



## Lionfish Response Plan

### *A Systematic Approach to Managing Impacts from the Lionfish, an Invasive Species, in Units of the National Park System*

Natural Resource Report NPS/NRSS/WRD/NRR—2012/497



**ON THE COVER**  
Lionfish (*Pterois volitans*)  
NPS Photo

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# Executive Summary

## Risks and Challenges of the Lionfish Invasion

The exotic red lionfish (*Pterois volitans*) is a venomous predatory fish native to the Indian and Pacific oceans and first observed in South Florida in the 1980s. The recent rapid expansion of the lionfish invasion throughout the southeastern Atlantic seaboard, the Caribbean and parts of the Gulf of Mexico is of great concern to the National Park Service and other marine resource managers. Lionfish are voracious predators of fish and invertebrates capable of removing tremendous amounts of prey and causing ecological impacts to coral reefs and other habitats, which are already stressed by coral bleaching, fishing pressure, pollution and other impacts. Lionfish also present risks of stings from their venomous spines to visitors and employees. Their rapid expansion threatens the very resources and values that parks were established to protect, and diminishes the quality of visitor experience for anglers, divers, snorkelers and other visitors.

The lionfish invasion is emblematic of the complex challenge of managing invasive species that originate from outside park boundaries. In addition, little information on lionfish biology, ecology and control was available prior to the invasion of marine areas where parks are located, and much of what has been learned so far in their invaded range is new information. In September 2011, the National Park Service held a workshop to bring together park resource managers, scientists, and nongovernmental organizations with experience in lionfish biology and control, to assist with developing a Service-wide Lionfish Response Plan with a practical management approach to the lionfish problem.

## Purpose and Scope of the Response Plan

The purpose of this plan is to guide the NPS and its partners in adequately addressing the invasion of the lionfish in the marine waters of National Park System units in the Caribbean, the Gulf of Mexico and the east coast of the United States. The plan describes Service-wide approaches for lionfish management and then guides park managers and staff in developing site-based plans specific to individual park units and conditions. Specific actions to prevent or mitigate resource impacts, to protect health and safety and to communicate the story of the lionfish invasion to partners, cooperators and the public are described. While this plan specifically applies to the waters, resources and visitors of the units of the National Park System, the plan recognizes that close coordination and cooperation with other agencies and organizations is essential for success.

## Prevent or Mitigate for Lionfish Impacts on Park Resources

This response plan advocates an aggressive approach to monitor and suppress lionfish invasions. Although they can be flexibly applied to suit the particular habitats and logistical considerations of individual parks, all of these elements need to be addressed for the lionfish response strategy to be effective:

- Prioritize park areas and natural and cultural resources for lionfish control.
- Set control targets for reducing lionfish populations.
- Detect and report the presence of lionfish, and utilize available tools and internal and external resources for their removal.
- Monitor lionfish populations and native species, and consider potential ecological impacts.

- Apply adaptive management approaches for learning from lionfish response efforts and adjusting lionfish monitoring and management efforts.

### **Protect Health and Safety of Visitors, Staff, Partners and Contractors**

Similarly, the response plan provides a structure for assessing risks and mitigating hazards to employees and the public, including the following:

#### ***Staff Strategies:***

- Use Operational Leadership concepts and tools to manage response actions.
- Ensure compliance with NPS policies and procedures regarding safe work practices for employees handling wildlife (RM 50B, NPS Occupational and Health Program, section 4.15).
- Ensure compliance with NPS policies and procedures regarding safe work practices for employees diving (RM 4, Dive Program).
- Ensure compliance with NPS policies and procedures regarding safe work practices for employees handling boats (DM 485, Small Craft Operations).
- Analyze the hazards associated with lionfish management tools and develop safe protocols for their use.
- Provide training and handouts that allow staff and volunteers to understand the hazards associated with lionfish management and perform management activities safely.
- Develop and provide specialized sting response advice and training for park EMS/first responder staff and selected partners.

#### ***Visitor-Use Strategies:***

- Ensure compliance with NPS policies and procedures regarding public risk management (DO 50C, NPS Public Risk Management).
- Train visitor contact staff and volunteers to assist visitors in identifying lionfish, recognizing the hazards of lionfish and avoiding envenomation.
- Integrate lionfish safety messages into the underwater hazard safety program, using media releases, signs and exhibits, publications and programs, as needed.

### **Inform the Public**

The response plan also includes actions to communicate and interpret the significance and implications of the lionfish invasion, so park audiences will appreciate the need for—and methods of—lionfish reporting and removal:

- Communicate impacts of the lionfish invasion to all park audiences through interpretation.
- Communicate the purpose and results of this planning process as a part of the communication program.
- Create an active public--across a variety of stakeholder groups—that responds to the invasion of lionfish.
- Use the introduction and expansion of invasive species, such as lionfish, as a case study to cultivate a responsible stewardship ethic.
- Ensure information sharing across relevant parks and all divisions while educating audiences about lionfish.

