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Author

Mulgrew, Bob

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**Putting the Cat Back in the Bag:
Turning the Invasive Lionfish Scourge into a Conservation
Opportunity**

Bob Mulgrew

Master of Advanced Studies Candidate – Marine Biodiversity and Conservation
Scripps Institution of Oceanography – UC San Diego

Capstone Advisory Committee

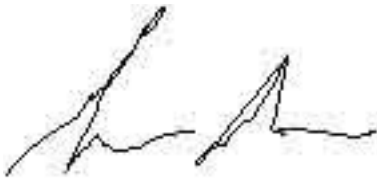
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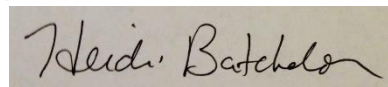
Scott Gonnello, Founder (Lionfish Central, LLC)

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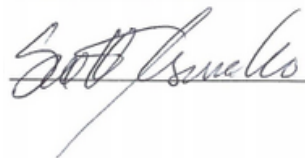
Stuart Sandin:



Heidi Batchelor:



Scott Gonnello:



Abstract –

In the last few decades, invasive lionfish from the Indo-Pacific, *Pterois volitans* and *Pterois miles*, have proliferated throughout the Gulf of Mexico and Caribbean Sea. This diaspora has caused major concerns for the health of marine ecosystems in this region. Research has shown that invasive lionfish can have potentially extremely detrimental impacts on the native reef fish populations which, in turn, can result in extensive ecologic shifts, thereby negatively affecting coral reef communities as a whole. In response to this epidemic, many of the region's coastal and island communities and nations have instituted culling programs in an attempt to reduce lionfish populations and mitigate the damage.

This study aimed to find strategies that can best be implemented to pursue lionfish mitigation by capitalizing on this unexpected resource to create viable conservation opportunities for coastal communities that depend on healthy reef ecosystems for sustenance and economic well-being. Due to the vagaries of designing a market around a resource that is ultimately intended to be depleted, it was found that a large scale commercial fishery is not economically feasible. It appears that small-scale artisanal and subsistence fisheries, coupled with engaging the multitude of recreational divers that visit the region to participate in culling efforts, will be the most cost effective and efficient way to keep lionfish populations low in order to protect the coral reef ecosystems on which so many coastal communities depend.

