected by the trip ticket program. Therefore, relatively little is known about the freshwater commercial fisheries in Louisiana, except for the fact that it is rapidly declining.

My objective was to analyze Louisiana's freshwater commercial fisheries using broad-scale harvest data from 1999 to 2016. Through visualizing industry data, such as fish harvest totals, fish harvest locations, and points of sale, I provide a general overview of trends and predictions of species landings and sale for the Louisiana's freshwater commercial fisheries.

2.2. Methods

2.2.1. Trip Ticket Data Analysis

Landings and value data were supplied by LDWF's trip ticket data program (LDWF, 2017). Due to confidentiality regulations, I accessed river-basin level landings data. River basins provide a larger geographic area to discuss sensitive data, such as economics and demographics, without revealing private information of the fishermen. When delimited by parish, sometimes there are less than three fishermen in that area. In this case, their data would be confidential to protect the privacy of these fishermen. When using larger areas, such as river basins, this issue is mostly avoided. I was provided landings and value data for inland commercial fisheries since the inception of the trip ticket program in Louisiana, 1999, until 2016.

The dataset included year, river basin, species type, pounds landed, and value ($) of landings for all years and basins where fish were harvested. Additionally, I was provided data that indicated how many fishermen were landing freshwater fish per river basin per year. LDWF also provided a dataset of locations of licensed freshwater fish dealers from 1999 until 2016. Freshwater dealers are individuals, wholesalers, retailers, or restaurants that buy freshwater fish directly from fishermen.

Using this data, I produced several maps using both the TMAP package in R (R Core Team, 2019) and QGIS (QGIS Development Team, 2019) with a choropleth scale to visualize how much catch is coming from each of the twelve river basins. I then supported these maps with a graphical equivalent showing the variation of landings (lbs.) and value ($) over years and basin. I began by creating general maps of all freshwater species landed over years by basin, and subsequently created maps of individual species. Because wild crawfish landings are an order of

magnitude higher than finfish in both landings and value, I created maps that visualized Louisiana's freshwater landings both with and without wild crawfish included.

With the licensed freshwater dealer data, I geocoded the physical addresses of each dealer and created a map depicting this data. However, not all licensed freshwater fish dealers are active. Therefore, I subsequently geocoded the addresses of known fish houses that actively buy, process, and/or sell freshwater fish and mapped those as well, denoted as "major fish houses" (Fig. 2.3.).

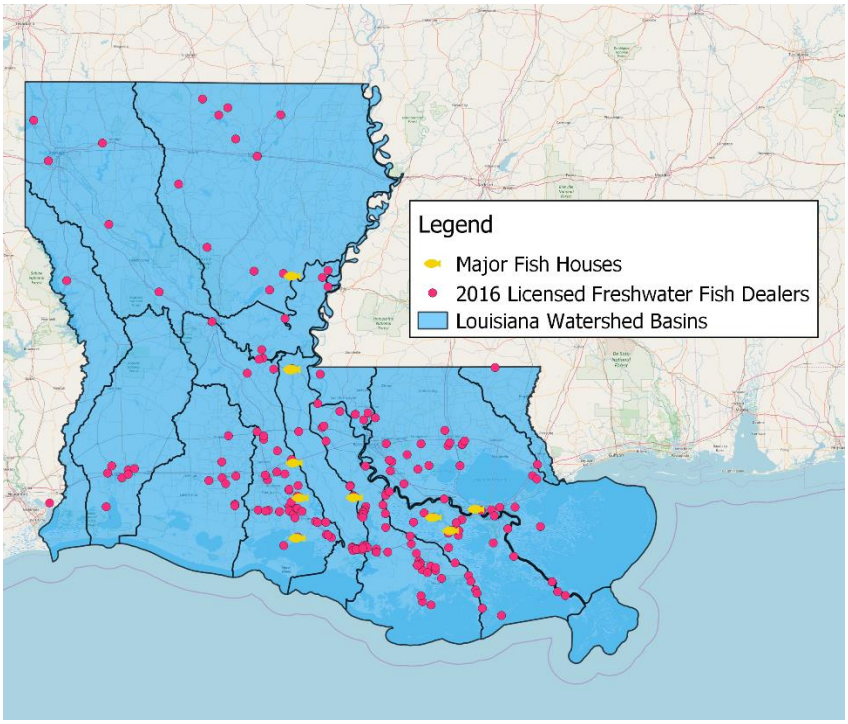

Fig. 2.3. Depiction of all licensed freshwater fish dealers in 2016 vs. all active fish buyers and processors. Source: LDWF.

To examine the data for temporal relationships between landings (lbs.) with year, I analyzed the data with a generalized linear model (GLM) with landings as the response variable, year as a 4^{th} order polynomial (quartic), a log link, and a negative binomial probability distribution (glm.nb(landings ~ basin + (basin/(poly(year,4))), using R (R Core Team, 2019) and

package MASS (Venables & Ripley, 2002). I observed that landings vary greatly by basin and through time. Therefore, a polynomial model appeared the most appropriate. This final model was selected based on a forward selection process from linear through 5^{th} order polynomial, determining 4^{th} order was optimal, based on fit statistics. Rather than Poisson, I chose to use a negative binomial regression because I had count data (landings) that were likely over dispersed, meaning the observed variance was higher than expected. I first conducted this test for total landings, including all species landings over all years and all basins. I then conducted more specific tests to understand the effects of basin and year on landings of a species or species group. I only accounted for the final polynomial, $year^4$, when discussing the results as this describes the most recent year trend for each species throughout basins. When running the test by species, some basins were removed from the analysis if there were not enough data points for that species. The Pearl River Basin (PRB) was removed from almost all analyses (except catfish) as there were too few landings over time within this basin. As commercial regulations use lbs., analyses were not converted to SI units to be consistent with fishery practices.

2.3. Results

2.3.1. Overall landings data

Over the period 1999-2016, trip ticket data summarized across all basin did not reveal obvious temporal patterns (Fig. 2.4.). The years 2000, 2006, and 2015 showed a sharp decline in landings that rebounded the following year, while the years 2010 - 2012 show a gradual decline in landings that recovered in 2013. As of 2016, total landings were down 11% from 1999. Summary data for total landings over time showed that the least number of lbs. landed per basin in one year was 74 lbs. while the most was 385,540,291 lbs., or 2,817,027 lbs. when excluding

wild crawfish. Similarly, the lowest value per basin in one year was $16 while the highest was $236,415,390, or $8,301,212 when excluding crawfish.

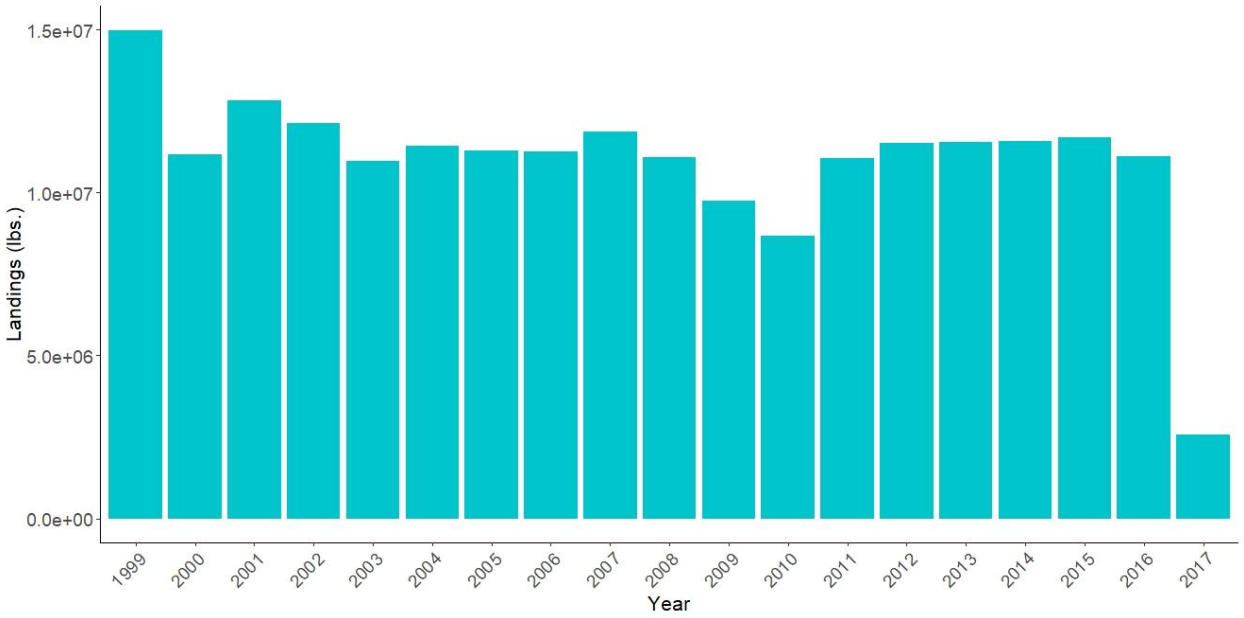

Fig. 2.4. Total freshwater commercial landings in Louisiana from 1999 – 2016. Source: LDWF.

When looking at total landings by basin, the most landings occur in the Atchafalaya River Basin (ARB) both when including and excluding wild crawfish (Figs. 2.5. and 2.6.). For all years, the ARB was by far the top producing river basin in Louisiana. Further, time series maps for both landings including and excluding wild crawfish (Fig. 2.7.) confirmed that the ARB produces the most landings. Landings in the Red River Basin (RRB), Ouachita River Basin (ORB), and Sabine River Basin (SRB) remain relatively stable (except for the year 2000, where all landings appear to be different from the rest of the years) while the southern basins (Barataria Basin (BRB), Terrebonne Basin (TRB), Vermilion-Teche Basin (VTB)) show more variation in landings over time. Together, the ORB, RRB, and SRB comprise 40% of the total acreage of Louisiana but only account for 7% of total landings (Table 2.1.). Interestingly, the ARB only

makes up about 4% of the total acreage of all river basins in Louisiana but accounts for 71% of all freshwater commercial landings.

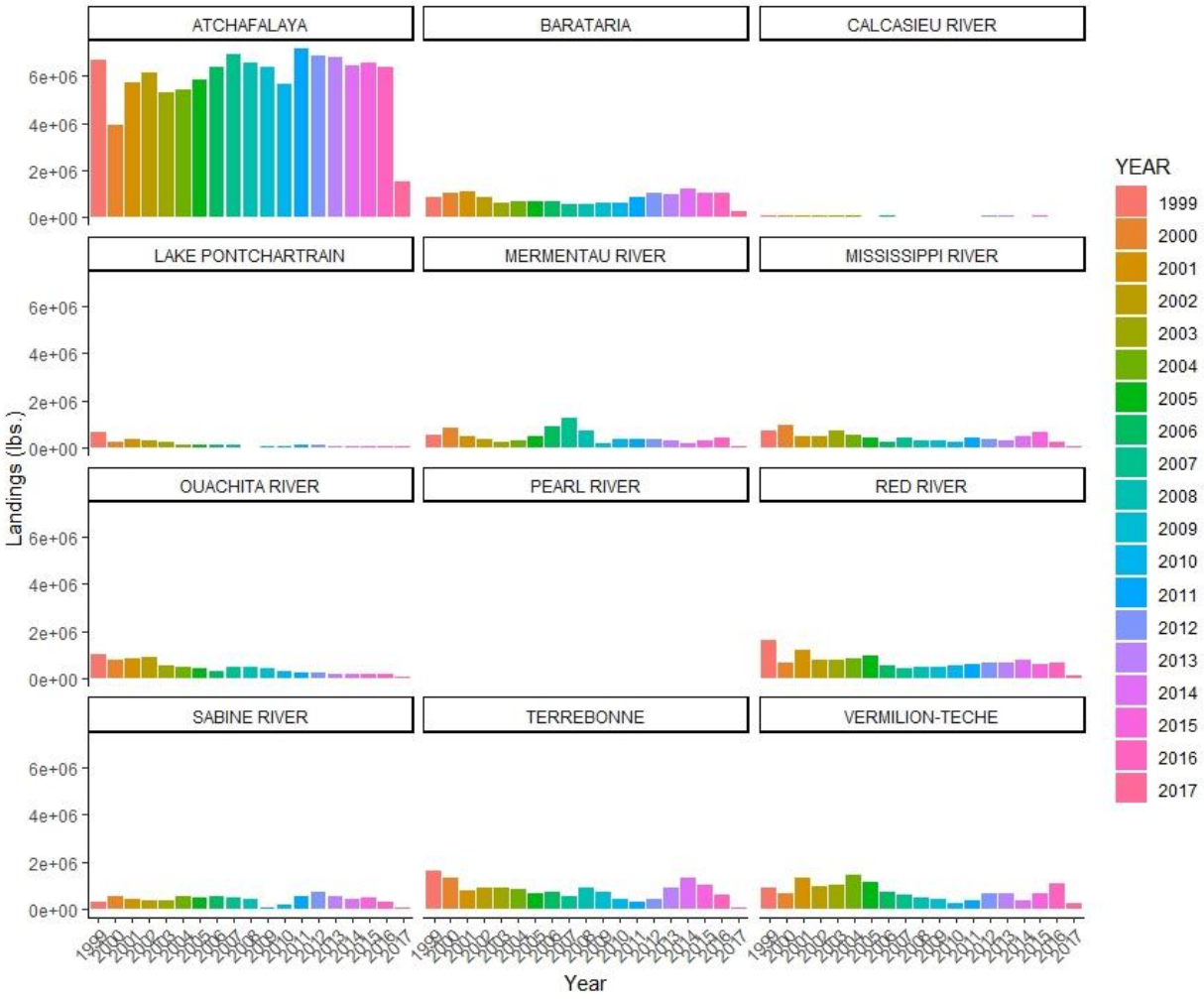

Fig. 2.5. Landings per basin over all years excluding wild crawfish. Source: LDWF.

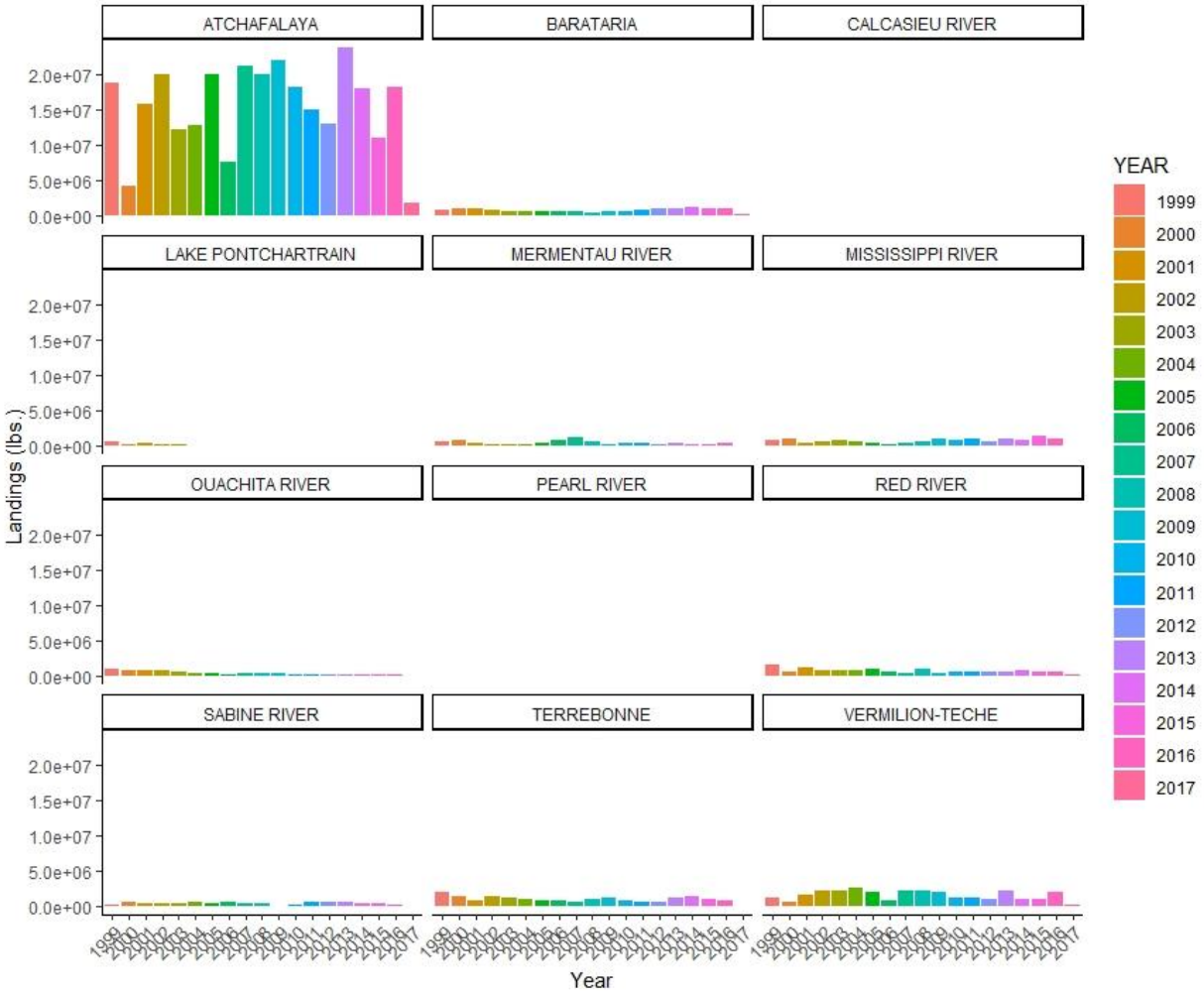

Fig. 2.6. Landings per basin over all years including wild crawfish. Source: LDWF.

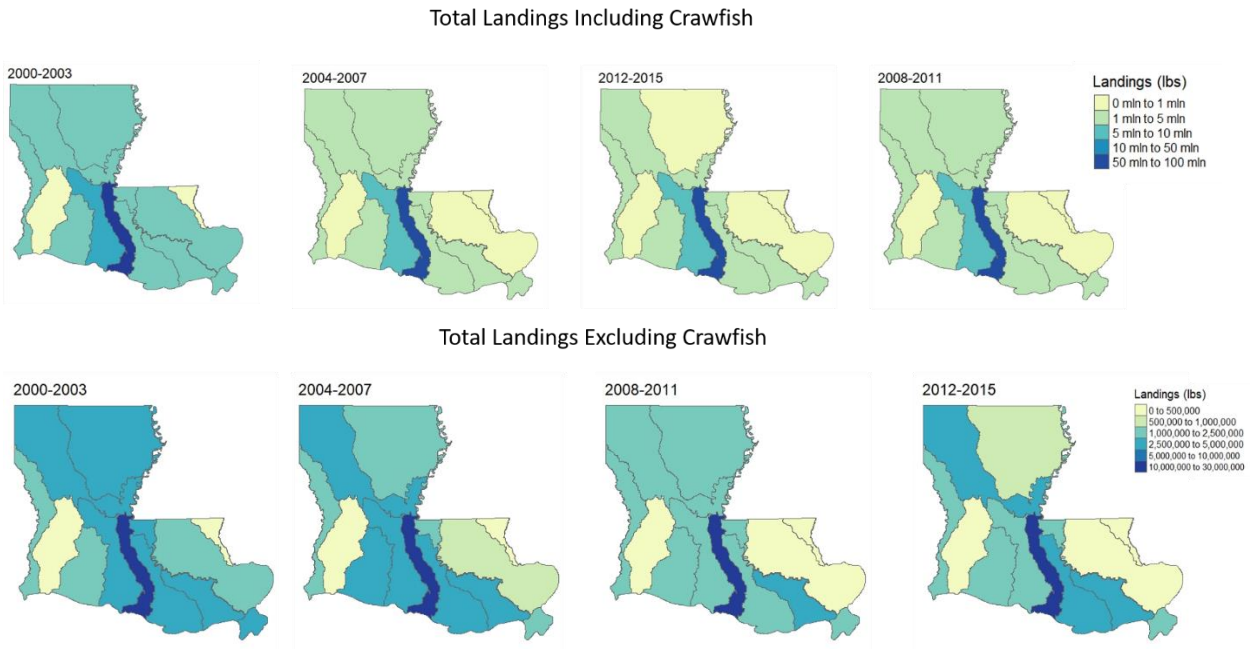

Fig. 2.7. Time series maps showing total freshwater commercial fish landings separated by river basin comparing grouped years: 2000-2003, 2004-2007, 2008-2011, and 2012-2015 both with crawfish (upper) and without crawfish (lower).

Table 2.1. Louisiana river basin size by acres. Source: Louisiana Department of Environmental Quality.

Basin	Acres	Percent of Total Acreage
Atchafalaya	1422890.5	4%
Barataria	1735014.1	5%
Calcasieu River	2596695	8%
Lake Pontchartrain	5072531.2	15%
Mermentau River	2494659.8	7%
Mississippi River	1324549.7	4%
Ouachita River	6400292.4	19%
Pearl River	580345.7	2%
Red River	4925871.7	15%
Sabine River	1866596.4	6%
Terrebonne	2502076.8	7%
Vermilion-Teche	2607641.3	8%

When considering landings over all years and basins, the negative binomial GLM predicts that landings throughout all basins are variable, but that the ARB has more landings than any other basin throughout all years (Fig. 2.8.). This confirms what the trip ticket data suggests. According to the GLM for all species, there was no effect of the variable "year" on number of species landings for any basin, so any specific change in landings trend over time is not expected.