## **Moving Forward**

The National Park Service must implement this plan as soon as possible to address the severity and scale of the lionfish invasion, by assessing the presence of lionfish and safely removing them in targeted park areas. NPS should develop funding and organizational capacity for park-level response plans to be fully operational no later than 2013. Observations gained from monitoring and management during these initial response efforts should yield valuable information to support research and adaptive management. In addition, NPS should pursue partnerships to accomplish lionfish control, research and outreach needs, with state and federal agencies, non-governmental organizations, foundations, universities, volunteers, and other sources.

Finally, the challenges from aquatic nuisance species (ANS) argue for a more consistent and sustained response generally from NPS. Lionfish are not the first ANS to threaten parks. Resource managers have been contending with the damaging effects from a multitude of exotic fish and invertebrates for many years in freshwater and marine environments. Aquatic resources in parks are no less vulnerable than terrestrial ecosystems to invasive species and require NPS to sharpen its focus on the profound ecological impacts of ANS.

## Glossary

**Adult** – a stage in the life history of an organism during which reproduction occurs

**Barrier reef** - a coral reef that parallels the shore but is separated from the landmass by open water

**Biodiversity** - means the variety of life and its processes

**Community** - an association of living organisms that have mutual relationships among themselves and to their environment and thus function, to some degree, as an ecological unit

**Dispersal** – the spread of a species, population, or individuals over time

**Ecology** – the study of the relationship among organisms and between organisms and their environment

**Ecosystem** – ecological communities together with their physical environment

**Environment** – the physical and biological conditions that surround an organism or a group of organisms

**Environmental stewardship** - responsible use and protection of the natural environment, through conservation and sustainable practices.

**Envenomation** – the process by which venom is injected from a venom gland into the recipient

**Exotic species** – those species that occupy or could occupy park lands directly or indirectly as the result of deliberate or accidental human activities

**Hardbottom communities** – Sea bottom consisting of a hard substrate such as rock, coral or carbonate platforms.

**Introduction** – the intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity.

**Invasive species** – an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health

**Juvenile** - a sexually immature organism

**Overfishing** – human harvesting of a fish population to the extent the fish population can no longer replenish itself

**Soft bottom:** Sea bottom consisting of sediments such as mud or sand; includes seagrass communities.

**Stressor** – environmental factors that cause negative impacts to biota and ecosystems. In the coastal and marine context, includes: pollution, invasive species, climate change, extreme events, and land and resource use

**Trophic level** - An organism's position in a food chain.

## **Acronyms**

ACETA – Aerial Capture, Eradication, and Tagging of Animals

ANS – Aquatic Nuisance Species

BISC – Biscayne National Park

BMP – Best Management Practices

BPM – Best Practices Manual

BUIS – Buck Island Reef National Monument

CANA – Canaveral National Seashore

CFP – Ciguatera Fish Poisoning

CORE – Caribbean Oceanic Restoration and Education Foundation

CPUE – Catch Per Unit Effort

DRTO – Dry Tortugas National Park

ECISMA – Everglades Cooperative Invasive Species Management Area

EVER – Everglades National Park

FDA – Food and Drug Administration

GUIS – Gulf Island National Seashore

JHA – Job Hazard Analysis

MSDS – Material Safety Data Sheets

NAS – Nonindigenous Aquatic Species

NEPA – National Environmental Policy Act

NGO – Non-governmental Organization

NOAA – National Oceanic and Atmospheric Administration

NPS – National Park Service

OSHA – Occupational Safety and Health Administration

PPE – Personal Protective Equipment

REEF – Reef Environmental Education Foundation

SCUBA – Self Contained Underwater Breathing Apparatus

USGS – United States Geological Survey

USGS – United States Geological Survey

VICR – Virgin Islands Coral Reef National Monument

VIIS – Virgin Islands National Park



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# Introduction

## Background

The lionfish is a venomous predatory fish native to the Indo-Pacific waters that was introduced into Atlantic waters as early as the 1980s. Lionfish have the potential to impact both National Park Service (NPS) marine ecosystems and visitor experiences. Preliminary evidence suggests that the proliferation of lionfish may diminish native species and, subsequently, change ecological community composition and function. For example, invasive lionfish severely reduce the abundance of small native reef fishes (including juveniles of fisheries species and ecologically important species). This key fact was first documented empirically by field experiments in the Bahamas where it was demonstrated that a single lionfish can reduce the net recruitment of fish (<5 cm total length [TL]) to a small coral patch reef by about 80% in only five weeks. Field experiments in the Bahamas indicate a reduction in over 93% of recruitment and loss of nearly five species surviving on small patch reefs in the presence of lionfish over eight weeks (Albins and Hixon 2008). Changes in the natural community not only effects ecosystem but the visitor experience. Lionfish stings are painful and occasionally serious, resulting in unpleasant visitor experiences and potential employee injuries.

The lionfish is currently the only known marine invasive fish recognized to have established itself throughout the Caribbean and the coastal waters of the southeastern United States. Management and control may require novel approaches and will require close coordination across jurisdictional boundaries.

