Effect of regular culling on the red lionfish (*Pterois volitans*) population in Martinique (FWI)

Effets d'un contrôle régulier sur les populations de poisson-lion (*Pterois volitans*) en Martinique (Petites Antilles)

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RÉSUMÉ

Observé pour la première fois en Martinique en 2011, le poisson-lion (Pterois volitans) a atteint des fortes densités dans les eaux côtières de l'île (480 ind.ha^{-1}). L'Observatoire du Milieu Marin Martiniquais (OMMM) a initié un programme de suivi en 2013 pour évaluer l'efficacité des mesures de contrôle des populations de poisson-lion. Au cours d'une année, les poissons-lions ont été capturés mensuellement sur 5 portions de récifs de surface comprise entre 500 m^2 et 2500 m^2. En moyenne, 74 ± 13 % de la population observée étaient capturés à chaque fois. Malgré les efforts de capture constant, les populations de poisson-lion ne rajeunissaient pas, et ne diminuaient pas non plus sur les portions de récifs continues. Nos résultats soulignent la vitesse de recolonisation des poissons-lions sur des espaces nettoyés au préalable à travers les processus de recrutement et de migration des juvéniles et adultes. La migration observée suggère une plus grande mobilité des poissons-lions juvéniles et adultes par rapport à d'autres régions envahies ou les poissons-lions semblent plus territoriaux. Sur les portions de récifs isolés, un contrôle régulier des populations entraine une diminution significative des densités de poissons-lions tandis que sur les portions de récifs continus, de tels efforts de captures maintiennent une densité comprise entre 100 et 200 ind.ha^{-1}. Les données de captures des centres de plongée sur 2 sites différents sur une période de deux années ont montrés qu'à effort de chasse constant sur 2 ans (respectivement hebdomadaire et mensuel), le nombre de poissons-lions capturés par plongée a doublé de manière significative sur le site « Batelière » et a même été multiplié par 4 sur le site de « Cap Salomon ». De nouvelles études sont nécessaires pour évaluer les densités des populations de poissons-lions dans les eaux profondes et les schémas de migration entre les eaux profondes et peu profondes, caractéristique des îles volcaniques, chez cette espèce.

SUMMARY

First observed in Martinique in 2011, the red lionfish (*Pterois volitans*) has reached high densities in coastal waters of the island (480 ind.ha^{-1}). The Marine Institute of Martinique (OMMM) initiated a monitoring program in 2013 to assess the efficacy of control measure efforts. Monthly lionfish culling were tested for one year on five reef patches ranging from 500 m^2 to 2500 m^2. An average of 74 ± 13 % of the observed population was removed each time. Despite consistent culling efforts, the lionfish population do not tend to be younger, neither to be smaller on continuous reef. Our results highlight how fast lionfish recolonize previously culled areas through recruitment and migration of juveniles and adults. Migration suggests low site fidelity and larger mobility of juvenile and adult lionfish compared to other invaded regions. On isolated patch reefs, regular culling tends to decrease lionfish abundance significantly while on continuous reef, such efforts maintain lionfish density ranging from 100 to 200 lionfish per hectare. Culling data collected from dive centres on two different sites for a period of two years revealed that with a constant culling effort frequency for 2 years (weekly and monthly respectively), the number of lionfish captured per dive doubled significantly from 2012 to 2013 at "Batelière" and a 4-fold significant increased capture rate at "Cap Salomon". More studies are needed to assess deep lionfish population and migrating patterns of lionfish from the depths to the shallows, especially in volcanic islands.

KEYWORDS : invasive species, Martinique, population control, *Pterois volitans*, colonization

INTRODUCTION

Indo-Pacific lionfish (*Pterois volitans/miles*) have invaded large parts of the western Atlantic, Caribbean and Gulf of Mexico, and have already caused measurable declines in native Atlantic reef fauna. Culling efforts are occurring across the region, particularly on coral reefs, to reduce local lionfish abundances. Some studies have suggested that they appear to have rapidly increasing populations (Albins & Hixon, 2008; Pimiento *et al.*, 2013). First recorded in Martinique in 2011 (Trégarot *et al.*, 2015), the lionfish has reached high densities in coastal waters of Martinique. The Marine Institute of Martinique (OMMM) investigates the effects of control efforts on lionfish population density along with processes of recruitment and immigration.

