Development of a Trap to Catch the Invasive Lionfish (*Pterois spp.*)

Desarrollo de una Trampa para Capturar al Pez León (*Pterois spp.*) Invasor

Contribution au Développement d'un Piège pour Capturer le Poisson-lion (*Pterois spp.*) Envahissant

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EXTENDED ABSTRACT

Lionfish (*Pterois volitans* and *P. miles*) first appeared along the east coast of south Florida in the mid-1980s and have since become established throughout the Western Atlantic (Bryan et al. 2018, Schofield 2009, Whitfield et al. 2002). They are now broadly distributed across a range of habitats and depths. Lionfish can have detrimental impacts in these invaded regions due to their generalist feeding behavior, high consumption rates, high reproductive output, and lack of predators (Albins 2013, Albins and Hixon 2008, Ballew et al. 2016, Ellis and Faletti 2016, Green et al. 2012, Morris 2009, Morris and Akins 2009). Due to these attributes, eliminating lionfish populations is generally considered unrealistic; however, reducing lionfish densities through targeted control measures to minimize their effects on the ecosystem and protect native fish populations may be possible (Frazer et al. 2012, Green et al. 2014).

Diver removal of lionfish using spears or nets has had some success in shallow water within SCUBA diving depths (de León et al. 2013, Frazer et al. 2012). However, the depth range of lionfish greatly exceeds common SCUBA diving limits of 30 to 40 meters. These deep-water habitats are likely a refuge for lionfish and provide population resilience to shallow-water culling. Andradi-Brown et al. (2017) demonstrated that lionfish found in deep-water habitats were typically larger and more fecund than those found on shallower reefs, indicating that these deep-water populations could contribute to continued recruitment to shallow populations. Addressing the removal of lionfish from these deep-water habitats remains a high priority and an underrepresented research and management direction.

Traps have been proposed as a possible method for lionfish removal in deep-water habitats. Spiny lobster fishermen, particularly in the Florida Keys, frequently catch lionfish as bycatch in lobster traps. However, fish traps are illegal in the United States South Atlantic and Gulf of Mexico fishery management regions except for black sea bass traps, as these traps are nearly species specific. Necessary attributes for a permitted lionfish trap in the United States include minimal bycatch and effective lionfish catch. The goal of this project was to develop a trap to catch lionfish in waters greater than 30 m through modifications of wire spiny lobster traps. Our objectives were to compare multiple trap modifications and bait types with respect to 1) lionfish catch and 2) bycatch of fish and crustacean species. Ultimately, we sought to develop an optimal trap design and fishing method to maximize lionfish catch and minimize bycatch.

Modifications were made to the Florida spiny lobster trap typically used in waters deeper than 30 m. This predominantly wire trap is constructed with a wood-lath lid, 3.8 cm (1.5 inch) wire mesh sides and bottom, a top-loading plastic throat with a 15.2 cm opening, and no escape gaps (Figure 1A). All traps were 81.3 cm long × 61.0 cm wide × 45.7 cm tall and weighted with cement. Trap treatments included combinations of throat placement (top or side), throat type (plastic throat with a 15.2 cm opening, narrow plastic throat with a 5.4 cm opening, wire throat with a 10.2 cm opening, or a horsehead wire throat [side-loading only]), and escape gap configuration (two vertical 3.8 x 19.1 cm gaps, one horizontal 3.8 x 33.0 cm gap, or no gap) (Figure 1B-1G). Various bait treatments were also tested, including pigs' feet, mullet, cat food, plastic reef fish, plastic lionfish, live lionfish, and no bait. The live lionfish bait was retained in the trap using an enclosure made from plastic mesh (Figure 1H). We contracted with a local commercial spiny lobster fisherman and completed 30 research trips between December 13, 2018 and October 4, 2019. All sampling locations occurred within the Florida Keys National Marine Sanctuary in Atlantic waters ranging in depth from 30 to 78 m.

A total of 24 traps were fished in each of four trawl lines, resulting in 96 traps fished per trip. Each trawl line had 50 m of rope between individual traps and 105 m of rope between the end traps and the surface buoys. Trap treatments were distributed randomly among each trawl line. Bait and trap treatments were discontinued when catch results were qualitatively deemed ineffective (i.e., low lionfish catch or high bycatch). Sample sizes of each trap-treatment/bait-treatment combination therefore varied depending on the length of time each treatment was tested. Upon trap retrieval, every organism caught in a trap was identified to the lowest taxonomic level possible and measured to the nearest cm for fish (total length) and to the nearest mm for crustaceans (carapace length/width). All lionfish were retained or used as bait in experimental traps. For analyses, trap catch was separated into lionfish, lobster, fishery, and non-fishery catch. Fishery bycatch was categorized as any species that is recreationally or commercially fished within Florida waters. Non-fishery bycatch included all other species for which there are no commercial or recreational regulations.

