

**The development of a derelict crab trap removal incentive program for commercial shrimpers**

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**Abstract:**

Due to fishery-tailored gear, shrimpers are often affected by benthic marine debris, specifically derelict crab traps. To alleviate the impacts on the commercial shrimping industry in the Mississippi Sound, a team of natural resource professionals and stakeholders developed a derelict crab trap removal incentive program for commercial shrimpers. In three years, this program led to the removal of 2,904 derelict crab traps from the north-central Gulf of Mexico at a total average cost of \$35,595 per year to implement the program, or \$53 per derelict crab trap. Results from this study showed the cost of the program could further be reduced while covering the same shrimping area, through the inclusion of fewer disposal locations and targeting active and engaged shrimpers. This program led to the removal of crab traps by non-registered shrimpers, indicating that the existence of the program and associated outreach could lead to improved environmental stewardship without an incentive.

**Keywords:** marine debris, derelict fishing gear, litter, cleanup, citizen science, economic benefit

## Introduction

While commercial seafood industries are facing a variety of threats (e.g. climate change, varying regulations and policies) (Erikson et al., 2014; Blasiak et al., 2021; Rozier, 2021), a less obvious threat that commercial fisheries must adapt to is marine debris (Posadas et al., 2021; Rodolfich et al., 2022). Marine debris is defined as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes (33 U.S.C. 1951-1958 (2006)).

Benthic marine debris is not widely monitored (Spengler & Costa, 2008; Galgani et al., 2015), so its impacts and distribution is poorly understood in most areas. Along the northern US Gulf Coast, benthic marine debris encountered by commercial shrimpers is predominantly derelict fishing gear (Rodolfich et al., 2022). Abandoned, lost, or otherwise discarded fishing gear (ALDFG) also known as ghost gear or derelict fishing gear is an issue worldwide (Macfadyen et al. 2009). Derelict crab traps are one of the most impactful types of derelict fishing gear both ecologically and economically, worldwide and in the north-central Gulf of Mexico (Anderson and Alford, 2014; Arthur et al., 2014; DelBene et al., 2019; Rodolfich et al., 2022). Unchecked traps actively continue to capture target and non-target marine life through feedback loops, a process termed “ghost fishing” (Guillory et al. 2001). There are several intentional and unintentional processes that lead to derelict fishing gear including improper fishing methods, wave action, and/or encounters with boat propellers leading to broken markers; thereby making derelict traps difficult to recover (Guillory et al., 2001; Antonelis et al., 2011; NOAA Marine Debris Program

2015). However, derelict crab traps continuously threaten the commercial shrimping industry. As shrimpers drag their nets across the seafloor, these derelict crab traps are often tangled into their nets. Historically, a common practice amongst shrimpers was to throw the derelict traps back into the water after they are untangled from netting. This results in a continuous, damaging cycle of derelict crab trap encounters among commercial shrimpers.

In late 2018, 44 commercial shrimpers licensed in Mississippi, USA were surveyed for their perceptions of marine debris and its impacts. Of the shrimpers surveyed, 93% indicated frequent encounters with marine debris, with most encounters (93%) being with derelict crab traps (Posadas et al. 2021). In a follow-up quantitative study, Rodolfich et al. (2022) found that shrimpers in Mississippi currently encounter marine debris in 19% of all tows, and 79% of those encounters were with derelict crab traps. These encounters resulted in direct economic impacts (e.g., lost fishing time, lost catch, and damaged gear only) of \$800,000 per year loss to the Mississippi commercial shrimping industry (Rodolfich et al., 2022). This calculated loss is equivalent to about 5% of gross dockside sales of the entire industry (i.e., \$15 million) in Mississippi (NOAA Fisheries, 2021) and does not even account for other potential direct and indirect impacts, such as ghost fishing impacts on the collective local commercial fishing industry. Until recent years, there have been few studies on the extent of the issue and efforts to remove derelict crab traps (Arthur et al., 2014).

Arthur et al. (2020) analyzed the benefits of derelict trap cleanups throughout the Gulf States and found that derelict fishing gear focused cleanups would be

beneficial for the economy, multiple fisheries, recreational boaters, and other aquatic wildlife. A 4-year program in which derelict fishing gear was removed, including over 31,000 crab traps, from the Chesapeake Bay, showed that lost blue crab traps are a significant source of marine debris (Bilkovic 2014). Scheld et al. (2016) analyzed derelict crab traps and the benefits on a global scale and found that about \$831 million in landings from major crustacean fisheries could be recovered annually by removing less than 10% of the derelict crab traps. These studies, however, only estimate the economic impacts derelict crab traps have on the blue crab fisheries (Scheld et al. 2016; Bilkovic et al., 2014; Arthur et al., 2014, 2020) and do not discuss the economic impacts on any other fisheries. Most derelict crab trap cleanups in the region focus on nearshore traps in shallow waters for shrimpers to encounter (Mississippi Department of Marine Resources (MDMR) 2022 ). While these cleanups reduce derelict traps and provide associated ecological benefits, they do not address the traps that directly impact the fragile shrimp industry.