## Purpose and Scope of the Plan

### *Purpose*

The purpose of this plan is to guide the NPS and its partners in adequately addressing the invasion of the lionfish in the marine waters of National Park System units in the Caribbean, the Gulf of Mexico and the east coast of the United States. This plan is the guiding document for protecting the resources and visitor experiences in these units.

### *Scope*

While this plan specifically applies to the waters, resources and visitors of the units of the National Park System, the plan recognizes that close coordination and cooperation with other agencies and organizations is essential for success.

## Objectives and Strategies

The following are the overall objectives and strategies for responding to the lionfish invasion in units of the National Park System:

1. Prevent and mitigate for lionfish impacts on NPS marine and estuarine resources.

### *Strategies*

- Assess lionfish and resource status.
- Use the best available science to develop and implement lionfish management options and protocols for prioritizing resources and areas for management emphasis.

- Conduct continuing evaluations of lionfish status, resource status and management techniques; use adaptive management concepts to improve management.

2. Protect the health and safety of visitors, staff, partners and contractors.

#### *Staff Strategies*

- Use Operational Leadership<sup>1</sup> concepts and tools to manage response actions.
- Ensure compliance with NPS policies and procedures regarding safe work practices for employees handling wildlife (RM 50B, NPS Occupational and Health Program, section 4.15).
- Ensure compliance with NPS policies<sup>2</sup> and procedures regarding safe work practices for employees diving (RM 4, Dive Program).
- Ensure compliance with NPS policies and procedures regarding safe work practices for employees handling boats (DM 485<sup>3</sup>, Small Craft Operations).
- Analyze the hazards associated with lionfish management tools and develop safe protocols for their use.
- Provide training and handouts that allow staff and volunteers to understand the hazards associated with lionfish management and perform management activities safely.
- Develop and provide specialized sting response advice and training for park EMS/first responder staff and selected partners.

#### *Visitor-use Strategies*

- Ensure compliance with NPS policies and procedures regarding public risk management (DO 50C, NPS Public Risk Management).
- Train visitor contact staff and volunteers to assist visitors in identifying lionfish, recognizing the hazards of lionfish and avoiding envenomation.
- Integrate lionfish safety messages into the underwater hazard safety program, using media releases, signs and exhibits, publications and programs, as needed.

3. Interpret the significance and implications of the lionfish invasion so park audiences (described in Table 2 on page 38) will appreciate the need for, and methods of, their reporting and removal.

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<sup>1</sup> Available at: <http://inside.nps.gov/waso/waso.cfm?lv=3&prg=892> (accessed February 24, 2012)

<sup>2</sup> NPS policies, Director's Orders, and Reference Manuals (RM) are available at: <http://www.nps.gov/applications/npspolicy/index.cfm>; accessed February 24, 2012

<sup>3</sup> Departmental Manual (DM) 485 is available at: <http://inside.nps.gov/waso/custommenu.cfm?lv=3&prg=953&id=8707>; accessed February 24, 2012.

### *Outreach Strategies*

- Communicate impacts of the lionfish invasion to all park audiences through interpretation.
- Communicate the purpose and results of this planning process as a part of the communication program.
- Create an active public—across a variety of stakeholder groups—that responds to the invasion of lionfish.
- Use the introduction and expansion of invasive species, such as lionfish, as a case study to cultivate a responsible stewardship ethic.
- Ensure information sharing across relevant parks and all divisions while educating audiences about lionfish.

### **Compliance Considerations**

The National Environmental Policy Act of 1969 (NEPA) and the Council on Environmental Quality's implementing regulations at Title 40 Code of Federal Regulations (CFR) 1500-1508 mandate that federal agencies prepare an in-depth study of the impacts of "major federal actions having a significant effect on the environment" and alternatives to those actions. NPS Director's Order 12 (DO-12): Conservation Planning, Environmental Impact Analysis and Decision-Making sets forth the policy and procedures by which the NPS will comply with NEPA. Section 7.2.A of the DO-12 Handbook states: "Before an on-the-ground" action (e.g., grading a trail, building a campground) can be taken, there must be site-specific environmental information available to a decision-maker in the form of a NEPA document." In addition, 2006 *NPS Management Policies* Chapter 4, Natural Resource Management provides policies and planning mechanisms to protect and mitigate park resources from potential damage caused by exotic species.

Parks will need to complete an Environmental Screening Form and follow the procedures outlined in the DO-12 Handbook to determine the appropriate level of NEPA review and documentation for implementing this Lionfish Response Plan and preparing a park-specific plan. Parks should consult with their Regional Environmental Coordinator regarding the appropriate approach to environmental compliance.



