LIONFISH INVASION RESPONSE PLAN FOR BARBADOS

Prepared by

Biodiversity Working Group
Natural Heritage Department

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Preface

This response plan was prepared by the Biodiversity Working Group (BWG), a multidisciplinary advisory group convened under the aegis of the Natural Heritage Department of the Ministry of the Environment, Natural Resources and Drainage to advise the Minister on general biodiversity issues and matters related to the implementation of the Convention on Biological Diversity. The BWG includes representatives from the University of the West Indies, Ministry of Agriculture, Food, Fisheries, Industry & Small Business Development, Fisheries Division, Coastal Zone Management Unit, National Conservation Commission and Veterinary Services.

The terms of reference of this advisory group include *inter alia*:

- Advising on national policy and recommending strategies for the management and conservation of marine and terrestrial biodiversity;
- Offering advice and providing the necessary technical input for projects in the area of biodiversity;
- Reviewing and monitoring the status of marine and terrestrial biodiversity in Barbados.

In relation to implementation of the Convention on Biological Diversity the BWG also has a specific role to play in offering advice on the control of invasive species.

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1 Background

1.1 Invasive species

An “invasive species" is defined by the National Invasive Species Council (NISC) of the USA as “an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health”.

One of the most successful and destructive examples of a terrestrial invasive species in Barbados in recent times is the giant African snail (*Achatina fulica*). Another invasive species that is anticipated to arrive in Barbados in the near future is one or both of the Pacific lionfishes, the red lionfish (*Pterois volitans*) and the devil firefish (*Pterois miles*) that are currently invading the western Atlantic, moving rapidly across the Caribbean. This on-going spread of lionfishes throughout the region is regarded as the most successful and rapid marine finfish invasion in history.

These invasive lionfishes belong to the genus Pterois. comprising several species of venomous marine fish, native to the Indo-Pacific region and belonging to the scorpionfish family, Scorpaenidae, together with the true scorpionfishes and stonefishes. Interestingly, one member of this family, the spotted scorpionfish (*Scorpaena plumieri*) is already present here as a native to Barbadian waters and has several local names including “lionfish”, “stonefish” and “sculpin”. As a native species, however, the local stonefish does not pose an ecological threat.

1.2 The response plan

As will be explained in this document, the expected imminent arrival of one or both species of lionfishes in Barbadian waters will be of concern to a number of public and private sector entities. However, given the potential impacts on the coastal marine ecosystem, the Government’s Biodiversity Working Group, convened under the Natural Heritage Department, has taken on the task of developing a plan to respond to the anticipated lionfish invasion of Barbados waters, recognizing that its implementation will largely be the joint responsibility of the Fisheries Division of the Ministry of Agriculture, Food, Fisheries, and,Water Resource Management and the Coastal Zone Management Unit of the Ministry of Environment and Drainage.

This first plan details recommended actions to be taken prior to and after the anticipated arrival in Barbadian waters of the invasive lionfish. The overall objective is to control the spread of this invasive species and thus mitigate the potentially serious social and economic impacts in Barbados.

Given the wider threat that lionfish pose as invasive species on the island’s marine biodiversity, this plan will first be forwarded to the Cabinet of Barbados for approval,

before being more widely distributed to other key agencies and persons in the public and private sectors as identified in the plan.

The structure of the lionfish response plan is outlined here.

The first section provides the background information related to the anticipated lionfish invasion and the potential threats that it poses in Barbados, including:

- A description of the lionfish species in the western Atlantic, and the current and expected geographic distribution and timeline for the invasion of these animals.
- A description of the life-history traits of lionfishes that make them successful invasive species.
- The potential social and economic threats that lionfish pose through impacts on reef ecology, income generation and human health.

The second section includes the core of the response plan including:

- Identification of the specific objectives of the plan
- Identification of persons and groups who are likely to be affected in the event that lionfish invade Barbadian waters.
- Identification of the roles of both individual stakeholders and partner institutions, who would directly be involved in various aspects of the response to the lionfish threat.
- Articulation of the public awareness and communication strategies to implement all aspects of the plan

2 Introduction

2.1 The lionfish invasion of the western Atlantic

Indo-Pacific lionfishes are highly prized in the international aquarium trade for their beauty, possessing striking bands of reddish brown and white, along with feathery, dorsal, anal and pelvic spines which extend from their body (see cover photo). In fact lionfishes are among the top 10 most popular fish species in the USA aquarium trade with 7,562 lionfish passing through Tampa's airport alone, over a six month period in 2003 (Ruiz-Carus et al. 2006). It is believed that the lionfishes currently invading the western Atlantic are descendents of some of these aquarium-reared fishes that were either accidentally or deliberately released into the sea.