Background –

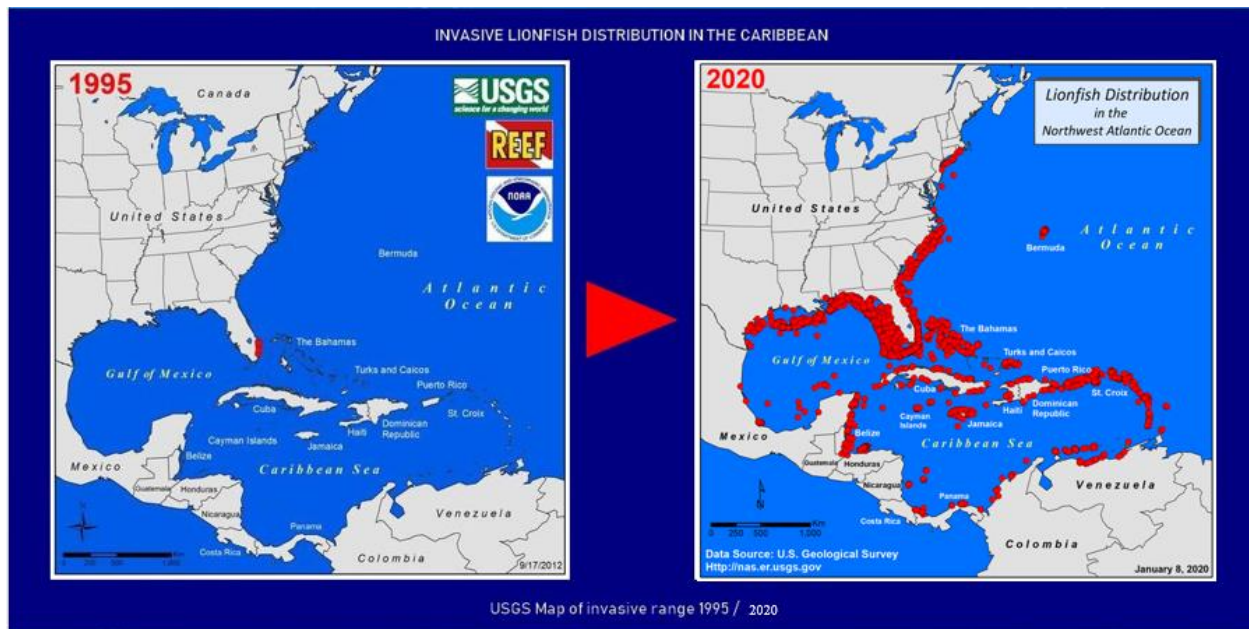


P. volitans – Red Lionfish. Photo credit: Shaun Doyle Photography

Lionfish are a predatory fish native to the Indo-Pacific characterized by flamboyant pectoral and dorsal fins, venomous spines in the fin rays, and elaborate banded warning colorations of red, white, and black. This flashy design has made them highly prized in the global aquarium trade, which is the most likely vector for introduction into the Atlantic and Caribbean. Intentionally, or inadvertently, lionfish were released into the wild off the east

coast of Florida and where they were first spotted in 1985.^[1] *P. volitans* have since spread throughout the western Atlantic and the Wider Caribbean, with sightings recorded as far north as New York and as far south as northern Brazil.^[2] The exponential growth of lionfish populations, resulting in their rapid spread, is multifaceted but not atypical of many invasive species.

Native prey do not recognize *P. volitans* as predators and native predators do not recognize them as potential prey.^[3,5] They are opportunistic predators, consuming anything that fits in their mouths.^[3,5] They are also habitat generalists able to reside in mangroves, seagrass beds, wrecks, and coral reef structures, although they tend to aggregate around structures with higher rugosity.^[3,5] In addition, lionfish mature in less than a year, can spawn year-round as often as every four days (3-5 times faster than local species), and females can produce up to 40,000 eggs per spawning event.^[5] Their egg masses are encased in a toxic mucus that prevents predation.^[6] Unlike terrestrial environments, the Wider Caribbean basin does not contain many natural barriers to dispersal, which has resulted in an unprecedented rate of invasion over an expansive geographic region.^[5] All of these factors contribute to the threat *P. volitans* pose to coral reef ecosystems throughout its newly established range.



Lionfish sightings reported to USGS, 1995-2020.

Reports have estimated that *P. volitans* can reduce small reef fish populations by up to 79%.^[4] This can heavily impact economically important species such as grouper and snapper as well as ecologically important species such as herbivorous ichthyoids that feed on pervasive algae, preventing it from overtaking coral reef structures.^[4,5] The potential to have broad ecological impacts on coral reef communities that would result in major economic impacts to many coastal communities and nations that depend on healthy marine ecosystems for fisheries, tourism, and other services is cause for concern. Therefore, the primary solution has been to institute culling programs designed to reduce lionfish populations coupled with attempts to raise public awareness of this invasive species and its negative impacts.^[5]

Project Objectives and Methodology –

The purpose of this project was to determine which strategies can be implemented to better capitalize on this under-utilized resource to create viable conservation opportunities. These

strategies should ideally provide economic incentives to pursue lionfish mitigation at constant levels over the long run to maintain low population levels.

In addition to extensive research of published literature, I conducted informal interviews with people in countries throughout the Caribbean who have been involved in lionfish mitigation efforts in order to determine the past and current status of lionfish markets. The information gathered was integrated into a synopsis of the most effective initiatives that can be used to lessen the impacts of this environmental scourge while at the same time providing pecuniary rewards benefits for such endeavors.

Results –

The invasion of the Caribbean by lionfish was an environmental scourge of epidemic proportions. Many coastal communities leapt into action in haphazard fashion to try to control the rate of spread of this novel species.

Belize created a program that offered a \$25 bounty per fish in an attempt to prevent the establishment of lionfish populations in their waters. Theoretically sound, conservation organizations typically have limited funding. The program was quickly overwhelmed by the yield. It ran out of funds within a few months and had to be cancelled.