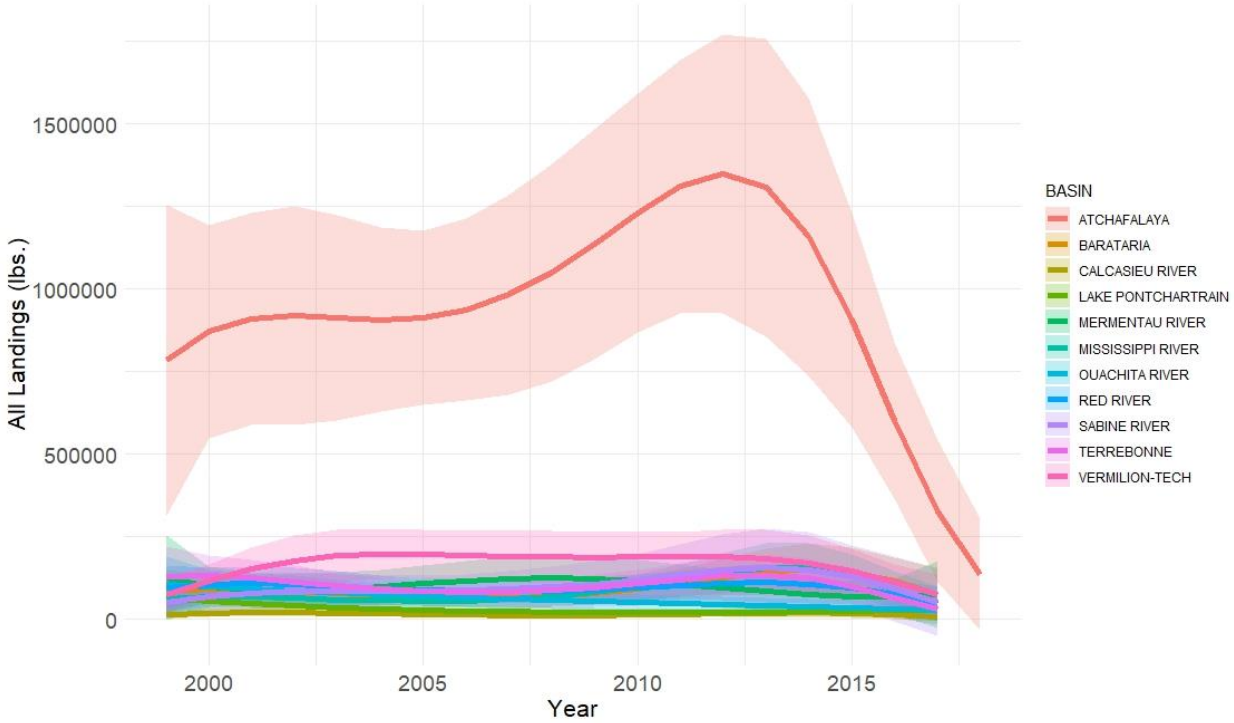

Fig. 2.8. Model-fitted variation in total landings (lbs.) within all basins from 1999-2017 with a 95% confidence level.

2.3.2. Species Overview

According to trip ticket data, wild crawfish, catfish, and buffalo are the most widely caught commercial species in Louisiana (Fig. 2.9.). While crawfish and catfish are also the top two valued species (price per pound), the "other" species – comprised mainly of freshwater drum and bowfin – surpass buffalo as the third highest values species group (Fig. 2.10.). Shad, carp,

and gar are niche fisheries that traditionally do not account of a large majority of landings or value, however there is still a small market for these species.

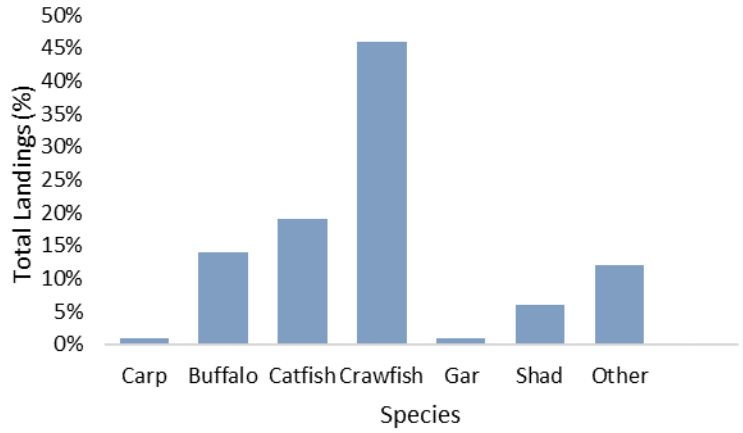

Fig. 2.9. Percent of total landings by species group from 1999-2016. "Other" includes bowfin and freshwater drum.

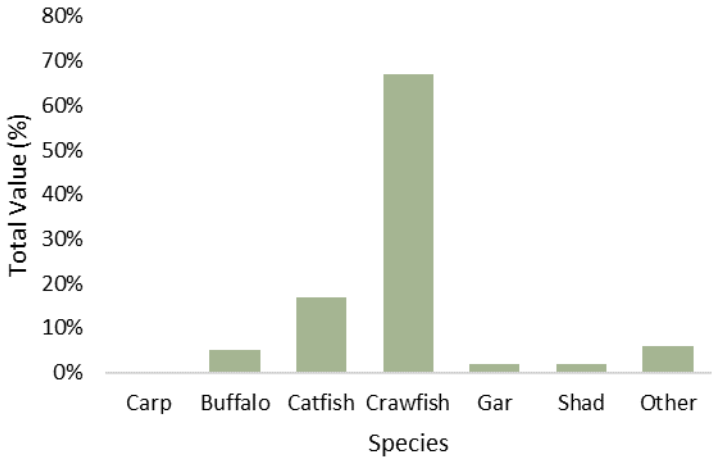

Fig. 2.10. Percent of total value by species group from 1999-2016. "Other" includes bowfin and freshwater drum.

2.3.3. Buffalofish

Buffalofishes (*Ictiobus* spp.) are comprised of two main species, bigmouth buffalo (*Ictiobus cyprinellus*) and black buffalo (*Ictiobus niger*). Combined, these species accounted for approximately 14% of all freshwater commercial fish landings from 1999-2016. Most buffalo

were landed in the ARB (63%), followed by the RRB (13%) and ORB (9%) (Fig. 2.11.). The market for buffalo is based in the northern part of Louisiana (LDWF pers. comm.) which is consistent with the large amount of buffalo landings that are from the RRB and ORB.

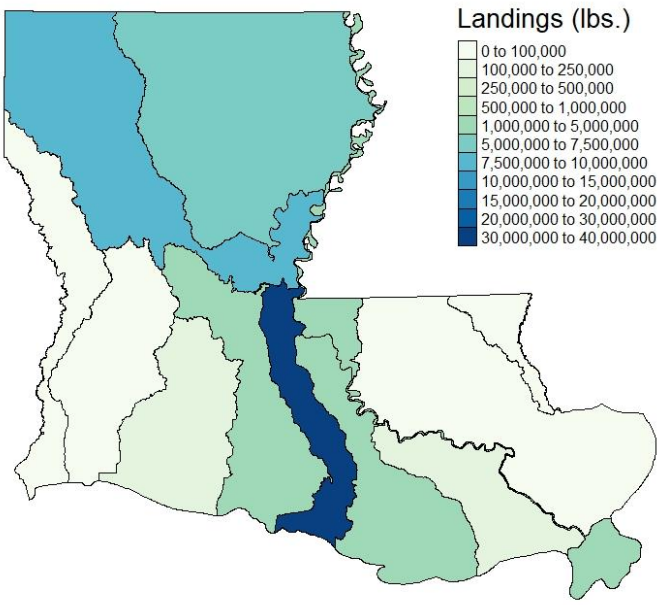

Fig. 2.11. Total buffalo landings from 1999-2016 by river basin.

The negative binomial GLM analysis revealed that buffalo landings throughout all basins are highly variable, however the ARB still has higher landings than all other basins in all years (Fig. 2.12.). In most years, the SRB and Calcasieu River Basin (CRB) have significantly fewer landings than any other basin. Data analysis suggested buffalo landings in BRB, Mermentau River Basin (MRB), Mississippi River Basin (MSRB), ORB, SRB, TRB, and VTB are significantly affected by year (α=.05). For BRB, MSRB, and VTB, year had a negative effect on number of buffalo landings. For MRB, ORB, SRB, and TRB, year had a positive effect on buffalo landings (Table 2.2.) However, there are few data points for buffalo landings in MRB and TRB from 2009 to 2017, suggesting these data may be skewed.

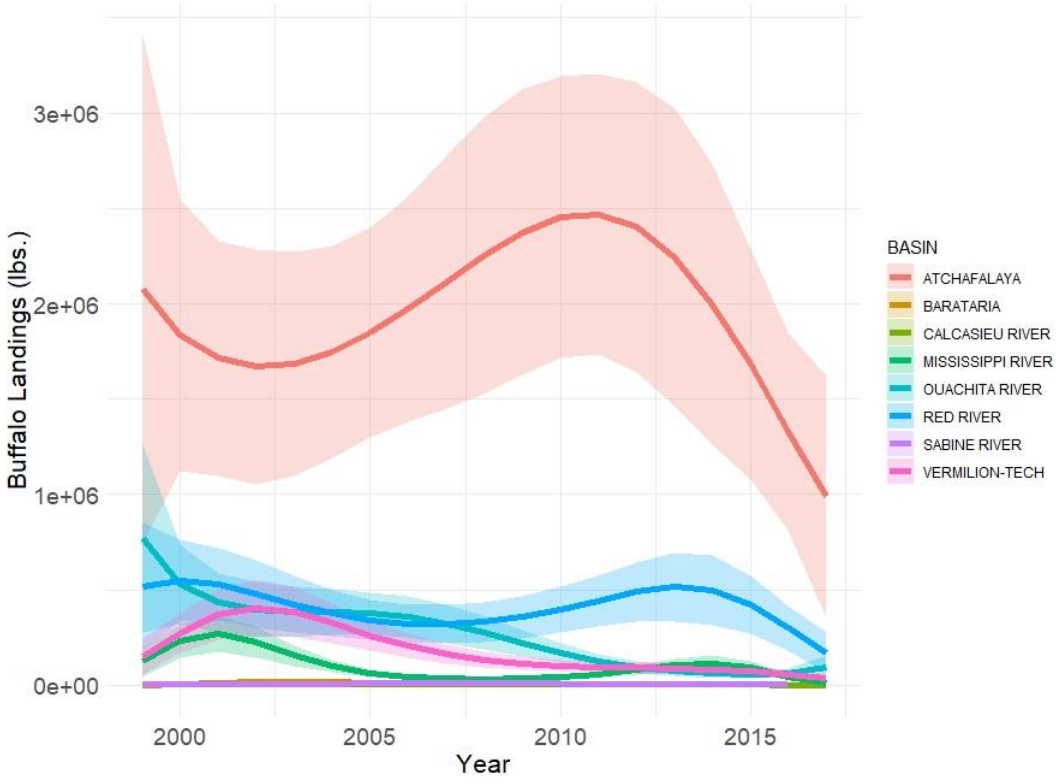

Fig. 2.12. Model-fitted variation in buffalofish landings with a 95% confidence interval by basin from 1999-2017.

Table 2.2. Summary of regression output for Buffalo landings by basin over time.

Basin	Year[4] Estimate	p-value (α=.05)	Test statistic (z)	df
Barataria	-8.07 ± 2.22	< 0.01	3.64	108
Mermentau River	17.23 ± 5.65	< 0.01	-3.05	108
Mississippi River	-7.89 ± 1.25	< 0.01	-6.36	108
Ouachita River	3.02 ± 1.25	0.02	2.43	108
Sabine River	5.57 ± 1.72	< 0.01	-3.24	108
Terrebonne	7.19 ± 2.45	< 0.01	2.94	108
Vermilion-Teche	-2.16 ± 1.25	0.02	2.38	108

2.3.4. Catfish

There are several species of freshwater catfishes (family *Ictaluridae*) that are commonly landed in Louisiana: channel catfish (*Ictalurus punctatus*), blue catfish (*Ictalurus furcatus*), bullhead catfish (*Ameiurus* spp.), and flathead catfish (*Pylodictis olivaris*). However, channel and blue catfish are the preferred species for commercial harvest. For all years and basins, catfish

landings accounted for 19% of the total commercial landings. Of those, 36% of all catfish landings occurred in the ARB (over 28.5 million lbs.), while 15% were in BRB and 10% were in MRB (Fig. 2.13.).

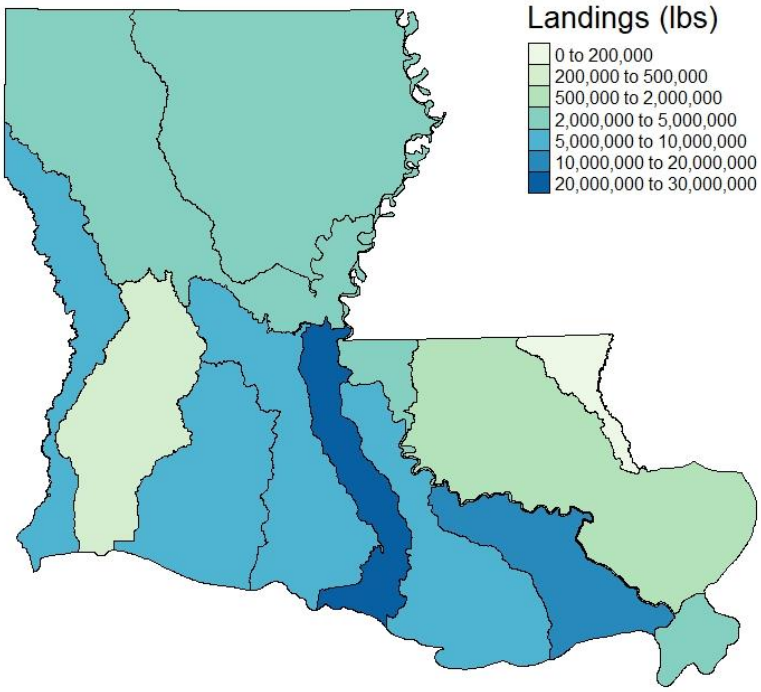

Fig. 2.13. Total catfish landings (lbs.) by basin from 1999-2016.

Over time, catfish landings have not varied much by basin as shown by Fig. 2.14. The ARB remains the top producer of catfish spanning all 18 years (1999-2016). The GLM analysis indicates that the ARB has significantly higher catfish landings than all other basins, however the landings within the ARB appears stable over time (Fig. 2.15.). The Pearl River Basin (PRB) and CRB appear stable as well with very few catfish landings over time. Landings in the BRB and MRB appear the most variable, with fluctuations between higher and lower numbers throughout the years. Data analysis suggests catfish landings in Lake Pontchartrain Basin (LPB), TRB,

VTB, and MRB are all significantly affected by year (α=.05). Given a one unit increase in the predictor variable, “year 4”, the expected log count of lbs. of catfish landings for recent years decreases by 3.08± 1.07 for LPB, 2.38± 1.07 for TRB, and 2.33± 1.07 for VTB. For MRB, the expected log count increases by 4.85± 1.07.

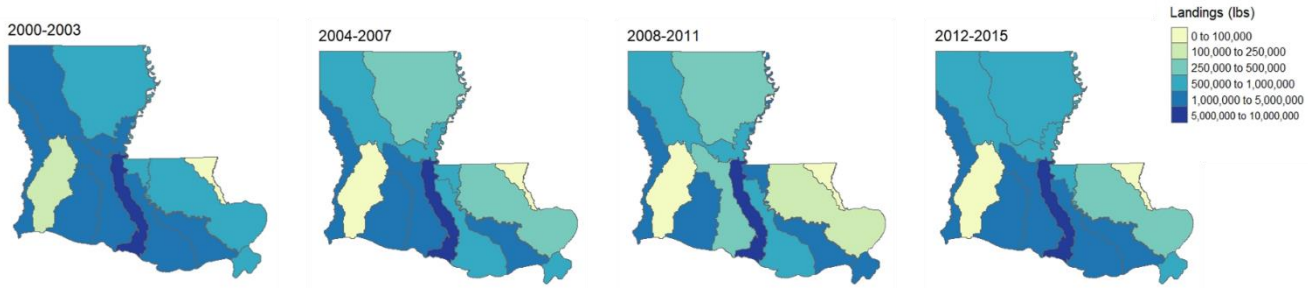

Fig. 2.14. Time series of catfish landings (lbs.) by river basin comparing grouped years: 2000-2003, 2004-2007, 2008-2011, and 2012-2015.

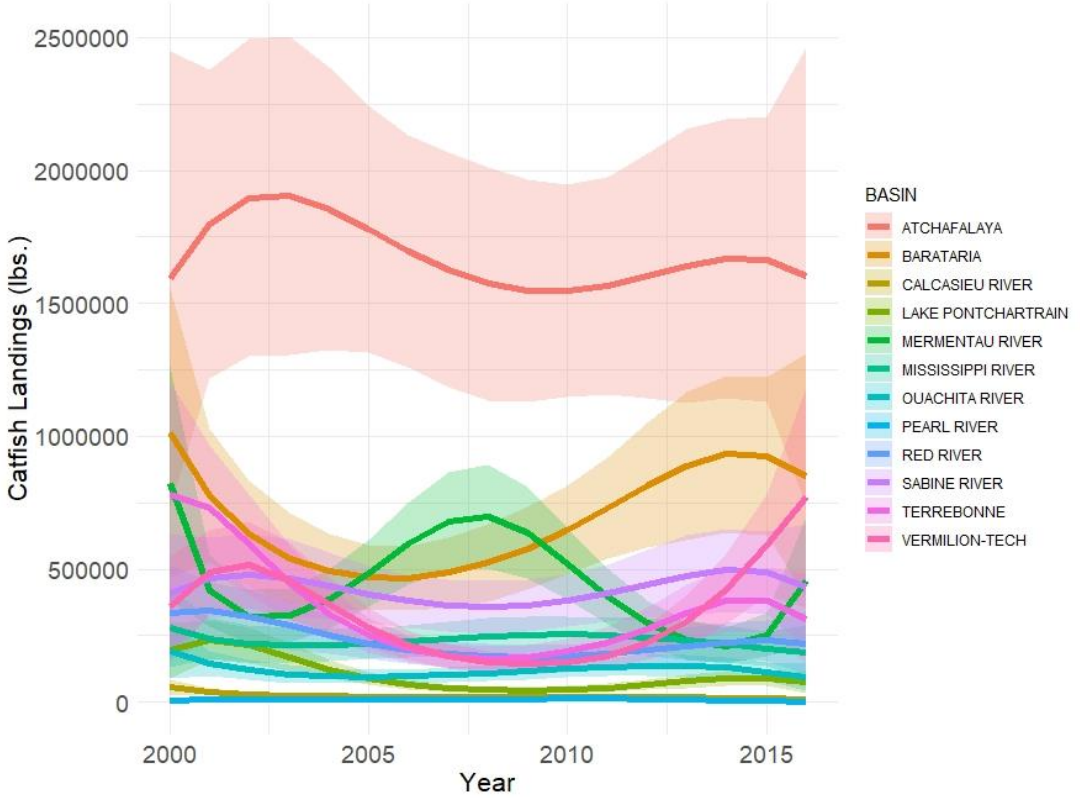

Fig. 2.15. Model-fitted variation in catfish landings with a 95% confidence interval by basin from 2000-2017.

2.3.5. Crawfish

Wild Crawfish is the most lucrative freshwater commercial fishery in Louisiana. There are two species of crawfish harvested for consumption: red swamp crayfish *(Procambarus clarki*) and white river crayfish (*Procambarus zonangulu*) although they are not reported separately in the trip ticket data. Between 1999 and 2016, there were over 193 million lbs. of wild crawfish harvested in Louisiana, with 87% (168 million) coming from the ARB, 8% coming from the VTB, and 3% coming from the MSRB (Fig. 2.16.). Crawfish has consistently remained the highest valued freshwater commercial species in Louisiana, bringing in approximately 67% ($154 million) of the total value of freshwater commercial harvest from 1999-2016.

