

A BRIEF REVIEW OF FISHING GEARS ASSOCIATED WITH INVASIVE LIONFISH REMOVALS

Research

AUTHOR: Samantha D. Farquhar

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Samantha D. Farquhar^{1,2}¹Asian Institute of Technology

The School of Environment, Resources, and Development
Bangkok, Thailand

²Agriculture and Forestry University

Department of Aquaculture and Fisheries
Rampur, Nepal

CORRESPONDENCE AUTHOR

Samantha D. Farquhar

Email: farquharsamantha6@gmail.com

CONFLICTS OF INTEREST

There are no conflicts of interest for any of the authors.

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ABSTRACT

Invasive lionfish (*Pterois miles* and *Pterois volitans*) continue to thrive in the western Atlantic Ocean, Gulf of Mexico, Caribbean Sea and most recently the Mediterranean. Their success has been attributed to their environmental tolerance, broad appetite, high fecundity, prey naivety, and lack of predators. However, lionfish populations have been shown to be successfully managed through their removal with the most common method being spearfishing. However, this method is limited to areas that are easily accessible to divers, thus largely ineffective as a large-scale fishery. Yet, there has been other accounts of lionfish being successfully captured with other fishing gears. This study compiled sources from scholarly journals, press releases, and nonprofit scientific organizations and searched for methods used to successfully remove lionfish within the invaded area. Results show that the most popular removal method was spearing (45%) followed by handnet (37%). The remaining removal gears were fish trap (5%), hook and line (5%), trawl (3%), lobster trap (2%), and other (1%). This review illuminates other lesser known methods successfully used to remove lionfish with hopes to evoke new management options to combat the future of the lionfish invasion.

INTRODUCTION

Invasive lionfish, known as both *Pterois miles* and *Pterois volitans* have become regarded as the most ecologically and economically damaging marine fish invasive species [1]. Since their accidental introduction in 1985 off the coast of Florida, lionfish have spread to the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea [2–5]. Further, they have been found in all marine habitat types and depths in this invaded area [6]. The lionfish invasion is still spreading. Most recently, they have reached Brazil [7]. It is expected the invasion will only be limited by water temperature as their lethal limit is 10°C [8]. Their success is fueled by lionfish's high environmental tolerance, broad appetite, high fecundity, prey naivety, and lack of predators [9–12]. Lionfish have been seen to occupy a wide range of habitats such as mangroves, estuaries, and rocky substrates in addition to reefs.

Further, they have been found to depths of 1000m. They have the ability to spawn every four days with up to 30,000 eggs per spawn. In the invaded area, some predation from groupers, snappers, and the occasional shark have been noted, but this has not been observed as a means of consistent predation. All of these factors have proven to be a dangerous combination for local fish communities. It was observed that lionfish prey biomass was reduced by an average of 65% over a two-year-period [12]. Further, another study saw a 79% reduction in fish recruitment in the presence of a single lionfish in only a five-week observation period [13]. This type of predation by lionfish results in the over-consumption of herbivore fishes and leads to ecosystems shifts [14]. Lionfish's behavior is unique among apex predators. They lethargically hover close to some type of underwater structure [15,16]. When they attack, they stalk prey by maneuvering themselves slowly with their large pectoral fins extended to corral it before making a rapid strike [16]. They also have been seen to extrude water jets at the prey to orient it towards the mouth before striking [17].

The same fearless behavior that lionfish show towards other fishes is also shown towards divers. This lack of shyness has made them an easy target to remove with spears. Multiple movements have since been started to combat the lionfish invasion through their removal. Spearfishing tournaments or 'lionfish derbies' will often be hosted by coastal communities within the invaded area. These tournaments span a few days and encourage great participation resulting in mass cullings of lionfish. A recent lionfish tournament from Fort Lauderdale, Florida reported that in 2 days 1,250 lionfish were successfully removed [18]. The culled lionfish are usually eaten. Their meat is described as white, flakey, and high in omega-3s [19]. Thus, this has helped them become marketed in some restaurants as a tasty sustainable dish. Further, these tournaments also give scientists the opportunity to collect a vast amount of data over a short amount of time. Ali et al. has described the role of volunteers and group effort as essential in reducing lionfish, increasing awareness, and furthering the understanding the lionfish invasion [20]. In some Caribbean nations, lionfish have made their way in the tourist market as well. Visitors can pay local dive shops to certify them as a 'lionfish hunter' then take them on a guided spearfishing tours or hunt on their own [21]. Beyond the typical tourist merchandise of T-shirts and visors, the fins of speared lionfish are being used to make jewelry such as earrings and boost local economies [22].

