QUALITATIVE ASSESSMENT OF THE IMPACTS OF MARINE DEBRIS ON MISSISSIPPI COMMERCIAL SHRIMPING

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INTRODUCTION

The commercial fishing industry is an economic and cultural driver along many coastlines. In the relatively small US State of Mississippi alone, commercial fishing generated total economic impacts amounting to $107 million and created almost 2,000 jobs (National Marine Fisheries Service, 2017). However, this industry is subjected to a variety of short- and long-term stressors that decreases its resilience. Hurricanes, degrading water quality, climate change, and an aging workforce (i.e., limited recruitment of young fishermen) are just some of these stressors (Cheung et al., 2012,, Geary et al., 2011, Petterson et al., 2006, Posadas, 2018, VanderKooy, 2012).

Marine debris is another potential stressor on this industry. Marine debris is known to have significant economic and environmental impacts from an ecosystem service or tourism perspective (Beaumont et al., 2020, Anderson and Alford 2013, Legget et al., 2018). However, the impacts of marine debris on other sectors, such as commercial fishing, are relatively unknown (McIlgorm et al., 2011). In the fisheries sector, the direct impacts of marine debris encounters, include repair and replacement of fishing gear lost or damaged, loss of fishing time, and loss of earnings (Newman et al., 2015); however, these have only been analyzed in a couple localized fisheries. Poor stewardship, inclement weather, poor fishing practices, and lack of convenient gear disposal infrastructure contribute to an ever-increasing influx of marine debris (Matthews and Glazer, 2010). As marine debris levels continue to grow worldwide, defining localized sources, composition, and distribution of debris, as well as potential effects, becomes increasingly important (Keller et al., 2010).

A specific type of fishing that is particularly susceptible to marine debris impacts is trawl shrimping. The two primary types of trawls used in Mississippi are otter and skimmer trawls. Otter trawls are towed directly behind the boat, while skimmer trawls are mounted on a frame and pushed along beside the boat. As shrimpers tow (otter) or push (skimmer) nets, marine debris can get caught in the net, which has the potential to cause substantial losses in catch and time dealing with marine debris as well as direct damage to vessels and fishing gear. Anecdotally, shrimpers in Mississippi and other locations have expressed frequent marine debris encounters and significant potential direct impacts to the commercial shrimping industry. However, the frequency of encounters, common types and potential impacts of marine debris on the local commercial shrimping industry hasn't been assessed. Therefore, this study attempts to address some of these knowledge gaps through a qualitative assessment of the perceived prevalence, types, and impacts of marine debris on the commercial shrimping industry in Mississippi.

MATERIALS & METHODS

Primary data collection

The perceived direct impacts of marine debris on commercial fishing were estimated using a one-time end-of-the-season-survey conducted in December 2018.

There was both an English and Vietnamese version of the survey. Survey participants provided information about the captains and crew, the fishing vessels/boats, fishing gear, the perceived direct impacts of marine debris, and associated damages to commercial shrimping operations. Most of this information was collected during a Mississippi commercial shrimpers workshop on December 5, 2018. During this workshop, shrimpers completed the survey, registered for marine debris data collection and removal programs (e.g., derelict crab trap and direct measurements of marine debris impacts programs), and were provided materials for the programs they signed up for. Later, more shrimpers participated in the survey through distribution by industry leaders. The survey solicited the following information about shrimp commercial fishing activities in the year 2018. A list of the specific data request is shown below, and the full survey instrument is included in Appendix 1.

- Commercial shrimp license (Yes or No)
- Boat/Vessel length (in feet)
- Type of gear (otter trawl, skimmer trawl, etc.)
- County of residence (Hancock, Harrison, or Jackson County, MS)
- Number of shrimping trips per month (#)
- Size of crew (# of crew members including captain)
- States in which you shrimped (Mississippi, Louisiana, Alabama, etc.)
- Impacts of marine debris on commercial shrimping (Yes or No)
- Types of marine debris caught (Select from list of common items)
- Frequency of marine debris (How often was marine debis encountered)
- Damages due to marine debris (net, boat, motor, etc.)
- Effects of marine debris (lost fishing time, direct damages, etc.)

Statistical analysis

The perceived impacts, types, and damages associated with marine debris caught by the participating captains or owners of shrimping boats or vessels were compared by characteristics of fishermen and fishing units, county location, gear type, and fishing effort. Chi-square tests were performed on the following responses of captains or owners of fishing units:

- Overall perceptions of marine debris impacts.
- Overall frequency of marine debris encounters.
- Encounters by fishing units for each type of marine debris caught
- Perceived damages of marine debris for each type of fishing asset.
- Perceived impacts of marine debris for each type of effect.