# Situational Analysis

## Lionfish Situation in the Region

The introduction of the Indo-Pacific red lionfish (*Pterois volitans*) and devil firefish (*P. miles*) (Scorpaenidae, order Scorpaeniformes) into the western North Atlantic, has resulted in a rapid rate of establishment. Lionfish were first reported in the 1980s along south Florida and have now spread along the southeast United States, well into the Caribbean and parts of the Gulf of Mexico. The eventual distribution of lionfish is likely to be restricted by thermal tolerance but will ultimately include the entire Gulf of Mexico, the entire Caribbean, as far north as the temperate regions of the east coast of North America, and as far south as Uruguay on the east coast of South America. Lionfish are considered invasive and they may have devastating impacts to native reef fish communities and to human health. Prior to the introduction of lionfish, little information on their biology and ecology was available. As a result, much of what has been learned about lionfish in their invaded range is new information for the species or genus.

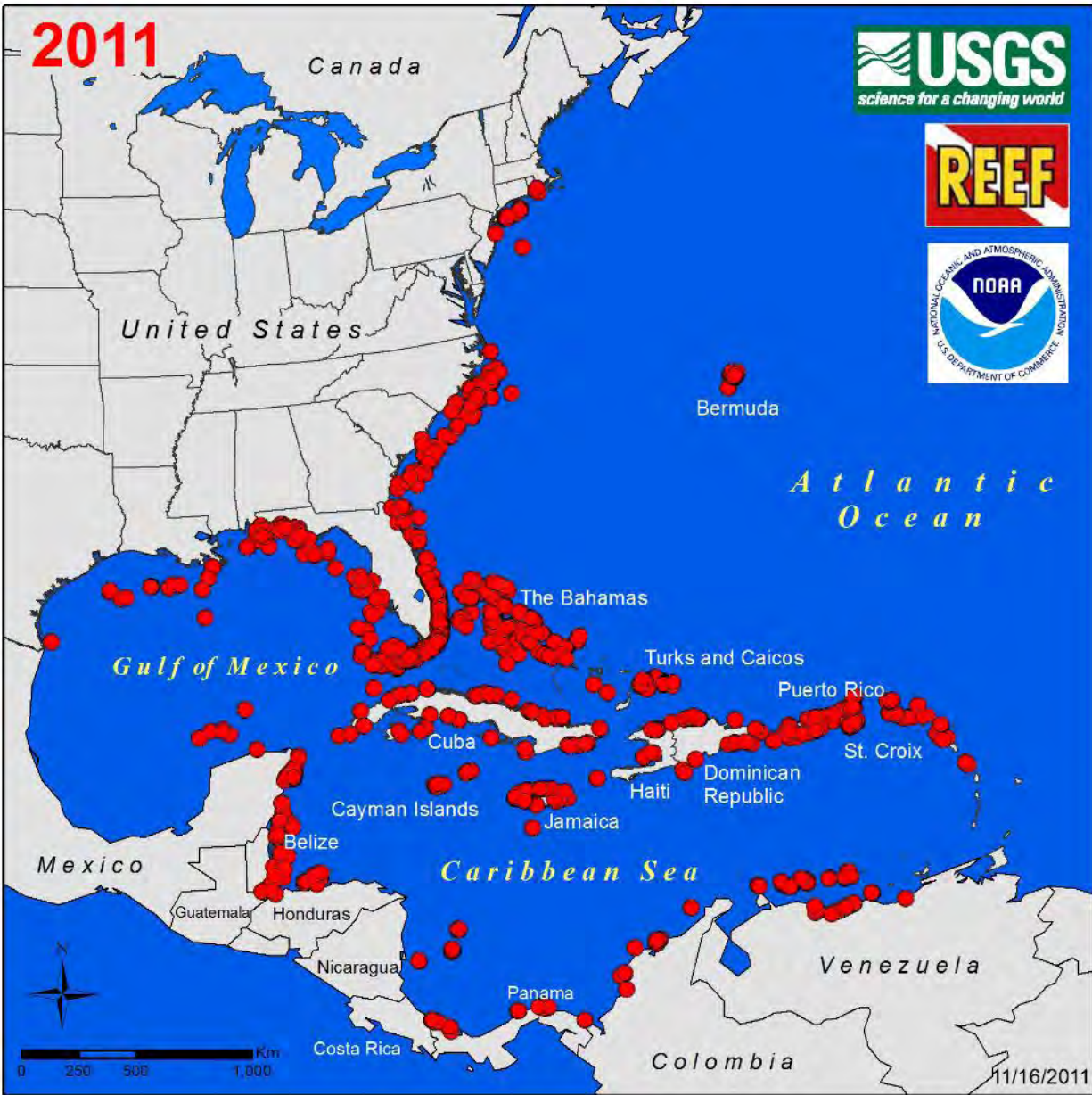
## Potential Sources of the Lionfish Introduction

The number of lionfish reported from 1985 to 2000 in south Florida provides strong evidence that the Atlantic coast of southern Florida could have been the location of the first introduction(s). South Florida is a known “hot-spot” for other marine introductions with over 30 species of non-indigenous marine and estuarine fish reported within the last decade. Lionfish are popular ornamental fish that are heavily-imported into the United States for the aquarium trade. Lionfish have been reported as one of the top-ten most valuable marine fish imported into the U.S. (7,562 were imported in six months through the Tampa airport in 2003).

