A Deep Dive into Lionfish

Una Inmersión Profunda en el Pez León

Une Plongée Profonde dans le Poisson-Lion

ALLISON CANDELMO[1]*, MADALYN MUSSEY[1], JESSICA A. KELLER[2], JACK BUTLER[2], JACK C. OLSON[2], and ALEJANDRO ACOSTA[2]

[1]Reef Environmental Education Foundation
98300 Overseas Hwy, Key Largo, Florida 33037 USA.
**alli@REEF.org*
[2]Florida Fish and Wildlife Conservation Commission
Fish and Wildlife Research Institute
2796 Overseas Hwy, Suite 119, Marathon, Florida 33050-7300 USA.

EXTENDED ABSTRACT

Introduction

Indo-Pacific lionfish (*Pterois volitans/miles*) pose a significant threat to Atlantic, Caribbean and Gulf of Mexico ecosystems due to widespread predation on native species, prolific reproduction and lack of controlling predators. While current lionfish control efforts are proving successful in heavily dived locations (Morris 2012, Green et al. 2017) and reports of decline are evident throughout the region (Harris et al. 2019), much of the invaded territory lies beyond the access of recreational divers. Currently, lionfish in mesophotic reefs are primarily removed as bycatch in local fisheries; hook and line (Akins 2012), bycatch in lobster traps (Morris and Whitfield 2009, Akins et al. 2012), and commercial shrimping and trawl sampling (Switzer et al. 2015) at catch rates too low to exert control over deep-water populations (Arias-González et al. 2011). Understanding lionfish densities and behavior in deep reefs is vital for adequate management of these habitats. Past research has shown that lionfish move vertically between deep and shallow habitats (Candelmo et al. 2017) and more knowledge of their movement between and within deep and shallow habitats in SE Florida could provide divers and managers vital information.

Methodologies

We conducted roving diver surveys on ten deep reef sites (>35m) and eleven adjacent shallow reef sites (<30m) in the Florida Keys off Islamorada, FL to gain a better understanding of lionfish densities, both spatially and temporally. Each site was surveyed one hour before sunset and again the subsequent morning. The number, size, and behavior of lionfish sighted were recorded. Each lionfish was assessed on a scale (1 - 4) for cryptic behavior (score 1: out in the open up off the reef; 2: out in open on the reef 3: under shelter but easily visible, 4: deep into shelter and not easily visible). Catch per unit effort (CPUE), i.e. the total lionfish sighted divided by the total survey time, was calculated and examined as a proxy for lionfish density.

We also examined the use of an acoustic signal (lionfish vocalization) to provide insights into the effects of conspecific sound as an effective control via attraction or repulsion of lionfish, particularly beyond recreational areas where dive time is limited or alternative capture methods, such as traps, is needed. In collaboration with FWC research scientists, we developed three underwater marine acoustic devices for delivery of the amplified acoustic signal. The lionfish call used was obtained from an *in situ* field recording collected in Marathon, Florida from collaborators with the Florida Fish and Wildlife Conservation Commission and described by Schärer et al. (2019). We tested the playback volume of the sound underwater utilizing a hydrophone positioned one meter away from the playback unit underwater for 24 hours. The unit was estimated to play putative lionfish sounds at 101-102 dB re: 1 uPa. The lionfish call was programmed to play for two minutes every ten minutes. We examined the response of fish to the acoustic signal at three sites off Islamorada, FL with three replicates and controls at each site deployed between 36 and 48 hours. Control units consisted of a similar housing unit with no sound emitted placed 100 meters from the playback unit. Roving diver surveys were conducted during deployment and upon retrieval. We deployed two Gopro Hero 3 cameras facing each playback unit in opposite directions programmed with CamDo intervalometers to film a 10 second video every 20 minutes to assess the presence of lionfish and native predators. In every location, lionfish were initially observed in the area of both the controls and sound units during the roving diver surveys. All videos from each deployment were examined for presence of lionfish and native predators (sharks, groupers, snappers, eels).

In addition, we deployed an Ocean Instrument Soundtrap 300 STD hydrophone programmed to continuously record at a deep low relief site (45 m) off of Islamorada, FL with high densities of lionfish. Our goal was to record additional lionfish calls that may be associates with aggregating behavior. At the time of first deployment, seven lionfish were detected on the coral head near the hydrophone. During retrieval of the hydrophone (3 days later) thirteen lionfish were observed within three feet of the hydrophone frame. Activities occurred within NOAA Florida Keys National Marine Sanctuary under permit number FKNMS-2019-073.

Results and Discussion

The average lionfish catch per unit effort (CPUE) at the deep sites were significantly greater than in the shallower sites. The CPUE at deep sites during the daytime was found to be significantly greater (4 fold) than at dusk ($F = 63.10$, $p < 0.00$; Figure 1). The opposite trend, although not significant, was seen on the shallow sites with dusk CPUE greater than daytime. This suggests significant movement or behavior shifts of the high density, deep reef population of lionfish at dusk.