Three logit regression equations for the following dependent variables were estimated using Stata 16 (StataCorp, College Station, TX):

- Type of marine debris caught
- Perceived damages of marine debris on fishing assets
- Perceived impacts of marine debris on commercial fishing

The logit equations' independent variables were county location, fishing gear, boat length, and the number of fishing trips. The empirical models were estimated by using the Logit procedure. The robust variance procedure calculated the Logit models in Stata 16 (StataCorp, College Station, TX). Precise calculations of the sample-to-sample variations of the parameter estimates are attained with the robust variance procedure (Rogers, 1993; Williams, 2000). The variance inflation factor (VIF) was calculated using the VIF procedure in Stata 16 to detect the possible presence of multicollinearity. The marginal impacts of the independent variables on computer usage were computed by using the margins procedure of Stata 16.

RESULTS AND DISCUSSION

Commercial fishing units, gear, crew, and effort

A total of 44 Mississippi commercial shrimpers responded, which corresponds to about 11% of the registered fleet in Mississippi. Of those participants 64% completed the survey in English and 36% in Vietnamese. There were 17 (39%) shrimpers each from Jackson and Harrison counties and 10 (23%) shrimpers from Hancock that participated in the survey. Many of these shrimpers were also licensed to commercially harvest oysters (41%), blue crabs (45%), food fish (16%), and baitfish (7%). Earlier surveys of all licensed Mississippi commercial fishermen have shown that a typical commercial fishing boat is licensed to harvest at least two species (Posadas, 2008; 2015).

The shrimping boats/vessels used by the participating commercial shrimpers ranged from 21 to 71 feet long with an average size of 45 feet. This average vessel size was similar across all three Mississippi coastal counties. Gear used by participating fishermen were otter-trawls and skimmer nets. There were no significant differences in the percent of commercial shrimpers using skimmer nets in the three coastal Mississippi counties. Approximately 70% of the participating shrimpers reported using skimmer nets and 57% using otter trawls. Of the 70% using skimmer nets, 40% used skimmer nets only while 30% were also using otter-trawls. Of the 57% using otter-trawls, 28% used otter-trawls only, while 2% also used skimmer nets. Participating shrimp boats/vessel was operated by the boat captain and one crew member (average crew size of 2.11 ± 1 SD of 0.61). The county location and fishing gear type did not significantly affect the number of crew members in each boat/vessel. However, larger boats/vessels were operated by a captain and more than one crew member.

Participating shrimpers were asked to report their number of monthly shrimping trips in 2018. A few shrimping trips were reported in January, February, March, and April, but the most effort was between May and December (Figure 1). The May-August period corresponds to the opening of brown shrimping season in nearshore waters (Posadas, 2020a), whereas the August-December time period corresponds with white shrimping season (Posadas, 2020b). The peak of the shrimping trips continued until November, and by December, it began to slow down (Figure 1).