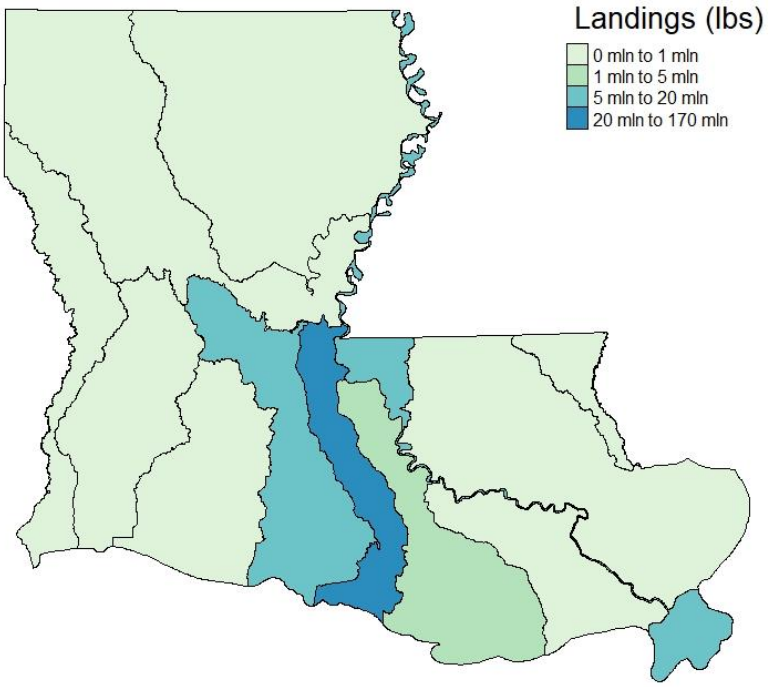

Fig. 2.16. Total wild crawfish landings (lbs.) by river basin from 1999-2016.

Crawfish are regularly harvested from only three to five river basins in Louisiana. Of these, the data analysis indicated that crawfish are harvested from the ARB more than other

basins (Fig. 2.17.). In early 2000s, the model reflected that the rest of the harvest came from the VTB, but in recent years that has shifted more towards the MSRB. The GLM suggested crawfish landings in LPB and VTB are significantly affected by year^4 (α=.05). Given a one unit increase in year^4, the expected log count of lbs. of crawfish landings decreases by 4.56 ± 1.96 for VTB but increased by 444.81 ± 144.27 for LPB. However, within the dataset there were only six usable datapoints when analyzing landings for LPB from the past twenty years, and the most recent datapoint was more than tenfold higher than the previous year. Therefore, this value (log count increase of 444.81 lbs. of landings) may be skewed and not representative of crawfish landings in LPB. For all other basins, the model did not suggest any significance for the effect of year^4 on crawfish landings.

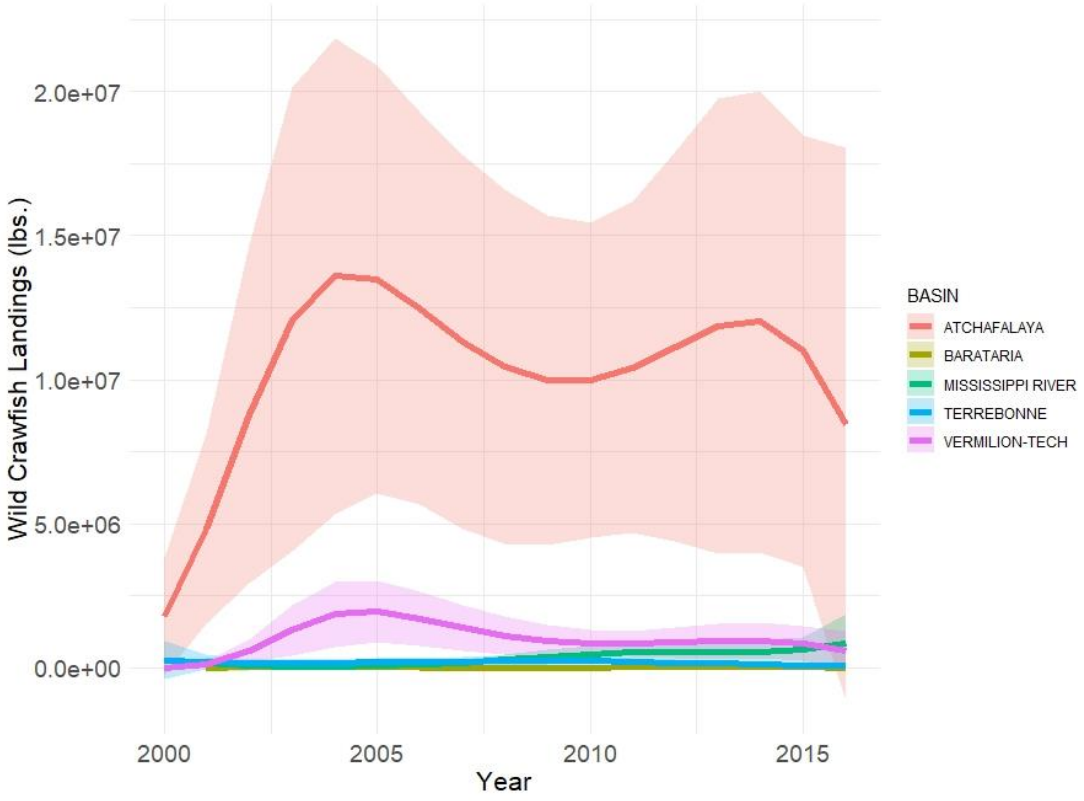

Fig. 2.17. Model-fitted variation in wild crawfish landings with a 95% confidence interval by basin from 2000-2017.

2.3.6. Shad

The shad fishery in Louisiana is a small niche fishery that is largely located within the ARB. There are two species of shad that are harvested: threadfin shad (*Dorosoma petenense*) and gizzard shad (*Dorosoma cepedianum*). However, gizzard shad is the more common of the two. The ARB accounts for 84% (22 million lbs.) of the total shad harvested in Louisiana followed by TRB with 15% (4 million lbs.) and the BRB accounting for 1% (390,000 lbs.) (Fig. 2.18.). There was no shad harvest within any other river basin from 1999-2016. In total, the shad fishery was valued at approximately $5 million for all years, which accounts for only 2% of the total value of freshwater commercial harvest. Of that $5 million, $4.5 million came from the ARB.

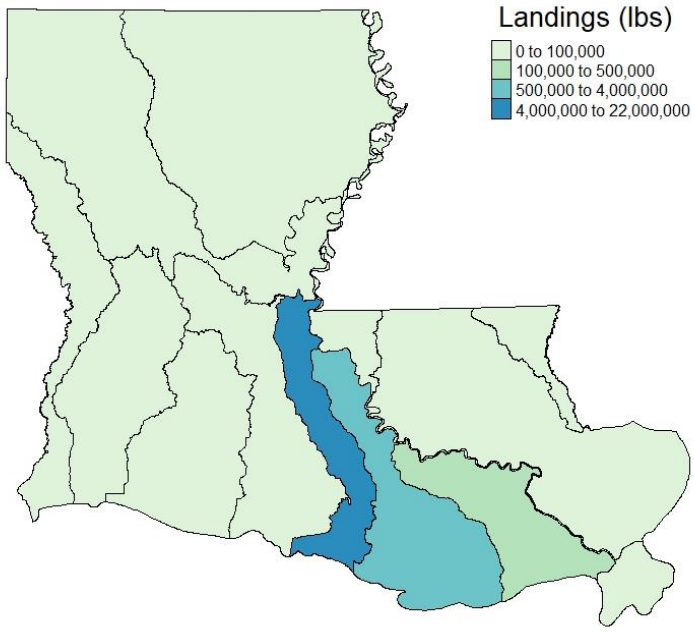

Fig. 2.18. Total shad landings (lbs.) per basin from 1999-2016.

Shad are regularly harvested within only five river basins. Of those five, the model shows that for most years, the ARB is predicted to have the most shad landings (Fig. 2.19.). Beginning in 2012, approximately, the model shows shad landings within TRB increasing, indicating that

shad landings in the ARB are no longer higher than TB. The GLM analysis suggested that for each increase in year[4], the effect on log count of shad landings (lbs.) decreases in BRB (-7.89 ± 3.98), ORB (-8.48, ± 4.17), and VTB (-3.19 ± 1.59). There was no effect of year[4] on any of the other basins for shad landings.

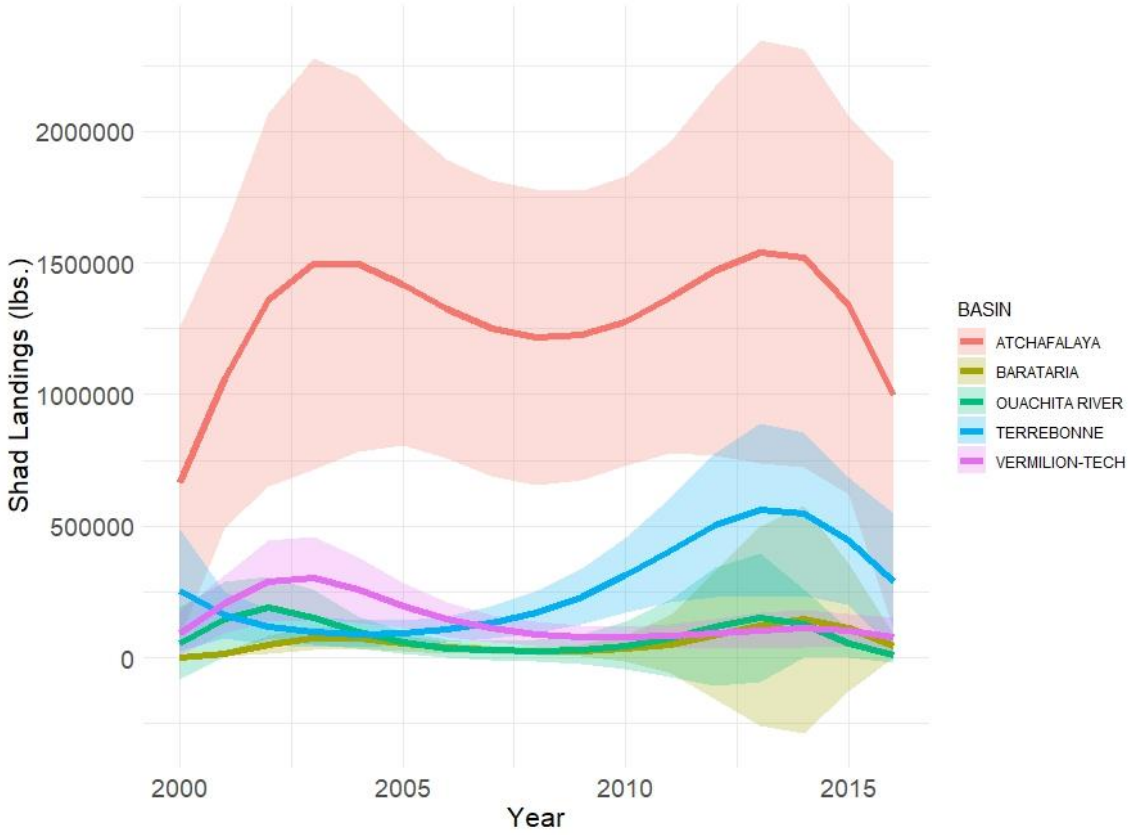

Fig. 2.19. Model-fitted variation in shad landings with a 95% confidence interval by basin from 2000-2017.

2.3.7. Carp

There is a small commercial market for carp in Louisiana. Common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), and bighead carp (*Hypophthalmichthys nobilis*) are all harvested carp species. All carp species are invasive in the U.S. and considered nuisance species as they have little commercial or recreational value. However, in recent years, silver carp and bighead carp are the center of the

invasive carp conversation and are most familiar to commercial fishermen. In Louisiana, all carp species combined accounted for less than 2% of the commercial harvest from 1999-2016. Bighead carp comprised 1% of the total commercial harvest (Fig. 2.20.) while silver, common, and grass carp were each well under 1% (Figs. 2.21., 2.22., & 2.23.). All four species were largely harvested within ARB, while noted amounts of common carp were also harvested in the TRB and BRB, and grass carp in the RRB. Altogether, carp species were valued at around $650,000 in total between 1999 and 2016, which makes up only 0.3% of the total value for all commercial harvest.

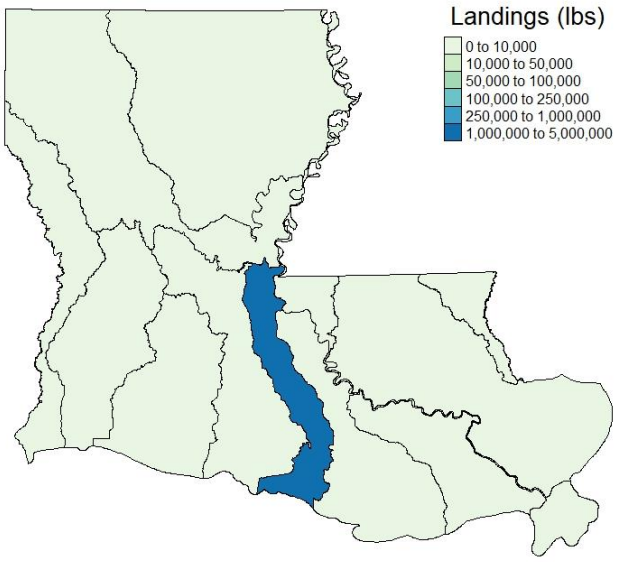

Fig. 2.20. Total bighead carp landings (lbs.) by basin from 1999-2016.

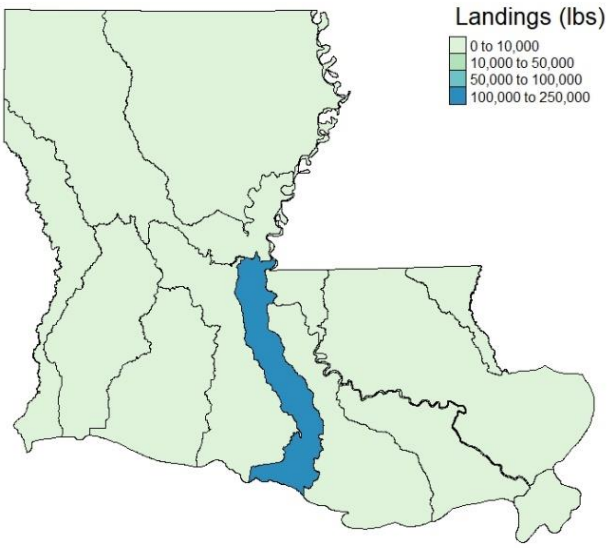

Fig. 2.21. Total silver carp landings (lbs.) by basin from 1999-2016.

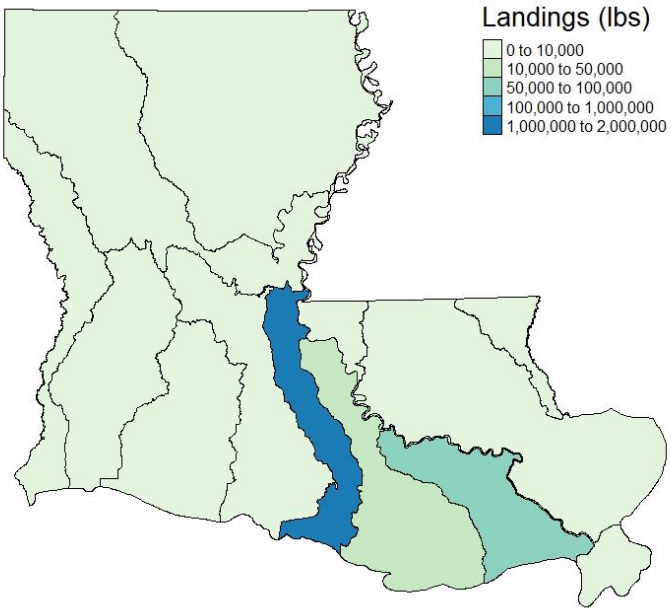

Fig. 2.22. Total common carp landings (lbs.) by basin from 1999-2016.

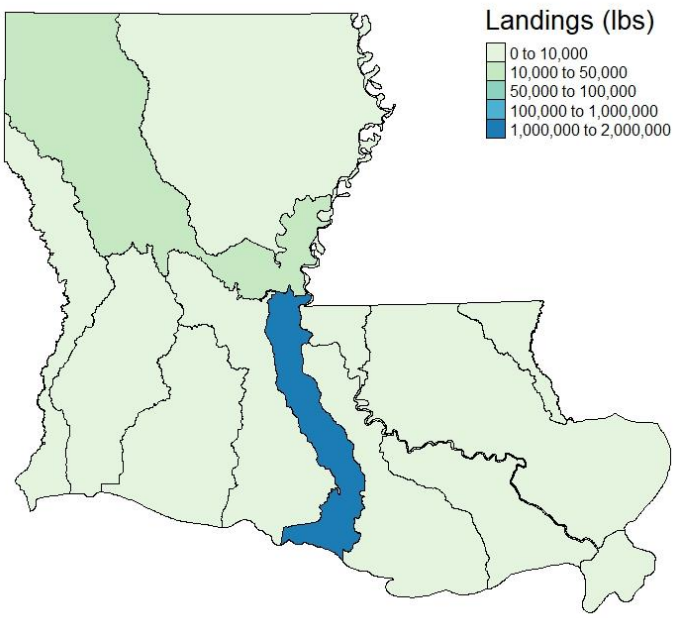

Fig. 2.23. Total grass carp landings (lbs.) by basin from 1999-2016.

Carp were regularly harvested four river basins: ARB, MSRB, ORB, and RRB. Of these, the model estimated that total carp landings were higher in the ARB over all years, especially between 2010 and 2015 (Fig. 2.24.). The GLM indicated that carp landings in BRB, ORB, MSRB, and RRB are significantly affected by year^4 (α=.05). Given a one unit increase in year4, in recent years, the expected log count of lbs. of carp landings decreases by 27.25 ± 12.3 lbs. for BRB, 6.98± 3.12 lbs. for ORB, and 4.79 ± 1.12 lbs. for RRB. The GLM projected an increase in log count of carp landings by 2.68± 1.32 lbs. for MSRB. However, there are only six data points for carp landings from BRB from 2000-2017, therefore the model may not be representative of the true effect of year on BRB for carp landings.

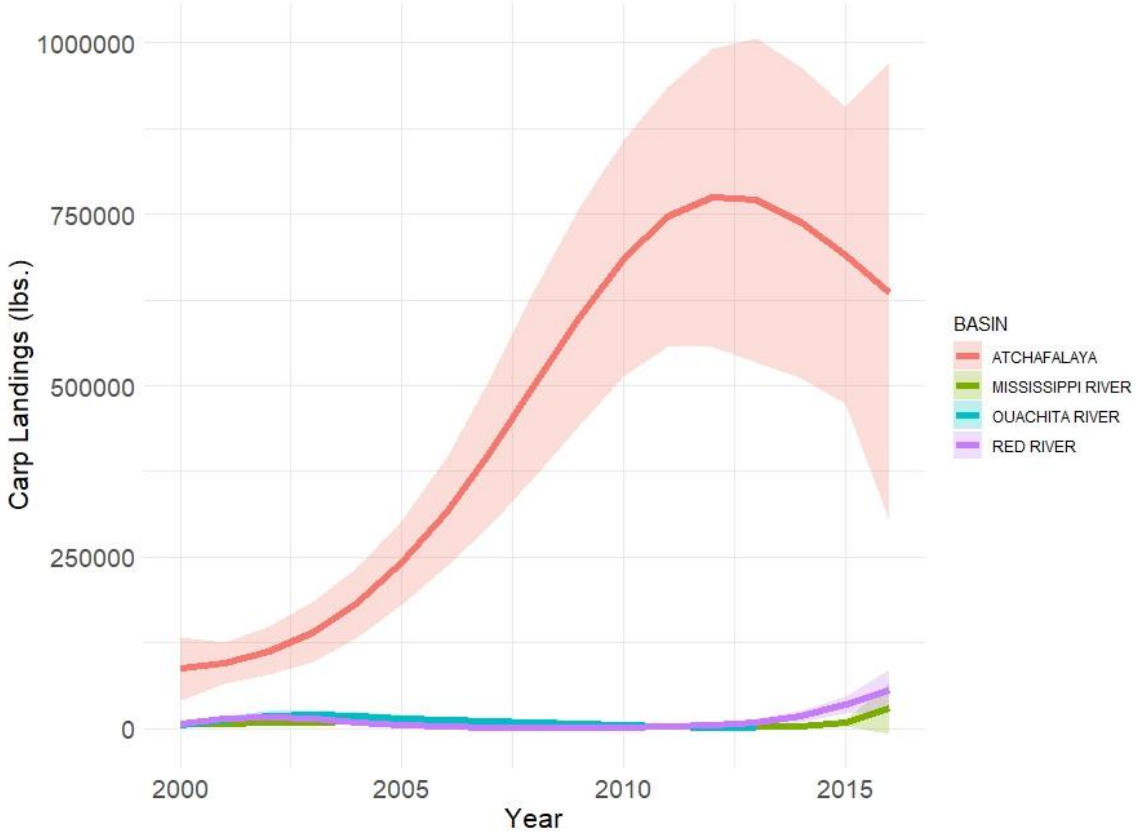

Fig. 2.24. Model-fitted variation in carp landings by basin from 1999-2017.