There are an estimated 22,000 actively fished crab traps in the Mississippi state fishery, and nearly 5,500 of those are estimated to be lost each year (Arthur et al., 2020). This high concentration of derelict crab traps, documented impacts on the shrimping industry, and the laws in this area that allow for commercial shrimpers to possess derelict crab traps (Miss. Code Ann. § 49-15-92 (4)) led to the development of a pilot incentive program for commercial shrimpers to remove derelict crab traps they encounter during shrimping operations. This article will discuss the success and lessons learned from this pilot program so that other areas experiencing derelict crab trap issues may adopt similar programs. With funding from the EPA Gulf of

Mexico Program and NOAA, the Mississippi State University Extension Service, Mississippi Commercial Fisheries United (MSCFU), NOAA Marine Debris Program and Mississippi Coalition for Vietnamese Fisher Folks & Families (MSCVAFFF) partnered to develop the Derelict Trap Reward Program for Mississippi shrimpers in order to alleviate the issue

## **Methods**

### **Incentive Program**

To prepare for the program, a comprehensive list of commercial shrimpers was obtained from the Mississippi Department of Marine Resources, and requests for access to harbors across the three coastal counties for disposal sites were placed with their respective harbor masters. In December 2018, all registered commercial shrimpers within the state of Mississippi were invited to register for the Derelict Trap Reward Program and were trained to identify, remove, and document derelict crab traps through group or individual training. After the initial sign-up period, year-round registration for additional shrimpers and individual training was made accessible at MSCVAFFF, MSCFU, and each coastal county Extension office in Hancock, Harrison, and Jackson counties.

In the Gulf States, Asian communities make up over 10% of the commercial fishing industry (Posadas, 2021). To create an inclusive program that represented the fishing community on the Mississippi Gulf Coast, all signage, outreach, contracts, and training materials were offered in both English and Vietnamese (Figure 1a). During signup, shrimpers were provided with a packet containing documentation of program purpose, rules, and a contract between themselves and

the organization managing payments (Appendix 1). MSCVAFFF managed payments to shrimpers in 2019 with MSCFU managing payments in 2020. Due to this change, shrimpers that had contracts in place with MSCVAFFF in 2019 had to establish another contract with MSCFU in 2020. This transition along with several shrimpers selling their boats, the COVID-19 pandemic and associated supply chain issues, and other reasons resulted in fewer participants in 2020 and 2021.

Printed versions of the program rules and a contract were made available to shrimpers at several different locations throughout coastal Mississippi. Once shrimpers sent in an application for the program, they were provided with their unique program ID code (assigned by the project team), a set of 50 metal dog tags engraved with their program ID codes (Figure 1b) for the shrimpers to tie to each derelict crab trap retrieved, a set of 50 data cards (described below; Figure 1c) and contact information for the program team. During these meetings with a representative from the program team, program rules were reviewed again with the while they were also trained on how to attach a tag to each derelict trap they caught and fill out a corresponding data card. For each crab trap removed from the water and properly disposed of in the collection sites and tagged, shrimpers received a payment of \$5. There was a brief period (e.g., August and September 2019) when this incentive was increased to \$10 per trap to assess whether a higher incentive led to more collected traps. While the increased incentive did result in a higher number of derelict crab traps turned in, the increase also resulted in suspected trap theft of both actively fished crab traps and the derelict traps that had been disposed of by other shrimpers. A clause in the contract with the shrimpers allows for removal from

the program at the organizers discretion, and that was used to remove the suspected shrimpers from the program. Shrimpers were encouraged to provide location data for each trap (via a completed data card), but that was not a requirement to receive payment. Shrimpers were paid each month for the total amount of tagged traps from the previous month. As shrimpers depleted their metal tags and data cards, they were replenished by the project team.

Before the start of the program, four 3m X 3m x 2m outdoor chain link dog kennels were purchased to be used as disposal sites (Figure 1a). Four disposal sites were set up at Ocean Springs Harbor, St. Michael's Fuel and Ice (Biloxi, MS), Pass Christian Harbor, and Bayou Caddy Harbor (Waveland, MS) (Figures 1a & 2). Permission to set up these disposal sites was obtained from the respective harbor masters or property owners at each location. On the side of each disposal site (i.e., kennel), a metal mailbox for submitting and acquiring data cards and signage was attached. Data cards were printed on waterproof paper; shrimpers used the cards to specify ID code, date of trap disposal, number of traps, and general location the trap was removed from using a blank map of the Mississippi Sound and surrounding waters printed on the back of the card (Figure 1c).

Throughout the program, the project team emptied the disposal sites (Figure 1a) at least once a month to ensure that the sites do not overflow, and shrimpers are receiving their rewards in a timely manner; the collected traps along with corresponding ID tags (Figure 1b) and data cards (Figure 1c) were counted and documented at each site. Additionally, the owners of the derelict crab traps (via state-issued crabber ID numbers on traps) were documented when possible; this



was done so that any salvageable traps could be returned to their owners (crabbers) and any potential trap theft could be monitored. The unsalvageable derelict crab traps were recycled at a local metal recycling facility.

In addition to the total cost of shrimper payouts per year, personnel time and associated cost was tracked individually for visiting disposal sites, collecting traps and data cards, disposing of the traps, managing payments, and training shrimpers. Additionally, the total amount spent on supplies (i.e., hauling trailer, tags, twine, kennels, signs, etc.) and transportation (mileage assessed at \$0.56 per mile) was tracked.