MATERIALS AND METHODS

In 2013, the survey area was increased to 50 m x 50 m quadrats to cover larger portion of habitats, from the shallows to the bottom of the reef slope. Five quadrats have been surveyed every month when possible. Only rocky reef and rocky shore habitats were sampled. Two scuba divers delimited a surface ranging from 500 m^2 to 2500 m^2 using two 50 m multi-decametres placed in parallel 50 m from each other, from the shallows to the bottom of the reef or rocky bottom. The divers scrutinized carefully every square meter following an S-shaped pattern. Every lionfish was recorded and captured/killed if possible. Total length was assessed underwater and reported on a dive sheet, along with depth and substratum details. The quadrat surveys occur over five sites along the west coast. Sites were surveyed multiple times, but only data collected during the first visit were used to calculate average density as number of lionfish per hectare to avoid the effect of removal on population density.

Two dive sites have been selected from the lionfish capture's database of Martinique: "Batelière" and "Cap Salomon" (Fig. 1). They have been the most controlled in terms of frequency and number of culled lionfish in Martinique, include date of capture and number of lionfish removed. Frequency of capture per year has been determined as the average number of days between two culling dives.

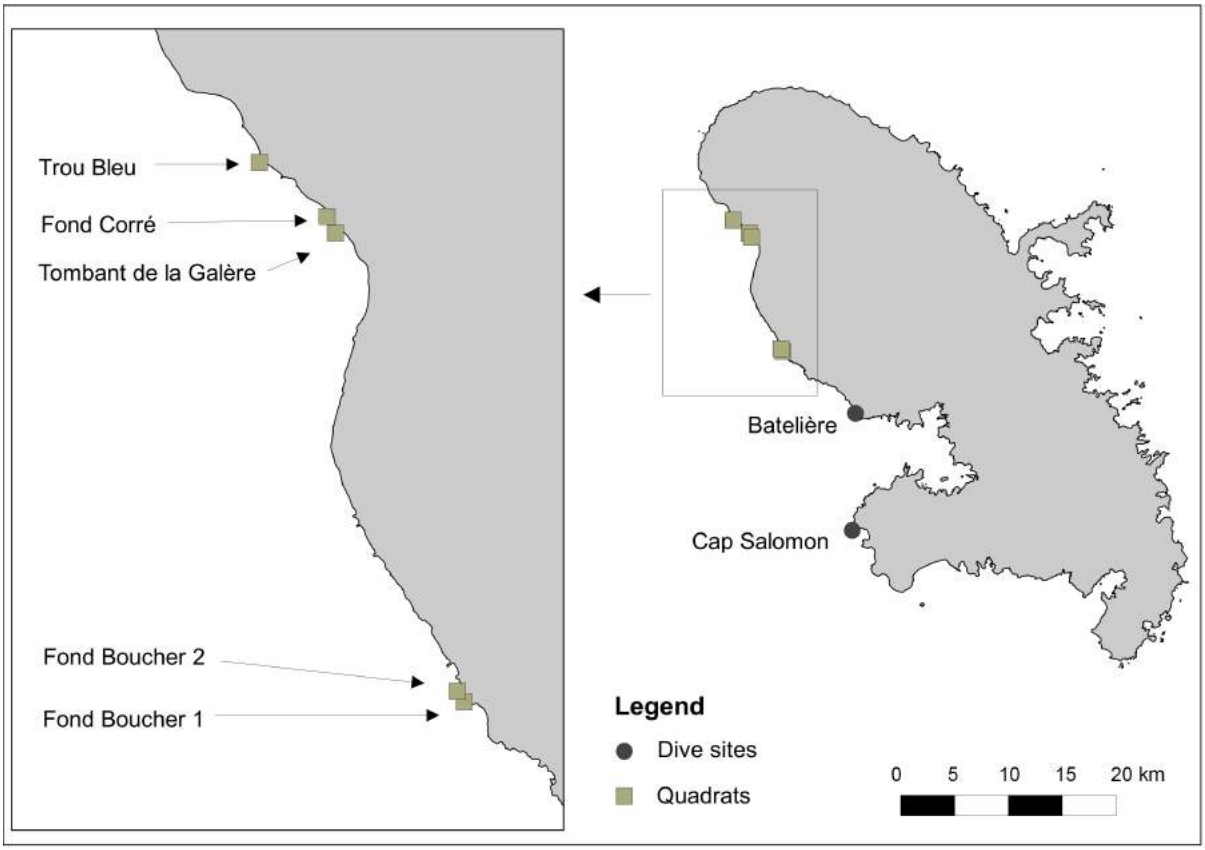

Figure 1. Location of quadrats and dives sites for the study of control efforts on lionfish population in Martinique

RESULTS & DISCUSSION

Despite careful searching efforts, lots of lionfish were likely to be missed during the survey given their cryptic behaviour and complex reef habitats. Besides, lionfish tends to be wary at the diver approach as mentioned by Côté *et al.* (2014), those lionfish were usually found in big cavity where they can hide deeply inside. Repetitive lionfish culling were tested for one year on five reefs' patch ranging from 500 m^2 to 2500 m^2, a total of 1195 lionfish were observed during the survey and 74 ± 13 % of the observed population were removed in average at each time.