2.3.8. Gar

There are three species of gar that are commercially harvested in Louisiana: alligator gar (*Atractosteus spatula*), spotted gar (*Lepisosteus oculatus*), and longnose gar (*Lepisosteus osseus*). Gar are euryhaline species, and only accounted for 1% (over 4.5 million lbs.) of the total commercial harvest from 1999-2016. Gar were most abundantly harvested in the BB, with almost 2 million lbs. (43%) from 1999-2016, followed by the ARB (30%) and the TB (28%) (Fig. 2.25.); 40% of the commercial value from gar landings are associated with the BRB (40%). Interestingly, TRB accounted for more value from commercial gar harvest (32%) than the ARB (28%) even though the ARB had more gar landings. This suggests that fish buyers within the

TRB may value gar higher than fish buyers in the ARB, shedding some light into the market for these fish.

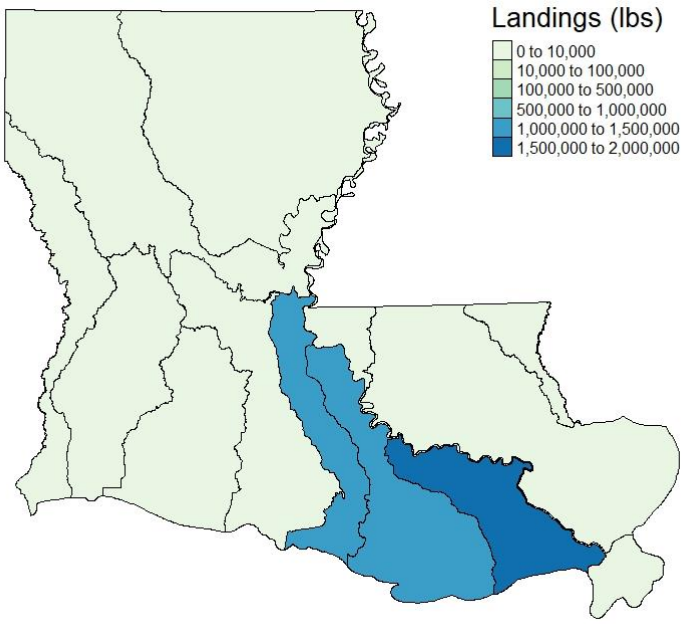

Fig. 2.25. Total gar landings (lbs.) by basin from 1999-2016.

The model estimated gar landings in ten out of the twelve river basins. BRB and TRB had the most gar landings, but their peaks vary over the 18 years (Fig. 2.26.). MSRB, ARB, and VTB slightly vary in gar landings over all years but remain generally stable in their landings. The model shows downward trend from 2000 until 2014 in LPB after which it remains stable. RRB and ORB both have low landings for all years. The GLM analysis showed gar landings in BRB and ORB are significantly affected by year (α=.05). Given a one-unit increase in year[4], in recent years, the expected log count of lbs. of gar landings decreases by 3.10 ± 1.36 for BRB and 5.49 ± 1.81 for ORB.

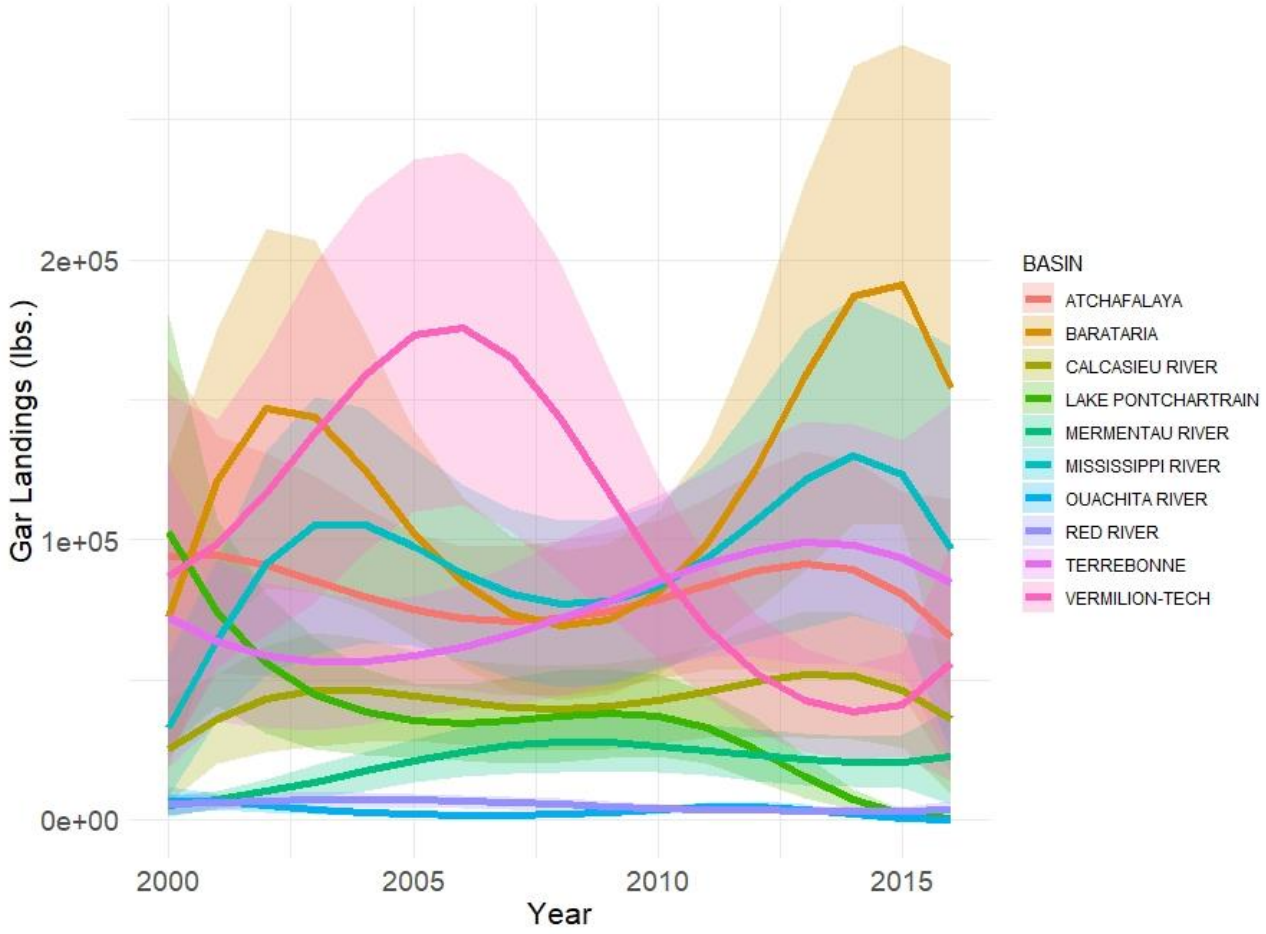

Fig. 2.26. Predicted variation in gar landings with a 95% confidence interval by basin from 2000-2017.

2.3.9. Bowfin and Freshwater Drum

Bowfin (*Amia calva*) and freshwater drum (*Aplodinotus grunniens*) are the two main species grouped under the "other" heading of the trip ticket data. Together they comprise about 12% of the total commercial harvest from 1999-2016 (48.8 million lbs.) and 6% of the total value ($14 million). The vast majority of these species were caught in the ARB (91.6%) followed by TRB (7.6%) and BRB (0.8%) (Fig. 2.27.). There were no reported landings of bowfin or freshwater drum in any of the other river basins. Bowfin and freshwater drum together accounted for 6% of the total value of commercial harvest from 1999-2016. Of that 6% ($14

million), 76% of the value was from the ARB, while 26% and 2% were from the TRB and BRB basins, respectively.

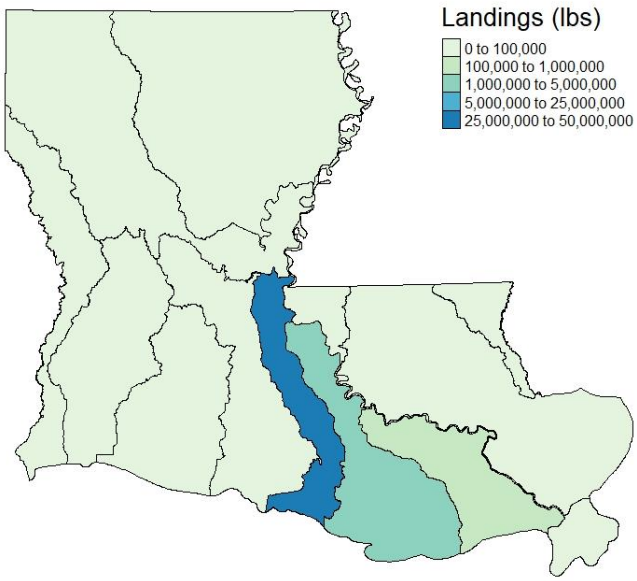

Fig. 2.27. Total freshwater drum and bowfin landings (lbs.) by basin from 1999-2016.

For all years, more bowfin and freshwater drum are harvested in the ARB than BRB and TRB basins. Similarly, for all years, more bowfin and freshwater drum are harvested within TRB than BRB (Fig. 2.28.). None of the predictions show much variation in landings over the eighteen years. The GLM suggested that for ORB, RRB, and VTB, in recent years, the expected log count of freshwater drum landings per one increase in year is a very large decrease over time: -21.6 ± 5.61, -4.04 ± 1.67, and -4.14 ±1.32, respectively. However, there are few datapoints for freshwater drum landings within RRB and ORB, suggesting that this result may not represent the year^4 effect of freshwater drum landings in those basins. For bowfin, in recent years, the expected log count of landings per year in TRB is -2.84 ±1.36. For all other basins, the model did not suggest any significance for the effect of year on freshwater drum or bowfin landings.

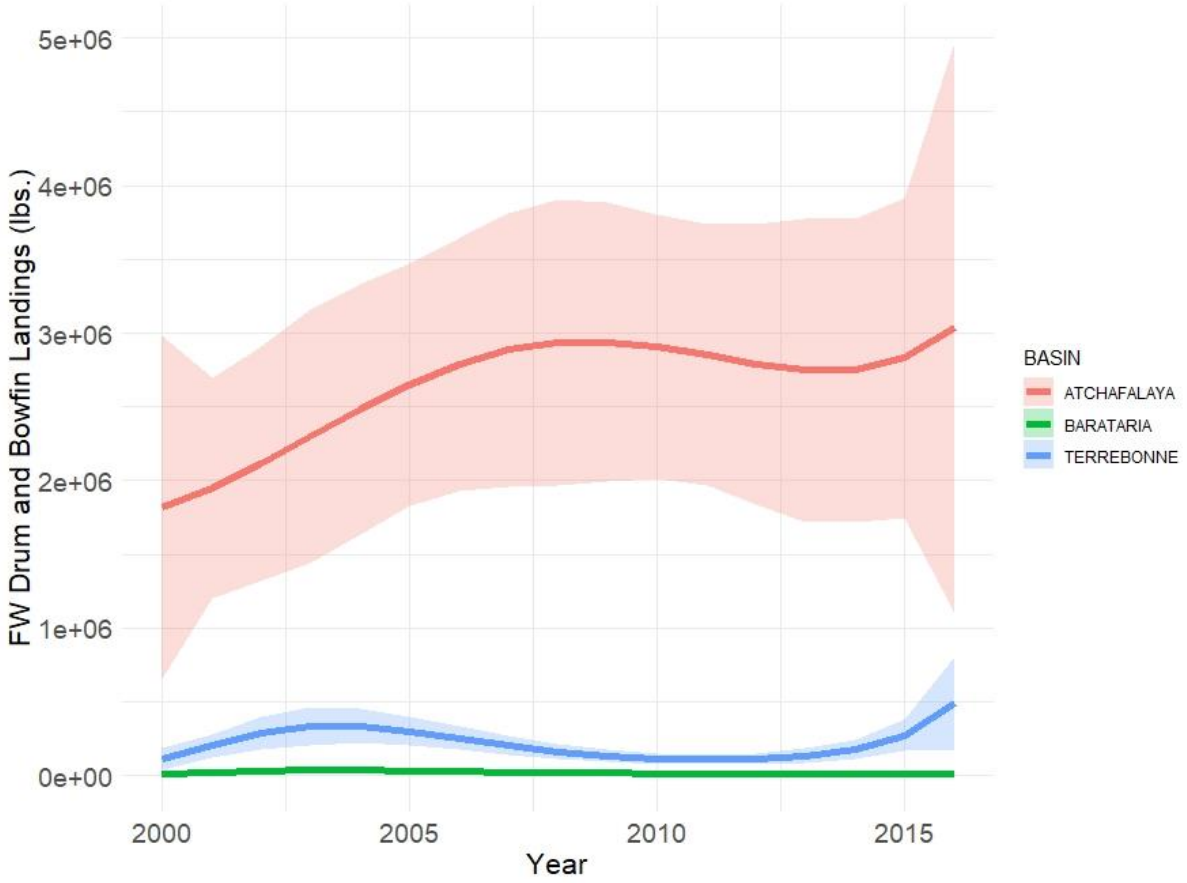

Fig. 2.28. Predicted variation in bowfin and freshwater drum landings with a 95% confidence interval by basin from 1999-2017.

2.3.10. Fish Houses and Commercial Fishermen

A realistic variable that influences the amount of catch coming out of a river basin is how readily accessible it is for fishermen to sell their catch to a fish house. According to the dealer license dataset provided by LDWF, most fish dealers are located in the southeast region of Louisiana (Fig. 2.26.). As mentioned previously, solely obtaining a dealer license does not imply that the licensee is actively buying fish from wild fishermen. Therefore, I reported major fish houses that I encountered that were currently active in buying large quantities of wild freshwater fish from commercial fishermen. Similarly, these were mostly located within the southeastern area of the state except for three that were located in the Simmesport and Jonesville areas (Fig

2.3.). The northern, central, and western regions of Louisiana are markedly devoid of both dealer license holders and practicing fish houses.

2.4. Discussion

2.4.1. Landings and Value by Species and River Basin

For all commercially harvested freshwater species except gar, the Atchafalaya River Basin (ARB) produced the most lbs. of finfish and crawfish since 1999 and likely earlier. The Atchafalaya River and surrounding area is the largest river-floodplain swamps in the United States (Ford and Nyman, 2011). A distributary of the Mississippi River, the Atchafalaya River is home to over 260 freshwater and estuarine fishes (Alford et al., 2013) and is popular among anglers. This is exemplified by the overwhelming commercial harvest (71%) that comes out of the ARB and is confirmed by the statistical analysis, which is very similar to estimates reported by Fleming et al. (1989) (Fig. 2.8.). When comparing landings data with the location of freshwater fish dealers, there is a high overlap within the ARB and surrounding region. Consequently, there are more fish buyers and processors that reside within or near the ARB than in other regions within Louisiana.

Secondary to the ARB, the BRB, TRB, and VTB are also relevant to the freshwater commercial fisheries. A majority of dealer license holders also span these basins (Fig. 2.3.). Similarly, most fish houses are within these basins as well. In addition, the GLM analysis estimates that all species except carp are regularly landed within BRB, TRB, and VTB, showing a consistency among this region. Analyses suggested that for gar, buffalo, carp, and shad, there is a negative effect of year on number of landings in BRB. Therefore, a decrease in landings is expected from these species. Similarly, for TRB the model suggested a decrease in catfish and

bowfin landings over time, but a possible increase in buffalo landings. In VTB, the model suggested a decrease in catfish, buffalo, crawfish, drum, and shad landings over time due to a significant year effect.

Currently, there are several reasons as to why these four river basins, ARB, BRB, TRB, and VTB, are the highest contributors to the freshwater commercial fisheries in Louisiana. All four basins share a border with the Gulf of Mexico. While this data focuses on freshwater landings, it is important to note that Louisiana commercial fishing licenses do not distinguish between freshwater and saltwater. This means that a fisherman who predominately targets saltwater fish is able to also land and sell freshwater fish if they happen to catch them. This is significant because most saltwater commercial fishermen work out of one of these four river basins and there are many more saltwater commercial fishermen than freshwater in Louisiana (LDWF Office of Fisheries, 2017). This suggests that in addition to fishermen who only target freshwater fish, such as fishermen from ORB or RRB, fishermen in the ARB, BRB, TRB, and VTB who target saltwater species may also be landing and selling freshwater fish, increasing the landings rate. Additionally, the salinity of Louisiana's gulf coast waters varies spatially and temporally (Das et al., 2012). Some freshwater species are able to withstand low salinities of the Gulf and may be found along the coastline, increasing the amount of freshwater fish landed by commercial saltwater fishermen. Gar is a prime example of this, as gar are euryhaline species and can survive in the brackish water of the coast (Allen at al., 2017). Gar are the only freshwater commercial species that were landed more frequently in BRB than the ARB, suggesting that they may be caught frequently by saltwater commercial fishermen. Predicted landings from the data analysis support this trend, showing most gar landings coming from either BRB or VTB, depending on the year (Fig. 2.26.).

The ARB is the hub of wild crawfish production. As 87% of wild crawfish harvest comes from the ARB (Fig. 2.16.), this accounts for a surge of landings and a dramatically increased value in this basin when compared to others. Wild crawfish landings account for more than 50% of all freshwater commercial harvest in Louisiana, which makes the ARB the most valuable river basin in the state. The GLM verifies this by showing more wild crawfish landings coming from the ARB than any other basin (Fig. 2.17.). Additionally, wild crawfish are quick to mature, meaning they can be regularly harvested without a real threat of overharvesting. Uniquely, the crawfish fishery in Louisiana has a strong consumer demand, which influences the high number of landings and value. The shad fishery goes hand-in-hand with the crawfish industry, as shad is almost exclusively harvested for crawfish bait (pers. comm., 2018). Shad season is usually in late fall or early winter, right before crawfish season starts up (January- February). Most shad are harvested within the ARB as well, followed by TRB and BRB, which are in close proximity to the ARB. No shad is harvested in the northern or western basins, as there is no crawfish fishery to support.

Overall, the GLM suggested that when year influences species landings per basin, it is almost always decreasing. This is corroborated by the trip ticket data and the models that show a general downward trend for almost all species.

2.4.2. Barriers to a Successful Industry

Though there are many freshwater fish dealer license holders, not many of them are regularly buying, processing, and/or selling freshwater fish for retail or wholesale. In the past 30 years, many fish buyers and processors have closed their businesses, unlike Louisiana's marine fisheries in which the last 30 years has seen expansion and innovation (e.g., Delcambre Direct Seafood and the Louisiana Direct Seafood programs). Nationally, this trend was first observed in

the 1940s and 1950s and attributed at the time to increasing popularity of packaged and frozen fish sold at more general retail outlets, rather than fish markets (Lagler,1956). In Louisiana, this is mostly due to lack of consumer demand and a diminished market (Fig. 2.1.). When adjusting for inflation, average price-per-pound of three finfish species (catfish, gar, and buffalo) gradually decreased after the late 1960s, and steadily dropped in the early 1990s, failing to recover. Simmesport, a town in east-central Louisiana near the confluence of the Red River, Mississippi River, and Atchafalaya River, was historically a top location for freshwater commercial fishing. When discussing with current fish processors about why many have shut down, the usual response is lack of money. The lack of consumer demand may be attributed to the threat of pollutants, including heavy metals such as mercury, that were found across Louisiana in the 1980s and early 1990s. The knowledge that contaminants were present may deter consumers from actively choosing to purchase freshwater fish.

Around the time that prices began dropping for commercial freshwater finfish in Louisiana, catfish farming was gaining traction within the United States. Beginning in Arkansas and Oklahoma in the mid-1960s, the Mississippi River delta quickly became the center of catfish farming in the United States (Hargreaves, 2002). Farmed catfish is often preferable to wild catfish to consumers (Kumar et al. 2008), likely because of the controlled environment where it is raised, and the convenience offered by previously dressed and frozen product (Surenhkal et al. 2017). Similar consumer preferences for farmed fish has been expressed for freshwater trout (Nauman et al. 1995) suggesting that this is a broader trend in personal consumption choices. Moreover, consumers also have more options than in the past, including frozen tilapia and imported Pangasius fish, which occupy increasing market share (sometimes through mislabeling; Bosko et al. 2018) and dominate some markets (Wang et al. 2016; Dey et al. 2017). Some

restaurants prefer purchasing farmed catfish to wild because of their ability to custom order their fish. Restaurants can rely on farms to produce certain sizes, species, and amounts of catfish, compared to the wild catfish fishery which is dependent on the size and amount of catfish harvested by fishermen at a time. The competition with farmed catfish has contributed to the closing of many fish processors, as catfish is the most valuable commercial finfish in Louisiana.

More recently, a new federal rule mandates that any business that participates in the commerce of catfishes, including processing, must be inspected by the Food and Safety Inspection Service (FSIS) which is a branch under the U.S. Department of Agriculture (USDA) (Mandatory Inspection of Fish Rule, 2015). Previously regulated under the Food and Drug Administration (FDA), this new rule, that went into full effect September 1, 2017, brought new inspection standards that required an entire overhaul of fish processing facilities and procedures. Many of the smaller catfish processors were not able to comply with this rule and had to shut down. Within the rule, a major change that is affecting the processors is the need for a USDA inspector to be available during processing times. This means that processors cannot process catfish during the early mornings, evenings, weekends, or federal holidays. This, in turn, affects fishermen, as many fishermen work very early mornings, even on weekends or holidays. There is less time for fishermen to drop off their catch, and less time that processors can actively process the catfish. Another change prevents catfish from being processed alongside other finfish. Fish processors must either process catfish at a different time or have a designated surface for catfish processing only. This requires processors to either choose between processing catfish or other species, or to expand their facility to accommodate this new regulation. Both options may pose financial burdens for the processors. The general closing down of fish houses has created a bottleneck effect within the commercial finfish industry. When there are only a few fish buyers

within a region, this creates competition between fishermen to be able to sell their catch. With limitations on places to sell their catch, and a limitation from processors on how much fish they can process within a day, some fishermen get turned away from the fish buyers after they have harvested their catch. This wastes hundreds of pounds of finfish that cannot be returned to the water, costs fishermen their time and money spent on boat and truck fuel and creates tension between the fishermen and the buyer.