Curious Shark - Shaun Doyle Photography

Another misguided idea was the attempt to teach native sharks, eels, and groupers to prey on lionfish. To do so many divers started feeding them lionfish they had caught. While the intention was good, this only taught those individuals that divers have food. As with feeding any wild animal, this generally disrupts their natural foraging behavior. It can be detrimental to the animals and potentially dangerous to humans with whom they come into contact. The unfortunate consequence is that these native predators became curious with divers, resulting sometimes in aggressive behavior. I personally had a shark bite the end of my spear that had no lionfish on it. It clearly knew where the food would be even though I had none. Fending off hungry sharks and eels can be a harrowing experience. (Pers. Obs.) It is highly discouraged to feed these creatures directly. If one catches unwanted lionfish, simply make sure it is dead, and leave it on the reef. Something will eat it and it prevents undesired interactions with wildlife.

Initially, conservationists and fisherman struggled to get rid of the lionfish they caught because there was no market for them. Most people had, and many still carry, the misconception that lionfish are poisonous. They are not. Lionfish do indeed have 18 venomous spines and require careful handling. Most NGOs and dive operators have been proactive in conducting workshops that train recreational divers and local fishermen in safe handling techniques. There are commercially available containment vessels to hold lionfish, such as the ZooKeeper, but it is

simple enough to create a homemade vessel using a water jug, a large diameter PVC pipe, or bucket and lid. A sting is not life threatening, but it is immediately and extremely painful. The venom causes severe pain and localized swelling around the wound site. (Pers. Obs.) Standard treatment procedures involve immersing the afflicted area in hot water as soon as possible and taking an anti-inflammatory/pain-killer, such as Ibuprofen. As it is a protein-based venom, the heat denatures the proteins, rendering the venom inactive, however, pain and swelling can persist for several days, depending of the efficacy of treatment.

Lionfish meat, however, is white, flaky, and delicious, comparable to snapper or catfish, and perfect for dish such as ceviche, sushi, tacos, or simply grilled whole. Extensive public outreach from a multitude of organizations has changed this perception to make lionfish a highly desired fish, utilizing slogans like "Eat 'em to beat 'em." This spurred a massive spike in the demand for lionfish amongst locals, tourists, and eco-conscious consumers.

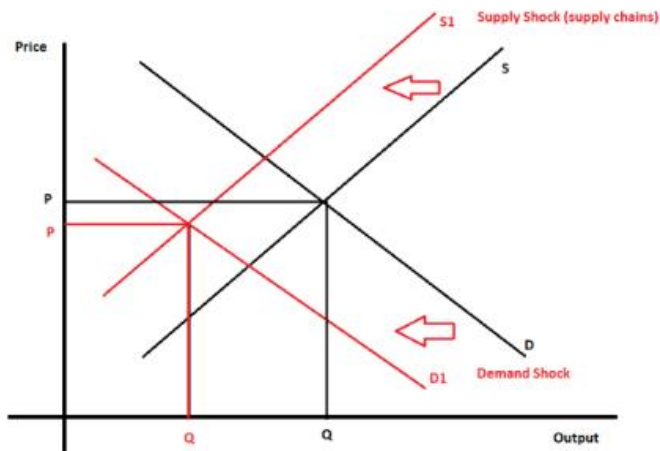
The growing demand resulted in a dramatic rise in prices, ranging from \$3/lb in Jamaica to almost \$18/lb in Bonaire, created a booming market for commercial fishermen. These prices made lionfish one of the most expensive fish at market. Many lobster fishermen, especially in Florida, had been hauling in hundreds and thousands of pounds of lionfish as by-catch, which they could now sell at a lucrative price. Whole Foods even started carrying lionfish in 2016. One fishmonger I spoke to from the Florida Fish and Wildlife Conservation Commission (FWC) lionfish wholesaler list claimed he used to be able to buy lionfish at \$5/lb and sell at \$15/lb, moving thousands of pounds of lionfish weekly. Apparently some high-end restaurants he worked with were able to serve lionfish at \$120/dish. However, ability for regular fishermen to purchase Saltwater Products Licenses from the FWC which allows them to sell their catch directly to restaurants has made it so he no longer carries lionfish except by special request. Every wholesale fishmonger on that list confirmed that they no longer deal in lionfish.