Molecular genetic analysis comparing samples from the southeastern U.S., the Bahamas, Indonesia and the Philippines, suggests that the introduced lionfish originated from Indonesia, a common origin for many lionfish imported into the United States. Additionally, there is no significant difference between Bahamian and southeastern U.S. lionfish specimens despite relatively high levels of genetic variation within the Indonesian population. To this end, either a single stock of lionfish from Indonesia was the source responsible for multiple lionfish invasions, or lionfish spread following the founding of a single population in their nonindigenous habitat. The most parsimonious explanation, based on the genetic similarity among invaded sites, combined with the invasion lag time (2000 NC, 2004 Bahamas), is that the initial source location of the lionfish introduction is the Florida Atlantic coast (Morris and Whitfield, 2009).

## Lionfish Density and Distribution

The first verified lionfish report was from the Atlantic coast of southeast Florida in 1985. Sporadic sightings and collections occurred in South Florida from that time until 2000 and 2001 when NOAA researchers documented multiple lionfish off the coast of North Carolina, South Carolina, Georgia, Florida and Bermuda. Over the next two years, lionfish densities and reports off the southeastern U.S. continental shelf continued to increase because of larval dispersal on ocean currents. In 2004, lionfish were first detected in the Bahamas and have since increased their range throughout much of the Caribbean and Gulf of Mexico. While lionfish have been observed as far north as Massachusetts and Rhode Island, Cape Hatteras represents the northern limit for year-round occupation (Figure 1).



**Figure 1.** Lionfish observations, 2011 ( U.S. Geological Survey, <http://nas2.er.usgs.gov/viewer/omap.aspx?SpeciesID=963>; accessed February 24, 2012).

The first estimates of lionfish densities in the Atlantic were documented at a mean of 21 lionfish per hectare across 17 locations off North Carolina in 2004. By 2008, mean lionfish densities were approximately 150 lionfish per hectare with some sites exhibiting nearly 350 lionfish per hectare. Similar high densities of lionfish have been reported in the Bahamas. These results suggest that lionfish are thriving in both the warm temperate and subtropical reaches of the Atlantic. Lionfish densities in invaded waters appear orders of magnitude higher than observed in their native range.



Factors controlling lionfish densities in their Indo-Pacific native range are unknown. Lionfish are reported to have few natural predators, likely due to their venomous spines. Native black sea basses (*Centropristis striata*) in the Atlantic avoided lionfish as prey in laboratory experiments (Morris and Whitfield, 2009). However, three grouper individuals in the Bahamas had lionfish in their stomachs. It is uncertain at present if groupers or any other reef predators will feed regularly on lionfish, or if mortality from natural predators is capable of significantly reducing the lionfish population.

### **Genetics and Taxonomy**

Two species of lionfish, *Pterois miles* and *P. volitans* were introduced into the Atlantic. In their native range, *P. miles* are distributed in the Red Sea, Persian Gulf, and the Indian Ocean (excluding Western Australia). *P. volitans* are observed in both the Western and Central Pacific as well as Western Australia. At the margins of their native range, *P. miles* and *P. volitans* are distinguishable by meristics (*P. volitans* exhibits one additional dorsal and anal fin ray). Overlapping meristics are common in regions co-occupied by both species making their identification to species difficult without genetic analysis. Recent assessments have confirmed that lionfish in the Atlantic have low genetic diversity, typical for invasive species in the early stages of the introduction.

### **Reproductive Biology**

Lionfish are gonochoristic (individuals are either male or female; e.g., no hermaphrodites) pair spawners that exhibit a complex courtship prior to spawn release. In their native range, lionfish courtship occurs shortly before dark and may extend well into the nighttime hours. Towards the end of the courtship, the female ascends toward the surface and releases two buoyant egg masses, one from each ovarian lobe. Each egg mass can contain 12,000-15,000 eggs. Lionfish spawn throughout the year at a frequency of approximately every four days in North Carolina and the Bahamas. This spawning frequency equates to an annual fecundity of over two million eggs. Lionfish females mature around 180 mm total length, while male lionfish mature at approximately 100 mm total length. Based on unvalidated estimates of daily age using otoliths, lionfish are capable of becoming sexually mature within their first year of life.

### **Early Life History and Larval Dispersal**

Lionfish embryos develop into larvae at the ocean surface within the gelatinous egg mass. Lionfish larvae are classified among an unresolved “morph B” morphotype for scorpaenid larvae. This morphotype is distinguishable by a large head, long triangular snout, serrated head spines, large pelvic spine, and pigmented pectoral fins. At hatching, pteroinae larvae are approximately 1.5 mm. Recent assessments of the lionfish larval duration suggest that settlement occurs around 26 days post hatch, a pelagic larval duration that facilitates dispersal via oceanographic currents (i.e., Gulf Stream, Gulf of Mexico loop current, Caribbean current) throughout the southeastern U.S., Gulf of Mexico and Caribbean. The specific larval duration of lionfish is likely to vary depending on factors such as temperature.