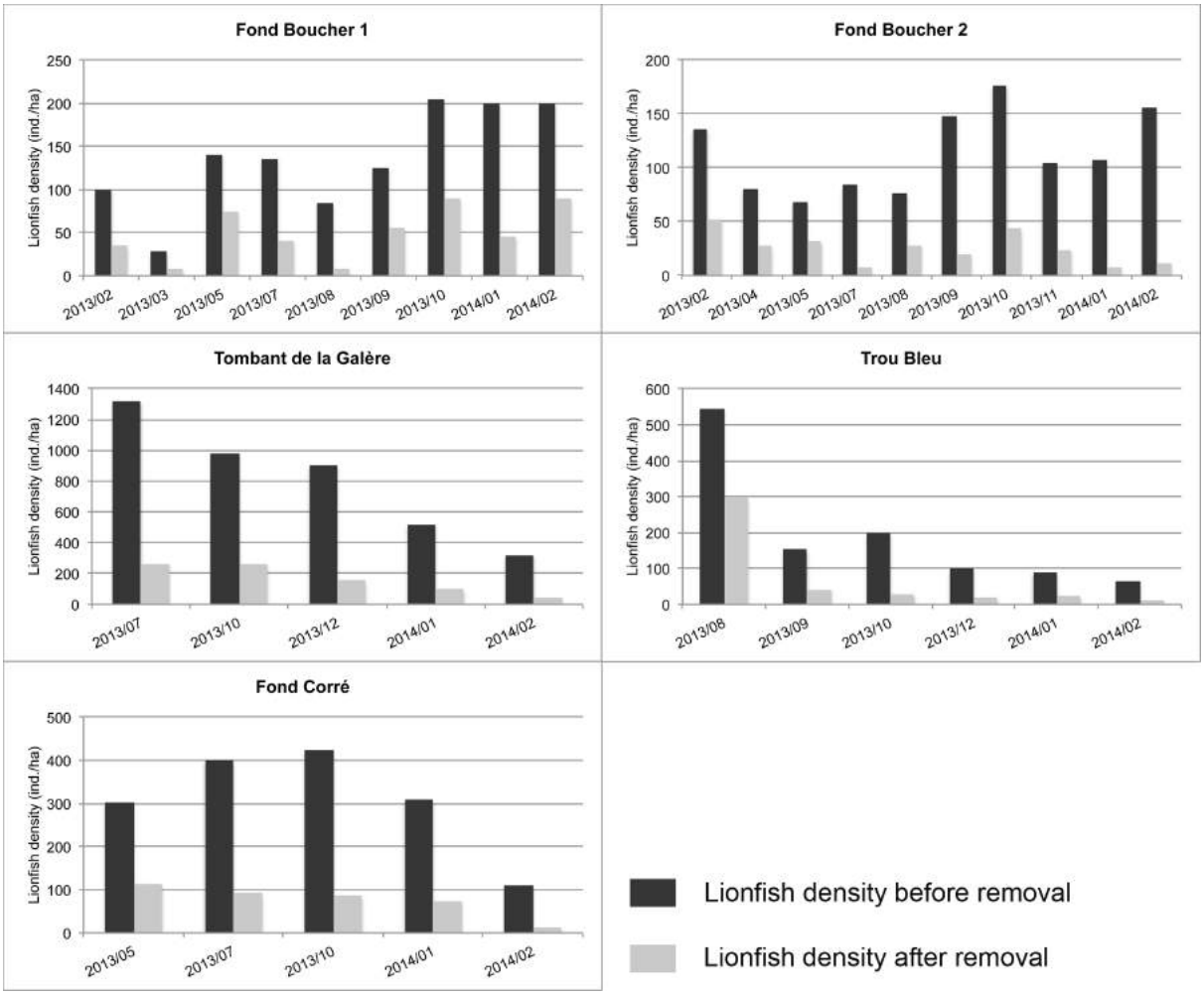

Figure 2. Lionfish density for each quadrat surveys (densitiy expressed in number of lionfish per hectare, before and after removal

On continuous reef such as Fond Boucher 1 & 2 (Fig.1), despite consistent culling efforts, the lionfish densities remained relatively stable over the year of experiment (in average 135 ± 60 ind./ha on Fond Boucher 1 – 113 ± 38 ind./ha on Fond Boucher 2). The lionfish population do not tend to be younger, neither to be smaller. This outcome reveals how fast lionfish have been able to recolonize a previously culled area through processes of recruitment, occurring all year long, and immigration.

Lionfish recruitment

Lionfish with a total length of 50 mm or less are considered as recruits (Benkwitt, 2013). A total of 15 recruits were observed within all quadrats except "Trou Bleu" during the survey from May 2013 to January 2014 suggesting there is recruitment all year long on the leeside of Martinique. The average depth recruits were found was 14,6 ± 5,1 m and 64 % were found on sponges, usually *Xestospongia muta*.

Juveniles and Adult Immigration

Jud and Layman (2012) found that in a Florida estuary, lionfish expressed high site fidelity and short movement pattern. This behaviour makes frequent localized control efforts very effective in order to maintain a younger and smaller population. In the experiment we conducted in Martinique, fast colonisation of previously culled area suggests lower site fidelity and greater movement pattern from juveniles and adults lionfish compared to other studies in the invaded range.

On isolated patch reefs (Trou Bleu, Tombant de la Galère, Fond Corré), repetitive culling tends to decrease significantly lionfish abundance. For instance, on Tombant de la Galère (sampling area is 500 m^2), lionfish densities went from 1320 to 520 ind./ha. On Trou Bleu, lionfish densities decreased from 544 ind./ha to 88 ind./ha.