Lionfish display at Whole Foods – Credit: Wall Street Journal

Building a fishery market around a product that will ideally be extirpated in the process is a double-edged sword. Booming market demand for the product is an excellent way to diminish that resource. However, a successful market means a reduction of lionfish populations, and with such a decline, the catch per unit effort (CPUE) to harvest that species also diminishes, reducing the commercial viability in pursuing the target species. In the last few years, lionfish populations have declined. A population study conducted in the northern Gulf of Mexico (nGOM) from 2016 to 2018 indicated population densities declined by as much as 79%.^[7] Fisheries-dependent data also indicated commercial landings and CPUE declined by up to 50%.^[7] Throughout the Caribbean, every single person I interviewed reported that landings have dropped significantly. This is most likely due to a combination of factors: fishing pressure, a recently discovered Ulcerative Skin Disease, possible native predation, and natural carrying capacity.

Ulcerative skin disease, first discovered in the nGOM in late 2017, is the first epizootic disease known to affect invasive lionfish.^[7] The bacteria eats away at the skin and eventually into the muscle tissue of afflicted individuals.^[7] This affects an individual's viability, reducing reproductive capacity. Low genetic diversity may also make populations more susceptible to such diseases.^[7] Lionfish remains have also been found in the stomach contents of native large bodied groupers, as well as sharks and eels, indicating that native predators are learning to eat lionfish without the influence of divers.^[8] In addition, invasive lionfish may be reaching their carrying capacity, which typically results in a mild decrease in population following initial rapid growth. (Pers. Comm.: Fogg, A.) Ecologically speaking, this is great news; from a large scale commercial standpoint, it's troubling.



Simple economics indicates that high demand and limited supply results in inflated prices for the product. This is the DeBeers model. The opposite is true in this case. Reduced supply means wholesalers won't stock it, therefore, restaurants cannot offer it regularly. Lack of availability causes customers to lose interest, and demand (i.e. price) plummets. This negative feedback loop makes a large scale commercial lionfish fishery economically unsustainable.

The most efficient way to harvest lionfish is diving with a spear, which has earned them the moniker of "Trash Pickers" from other fishermen. This requires a lot more time and effort than traditional fishing with hook and line, trawls, or traps. It's also important for divers to be conscientious of their shots so as not to damage fragile coral or other reef creatures. Thus, higher prices for lionfish are crucial for a viable market.

It is important that culling efforts continue to be aimed at overfishing the populations rather than trying to manage a sustainable population which would continue to be detrimental to reef ecosystems. Some people that I spoke to indicate that fisherman in certain areas considered cultivating lionfish populations to ensure harvest. This is clearly counterproductive. It is estimated that lionfish populations need to be reduced to 40-20% to allow native reef fish populations to rebound.^[9] This happens to coincide with U.S. federal fisheries management guidelines concerning an overfished stock.^[10] An amendment to the Magnusson-Stevens Act, called the Reef Assassin Act, was even recently introduced to specifically allow exploitation of lionfish to the point of extirpation.



Trash Picking in Style

Since large scale commercial operations are destined to flounder, then how is it possible to keep constant pressure only lionfish populations?



Lionfish Jewelry – Credit: Etsy

One solution is jewelry. Jewelry made from the fins and spines has been gaining in popularity. Because the fins and spines are venomous and contain no meat, they are typically removed and discarded before sale, although some restaurants do prefer them left on to enhance the presentation in the dish. These discards can actually be sold for use to make jewelry, which can increase the price of landed lionfish by up to 61%.^[11] It has provided occupations for women in many traditionally male-dominated fishing communities.^[11] Handcrafted jewelry has the added benefit of being an excellent conversation piece which helps further engage public awareness about invasive lionfish issues.

Derbies (or tournaments) are another valuable platform to inform people about lionfish. What started as friendly competitions between dive buddies to catch the most, biggest, or smallest lionfish (standard among fishermen of all kinds), have burgeoned into grand, sometimes multi-day, events throughout the Caribbean. These events attract sponsors, divers, families, and restaurateurs alike. They provide a festive opportunity to engage the public, exhibit lionfish products, and have a significant impact on local reef populations. Most are held about twice a year in locations throughout the Caribbean and competitors can potentially win significant prizes, up to thousands of dollars. In May of 2019, the Lionfish Removal and Awareness Day in conjunction with the Emerald Coast Open help in Destin, Florida (the largest tournament to date) resulted in the removal of 19,167 lionfish. The winning team, Florida Man, won \$10,000 for catch 2,241 lionfish over the 2 day event.^[12] I was personally interviewed on Honduran national TV a couple of years ago during a derby in Utila. I later had non-divers on the mainland approach me asking about it which demonstrates that derbies are indeed a productive way to raise awareness about lionfish. I didn't win thousands of dollars, just a crudely painted plaque of wood. Either way, it's the adventure, pride of having an impact, and festive nature of derbies that makes them worthwhile.