Trap catch results from the 30 research trips included a total of 396 lionfish, 1,379 lobsters, 1,885 fishery bycatch individuals, and 3,273 non-fishery bycatch individuals. Hermit crabs (Paguroidae) were excluded from non-fishery bycatch due to their ubiquitous distribution and prevalence (n = 1,174) which obscured analyses of other important species. Lionfish catch rates per trap were low (<0.3 lionfish/trap) for the duration of this study; however, our results indicated that side-loading throats had the lowest catch of lionfish (Figure 2A). Lobster catch was highest in traps that had a top plastic throat with a 15.2 cm opening and no escape gap. This is the trap design typically used by commercial lobster fishermen in Florida. Many trap modifications reduced the catch of lobster; however, narrow plastic throats and side throats greatly reduced lobster catch (Figure 2B). A total of 19 different species of fishery bycatch were caught; lane snapper (*Lutjanus synagris*), gray triggerfish (*Balistes capriscus*), mutton snapper (*Lutjanus analis*), and red snapper (*Lutjanus campechanus*) represented 42, 24, 10, and 9 percent of the fishery bycatch, respectively. Fifty-eight species of non-fishery bycatch were observed; scrawled cowfish (*Acanthostracion quadricornis*),

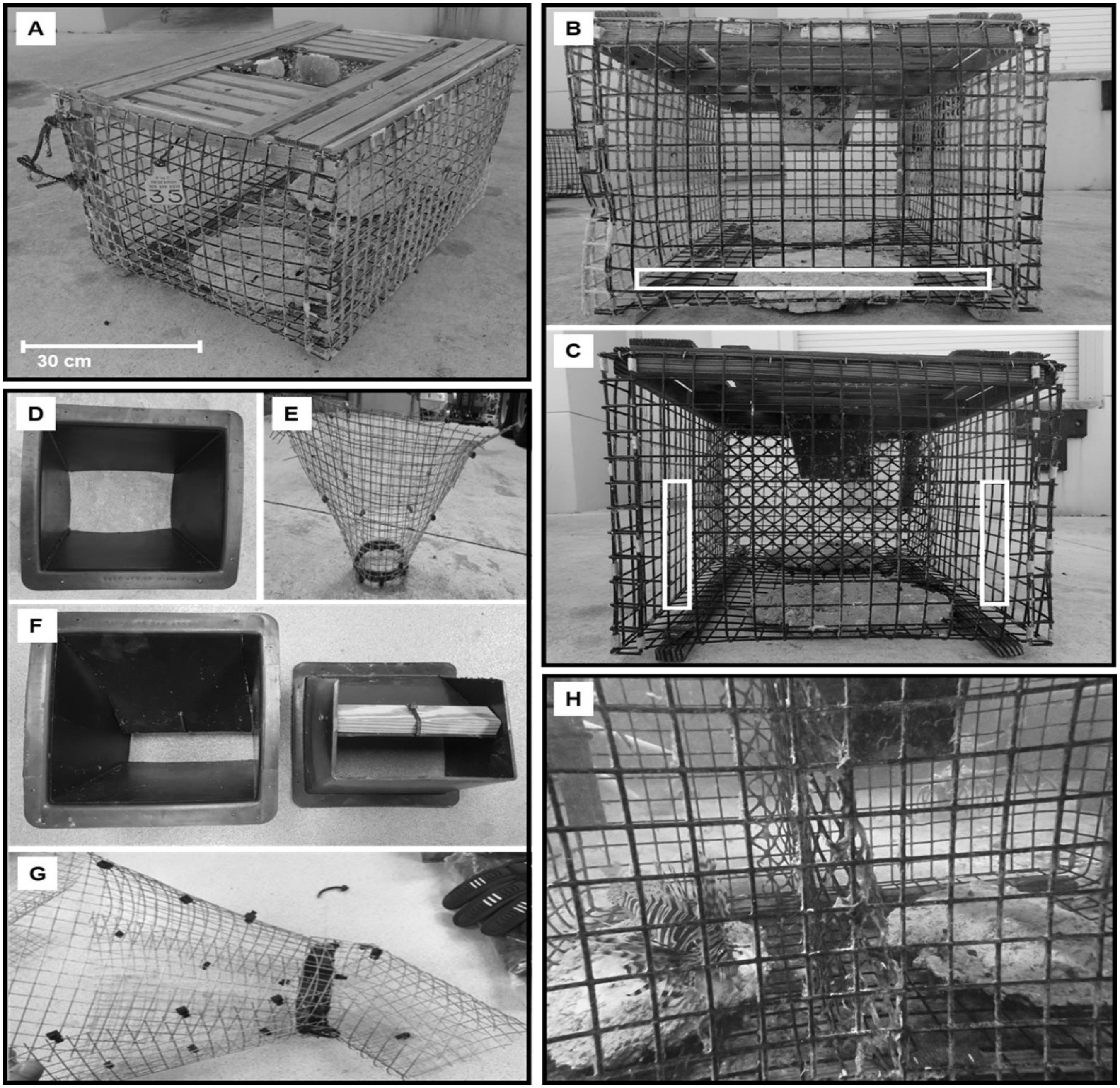

Figure 1. Images of A) a Florida wire spiny lobster trap, B) a horizontal escape gap, C) vertical escape gaps, D) a plastic throat with a 15.2 cm opening, E) a wire throat with a 10.2 cm opening, F) a top and bottom view of a narrow plastic throat with a 5.4 cm opening, G) a wire horsethroat, and H) a trap with a lionfish enclosure and live lionfish bait. The white rectangles in images B and C indicate the escape gaps.