2.4.3. Conclusions and Industry Needs

To further understand the freshwater commercial fisheries in Louisiana, there is a need to fill in the data gaps both economically and ecologically. There are different markets that freshwater fish supply, such as bait, pet food, and human consumption. Learning what each of these markets needs in terms of amounts and species can better inform the fisheries in Louisiana.

Further, analyzing consumer preferences when shopping for seafood and learning the reasons behind their preferences can apprise industry professionals of ways to market their product to be more appealing. Ecologically, there are very few fisheries independent data for all commercially harvested freshwater finfish species. Full stock assessments with distribution, population estimates can help provide fishery managers with relevant data to manage these fisheries in a way that produces the most optimal product. Ultimately, this industry can benefit from a collaboration between academia, extension, and management.

CHAPTER 3. SURVEY OF PRACTICING FRESHWATER COMMERCIAL FISHERMEN IN LOUISIANA

3.1. Introduction

Whereas the fishery includes the fish, the habitat, and the stakeholders, fisheries management is more about managing the users of the resource, as they affect all components of the fishery (McMullin and Pert, 2010; Hunt and Grado, 2010). In addition to having an in-depth understanding of catch and effort, life history traits, and fish population trends, managers must understand the attitudes and behaviors of the fishermen who participate in the fishery, whether recreationally or commercially.

In fisheries, human dimensions data are often collected through different types of surveys. On-site surveys, otherwise known as creel intercept surveys, are given orally to fishermen who are returning from their trips. They typically report catch and effort data about their fishing experience. Mail or telephone surveys are off-site methods that may target specific information about fishermen demographics, experiences, activity, preferences, and satisfaction. Mixed-mode surveying, usually a combination of telephone, email, or mail-in surveys, are another approach when trying to increase response rates (Wallen et al., 2016).

Survey nonresponse has been increasing both internationally and within the United States. This is likely due to refusal to respond. The increase in refusals is often attributed to the phenomenon called “survey fatigue” – an overexposure to the survey process (Porter et al., 2004). Survey length is also a factor in survey fatigue – longer surveys are less frequently completed. Because of this, collecting human dimensions data is becoming more difficult as it increases in importance.

Deciding which method of surveying to use can be difficult. Mail, telephone, and online surveys are often easier and more cost effective when surveying a large population but can suffer

greatly from nonresponse bias (Dillman et al., 2009). In-person surveys are more labor intensive and costly, but have a higher response rate (Maguire, 2009). In-person surveys are also more ideal for smaller populations.

In Louisiana, surveys are regularly used to assess the status of fisheries. Participants in recreational fisheries are frequently surveyed via the LA Creel program (wlf.la.gov/lacreel), which seeks to provide weekly estimates of recreational fish harvests through a combination of interviews at public boat launches (creel surveys) and phone and email surveys. Louisiana Department of Wildlife and Fisheries (LDWF) Office of Fisheries has completed several human dimensions surveys based in both freshwater and saltwater ecosystems, seeking beliefs, concerns, and opinions from user groups within that environment. Most of these surveys were completed using mailings or online surveys.

The commercial freshwater fisheries industry in Louisiana is one that may be improved by the use of human dimensions research. The value of these fisheries is in decline and there are few signs of growth. Because of a general lack of data regarding this industry, the reasons behind this decline are unknown. Anecdotally, it is known that the price per pound of all species have been declining or stagnant since the mid 1970's (Fig. 2.1.). Additionally, a recent regulation requiring all catfish processors to update their facilities and a shift in regulatory authority to the U.S. Department of Agriculture (USDA), rather than the Food and Drug Administration (FDA), has forced some processing facilities to close. Under the new regulation, catfish (Ictaluridae) processors are only able to process catfish during normal weekday hours when an inspector is available (Mandatory Inspection of Fish Rule, 2015). No processing is allowed on weekends or holidays unless processors pay an inspection agent to be present. Further, catfish may not be processed on the same surface as any other species, which had been a common practice in multi-

species fish houses. As catfish are one of the most landed species groups in Louisiana (Fig. 2.7.), these regulations have severely hurt the processing capabilities of fish houses and have subsequently prevented commercial fishermen from landing larger amounts of catfish. With this in mind, my overall goal was to characterize the inland commercial fisheries of Louisiana. To do this, I elected to design and implement a survey of practicing inland commercial fishermen to gather data about the strengths and weaknesses of the industry, common fishing practice, and the opportunity for growth.

3.2. Methods

3.2.1. Fish House and Management Interviews

Before designing the survey for fishermen, I collected preliminary information about inland fisheries to better familiarize ourselves with the industry. First, I consulted LDWF inland fisheries managers around the state and LDWF's Socioeconomic Research and Development Office via informal interviews. In addition to providing recommendations and feedback on survey questions, they provided information regarding where local fish houses were, what the market for freshwater fish was like in their region, and any details they know about the local industry. After speaking with inland managers, I visited fish houses. At the fish houses, I asked an informal set of questions, such as what species they buy and/or process, how many fishermen they buy from, and where they sell their fish. After collecting this preliminary data, I mapped out the various fish houses where I would return to survey local commercial fishermen.

3.2.2. Fishermen Surveys

The survey was presented to practicing inland commercial fishermen as an in-person interview. An interpersonal methodology was selected for several reasons. First, due to the anticipated high likelihood of survey fatigue, I hypothesized that fishermen would be less likely to avoid surveys if approached in person, rather than by mail, email, or telephone. Second, any new concepts or issues with regional colloquialisms within the survey could be explained. I also expected fishermen to expand on answers, and it would be unlikely to capture that in a written survey. Literacy was also a concern that could be avoided with interviews. In addition, I decided to give surveys to fishermen at the location of sale, namely, fish houses. Though in-person surveys (creel) are usually given at fishing access points, there are over 600 boat launches in Louisiana (LOSCO, 2004). Additionally, boat launches can be very remote, and the fishermen are usually focused on getting off the water with little time for any distractions. To narrow my search for commercial fishermen to survey, I decided to conduct the surveys at fish houses where fishermen go to sell their catch. Before surveying, I contacted fish houses and received their permission to survey on their premises. Surveying at fish houses also allowed plenty of time for fishermen to unload their catch, a time-sensitive activity, before answering the questions. This created a low-pressure environment for both the fishermen and the interviewer. Additionally, this helped me target individuals who are active in the freshwater commercial fisheries, as opposed to saltwater fishermen or others who occasionally land a freshwater species.

I trained three interviewers to administer the surveys. All interviewers were instructed to keep the tone of the interview akin to a conversation while keeping a neutral tone and ensuring their personal opinions did not interfere with the survey questions. This was to minimize the occurrence of interviewer bias. However, in-person surveys are especially vulnerable to

interviewer effects as subconscious body language or subtle change in tone can influence the respondent (Cullen, 2005). I accept that there may be a slight impact on responses due to this innate effect.

I chose to use a mix of open-ended and close-ended survey questions. Our close-ended questions were nominal (Dillman et al. 2009) and I included some yes or no questions as filter questions. These questions were better suited for the oral presentation of the survey. They also allowed for respondents to elaborate on any topic that was presented. For this survey, that extra information was helpful considering the ultimate goal of characterizing the inland commercial fisheries.

The survey contained six different constructs focusing on varying attributes of freshwater commercial fishing (Appendix A.1). Construct one, Fishing Activity, contained items relating to catch and effort of the fishermen. This included targeted species, number of fishing trips per week, and gear type. Construct two, Factors Impacting Fishing, included items relating to fishermen's impression of ecological and human activities and how they influence the fisheries. Construct three, Barriers to Success, contained items that assess attitudes of fishermen towards potential hardships within their fishery and concerns about industry survival. Construct four, Outreach and Extension, included items that assess fishermen's openness to outreach and education material aimed to improve the industry. Construct five, Fishermen Information, had items about the fishermen's relationship with the industry, such as how long they have been commercially fishing, as well as other socioeconomic data. Finally, construct six contained basic demographic items, such as age and education. I chose not to include demographic items directly about sex, gender, or race due to the survey audience. Upon examining LDWF's 2013 freshwater commercial fisherman survey (LDWF Office of Fisheries, 2013), I decided to replicate some

questions and compare them between 2013 and present day. The final survey received Louisiana State University Institutional Review Board exemption approval (IRB # E111121) (Appendix A.2).

After surveys were collected, I created a method to code the surveys into an electronic database. For each survey question, there was a corresponding code for all possible answers to that question. When the database was completed with all coded surveys, I was able to look at raw percentages, averages, and medians for each question. Most survey questions were analyzed using descriptive statistics.

3.3. Results

3.3.1. Overview

To collect preliminary data, I visited eleven fish houses around the state and spoke with eight LDWF regional inland fisheries managers. I also met with inland fisheries managers at LDWF headquarters. Subsequently, I gave the survey to practicing commercial freshwater fishermen at nine fish houses around the state from July 2018 until February 2019. Of these nine fish houses, I surveyed more than once at four of them. I had a total of 34 survey respondents. I approached all fishermen that came to a fish house while I was there, and of all fishermen approached, fewer than five declined to participate in the survey. While difficult to measure the number of active freshwater commercial fishermen, according to latest data available from LDWF, there were approximately 940 commercial fishermen who landed at least 1 freshwater species in 2017. Based on this number, I sampled approximately 4% of the commercial freshwater fisherman population (17% margin of error at 95% confidence level).

3.3.2. Demographics

The average age of survey respondents is 56 years, ranging from 25 years to 85 years (Fig. 3.1.). Over half (56%) of respondents had completed high school, while 16% did not attend high school. Nine percent of respondents attended high school but did not graduate, and 9% of respondents went on to complete some college. Six percent of respondents got their GED, and 3% attended trade school. There were no college graduates among the respondents. Almost all (97%) of the respondents were male and 97% of respondents were white. All respondents provided their zip codes which were then sorted into river basin (Fig. 3.2.). Twenty-seven percent of respondents lived within the Vermilion-Teche basin (VTB) while 3% lived within the MSRB, ORB, and Pearl River Basin (PRB). Three percent of respondents also resided out of state.

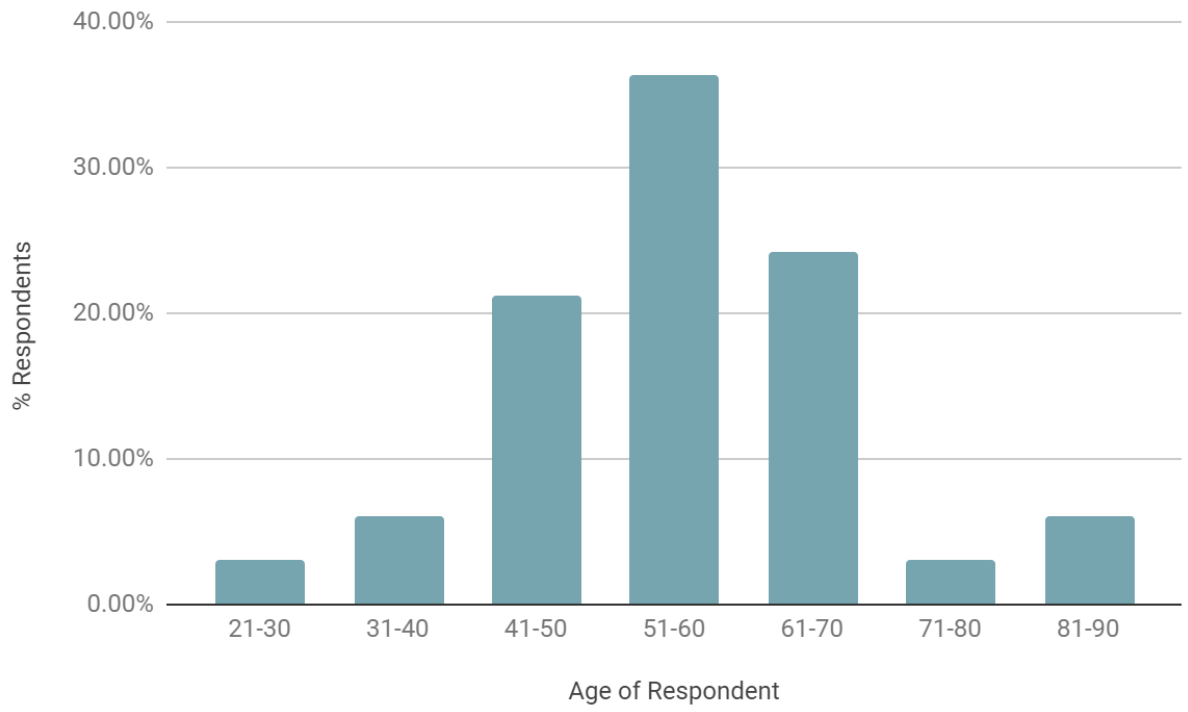

Fig. 3.1. Respondent's age (n= 33).

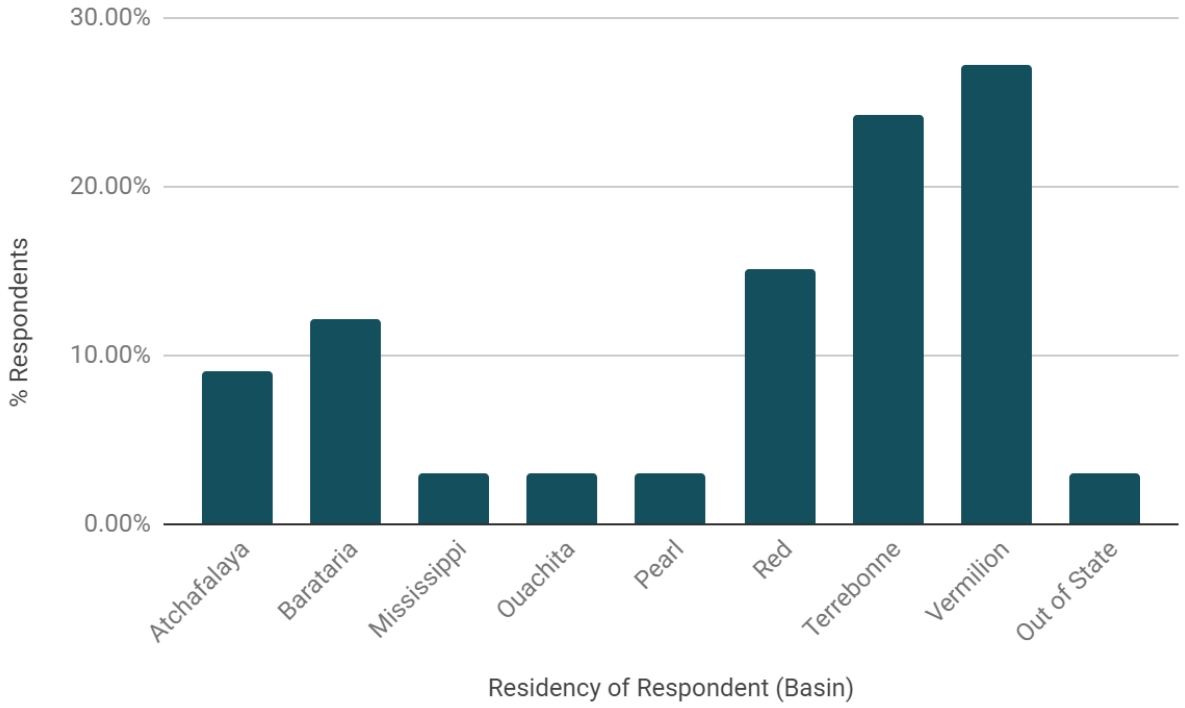

Fig. 3.2. River basin in which respondents reside (n=33).

3.3.3. Fisherman Information

I included items in this survey to better understand the fishermen that comprise the commercial freshwater industry. Under this construct, I included items focusing on retirement plans, whether they fish full-time or part-time, whether they work alone or in groups, and how long they have been a commercial fisherman. On average, respondents worked as a commercial fisherman for 37 yrs., although responses ranged from 2 yrs. to 66 yrs. (Fig. 3.3.). Almost all (98%) of respondents indicated that they do not ever plan on retiring from the industry, while 3% of respondents said they would likely retire within the next 6-10 years. When asked

hypothetically if they would sell their gear when they retired, an item question requested by LDWF, 52% said they would sell their gear and 48% said they would either throw it away or hand it down to a family member. While all of the respondents fish commercially in freshwater systems, 30% indicated that they also fish commercially in saltwater. Over half (58%) of respondents reported that all of their individual income comes from commercial fishing alone, while 42% said they have other forms of income. Of this 42%, 67% of respondents said that the majority of their income is from commercial fishing; the rest is supplemental. Similarly, 34% of respondents said that all of their household income comes directly from commercial fishing, while 62% said it does not. Of that 62%, 67% of respondents indicated that the majority of their household income comes from fishing. When asked whether they captained their own boat, 100% of respondents reported that they do. Additionally, 48.5% fish alone, while 42.5% have one deckhand, 6% have two deckhands, and 3% have three deckhands.

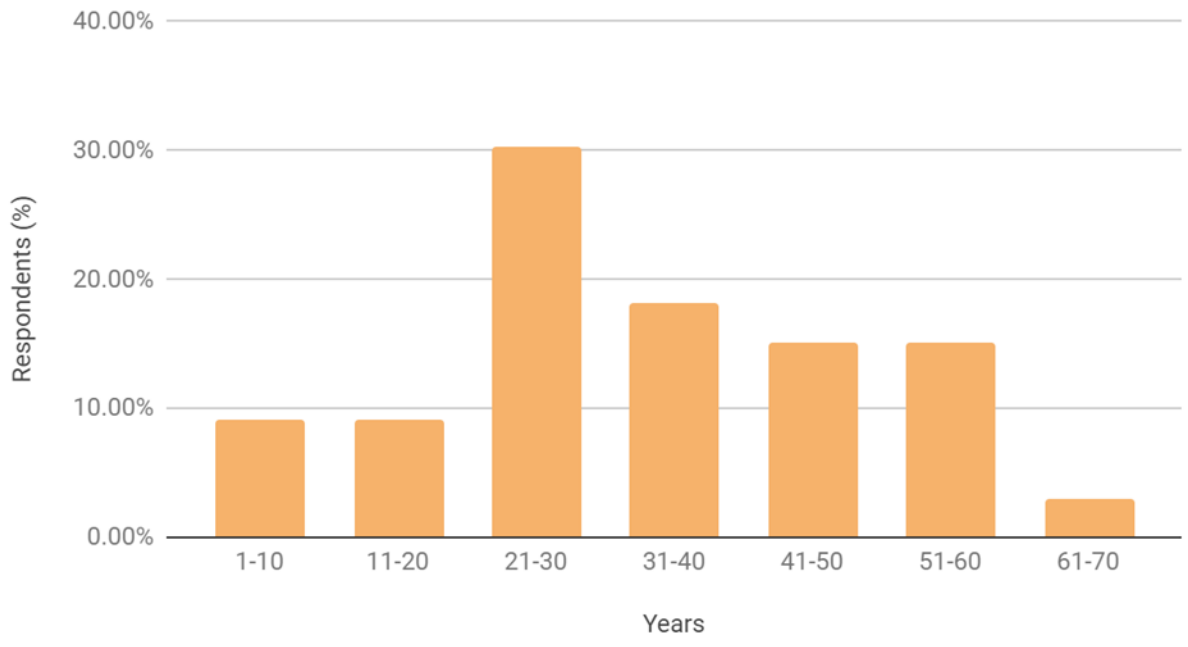

Fig. 3.3. Reported length of time (in years) a respondent has been commercial fishing (n=33).

3.3.4. Fishing Activity

Items one and two in the survey required the respondent to indicate which freshwater commercial species they target when they embark on a fishing trip, and which species they ultimately land onshore after their fishing trip. The subtle difference between these two items aimed to understand if fishermen truly target specific fish species within the freshwater commercial fishing industry, or if fishermen tend to indiscriminately land whichever species they can sell. The vast majority of respondents (70.59%) targeted catfish, specifically blue catfish (*Ictalurus furcatus*) and channel catfish (*Ictalurus punctatus*), and 73.53% indicated that they land them, whether or not they target them. Flathead catfish (*Pylodictis olivaris*) are the second highest targeted species at 55.88%, followed by buffalofish (*Ictiobus* spp.) at 47.06%. The least targeted finfish are grass carp (*Ctenopharyngodon idella*) and bowfin (*Amia calva*), and most non-finfish were either not targeted at all (turtles, 0%), or minimally targeted (alligator and frogs, 5.88%). The percent of respondents who indicate targeting species versus landing them are close, however for almost every species (except frogs), there is a higher percentage of respondents who land species than who target them (Table 3.1.).