Increased sightings on the shallow sites during the dusk surveys can likely be explained by decreased cryptic behavior during this crepuscular period. Lionfish are more out in the open, moving around, hunting and looking for spawning mates during at dusk. While they are moving around on top of the reef tract as opposed to resting within the more complex structure, they are easier for divers to find. On the deep low relief sites, increased movement may instead result in a decrease in sightings/capture at dusk. During the day on deep sites, lionfish were easily found in a short period of time (5-minute search time) in large numbers, e.g. 10 - 20 individuals on small structures. In the evening, these daytime aggregations disperse and make it more difficult to find large numbers of lionfish in a short search. time.

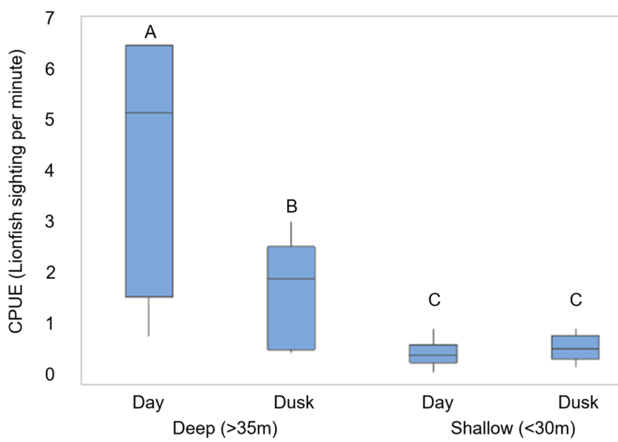

Figure 1. Catch per unit effort (CPUE) of the number of lionfish sighted per minute during roving diver survey. Deep sites (> 35 m) n = 10. Shallow sites (< 30 m) n = 11. Boxplots with different letters were significantly different in a Tukeys post-hoc test.

In summary, deep reef sites should be targeted by divers during the day when lionfish are more concentrated and moving around less, therefore easier to target quickly at these time-limited sites. This information should also be applied to trapping studies. Lionfish specific traps are being developed to help meet market demand through the targeted capture of lionfish in water beyond recreational scuba diving depths in mesophotic habitats. Over the past several years, design and testing of innovative, lionfish traps that are bait-less and Fish Attracting Device (FAD)-based has yielded encouraging results (Gittings et al. 2017). The FAD-based, non-containment trap design takes advantage of the natural tendency of lionfish to associate near structure and manmade objects. Timing of retrieval of these traps is important to maximize catch rate and economic worth. Based on our findings, these traps should be retrieved during daylight hours as opposed to crepuscular hours. Further research is needed on lionfish aggregating behavior to determine an optimal time of day as well as month and season for highest catch success. During these research dives, 451 lionfish were removed, measured and dissected from both deep and shallow sites (Figure 1). On average, both males and females were larger on deep sites than on shallow sites ($F = 12.41$, $p < 0.001$) and males were larger than females ($F = 60.45$; $p < 0.001$). These re-

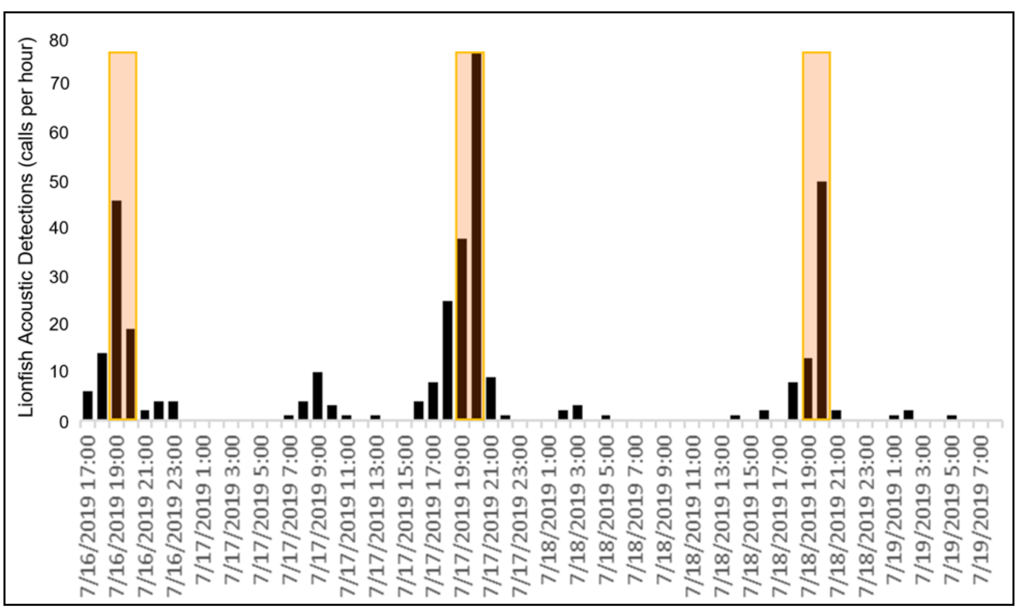

Figure 2. Number of lionfish calls detected per hour during a 72-hour Ocean Instruments Soundtrap 300 STD deployment. Shaded bands designate dusk time period.

sults highlight the need to continue to seek effective methods for targeting lionfish on mesophotic habitats and lessen the impact of larger individuals which can consume more, reproduce more frequently and produce more eggs.