These types of removal efforts have proven effective in reducing lionfish abundance from various locations in the Caribbean [9,20,23,24]. For example, a study that compared fished and unfished areas of Bonaire over a two year period (2009-2011) found that lionfish biomass in fished locations on Bonaire was 2.76-fold lower than in unfished areas from the same island [23]. However, while lionfish's sedentary behavior makes them easy to spear, it makes them difficult to remove with other fishing methods. This has impeded the anthropologic counterattack on lionfish as spearfishing is limited to warm, shallow, and clear water. There have been other accounts of using fishing gears other than spears to successfully remove lionfish, yet they are lesser known and not as popular. Thus, this review hopes to illuminate other fishing methods and gears used to remove lionfish with hopes to evoke alternative solutions to combat the lionfish invasion where spearfishing is not accessible.

METHODS:

Sources were compiled from scientific studies in scholarly journals, press releases from local news networks, and scientific nonprofit science organizations such as the Gulf Caribbean Fisheries Institute and Reef Environmental Education Foundation. This led to a database filled with 150 records dating from 2005-2016. For each record, the method(s) described in the removal or capture of lionfish were noted along with the location and if specified, the species.

RESULTS AND DISCUSSION:

From the compiled sources, 30 different island countries as well as U.S. states and territories throughout the Atlantic, Caribbean, and Gulf of Mexico were observed. Some records detailed more than one method used to collect lionfish. Of the records, the most common method of removal indicated was spearing at 45% followed by handnet at 37%. The remaining removal gears were fish trap (5%), hook and line (5%), trawl (3%), lobster trap (2%), and other (1%) (Figure 1.).

Spearfishing records were associated with recreation and scientific experiments. All spear records indicated that lionfish were specifically targeted. Hook and line records suggested that lionfish were caught bottom fishing using live bait. In this case, some fishers specifically targeted lionfish while others lionfish were caught accidentally. The few records that indicated that lionfish were captured while performing a bottom trawls were accidental. Fish and lobster traps records indicated that lionfish were being caught as by-catch in the fishery. Later, fishers and scientists alike began using these to target lionfish. Collection bags and hand nets were largely asso-

ciated with scientific experiments. The last gear category, other, included reports of robotic removal methods. Specifically, a lionfish removing ROV and an underwater vacuum-like device. Of all the removal records, it was observed that *Pterois volitans* was more commonly removed than *Pterois miles* and that the majority of the records came from the Caribbean.



Figure 1. Break-down of various fishing gears associated with successful lionfish removals. Of the 142 records reviewed

Results are likely due to location and accessibility. The waters of the Caribbean are consistently warm, clear, and shallow. This is conducive for recreational water activities such as spearfishing. Additionally, these conditions make research efforts more accessible explaining why more scientific records came from the Caribbean area.

The results also indicated that *Pterois volitans* was more commonly removed than *Pterois miles*. This is due to the fact that *P. volitans* has a wider geographic range and is more dominant than *P. miles*. Of the Atlantic population, 93% of lionfish population consists of *P. volitans*, while the remaining 7% is *P. miles* [25]. However, of the records compiled, misidentification by the collector could be a factor. Both species look and behave identically with the only difference between the two is meristic counts of fin rays. *P. miles* generally has 10 dorsal-fin rays and 6 anal-fin rays while *P. volitans* has 11 dorsal-fin rays and 7 anal-fin rays [26].

It should be emphasized that these results only show popularity based on published records, not effectiveness. For example, despite the low use of lobster trap gears, they have shown promising results in capturing lionfish. Bermuda's commercial lobster trap fishery reported that 1,666 lionfish were captured in their lobster traps over four fishing seasons [27]. The lionfish invasion has prompted scientists and community members alike to research and troubleshoot new methods. This includes advanced ROVs to simple fish aggregating devices (FADs). This short communication goes to show that other solutions are available and being actively researched to help combat the lionfish invasion. Thus, the development of these gears into a consistent removal method for a variety of depths and locations will be essential in mitigation and management of the future of the lionfish invasion.

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Contact Us

SIFT DESK Deerpark Dr, #75, Fullerton, CA, 92831 United States.

E-mail: helpdesk@siftdesk.org