Lionfish Population Density in Discovery Bay, Jamaica.

Denise A. Chin, Karl A. Aiken, Dayne Buddo

Abstract— Lionfishes, *Pterois volitans* and *Pterois miles*, were first recorded on the north coast of Jamaica in 2008. They are now found in all Jamaica's coastal waters including offshore banks such as Pedro and Morant Cays. These native species of the Indian and Pacific Oceans have now established populations along the southeast coast of the United States, the Gulf of Mexico, the Caribbean and South America. Due to their potential negative impact on fisheries and the marine ecosystem, we sought to investigate their population densities at three sites along the Discovery Bay coastline over 26 months. The lionfish population density decreased at two of the three sites surveyed. At Skeggy Reef (the westward site) and Dairy Bull (the middle site) there was a decline in the population by approximately 26% and 31% respectively. Pear Tree Bottom (eastward site) showed an increase in the lionfish population density of 85% over the same time period. The ratio of female to male lionfish was 1: 1.2 with 60% (n=179) of the female population noted to have spawning capable to actively spawning gonads. This reduction in the population could be attributed to an increase in public education and awareness on lionfish through a national campaign promoting the consumption of lionfish as a control mechansim. Other possible reasons for the decline could be due to migration to deeper waters and behavioural changes to humans. Continued promotion of lionfish consumption is recommended to control this alien invasive fish as well as further research.

Index Terms—Discovery Bay, Invasive Species, Jamaica, Lionfish, Population Density, *Pterois volitans.*

1 Introduction

INVASIVE species are often known to cause negative impacts on the ecosystem such as the reduction of biodiversity [1], [2] and may cause negative ecological and economical impacts [3]. Pimentel et al. [4] estimated that invasive species in the United States alone were estimated to cost that economy approximately 120 billion US dollars annually. The introduction of the marine alien invasive species Lionfish (*Pterois volitans* and *Pterois miles*) in Jamaica, the wider Caribbean and the Northeast Atlantic [5], [6] has been of concern among some stakeholders. Lionfish are native to the Indian and Pacific Oceans [7], [8] and was introduced to the Atlantic Ocean [1] around the 1980s [9]. In Jamaica, confirmed sightings of the invasive lionfish were first documented in 2008. Since then, the lionfish is found in all coastal waters of Jamaica.

Lionfish have high growth and reproductive rates, spawning year round [10], [9] in the invaded areas. The Bahamas has been reporting population densities of up to 390 lionfish per hectare [12] and up to 55 lionfish per hectare off the Venezulan coastline [13]. Lionfish are ambush predators [14] that posess venomous spines for defense [15]. Additionally, lionfish in the invaded areas seem to have less parasite load in the Atlantic and Caribbean [16], [17] giving them an added chance to thrive more successfully.

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Lionfish are generalist feeders having the capability of reducing coral reef fish populations [15] including commercially important fish species. For Jamaica, a Small Island Developing State (SIDS), the potential cascading effects on coral reef systems [10] and food webs [18] of the Lionfish invasion is of concern since this can have serious implications on fisheries and by extension the tourism sectors.

This study examined the population densities of Lionfish across three sites on the north coast of Jamaica, Discovery Bay, St. Ann over a period of 26 months in an effort to assess the level of invasion and the ongoing population dynamics. The aim is therefore to determine the population density, size and structure along the Discovery Bay coastline in Jamaica.

2 Method

2.1 Study Sites

The study station, Discovery Bay, 18°27'58.17"N 77°24'29.32"W is situated on the north coast of Jamaica in the parish of St. Ann. There are approximately 2535 persons [19] residing in the town of Discovery Bay. The main sources of employment for the residents are in the bauxite and tourism industries. Artisinal fishing, research, teaching, as well as the other social support services are other avenues for employment [20]. The fish populations being exploited are mainly pelagic and reef fishes, lobster, conch, and octopus [20].

Within the Discovery Bay area, three sites [Pear Tree Bottom (PTB), 18°27'49.73"N 77°21'15.63"W; Dairy Bull (DB), 18°28'6.90"N 77°23'15.07"W and Skeggy Reef (SR), 18°28'44.55"N 77°25'58.33"W] (Fig. 1) were chosen along the Discovery Bay coastline based on accessibility to dive sites and availability of personnel to conduct surveys.

Fig.1. Survey Stations in Discovery Bay, St. Ann, Jamaica.

