The Effect of Lionfish (*Pterois volitans*) on Biodiversity of Patch Reefs in Southern Eleuthera, Bahamas

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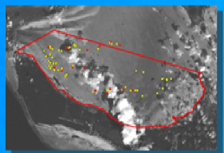


Figure 1: Cape Eluethera Study Area

Introduction

Lionfish (*Pterois volitans*) are carnivorous marine predators which originate from the Indo-Pacific. However, since the first sighting of lionfish in The Bahamas in 2004, their density has become eight times greater than that of their native range (Morris et al. 2009 and references therein). Lionfish are well suited for The Bahamas, and represent a great potential threat to reef ecosystems in the area. The successful introduction of lionfish has been attributed to limited natural predators, rapid rates of reproduction, and the naiveté of native fish populations with lionfish hunting techniques and behavior (Albins and Hixon 2008).

Lionfish prey on juvenile reef fish and crustaceans (Morris et al. 2009). Experimental studies have shown that lionfish can decrease native reef fish recruitment by 79% (Albins and Hixon 2008). The overfishing of possible lionfish predators and competitors, such as groupers in The Bahamas, is also problematic. With decreasing numbers of competitors and predators, and increasing numbers of lionfish, the already massive invasion into the Atlantic and Caribbean is being exacerbated by human activities. Due to their predatory efficiency, lionfish may negatively impact biodiversity, which is important to ecosystem stability (Worm et al. 2006).

The purpose of this study was to (1) continue data collection on the abundance of 7 ecologically and environmentally important species and (2) to assess the impact of lionfish on the biodiversity of patch reefs in South Eleuthera. We hypothesized that due to their rapid proliferation, predatory efficiency, and ability to compete with native reef species, lionfish will be detrimental to the biodiversity of near-shore patch reefs in South Eleuthera.

Figure 2: Lionfish Distribution in the Atlantic and Caribbean in 2009

Key Species Abundance

Methods

Visual surveys of 29 randomly selected patch reefs were conducted to assess the abundance of 7 key species (Black Grouper, Nassau Grouper, Lionfish, Caribbean Spiny Lobster, French Grunt, Queen Triggerfish and Yellowtail Snapper). At each patch reef, environmental parameters, including water depth, water temperature, cloud coverage, and tide state, were taken. Physical reef characteristics, including the presence of sand halos, surrounding habitat, size and complexity were also recorded. Four replicates were taken at each reef and the mean species abundance was calculated using Excel.

Results

Of the 29 reefs surveyed this semester, lionfish, Black Grouper, and Caribbean Spiny Lobster were most common with lionfish being the most abundant species observed (Fig. 3).

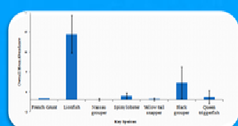


Figure 3: Over all mean abundance of the key spices on the 29 patch reefs surveyed this semester.

Lionfish, queen triggerfish, spiny lobster, and Nassau Grouper have showed significant changes in abundance since 2004. There has been a significant increase ($p<0.001$) in the mean abundance of lionfish from a mean abundance of .06667 in Spring 2007 to a mean abundance of 4.25 in Spring 2010 (Fig. 4).

Queen triggerfish abundance decreased since Spring 2007 while spiny lobster populations appear to have seasonal changes in mean abundance (Fig. 2). Both Black and Nassau grouper showed an overall decrease in mean abundance with Nassau grouper decreasing from a mean abundance of 1.53 in the Fall of 2004 to a mean abundance of 1.25 in Spring 2010 (Fig. 4.).

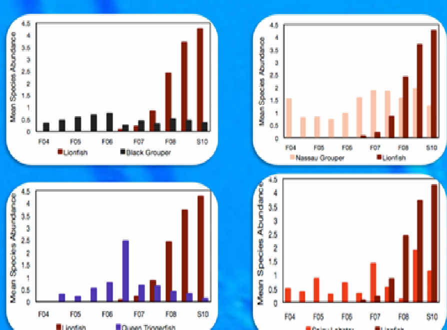
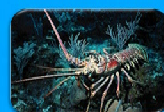
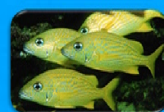


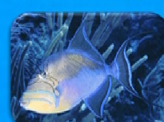
Figure 4. Comparisons of the mean abundance of four key species (Spiny Lobster, Queen Triggerfish, Nassau Grouper, and Black Grouper) and the mean abundance of lionfish over the past 11 semesters.