Dive centre control efforts

The local strategy to control lionfish population relies mainly on scuba divers and so we went through culling data collected from dive centres on two different sites for a period of two years. With a culling effort remaining constant for 2 years, the number of lionfish captured per dive doubled significantly from 2012 to 2013 in Batelière and increase significantly by a factor 4 in Cap Salomon with culling frequency occurring respectively every week and every month in average.

On the rocky reef called “Batelière” in Schoelcher, lionfish were frequently removed from a dive centre located next to the reef. We compared the control effort from the years 2012 and 2013. While there is no significant difference with the frequency of lionfish captures (Wilcoxon-test, *p*-value = 0,40), the number of lionfish captures per culling dive is significantly higher in 2013 (Wilcoxon-test, *p*-value < 0,01).

The same occurs on another spot called “Cap Salomon”. No difference appears on the frequency of culling (in average every 25 days), suggesting constant control effort. However the number of lionfish captures per dive is significantly higher in 2013 (2012 : 6,2 ; 2013 : 36,8 Wilcoxon-test, *p-value* < 0,01).

Volcanic islands in the Lesser Antilles raise the issue of deep lionfish populations very close to the coastline, which are likely to impede the efficiency of constant control effort by scuba divers. Fortunately fishermen in Martinique are catching lionfish at depth greater than the scuba diving

range (up to 200 m in depth). Some more studies on lionfish movement pattern should be carried out in Martinique using fish tags along with an evaluation of deep lionfish population, through fishermen captures effort, to highlight migration from the depths to the shallows.

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