### **Statistical analyses**

Shrimper ID, derelict crab trap recovery location (i.e., where the trap was caught), and derelict trap disposal site (i.e., disposal site of where the trap was deposited), derived from the data cards, a utilization distribution overlap index analysis was conducted using a 95% confidence interval, following the methods of Fieberg and Kochanny (2005) for all collected traps and a subset of traps only collected from Mississippi Sound (Figure 2). The subset of collected traps was analyzed because this was our target area for this trap removal program. Trap locations were georeferenced from the scanned data cards to a base map, followed by the creation of a set of new points to represent the location of the derelict crab trap documented by the shrimper. The purpose of these analyses was to 1) determine the spatial and temporal distribution of derelict crab traps and 2) whether there was a relationship between derelict trap disposal and the trap recovery site.

### **Results**

A total of 59 shrimpers registered for the program in 2019 and 43 in 2020 and 2021. Of the 59 registered shrimpers, 46 (78%) participated by turning in derelict crab traps; of the 2,904 derelict crab traps, nearly 18% did not have shrimper ID tags attached to them (i.e., were likely turned in by shrimpers not registered for the program). In 2019, 1,292 derelict crab traps (17% untagged) were removed by 37 (63%) participating shrimpers while 1,043 (24% untagged) were removed in 2020 by 26 (60%) shrimpers and 569 (31% untagged) were removed by 17 (40%) shrimpers in 2021. Across all three years, peak trap removal occurred in October and November with relatively few traps turned in from January to April (Figure 3). Ocean Springs Harbor was the most popular disposal site, and St. Michael's Fuel and Ice was the least popular disposal site in all three years (Figure 3). Ocean Springs Harbor was the most popular disposal site each year with an average of 50% of all derelict traps that were disposed of while St. Michael's Fuel and Ice was the least popular site with an average of 2% of all traps disposed of (Table 1). Similar numbers of traps were disposed of at Pass Christian Harbor (26%) and Bayou Caddy Harbor (21%) (Table 1). Of the 2,904 derelict traps removed, only 831 (29%) were documented on data cards with location data. Of the 831 derelict traps with location data, 588 (71%) were disposed of at the Ocean Springs Harbor, 153 (18%) were disposed of at the Pass Christian Harbor, 84 (10%) at the Bayou Caddy Harbor, and 6 (<1%) at St. Michael's Fuel and Ice (Figure 2).

Prior to removal, derelict crab traps disposed of at Bayou Caddy had the widest area of distribution (Figure 2). When analyzing the utilization distribution overlap results, traps disposed at the Bayou Caddy and Ocean Springs locations

covered most of the same areas across the Mississippi Sound ( $0.46 \pm 0.12$ ). However, in analyzing all traps, mean utilization distribution overlap was highest when comparing derelict traps disposed of at Bayou Caddy and Pass Christian ( $0.72 \pm 0.22$ ), and it was the lowest when comparing Ocean Springs and Pass Christian ( $0.43 \pm 0.03$ ). Derelict crab traps disposed of at St. Michael's had the smallest spatial range, and all 6 of those traps were central to Mississippi Sound. For St. Michael's the utilization distribution overlap was the largest when comparing Pass Christian ( $0.55 \pm 0.45$ ); results were similar when comparing St. Michael's to Bayou Caddy ( $0.52 \pm 0.48$ ) and Ocean Springs ( $0.54 \pm 0.46$ ) (Figure 2a; Appendix 2). In summary for all the recovered traps with location data, traps deposited at the Bayou Caddy site encompassed the geographic distribution of traps from both the Pass Christian and St. Michael's sites (Figure 2a). Whereas traps turned into the Ocean Springs site came from a generally separate area from those turned into the Bayou Caddy site (Figure 2a).

When only analyzing the spatial distribution of the derelict crab traps removed from the Mississippi Sound, traps disposed of at Bayou Caddy no longer had the largest distribution. Derelict crab traps disposed of at the Ocean Springs site had the largest area of distribution (Figure 2b). When analyzing the utilization distribution overlap for Ocean Springs, traps disposed of at St. Michael's were the highest ( $0.56 \pm 0.44$ ) with similar results when comparing Bayou Caddy ( $0.51 \pm 0.01$ ). Mean utilization distribution overlap was highest when comparing derelict traps disposed of at Bayou Caddy and Pass Christian ( $0.73 \pm 0.24$ ), and it was the lowest when comparing Ocean Springs and Pass Christian ( $0.49 \pm 0.17$ ). Derelict crab traps

disposed of at St. Michael's still had the smallest spatial distribution, and Ocean Springs ( $0.56 \pm 0.44$ ), Pass Christian ( $0.56 \pm 0.33$ ), and Bayou Caddy ( $0.56 \pm 0.44$ ) had equal utilization distribution overlap results.