littlehead porgies (*Calamus proridens*), and tomtates (*Haemulon aurolineatum*) represented 24, 23, and 16 percent of non-fishery bycatch, respectively. No other fishery or non-fishery species represented more than 6% of the bycatch. Both fishery and non-fishery bycatch were reduced by the addition of escape gaps (Figures 2C and 2D). Traps with vertical escape gaps had 53% less fishery and 58% less non-fishery bycatch per trap in comparison to traps with no escape gaps. The narrow top plastic throat also had low non-fishery bycatch (Figure 2D). Using a live lionfish as bait produced the lowest lobster, fishery, and non-fishery bycatch as well as slightly higher lionfish catch relative to other bait types. All other bait types were less effective by these measures and did not differ from each other.

Continued testing of live lionfish as bait is warranted. Although traps baited with live lionfish had lower bycatch of both lobsters and fishes, it is unknown whether the difference in bycatch was due to a true effect of the bait, less volume in the trap due to the lionfish enclosure, or other experimental artifacts. Similarly, it is unclear if increased catch of lionfish was due to the reduction of bycatch or the presence of the live lionfish bait. Lionfish may be attracted to the traps because of the structure they provide, more so than to a conspecific. To further determine the effectiveness of live lionfish bait, future research should continue to test the live lionfish and no bait treatments, including the use of video observation to