### **Venom Defense**

Lionfish dorsal, ventral, and anal spines are venomous. The lionfish venom apparatus consists of two glandular grooves extending from the base of the spine three quarter distance towards the tip. The apocrine-type glands secrete venom when the tissue is disturbed, typically the result of the end of the spine entering the victim. This penetration pushes the spine integumentary sheath

ventrally, exposing and tearing the glandular tissue and releasing the venom. Lionfish venom is composed of acetylcholine and a neurotoxin that causes pain and other physiological problems in humans. Lionfish stings in humans can be treated. First aid treatment includes use of heat and more severe cases can be treated with antivenom from the closely related stonefish (*Synanceia* spp.). Lionfish venom defense as a predation deterrent is not well understood. Lionfish venom can kill other fish species; however, anecdotal observations suggest that this is rare.

### ***Feeding Ecology***

Adult lionfish in the Bahamas feed on more than 60 species of prey fishes as well as a variety of invertebrates. Fish prey include small bodied reef fishes as well as juveniles of larger bodied species. Lionfish are capable of withstanding long periods of fasting, which may be explained by their low metabolism, large volumes of visceral fat and the ability of their stomach to expand over 30 times the initial volume. This characteristic has been observed in the Atlantic, where lionfish have been collected with over 20 haemulids in the stomach.

### ***Values at Risk***

#### Natural Resources

The expansion of lionfish throughout the region is of great concern. Invaded habitats are already under stress from environmental and anthropogenic factors including coral bleaching, fishing pressure, pollution, global climate change, and disruptive algal growth. The addition of a non-indigenous, predatory reef fish along with the existing stressors could cause irreversible changes in these systems. Probable impacts include a reduction of forage fish biomass, possible phase shifts increasing algal growth from herbivore removal by lionfish, and active competition with native reef fish. Lionfish are becoming an influential predator known to impact prey community structure. This influence could cause cascading trophic impacts on ecologically important species and result in niche takeover by lionfish. Recent visual census surveys indicate that lionfish at their present densities are capable of removing a tremendous amount of forage fish biomass produced in some reef systems. Future monitoring of lionfish diets could indicate prey switching whereby more crustaceans enter their diet as forage fish abundance declines. Lionfish are piscivores and invertivores, thus competing with native predatory fish for prey fish resources. The Snapper-Grouper Complex (i.e., snappers, groupers, porgies, triggerfish, jacks, tilefishes, grunts, spadefishes, wrasses, and sea basses) is heavily exploited by commercial and recreational fisheries hypothetically resulting in niche vacancy in the reef fish community. Any future occupation of this hypothesized vacated niche by lionfish could be problematic for stock rebuilding programs or restoring native fish communities in park ecosystems.

#### Visitor Experience

Increased lionfish densities may negatively affect visitor experiences through direct and indirect impacts. As lionfish populations increase, the risk of human/lionfish encounters will increase with potentially higher impacts to visitor safety. Direct effects on divers and snorkelers include potential envenomations, reduced opportunities to observe abundant marine life and pristine habitats and restricted access to areas with high lionfish densities. Bathers may be affected by encounters with lionfish in nearshore areas where envenomation could occur. Lionfish affinity for artificial structure could result in decreased access and enjoyment of submerged cultural resources. Indirect effects of lionfish include the overall reduction of biodiversity and the health of marine systems, resulting in reduced aesthetic values. This reduction in biodiversity and health could also result in the potential reduction of recreational fish landings.

References: Material modified from Morris and Whitfield (2009) and the Biscayne National Park *Lionfish Rapid Response and Early Detection Plan*.

## **Lionfish Situation and Management in Parks**

Parks with marine resources on the eastern seaboard of the United States, the Caribbean and Gulf of Mexico have varied experiences with the lionfish invasion and its management. This section lists those parks that are likely to be impacted by lionfish and their status as of the date of this report.

### ***Biscayne National Park***

#### Park Resources

Biscayne National Park was set aside to protect outstanding natural and cultural resources nestled within a semi-tropical marine environment of Northern Key Largo. Nearly 95% of the park's acreage lies below the ocean, preserving the northernmost stretch of the third-largest living barrier reef tract in the world. In addition, the park also protects the associated barrier islands of the northernmost Florida Keys, stretches of productive mangrove shoreline, and an estuary of national significance—Biscayne Bay. A variety of threatened and endangered marine life can be encountered within this inshore complex, including sea turtles, marine mammals, and colonies of federally listed staghorn and elkhorn corals. The park also serves as a repository for an outstanding collection of submerged cultural resources that chronicles the area's maritime history.

#### Visitor Experience

Biscayne National Park receives over 500,000 visitors per year. The park maintains one visitor contact station on the mainland, which caters primarily to day visitors and serves as the point of departure for year-round organized boat tours to the islands, as well as snorkel and dive excursions to the reef. Significant visitation occurs through the use of private vessels originating from the areas of Miami and the northern Florida Keys. Visitor use within the park is varied, with many people visiting park islands and shallows purely for cruising and swimming. Others fish the flats or venture beyond the barrier islands in search of fish that inhabit the reef and originate in the protected mangrove shoreline and seagrass beds of the bay. The park's natural and artificial reefs are particularly popular with divers and snorkelers, as they are some of those most accessible from major urban centers.