Although many reports cite 1992 as the year when lionfish were first confirmed as present in the Atlantic off the eastern coast of Florida , it appears that single specimens were spotted around the same area from as early as 1985. However, it was not until 2000 that lionfish were also found at a number of other locations along the eastern seaboard of the

USA and around Bermuda. By 2008 the lionfish had spread throughout the northern Caribbean islands, as far east as Puerto Rico, and had started their invasion of Central America and the southern Caribbean Sea, including the Yucatan Peninsula, Belize and the San Andres Islands. At the time of writing, lionfish have now been reported throughout the Caribbean coast of the South American from Columbia to Venezuela, including the offshore islands and southern Netherlands Antilles. The invasion is also making its way south down the the Lesser Antilles island chain, and has now reached as far south as Martinique. Based on the observed geographic distribution pattern as well as the apparent speed of the invasion, it is expected that lionfish will be in Barbadian waters within a few months.

In their native environment, *P. volitans* and *P. miles* are reported to occur in waters between 22°C and 28°C. However, in the Atlantic they have been found in waters as cold as 14°C off the USA (Meister et al. 2005). Given this, it is hypothesized that the range of the lionfish invasion will eventually extend throughout the Gulf of Mexico and south along the eastern coast of South America down to along the eastern coast on Brazil, (Figure 1) the latitude at which the animals' low lethal temperature range will be reached (Figure 2; Hare and Whitfield 2003, in Richter 2009).

Figure 1. Distribution of lionfishes through the western Atlantic region by the end of 2010

Figure 2. Forecasted range of lionfishes within the western Atlantic, based on the minimum lethal temperature limits of the species. Image from Richter (2009)

2.2 Life-history traits facilitating the invasion of lionfishes

Both species of lionfish currently in the western Atlantic possess a number of life-history traits that facilitate their invasive success. These include:

- A high reproductive and dispersal capacity facilitated by:
    - Attainment of sexual maturity within the first year of life
    - A relatively long life span of approximately 15 years, which coupled with early maturity, gives the animals a relatively long reproductive life.
    - High fecundity; for example females may produce at least 2 million eggs annually.
    - Frequent spawning: In the Caribbean spawning is believed to occur year-round and possibly as often as every 4 days.
    - They reproduce by releasing floating egg masses which are dispersed by wind-driven water currents

- Lionfish can live in a wide variety of habitats across many depths, ranging from the shoreline to at least 1000m.
- A faster growth rate (estimated at around 0.5 mm per day in the Caribbean) than the native species with which they compete for food and space. This gives them a competitive advantage over native species in the same trophic level.
- The ability to grow to sizes greater than 47 cm (20 in) and 1.2 kg (2.6 lb) in weight making them one of the relatively large-bodied reef fish.
- Less susceptibility to parasites compared with other fish species. In fact there are no known parasites that target lionfish and if attacked, a lionfish can actually shed its skin to rid itself of the parasite. This enhances the lionfish's overall health, survival and consequently its reproductive capacity, giving it additional competitive advantages over native reef fish.
- An arsenal of long, sharp, poison-producing spines that effectively protects the animals from predation, as such there are few potential natural predators in the region. However, some groupers apparently will eat lionfish. Note however that currently very few groupers within the size range capable of eating lionfish are known to exist in Barbadian waters.

The fact that lionfish densities are much higher in the Atlantic than those reported in their native range bears testimony to their success as invasive species.

2.3 Potential ecological, social and economic Impacts

2.3.1 Ecosystem services and revenue generation

- Lionfishes are highly efficient predators that consume a wide variety of fish and invertebrates, including juvenile lobsters, shrimp and crabs. For example, 41 different fish species were found in red lionfish gut samples collected during a feeding ecology study conducted in the Bahamas.

- Lionfishes have voracious appetites. A recent study conducted in the Bahamas estimated that individual lionfish consumed an average of 1.4 fish per hour.

- Lionfishes also exhibit site fidelity and as such, once established, may continue to substantially deplete the resident fauna before moving to another site.