These sites were surveyed on a monthly basis over 26 months. The sites are areas that experience spear, gill net, line and pot fishing. The sites feature fringing coral reef systems [21], [22] and were assessed using SCUBA.

2.2 Survey Method

Within the Discovery Bay station, the three sites [Pear Tree Bottom (PTB), Dairy Bull (DB) and Skeggy Reef (SR)] were assessed monthly over 26 months (February 2012 – March 2014).

The sites were accessed by boat from the Discovery Bay Marine Laboratory (DBML). Using SCUBA, a team of at least two persons conducted lionfish population density surveys.The date, time of dive, name of site and depth were recorded for each site. Transects are usually conducted at a depth of 18.3metres (60 feet). Once in at the specified depth, a stratified random sampling method was employed. Six belt transects with dimensions of 10m x 25m each were conducted at each site running parallel to the shoreline. Each diver in a buddy pair surveyed one half of the transect (5m x 25m) swimming in a S-shaped pattern (Fig. 2) thoroughly searching under crevices.

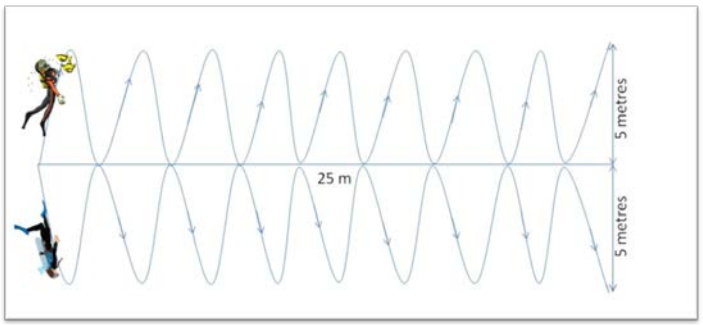

Fig. 2. Illustration of Lionfish Population Density Survey Swim Pattern.

The number of lionfish observed was recorded including an estimation of their total length using the 5cm graduations on the T-bar, the location at the time of observation (exposed or hidden) and whether it was solitary or found in a group. Additional observations were noted if necessary, for example, appearance of scars or unusual behavioural patterns. Specimens were collected by using a polespear and transported in a lionfish collection bag for further analysis.

2.3 Coral Reef Rugosity

At each sampling site, the rugosity was calculated by using the chain-and-tape method [23]. This was done by laying a transect line 9.14 meters (30 feet) in parallel to the shoreline. A steel chain 6.1 meters (30 feet) in length was then laid along the transect line contouring the surface of the reef. The length covered by the steel chain was noted using the transect tape. This was repeated 5 times at each sampling site. The rugosity index, C, was calculated using the equation $C = 1 - d/l$; where d is the distance covered by the steel chain and l is the actual length of the steel chain [24], [25].

2.4 Lionfish Biometric Analysis

Lionfish for biometric analysis were captured using a pole spear. Total length (mm) and weight (g) were measured from 419 lionfish (both sexes combined) collected across the three sites. Each specimen was sexed, when possible, and the stage of gonad development was noted [15].

2.5 Statiscal Analyses

2.5.1 Population Density

The survey data were entered into Excel and the density for each site was calculated. The overall abundance was then obtained as the mean of the transect abundances [12], [9]. Using STATISTICA 7 software, the significant differences between the sampling sites was tested using ANOVA (95% confidence limit) followed by Tukey HSD post hoc test ($\alpha = 0.05$).

2.5.2 Coral Reef Rugosity

From the coral reef survey rugosity surveys conducted, the rugosity index, C, was calculated. An ANOVA was carried out using STATISTICA 7 to assess any significant variation between the three sampling stations (PTB, DB, and SR). A 95% confidence level was used.

2.5.3 Lionfish Biometry

To test for significant differences (at an α level of 0.05) in fish length between the different sampling locations. An one-way analysis of variance (ANOVA) was carried out followed by Bonferroni post-hoc testing.

RESULTS

Over 26 months of monitoring, the mean lionfish densities (±SE) were highest at Pear Tree Bottom (39.51 ± 5.60) followed by Skeggy Reef (32.58 ± 4.89) and lowest at Dairy Bull (21.29 ± 3.47) (Fig. 3). ANOVA showed that there were significant difference in lionfish densities across the three sampling sites ($\alpha = 0.05$; $F(2, 75 = 3.771$; $p= 0.028$). Tukey HSD test revealed that there was a significant difference between Dairy Bull and Pear Tree Bottom ($\alpha = 0.05$; $p= 0.02$).

