Current Directions in Managing Invasive Lionfish Populations to Protect Reef Biodiversity

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Abstract

Invasive lionfish pose a significant threat to reef biodiversity in coastal Atlantic regions through their aggressive feeding habits, lack of predators, and overall hardiness in a wide range of climatic conditions. Their impact has resulted in targeted human efforts to manage and reduce invasive populations where possible. It is important to identify the current methods being employed, such as manual culling and traps, and to analyze their strengths and weaknesses. Additionally, looking at non-human interactions between lionfish and their ecosystems and how they have developed, such as the effects of grouper non-consumptive pressures, may influence how management is approached. By learning from relevant approaches, we can look towards integrating them into a holistic plan that targets lionfish at multiple levels from different angles and formulate incentives to gather greater support and participation in the preservation of reef biodiversity through economically and environmentally feasible options.

Keywords: Lionfish, *Pterois volitans*, Coral Reefs, Biodiversity, Habitat Preservation, Invasive

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Introduction

Lionfish (*Pterois spp.*) are invasive predatory fishes native to the Indo-Pacific that are now found throughout coasts along the Atlantic (Green et al. 2012). Numerous factors contribute to the continued success of lionfish species in the Atlantic (Chagaris et al. 2017). These include high reproductive rates, aggressive territorial nature (Chagaris et al. 2017), venomous spines, cryptic colouring, wide habitat range tolerances, and lack of predators or parasites present to cull numbers naturally (Albins and Hixon 2013). The result of this combination is the unprecedented success displayed by these fish in colonizing a wide swath of ocean, becoming one of the most pervasive marine invaders identified by humans (Albins and Hixon 2013). Their hardiness, combined with their voracious appetite, results in severe depletion of marine biodiversity on reefs colonized by lionfish (Andradi-Brown 2019). Observations indicate that the presence of invasive lionfish species is correlated with a marked reduction of anywhere from 65% to 90% of prey species depending on location and ecosystem as a direct result of predation, with lionfish often comprising 40% of total predator biomass at the time of survey (Green et al. 2012). Currently, lionfish continue to expand their invaded territory and show little sign of stopping, and therefore regular intervention from humans has become a topic of conversation in maintaining biodiversity of reef ecosystems (Chagaris et al. 2017).

Current Methods of Population Control

One method of control is manual recurrent culling through the use of divers with spearguns (Goodbody-Gringley et al. 2023). This method is the most widely used due to its cost-effectiveness. Monthly culling in the Bahamas was conducted over six months, with mean lionfish density reduced following a large cull (Goodbody-Gringley et al. 2023). A large initial culling followed by smaller subsequent culling also was found to reduce both density and average size of recolonizing lionfish over the six month period (Goodbody-Gringley et al. 2023). Limitations of persistent culling include the need for continuous manual hunting, which is influenced by reef geography—complex shapes can conceal lionfish populations—and proximity to human settlements. Additionally, the frequency of culling must exceed the rate of recolonization for any significant impact to be achieved. Furthermore, lionfish recolonization is dependent on the number of young lionfish, which is inversely proportional to the number of adult lionfish as adult lionfish are aggressive towards young and outcompete them (Albins 2013). With the removal of larger adult lionfish, a cycle occurs where the recolonization rate may increase proportionally with efforts to cull them. Additionally, a major restriction with lionfish culling using divers with spearguns is the effective diving range of a human. Depths beyond 60 meters in the lower mesophotic zone remain a haven for lionfish to retreat to and return from (Goodbody-Gringley et al. 2023).