We did not see a response to the number of lionfish sighted during roving diver surveys after the playback of the acoustic signal (p = 0.67). Between 18 - 35 lionfish were removed from each site after the playback tests were complete, meaning lionfish were present in the area during this time. However, concentrations of lionfish were not influenced by the conspecific call. Lionfish were observed near the playback units and certain individuals present when the unit was initially deployed remained at the location at retrieval, suggesting that the individuals were not repelled by, but also not attracted to, the repeated sound after 36 hours. The video surveys recorded zero sightings of lionfish on all deployment locations and therefore revealed no influence of the call. This does suggest that video surveys may not be an adequate method for detecting lionfish presence/absence. While certain predators (nurse shark, grouper, large snapper) were filmed, the video surveys revealed no evidence of a predator response (attraction) to the acoustic signal deployed in this study. Future acoustic tests should assess the response with the presence of a trap or structure, potentially in a less complex reef system. Lionfish may be lured in by a call, but need a single, obvious structure to aggregate to.

We did detect over 300 lionfish calls similar to that described by Schärer et al. (2019) during the 72-hour hydrophone deployment. Over 80% of the calls were detected within 2 hours of sunset (Figure 2) suggesting that these calls are linked to reproductive behavior during this crepuscular period. Future work examining this call and others as an aggregation tool would be useful for managers. Lionfish vocalization and passive acoustics could be a useful method for determining viable fishing grounds for divers or trap deployment targeting lionfish in mesophotic habitats.

KEYWORDS: Lionfish, deep habitats, acoustics, CPUE

ACKNOWLEDGEMENT

Financial support was provided by a grant from the National Fish and Wildlife Foundation (NFWF) and National Oceanic and Atmospheric Foundation (NOAA), through the Fish and Wildlife Foundation of Florida (FWFF). Activities occurred within NOAA Florida Keys National Marine Sanctuary under permit Special thank you to Forever Young Dive Charter, Tony Young and Jeff Leonia for their tireless help and shared local knowledge throughout the project.

LITERATURE CITED

Akins, L. 2012. Best practices and strategies for lionfish control. In: Morris, J.A., Jr. (Ed.), *Invasive Lionfish: A Guide to Control and Management.* Gulf and Caribbean Fisheries Institute Special Publication Series 1, Marathon, Florida, USA. 113 pp.

Arias-González, J.E., C. González-Gándara, J. Luis Cabrera, and V. Christensen. 2011. Predicted impact of the invasive lionfish *Pterois volitans* on the food web of a Caribbean coral reef. *Environmental Research* **111**:917 - 925. doi: 10.1016/j.envres.2011.07.008

Candelmo, A., T. Sparke, and D. Butkowski. 2018. Vertical movement and site fidelity of lionfish (*Pterois volitans*) along a deep reef wall using *in situ* acoustic telemetry. *Proceedings of the Gulf and Caribbean Fisheries Institute* **70**:196 - 203.

Green S.J., J.L. Akins, A. Maljković and I.M. Côté. 2012. *Invasive Lionfish Drive Atlantic Coral Reef Fish Declines. PLoS ONE* **7**:e32596.

Green S.J., E.B. Underwood, and J.L. Akins. 2017. Mobilizing volunteers to sustain local suppression of a global marine invasion. *Conservation Letters* **10**:726–735. https://doi.org/10.1111/conl.12426

Gittings S.R., A.Q. Fogg, and S. Frank. 2017. *Going deep for lionfish: Designs for Two New Traps for Capturing Lionfish in Deep Water*. Marine Sanctuaries Conservation Series ONMS- 17-05. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, Maryland USA. 9 pp.

Harris, H.E., A.Q. Fogg, M.S. Allen, et al. 2020. Precipitous declines in northern Gulf of Mexico invasive lionfish populations following the emergence of an ulcerative skin disease. *Sciemce Reports* **10**:1934 https://doi.org/10.1038/s41598-020-58886-8

Morris, J.A., ang P.E. Whitfield. 2009. *Biology, Ecology, Control and Management of the Invasive Indo-Pacific Lionfish: An Updated Integrated Assessment.* NOAA Technical Memorandum NOS NCCOS. NOAA/National Ocean Service/Center for Coastal Fisheries and Habitat Research/ 57 pp.

Morris J.A., Jr. (Ed.). 2012. *Invasive Lionfish: A Guide to Control and Management*. Gulf and Caribbean Fisheries Institute Special Publication Series 1, Marathon, Florida, USA.113 pp.

Scharer-Umpierre M., C. Zayas-Santiago, R. Applerdoorn, E. Tuohy, J. Olson, J. Keller, and A. Acosta. 2019. The Purr of the Lionfish: Sound and Behavioral Context of Wild Lionfish in the Greater Caribbean. *Gulf and Caribbean Research*. **30**. 10.18785/gcr.3001.17.