- Lionfishes have the potential to remove large numbers of a wide range of fish species from reef ecosystems. This includes the both juveniles and adults of small bodied reef fish and juveniles of the large bodied reef fish species.

By definition all members of an ecosystem play specific roles in its maintenance and it is not possible to describe the impacts on the ecosystem on a species by species basis.

However, a clear picture of the impact of the lionfish on the ecosystem can be obtained by considering the impacts across trophic (feeding) levels.

- At the lowest trophic level, the removal of herbivorous fish from the reef exposes the reef substrate to the risk of being overgrown by macroalgae which in turn may have several deleterious consequences including;

    - Reducing the coral recruitment, as new recruits will not be able to settle and establish new colonies.
    - Overgrowth and shading of the corals by macroalgae will result in a general increase in coral mortality rates and a reduction in growth rates of the surviving corals.
    - Ultimately the increase in coral mortality and reduction in coral growth and recruitment capacity will reduce the process of reef accretion. As such the natural erosion process will outstrip the accretion and will result in the eventual destruction and collapse of the reef framework.
    - In turn, the loss of reef framework will deprive beaches of a sustainable sand supply, reduce the effectiveness of the reef as a protective natural breakwater for the coastline and reduce the efficacy of the reef as a habitat for fishes and other reef associated organisms.

- Lionfishes will also have impacts at higher trophic levels. For example, many of the small bodied reef fish species susceptible to lionfish predation not only serve the important ecological role as herbivores, but they are also an important component of the diet of carnivorous reef fishes. This includes native piscivores that are important target species in reef fisheries such as snappers and groupers. Removal of these forage species by lionfish therefore reduces the quantity available as food to sustain these native predatory fish species.

- Juveniles of all fish species including those of the large-bodied species are susceptible to predation by lionfishes. Lionfish predation is therefore likely to have a direct impact on all these fish populations through compromising their recruitment capacity. To illustrate this point, a study conducted on experimental reefs in the Bahamas demonstrated that lionfish reduced the recruitment rate of coral reef fishes by nearly 80%.

- Barbados' near-shore reefs are already in a very poor state and thus especially vulnerable to the destructive effects of an established lionfish population. Not only will a lionfish invasion impact on the productivity of the reefs but it could ultimately reduce the reefs' aesthetic value. This will in turn directly impact negatively on the dive tourism sector.

- In the longer-term the compromised functionality of coral reefs in coastal protection is likely to both increase beach erosion and imperil coastal infrastructure including that which is critical to the tourism industry.

- Collectively therefore, establishment of lionfish populations may have serious negative impacts on the much touted Barbados tourism package of "sun, sand and sea".

- Overall, the establishment of lionfishes in the island's waters has the ability to disrupt the coral reef ecosystem, resulting in losses of ecosystem services and goods and services to the tourism and fisheries sectors. The annual value of services from Caribbean coral reefs has been estimated at US $3.1 billion – 4.6 billion.

- It has further been estimated that by 2015, if drastic changes have not been made to slow the deterioration of coral reefs, between US$350 million – 820 million will be lost annually.

- It is difficult to place a monetary value on the combined negative cultural and social impacts that are likely to result directly or indirectly from a successful lionfish invasion.

- An immediate negative impact of establishment of a lionfish population in Barbadian waters would likely be the reduction in reef fish species available for the traditional capture fisheries, especially the hook and line, fish pot and seine fisheries. This is the primary source of income and protein for a small, yet important set of fishers. As such, the loss of these species would result in loss of revenue and social dislocation for the cadre of persons involved in these traditional fisheries. This includes the numerous fishers that resort to reef fisheries during the pelagic off-season as well as those that are involved year-round. In this context it must be further noted that the majority of year-round reef fishermen are elderly and/or in the lower income bracket.

2.3.2 Human health

- The lionfish possesses around 33 venomous spines

- The venom is a combination of a protein, a neuromuscular toxin, and a neurotransmitter (acetylcholine). Lionfish envenomation should be treated as a serious health emergency.

- Localized symptoms of envenomation by the red lionfish include, but are not limited to, persistent, intense, throbbing, radiating, sharp pain at the site of envenomation, tingling sensations, sweating and blistering.

- In more severe cases, systemic repercussions including headache, nausea, vomiting, abdominal pain, delirium, seizures, paralysis of limbs, a rise or drop in blood pressure, respiratory distress, and heart complications including congestive heart failure, pulmonary edema, tremors, muscle weakness, and loss of consciousness may occur.