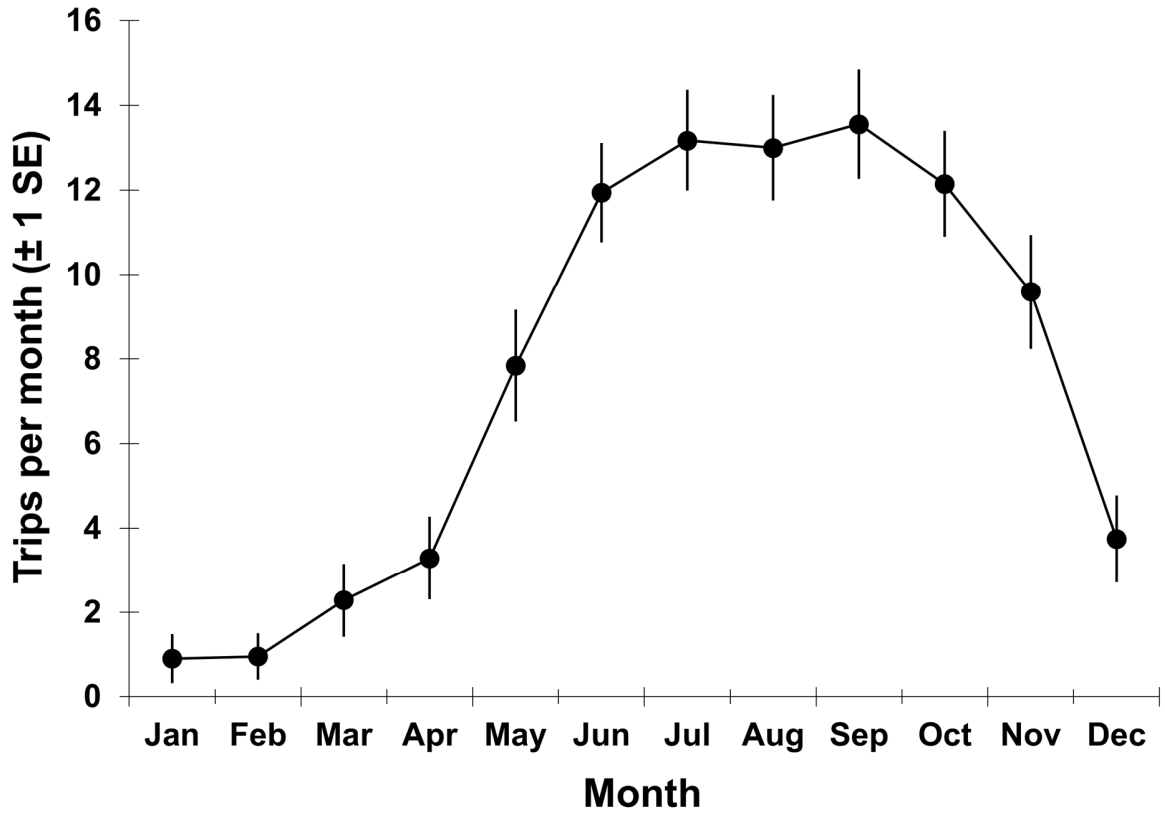

Figure 1. Average monthly shrimping trips reported by captains/owners who participated in the 2018 preliminary survey.

Types of marine debris encountered and frequency of marine debris encounters

Survey respondents also reported the types of marine debris frequently caught during commercial shrimping activities in 2018. Abandoned fishing gear was the leading marine debris item encountered during commercial fishing activity with 93% of

respondents indicating encounters in 2018 (Table 1). Shrimpers indicated that most of these encounters were with derelict crab traps. These results correspond to other studies that have shown derelict fishing gear as one of the most ubiquitous and troublesome forms of marine debris (Anderson and Alford 2013, Arthur et al. 2014, DelBene et al. 2019). In other areas of the US, derelict (abandoned or lost) traps targeting blue crab *Callinectes sapidus* are one of the most common and detrimental items to the blue crab fishery and other marine-oriented species (Bilkovic et al. 2014, Havens et al. 2011).

The majority of shrimpers (73%) also reported encounters with plastic containers (Table 1). The monitoring of the occurrence and accumulation of marine debris on barrier islands across the Gulf of Mexico conducted by Wessel et al. (2019) showed that more than 90% consisted of plastics. This trend is corroborated with comparisons to data collected by citizen scientists during Mississippi Coastal Cleanup events (Sartain et al. 2020, Sartain et al. 2019, Sparks et al. 2018, Sparks et al. 2017). In other areas, plastics occurred mostly in hauls during the Groundfish Bottom Trawl Surveys conducted in the U.S. West Coast (Keller et al. 2019), which is analogous to shrimping methods (e.g., trawls) in the shallow inshore Gulf waters.

In this study, nearly 66% of shrimpers also encountered tires, monofilament lines, and glass bottles and 45% encountered appliances and machinery and metal containers during shrimping operations. Participating shrimp boats or vessels also reported entangling styrofoam (43%), crates and palettes (34%), and other types of marine debris (43%). These findings are also similar to other studies along the U.S. West Coast where plastic and metallic debris occurred in the greatest number of bottom trawl hauls, followed by fabric and glass (Keller et al. 2010).

The captains/owners of participating boats/vessels were asked the question, “How frequently did you and your crew catch marine debris during your commercial shrimping activities in 2018?” and were given a range of response options that included “Always”, “Frequently”, “Seldom”, or “Never” (Appendix 1). The majority of survey participants “frequently” encountered marine debris (60%) during shrimping operations in 2018, followed by “always” (25%), “seldom” (14%), and “never” (2%). Logit regression results showed that shrimpers who used otter trawls reported encountering marine debris more frequently that skimmer nets. Given that the majority of marine debris encountered by shrimpers participating in this survey was abandoned fishing gear, it isn’t surprising that otter trawls encountered marine debris more often than skimmer trawls. While not formally surveyed, discussions with shrimpers indicated that derelict crap traps were the dominant form of abandoned fishing gear they encountered. These traps are relatively heavy and found on the bottom. Skimmer trawls are more likely to “skip” over bottom structure, such as crab traps, than otter trawls. Chi-square tests of the frequency of marine debris encounters showed no significant differences by county location and boat length.