Personnel time required to manage the program annually was approximately 980 hours or 122 days for visiting disposal sites (126 hours), collecting traps and data cards (144 hours), disposing of the traps (60 hours), managing payments (40 hours), and training shrimpers (19 hours), which led to an average cost of \$28,000 per year if the average annual salary for these personnel was \$64,000 or an hourly rate of \$30.77 plus 40% in fringe benefits (Table 2). Additionally, an average of \$2,167 was spent on supplies and transportation (e.g., approximately 3,600 miles) per year, and shrimpers were rewarded an average of \$5,428 each year for their removal efforts (Table 2). Due to the decrease in number of derelict crab traps each year and initial program costs (e.g., disposal site supplies, bulk dogs tags, etc.), the total cost of the program has decreased each year with an average cost of \$35,595 (Table 2). When comparing the total program cost to the number of derelict crab traps collected each year, the removal of each trap cost about \$39 in 2019; \$43 in 2020; and \$76 in 2021.

## **Discussion**

### **Benefits and Sustainability of Pilot Incentive Program**

This study aimed to develop and assess the feasibility and productivity of a pilot derelict crab trap cleanup program for commercial shrimpers. With 120 registered shrimpers in Mississippi (MDMR 2021), 49% participated in the Derelict Trap

Reward Program (<http://coastal.msstate.edu/crab-traps>) and removed a total of 2,904 derelict crab traps in the first three years of the program (i.e., 1,292 in 2019; 1,043 in 2020; and 569 in 2021). In comparison to nearshore-based cleanups in areas where derelict crab traps are a much bigger issue, this is a relatively small number of traps removed (Scheld et al. 2016; Bilkovic 2014; Arthur et al. 2014, 2020). For example, the MDMR has a nearshore-based crab trap removal program that was responsible for the removal of 11,150 traps in 2007, 1,259 in 2008, and 2,542 in 2016 (MDMR 2022). Similarly, Louisiana Department of Wildlife and Fisheries (LDWF) established an annual volunteer-based removal program in 2004 where the crabbing fishery is closed for up to 30 days and certain areas are focused on each year. By 2020, the program had removed a total of 45,333 with an average of 2,667 removed each year (Songy et al., 2020). However, this Derelict Trap Reward Program facilitated the removal of specific traps that are documented to have a large economic impact on the Mississippi commercial shrimping industry (Rodolfich et al., 2022).

Although it is difficult to estimate due to different management practices in each state, Arthur et al. (2020) estimate that there is an annual loss of 5,500 crab traps in the Mississippi Sound. While Arthur et al. (2020) estimate that derelict trap removal programs target 10% of annual derelict crab traps generated, results from the Derelict Trap Reward Program have shown that shrimpers in this pilot program have removed an average of 18% of the annually generated derelict crab traps in Mississippi. Therefore, nearly doubling the target number with this low-cost program.

Shrimpers have expressed that frequently fished areas that were once littered with derelict traps are now clean, making fishing easier and more profitable. Unlike the Derelict Trap Reward Program, the removal programs discussed by Arthur et al. (2020) are not led by commercial fishermen, and the cleanups are focused on easily accessible locations. Using commercial shrimpers, derelict crab traps have been removed throughout the Mississippi Sound, and the year-round cleanup efforts have resulted in fewer derelict crab traps impacting shrimpers. Additionally, the number of traps turned in without a dog tag with a shrimper ID has risen each year. In 2019, 17% of traps turned in did not have corresponding shrimper IDs; in 2020, that number rose to 24%, and in 2021, 31% of derelict traps did not have shrimper IDs attached to them. This may suggest that shrimpers are taking an active role in removing and disposing of traps even without the need for incentives. This could be a result of simply providing a disposal site specifically designated to derelict gear, more awareness of how the program has benefitted fishing efforts, or individuals outside of the program disposing of traps. Future research could be conducted to investigate the shrimpers perceived barriers and benefits of removing crab traps through a series of surveys.

Shrimpers have been rewarded about \$5,000 each year (i.e., \$5 per trap x 1,000 traps per year). Annual personnel time required to run the program totaled about 980 hours and the low cost of living in Mississippi related to lower-than-average hourly rates has allowed this program to be run at a relatively low annual cost of approximately \$35,595. However, the drastic difference between the economic impacts and the cost of this program (e.g., estimated \$800,000 in direct

impacts – Rodolfich et al. 2022 vs. \$35,595 in annual operating cost for the program) could accommodate significantly higher hourly salary rates while maintaining a justifiable and cost-effective program.

When assessing the number of traps removed relative to the cost of the program (e.g., reward stipends to shrimpers, salaries for the operation of the program, and purchasing supplies), it costs roughly \$53 to remove each trap. While that number on the surface seems high, the direct costs per average marine debris encounter on the Mississippi shrimping industry equates to \$86 (Rodolfich et al. 2022), and a derelict trap will likely lead to many different marine debris encounters and impacts until it is removed.

