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Lionfish invaded the mesophotic coral ecosystem of the Parque Nacional Arrecife Alacranes, Southern Gulf of Mexico

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After the first detection of the Indo-Pacific lionfish (*Pterois volitans*) off the Florida coast (USA) approximately 30 years ago, its populations have continued spreading throughout the Western Atlantic. The invasive lionfish is a threat to the marine ecosystems because individuals reproduce fast, reach high population densities, prey on many taxa without discrimination, disperse as larvae by currents, and lack predators (Côté et al. 2013). Now, the lionfish has been detected in the mesophotic coral ecosystems (Lesser and Slattery 2011), which are deep (30–150 m) fore-reef communities with low light adapted macroalgae and zooxanthellate corals and gorgonians (Lesser and Slattery 2011). These habitats are considered a buffer against anthropogenic disturbances that impact their shallow reef counterparts. It is necessary to document as much biological information as possible on lionfish not only to follow the progression of its invasion in the Western Atlantic, but also to identify locations where it is particularly abundant.

Here, we report the presence of lionfish in the mesophotic coral ecosystem (>35 m deep) of the Alacranes reef (22°21′44, 22°35′12N; 89°36′30, 89°48′00W), the largest reef complex in the Southern Gulf of Mexico. Alacranes reef is located approximately 130 km off the northern coast of the Yucatan Peninsula, Mexico. While declared in 1994 a natural protected area known as Parque Nacional Arrecife Alacranes (PNAA), commercial and recreational fishing are allowed in the area. The PNAA is an important fishing ground for lobster (*Panulirus argus*) and groupers (Epinephelidae). During SCUBA incursions in a deep reef, known as "Juanchos" (22°21′0.66″N; 89°41′48.04″W) located at southern PNAA, we sighted 30 lionfish (in ~100 m^2) on September 2014 and 40 (in ~100 m^2) on October 2015, at a deep range between 40 and 45 m (Fig. 1). These observations were conducted during SCUBA incursions—only one dive per year—at the reef "Juanchos", which is a relatively large reef formation (~2 ha) comprising several high-relief boulders (5 and 10 feet over the bottom) containing corals, sponges, leafy algae, and coralline algae. Diving bottom time (less than 9 min per dive) at this deep site limited activities; thus, one diver counted lionfish while another diver speared individuals during each dive. Probabilities of recounting lionfish in each visit to "Juanchos" could be minimized by the fact that the diving spot visited each year was not exactly the same as that in the previous years, but it was the same reef. A lionfish sample collected with a Hawaiian sling (Fig. 1) was taken to the laboratory for processing. Collected individuals showed a size range between 36 and 44 cm in total length (TL) ($N = 12$, September 2014) and 21 and 42 cm TL ($N = 22$, October 2015).

In the Western Atlantic, the invasive lionfish has been reported in mesophotic coral ecosystems previously. In the Bahamas, individuals were found at 91 m depth (Lesser and Slattery 2011). During ROV video surveys, Nuttall et al. (2014) recorded almost 400 lionfish in banks of the northwestern Gulf of Mexico at a depth range of 50 to 176 m, with the greatest lionfish abundance between 80 m and 89 m. In the eastern Gulf of Mexico, trawl surveys revealed high abundance at depths between 40 and 80 m, with individuals up to 40 cm TL (Switzer et al. 2015).

In 2010, the first record of lionfish in the Southern Gulf of Mexico was made at a mesophotic coral ecosystem (38 m deep) located 50 km west of the PNAA, but only two small individuals were sighted and one was collected (<15 cm TL) (Aguilar-Perera and Tuz-Sulub 2010). However, our present

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Fig. 1 Lionfish (*Pterois volitans*) hovering on mesophotic coral ecosystems (at 40 m depth) in the Parque Nacional Arrecife Alacranes, Southern Gulf of Mexico

work reports that lionfish invaded (high abundance) the mesophotic coral ecosystem in the PNAA, and also accounts for the largest lionfish captured in the region (44 cm TL) so far.

In general, given such an abundance and large size of lionfish in mesophotic coral ecosystems, it is a concern for scientists and managers on how to implement population control measures to tackle the invasion properly. Removal by divers is the more common and recommended method for population control (Barbour et al. 2011); however, such a method is only possible for divers in waters shallower than 35 m. Thus, scientists have to find sound solutions addressing the lionfish invasion to prevent their devastating effects on these deep ecosystems. An alternative could be the development of specially designed traps to attract lionfish selectively.

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