Table 1. The number and percent of captains/owners who reported catching marine debris during shrimping activities by type of marine debris caught showed no significant differences by county location, fishing gear, boat length, and the number of fishing trips.

Types of marine debris	Number	Percent
Abandoned fishing gear	41	93.18
Plastic containers	32	72.73
Tires	29	65.91
Monofilament lines	29	65.91
Glass bottles	29	65.91
Appliances and machinery	20	45.45
Metal containers	20	45.45
Styrofoam	19	43.18
Other types of marine debris	18	40.91
Crates and palettes	15	34.09

Perceived impacts of marine debris on commerical shrimping industry

Mississippi commercial shrimpers were asked the question, “How were your commercial shrimping activities in 2018 affected by marine debris?” and were given a wide range of potential responses that covered lost time and perceived loss of catch attributed to marine debris as well as strategies to either avoid marine debris or increase effort to compensate for marine debris impacts in 2018 (Table 2). Nearly 82% percent reported spending more time in removing and disposing of marine debris and almost 80% reported that their shrimp catch was reduced due to marine debris (Table 2). More than 70% reported wasting more time repairing fishing gear at sea due to marine debris (Table 2). Whereas, relatively few respondants conducted activities to compensate for time lost due to marine debis, such as more tows per night (20%) or generally spending more time time towing due to marine debris (34%; Table 2). The lack of compensatory activities is likely due to limited availabilty of more time to shrimp (i.e., shrimpers are already maximizing their effort). Lost fishing time, due to marine

debris or other reasons, likely cannot be compensated for. Therefore, any issues, such as marine debris, that causes losses in fishing time is a significant stressor on an already stressed industry.

Survey participants were also asked the question, “were your fishing boat/vessel, fishing gear, and motor/engine damaged due to marine debris during your commercial shrimping activities in 2018?” and were given answer options that covered whether they incurred repair or replacement costs caused by marine debris individually for their fishing gear, motor, or vessel. Their responses indicated that 75% of shrimp boats/vessels experienced an increase in repair costs of fishing gear damaged by marine. This result was followed by almost 30% of respondants reporting an increase in repair costs of motor, engine, or propeller damaged by marine debris and 28% stating that they incurred expenses in repairing fishing boats or vessels damaged by marine debris. These results are comparable to similar findings along the US East Coast where over 45% of commerical fishers had their propellors caught, 30% had their gear foulded, and nearly 40% had their engine cooling system clogged by plastic debris (Wallace 1990).

Finally, shrimpers were asked the question, “What is your overall opinion regarding the impacts of marine debris on your commercial shrimping activities in 2018?” and were given answer options of “Most destructive”, “More destructive”, “Less destructive”, and “Neutral effects” (Appendix 1). Verbally while administering the survey, shrimpers were prompted to indicate their response to this question relative to other stressors they encounter during daily operations. More than 90% of the participating captains or owners of shrimping boats or vessels considered marine debris encountered during their shrimping trips in 2018 to be either “Most destructive” (34%) or “More destructive” (59%). The rest thought marine debris to be less (5%) or non-destructive (2%). The overall perceptions of marine debris impacts showed no significant differences by county location and boat length. However, slightly stronger negative impacts were observed among fishermen using otter trawls as compared to those using skimmer nets.

Table 2. The number and percent of captains/owners who reported perceived impacts of marine debris on commercial fishing were not significantly different by county location, fishing gear, boat length, and the number of fishing trips.

Effects of marine debris on commercial shrimping in 2018	Number	Percent
Spent more time in removing and disposing of marine debris in 2018	36	81.82
Shrimp catch in 2018 was reduced due to marine debris	35	79.55
Spent more time to repair fishing gear at sea in 2018 due to marine debris	32	72.73
More tows per night in 2018 due to marine debris	15	34.09
Barely achieved good shrimp catch per night in 2018	13	29.55
Went shrimping in Alabama and/or Louisiana state waters in 2018	12	27.27
Longer towing time in 2018 due to marine debris	9	20.45