Reducing the number of derelict crab trap encounters over time will result in shrimpers spending less time and losing less catch, ultimately reducing the direct economic impacts of derelict crab traps (Rodolfich et al. 2022). Additionally, Arthur et al. (2020) suggested that of the 10% of derelict traps targeted in cleanups, 30% are ghost fishing, and they found that a 5-year cleanup program reduced ghost fishing of blue crabs and finfish, saving a total of 17,017 kg of biomass in Mississippi over 5 years. A cleanup initiative that began in 2008 after the US Department of Commerce declared commercial fishery failure of the Chesapeake Bay blue crab industry hired commercial crabbers to remove the derelict gear throughout the area, and over the course of 6 years, 34,408 derelict crab traps were removed (Scheld et al., 2016). The total cost of the program was \$4.2 million while the removal of those traps resulted in \$21.3 million in blue crab revenues (Scheld et al., 2016). Another study analyzed the impacts of derelict fishing gear in southwest Nova Scotia. Through the efforts of

fishermen during 6 different fishing trips, Goodman et al. (2021) found that ghost fishing by derelict lobster traps (66% of the weight of debris collected) caused a loss of up to \$176,216 in revenue. While the results of ghost fishing have not been observed throughout the Derelict Trap Reward Program, it can be assumed that the program has been beneficial for these populations and fishing industries. When assessing the benefits to the commercial shrimping industry and the ecosystem of a derelict trap removal program, the cost of removing each trap is justifiable.

The framework for this program is scalable and adaptable for other communities and industries facing issues with different types of marine debris (e.g., the lobster and shrimp industry in Florida; Anderson & Alford, 2014; Scheld et al., 2016). For example, this study maintained four disposal kennels throughout 2019, 2020, and 2021. However, results from the utilization distribution overlap index analyses showed that at least 1 if not 2 of those kennel locations could have been eliminated and derelict traps from the same general areas within the Mississippi Sound and beyond would have been removed by program participants. The added program cost associated with these additional, yet possibly unnecessary disposal locations, could be avoided in future years to increase the cost-effectiveness of the program. The Mississippi Sound is an ideal location to pilot a removal program because there is a significant overlap between the shrimping and crabbing industries, the small coastline, and the easily accessible harbors. Other states with more expansive coastlines such as Louisiana or Florida may require a different structural approach such as using more strategically places disposal sites and would like



require multiple organizational headquarters or more collaborative efforts with the program partners.

Another example of streamlining the program would be to target specific shrimpers that contribute the most to the removal efforts. For instance, in this study, 5 to 10 shrimpers each year were responsible for turning in the majority of traps (Appendix 3). Focusing efforts on those highly participatory shrimpers should also reduce personnel management, training, and processing times associated with running an incentive-based derelict trap removal program for commercial shrimpers. Areas interested in creating a similar cleanup program should consider preliminary surveys of fishing spatial distribution and efforts from the fleet before selecting disposal sites and participants. Finally, if the removal efforts exceed the loading of derelict traps in an area, an annual derelict trap cleanup program may not be necessary. Instead, a program may provide significant benefits if implemented at 2+ year intervals or only running the program during the most productive months for the shrimping industry. The Derelict Trap Reward Program that was the subject of this study removed more than twice the recommended removal amounts from Arthur et al. (2020), which suggests it could be implemented every two years and achieve the recommended removal goals – thereby cutting operational costs. Interestingly in this study, we observed a nearly 50% reduction in removed derelict crab traps in Year 3 as compared to Years 1 and 2 with similar fishing efforts. This could be a result of the decreasing number in active participants each year, but it may also imply that derelict trap removal associated with this program has started to exceed the derelict crab trap loading rate in shrimping waters, which could make it more cost-effective to

implement a biannual cleanup program after the initial program launch. Anecdotally, participating shrimpers have expressed that they are encountering much fewer traps now than previously and attributed this reduction to this program.

Given the high benefit-to-cost ratio and change in attitudes and action taken associated with a program like this, obtaining continued funding from local, state, federal, or other sources should be justifiable. Coastal stewardship-based organizations such as some NGOs, commercial fishing organizations, state natural resource agencies, Sea Grant, or a combination of several groups could likely obtain funding for a similar program in different areas for at least a pilot project. Additionally, some resource agencies may be able to support the personnel time for running a similar program and then the only remaining costs would be the cheapest portions of the program of supplies and reward funds.

### **Considerations for establishing a derelict crab trap program for shrimpers**

Many factors have allowed this program to succeed. Partnering with local organizations and key industry leaders that are trusted by the local shrimp and crab industries is one of the key components for the success of these types of programs as they give credibility and accelerate trust in the program (Fields et al., 2021). For this project, that role was served by MSCFU and MSCVAFFF but will vary by location. Once trust is established, creating personal relationships, and keeping regular contact with the shrimpers and harbor masters ensured that the shrimpers always had the necessary supplies (ID tags and data cards) and that the program was not abused.

Additionally, the placement of the disposal sites played a key role in keeping the program active. Most of the shrimpers enrolled in the program docked their boats in Ocean Springs Harbor (33 participants) followed by Pass Christian (18 participants) while Bayou Caddy had the lowest number of participating shrimpers (14 participants); the rate at which each disposal site was used correlated with the number of participating boats docking at those sites (Figure 2). Figure 2 shows that generally, the derelict traps collected were clustered near the harbor in which they were disposed at. Something to consider is that shrimpers may have been more inclined to keep the traps that they picked up on their way back into the harbor for the day rather than piling traps up on the deck throughout a fishing trip. St. Michael's Fuel and Ice was not a harbor for boats to dock permanently, and it was the least utilized disposal site (Figure 2) with only 60 traps deposited there over the entire 3-year duration.