- Lionfish venom itself is very rarely fatal although anaphylactic reactions to the venom in some people may lead to death and death from drowning may also occur. It

should be noted that lionfish venom is actually considered to be the least potent of that produced by other members of the Scorpinaedae family, such as the scorpionfish and the stonefish (the latter producing the most potent venom).

- In the few reported cases in which death occurred, the victims already had existing, underlying health conditions or were particularly sensitive to the toxin.

- Divers are at risk of additional indirect fatality factors such as decompression sickness and drowning that may result from disorientation caused by the pain and panic or loss of consciousness caused by envenomation whilst underwater.

- While it is expected that fishers and divers will be at greatest risk of lionfish envenomation due to the nature of their professions/recreational activities, it is also possible that sea bathers will come into contact with the animals, and the risk of encounter will obviously increase with expansion of lionfish populations.

3 Management of the lionfish invasion

3.1 Objectives

Based on the experiences of other Caribbean territories that have already been invaded by lionfishes, it is anticipated that eradication of these fishes will be impossible once they invade Barbadian waters. The overall objectives of this response plan are therefore oriented towards mitigating the potential negative ecological, social and economic impacts of lionfishes as they insinuate themselves into the island's native marine ecosystems. This will be done, in the first instance, through a combination of public awareness, training and removal of encountered specimens wherever possible.

This approach will rely heavily on the active participation of divers and fishers in removing lionfishes. To encourage a sustained removal effort, the importance of economic incentives is recognized. This may be achieved through the creation of a market for lionfishes as a superior or speciality food fish. Other options could include offering a bounty, and/or sponsoring recreational lionfish fishing tournaments.

Against this background, the ultimate specific response objectives include:

- Informing all relevant stakeholders of the threats posed by a lionfish invasion, and assigning specific roles in the monitoring and response to the invasion.

- Training key stakeholders in methods for the safe capture and handling of these animals.

- Establishing a local market for lionfishes in Barbados that in turn will promote a viable fishery for these species from the earliest stages of the invasion.

- Conducting research aimed at increasing the scientific knowledge base regarding these animals.

- Maintaining a reference collection of articles relating to the ecology, biology, and control of lionfishes

- Reviewing existing management approaches in use in other affected countries to identify and incorporate as appropriate, alternative means of controlling the proliferation of lionfishes.

- Identifying resources and strategies needed to cushion social and economic shocks that may befall persons, particularly those who rely on reef services for their livelihoods.

- Establishing a pre-invasion baseline profile of reef ecosystems such as species diversity and abundance and monitor changes in key indicator parameters following the invasion to assess its impacts.

- Establishing a baseline pre-invasion social and economic profile of reef services and monitor changes in key indicator parameters, for example reef fishery catch statistics, numbers of tourist dive trips etc.

- Strenuously enforcing existing protective legislation for fish, urchins and corals to support natural reef processes in the face of the lionfish stressor

3.2 Identification of stakeholders

In relation to the lionfish invasion, stakeholders range from recreational sea-bathers whose direct concern would be the possibility of accidental envenomation, to individuals and groups whose livelihoods are likely to be impacted directly, to Government agencies tasked with overseeing the control of the proliferation of the animals and mitigating their social and economic impacts. In this context the following stakeholder groups are identified. An asterisk is used to identify bodies representing groups of key stakeholders.

- **The Cabinet of Barbados**

- **Technical personnel and agencies directly involved in marine research and management (Governmental and Non-governmental):**

    - Fisheries Division (FD)
    - Coastal Zone Management Unit (CZMU)
    - Center for Resource Management and Environmental Studies (CERMES) and Barbados Sea Turtle Project of the University of the West Indies, Cave Hill Campus
    - Natural Heritage Department (NHD)
    - Barbados Marine Trust
    - Folkestone Marine Park

- **Persons in the fishing and tourism sectors who depend wholly or in part on reef services for their livelihoods:**

    - Professional Dive Operators
    - Fishers
    - Fish vendors and processors
    - Barbados National Union of Fisherfolk Organisations (BARNUFO)
    - Water sports (especially diving and glass bottom boat) operators
    - Association of water sports operators
    - Atlantis Submarines
    - Barbados Tourism Authority (BTA)
    - Barbados Hotel Tourism Association (BHTA)
    - Hotel owners and managers

- **Healthcare professionals:**

    - Ministry of Health
    - Barbados Association of Medical Practitioners
    - Barbados Nurses Association*
    - Doctors
    - Nurses
    - Emergency Medical Technicians

- **Associated agencies in the context of marine monitoring and management:**

    - Marine Police
    - Coast Guard
    - NCC lifeguard and ranger service

- **Recreational resource users:**

    - Barbados Amateur Divers Association (BADASS)
    - Recreational divers
    - The general public

3.3 Roles of key stakeholders

The CZMU and the FD

The CZMU and the FD are presently the two local government agencies tasked in various ways with monitoring the marine ecosystem of Barbados and managing its use. These two agencies will be responsible for the development and implementation of systems to monitor the invasion and to provide all necessary scientific information and management advice. This of course can only be accomplished through collaboration between these two

agencies and a number of the other stakeholder groups previously identified. The specific roles of key stakeholder groups in this context are as follows:

Cabinet

Cabinet will review and endorse the lionfish response plan and facilitate its implementation, especially through the identification and allocation of the necessary financial and human resources. Cabinet will also be responsible for developing policies and guiding the development of strategies for mitigating any possible social and economic dislocation caused by lionfishes becoming established here.

CERMES and the diver and fisher communities

The monitoring and research work should be a collaborative effort between the FD, CZMU, the University of the West Indies; and the diver and fishing communities. It is anticipated that staff divers of the CZMU, FD and private volunteer divers and fishers will be involved in a sustained removal of lionfishes for a long as required.

While divers and fishers will be engaged on an individual basis by the FD and CZMU, these agencies will also work with umbrella representative agencies where they exist, for example, BARNUFO, BADASS, Association of water-sports operators (especially glass-bottom boats) etc.

The Barbados Tourism Authority (BTA)

The BTA is primarily responsible for promoting Barbados as a tourist destination. The BTA will therefore be responsible for handling international public relations associated with a lionfish invasion such as sensitizing visitors to the dangers associated with lionfishes whilst ensuring that they are not panicked and shy away from engaging in marine activities.

The Barbados Hotel and Tourism Association (BHTA)

The BHTA and their individual members will also have to engage in sober public relations that ensure the protection of their visitors from the attendant potential risks posed by lionfish encounters, while not deterring them from enjoying the marine environment. It should be noted that they already play this role with regard to the long-spined sea urchin (*Diadema antillarum*) and the local stonefish (*Scorpaena plumieri*). In addition, the BHTA should facilitate the introduction of the use of lionfish as a viable food-fish within the culinary sector of its membership. The development of a market and a species-specific fishery is viewed as an important component of the control plan.

The Barbados Agricultural Development Management Corporation (BADMC), The Division of Hospitality Studies of the Barbados Community College (BCC), Secondary schools

While not a primary stakeholder in fisheries per se, the BADMC is seen as a potentially important partner in developing lionfish products for the local marketplace, including the popular "fish-fry" establishments. In this regard, it is hoped that the product development section in particular could be engaged in the training of fish processors and Barbadian cooks. This could begin with professional chefs and then be offered to non-professional and should include training in the safe handling and preparation of lionfish for human consumption.

As the lionfish population expands and becomes more readily available, the Division of Hospitality Studies of the BCC should also be encouraged to include the use of lionfish in their culinary courses. Students could be challenged to create lionfish-based dishes that have a Barbadian flavour. Secondary schools could also be encouraged to use lionfish in their cooking courses. The Fisheries Division could consider a lionfish theme for their annual fish dish competitions once the lionfish becomes readily available locally.

To deliver these services, all persons expected to offer the wider training in processing and cooking lionfish including the staff of the BADMC and teachers of the BCC and secondary schools must themselves be trained. In this regard it is noted that educational material on these topics including lionfish cookbooks are already commercially and freely available and should be acquired and distributed. In addition, the services of persons from outside the island with these skills may be engaged as the trainers of trainers. It must be stressed that for fishing pressure to be an effective tool in curbing the proliferation of the lionfish, it is important that a market for the animal be in place from the very beginning of the invasion. As such prompt action in this area is seen as important.

Healthcare professionals

It is expected that lionfish envenomations will occur with increasing frequency as the lionfish population expands. Health professionals, especially the wide cadre of primary healthcare workers ranging from EMTs, nurses and physicians, must be alerted to the impending invasion and associated heath risks. To this end, the offices of the Ministry of Health and the health professional associations such as BAMP and the BNA should be alerted immediately to enable them to fashion their health care management plans for lionfish. This of course would include advising their membership of the recommended long term treatment protocols for treating lionfish envenomation. These include:

Primary first aid treatment - Removal of all traces of the spine and application of a heat pad or immersion of the wounded area in very hot water (as hot as can be tolerated without burning the skin or no more than 45^{o}C) for at least 30 minutes. The heat denatures the venom reducing its spread.

Secondary treatment - The use of analgesics ranging from over the counter pain killers to local or regional anesthetics. Antibiotics and prophylactic anti-tetanus treatment may also be indicated.

The anti-venom used to treat envenomation by the more dangerous stonefish is also effective at treating lionfish venom but will only be used in very rare, severe and life-threatening cases of lionfish envenomation. The Ministry of Health through the Barbados Drug Service should source, acquire and maintain an adequate stock of lionfish anti-venom.

Officers of the Environmental Health Department of the Ministry of Health will also be charged with the responsibility of ensuring that lionfish are being properly prepared for consumption. This will be in the contexts of both basic fish quality standards and removal of all traces of the venom.

Coastguard, NCC rangers and Lifeguards

In the interim the FD and CZMU undertakes to advise the wider public on the appropriate first-aid treatment procedures., especially persons that are likely to be called on to administer first-aid to envenomation victims such as Coast Guard personnel, NCC rangers and lifeguards, and dive and charter boat operators

The Media

The local media will play a pivotal role in distributing all relevant information related to the lionfish to the general public. However, balanced reporting is vital to ensure that the public is accurately informed without causing panic. As such it is recommended that a public information plan be developed with the Government Information Service.

3.4 Specific activities

3.4.1 Public awareness and Communication

In general the education programme will be implemented via a combination of focused meetings, seminars and workshops, television and radio call-in shows, newspaper articles, the Barbados National Bank's "big screen" on Broad Street, informational pamphlets and postings on the web sites of the CZMU and FD. Wider public awareness programmes will be developed in association with the Government Information Service (GIS). However, relevant educational material and strategies must be tailored to match the varied categories of stakeholders previously defined.

The FD and CZMU will primarily focus on the ecological and socioeconomic related aspects of the lionfish invasion. This includes overseeing the monitoring and culling programmes, as well as participating in any relevant targeted research in partnership with established scientists and research institutions such as the UWI, in addition to disseminating all relevant information to stakeholders as required. It is incumbent on experts in the other specialized fields identified earlier such as health and tourism, to identify their specific information needs and to develop appropriate information collection and educational strategies. Nevertheless, the FD and CZMU stand ready to offer any

information or advice within their area of expertise to all stakeholder groups. To facilitate this, it is envisaged that the key stakeholder bodies identified earlier (with asterisks) will be used as nodes via which information may be exchanged between the FD and CZMU and respective groups of individuals that these bodies represent.

While Cabinet should be initially informed on all technical facets of the lionfish invasion, there should be a sharp focus on its short and long-term social and economic ramifications. A reporting system must also be put in place to ensure that Cabinet is kept up to date on pertinent developments and issues in relation to the invasion. Such reporting should be as concise as possible.

It is anticipated that reef-fishers and divers (sport and commercial) will be one of the first stakeholders to come into contact with the lionfish and will be major participants in the research and culling programmes. As such, for this group, there must be great emphasis on providing in-depth technical information on the animal, hands-on training in research and collection techniques, with an emphasis on safe-handling procedures. This will include a number of focused meetings, seminars and workshops. The first meeting has already taken place with this sector, both to inform them, and also to enlist their assistance in reporting and capturing the first lionfish arrivals. A lionfish reporting form was distributed to the participants as well as a request to bring live (if possible) or freshly dead animals to the FD. Efforts will be made to further expand this group of partner divers as well as to enlist recreational divers not associated with dive shops, employees of Atlantis Submarines and non-diver reef fishers (e.g. hook and line, seine net and pot fishers).

Additionally, dive shops will be supplied with information on the lionfish and encouraged to discuss the safety issues during their dive briefings, so that their guests are fully aware of the potential dangers associated with these fish.