Items four and five aimed to quantify fishing effort per each river basin in Louisiana. First, respondents identified the river basin in which they primarily fished, followed by the number of fishing trips they take per week, and the number of pounds they land from each trip on average. The majority of respondents (53%) fished in the Atchafalaya River Basin (ARB), followed by the Red River basin (RRB) (15%), the Mississippi River basin (MSRB) and Barataria basin (BRB) (both 9%), Ouachita River basin (ORB) and Terrebonne basin (TRB) (both 6%) and Lake Pontchartrain basin (LPB) (3%). The number of fishing trips in the ARB was the highest with 73 total trips per week among all respondents with an average of 4 trips per

week (Fig. 3.4.). while LPB was the lowest, with a total of three fishing trips per week and three trips on average Similarly, respondents landed the most fish in the ARB with 5,000 total pounds landed per week and approximately 2,800 pounds landed per trip. Respondents landed the least fish from LPB, with both 600 total pounds per week and total pounds per trip (Fig. 3.5.). Additionally, respondents reported fishing for an average (±SD) of 10.63 ± 2.69 months out of the year.

Table 3.1. Reported freshwater commercial species targeted and landed (n = 34).

	Target	**Land**
Species	**Respondents (%)**	
Blue Catfish (*Ictalurus furcatus*)	70.59	73.53
Bullhead Catfish (*Ameiurus* spp.)	35.29	38.24
Channel Catfish (*Ictalurus punctatus*)	70.59	73.53
Flathead Catfish (*Pylodictis olivaris*)	55.88	61.76
Common Carp (*Cyprinus carpio*)	20.59	20.59
Bighead Carp (*Hypophthalmichthys nobilis*)	14.71	17.65
Grass Carp (*Ctenopharyngodon idella*)	8.82	11.76
Silver Carp (*Hypophthalmichthys molitrix*)	14.71	20.59
Black Carp (*Mylopharyngodon piceus*)	0	2.94
Alligator Gar (*Atractosteus spatula*)	26.47	32.35
Longnose Gar (*Lepisosteus osseus*)	26.47	32.35
Spotted Gar (*Lepisosteus oculatus*)	0	0
Shad (*Dorosoma* spp.)	17.5	17.65
Bowfin (*Amia calva*)	8.82	8.82
Buffalofish (*Ictiobus* spp.)	47.06	50
Freshwater Drum (*Aplodinotus grunniens*)	23.53	29.41
American Eel (*Anguilla rostrata*)	2.94	2.94
American Alligator (*Alligator mississippiensis*)	5.88	5.88
Crawfish (*Procambarus* spp.)	32.35	32.35
Frogs (*Ranidae* spp.)	5.88	2.94
Turtles (*Chelydridae* spp., *Trionychidae* spp., *Emydidae* spp., etc.)	0	0
Other	0	0

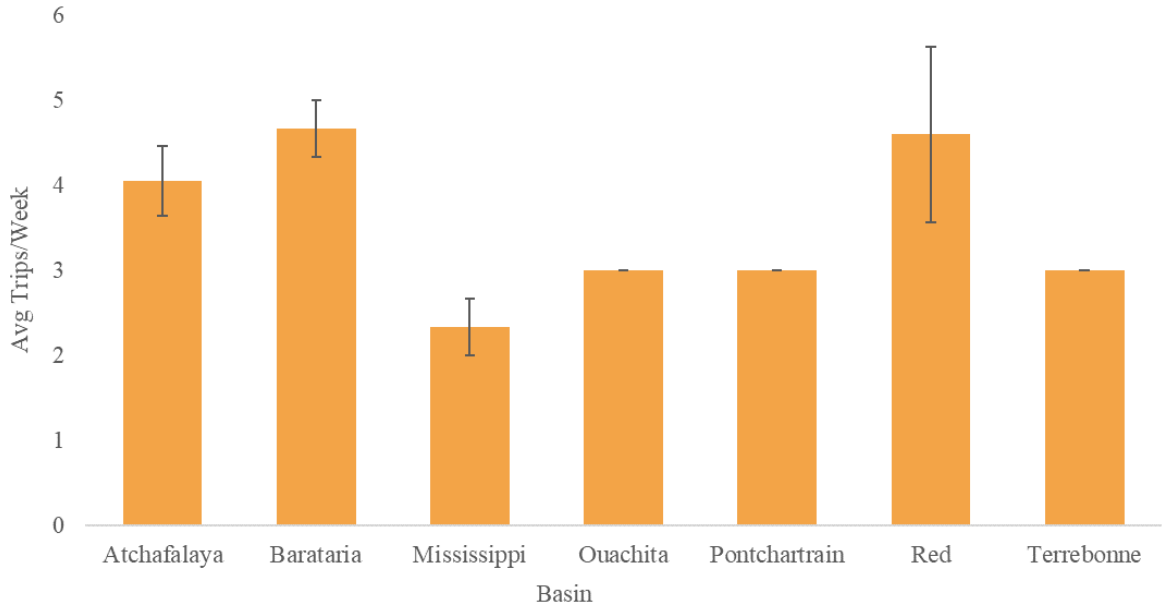

Fig. 3.4. Average trips per week for each river basin with standard error (n= 33).

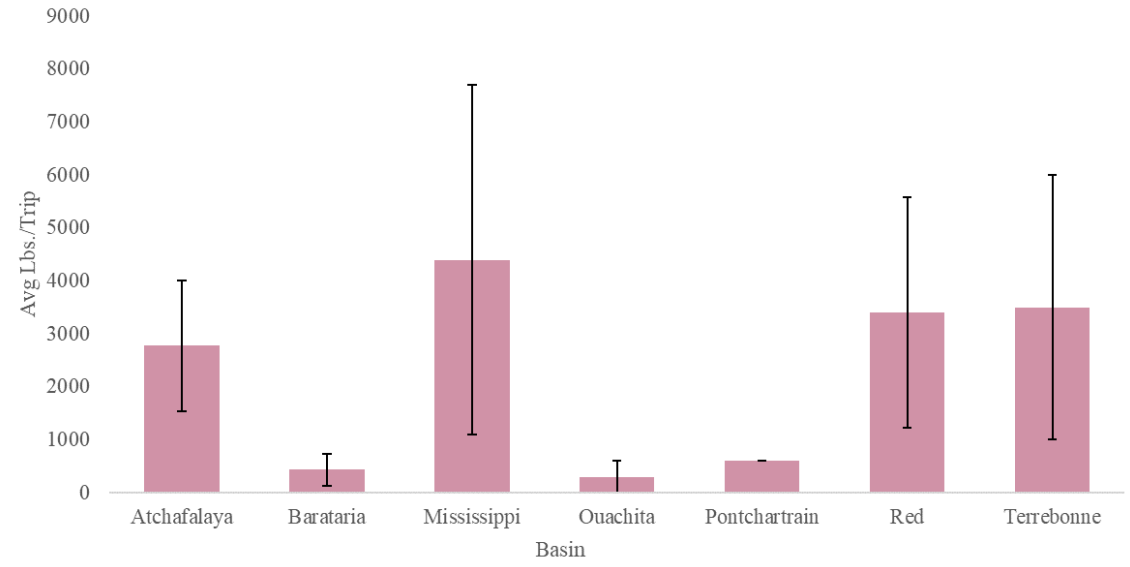

Fig. 3.5. Average pounds landed per trip for each river basin with standard error (n=31).

Items seven and eight referred to the fishing gear used. Hoop nets, gill nets, and trotlines were the most used and least selective gear type. Some gear types, such as shad seines and crawfish traps, are specific to an individual species. Other gear types, such as cans, buckets, pipes, and drums, were less popular among the respondents (Table 3.2.).

Table 3.2. Reported prevalence of gear type use by respondents (n = 34).

Gear Type	Fishermen use (%)	Amount of gear type used (all basins)(Avg ± SD)
Hoop net	70.6%	31 ± 20
Gill net	41.2%	15 ± 9
Shad gill net	2.9%	0
Slat trap	0.00%	0
Vertical hoop net	0.00%	0
Trammel net	2.9%	8 ± 2
Trotline	26.5%	9 ± 4
Shad seine	8.9%	1 ± .2
Minnow trap	0.00%	0
Bow and arrow	0.00%	0
Cans, buckets, pipes, drums	2.9%	300 ± 51
Garfish gig	0.00%	0
Rod and reel	0.00%	0
Wire net	0.00%	0
Jug lines	8.8%	350 ± 91
Crawfish traps	20.6%	364 ± 157

Fishermen use different types of bait depending on the season and their targeted catch (pers. comm. LDWF; McClain et al. (2007), Johnson et al. (2008)). In order to get some rough estimates on expenses, items nine and ten aimed to get a better understanding of the type of bait

most fishermen used, the amount they use, and the average amount of boat fuel they go through per trip. Fish bait, such as menhaden, was the most frequently used bait-type among fishermen, however some respondents prefer not to use any bait (Fig. 3.6.) On average (±SD), respondents used 220.0 ± 188.0 lbs. of bait per trip. For fuel, on average (±SD), respondents used 15.0 ± 11.9 gallons of boat fuel per trip. Considering the highest gas rate in 2018 in Baton Rouge, Louisiana, about $2.62 per gallon (gasbuddy.com), one fishing trip could cost the average respondent $39 in boat fuel alone.

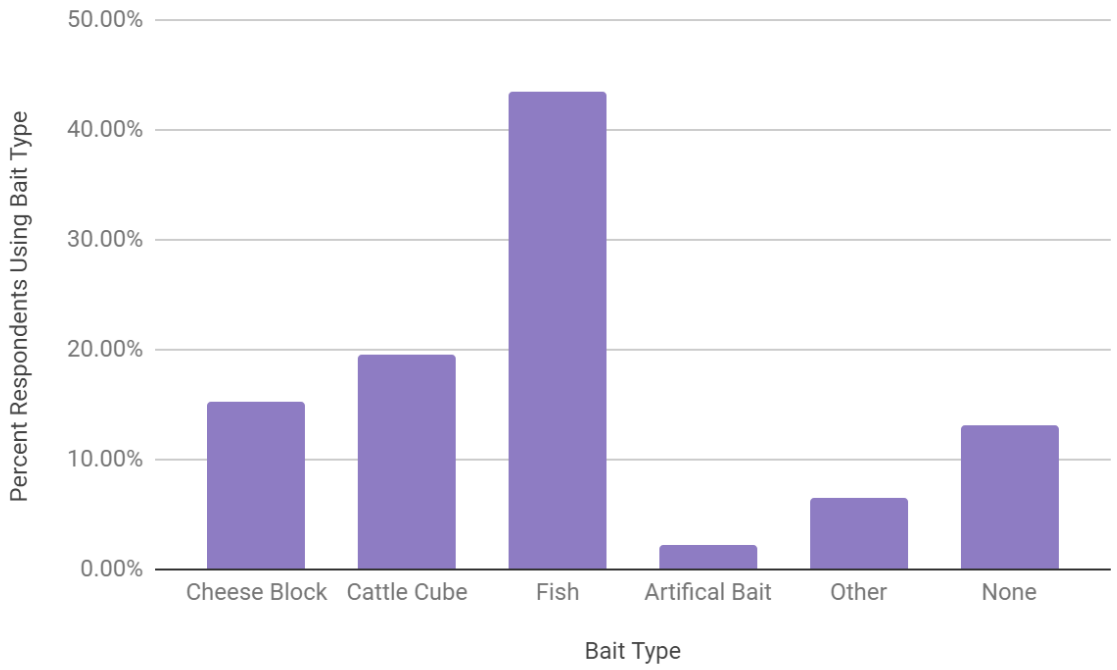

Fig. 3.6. Percent of bait type used by respondents (n=46).

3.3.5. Factors Impacting Fishing

I included two items in the survey that aim to see if fishermen believe either overfishing or, conversely, over-population of fish species is occurring within Louisiana. Only 13% of

respondents indicated that they do believe commercial species are being overharvested in Louisiana (n=31). All of these respondents identified wild crawfish as the overharvested species. Of these respondents, 75% fish in the ARB, while 25% fish in the MSRB; 87% of respondents do not believe overharvesting is occurring.

Conversely, 76% of respondents indicated that they believe their fisheries are overpopulated while 24% do not (n=33). Respondents indicated that catfish (4%), bighead carp (8%), silver carp (52%), alligator (28%), bowfin (4%), and red drum (4%) were the most abundant species they experienced while fishing. When considering the river basin, 68% of the responses came from fishermen who fish within the ARB (Table 3.3.). Of the 68%, most respondents reported alligator as overpopulated (47%), followed closely by silver carp (35%), and then bighead carp, bowfin, and red drum (all 5.9%) (Table 3.4.).

Table 3.3. Respondents' beliefs of species overpopulation by basin (n=33).

Basin	Yes (%)	No (%)
ARB	64.00	25.00
BRB	4.00	25.00
MSRB	8.00	12.50
ORB	4.00	0.00
LPB	0.00	12.50
RRB	16.00	12.50
TRB	4.00	12.50
Total	100.00	100.00

Table 3.4. Respondents' beliefs of overpopulation by species and basin (n=33).

	Species					
	Blue Catfish	Bighead Carp	Silver Carp	Alligator	Other	Bowfin
ARB	0.00%	100.00%	46.15%	100.00%	100.00%	100.00%
BRB	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
MSRB	0.00%	0.00%	7.69%	0.00%	0.00%	0.00%
ORB	0.00%	0.00%	7.69%	0.00%	0.00%	0.00%
RRB	0.00%	0.00%	30.77%	0.00%	0.00%	0.00%
TRB	0.00%	0.00%	7.69%	0.00%	0.00%	0.00%

Fishermen from the RRB accounted for 16% of the responses, and all of them indicated that silver carp was overpopulated. MSRB, ORB, and TRB each accounted for 4% of the responses, and all fishermen from those basins also identified silver carp as the only overpopulated species. Finally, the BRB accounted for 4% of responses, and blue catfish was the species identified as overpopulated.

Environmental changes can provide inherent challenges to the commercial fishery. I included an item that lists several common issues in Louisiana and asked respondents to identify which of these affects their fishing success, and if so, whether they have worsened within the past five years (Table 3.5.). Forty-five percent of respondents indicated that predators, namely alligators, were negatively impacting their fishing success. Some marine species, such as sharks, were also mentioned as predators. Of the respondents that experienced an effect from these environmental factors, about 68% indicated that predators have worsened within the last five years, followed by poor water quality (21%) and habitat loss (5%) (Table 3.5.)

Table 3.5. Respondents reporting being negatively impacted by environmental factors (n = 40).

Factor	Respondents Impacted (%)	Worse in Last 5 yrs. (%)
Poor Water Quality	35.00	26.32
Habitat Loss	7.50	5.26
Coastal Land Loss	7.50	0.00
Predators	45.00	68.42
None	5.00	N/A
Total	100.00	100.00

I included an item that listed several management and restoration activities that commonly occur within or around Louisiana waterbodies in order to determine if effects from these activities impact the commercial fishermen. I asked respondents to indicate which of these affect their fishing success and then if they have worsened within the last five years. Overall, 56% of respondents experienced effects from management and restoration activities. Over one-quarter (27.78%) of these respondents indicated water management projects affect them, followed by regulations and management, drainage, recreational fishing, restoration projects and access (Table 3.6.). Of the respondents that experienced effects from management and restoration factors, about 80% indicated that water management projects have worsened within the last five years, followed by drainage (20%). However, most respondents did not believe that these management and restoration effects were worsening.

Seventy-five percent of the respondents concerned about water management projects fish from the ARB, while 25% fish from BRB. All the respondents concerned about drainage projects fish predominately in the LPB (Table 3.7.).

Table 3.6. Respondents reporting being impacted by management and restoration factors (n=36).

Factor	Respondents Impacted (%)	Worse in Last 5 yrs. (%)
Drainage	8.38	20.00
Restoration Projects	2.78	0.00
Water Mgmt. Projects	27.78	80.00
Recreational Fishing	5.56	0.00
Access	2.78	0.00
Regulations and Management	13.89	0.00
None	38.89	N/A
Total	100.00	100.00

Table 3.7. Respondents reporting management and restoration impacts by basin (n = 36).

Basin	Drainage	Restoration	Water Mgmt.	Rec. Fishing	Access	Regs & Mgmt.	None
ARB	0.00%	0.00%	58.33%	50.00%	0.00%	60.00%	64.29%
BRB	0.00%	0.00%	8.33%	0.00%	0.00%	20.00%	7.14%
MSRB	33.33%	100.00%	8.33%	0.00%	0.00%	0.00%	7.14%
ORB	0.00%	0.00%	0.00%	50.00%	0.00%	0.00%	0.00%
LPB	33.33%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
RRB	33.33%	0.00%	25.00%	0.00%	100.00%	20.00%	7.14%
TRB	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	14.29%

In order to understand the possible impact from invasive species, I asked respondents to identify from a list which are impacting their fishing success, and of those, which have worsened within the last five years. About half (49%) of respondents identified Asian carp in general (not specifying between silver or bighead carp), as a nuisance species. An additional seventeen percent listed silver carp (*Hypophthalmichthys molitrix*) alone, followed by apple snail (*Pomacea maculata)* (10%), giant salvinia (*Salvinia molesta*) (7%), water hyacinth (*Eichhornia crassipes*) (5%), hydrilla (*Hydrilla verticillata*) (2%) and bighead carp (*Hypophthalmichthys nobilis*) (2%) (Table 3.8.). Of these, 39% of respondents identified Asian carp (general) as worsening within the last five years, followed by apple snail (11%), silver carp (8%), giant salvinia (6%), and water hyacinth (3%). Seven percent of survey respondents did not indicate any invasive species as impacting their fishing success.

LDWF requested that I query fishermen as to whether hatching, rearing, and subsequent stocking freshwater game fish impacted their fishing. Upon asking this survey question, sixty-eight percent of respondents said fish hatcheries are not impacting the fisheries, and 16% said they were. Sixteen percent of respondents were either unfamiliar with the hatchery and stocking programs or were not sure whether they were causing an impact.

Table 3.8. Respondents reporting being impacted by invasive species (n=41).

Invasive Species	Respondents Impacted (%)	Worse in Last 5 yrs. (%)
Silver carp (*Hypophthalmichthys molitrix*)	17.07	8.33
Bighead carp (*Hypophthalmichthys nobilis*)	2.44	0.00
Asian carp general (*Hypophthalmichthys* spp.)	48.78	38.89
Apple snail (*Pomacea maculata)*	9.76	11.11
Giant salvinia (*Salvinia molesta*)	7.32	5.56
Water hyacinth (*Eichhornia crassipes*)	4.88	2.78
Hydrilla (*Hydrilla verticillata*)	2.44	0.00
None	7.31	33.33
Total	100.00	100.00

3.3.6. Barriers to Success

In order to identify hardships in the freshwater industry, I asked fishermen about different potential problems. First, I included an item discussing barriers to commercial sales. Given the options of places to sell, distance to place of sale, and market prices, I asked the respondents to identify which of those were preventing them from increased success within their industry. Over half (56.5%) of respondents indicated market prices as a concern, followed by places to sell (26%) and distance to place of sale (13%). Only 4% of respondents did not share any of these commercial concerns (Fig. 3.7.). Of the respondents that indicated market value as a concern, I asked them to identify which species they are concerned about. Sixty-eight percent of respondents said that the market value of all species was concerning to them, followed by crawfish only (20%) and catfish only (12%) (Fig. 3.8.).

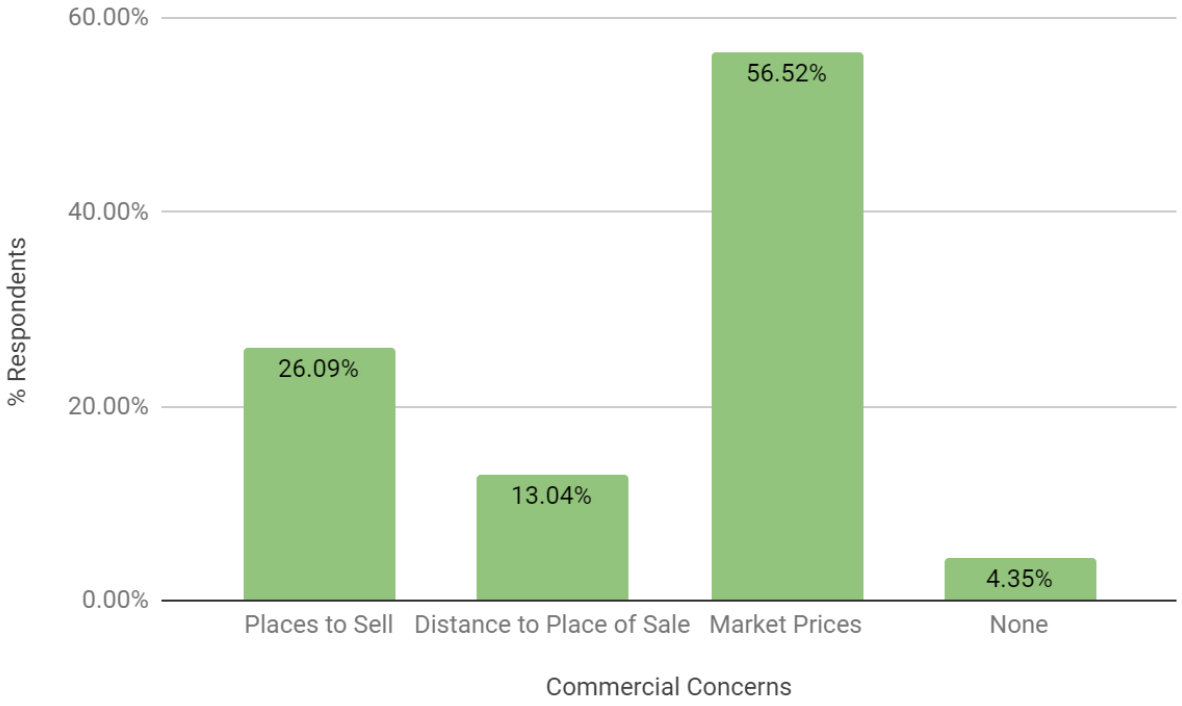

Fig. 3.7. Respondents indicating a concern with certain industry barriers (n= 31).

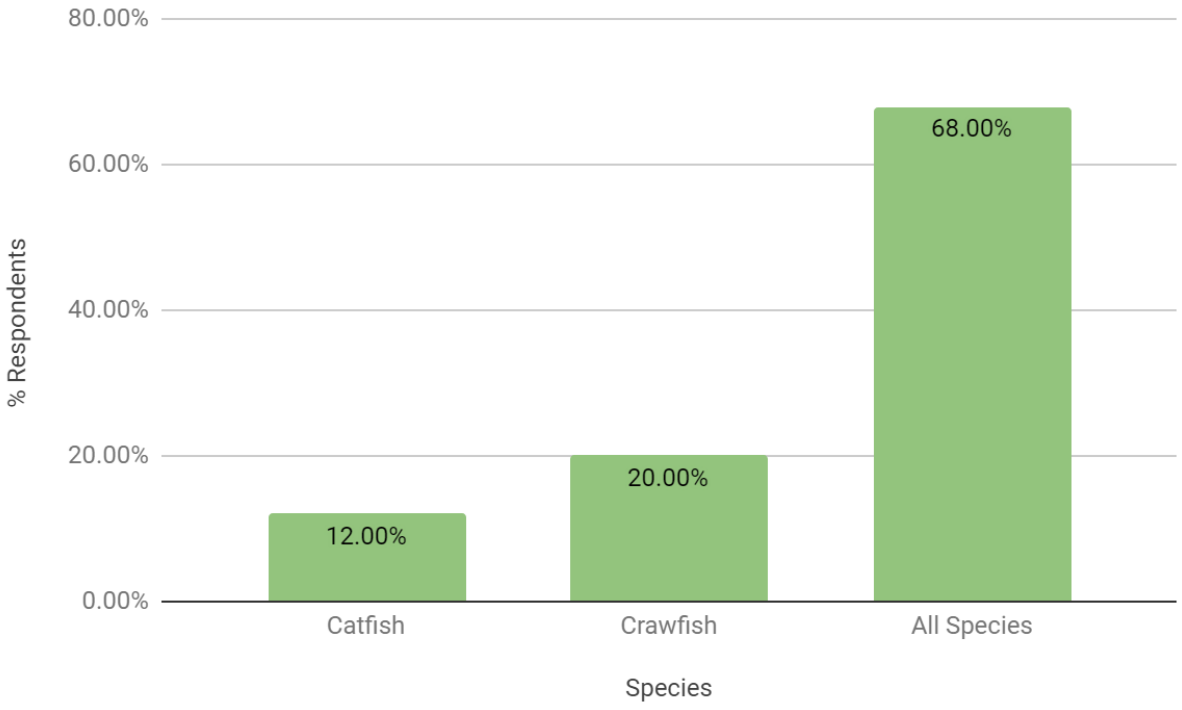

Fig. 3.8. Percent of respondents concerned with market prices of certain freshwater species (n=25).

I asked respondents if they would become a fisherman again if they could start over. Eighty-eight percent of respondents indicated that they would, while 9% said they would not; 3% were not sure. Similarly, I asked respondents if they would encourage their children to become fishermen, knowing the current state of the industry. Seventy-two percent said they would not encourage their children to become fishermen, while 25% said they would. Again, 3% were not sure if they would encourage their children to enter the industry.

3.3.7. Outreach and Extension

This construct included items specifically aimed to understand respondents current use of resources that are already available for them, their engagement in decision making, and their willingness to make changes with the goal of progressing their industry.

I first asked respondents what vessels they use to learn new information about their fisheries. Eighteen percent of respondents interact with LDWF to keep up with information about the fisheries, while 6% use LSU AgExtension, a lobby group, internet resources, or friends and family. Three percent of respondents consult another university for fishery information (Table 3.9.).

Table 3.9. Respondents seeking fishery information from certain outlets (n=30).

	LDWF	AgExtension	University	Lobby Group	Online	Friends/Family
Use (%)	18.18	6.06	3.03	6.06	6.06	6.06
Do not Use (%)	72.73	72.73	75.76	75.76	69.70	69.70

I then asked respondents to indicate whether they have been involved structuring fisheries regulations in any way, including attending regulations meetings, submitting public comment, or

becoming a member of a lobby group of association. Most respondents, 66%, had not been involved in any of these. Eleven percent had been a member of a lobby group or association, 8.5% had submitted a public comment, and about 6% had attending regulations or task force meetings. Three percent of respondents had been involved in all listed options (Table 3.10.).

Table 3.10. Respondents who recently participated the development or influence of fisheries regulations and management (n=32).

	% Respondents Participating
Been a Member of Lobby Group or Association	11.43
Attended Regulations Meeting	5.71
Attended Task Force Meeting	5.71
Submitted a Public Comment	8.57
None of the Above	65.71
All of the Above	2.86

To understand whether fishermen would be interested in learning about ways to improve their industry, I first asked if they would be interested in attending educational workshops. Over half (53%) of respondents indicated they would attend a workshop, while 40% said they would not. Subsequently, I polled the respondents to learn their preferred method of communication concerning outreach and educational material. One-third (34%) of respondents said they would not like to be contacted. Twenty-two percent of respondents indicated that mail-outs were preferred, while 18% of respondents preferred just to attend workshops. Phone calls were preferred by 12% of respondents and emails were selected by 9%. A few respondents, 3%,

preferred to be contacted by texts. Interestingly, no respondents identified social media as their preferred method of contact.

I included a survey item asking the respondents if they would be interested in learning about value added, direct marketing, or alternative species harvest to improve price (Fig. 3.9.). The majority of respondents showed interest in alternative species harvest, followed by value added methods, and finally direct marketing. Some respondents already implement direct marketing and value-added methods into their fishing operation.

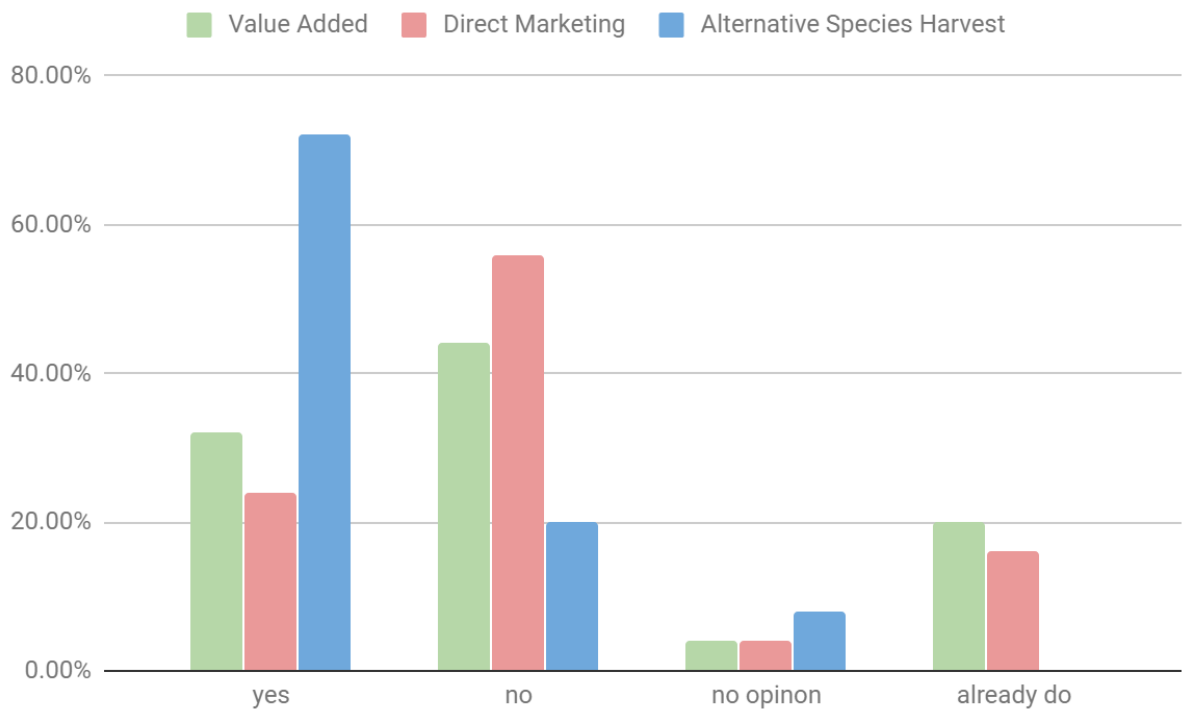

Fig. 3.9. Respondents willingness to learn or participate in new methods to improve the fishery (n=25).

3.4. Discussion

Results of my study help characterize the declining freshwater commercial fisheries in Louisiana. Primarily targeting crawfish, catfish, and buffalo, a wide variety of other finfish, reptiles, and amphibians are caught. Our results corroborated some of the anecdotal evidence, showing a decline in price and aging industry as a potential barrier to success. Additionally, an overpopulation of species such as alligator and Asian carp are posing negative impacts on the success of fishermen. Location and number of fish houses are concentrated to one general area of Louisiana and prevent the easy expansion of the industry into the rest of the state. With this, rising costs of fuel and equipment likely hinder the ability for those across the state to access a fish buyer. These results provide a better understanding of the day-to-day efforts of commercial freshwater fishermen and the environmental, management, and industry-based challenges they face.

3.4.1. Sample size

Our sample size makes up 4% of the population of active freshwater commercial fishermen in Louisiana, however according to Baker and Edwards (2012) the appropriate sample size for in-person surveys is ideally between 12 and 50 individuals. Based on this, the sample size, n=34, is appropriate. Additionally, my goal was to characterize the major, dominant players within the fisheries, not just the fishermen who sell an occasional gar or catfish. For several reasons, the sample size seems appropriate. First, all freshwater fishermen reported by LDWF are those commercial fishermen who reported landing at least one freshwater species within that year. Therefore, if a fisherman fishes predominately in saltwater but happens to catch and sell a garfish, for example, he or she would count as a commercial freshwater fisherman. Given the data, there is no way to determine a threshold between what qualifies as a freshwater fisherman

versus a saltwater fisherman, especially since they do not hold separate licenses. This could inflate the reported amount of practicing commercial freshwater fishermen to an unrealistic number, so likely the 34 surveys represent a much larger portion of the active, primarily freshwater fisheries. Second, my method of surveying is time and labor intensive compared to traditional methods such as phone, mail, or email surveys. Frequently, lengthy visits to fish houses would result in zero contacts with fishermen. Although I made a concerted effort to coordinate with fish houses and visit them on their busiest days, it was not often that they could be sure of when or how many fishermen would arrive. This is indicative of the industry itself. The commercial freshwater industry is less organized and predictable than the saltwater industry. Finally, when consulting with fish houses, most said I had already talked to all of their main commercial fishermen. Given that a few fishermen visit multiple fish houses, these were likely the dominant fishers in the area, supporting my contention that I sampled the active fishermen, rather than occasional fishers.

3.4.2. Fish Houses

Most major fish houses in Louisiana are located near Simmesport, the Atchafalaya River Basin (ARB), or the Gulf Coast (Chapter 2, Fig. 2.3.). I spoke to LDWF inland fisheries managers across the entire state looking for fish houses within each river basin. In the northern and western regions of Louisiana, there were no known fish houses that bought fish directly from fishermen. Some biologists in the west even knew their fishermen drove to Simmesport. Because of this, all my surveying was limited to a small region of the state. Within this area, there were several fish houses that bought and processed as much fish as they could effectively handle, both physically and economically. When discussing with fish houses about their supply chain, each one varied with their responses. Several fish houses shipped out of state but only to

surrounding states such as Texas and Arkansas. Many fish houses had previously shipped product to the west coast but had recently stopped because of cost. Mostly, fish houses sold their product in-state to restaurants or wholesale to grocery store suppliers. In addition, most fish houses had some semblance of a retail store at their location.

Fish houses ranged in size from a five-person operation to tens of employees. Those with larger facilities, a proximity to larger cities like Baton Rouge and New Orleans, and a good working relationship with restaurants were looking for more product to buy and process. Conversely, most fish houses were overworked, understaffed, and struggling to find a steady market for their product. Additionally, the change in catfish regulations to USDA inspection dissuaded fish houses from keeping their businesses open, mostly because of the large structural changes they would have to make to remain compliant. This limited the amount and locations of working fish houses even more, increasing the burden on those that remained open.

3.4.3. Fisherman Information and Demographics

Understanding the stakeholders within this industry helps to elucidate the type of outreach and education material – as well as the format of this material – needed to provide suggestions of industry improvement. Responses from the survey confirmed what I had learned anecdotally: that fishermen are aging out of the industry. The average age of the respondents is 56 years of age, which is slightly higher than the average age of 51 years from LDWF's 2013 survey. According to the U.S. Bureau of Labor Statistics (USBLS, 2017), in 2016 the average age of the labor force was 42 years old, suggesting that freshwater commercial fishermen are 14 years older than the general workforce. Additionally, the survey respondents had reported fishing commercially for 37 years on average, which again is higher than the average of 25 years from the 2013 survey (LDWF Office of Fisheries, 2013). Comparing these results, there is

evidence that very few young fishermen are entering the field. Rather than new people entering to keep the average age and time in the industry constant, both values are increasing. Most of the survey respondents indicated they never plan to retire. This could be a reflection on the low wages that fishermen are earning. They may not earn enough to support themselves through retirement. On the other hand, knowing that 88% of fishermen would choose to do it all over again, it is possible they do not plan to retire simply because they love fishing. Unsurprisingly, 97% of all respondents were male while 3% were female. As a historically male dominated industry, it does not appear to be changing. However, female family members of male fishermen were typically involved in the operation in some capacity, whether it be working as a deckhand or financial management. The majority of respondents completed their high school degree, which suggests they actively chose to enter the freshwater fishing industry instead of pursuing a more stable job. However, commercial fishing was likely considered a stable job when several of the respondents were graduating high school. Some respondents, however, dropped out of school before entering high school; some even dropped out in the third grade. These respondents were likely forced to drop out to help their families fish or go to work and continued to fish even after they reached adulthood.

In an effort to understand whether the survey respondents work full-time or part-time as a commercial fisherman, I asked them if all of their individual income came directly from commercial fishing. I declined to ask them directly if they considered themselves full-time or part-time as that question is ambiguous and difficult to measure. If respondents indicated that all of their individual income was from fishing, then I considered them to be full-time commercial fishermen. Conversely, if their income was supplemented by something else, then I considered them part-time. Of all respondents, 58% were full time and 42% were part time. Some

respondents indicated that commercial fishing was their only occupation, but they receive social security checks as supplemental income. Since I did not ask all respondents where their supplemental income came from, I still categorized these respondents as part time. In 2013, there were approximately 52% full time respondents and 45% part time respondents (LDWF. 2013). Additionally, I was interested in if respondents supported their households solely on their income from commercial fishing. Approximately 34% of respondents reported that all of their household income comes directly from fishing. However, I did not ask how many people reside within their household. Without knowing how much income the respondents earn each year from fishing, it is likely that money is a constraint for them. Having to support multiple people on the income of a fisherman may be an obstacle that they are facing, and likely influences their perception of fair market prices and the ability to retire.

I asked respondents if they were captains of their own boat, to which 100% responded affirmatively. On average, respondents had no deckhands helping with the fishing vessel. Unlike the saltwater industry, there are no fleets in the freshwater industry; each fisherman and his or her deckhand were independent. Boats were typically small; the average vessel size for a freshwater commercial fisherman was 18.4 feet long (LDWF, 2013).

3.4.4. Fishing Activity

Catfishes were the most harvested species, while bowfin, eel, frogs and turtles were the least harvested. This relates directly back to the markets. Fishermen will only land what they can sell. While catfishes and buffalo are the most frequently harvested, they also have a small price tag. One fish house pays only 30 cents per pound for catfish they buy (pers. comm., 2018). Garfish have one of the highest values per pound, which likely explains why they are one of the most frequently landed species as well. However, garfish are notoriously difficult to process, and

fish houses may choose not to buy garfish from fishermen depending on how many they have already purchased and their recent value. Asian carp have a surprisingly high landing rate. Commonly referred to as a "trash fish" by the general public, Asian carp has a few niche markets, specifically within Asian communities. Some fish houses have good relationships with these niche markets and can regularly sell Asian carp. Freshwater commercial fishermen often have a loyalty to a particular fish market, on average selling to 1.4 fish houses. Maintaining these relationships can be beneficial to both the fisherman and the fish house, as the fish house will rely on the fisherman to bring in a certain species or number of pounds, and the fishermen can be guaranteed a paycheck.

The wild crawfish fishery operates a little differently than the freshwater finfish fisheries. Crawfish harvesters will typically only target and land crawfish, and they sell directly to fish houses that work only with crawfish. As crawfish are in high demand in Louisiana, most of the harvest stays in state. It is the most popular and most lucrative commercial freshwater fishery in Louisiana. It is also very seasonal. Even with competition of farmed crawfish, wild crawfish are in high demand. Due to the timing of this survey, I missed the majority of crawfish season and were only able to survey a small handful of crawfish harvesters. However, my focus was the finfish fishermen. Additionally, LDWF completed a crawfish harvesters report in 2011 that characterized this fishery in detail. According to this report, in 2009 there were over 1,000 active wild crawfish harvesters. From results of a survey given to those harvesters, over 90% of respondents reported harvesting their wild crawfish within the ARB. Currently, there is no mandated "season" for harvesting crawfish as it is very weather dependent. Interestingly, in the survey, several of the crawfish harvesters indicated that they believe crawfish is overharvested and part of the solution would be to regulate the crawfish season. According to LDWF's 2011

crawfish harvester report, 45% of survey respondents reported a preference for setting a season for crawfish harvesting.

Alligators are a unique fishery in Louisiana. Alligator harvest is considered a freshwater fishery but is managed by the LDWF wildlife division. Historically, alligators have been used commercially for their hides which are made into leather products with meat as a secondary product. Their harvest was unregulated and in the 1900s, their population began to decline until alligator harvest was closed in the 1960s (LDWF, 2018). After several years of protection, LDWF opened up alligator harvest again statewide in 1981, implementing their wild harvest program. This program provides a quota to commercial harvesters who win the right to harvest alligators via a lottery system. The annual harvest typically takes place during the month of September. In 2016, over 3,000 hunters harvested over 33,600 alligators (LDWF Alligator Harvest Data, 2019). Managing the alligator harvest using a lottery and quota has helped regulate the alligator population while continuing to conserve it. Few of the survey respondents indicated targeting alligators when they fished. However, 45% of respondents indicated that predators were an issue for them when fishing (Table 3.5.). When asked which predators specifically they have trouble with, almost all of them listed alligators as a main predator. Alligators prey upon the fish that are caught in nets, subsequently eating all the fishermen's catch as well as damaging their gear. Skin price has dropped and while 89.5% of tags were filled in 2016, only 59.1% were filled in 2017 as prices dropped (LDWF Alligator Harvest Data, 2019). Several respondents suggested that making alligator seasons longer, or increasing alligator quotas, would ultimately benefit other freshwater fisheries.

3.4.5 River Basins

For all commercial freshwater species, the Atchafalaya River Basin is the most used location to fish. Survey results showed that the ARB had the most fishermen fishing there, the most fishing trips of all basins, and the most pounds landed, compared with all other basins, which corresponds with analysis from trip ticket data (Chapter 2, Figs. 2.5. and 2.6.). The ARB also has the most fish houses of any other river basin. Trip ticket data corresponds to survey responses as well. For all intents and purposes, the ARB is now the hub of Louisiana's freshwater commercial fisheries.

Historically, Simmesport was the most popular area for commercial freshwater fishing activity. As many fish houses have closed in recent decades, only three processors remain in that vicinity. Simmesport, located within the Red River Basin, is also the city with the northernmost fish houses in the state. It still serves as the hub for fishermen from northern or western areas of Louisiana, such as Toledo Bend, who want to sell their catch.

Barataria Basin, which shares a border with the Gulf of Mexico, serves both freshwater and saltwater commercial fishermen. Those who fish within this basin are likely landed species within both habitats. Some respondents reported fishing for catfish solely in Lake Des Allemands which falls within Barataria Basin.