#### Current Management Efforts

The first lionfish documented by staff in Biscayne National Park was observed in June of 2009, with no subsequent sightings until May of 2010. Thereafter, sightings became far more frequent and distributed spatially. The park implemented a site-specific lionfish management plan formulated in 2008 in anticipation of a future appearance of lionfish. Per the plan, the Resource Management Division has utilized the services of employees furnished by the American Conservation Experience program to respond to visitor reports, assess lionfish distribution, conduct gut content analysis, and facilitate routine monitoring and removal. The park partners with research agencies to conduct original research that answers key management questions. Nearly 900 lionfish have been removed throughout the park from both the bay and offshore reefs, and significant concentrations have been observed around artificial structures and in deeper waters along the parks boundary.

## ***Buck Island Reef National Monument***

### Park Resources

Buck Island Reef protects roughly 20,000 acres of primarily marine environments comprised primarily of deep water environments, hardbottom communities, and softbottom seagrass beds and algae plains in the U.S. Virgin Islands. The national monument is home to resident and migratory populations of birds, marine mammals, and sea turtles. Buck Island, a small island of only 176 acres, is ringed by a living barrier reef that provides critical habitat for colonies of federally-listed elkhorn and staghorn corals. Additional marine species of special management concern appear occasionally within the monument.

### Visitor Experience

Buck Island Reef receives approximately 40,000 visitors a year, with peak visitation occurring during the winter months. In addition to some terrestrial opportunities on Buck Island, the bulk of visitor activity occurs at two main areas of the monument. Concession operations facilitate access for primarily off-island visitors to snorkel a popular underwater trail on the island's eastern side. The western side of the island provides a temporary anchorage utilized primarily for island residents as a popular gathering spot.

Consumptive uses are not permitted within the monument, thus no fishing or collection occurs. With the exception of the temporary anchorage area, the use of anchors is also expressly forbidden. Consequently diving—which is a permitted visitor activity—is typically concentrated around one particular site within the monument that is serviced by a concessionaire.

### Current Management Efforts

The first documented lionfish sighting on St. Croix occurred in 2009. Subsequently, lionfish were first observed at Buck Island Reef in 2010. That same year, park personnel contracted with a local dive shop to organize surveys of the monument's hardbottom community and remove lionfish observed. The program was extended for a second year and, to date, has resulted in the physical removal of several dozen lionfish from the waters of the national monument. Park personnel also work with partners conducting ongoing research in the monument to report lionfish sightings and/or remove individuals as appropriate. Park personnel have also worked alongside conservation partners to create a lionfish management plan for St. Croix and U.S. Virgin Island waters.

## ***Canaveral National Seashore***

### Park Resources

Canaveral National Seashore was established to protect the outstanding natural, scenic, scientific, ecologic and historic values of a classic barrier island ecosystem between Florida's Volusia and Brevard counties. It protects a diverse array of upland, coastal, and barrier island communities including pine flatwoods, coastal strand, salt marsh, mangrove forest, and beach dunes. The centerpiece of the seashore is Mosquito Lagoon, a 40,000-acre expanse of shallow-water seagrass flats. The northern reaches of the lagoon are notable for boasting both an intricate complex of islands and some of the healthiest oyster reefs in the southeast. Because the lagoon receives very little freshwater influx, it retains high salinities that support the spawning and growth of residential populations of commercially, recreationally, and ecologically important species. This productive nursery provides forage vital to the nesting success of numerous resident and migratory wading birds. The park provides habitat to a variety of federally-listed

threatened and endangered species, including the Atlantic salt marsh snake and several thousand juvenile sea turtles.

### Visitor Experience

Canaveral National Seashore receives approximately 800,000 visitors annually, mostly from local communities. Though the peak visitor season occurs in the warm summer months, the seashore is popular year-round thanks to the seasonal influx of visitors from the north. Visitor activity is primarily day-use and centers around beach activities, including swimming, surfing, and surf fishing. Fishing guides also ply the waters of the lagoon with visitors looking to land redfish, spotted seatrout, black drum, or snook. Visitors occasionally access backcountry areas of Mosquito Lagoon via kayaks and canoes, often to enjoy overnight stays at designated backcountry campsites. Access to park waters is almost exclusively through private vessels, and navigation is subject to compliance with designated pole and troll zones. Some commercial harvesting also occurs within the confines of the lagoon, including clamming, oystering, crabbing, and some finfish extraction.

### Current Management Efforts

Park personnel are not aware of any lionfish observed in the waters of Canaveral National Seashore, although the park is within their current range. However, park staff are actively working alongside other units on a service-wide response plan to apply in the park should invasion occur. Furthermore, park staff are working alongside state and federal authorities—particularly those that administer nearby lands—in formulating plans for monitoring, reporting, and early detection.