Another helpful practice is regular maintenance of the disposal sites. Reinforcing kennels for hurricanes and wind with weighted stakes and metal data boxes and signs allowed for the disposal sites to stay in place year-round. Despite reinforcements, the metal data boxes only lasted the first year and a half of the program before rusting out/falling apart. However, replacing the data boxes with handmade, durable plastic boxes was beneficial. The new data boxes were designed for rain cover and have an additional compartment to keep blank data sheets for convenience and leave additional ID tags upon request (Figure 1d).

There were several limitations with the inception of the program. Initially, MSCVAFFF was used as a bridge to the Vietnamese shrimping community, but the

project team decided to shift the responsibility of paying rewards to shrimpers to MSCFU in Year 2. This shift reduced removal efforts from the Vietnamese shrimpers that participated in the program through MSCVAFFF. While some of these shrimpers were able to migrate over to contracts with MSCFU, 15 shrimpers were lost in this transition. This situation highlights the need to identify a single group as a point of contact for the program so that participants aren't lost if partners change during the project.

Mississippi's shrimping fleet is relatively small, so, initially, our goal was to register as many shrimpers into the program as possible. Additionally, the Mississippi Sound is a relatively small body of water, so many shrimpers in the state have fishing licenses for the surrounding state waters (LA and AL). This resulted in traps being removed from those water bodies and despite this being a relatively small number (e.g., 70 documented over 3 years) and most of the traps being derelict and unfishable, many crabbers contacted the project team with complaints about the program in Year 1. Additionally, reports of trap theft and shrimpers who also held crabbing licenses turning in their traps became a problem when the reward per trap was increased to \$10 per trap (August – September 2019) to offset some of the economic impacts shrimpers endured during and after the 2019 opening of the Bonnet Carré Spillway. Those issues were alleviated by simply reducing the reward back to \$5 per trap, temporarily suspending two participants from the program, and sending out reminders about the program rules; there have been no complaints since. This highlights the need to find the most appropriate reward level that encourages participation, but doesn't lead to unwanted activities, and having

language in the contract that participants can be removed or suspended from the program at any time at the discretion of the project team.

The cost of a new blue crab trap is generally over \$50, so another goal was to return salvageable crab traps to their owners, initially. However, for all three years, 94% of all traps were recycled; there was a total of 177 crab traps, only 6%, that were undamaged and in salvageable condition. Twenty percent (20%) of those salvageable traps did not include any ownership information and contacting the owners of the crab traps whose information was available was difficult and often unsuccessful. Goodman et al. (2021) attempted to do this with derelict lobster traps as well, but the results do not discuss whether or not they were successful.

While shrimpers were encouraged to turn in data cards (Figure 1c; with temporal and spatial data), it was not required to receive the trap reward. Overall, there were data cards turned in for 56% of the recovered traps. In the pilot stage of this program, it would have been beneficial to require and enforce data card submission for each trap. This requirement could have led to a better understanding of spatial and temporal trends in trap recovery and allowed adaptive modifications to the program (i.e., disposal sites, etc.).

### **Caveats to results**

The Derelict Trap Reward Program began in 2019. Typically, the shrimping season begins in early June, and peaks between July and September (Posadas et al. 2021). The extended opening of the Bonnet Carré Spillway in 2019 stunted the growth of shrimp and delayed the opening of the fishing season. Additionally,

stay-at-home orders and unemployment benefits following the COVID-19 pandemic delayed shrimping efforts in 2020. The 2020 season also corresponded with a busy hurricane season (NOAA 2021). These implications may have skewed fishing efforts and the removal of derelict crab traps to September through November (Figure 3) and possibly decrease the potential amount of traps removed each year. In addition to the environmental and anthropogenic factors, data may be skewed due to shrimpers hoarding the derelict traps they catch and then turning them all in at once.

## **Conclusion**

This is the first program, to our knowledge, to partner with commercial shrimpers and incentivize them to remove derelict crab traps in the Gulf of Mexico region. The pilot period of this program was highly successful with 2,904 derelict crab traps removed over three years. However, lessons were learned that have led to adaptive improvements to the program and could inform future programs. The Derelict Trap Reward Program is an ongoing program in Mississippi with plans of expanding offshore and establishing a program in Alabama. Any coastal community with a commercial shrimping industry and trap fishery is likely to experience similar issues. A program, like this one, can be a cost-effective method for environmental and economic benefits. Future research on the economic and environmental benefits of these programs in other areas or industries and the ideal frequency for these programs could improve management and, subsequently, the resilience of coastal communities.

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#### **Data Availability Statement:**

All data associated with this project is formatted and ready for upload into the Mississippi State University Institutional Repository. Upon acceptance of publication, all data will be uploaded to the repository and made fully available.