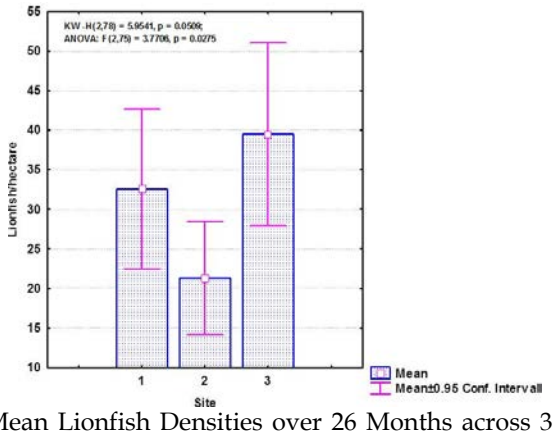

Fig.3. Mean Lionfish Densities over 26 Months across 3 Sampling Sites (1- Skeggy Reef, 2- Dairy Bull and 3- Pear Tree Bottom).

Over two sampling years, Skeggy Reef showed a decline in the mean lionfish density (±SE) from 37.45 ± 8.76 lionfish ha^{-1} to 27.71 ± 4.33 lionfish ha^{-1} (Fig. 4) (ANOVA: α = 0.05; F(1, 24)=.99540, p= 0.33).

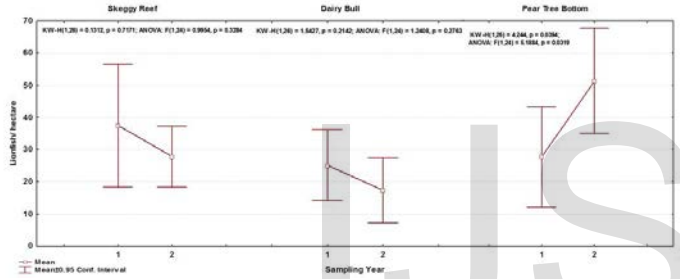

Fig.4. Lionfish density per hectare for two sampling years at three sites in Discovery Bay, St. Ann, Jamaica.

Dairy Bull also showed a decline in the mean lionfish density (±SE) from 25.14 ± 5.07 lionfish ha^{-1} to 17.44 ± 4.69 lionfish ha^{-1} (ANOVA: α = 0.05; F(1, 24)=1.2408, p= 0.28). Pear Tree Bottom, however, showed an increase in lionfish density (±SE) from 27.71 ± 7.12 lionfish ha^{-1} to 51.31 ± 7.53 lionfish ha^{-1}. Pear Tree Bottom also showed a significant difference in lionfish density over the 2 sampling years (ANOVA: α = 0.05; F (1, 24) =5.1884; p= 0.03). There was no significant difference in rugosity across the three sites (ANOVA: α = 0.05; F (2, 12) = 0.22951; p= 0.79833).

Lionfish Biometry:

The mean total length (TL) of lionfish was significantly different across the three sampling sites (ANOVA: α = 0.05; F (2,416) = 15.3663; p= < 0.001). The mean lionfish TL was highest at Skeggy Reef (Fig. 5) followed by Dairy Bull and lowest at Pear Tree Bottom.

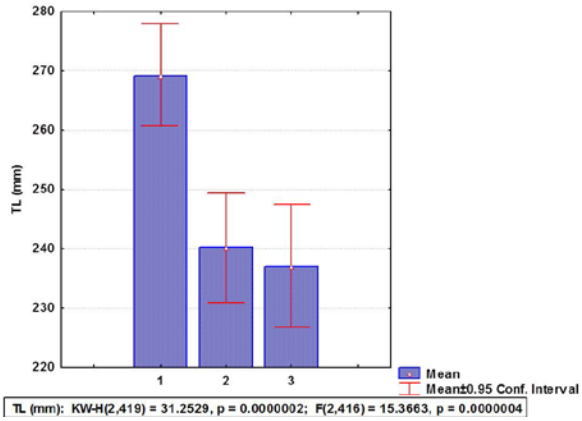

Fig.5. Mean lionfish total length (TL) across the three sampling sites (1- Skeggy Reef, 2- Dairy Bull and 3- Pear Tree Bottom); both sexes combined.