CONCLUSIONS AND SUGGESTIONS

Unsurprisingly, commercial shrimpers that were surveyed for this study indicated that they frequently encounter marine debris and it has significant impacts on their operations. Similar to other studies, abandoned fishing gear, primarily derelict crab traps, was reported to be the most common and destructive type of marine debris encountered by shrimpers. However, the majority of shrimpers did also encounter multiple categories of land-based debris (e.g., plastic and glass containers) that is ubiquitous throughout terrestrial, aquatic, and marine ecosystems. Most shrimpers also reported that encounters with marine debris caused direct damage to their vessels and gear, while also leading to losses in time and catch. The results of this qualitative study indicate the impact of marine debris on the shrimping industry could be large. Quantitative estimates of the direct and indirect impacts of marine debris on the commercial shrimping industry should be also be derived and utilized to inform management decisions. The prevalence of abandoned fishing gear, such as derelict crab traps, should be addressed in creative ways. In some states it is currently illegal for a shrimper to have a tagged fishing gear, such as crab traps, on their vessel even if they were obviously derelict. This leads to the caught derelict traps being returned to the water where they will be caught by future shrimpers. Changes in policy and possible incentive programs for shrimpers to begin disposing of caught traps could potentially have a large positive impact on the shrimp industry. Minimizing detrimental impacts on

the already stressed domestic commercial fishing industry, such as marine debris, is imperative to maintaining a fishing fleet.

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APPENDIX 1. PRELIMINARY SURVEY OF COMMERCIAL FISHING OATS/VESSELS FOR THE YEAR 2018

INSTRUCTIONS: Please answer all 12 questions in the next two pages.

1. Are you a commercial fisherman licensed to shrimp in Mississippi in 2018? Encircle one.

1	0	If the answer is yes, proceed to No. 2. If No, discontinue the survey.
Yes	No	

2. What species were you licensed to fish in 2018 commercially? Encircle all that apply.

1	2	3	4	5	6
Shrimps	Crabs	Oysters	Foodfish	Baitfish	Others, specify:

3. What is the length of your fishing boat/vessel in 2018?

   Boat/Vessel length (feet) _____

4. What type of shrimp gear did you use in 2018? Encircle one.

1	2	3
Skimmer	Otter trawl	Other, please specify

5. Which Mississippi county is your boat/vessel located in 2018? Encircle one answer.

1	2	3	4
Jackson	Harrison	Hancock	Others, specify:

6. How many times did you use your fishing boat/vessel for commercial shrimping in 2018? Please write the number of shrimping trips per month. Write 0, if no trips.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

7. Including the captain, how many crew members are there in your fishing boat/vessel in 2018? Encircle the number of the crew including the captain.

1	2	3	4	5	6

8. What is your overall opinion regarding the impacts of marine debris on your commercial shrimping activities in 2018? Encircle the number that applies to your answer.

1	2	3	4	5	6	0
Most destructive		More destructive		Less destructive		Neutral effect

9. What types of marine debris did you frequently catch during your commercial shrimping activities in 2018? Encircle all the codes that apply to your answers.

Code	Types of marine debris caught in 2018
1	Abandoned fishing gear
2	Appliances and machinery
3	Metal containers
4	Tires
5	Plastic containers
6	Crates and palettes
7	Monofilament lines
8	Glass bottles
9	Styrofoam
10	Others, specify:

10. How frequently did you and your crew catch marine debris during your commercial shrimping activities in 2018? Encircle one that applies to your answer.

0	1	2	3	4	5	6
Never	Seldom		Frequently		Always	

11. Were your fishing boat/vessel, fishing gear, and motor/engine damaged due to marine debris during your commercial shrimping activities in 2018? Encircle all the codes that apply to your answers.

Code	Damages due to marine debris in 2018
1	Incurred costs in repairing fishing boat/vessel damaged by marine debris in
2	Increase in repair costs of fishing gear damaged by marine debris in 2018

3	Increase in repair costs of motor/engine/propeller damaged by marine debris
4	Others, specify:

12. How were your commercial shrimping activities in 2018 affected by marine debris? Encircle all the codes that apply to your answers.

Code	Effects of marine debris on commercial shrimping in 2018
1	Shrimp catch in 2018 was reduced due to marine debris
2	Spent more time in removing and disposing of marine debris in 2018
3	Barely achieved good shrimp catch per night in 2018
4	Longer towing time in 2018 due to marine debris
5	Spent more time to repair fishing gear at sea in 2018 due to marine debris
6	More tows per night in 2018 due to marine debris
7	Went shrimping in Alabama and/or Louisiana state waters in 2018
8	Others, specify: