

# Lionfish

## *Kudzu of the Caribbean*

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## I. Introduction

### A. Lionfish biology

The lionfish family, including *Pterois miles* and *P. volitans*, are voracious predators native to the Indo-Pacific region. Lionfish are classified as "invasive species" because they outgrow and out compete native species for food, and have no natural predators (REEF 2007). They primarily rely on camouflage for protection, but their spines are a second and effective defense. The reason for the lack of predation is the lionfish's poisonous spines that protrude out the top of their bodies and cause serious pain for any creature that is stuck by them. Lionfish poison is not fatal to humans, but can cause serious discomfort if injected into the skin tissue. Lionfish can grow up to almost three pounds and eat almost any organism smaller in size, such as crustaceans and small fish (REEF 2007). Their reproduction poses a serious problem along the Eastern Coast of the United States. "Females spawn year round, every 4 days and produce 25,000 eggs per batch or spawning" (Richardson 2010). This short reproductive cycle could be partially responsible for the increase in Lionfish numbers over the last two decades, and could pose a serious problem for the coastal ecosystem.



### B. The invasion

Scientists believe lionfish were introduced to Florida coastal waters in the mid to early 1990's. The warm waters of the Gulf Stream have aided in their distribution to the waters of the eastern United States and waters as far east as Bermuda in only one decade ("The Lionfish Invasion", 2012). The two species of lionfish that are believed to be causing this invasion are *Pterois volitans* and *Pterois miles*. Scientists are uncertain to how the invasion began; however, there is strong evidence to suggest they were introduced to southeastern Florida because this is where they were first sighted. The lionfish have also spread southward and are located throughout the Caribbean, the Gulf of

Mexico, and the northern coast of South America where they are disrupting the ecosystems of many coral reefs by causing a threat to many other reef fish populations (Morris, 2012). Characteristics that have allowed lionfish to become a successful invasive species include: they have few natural predators due to venomous spines, they are voracious nonspecific hunters (over 50 different species of fish), they multiply quickly (more than 2 million eggs per year), and they live in multiple coastal habitats. Most predators that would naturally hunt the lionfish are over fished so their presence is decreased, allowing the Lionfish to thrive (Morris, 2012).



## C. Summary

The lionfish, also known as *Pterois volitans* and *Pterois miles*, is a voracious predator native to the Indo-Pacific region. Lionfish are considered an invasive species because they outgrow and outcompete native species and have no natural predators. The reason for the lack of predation is due to the lionfish's poisonous spine that protrudes out the top of their bodies and causes serious pain. Lionfish also negatively affect the environment because they consume almost any organism that is smaller in size. Female lionfish can reproduce rapidly, which is the cause for the large increase in numbers in just a decade. It is believed that in the mid to

early 1990's the lionfish was introduced into Florida coastal waters. Although scientists are uncertain to how the exact spread began, it has been confirmed that the warm waters of the Gulf Stream are aiding in the dispersion of Lionfish.

## II. Current status

### A. Negative effects

#### 1. Environmental

The introduction of lionfish has raised concern for coastal areas. The invasive lionfish has become an impending threat to native fish communities, human health, and fisheries resources. Lionfish are predatory and reduce the recruitment of young and native fishes, which can disrupt the biodiversity of the reef and lead to disruption of the marine ecosystem process. Lionfish caused an average reduction of 79% in native fish over a 5 week experiment in a translocated coral and artificial patch reefs matrix (Albins and Hixon, 2008).

Lionfish can cause significant harm to coral reef ecosystems (Albins and Hixon, 2008). They have few predators and are aggressive predators themselves. This allows lionfish to reduce the population of native fish at alarmingly quick rates. The lionfish diet consists of a wide variety of prey species and size levels. Adults in the Indo-Pacific are reported to consume 8.5 g of prey per day or 230 kg per year (Albins and Hixon, 2008). This highly efficient predation could result in large ecological effects on native prey species and competitors. Large reductions in recruitment suggest that they compete with native piscivores by dominating the food source. Lionfish could potentially decrease the abundance of ecologically important species, such as parrotfish and other herbivorous reef fish. These fish are necessary for preventing the overgrowth of seaweeds in the coral (Albins and Hixon, 2008).

The lionfish invasion has significantly lowered the amount of a variety of native fish that reside in the coral reefs of the Bahamas. The presence of these invasive species, along with the decrease of the natives, has brought on a shift to an algal-dominated community. This shift has the potential to reduce the number of coral and sponges to nearly zero. Placing this benthic cover over the coral reef also diminishes the possible refuge for young fish to mature. Data taken before the invasion of the lionfish showed less than 6% of macroalgae on the cover. The most recent study shows that more than 50% of the reef is covered. This dramatic shift was produced less than three years after the invasion. Herbivorous fish are essential in managing this cover of macroalgae, as well as keeping the overall coral reef in a healthy state. Unfortunately, the diet of the lionfish comprises of 71% fish. The predation by these invaders is significantly decreasing necessary counterparts in the ecological communities of coral reefs (Lesser et al., 2011).

## 2. Human

### *Envenomation/treatment*

Lionfish belong to the family *Scorpaenidae*, which can be divided into three groups: lionfish (*Pterois*), scorpionfish (*Scorpaena*), and stonefish (*Synanceia*). The number of envenomations from the *Scorpaenidae* is second only to stingrays in marine fish envenomations. Among these groups, the venom is very similar, but differs in potency. The potency of the lionfish venom is the least of the three (Vetrano et al., 2002). The lionfish poses a serious threat to the general public, as well as those who encounter lionfish on a daily basis (Ruiz-Carus et al., 2006), which will continue increasing as its population increases (Hare and Whitfield, 2003). Even after death its 18 venomous spines can produce wounds if not handled properly (Ruiz-Carus et al., 2006). The venom of lionfish is contained in venom glands in the dorsal, pelvic, and anal fin spines. The pectoral spines do not contain venom. The venom glands are found at the base of the spine, which is covered in an integumentary sheath. The venom is

secreted along grooves in the spine and is injected through the puncture wound (Vetrano et al., 2002). The sting will only produce minor pain at first, but hours of severe discomfort follows. General symptoms may include redness, swelling, nausea, and dizziness (Ruiz-Carus et al., 2006). Along with these, more extreme reactions may include abdominal pain, seizures, heart failure, and respiratory distress. Repeated contact may lead to hypersensitivity, which in turn may cause anaphylactic reactions during future attacks. Wounds from envenomations may take months to heal, and infection may reemerge (Vetrano et al., 2002). If not treated, the pain could persist for weeks (Vetrano et al., 2002) and motion may be lost in the envenomated area (Ruiz-Carus et al., 2006). Although most sources list the lionfish as non-lethal, some have suggested otherwise (Ruiz-Carus et al., 2006). The common treatment is to place the injured area in warm water for 30-90 minutes, and repeat the process if the pain recurs. One study showed that this treatment produced instant relief in over 50% of the patients. Another study reported an 80% pain relief (Vetrano et al., 2002). Lionfish venom shows similarities with the stonefish venom. The stonefish antivenom has actually been shown to neutralize the effects of the lionfish venom. There appears to be cross-reactivity between the two (Church et al., 2003). The lionfish venom contains a protein that is heat-labile, as well as antigenic. Acetylcholine can also be found in the venom, along with a toxin which attacks neuromuscular transmission (Vetrano et al., 2002). Antivenom appears to be the most effective, and quite simple, treatment for envenomations (Church et al., 2003).

## B. What's already being done (awareness)

Lionfish breeds are commonly sold in speciality saltwater fish stores with most stores supplying the common and red lionfish. A problem with having these particular breeds of lionfish is the size that they grow to, as the store owner from Reef Keepers Aquarium claims. His store does

not carry the common or red lionfish, as they grow to great size and are typically too much to handle in an at-home aquarium. Reef Keepers and Greendale aquarium both try to enforce to their customers the problem of releasing fish into the wild and as well as the fines associated with these actions. Both owners were aware of the invasion, but had no information within the shop regarding the invasion for their customers. The main focus of the store owners was to ensure that fish owners knew the difficulties of owning a larger lionfish, with envenomation being a key component. The Fintastic Fish Store, located in Charlotte, North Carolina, is currently aware of the lionfish invasion threatening our coastal waters, but provide no education to customers that wish to purchase lionfish. However, they do get their lionfish supply from a reliable source, ORA (Oceans Reefs and Aquaculture), that is also aware of the invasion and is looking to control this issue. Some stores like these have a buy back policy if the fish become too large as a means of preventing the release of the creatures into the wild.

## 1. Regulation

### *Regulation of Exotic Species*

The exotic pet ownership laws in North Carolina state that the county or city must make its own laws regarding ownership. The state regulations only require that certain mammals, those that are common rabies vectors, to obtain veterinary permits to import into the state. In Florida, where the problem is more severe, there is a partial ban on exotic pet ownership, but it is still legal to own lionfish. On the other hand, all exotic pets must be registered by the Department of Fisheries and Wildlife and permits are required to be obtained (Born Free USA). Although there are no ownership laws, there are special permits needed for lionfish captures. The organization REEF asks that any and all divers who come across nonnative species of fish while diving, report them online (REEF).

## 2. Rodeos and Spearfishing

### *Lionfish Derbies*

A lionfish derby is essentially a competition between multiple teams to catch as many lionfish as possible from sunup till sundown (Weintraub, 2012). Various methods of capture include SCUBA diving, free diving, or snorkeling. Prizes are generally awarded to teams with the most caught, biggest fish, and smallest fish. Besides actually removing the fish from their unnatural environment, derbies also play an important role in educating the public about the problem as well as teaching them how to properly handle the fish. The derbies are also designed to create exposure to the media so more people can be made aware of the ever growing problem.

An organization that is very involved in aquatic environmental issues is the Reef Environmental Education Foundation (REEF). REEF has sponsored several derbies in southern Florida and the Bahamas in recent years with the following totals: in 2011 the total fish count was 3542, another held in 2011 totaled 1578 fish caught, and a derby held in 2009 totaled 1408 lionfish caught (Weintraub, 2012). On REEF's website, they also make it easy to register for upcoming lionfish derbies being held in southern Florida and the Bahamas. Another organization participating and sponsoring similar derbies is the NAUI Green Diver Initiative.

With recent approval from the Marine Conservation Board, Cayman's dive operators are now able to teach the PADI lionfish tracker distinctive speciality course (Sport Diver). In this course, participants will be taught how to appropriately track and kill lionfish as well as handling them after they are caught to avoid invenomation.

## 3. Consumption

Lionfish consumption is an increasingly popular way to spread awareness and begin to control the invasion, both in restaurants and at home. The National Oceanic and Atmospheric Administration (NOAA) is

currently working on a series of lionfish events at restaurants across the United States in hopes of creating a chain of demand (Huus, 2010). The Reef Environmental Education Foundation (REEF) has recently produced a lionfish cookbook full of recipes and instructions of how to prepare the fish. A local restaurant on the island of Grand Turk, The Sandbar, hosted a lionfish derby that awarded prizes for the most lionfish caught. After the derby the restaurant prepared the fish for their guests to enjoy. Other local restaurants have also donated lionfish cookbooks with similar information as the ones that REEF produced in hopes of encouraging more people to prepare and eat these fish.

#### 4. Amnesty days

In 2011 the Florida Fish and Wildlife Conservation (FWC) held their first Exotic Pet Amnesty Day. This was a chance for the public to turn in any exotic pets, including lionfish, that were getting too big or too dangerous to authorities with no consequences or questions asked. The purpose of this day was not simply to collect animals but to prevent the owners from releasing these animals into the wild where they could become invasive. Overall, they collected 64 animals and taught employees of FWC how to care for them (FWC 2012). The FWC has now implemented regularly scheduled amnesty days where they accept non-native reptiles, amphibians, birds, fish, mammals and invertebrates. The last amnesty day was March 10, 2012 at the Miami Zoo. The FWC advertises, "If you have an exotic pet that you can't keep, bring it to Exotic Pet Amnesty Day. We place all healthy pets with pre-qualified adopters. We'll accept all types of exotic pets- no questions, no penalties" (FWC 2012). They are also looking for qualified adopters to give homes to these animals (FWC 2012).

### C. Summary

It is very apparent that the lionfish are having a huge impact on the reef fish populations on the eastern coast of the United States and

the Caribbean. In a study performed over a five week period in the Caribbean, it was found that the lionfish caused a 79% decrease in the native fish population. The presence of these invasive species, along with the decrease of the natives, has also brought on a dramatic shift in the algal-dominated community that has the potential to reduce the number of coral and sponges to zero. Similar results have been found in other areas of the Caribbean. In addition, the invasion has had a huge human impact on the general public with the very painful envenomations becoming much more prevalent. There are certain avenues that are currently being utilized to spread awareness about the invasion, as well as small scale fixes to counteract the increase in the invasive species population. Currently in the state of Florida it is legal to purchase the exotic animal, but a permit must be obtained to own a lionfish and the animal must be registered with the United States Department of Fish and Wildlife.

Another avenue that is being pursued to counteract and spread awareness of the problem is the utilization of lionfish derbies. These derbies are essentially all day fish-catching tournaments with the goal to catch as many lionfish as possible by the end of the day. Along with physically removing some of the invasive species from the environment, the derbies also serve to spread awareness and educate the public of the invasion. Similar to the derbies, many dive shops are spreading awareness of the problem by offering certain courses that are tailored to teaching participants how to safely track and kill lionfish while avoiding envenomation.

Certain state Fish and Wildlife Conservation agencies have begun to sponsor Exotic Fish Amnesty Days. The overall purpose of these events is to not only collect the exotic animals, but keep them from being released into the environment to cause further harm to the ecosystems.

## III. Proposal

### A. Short-term

#### 1. Awareness

Raising awareness of the invasion is the first step in finding a solution. Though the Invasion has been going on for over an decade many people are still unaware of the problem in full (Morris). There are several ways to spread information about the lionfish. Putting informational posters or bulletins at popular coastal tourist locations is a straightforward way to raise awareness of the situation. There are secondary means used to raise awareness as well, such as increasing lionfish consumption and allowing spearfishing of the lionfish during derbys or in protected areas where spearfishing is usually banned. Derbies are not an effective way to actually decrease an overall population of lionfish, but it does attract tourists as well as locals; spreading information about the invasion (Sport Diver). Some local coastal seafood restaurants will offer the lionfish as a menu item, and when it is served information about the invasion and conservation issues related to the state of the reef are given to the customers (Sandbar in Grand Turk). With increased awareness of the problem, more people will be working to find a permanent solution; creating a trickle down effect that will hopefully lead to control of the lionfish invasion.

##### *a. Allowing spearfishing of lionfish in protected areas*

One immediate action in response to the lionfish invasion is to allow spear fishing, for lionfish only, in currently protected areas. Areas of protected reef and ocean are established as a conservation effort to maintain biodiversity of the native marine life. Protected areas also draw in a lot of tourism, which is a large part of the economy of small seaside communities. Allowing spearfishing in a protected area for lionfish will not only slightly decrease the lionfish numbers, but also has the potential to expand tourism for a particular area of reef (Sport Diver).

Spearfishing for lionfish will not significantly decrease the lionfish population due to their widespread invasion and ability to reproduce rapidly. Divers would have to kill “at least 27% of reproductive adults monthly” just to keep the population from growing in a condensed area of ocean (Barbour et. al.). However spearfishing would be a novel experience to increased tourism because most diving areas do not allow this activity due to the conservation efforts in the protected areas. The most important result of allowing spearfishing in protected areas would be to raise awareness of the lionfish invasion and increase the popularity of lionfish consumption (REEF).

##### *b. Consumption of lionfish in restaurants*

Although consumption of lionfish is already present in some higher class restaurants, an increase in consumption is another short-term action in the reversal of the lionfish invasion. A survey we performed showed that many chain restaurants, such as Red Lobster, Joe’s Crab Shack, and Bonefish Grill, were unaware of the lionfish invasion and did not serve the fish on their menu. However, smaller family owned restaurants on the coast seemed to be very aware of the issue and were already acting to lessen the invasion effects. These smaller restaurants, such as The Sandbar in Grand Turk, participated in lionfish derbies and have large fish fries to raise awareness. Some also sell t-shirts in their restaurant stores for tourists to take home as souvenirs. Several possible ways to increase lion-fish consumption are to encourage fishermen to catch and provide lionfish to seafood markets, increase the number of restaurants willing to prepare and serve lionfish as a delicacy, and include conservation effort information to add to the appeal of the dish. Also, convincing the general public that only the spine is poisonous, not the meat, and increasing the number of lionfish derbies conducted by seafood restaurants and popular seafood chains could also help reduce the invasion effects. Overall, these small but potentially effective measures will help raise awareness about the invasion and help decrease the thriving lionfish population.

## B. Long-term

### 1. Encouraging pharmaceutical companies to look at venom

Since complete eradication is not currently viable, learning how the lionfish can be beneficial to society is crucial to handling the invasive situation. One long-term proposal is to utilize the lionfish by harvesting the venom for pharmaceutical research and development. Using animal venom to create pharmaceutical drugs has been done before. Captopril, a drug used for cardiac conditions, was developed from the structure of bradykinin-potentiating peptides from the venom of a snake called *Bothrops jararaca* (Manjunatha, 2011). Six pharmaceuticals, going through various stages of the US Food and Drug Administration regulatory review, have been developed from terrestrial animals (Sivan, 2009). However, fish venom has just recently been realized as an untapped pharmaceutical resource. In 2006, William Smith and Ward Wheeler made a “phylogenetic road map for the bioprospecting of piscine venom” in hopes that it would be useful to future research efforts in targeting specific fish species with desirable qualities in their venom. Later in 2009, Gisha Sivan wrote a literature review about the studies done on fish venom and concluded that the piscine venom is less hindering in the context of finding its possible curative properties and therefore has an advantage over highly toxic species. Therefore, the invasion of lionfish provides the United States with an opportunity to assist in fish venom research.

Studies have been done to observe how varying doses of the lionfish venom affect laboratory animals. In a study on mice, the venom had significant cardiovascular and neurotransmission effects (Sri Balasubashini, 2006). It was suggested that the reason for the reduction in the hematological parameters was due to decreased blood cell count which would be caused by increased hemolysis (Sri Balasubashini, 2006). A proteolytic enzyme in the venom is suspected to be the prime cause for the hemolysis (Sri Balasubashini, 2006). Acetyl cholinesterase

is an enzyme involved in the hydrolysis of the neurotransmitter acetylcholine (Sri Balasubashini, 2006). The lionfish venom increased the activity of acetyl cholinesterase (Sri Balasubashini, 2006). The venom also increased the activity of sodium, potassium, and ATPase (Sri Balasubashini, 2006). The study concluded the lionfish venom contained targeting bioactive substances (peptides and proteases) that could be used for future medicinal purposes (Sri Balasubashini, 2006). In addition to the study on mice, there have been tests on rabbits and frogs, both of which showed neurotransmission and cardiovascular effects.

The process for developing a drug from the venom involves studying the effects, isolating the specific part of the venom that is desired, altering it to decrease its adverse effects, and then getting a drug company to invest in additional studies (Mark Papich, personal communication). Lab animal testing would be performed for a long time before there would be any testing on human subjects (Mark Papich, personal communication). Developing a new drug for people is about \$500 to \$800 million (Mark Papich, personal communication). Developing new Veterinary drugs are about a tenth of that cost (Mark Papich, personal communication). Overall, research on fish venom is slow and still in the early stages, but it is a field that is actively being explored and is sparking the interest of current and rising scientists.

### 2. Teaching sharks to consume lionfish

It has been over ten years since the first lionfish was spotted in the U.S. south Atlantic sea coast and the Caribbean sea. As time passes more native species learn to consume the lionfish, creating a cycle of biological control for this booming population. Species that have been found to consume lionfish include native sharks, large grouper, and the blue spotted cornet fish. In fact studies have shown that in "locations with high numbers of large and medium-sized groupers also had low numbers of lionfish"(NOAA); however "this observation provides no assessment of the frequency of

lionfish consumption by grouper" (Schram). Grouper are over-fished in most areas, aside from protected marine waters, and through a more strict regulation of large grouper populations among fishing industries their numbers will increase. An increase in the amount of large grouper will decrease some of the lionfish population as they will have more natural predators (Mumby).

A more promising method of natural predation on the lionfish is through native shark species. The sharks will not be able to eliminate the lionfish, but through time they should be able to regulate the numbers and keep the population in proportion to other native species' populations. Sharks will not naturally prey on the lionfish because they are not a native species, so some groups have been starting to spear the fish and feed them to sharks to "teach" them that they are a food source. Once the lionfish are speared they attract the sharks with the blood and the sharks will become curious and eventually try and eat the lionfish. They learn how to eat the fish without coming into contact with the poisonous spines by eating them tail first. The sharks will eventually begin to prey on the lionfish live and in some cases other sharks will learn the lionfish are a food source by observation from other sharks or eating other shark's scraps. There have been at least four different species of sharks recorded consuming the lionfish (BahamaLouie). This could be an important measure in controlling the lionfish population in U.S. waters. This method is something that is being practiced now and something that should continue to be encouraged as a long term means in biological control.



## Summary

The most likely solution to the problem of this ever increasing population of the invasive lionfish will be a combination of several proposals. Most of the short term methods of control have already been implemented and some of the long term solutions have started attracting the public's attention. The short term solutions we propose would be to increase awareness of the lionfish invasion through organized lionfish derbies and increasing consumption of the fish in restaurants. While neither one of these solutions will actually decrease the population of lionfish significantly, they do play a large role in raising awareness of the problem so that more attention will be focused on finding a long term solution. Some of the long term solutions include finding a pharmaceutical use for the lionfish venom and to teach sharks how to consume lionfish in the wild. There has been some experiments done with both of these methods of population control. If the venom in the spines of the fish could be used in medicines, then there will be a large market for lionfish; which will in turn motivate people to collect the fish in large quantities. Teaching sharks to eat lionfish has also been done by divers who spear the fish and then feed them to the sharks. The sharks eventually learn how to consume the fish while avoiding the poisonous spines. They will naturally regulate the lionfish numbers until they become a normal part of the food-chain. Choosing one solution will not solve the invasion. A combination of different efforts and methods of control will have to be implemented for there to be an impact on this rampant species.

## IV. Conclusion

### A. Our efforts

#### 1. Posters/flyers

As the research was being conducted for this project it became apparent that many popular

marine venues, such as aquariums, restaurants and salt-water aquarium vendors either were not aware of the lionfish invasion or did not provide the public with any information regarding the increasing lionfish population. As a group we have put together an informational flyer as well as a poster to distribute around several popular marine areas in North Carolina. The poster is an artistic representation of a lionfish with the caption "Alien Invasion" to entice the public's attention. The flyers will be located in close proximity to the poster to provide information on basic lionfish biology, the invasion and the current efforts to slow the fish's population growth; there will be approximately 15 flyers to each poster. This is a means to educate North Carolina citizens about the invasion when they are purchasing marine fish for their own salt-water aquariums or while they are visiting one of the large North Carolina Aquariums in Fort Fisher, Wilmington or the Outer Banks.

## 2. WRAL Cooking show

One of our efforts included contacting WRAL, a local news station, and asking them if they would do a special on preparing lionfish for consumption during the weekly morning cooking show portion of the program. Our hopes were that having lionfish as the meal of the week would both raise awareness in North Carolina about the invasion and also teach people how to prepare lionfish, letting them know that the fish are okay to consume even though they have poisonous spines. Securing a spot on the cooking show is an on going process with no results presently.

## 3. October seafood festival

The October seafood festival is held in eastern North Carolina every fall. Currently, the seafood festival has partnered with the NOAA Beaufort Laboratory in order to educate the public on how to prepare lionfish and inform them about the invasion offshore. NOAA Beaufort Laboratory has taken the initiative to provide a service that will show the public that there is a serious threat right

off the shore of North Carolina's coast. As we have been in contact with this organization, there have been no results on whether our posters and flyers will be able to be displayed at the seafood festival.

## B. Summary

While complete eradication may not be realistic, affected areas may benefit from lionfish control efforts. Natural control may take over and diminish the effects of the lionfish invasion. A predator or parasite may become a threat to the lionfish populations, if the numbers become too great. For example, the cottony cushion scale is a pest that caused huge problems in citrus production, which was completely controlled for biologically by predatory *Vidalia* Beetle (Cardwell, 2002). However, there have been cases where natural control has not occurred. For example, kudzu, which was introduced for erosion control, has crowded out native species (USDA, 2011). Compared to the devastating effects of invasive species, such as kudzu, the lionfish invasion may not be as detrimental if containment and control are coordinated with additional study of this organism. The effects of the lionfish may be diminished using these methods, which is better than if nothing is done and reefs are taken over by this invasive species.

## V. Citations

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