3.4.6. Gear Use and Trip Costs

Hoop nets, gill nets, and trotlines are the most frequently used gear type based on survey responses (Table 3.2.). All of these can be used to catch catfish depending on the time of year. Similarly, hoop nets are often used to target buffalofish. Unlike many saltwater fisheries, most gear used in the freshwater industry are not species-specific. However, shad seines are for

targeting shad, while crawfish traps are exclusively for the harvest of crawfish. Shad seines will catch other fish as bycatch.

Based on boat fuel alone, each fishing trip costs over $39 on average (Ch. 3.3.4.). This is not including truck fuel, bait costs, and gear costs. According to the survey results, the average fishermen takes about 4 trips per week, which is about 208 trips per year if they fish 12 months of the year. This brings the total cost of boat fuel to $7,904 per year. Our survey respondents fished for about 10.63 months on average, bringing their total boat fuel costs to $7,022. Given the relatively low price per pound for most species, this is likely a significant cost to the fishermen. At $0.30 per lb. of catfish, a fisherman must land over 23,000 pounds just to pay for gas. Bait costs can be high depending on the type and amount of bait used. Most fishermen do not use bait for finfish in the springtime, as they say the high water levels keep the fish running. However, in the summer and fall as the water levels decrease, bait is often used to lure fish into nets or near trotlines. Fish bait, such as menhaden, shad, or alewives, are frequently used, especially when harvesting crawfish. For those targeting catfish, cheese blocks or cattle cubes (typical feed for cattle) are often used (Fig. 3.6.). Although fishermen reuse their nets, hooks, and lines as frequently as possible, they will inevitably have to replace nets at some point, whether due to predator destruction, theft, weather events, or time. Replacing nets are costly and time consuming – another added expense that fishermen usually cannot afford.

3.4.7. Environmental Effects

In commercial saltwater fisheries, overfishing is a widely known catastrophe that affects marine environmental systems as well as the seafood market (Jackson et al., 2001). However, it is unknown whether this is also true in commercial freshwater fisheries. As mentioned previously, some crawfish harvesters believe that crawfish are showing signs of overharvesting

and would prefer a regulated season for crawfish harvest. Aside from that, no other fishermen believe that overharvesting is a problem within Louisiana's freshwater fisheries. In fact, more respondents reported that they believe some species are overpopulated, such as catfishes and carp. Overpopulation of fish species is potentially good news for the commercial industry, as populations are likely thriving and could stand being targeted for additional commercial harvest. Ecologically, overpopulation of fish species can be detrimental to the condition of the fish by stunting growth and reducing length-at-age due to increased competition for food and other resources (Ylikarjula et al., 2000). In a study comparing channel catfish in commercially fished and non-commercial fished areas of the Wabash River in Indiana and Illinois, those catfish residing in the commercially fished areas had a higher body condition and an increased growth rate than those in non-commercially fished areas (Willenberg et. al., 2010). Therefore, increasing commercial harvest of overpopulated species in Louisiana may improve growth and condition for individuals within that species. About 6% of survey respondents indicated that they consider red drum (*Sciaenops ocellatus*) to be overpopulated. Red drum is not a freshwater fish species but can be found in brackish areas. This response reinforces my thought that fishermen are fishing for both saltwater and freshwater fish at the same time, and in that time, encountering an abundance of red drum.

Other than predators, water quality was reported by survey respondents to be one of the biggest negative ecological impacts on their fishing success. Runoff from agricultural operations, industrial factories, and large weather events regularly enter the Mississippi River from its headwaters down to the delta (Rabalais et al., 2002). In Louisiana, the Mississippi River reaches a point at Old River Control Structure in Louisiana where it empties a third of its water, and some sediment and nutrients into the Atchafalaya River. Of those respondents that reported water

quality as an issue, 83% of them predominantly fish within the ARB and 17% fish within the Mississippi River Basin. Water quality of the Mississippi River is a major concern to those who fish in its waters. Survey respondents were not overly concerned with pollution, habitat loss, or coastal land loss.

There are several invasive species that reside in or around Louisiana's waterbodies. Silver carp and bighead carp, together referred to as Asian carp, are common, as well as plant species such as giant salvinia, water hyacinth, and hydrilla. Apple snails (*Pomacea maculata)* are a relatively new invasive species that is becoming more prominent in south Louisiana. The majority, 68%, of respondents reported that Asian carp are negatively impacting their fisheries (Table 3.8.). Many respondents reported an increase of incidental catch of Asian carp with no place to sell it. Aside from niche markets mentioned earlier, there is no general market for Asian carp, rendering them useless from a commercial standpoint. Further, Asian carp compete with native species, driving some of them out and potentially impacting the success of other fisheries (Pendleton et al., 2017). While there has been an increase over the last decade in businesses looking to buy and ship frozen carp to Asia, most are not willing to pay enough to the fishermen to bother landing the fish in large quantities (Lively, pers. comm.).

Plant species, such as giant salvinia, water hyacinth, and hydrilla accounted for about 14% of respondents concerns of invasive species. These plants can grow so thick that they completely cover a body of water, blocking out sunlight and decreasing oxygen concentrations, killing the fish species that live there. From a commercial standpoint, these plants can clog fishing nets and prevent access into the water (Oliver, 1993). All (100%) of respondents that reported invasive plants as having a negative impact on their fishing success primarily fish within the ARB, suggesting that these species may be having more an impact there.

The apple snail is notorious for its negative effects on natural habitats and agricultural areas, even in its home range in southeast Asia (Rawlings et al., 2007). They have the potential to significantly change freshwater ecosystems in both structure and function. They are predominantly threatening to rice fields, of which there are many in south Louisiana. Approximately 10% of survey respondents indicated being impacted by apple snail. It is not clear to what extent the apple snail is harming their fishing success, however just by learning about the invasive may have fishermen on alert.

3.4.8. Management and Restoration Effects

When presented with several management and restoration factors that are common in Louisiana, 28% of respondents reported that water management projects were negatively affecting their fishing success (Table 3.6.). Most fishermen cited drawdowns within the ARB as a negative effect, however some fishermen believed that drawdowns were in fact helping their fishing success. Their experience was that it is easier to catch fish in shallow water. Fourteen percent of respondents were concerned by regulations and management of the freshwater fisheries. Approximately 39% of all respondents had no issues with these factors occurring within Louisiana, suggesting that they were unaffected or unaware by factors presented to them.

3.4.9. Barriers to Success

The survey results suggest that most commercial fishermen are unhappy with market prices of all freshwater species. As the average price per pound for freshwater finfish has steadily decreased in the last 30 years, this result is unsurprising (Chapter 2, Fig. 2.2.). Interestingly, survey respondents are not as concerned with the number of places available to sell their catch or how far they have to travel to sell. Because commercial fishermen only sell their catch to 1.4 fish houses on average, this suggests that they form relationships with one or two fish houses and

regularly sell their catch there. Many fishermen are usually able to sell their catch; the problem lies within the price at which they can sell, which is determined by the fish houses. Further, the survey area covered only part of Louisiana where there were abundant fish houses. Most fishermen I surveyed live within proximity to at least one fish house (Chapter 2, Fig. 2.3.), where distance to place of sale would not pose a great problem. However, I know some are driving several hours to sell their catch.

When discussing their decisions to enter the field of commercial fishing, 88% of respondents said that they would choose their same career path if they had a chance to start over. This lends itself to the pride fishermen take in their work. Many respondents expressed genuine interest in their work, and their long laborious days are evidence of that. However, when asked if they would encourage their children to make the same decision, 72% of respondents said they would not. Fishermen are aware that their profession is currently economically unsustainable. They have come to terms with their choice but would encourage their children pursue another path.

3.4.10. Outreach and Extension

Louisiana Sea Grant (LASG) and LSU AgCenter (LSUAG) work to identify potential problems within Louisiana's local fisheries and present education and outreach material to help improve these industries. Commercial freshwater fishermen are typically not as connected to local organizations and state agencies as other industries are. The industry has not historically been the center of LDWF's attention, which originally started as the Oyster Commission. With little focus, commercial fishermen have had to be independent when it comes to obtaining, updated information about their fisheries. When asked if they used any outside sources to help inform their fishing success, most survey respondents said they did not use any (Table 3.9.). Of

those that did use other sources, most of them used LDWF, either through encounters with state agents or by looking up information online. In addition, commercial freshwater fishermen are not particularly involved in their industry at the local or state level. Approximately 66% of all respondents had never attended a regulations meeting, task force meeting, or submitted a public comment. This is higher than reported participation by marine recreational anglers (54%) (Crandall et al., 2019). The difference in participation is notable given that commercial fishermen rely on the fisheries for their livelihood, while recreational anglers do not, yet still participate more in regulations and management roles. It is unclear whether respondents choose not to attend these meetings, or if they are unaware of any that occur.

When asked if survey respondents would be interested in attending educational workshops aiming to present information about the fisheries, about 50% of respondents said they would. Those that said they would not be interested mostly cited lack of time as a reason they would not attend. Though I did not include a specific topic for workshops in this survey, workshops could range from information on invasive species to how to use ice to keep their product fresh, among other topics. Most survey respondents reported that they would prefer receiving mailouts to communicate, followed by phone calls and emails. No respondents indicated social media as a preferred method of communication. Their lack of participation in social media may be a function of the age of most respondents, or a general lack of time to log-on to social media accounts, or both.

Louisiana Sea Grant and Louisiana AgCenter have begun successful initiatives within the commercial saltwater fisheries to reduce dependency on commodity pricing. Of these, value-added techniques and direct marketing are programs that have been developed and implemented. Value-added techniques are small changes within harvest and post-harvest practices that can

increase the value of a product. An example of this is vacuum-packing fish fillets once they are processed. This increases their shelf life. In return, the price of this product is more than it would be if it were not vacuum-packed. The idea is that these small changes would benefit both the processors and the fishermen. Direct marketing is a method where the fishermen or processors by-passes part of the supply chain and sell their product directly to the consumers. Without the mark up at each step of the supply chain, fishermen will automatically earn more money. Combining direct marketing with value-added techniques can improve the price of the product. Within the survey, I polled respondents to see if they would be open to learning about these techniques in the freshwater fishing industry. I included an item asking if respondents would be interested in alternative species harvest, knowing that many species are not harvested to the full population potential. While interest in alternative species harvest was high (72%), fewer respondents were interested in vacuum packing or direct marketing. Again, most respondents cited not having enough time to learn and implement a new task in addition to fishing. However, there was a possible bias in the question about direct marketing. As the survey took place at fish houses, respondents might not have been comfortable answering that question as they were currently selling their catch to a buyer.

3.4.11. Opportunities and Needs

The commercial freshwater fisheries in Louisiana provide employment to many and contribute substantially to the state's economy. Despite this, the freshwater fisheries have operated in relative obscurity, likely due to the more prominent constituents that fish recreationally and lack of overfishing concerns. However, from the results of the survey, there are several areas of improvement that may benefit this industry and prevent it from declining past its tipping point.

Engaging practicing freshwater commercial fishermen is the first step towards making change. If participants do not have the motivation or will to help improve the fisheries, then it is unlikely they will thrive. Creating educational material that explains why their product is not increasing in price can lead to action within the community. Providing simple paths to communicate with decision-makers within the industry can be helpful as well. The survey respondents had a lot of ideas, knowledge, and opinions about the freshwater fisheries that are worthy of being discussed. Many fishermen mentioned lack of time as a barrier to participation. Offering straightforward, local, and frequent educational and outreach events may be the easiest way to earn their attention.

Providing fishermen with new methods to increase the value of their product, again, would be helpful. However, gaining trust from the fishermen is an obstacle in and of itself. Beginning with small improvements, such as the use of ice when traveling from boat launch to fish house, could trigger larger more substantive changes in the future.

Although the closure of local fish houses is not a new phenomenon (Lagler 1965), opening more fish houses around the state could create markets in areas where none exist, such as in northern and western Louisiana. Though number of places to sell their catch was not a top industry concern for the survey respondents, there may be an untapped market in areas of the state where commercial freshwater fishing does not exist. In addition, both the new catfish law and alligator harvest rates are potentially detrimental for the industry. Bringing this to the attention of managers and policy makers could shed some light on how these policies affect other industries.

There is a general lack of scientific data for the freshwater fisheries. Most of the inland fisheries independent data collection is focused on gamefish rather than commercial species

because of the perceived greater stakeholder interest and economic value. Shifting the focus to the commercial species will provide a breadth of data could potentially improve this industry as well.

Overall, this industry needs a robust market. Consumer demand is what will ultimately perpetuate the success of the fisheries. As consumers are becoming more educated about their food choices, fishermen and fish processors need to adjust their methods to appease the market they are catering to. The fish are abundant, the fishermen are hardworking, and the processors are looking for a reason to stay open. The opportunities are there, but the market is lacking. An in-depth market analysis could further elucidate the steps that the commercial freshwater industry needs to take to stay afloat in Louisiana.

APPENDIX. CHAPTER 3 SUPPLEMENTARY MATERIAL

1. Fisherman Survey

DATE: INVESTIGATOR INITIALS:
LOCATION:

Survey of Freshwater Commercial Fishermen

FISHING ACTIVITY

1. In a typical trip, what species do you:

	Target	*Land*	*Catch*
CATFISH			
Blue			
Bullhead (mudcat)			
Channel (eelcat)			
Flathead (goujon, yellow cat)			
CARP			
Common (German)			
Bighead			
Grass			
Silver (Asian)			
Black			
GAR			
Alligator			
Longnose			
Spotted			
SHAD			
BOWFIN *(choupique or grinnell)*			
BUFFALO			
FRESHWATER DRUM *(gaspergou/gou)*			
EEL			
NON-FINFISH			
Alligator			
Crawfish			
Frogs			
Frog Species			
Turtles			
Turtle Species			
OTHER			

2. In a typical year, in which river basin do you take most of your fishing trips?

3. In a typical week:

a. How many commercial fishing trips do you take?

b. How many pounds do you land?

c. How many places do you sell your catch to (incl. fish houses/ any direct sales)?

4. How many months of the year do you fish commercially?

5. In a typical year, what type of fishing gear do you use?

Gear Type		*Avg number per trip*
Hoop net		
Gill net		
Shad gill net		
Slat trap		
Vertical hoop net		
Trammel net		
Trotline		
Shad seine		
Minnow Trap		
Bow and Arrow		
Cans, buckets, pipes, drums		
Garfish gig		
Rod and reel		
Wire net		
Other:		

6. What type of bait do you most often use?

☐ Artificial
- ☐ Bought
- ☐ Homemade

☐ Cheese block
- ☐ Bought
- ☐ Homemade

☐ Soy/corn block
- ☐ Bought
- ☐ Homemade

☐ Fish

☐ Other

7. In a typical trip:

How much bait do you use (in lbs.)?

How much boat fuel do you use (in gallons)?

ECOLOGICAL FACTORS

8. Have you noticed areas of:

a.

	Y	N
Overpopulation of individual species		
Over-harvested species		

b. If yes:

Species name: _____

Body of water: _____

9.

a. Which of the following do you think is negatively impacting the commercial fishery?

- ☐ Pollution
- ☐ Loss of habitat
- ☐ Poor water quality
- ☐ Coastal land loss
- ☐ Predators
- ☐ None of the above

b. Of the selected, which have gotten worse in the last 5 years?

10.

a. Which of the following are negatively impacting the commercial fishery?

- ☐ Drainage
- ☐ Restoration
- ☐ Water management projects
- ☐ Recreational fishing
- ☐ Access
- ☐ Regulations and management
- ☐ None of the above

b. Of the selected, which have gotten worse in the last 5 years?

11.

a. Which of these invasive species are negatively impacting your commercial fishing operation? (Photos available)

- ☐ Asian Carp
  - ☐ Silver Carp
  - ☐ Bighead Carp
- ☐ Giant Salvinia
- ☐ Water Hyacinth
- ☐ Apple Snail
- ☐ Hydrilla
- ☐ Nutria Rat
- ☐ None of the above

b. Of the selected, which have gotten worse in the last 5 years?

12. Do you think fish hatcheries/stocking are having an impact on the commercial fishery?

- ☐ Yes
- ☐ No
- ☐ Don't know

COMMERCIAL FACTORS

13. Of the following, which is a concern to you as a commercial fisherman?
    - ☐ Number of fish houses / places to sell
    - ☐ Distance to place of sale
    - ☐ Market prices
        - Which species?

SOCIAL FACTORS

14. If you could go back in time, would you choose to be a freshwater commercial fisherman again?

- ☐ Yes
- ☐ No
- ☐ Not sure

15. If you have children, would you encourage them to be freshwater commercial fishermen?

- ☐ Yes
- ☐ No
- ☐ Not sure

16. In how many years do you plan on retiring / leaving the freshwater commercial fishing industry?

17. When you retire/leave, do you plan to sell your gear?
    - ☐ Yes
    - ☐ No

18. Of the following:

a. Which do you use to get information about the fishery? (regulations, gear, bait, etc.)
b. Do you trust each of the following sources for accurate information?

	USE?	*TRUST?*
	Y/N	Y/N
LDWF		
University Extension (AgCenter/Sea Grant)		
University/College		
Lobby Group/ Nonprofit /Association		
Online		
Friends and Family		

19. In the last 5 years, have you:

- ☐ Been a member of lobbying group or association
- ☐ Attended a regulations meeting (including Commission meeting)
- ☐ Attended a task force meeting
- ☐ Submitted a public comment (either through letter writing, phone calls, or email)
- ☐ None of the above

20. Do you think LDWF has a positive view of commercial fishing in your area?

- ☐ Yes
- ☐ No
- ☐ No opinion

21. Which of the following regulations are negatively affecting your fishing success?

- ☐ Gear Restrictions
- ☐ Size Limits
- ☐ Permit Fees
- ☐ Other:

22. Would you like to see more workshops / educational opportunities about the fishery in your area?

- ☐ Yes
- ☐ No
- ☐ No opinion

23. How would you like to get new information? (regulation changes, events, new products, research)

- ☐ Workshops
- ☐ Mail-outs
- ☐ Emails
- ☐ Social Media
- ☐ Texts
- ☐ Other: _____

24. Are you interested in learning more about the following ways to increase your price?

	Yes	No	No opinion/Don't know
Value Added (i.e. vacuum packing yourself)			
Direct Marketing (i.e. selling directly to consumers)			
Alternate Species Harvest			

<u>FISHERMAN INFORMATION</u>

25. Do you catch saltwater fish commercially?

- ☐ Yes
- ☐ No

26. Do you catch freshwater fish commercially?

- ☐ Yes
- ☐ No

27.

a. Does all your current individual income come from commercial fishing?

b. If not, is the majority from fishing?

28.

a. Does all your current household income come from commercial fishing?

b. If not, is the majority from fishing?

29.

a. Do you run your own boat or are you a deckhand/crewmember?

- ☐ Run own boat
- ☐ Deckhand/crewmember

b. If you run your own boat, how many deckhands / crewmembers do you have?

30. How long have you been a commercial fisherman?

_____Number of years / Year started

<u>DEMOGRAPHICS</u>

31. What is your current age?

32. What is your home zip code?

33. What is the highest level of education you have completed?

Audio Recorder #: _____ **Audio File #: _____**

2. IRB Exemption Approval

ACTION ON EXEMPTION APPROVAL REQUEST

Institutional Review Board
Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu
lsu.edu/research

TO: Julie Lively
Renewable Natural Resources

FROM: Dennis Landin
Chair, Institutional Review Board

DATE: July 10, 2018

RE: **IRB#** E11121

TITLE: Characterizing the Freshwater Commercial Fishery of Louisiana

New Protocol/Modification/Continuation: New Protocol

Review Date: 7/9/2018

Approved X **Disapproved**

Approval Date: 7/10/2018 **Approval Expiration Date:** 7/9/2021

Exemption Category/Paragraph: 2a,b

Signed Consent Waived?: Yes for online; No for in person

Re-review frequency: (three years unless otherwise stated)

LSU Proposal Number (if applicable):

Protocol Matches Scope of Work in Grant proposal: (if applicable)

By: Dennis Landin, Chairman

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc. Approvals will automatically be closed by the IRB on the expiration date unless the PI requests a continuation.**

* *All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

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VITA

Lauren Elizabeth Bonatakis grew up in South Hadley, Massachusetts and graduated from South Hadley High School in 2009. She attended Simmons College (now Simmons University) in Boston, Massachusetts and graduated in 2013 with a Bachelor of Science in both Biology and Environmental Science, as well as a minor in Chemistry. She then worked as a research assistant at Vanderbilt University Medical Center in Nashville, Tennessee from 2013 until 2015. Subsequently, she served one 11-month term in AmeriCorps Cape Cod in Wellfleet, Massachusetts from 2015 to 2016, and one 11-month term in MassLIFT (now TerraCorps), another AmeriCorps program, in Athol, Massachusetts, from 2016 to 2017.

Lauren began her studies at Louisiana State University in 2017 in pursuit of a Master of Science degree in Renewable Natural Resources with an area of concentration in Aquaculture and Fisheries under the supervision of Dr. Julie Lively. Upon completion of her master's degree, she will work as a marine policy fellow through the Sea Grant Knauss Fellowship Program in Washington DC.