

**STAP advice on a lionfish control projects within:
GEF project 3729, Building a Sustainable National Marine Protected Area Network
(The Bahamas); and
GEF project 3813, Mitigating the Threats of Invasive Alien Species in the Insular
Caribbean (Bahamas, Dominican Republic, Jamaica, Saint Lucia, Trinidad and
Tobago)**

19 June 2009

Summary

Based on a desktop review of available information, STAP advises that the recommendations set out below are considered in developing the lionfish control components of GEF projects in the Caribbean. The endorsement package for project 3729 has not yet been received and was not included in this review.

The principle recommendation is that within the set of three lionfish pilot interventions proposed to date, a clear theory of impact is established and tested in the field. The pilot studies should be designed so that they establish the relationship between lionfish populations and the impact of lionfish on the environment, as well as the impact of potential control methods on lionfish populations.

There is a clear need for the three pilot projects to be run separately and address different parts of the lionfish problem. Ideally some activities would run concurrently and others sequentially however the threat posed by the lionfish invasion is such that an urgent response is required. Project work on impact assessment in Jamaica (GEF project 3183) and the effectiveness of different control measures in the Bahamas (GEF project 3183) can and should be concurrent. The experimental work on how much control is needed to make a difference in the Bahamas (GEF project 3729) would ideally be sequenced after these first two projects so that there is a well defined impact to measure the effect of lionfish control on, and a verified control method to apply in the experiment.

For practical reasons, the impact assessment work (GEF project 3183) is spread over 4 years and therefore GEF project 3729 may need to commence with a theory of impact based on a desktop review, this review could be shared with GEF project 3183 which also intends to start measuring and monitoring an impact or set of impacts on a quarterly basis from year 1. The control method work (GEF project 3183) will take two years and therefore GEF project 3729 may have to commence with the most promising control method identified during or after year one, or a desktop review shared with GEF project 3183.

Recommendations

1. Analyze possible invasion pathways for lionfish to continue to spread to the pilot site

Indo-Pacific lionfish are thought to have established in the Atlantic through repeated unintentional or intentional releases from aquaria in North America. Some references still point to a single release of six specimens from an aquarium at Biscayne Bay, Florida, during Hurricane Andrew in 1992, although the evidence for this causing the entire invasion is not strong and multiple introductions are typical in successful invasions. Likewise, introduction via ballast water has not been proven but cannot be ruled out. Since lionfish eggs and larvae can be dispersed over great distances on ocean currents, eradication of

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lionfish from the Atlantic is extremely unlikely. However control efforts in strategic locations could help reduce the impact of this invasive species on the environment and economy of the region.¹

Data on both the presence and the absence of lionfish, including the reliability and timing of the observations, are critical to inform analysis of the establishment and spread of lionfish in the Caribbean. This in turn can inform any future lionfish control investments and policies.

Public awareness and community engagement can be cost-effective approaches to obtain information on the presence of an invasive species and efforts are already being made to gather information on lionfish presence in the Bahamas and the Caribbean more broadly² (see map over page). Defining absence is more difficult and costly since an invasive species may not always be conspicuous when present, e.g. fish eggs or larvae may not be detectable with a single inspection, but multiple inspections over time could reveal the existence of a population. Therefore, the criteria for declaring absence must be clearly defined, less reliable data may still be useful but it must be identified according to reliability, which is a function of quality and frequency of observations.

Recommendation A: Establish a regional reporting system for presence and absence of lionfish in Caribbean GEF projects and, if possible, related initiatives in the region and the GCRMN.

If possible, information on lionfish species should also be collected. Two Indo-Pacific species are thought to have invaded the Caribbean while only one is thought to have established so far in the Bahamas, *Pterois volitans*. Therefore, it may still be possible to prevent the establishment of *P. miles* the Bahamas, and its further spread in the Caribbean.

While this recommendation may not be possible within the Bahamas GEF project 3729, the data model adopted for the project should be scalable to the regional level so that the Bahamas data can be used in any regionally coordinated efforts. GEF project 3183, Mitigating the Threats of Invasive Alien Species in the Insular Caribbean, will support work on pathway analysis and spread in the broader region, and other basic ecological research needed to plan lionfish control measures (Appendix 16, Section 5.3). Thus, GEF project 3183 may be better placed to focus regional reporting, including by collaboration with existing efforts such as the USGS NAS (see map over page).

Data from the Caribbean could be made available to the 4-yearly Global Coral Reef Monitoring Network (GCRMN) report on the status of coral reefs.³

¹ See for example, Albins and Hixon (2008) Marine Ecology Progress Series Vol. 367: 233-238 (http://media.eurekaalert.org/aaasnewsroom/MCM/FIL_00000000296/Albins_Hixon_2008_MEPS.pdf); and Syngajewski and Forman-Orth (2004) <http://home.comcast.net/~cihuapilli/lionfish.pdf>.