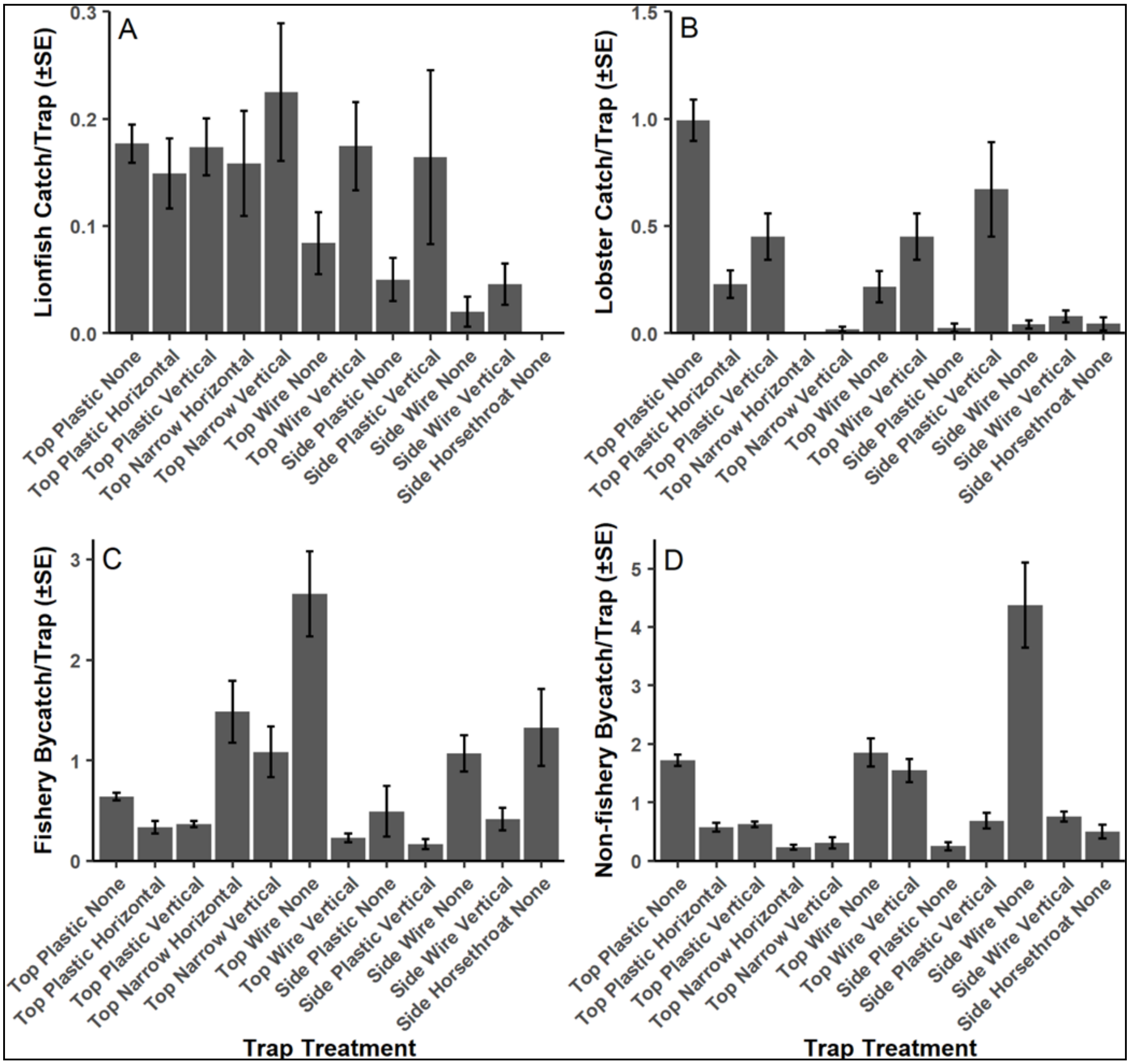

Figure 2. Average catch per trap (±SE) of A) lionfish, B) lobster, C) fishery bycatch, and D) non-fishery bycatch for each trap treatment (all bait types pooled). Trap treatments include throat placement (top or side), throat type (plastic, narrow plastic, wire, or horsethroat), and escape gap type (vertical, horizontal, or none).

understand lionfish and bycatch interaction with traps.

Critical elements of a species-specific lionfish trap appear to include narrowing the top entrance plastic throat to preclude entry of legal-sized lobsters and large fish (Figure 1F), and adding an escape gap (Figure 1B and 1C) to prevent the retention of small lobsters and fish. Although the top throat often had higher bycatch in comparison to the side throat, the latter caught very few lionfish. Narrowing the top plastic throat to a 5.4 cm (2.125 inch) opening reduced bycatch and increased lionfish catch. Only two sublegal-sized lobsters were caught in the narrow throat traps. However, the narrow throat had high bycatch of large mutton snappers, possibly due to a local increase in abundance of these fish during the months this trap modification was tested. The mutton snappers could enter the narrow throat, even when the fish size appeared greater than the trap throat dimensions. This narrow throat appears to be effective at reducing bycatch in many, but not all situations.

This lionfish specific trap design provides a means to remove lionfish from deep water refuges. The design limits bycatch of fishery species, making this trap a good candidate for use during closed fishing seasons and in other situations where fishery bycatch needs to be managed. Further, the design reduces bycatch of non-fishery species and reduces harm from entrapment or embolism during trap retrieval. This trap design would be well suited for use in marine protected areas where impacts on indigenous species are a concern. In much of the Caribbean, fish traps are used to catch a diverse array of species, which based on our study results likely reduces the catch of lionfish. The use of a lionfish specific trap in these regions might be a more effective lionfish culling technique.

The best trap design determined from this study to maximize lionfish catch and minimize bycatch includes a narrow plastic throat placed at the top of the trap, escape gaps, and either live lionfish- or no-bait. Moving forward, these trap designs will be tested by commercial lobster fishermen to evaluate trap utility at a larger geographic scale and over a broader range of habitats and depths. We postulate that the use of lionfish specific traps may not be feasible to support a commercial fishery for lionfish in Florida but might be used to enhance commercial fisher income when used as an additional gear to supplement fishing trips targeting other species.

KEYWORDS: Lionfish trap, spiny lobster, invasive species, Florida, bycatch

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