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TARGETED REMOVALS OF INVASIVE SPECIES IN MARINE PROTECTED AREAS

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Abstract
Invasive species are proliferating in the Mediterranean basin and affect Marine Protected Areas (MPAs). Targeted removals offer potential to control invasive fish populations. Society needs information on their cost-effectiveness to assess whether costs are proportionate to the expected impacts on the environment. This study provides insights into the cost-effectiveness and potential of using targeted removals to manage lionfish invasion in priority habitats of the Mediterranean Sea.

Keywords: Mediterranean Sea, Invasive species, MPAs, Coastal management

Well policed, highly protected areas can prevent further degradation of marine resources and provide a refuge against the impacts of climate change and biological invasions. However, many MPAs host high invasive species richness [1]. South and Eastern Mediterranean MPAs host higher biomass of non-indigenous and native-range expanding fish than adjacent unprotected areas, leading to calls for targeted removals to control invasive fish [2].

Inclusion of a species on the Invasive Alien Species list of the EU (EC/2016/1141) requires that management measures are cost-effective and proportionate to the impact on the environment. This study elucidates the efficiency of coordinated removals of lionfish *Pterois miles* (Bennett, 1828) in priority areas within MPAs of the eastern Mediterranean.

We coordinated removals in highly infected areas to assess their efficiency in mitigating impacts, and to understand lionfish recolonization. Lionfish were caught using slingshots and removed using specialized containers (Figure 1). Nine ca 0.01 km^2 monitoring stations were selected within two MPAs; six at 20 m (± 2 m) depth and three at 7 m (± 2 m), and removals of different intensities were carried out at four intervals during the summers of 2018 and 2019. Underwater visual census was used to monitor lionfish and surrounding fish communities on replicate strip transects.

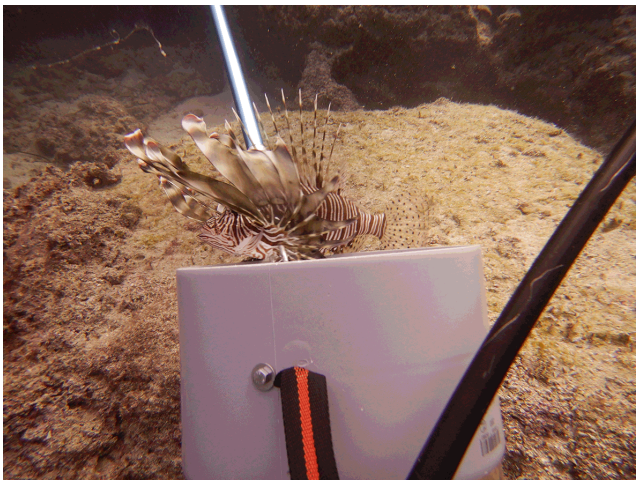

Fig. 1. Lionfish captured using a slingshot being put into a container at 7 m depth of the Cape Greco MPA during summer 2018. These invasive fish have rapidly increased in abundance since the recent widening and deepening of the Suez Canal in Egypt [3].

We found that strip transects underestimated lionfish biomass and that targeted surveys provided a better estimate of the lionfish present. Full removal of lionfish was not possible since some individuals, especially juveniles, escaped. Alternative methods for capturing juveniles should be explored in future (e.g. handheld nets). Seabed habitat features were a major factor influencing lionfish recolonization following removals, those sites that were highly connected required more effort to reduce lionfish densities.

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