² For example, online surveys at [https://www.surveymonkey.com/s.aspx?sm=qn4KufOIFUFg9YbbOLntPA_3d_3d](https://www.surveymonkey.com/s.aspx?sm=qn4KufOIFUFg9YbbOLntPA_3d_3d;); <http://www.reef.org/programs/exotic/report>; and data published at <http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=963>

³ http://www.reefbase.org/resource_center/publication/main.aspx?refid=27173&referrer=GCRMN.



Figure 1. Lionfish sightings as of June 3, 2009. Nonindigenous Aquatic Species (NAS) information resource for the United States Geological Survey.

<http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=963>

While complete eradication of lionfish is extremely unlikely, pilot control projects could identify effective measures to reduce environmental impacts or even achieve “local eradications”. If the pattern of establishment and spread of the species can be characterized through regional data collection it may be possible to identify strategic locations at which to deploy the most successful control measures, such as dispersal points for either or both invasive lionfish species. It may still be possible to prevent invasions of the Gulf of Mexico and South America.

2. Demonstration and control site selection in the Bahamas (GEF project 3729)

If re-invasion of the site is likely based on the analysis of invasion pathways, the pilot project in the Bahamas (GEF project 3729) can only be considered an *ongoing control program* and should not be referred to as eradication, which by definition is time-limited. Unless it can be established that a *local eradication* can be accomplished (e.g. because the site is somehow isolated from the spread of lionfish in the rest of the Atlantic), the objective should be to manage the impacts of the lionfish on the site and the pilot could investigate the effectiveness of control at the site.

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Recommendation B: Establish a pilot project to minimize the impact of lionfish on a demonstration site, with adequate data collection at other site(s) to establish a statistical difference, if any, between the demonstration site and a comparable site or sites not subject to the pilot intervention.

Preliminary work has identified potential areas for the demonstration project (GEF PPG meeting, Nassau, 16 April 2009). The Exuma Cays Land and Sea Park was identified as the most suitable due to: good biological data availability (monitoring of groupers, lobsters, lionfish, conch etc); access to a diver operation; and a substantial area that is buffered from outside influences. The second most suitable site based on the same criteria was South Berry Islands Marine Reserve.

Preliminary recommendation C: Consider using Exuma Cays site for the intervention and South Berry Islands as the main control site (if a large-scale intervention is planned)

In conducting the experiment, it will be critical to collect a range of data, including on factors not obviously associated with lionfish control, to be able to identify and account for confounding factors.

Without knowing the proposed control methods, STAP cannot offer conclusive advice on which sites to use for interventions and controls. The appropriate unit of area for the experiment will depend on the size of the area at which the intervention is hypothesized to work. For example an intervention based on hand-netting or spearing lionfish would operate at a small scale⁴ while an intervention based on restoring populations of predatory fish would operate at a larger scale. Further details of the geography of the Exuma Cays site will be required to inform the pilot project design for the GEF project. Within the Exuma Cays site there are a variety of habitats which potentially offer the opportunity for statistical replication of interventions within the site. If however, as seems likely, the habitats are contiguous and allow for lionfish to move freely between them, the entire area could be considered one site with the South Berry Islands site being the control. If this is the case only one intervention could be piloted. However, if carefully designed, the demonstration could also contribute to understanding the relationship between lionfish population density and impact on the environment. This would help establish the goal for any widespread control measures in terms of how much the lionfish population would need to be reduced to achieve a meaningful reduction in their impact on the environment.

3. Define the negative impact of lionfish that a control measure may be able to reduce

In order to justify a control measure, and determine whether it is successful, there must be an outcome sought beyond reducing or eliminating populations of lionfish. Albins and Hixon (2008) established that lionfish can cause significant reductions in the recruitment of native fishes (by 79% over a 5 week experiment). An intervention could address one or more actual or possible negative impacts of lionfish including:

- a. Direct predation on a range of fish species and sizes
- b. Competition for food with native predatory fish species
- c. Overcrowding of native fish populations
- d. Cascading impacts through the food chain
- e. Reduced value of invaded reefs for recreational diving
- f. Injury of divers and swimmers by poisonous spines
- g. Reduced economic returns from commercial fisheries.

⁴ e.g. Albins and Hixon (2008) undertook an experiment at the scale of relatively small reefs within the 200 km × 70 km Exuma Sound of the Bahamas. They were able to use 10 pairs of like reefs (with lionfish present and absent) to statistically measure impact of lionfish on recruitment of native fishes over a short period of time.