A wider public education programme that will utilize the print and broadcast media will be developed through collaboration of the CZMU and FD with the GIS. The Ministry of Education will also be engaged to educate school children on the island about the lionfish.

3.4.2 Harvest and culling

Given the fact that these animals tend to be easily approached by divers, the use of conventional spear guns that can damage reefs and potentially injure people is not necessary or recommended. Instead simple, small spears such as the 'Hawaiian sling' are more suited for use in killing these bottom dwellers. The CZMU is in the process of bringing in a few of these Hawaiian-sling style spears as prototypes, and the dive community has already been informed and most have agreed to participate in testing this gear. Local artisans capable of constructing these sling-spears should be identified and arrangements made for producing and providing this gear at low cost to the diving and fishing communities.

During the initial period, before the anticipated fishery for lionfishes is established, it will be necessary to both encourage the slaughter of the lionfish particularly in ecologically sensitive or important areas, such as within the Folkestone Marine Park. Volunteers for these initial culling activities must be urgently sought and the possibility of offering a bounty for collection could perhaps be considered as a stopgap measure. Recreational lionfish fishing tournaments may also be used to ramp up fishing pressure periodically. A list of volunteers for these culling activities has already been compiled, and divers from Government agencies such as the CZMU, FD and the Barbados Coast Guard, will also be considered in these exercises.

3.4.3 Research

Several aspects of the lionfish invasion including its biology and its ecological impacts are the subject of scientific research throughout the region. It is expected that UWI and other regional scientific institutions will also formulate their own research programmes on the lionfish. It is strongly recommended that the FD and CZMU collaborate with partners in worthy scientific projects. At a minimum, this collaboration should be in the collection of specimens, samples and basic information on lionfish as they begin the colonization of Barbadian waters. This will include inter alia:

- Tracking the spatial spread of the lionfishes around the island
- Identifying the species of lionfish present through time
- Gathering basic morphometric data on the lionfishes
- Collecting hard parts such as scales, spines and/or otoliths (ear bones) for age and growth studies
- Collecting gut samples for diet studies
- Collecting and storing tissue samples for genetics studies

Resources will be needed to purchase equipment (e.g. freezer for FD) and supplies (e.g. for preservation of gut samples, tissue samples etc).

3.4.4 Reporting

It is anticipated that fishers and divers will be the first stakeholders to come into contact with the lionfishes. One meeting has already been carried out with these sectors, both to inform them, and also to enlist their assistance in reporting and capturing the initial animals. A lionfish reporting form (Appendix 2) was handed out to the participants as well as a request to bring live or freshly dead animals to the Fisheries Division. Issues such as a bounty for capture will have to be discussed further. Recreational divers not associated

with dive shops, employees of Atlantis Submarines and pot fishers will also be encouraged to report lionfish sightings.

4 Summary

Lionfishes are expected to arrive in Barbados in the near future and could have severe negative impacts on our coral reef ecosystem and associated fauna. While it is not expected that the animals will be eradicated by any measures suggested here, it is hoped that the actions outlined in this plan will allow for the numbers of lionfishes to be controlled, and thus avert a major impact on reef health and nearshore fisheries productivity . The fact that lionfishes are highly palatable should be seen as a good opportunity for both the harvest and post-harvest sectors to benefit from their removal. A summary of the priority actions and relevant lead agencies is presented in Appendix 1.

5 References and Useful Links

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Gulf and Caribbean Fisheries Institute (GCFI) searchable archive of proceedings with many papers on lionfishes in the Caribbean http://www.gcfi.org/Lionfish/Lionfish.html

The NGO 'REEF' has a lionfish research programme with available literature, factsheets, facebook link etc. on their website: http://www.reef.org/programs/exotic/lionfish

The National Oceanic and Atmospheric Administration (NOAA) of the US has a lionfish information website: http://oceanservice.noaa.gov/education/stories/lionfish/

Other useful lionfish information at the Essential Image Source Foundation webstie: http://home.eisf.org/node/1082

The Caribbean Fisheries Management Council (CFMC) in Puerto Rico has useful facts and links on lionfish on their website: http://www.caribbeanfmc.com/LIONFISH/lionfish.htm

6 Appendices

Appendix 1:

Pre and Early Invasion Priority Actions and Respective Lead Agencies

TIME	OBJECTIVE	ACTION	LEAD AGENCIES
Pre-Invasion	Public awareness	1. Brochure & Poster Preparation & Distribution	FD & CZMU
		2. Newspaper articles	GIS, FD & CZMU
		3. Radio & T.V. ads	GIS, FD & CZMU
		4. Meetings	FD & CZMU
	Reporting	1. Distribution of sighting forms	FD & CZMU
	Control	1. Importation of limited number of slings	CZMU
		2. Local manufacture of slings	PD
		3. Bounty/recreational tournaments	FD
	Health issues	1. Train primary health care providers.	MOH
		2. Facilitate availability of all required medical supplies including antivenom	
Early Invasion	Reporting	1. Collection & distribution of sighting forms	FD & CZMU
		2. GIS lionfish distribution mapping	CZMU
	Control	1. Confirmation & Collection dives	FD, CZMU, CERMES, PD
		2. Culling dives	PD, CZMU, CERMES, FD
		3. Development of market and associated fishery	FD, BADMC, BHTA
	Public Awareness	1. Brochure & Poster Preparation & Distribution	FD & CZMU
		2. Newspaper articles	GIS, FD & CZMU
		3. Radio & T.V. infomercials	GIS, FD & CZMU
		4. Meetings	FD & CZMU

CZMU – Coastal Zone Management Unit
FD – Fisheries Division
PD – Professional Divers
GIS – Government Information Service
BADMC – Barbados Agricultural Development Management Corporation
BHTA - Barbados Hotel and Tourism Association
MOH – Ministry of Health

Appendix 2: Lionfish Sighting Reporting Form

LIONFISH SIGHTING FORM

The red lionfish (*Pterois volitans*). Image courtesy NOAA

Coastal Zone Management Unit
Bay Street, St. Michael.
Tel: 2285950/ 1/ 2
Fax: 2285956
info@coastal.gov.bb

Fisheries Division,
Ministry of Agriculture, Food,
Fisheries, Industry and
Small Business Development
Bridgetown
Tel: 4263745/ 4265973/ 4278480
Fax: 4369068
fishbarbados@caribsurf.com

RECORD NO (*Official use only*): _____

Data Recorder: _____ ***Contact #***: _____

Observer _____
(if not the same as Recorder): ***Contact #***: _____

Date of sighting: (dd/mm/yy) ___/___/___ ***Time of sighting:*** _____

Sighting Location:
Site Name: _____ Landmarks: _____

Latitude: _____ Longitude: _____

Depth: _____

Habitat Type:
☐ Sand ☐ Rubble ☐ Patch Reef ☐ Bank Reef ☐ Fringe Reef ☐ Sea grass
☐ Other (Specify) _____

Activity of the observer:
☐ Diving ☐ Fishing ☐ Swimming ☐ Other (Specify) _____

Number of lionfish observed: _____

Approximate size (or size range if more than 1 fish) _____ (cm/ inches)

What was the lionfish doing?
☐ Hiding ☐ Hovering ☐ Swimming ☐ Feeding ☐ Other (Specify) _____

Appendix 3: Lionfish Brochure

Monitoring and Control

- All divers, fishermen and sea bathers are asked to be on the lookout for these fish.
- If you encounter them please record the date and location of the sighting and inform the Fisheries Division or Coastal Zone Management Unit as soon as possible.
- Lionfish are tasty and they are now fished and eaten in many countries in which they have become established. The toxin is not in the flesh itself and cooking will remove any traces accidentally left from processing.
- However, one needs to know how to safely fish for and process lionfish. Without this knowledge, do not touch or handle these fish.
- The public will be informed when these fish reach our waters and of the steps to control them.

Red lionfish - Image by NOAA

Human Health Threats

Lionfish have sharp spines by which they deliver a toxin into the skin that causes severe pain and swelling. However, the toxin is rarely fatal.

Venomous spines of the Lionfish - Image by NOAA

If stuck with a lionfish spine:

1. Remove all traces of the spine.
2. Irrigate the wound with water as hot as can be tolerated without burning the skin for at least 30 minutes. The hot water degrades the toxin and reduces its spread and effects.
3. Seek professional medical help.

Fisheries Division,
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Lionfish

The red lionfish - Image by NOAA

If you see this beautiful but dangerous fish DO NOT TOUCH IT but please let us know immediately where and when you saw it

Please call:

Fisheries Division
Tel: 4263745/ 4265973/ 4278480
Or:
Coastal Zone Management Unit
Tel: 228 5950/1/2