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## Figures and Tables

**Figure 1** Components of the Derelict Trap Reward Program that include a) disposal kennels, b) crab trap tags, c) data cards for shrimpers, and d) redesigned data boxes



**c**

**TRAP DISPOSAL DATA CARD/ THẺ DỮ LIỆU BỎ TRÌ BÃY GHE**

Participant ID /  
Số Nhân Dạng Của Bạn: \_\_\_\_\_

Date /  
Ngày: \_\_\_\_\_

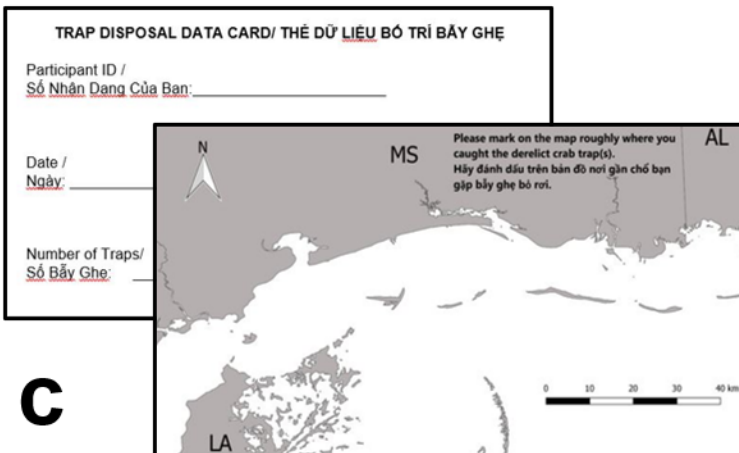
Number of Traps/  
Số Bẫy Ghẹ: \_\_\_\_\_

MS AL

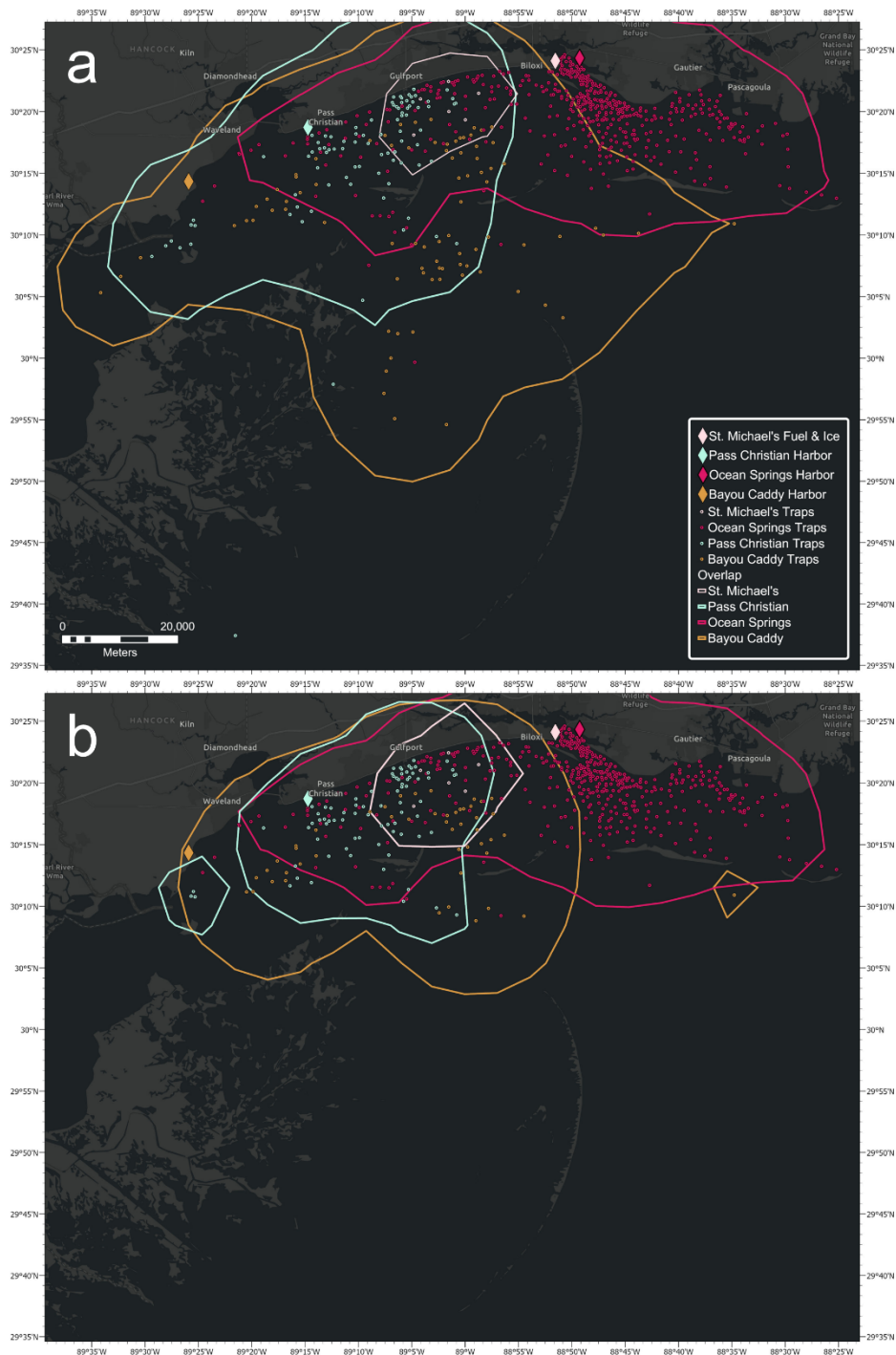
Please mark on the map roughly where you caught the derelict crab trap(s).  
Hãy đánh dấu trên bản đồ nơi gần chỗ bạn gặp bẫy ghẹ bỏ rơi.

LA

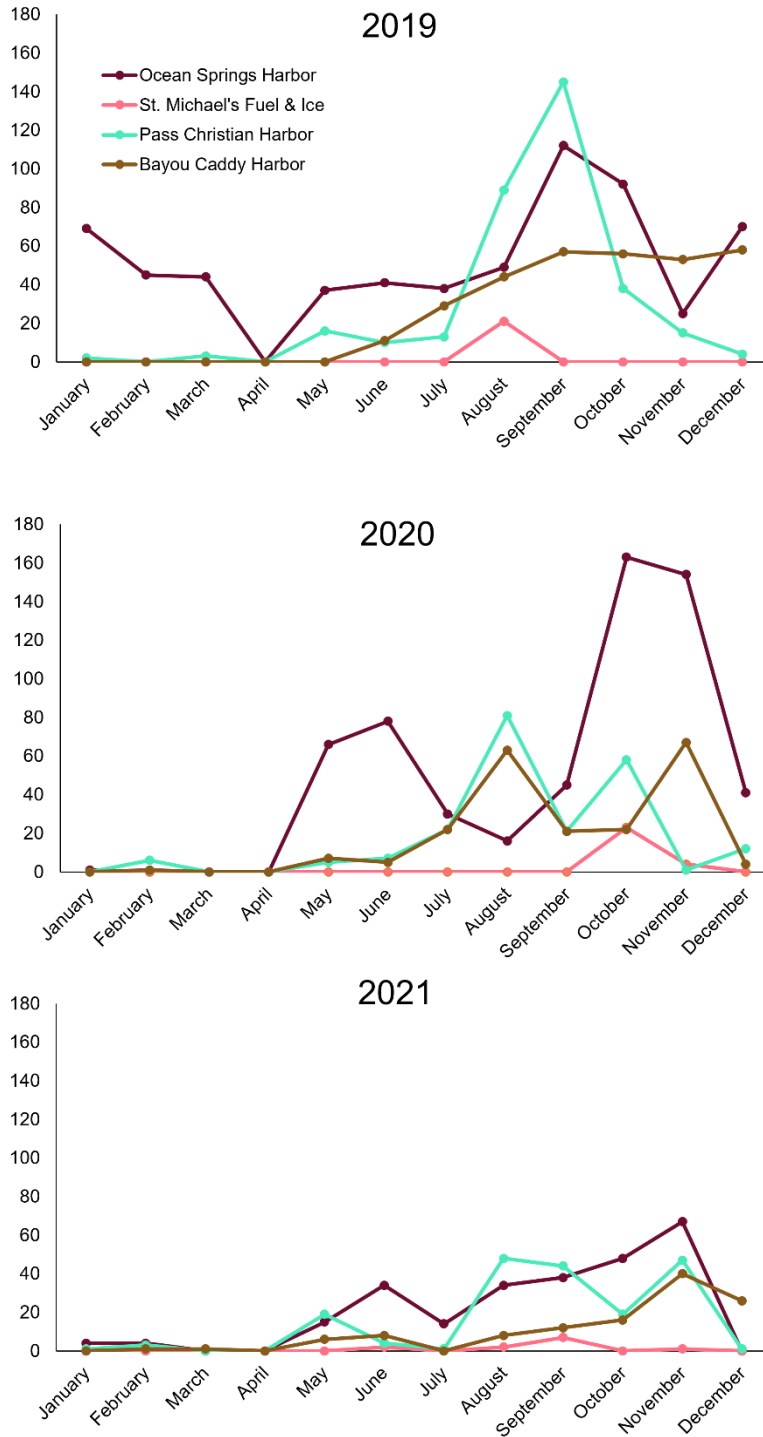
0 10 20 30 40 km



**Figure 2** Map of documented derelict crab traps and disposal sites color-coded by disposal site for all traps and results of the utilization distribution overlap index analysis for all traps (a) and only traps collected from Mississippi Sound and only those collected from Mississippi Sound (b).



**Figure 3** Number of derelict crab traps turned in monthly at each disposal site per year.



**Table 1** The annual number of derelict crab traps disposed of at each disposal site and the percentage of the total number of traps of the corresponding year.

Disposal Site:	Year					
	2019	% of total	2020	% of total	2021	% of total
Ocean Springs Harbor	625	48%	594	57%	258	45%
St. Michael's Fuel & Ice	21	2%	27	3%	12	2%
Pass Christian Harbor	338	26%	213	20%	187	33%
Bayou Caddy Harbor	308	24%	212	20%	118	20%

**Table 2** The annual costs of supplies and transportation, shrimper rewards, and total cost of the program

Cost Categories:	Year		
	2019	2020	2021
Supplies & transportation	\$2,500	\$2,000	\$2,000
Shrimper rewards	\$9,000	\$4,435	\$2,850
Personnel costs (salary and fringe benefits)	\$28,000	\$28,000	\$28,000
Total program cost	\$39,500	\$34,435	\$32,850