

# The Reef Sweeper: A Remotely Operated Vehicle for Harvesting Invasive Lionfish Without Bycatch at Depths to 300 M

## The Reef Sweeper: Un Vehículo Operado de Forma Remota para la Captura de Pez León Invasivo sin Captura Incidental a Profundidades de Hasta 300 M

## Le Reef Sweeper: Un Véhicule Télécommandé pour la Capture de Poissons-lions Envahissants sans Capture Accessoire à une Profondeur de 300 M

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### EXTENDED ABSTRACT

Lionfish in the western Atlantic Ocean pose a threat to marine ecosystems across their invaded range, whether it be via predation on ecologically or economically important species or through competition with native mesopredators (see review by Arndt et al., 2018). To mitigate this threat, managers have focused on programs that encourage volunteer cullers to spear lionfish for consumption and, in some jurisdictions, speared lionfish may be sold. There have also been efforts to commercialize lionfish harvest, both in association with existing commercial trap fisheries and using dedicated traps designed to catch lionfish with minimal bycatch. However, these approaches have their limitations. Divers are limited to depths that they can safely access, and the amount of time that can be spent culling decreases with increasing depth. Even technical diving equipment has limits, and its use must be weighed against cost and safety considerations. In contrast, traps can theoretically operate at any depth, but generally require a flat seabed. Further, they may not be allowed in Marine Protected Areas because of the risk of harm to other species.

Atlantic Lionshare, a Bermuda-based company, has developed a Remotely Operated Vehicle (ROV) designed specifically to harvest lionfish. With the aim of targeting commercial markets for sales, the company is based on a robust business model that incorporates investors, sponsors and donors, as well as utilizing grant funds for development. Importantly, the company has acquired a commercial fishing licence in order to comply with Bermuda laws governing selling fish.

The Reef Sweeper ROV (Figure 1) was custom-built in collaboration with SeaView systems. It utilizes a retractable spear to capture individual lionfish and then retain them within a cage until it returns to the surface. Forward and rear-facing camera feeds allow real-time visual identification of lionfish, and lasers guide the operator firing the spear. Station-keeping software helps the vessel and ROV maintain position while hunting. Another interior camera monitors the removal of the lionfish from the spear and the reloading process, which takes 20 seconds. The Reef Sweeper can be seen in action at <https://www.youtube.com/watch?v=kVqbceqmKIs> or by searching for Atlantic Lionshare on Youtube or Facebook.



**Figure 1.** The Reef Sweeper in operation at a depth of 60 m.

The Reef Sweeper team removed more than 1,000 lionfish from deep Bermuda reefs while developing the ROV, with most of these captures occurring in the final 6 months of testing. During 79 deployments across 23 fishing days between January and June of 2019, a total of 860 lionfish were captured at an average operating depth of 60 m. This represented 66% of all lionfish seen during these deployments. The capture rate per site, for sites with at least one lionfish present, was 54%, and this was heavily influenced by sites where a single lionfish was observed and where the capture rate could thus only be either 0% or 100%. As lionfish density increased, capture success was correlated with the total number of lionfish initially present at a site, and averaged 71% when 20 or more lionfish were present (Figure 2). During the final six months of testing, this was not affected by season, nor by additional operator experience.

The Reef Sweeper is now operating in Florida waters, in collaboration with the Florida Fish and Wildlife Conservation Commission, and the team is removing invasive lionfish from vulnerable deepwater habitats below 46 m while supplying markets with quality fish for consumption. Based on this work, further design refinements to improve spearing efficiency around artificial structures are anticipated. This highlights the fact that the use of remote technology for complex tasks requires continual adaptations to new situations and environments, particularly when the task involves predicting the behavior of an animal in relation to its habitat.

The Reef Sweeper ROV complements other lionfish removal efforts as it can operate for extended periods at depths down to 300 m and can target lionfish regardless of benthic habitat type or the slope of the seabed. This specially designed ROV technology makes harvesting lionfish on a commercial scale, with no by-catch, feasible.

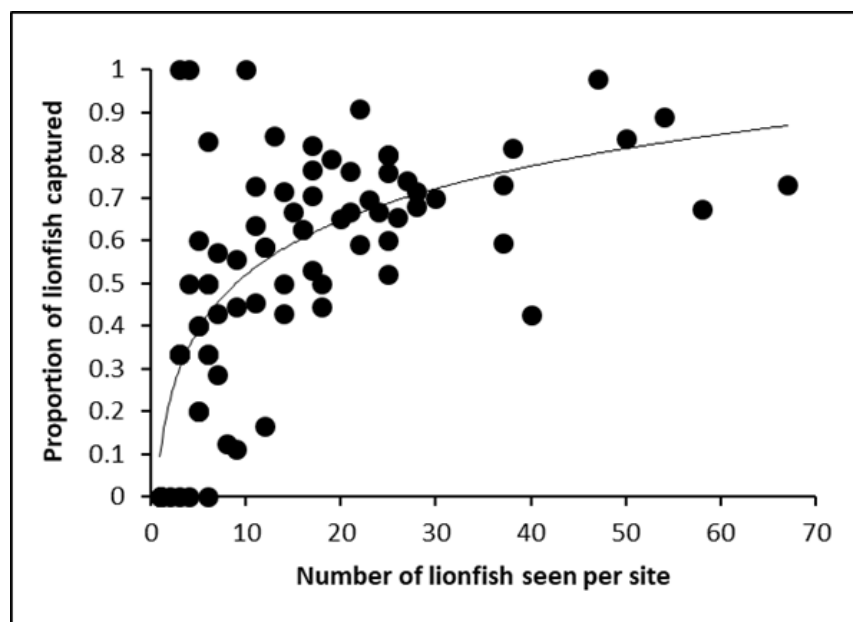
**KEYWORDS:** Invasive lionfish, lionfish control, ROV, Bermuda, Reef Sweeper

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#### LITERATURE CITED

Arndt, E., M.P. Marchetti, and P.J. Schembri. 2018. Ecological impact of alien marine fishes: insights from freshwater systems based on a comparative review. *Hydrobiologia* **817**:457 - 474.



**Figure 2.** Capture rates across 79 lionfish-hunting ROV deployments, showing the relationship between capture success and the number of lionfish initially observed at the site.