Discussion

There were no trends or patterns apparent on the graphs that could be related to the invasion of lionfish. Because lionfish consume juvenile fish (Morris et al. 2009), they would not have an immediate impact on the adult population of reef fish. The decrease in abundance of Nassau and Black Grouper may be due to fishing pressure as groupers are key target species for fishermen. The evenly fluctuated abundance of spiny lobster may be due to their seasonal behavior. Lastly, the high abundance of Queen Triggerfish may be due to natural variability or the change in methodology during previous semester. An example of this is repeated surveys on the same reef.







Biodiversity Surveys

Methods

Biodiversity Surveys

Two reefs were chosen, a control reef and an experimental reef, both had never had lionfish on them. One replicate biodiversity survey was conducted on both control and experimental reefs prior to lionfish introduction. Seven lionfish were collected and placed on the experimental reef. During Fall 2009-Spring 2010, 4 replicate biodiversity surveys using transect lines were conducted on both reefs to record the abundance of all fish species and spiny lobsters present post lionfish introduction.

Statistical Analysis

The Shannon-Wiener Index is a mathematical calculation that was used to assess biodiversity for each survey period (Eq. 1).

$H = -(\sum(p_i \ln p_i))$ - Eq. 1

Systat was used to run Mann-Whitney tests, which compared the difference in biodiversity and mean abundance within and between the control and experimental reefs. P-values were produced from these tests and significance was set at $p \leq 0.05$ for all statistical analysis.

Results

Comparisons between the control and experimental reefs, revealed that there was a significant ($p=0.015$) difference in mean species abundance between the two following the introduction of lionfish into the experimental reef.

The control reef had a higher species richness when compared to the experimental after lionfish introduction (Fig. 5).

However, the mean species evenness of the experimental reef was higher than that of the control .

Using the Shannon-Wiener index (H), it was also shown that the biodiversity of the experimental reef was higher than that of the control (Figs. 6 and 7).

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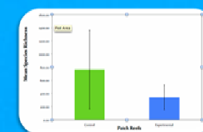

Figure 5. Comparison between the mean species richness among the control and experimental patch reefs post lionfish introduction.

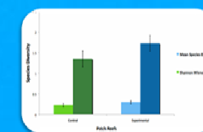

Figure 6: Comparison of species diversity between and within the control and experimental reefs.

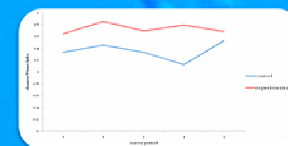

Figure 7. Changes in biodiversity denoted by the Shannon-Wiener's index (H) between the control and experimental reefs during the survey period.

Discussion

There was no significant change in biodiversity at the experimental reef post lionfish introduction. This may be due to fish migrating outside the survey area between survey periods. Low densities of lionfish introduced to the experimental reef ($n \leq 7$ during experiment) may not have been enough to produce a significant change in diversity of native fish populations. Lionfish also moved from the experimental reef during the survey periods. Structural differences in habitat or natural variability between both reefs could also explain the differences in fish populations and diversity. Future studies should examine multiple experimental reefs of similar characteristics with higher densities of lionfish. In this experiment, the control and experimental reefs differed in both size and complexity, and studies have shown that biodiversity is higher on more complex reefs (Maragos et al. 1996).

Although the hypothesis could not be supported in this study, research has demonstrated that lionfish may have a significant role in altering community structure through predation and competition (Cote and Maljkovic 2010; Morris et al. 2009 Albins and Hixon 2008). As gape limited predators (Morris et al. 2009), lionfish are unable to prey on adult size reef fish. Therefore future studies should also conduct size class estimations of prey and competitors of lionfish.

There has been a change in marine ecosystems of the eastern Atlantic as reefs recover from natural and anthropogenic disturbances and invasive lionfish continue to increase in distribution and abundance (Morris et al. 2009). Effects of this invasion may be alleviated if the ecosystem was healthier. MPAs can be created to allow species targeted by fisheries to replenish and thereby restock the competitors and potential predators of lionfish such as adult groupers (Mumby et al. 2006; Hare and Whitfield 2003).

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