A solution to lower mesotrophic lionfish populations has been the use of traps and remote-operated vehicles (ROV) monitoring as population control methods. The use of traps may provide a cost-effective and easily implemented solution that can be scaled with the severity of infestation (Harris et al. 2023). Tests run in the Gulf of Mexico used three different types of traps, a wooden slat trap commonly used for lobster, a wire mesh trap used for black sea bass, and a Gittings trap which is designed as two semicircular halves that trap the target in a clamshell motion when a central erect plate is triggered (Harris et al. 2023). The effective rate of trapping was monitored using ROVs and Gittings traps were found to be the most effective. The highest trapping rates were only about 1 lionfish per trap, with Gitting traps having a high ratio (5:1) of target species compared to non-target species caught (Harris et al. 2023). If these traps are to become widespread, modifications may be needed to increase efficiency as 20% of traps failed to deploy. Failure to retrieve traps may result in ghost fishing (abandoned fishing equipment left in the sea can still catch and kill marine life) (Harris et al. 2023). There is hope that promotion for fishing traps will form the ground for a fishing industry centred on unsustainably catching lionfish, as a food source and for other products. Some caution should be exercised when promoting the trapping of lionfish for commercial purposes, as it is possible that sustainable fishing practices would emerge that could ultimately promote lionfish population growth instead of limiting it if fishers became dependent on this income (Harris et al. 2023). Lionfish traps look to address the time-intensive nature of manual culls as well as circumvent the depth range of human divers, but ultimately, they may work best when used in conjunction, which may reduce their time-saving benefits.

Potential Directions for Population Control

Historically the focus of lionfish population control has fallen into direct management of the species through killing, but promotion of biotic resistance, the ability of an ecosystem to naturally resist invaders, has been largely unexplored.

Although lionfish do not have any predators in the Atlantic, various grouper (*Epinephelus spp.*) species are natural predators of lionfish in their native Indo-pacific habitats (Smith and Côté 2021). Lionfish predation behaviour is incompatible with their defensive behaviour, and the presence of large groupers in both quantity and size was shown to trigger fear responses in the lionfish, increasing the probability of the lionfish spending their most active hunting hours of dawn in hiding, even when the groupers were not actively preying upon them (Smith and Côté 2021). These non-consumptive effects groupers inflict may provide a much-needed form of biotic resistance for reefs against lionfish. However, groupers are subject to overfishing and are threatened species in much of the Atlantic (Sadovy de Mitcheson et al. 2013). Smith and Côté (2021) highlight the importance of looking at reef ecosystems when determining lionfish control methods. Reestablishing natural large predator species such as groupers could reduce the impact invaders species have on biodiversity within reef ecosystems. Were grouper populations to become protected, it is possible that the reduced lionfish behaviour would eventually result in a trophic cascade of returning prey species due to simple predator-prey dynamics (Smith and Côté 2021). Similarly, species of sharks have also been noted as natural predators of lionfish, and protection of declining shark populations could also influence the abundance of lionfish (Ferretti et al. 2010).

Further studies into the effects of grouper or indigenous large predator species must be made to fully determine the capacity through which non-consumptive biotic resistance may result in increased prey biomass (Smith and Côté 2021). Smith and Côté (2021) did not demonstrate an increase in prey species biomass related to grouper presence, but factors such as study length and relative stability of grouper abundance may be contributing factors. Studies will also need to monitor whether or not grouper species view lionfish as potential prey items as the novelty of their invasion declines (Diller et al. 2014) and whether invasive lionfish continue to respond in fear to groupers in the Atlantic if they are not subject to predation pressure.

Biotic resistance is unlikely to provide a comprehensive solution given the magnitude of success of the lionfish invasion, and lionfish reduction efforts in conjunction with protection of predator species would likely be the most effective option (Albins 2013). Human interventions could include encouraging fisheries to shift their focus from groupers to lionfish. This would serve as a two-pronged approach which would foster native predators while reducing invaders. Research on this topic could monitor both the economic and ecological success as a result of lionfish fishing and observe consumer psychology surrounding ethical seafood consumption. Further research into variation between geographic regions to determine potential factors that either promote or limit growth could elucidate why reefs invaded by lionfish are affected unequally. It would be helpful to understand how proximity to human settlement where spearfishing already occurs influences behaviour, whether lionfish see humans as potential predators when they are hunted frequently, and how the complexity of reef geography affects the ability for lionfish to evade detection from humans and potential predators should they arise (Goodbody-Gringley et al. 2023).

Conclusion

Population control of lionfish is in its infancy despite being an ongoing issue for roughly 30 years. Many solutions have been proposed but lionfish populations continue to bounce back, perhaps through the sheer scale of their invasion, making endeavours costly and attempts almost futile over the long term. Holistic approaches that strengthen the whole ecosystem in conjunction with human assistance are likely to offer the greatest chance of success. With incentives towards lionfish fishing and penalties against native predator overfishing, we may see a shift in biodiversity for the better. Human interventions have been shown to reduce lionfish populations, but studies have not highlighted whether prey species can rebound based on these methods. Reliance on humans requires constant input, through culling and trapping, to maintain lower levels of lionfish populations as full eradications have not yet been achieved. Finding solutions that benefit reef health overall is the best path forward to limit the threat to biodiversity these invaders pose.

References

Albins MA. 2013. Effects of invasive Pacific red lionfish Pterois volitans versus a native predator on Bahamian coral-reef fish communities. Biol Invasions. 15(1):29–43. doi:10.1007/s10530-012-0266-1.

Albins MA, Hixon MA. 2013. Worst case scenario: potential long-term effects of invasive predatory lionfish (Pterois volitans) on Atlantic and Caribbean coral-reef communities. Environ Biol Fish. 96(10):1151–1157. doi:10.1007/s10641-011-9795-1.

Andradi-Brown DA. 2019. Invasive Lionfish (Pterois volitans and P. miles): Distribution, Impact, and Management. In Mesophotic Coral Ecosystems. Cham: Springer International Publishing. (Coral Reefs of the World). p. 931–941. https://doi.org/10.1007/978-3-319-92735-0_48.

Chagaris D, Binion-Rock S, Bogdanoff A, Dahl K, Granneman J, Harris H, Mohan J, Rudd MB, Swenarton MK, Ahrens R, et al. 2017. An Ecosystem-Based Approach to Evaluating Impacts and Management of Invasive Lionfish. Fisheries. 42(8):421–431. doi:10.1080/03632415.2017.1340273.

Diller JL, Frazer TK, Jacoby CA. 2014. Coping with the lionfish invasion: Evidence that naïve, native predators can learn to help. J, Exp. Mar. Biol. Ecol. 455:45–49. doi:10.1016/j.jembe.2014.02.014.

Ferretti F, Worm B, Britten GL, Heithaus MR, Lotze HK. 2010. Patterns and ecosystem consequences of shark declines in the ocean. Ecol. 13(8):1055–1071. doi:10.1111/j.1461-0248.2010.01489.x.

Goodbody-Gringley G, Chequer A, Grincavitch C, Noyes T, Dowell R, Lundberg A, Corbett E, Smith A. 2023. Impacts of recurrent culling of invasive lionfish on mesophotic reefs in Bermuda. Coral Reefs. 42(2):443–452. doi:10.1007/s00338-023-02354-y.

Green SJ, Akins JL, Maljković A, Côté IM. 2012. Invasive Lionfish Drive Atlantic Coral Reef Fish Declines. PLOS ONE. 7(3): e32596. doi:10.1371/journal.pone.0032596.

Harris HE, Garner SB, Tarnecki JH, Gittings SR, Chagaris DD, Patterson WF. 2023. Three trap designs evaluated for a deepwater lionfish fishery. Front. mar. sci. 10. [accessed 2023 Dec 12]. https://www.frontiersin.org/articles/10.3389/fmars.2023.1121642.

Sadovy de Mitcheson Y, Craig MT, Bertoncini AA, Carpenter KE, Cheung WWL, Choat JH, Cornish AS, Fennessy ST, Ferreira BP, Heemstra PC, et al. 2013. Fishing groupers towards extinction: a global assessment of threats and extinction risks in a billion dollar fishery. Fish and Fisheries. 14(2):119–136. doi:10.1111/j.1467-2979.2011.00455.x.

Smith NS, Côté IM. 2021. Biotic resistance on coral reefs? Direct and indirect effects of native predators and competitors on invasive lionfish. Coral Reefs. 40(4):1127–1136. doi:10.1007/s00338-021-02117-7.