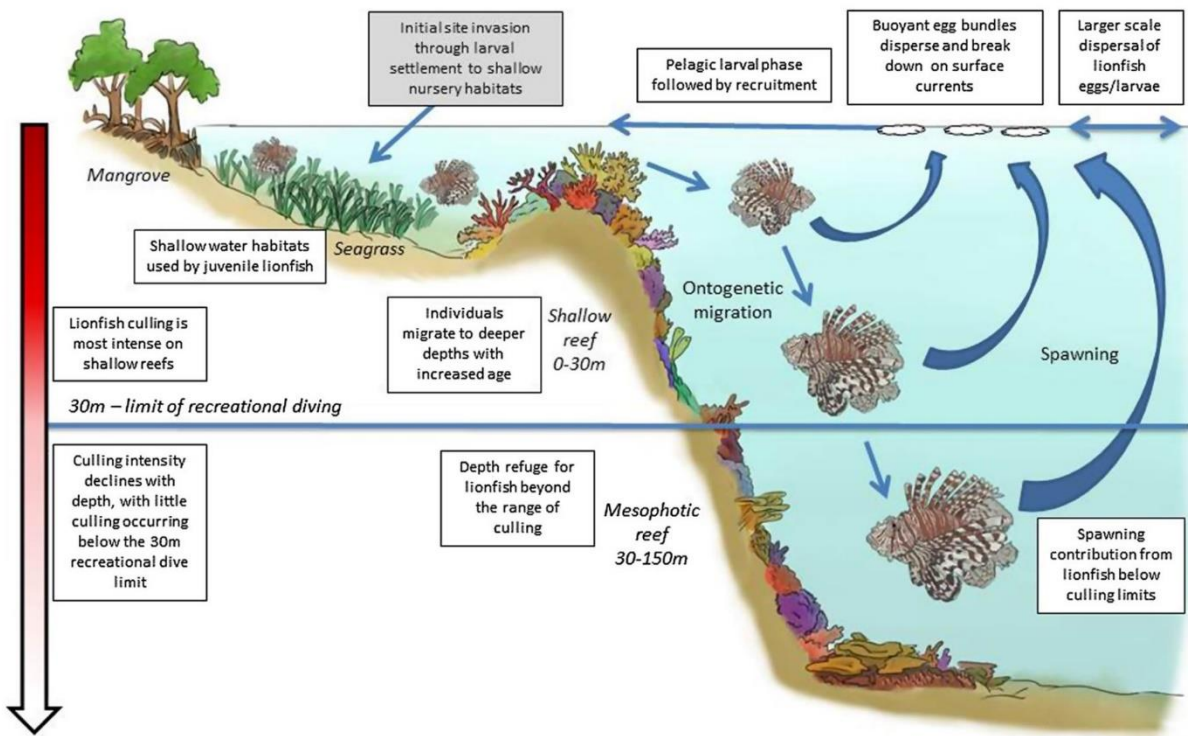


Winning team Florida Man. Credit:FWC

The FWC has been very proactive in instituting programs to combat invasive lionfish. One such is the Lionfish Harvest Charter Program. This program pays \$50 to any charter operation for each diver that brings in 8 lionfish per trip. It requires that the charter provides proof of the harvest with pictures and a short video including a time/date stamp. This helps defray operating costs, and divers may keep or sell their catch. Recent declines in lionfish landings have made this one of the few financially viable options left for several boat operators

and divers. Rachel Bowman, the first commercial diver to sell lionfish to Whole Foods, told me that without this program, it would not be feasible for her to go out targeting lionfish. Additionally, if she only gets 20 pounds of fish, she gives it to friends; only if she gets 50+ pounds is it worth it to go sell, which is happening less frequently. She also informed me that recently, a close friend that is a lobster fisherman brought in around two hundred pounds of lionfish as by-catch in his traps, but due to the closure of restaurants from Covid-19, he was unable to sell them.