Of 419 Lionfish measured, the maximum TL was 410 mm and the minimum TL was 93 mm. Growth parameters for the length-weight-relationship for both sexes were estimated as a= -4.56 and b= 2.85 (Fig. 6), r ^{2} = 0.8715 showing a negative allometric growth pattern. 590 lionfish were examined for gender, 64% were males, 30% females and 6% immature. 60% (n=178) of the female population were noted to have spawing capable to actively spawning gonads.

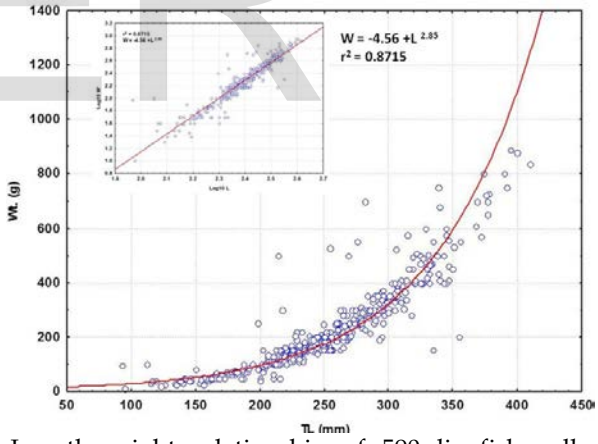

Fig.6. Length-weight relationship of 590 lionfish collected along the three sampling sites (both sexes combined).

DISCUSSION

The mean lionfish densities across the three sites in Discovery Bay coastline can be considered conservative. These mean densities were over nine times less than those recorded in the Bahamas [12] and over three times less than Venezula [26]. However, the mean densities are comparable to those found in Southern Costa Rica [27]. Of the three sites surveyed, Skeggy Reef and Dairy Bull showed a decrease in lionfish densities with Dairy Bull having the lowest of the three sites [28]. Dairy Bull is the closest fishing site from the nearby fishing communities (Old Folly Fishing Beach and Fortland Rhoades Fish-

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ing Beach) and is known to be heavily fished using a combination of spearfishing, gill nets, lines and traps. This could possibly explain Dairy Bull having the lowest lionfish density of the three sites over the 26 months. Pear Tree Bottom, however, showed an increase in the lionfish density over the same time period. Lionfish are known to be cryptic and can be found under overhangs and in crevices [7]. Pear Tree Bottom was observed to have more overhangs than the other two sites; this could have possibly increased the areas for lionfish to shelter and be hidden from spearfishers. Spearfishers at this site (Pear Tree Bottom) normally dive to approximately 12.2 meters (40 feet) in depth. It was also observed that fish traps were the main fishing gear used at Pear Tree Bottom. Hence, this reduced fishing pressure at this site may acccount for the increase in the lionfish populations at this depth. It should be noted that statistically there was no significant difference in rugosity among the sites. The surveys were done at 18.3metres (60 feet) and therefore would not take into account any migration that may occur.

However, during this survey there was a national campaign focused on Lionfish consumption as a control mechanism which was believed to have increased the demand for Lionfish. Noteworthy, is that some fishermen would previously throw back these Lionfish caught in their traps. The campaign educated the fishermen within the sampling sites on safe handling and preparation of Lionfish for their customers.

Skeggy Reef has the highest mean lionfish total length (TL) followed by Pear Tree Bottom and Dairy Bull having the lowest. Most of these lionfish caught were removed using polespears by SCUBA divers. This may have resulted from a sampling bias as smaller specimens could have been less apparent on reefs, more difficult to spear, and less favourable by the divers. The length- weight relationship showed a negative allometric growth pattern. This was found to be similar to North Carolina where 'b' was 2.89 [29]. Rodríguez-Cortés et al. [30] found the 'b' parameter of lionfish in Southern Gulf of Mexico to have a positive allometric growth pattern. However it should be noted that the parameter 'b' is subject to changes because of sample size, environmental factors, and seasonality [31].

CONCLUSION

Overall, the decrease in the two sampling sites may have been due to increased demand for fishermen to hunt Lionfish creating additional income with little to no added effort to their normal fishing routines. Public education and capacity building especially fisherfolks are important in controlling this invasive species. Continued research is recommended to monitor the population densities at these and other sites around the island. The continued efforts to promote Lionfish consumption are necessary to drive the demand for removals of this marine invasive species.

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