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The pilot projects in the Caribbean should develop a data model to collect information on one or more of these, and/or other potential or actual impacts. Like the presence-absence data recommended at 1, it should be scalable to the regional level. For example, a pilot study may be able to collect data on a range of prey species but for regional analysis this information may be scaled up by grouping it into categories such as size classes or other ecologically significant groups.

Recommendation D: Establish a theory of environmental impact of lionfish that can be expressed in terms of a measurable impact or set of impacts that a control measure could reduce, if effective.

This stage should also identify alternative factors likely to influence the impact of lionfish, which may include, for example, overfishing, climate change impacts or pollution. The pilot intervention design should be able to statistically separate out the change in impact resulting from change in lionfish population from other factors.

4. Selection of a control measure (intervention)

A number of possible control measures or interventions may be possible including:

- A) Recovering and maintaining populations of native predators of lionfish which may include sharks and large grouper (Albins and Hixon 2008, A. Maljković et al. 2008⁵) predating on larger lionfish and other species predating on eggs and larvae of lionfish
- B) Reducing fishing pressure on native fish at similar trophic levels as the lionfish
- C) Biological control (no options reported)
- D) Kill lionfish that are easily visible and identifiable, i.e. large juveniles and adults through:
 - i) Payment of local community members to kill lionfish (e.g. by spearing or hand-netting)
 - ii) Payment or encouragement of recreational dive operators to kill lionfish
- E) Control the aquarium trade in lionfish throughout Central and North America
- F) Encourage commercial use such as fishing for human consumption or harvest of live lionfish for the aquarium trade.

Option A is the most likely to be effective over the wide range of the invasion. However, it may not always be possible and for strategic interventions as discussed at 1 above, a more intensive control measure may be required and should be included within the pilot projects, at least as one option.

Commercial use (Option F) may have some effect but any systematic approach to encouraging it must be very carefully implemented and monitored to avoid creating incentives for people to intentionally spread lionfish or replenish their populations.

Any system of payment for killing lionfish must be designed so that it does not resemble a “bounty system” whereby people derive ongoing income from presenting evidence of the number of lionfish they have killed. Bounty systems have the potential to encourage people to intentionally spread lionfish or replenish their populations. This would also be problematic if a live harvest trade is established for aquarium collections, option F is not recommended for this reason and because it could increase the potential for unintentional reintroductions.

⁵ Anecdotal evidence provided by fishers suggests that native grouper species prey on red lionfish with some regularity <http://www.springerlink.com/content/t4177q71283p0t67/>.

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Control of lionfish in aquaria may have long term benefits but will not address the problem of reproductive populations of lionfish already established in the Atlantic. In-water control of lionfish will still be effective if the propagule pressure from aquaria releases is minor or insignificant compared to reproduction in the ocean. If the oceanic population is only sustained by repeated releases from aquaria (which seems unlikely) then interventions should focus only on aquaria.

Recommendation E: Establish a control measure for the intervention site based on a systematic approach to killing lionfish.

The approach will depend on the methodology. While it is preferably that the local community be engaged in the control efforts it may be that the skills and equipment required precludes this. For example if removal by hand-netting by SCUBA divers is required, it may be more effective for the pilot study to engage local dive operators (at least one apparently works at the Exuma Cays site).

Lessons may be learnt from other efforts to control marine invasive species such as the crown of thorn starfish. Collectors of lionfish for aquaria may be able to advise on the most effective methods.

5. Design of the Bahamas pilot project (within GEF project 3729)

Data likely to be required include:

- A) Lionfish population census at the start of project and then at intervals
 - i) Intervals will depend on the life cycle of the lionfish
 - ii) Methods for determining lionfish abundance include SCUBA diver visual transect surveys⁶.
- B) Populations of key predator species (e.g. tiger grouper, *Mycteroperca tigris*⁷) and prey species to be determined based on part 3 above.
- C) Information on other potentially confounding factors, including:
 - i) Fishing pressure
 - ii) Climate change
 - iii) Pollution.

This section can only be developed when further site-specific information is available. The overall project design may include a number of paired sites or a simple comparison of two large areas, as discussed under section 2.

Other references (not footnoted)

Whitfield et al (2002) <http://www.int-res.com/articles/meps2002/235/m235p289.pdf>
The Lionfish Invasion! (n.d.) http://oceanservice.noaa.gov/education/stories/lionfish/lion02_inva.html
Syngajewski and Forman-Orth (2004) <http://home.comcast.net/~cihuapilli/lionfish.pdf>

⁶ See <http://www.springerlink.com/content/m702344177gg7005/>.

⁷ A. Maljković et al. 2008, <http://www.springerlink.com/content/t4177q71283p0t67/>.