Given that a large contingent of the lionfish population resides well below recreational diving depths (up to 300 m), and technical diving is limited/expensive, it is highly unlikely to extirpate lionfish as there is a large stable brood stock that will continually resupply shallow reef habitats with new recruits.^[3] Reduced interest, resulting in reduced culling efforts will likely allow lionfish populations to rebound, a second wave so to speak.^[3]



Andradi-Brown et al.

In an effort to target these deeper populations, some entities have been working to adapt ROV/AUV technology and enhanced trap designs to access deeper environments. These include the Guardian LF1 ROV designed to capture lionfish, smart trap adaptations for lobster traps, and the Gittings purse trap.

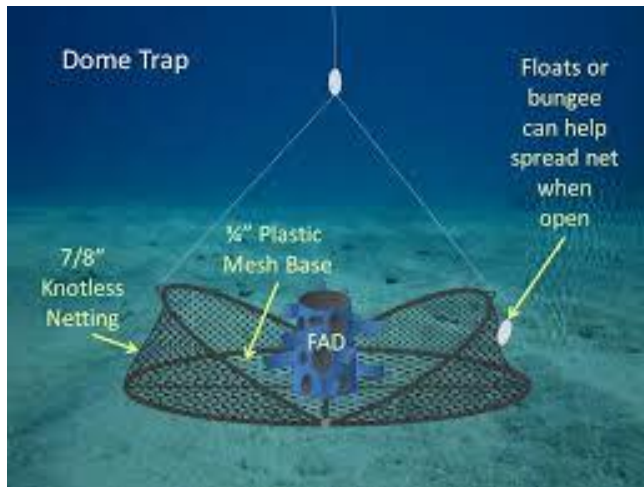
The Guardian LF1, designed by Robots in Service of the Environment (RSE), is a Remotely Operated Vehicle (ROV), controlled by an operator on the surface, armed with a pair of electric paddles. The paddles deliver an electric shock that stuns the lionfish, which is then vacuumed into a containment vessel. This enables the culling of



lionfish beyond recreational diving limits, however, still requires a significant amount of time and effort by the operator in addition to the equipment costs.

Guardian LF1

R3Designs has been developing a smart trap, the Fish Trap Extension Kit, for adapting lobster traps into lionfish traps. This module was created to use technology that can identify lionfish using recognition software so that the trap only opens when a lionfish enters the aperture. This would greatly reduce by-catch and allow lobster fishermen to utilize their traps in the off season. Lab trials worked, but field trials were less than favorable. Design improvements are being made. View the latest report here: https://www.youtube.com/watch?v=A_LJMErpttc.



Gittings Purse Trap – Credit: Dr. Steve Gittings, Chief Scientist, NOAA

of this trap design is that it is relatively inexpensive; it is even possible to purchase the materials and build it at home. Although found to be effective in areas with high lionfish density, confirmed field trials were less successful, most likely due to reduced population densities.

The Gittings purse trap, which is possibly the most efficient, involves dropping a purse net which lies flat on the bottom with a structure known as a fish aggregation device (FAD) in the center. Lionfish naturally congregate near structures, but don't move quickly, whereas many other reef fish tend to be skittish. The trap can be left to soak for several days allowing lionfish to congregate while other reef fish can come and go as they please. When the trap is retrieved, the net closes around the lionfish and FAD with minimal by-catch. One of the most attractive aspects

Conclusion –

Unfortunately, it is highly unlikely that invasive lionfish can be extirpated. In the long run, even with the advent of efficient traps, a large scale commercial fishery is simply not economically feasible. From all accounts, it seems that small scale artisanal and subsistence

fisheries will be the most effective and cost efficient method of lionfish mitigation on a broad spatial scale in the long run. Think of it like this: Instead of having one massive commercial farm, there can be thousands of backyard gardens where people can harvest for themselves or take their produce to local farmers markets. Sales of fins and spines for jewelry provide added economic incentive to harvest lionfish. Coupled with engaging the multitudes of recreational divers that visit the Caribbean to participate in lionfish culling activities, like derbies or charters, this would serve to keep constant pressure on populations and protect coral reef ecosystems on which so many coastal communities depend. It is necessary to use strategies that provide economic incentives to control invasive lionfish populations and combat this environmental scourge.

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