Environmental DNA FOR Lionfish Mapping

When a new species is introduced to a foreign environment, it can upset the natural balance. One such example, was the introduction of the Pacific Red Lionfish (Pterois volitans) into the Atlantic Ocean during the 1980's (Morris and Whitfield, 2009). Lionfish are capable of reproducing very quickly, with an individual female laying approximately 2 million eggs per year (Morris and Whitfield, 2009). The combination of high reproduction rates and a lack of natural predators led this species to populate quickly, rapidly spreading throughout the Caribbean Sea.

Lionfish have a seemingly insatiable appetite, capable of consuming up to 20 reef fish within 30 minutes. There have been cases where up to 80% of local fish populations are consumed by invading lionfish (Albins and Hixon, 2008). This large appetite is destructive to the reef in other ways as well. They consume a significant number of algae eating fish. Without these fish to keep local algae under control, algae can spread choking out native coral populations (Albins and Hixon, 2011).

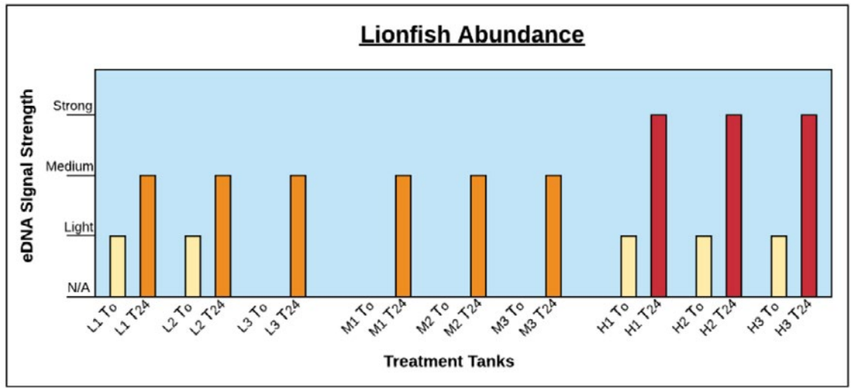
Historically, marine parks have relied on visual surveys to track lionfish numbers and population shifts. This requires a significant investment in both time and money, as lionfish can be hard to spot because they often hide within the coral structures during the day. Fortunately, a new technique using environmental DNA (eDNA) is emerging which has the potential to reduce the time, money and labor required to conduct lionfish surveys. All living organisms leave DNA evidence in their environment (through hair, scales, excrement, etc.), which means, if scientists are able to detect this DNA, it's possible to have a comprehensive list of each species living within an area (Pilliod et al, 2013). This is known as environmental DNA (eDNA), and scientists are getting progressively better at mapping and reading these samples.

eDNA Research on Bonaire

Researchers from Indiana University and CIEE Bonaire completed a series of studies to apply eDNA sampling techniques within the waters of Bonaire. During these controlled laboratory experiments, scientists worked to better understand if eDNA detection strength was related to the number of lionfish present. They hypothesized that the more lionfish within an area, the stronger the eDNA signal would be, even as fish density was held constant. There was also a question concerning how long after a lionfish has left an area, would it's eDNA be detectable. To complete these tests, laboratory environments were set up to mimic conditions similar to waters around Bonaire. These tests found that eDNA strength does directly correlate to number of lionfish present. Therefore, a stronger signal could indicate the presence of multiple lionfish within a particular area. However, distance and time are still important covariates that could mask or enhance signal strength and more research is needed. This study also found that eDNA was detectable up to 48 hours after a lionfish had been removed. Knowing this expiration data on eDNA is critical in understanding when an organism was present in that area.

Once the laboratory portion of the experiments were completed, a field study was conducted to validate these findings within the lionfish's habitat. Using a caged lionfish, sitting 50 cm off the sandy bottom, researchers took water samples both upstream and downstream at varying distances and depths. Upstream sampling would take into account lionfish eDNA already within the sampled area. The measurements downstream would then measure the existing eDNA from lionfish in the water plus the eDNA from the caged lionfish.

One interesting finding during this study was that although divers visually inspected the area for three days leading up to the start of the experiment and found no lionfish, these background samples proved that lionfish had in fact been within (or near) the testing area prior to the start of the test. One suggestion was that lionfish were moving into the shallow areas to hunt at night. This experiment also proved that traces of lionfish eDNA could be detected both on the surface and at the bottom with similar strengths. Due to the eDNA of lionfish already in the water during the field tests, they were unable to determine exactly how far away from the caged lionfish eDNA could be detected. Knowing that lionfish eDNA signals can be detected with similar strengths throughout the water column is very important, as this means sampling can be conducted at the sea surface, removing the need for divers. This also means that more samples can be collected within a shorter period of time, allowing larger regions to be patrolled for lionfish. Furthermore, knowing the length of time it takes for eDNA to breakdown (48 hrs), the high sensitivity of detecting eDNA and the speed of the current at your sight of interest, one can predict the detection distance of eDNA for any aquatic species of interest.



eDNA signatures of Light (L), Medium (M) and High (H) density Lionfish taken at the beginning (To) and 24 hours later (T24) in controlled labratory experiment

Photo provided by: https://fishbio.com/field-notes/conservation/traces-left-behind

Placing the cage lionfish in place for the field experiment. Photo by: © Haley Erickson

The Future of eDNA Research

This study illustrates the important role that eDNA could play on the future of environmental monitoring. The results of this study show that under controlled laboratory settings, eDNA strength can indicate presence and abundance of local lionfish. This experiment also demonstrated the high sensitivity of eDNA. This sensitivity could allow researchers to detect rare or difficult to find species in conditions where visual inspects fall short. For example, this could have significant implications for shark conservation efforts. Around Bonaire, shark populations can be difficult to inspect visually as they tend to stay in areas not visited by divers, especially on the east side of the island. STINAPA is currently trying to implement eDNA measuring techniques to monitor the species, timing and areas visited by sharks on Bonaire.

New eDNA sampling techniques could prove to be a game changer in understanding species composition of local environments. The processing of samples in this study cost approximately $0.05 per sample for a standard laboratory to collect and process. If these samples can be taken using surface water, this saves even more time and reduces risk to researchers, having eliminated the need for diving, especially in areas which could be hazardous or difficult to sample. The ability to detect multiple species out of a single sample could allow scientists to gain insight into rare or difficult to find species. The possibilities of this application to conservation biology and environmental monitoring are very exciting.

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