## ***Dry Tortugas National Park***

### Park Resources

Dry Tortugas National Park protects approximately 100 square miles of a mature subtropical marine ecosystem. There are seven islands that are composed of sand, limestone, and coral reef rubble, surrounded by brilliant blue water, shoals, and abundant, intact coral reef communities. Over 99% of the park consists of marine waters. In February 2007, the park established a Research Natural Area, which is a 46-square-mile marine reserve designed to study the ecological integrity and capacity for self-renewal by minimizing the impacts of human disturbance. Dry Tortugas also has a coral special protection zone that provides important habitat for communities of federally-listed elkhorn and staghorn corals.

### Visitor Experience

Visitation to Dry Tortugas National Park is almost exclusively through concession ferries or seaplanes that transport visitors to the islands for day-long tours. Typically, these excursions involve guided tours of Fort Jefferson and afternoon opportunities to snorkel patch reefs just off the island. A small percentage of these visitors may also elect to stay overnight at a small campground on Garden Key. Access to park waters beyond Garden Key typically requires a private vessel, and relatively few are willing to make the distant journey to the park. Snorkeling and diving are permitted throughout the park, though anchoring is not permitted within the RNA. Similarly, fishing is only allowed outside of the RNA.

### Current Management Efforts

The first lionfish reported in Dry Tortugas National Park was observed in October of 2009. In 2010, park staff reported a total of fourteen lionfish captures. Today, lionfish can be found on nearly every dive and snorkel site in the park. To date, park staff and cooperators have removed approximately 275 fish. This indicates that they are becoming established in the park. The Everglades and Dry Tortugas lionfish management plan is expected to be published early in 2012. The preferred alternative outlined in the plan is to “target specific areas within each park to suppress the invasion of lionfish.” Key areas will be identified in both Florida Bay and the Dry Tortugas where staff will continually survey for and remove lionfish on a regular schedule. This option will work best for both parks as they are limited in both resources and staff. Ongoing removal of lionfish will help preserve these key areas in their natural state, thus affording visitors opportunities to experience the character of park resources prior to invasion by lionfish.

### ***Everglades National Park***

#### Park Resources

Everglades National Park protects important resources of national significance, including the largest subtropical wilderness in the continental United States, the largest protected mangrove forest in the northern hemisphere, and cultural resources chronicling 10,000 years of human occupation in southern Florida. Two-thirds of the park’s total acreage span the shallow, estuarine waters of Florida Bay and the dense maze of tidal creeks and mangrove forests that dominate the southwest coast of Florida. The park protects important habitat for 22 federally-listed threatened and endangered species, many of which rely upon the productive inshore waters of the estuary for forage and nursery habitat.

#### Visitor Experience

The park hosts nearly one million visitors annually, with peak visitation occurring during the mild winter months. The difficulty of access into the park’s terrestrial wilderness limits visitation primarily to day use along park roads and other developed facilities. Park waters, however, are regularly accessed by private vessel among the Ten Thousand Islands and Florida Bay, where fishing is a popular activity. Both areas support productive fisheries and an active network of guides, concessions, and outfitters. Neither the estuarine shallows of the bay, nor the tannin-stained waters of the mangrove forests encourage snorkeling or diving, and little occurs within park boundaries. Commercial fishing—though prohibited within the park—does occur along the southwestern boundary of Everglades.

### Current Management Efforts

In 2010, four lionfish were removed from the waters of Florida Bay near the Arsnicker Keys within the southern boundary of the Everglades National Park. Additional sightings have been reported to the U.S. Geologic Survey National Aquatic Species database. Given the growing abundance of lionfish in nearby waters, and the availability of favorable habitat within the park, it is expected that observations of additional specimens will increase in both number and distribution in Everglades.

## ***Gulf Islands National Seashore***

### Park Resources

Gulf Islands National Seashore protects an assemblage of coastal communities that includes beach dunes, seagrass habitats, oyster reefs, and numerous artificial reef structures along the Gulf of Mexico barrier islands of Florida and Mississippi. The park is largely linear—stretching approximately 160 miles east-west and spanning two states in the northern Gulf of Mexico. Along its approximately 60 miles of shoreline, the park protects waters extending 1 mile offshore and up to 1 mile inshore, with depths up to 45 feet offshore and 15 feet inshore. The park also preserves numerous artifacts chronicling military history, a handful of which occur as submerged cultural resources. A variety of threatened and endangered marine life is encountered along the seashore, including sea turtles, marine mammals, and an imperiled species of goby that occupies tidal creeks within a very limited range.

### Visitor Experience

Visitor access and use within Gulf Islands National Seashore differs between the park's two districts. The beaches of the Florida district attract throngs of visitors annually to bathe in the area's warm, shallow waters. Along the Mississippi district, the unit is most frequently accessed by revelers cruising on personal vessels. In addition to such passive pursuits, business permit holders with the park offer a wider array of visitor experiences, including kayak tours, ferry operations, and fishing guide services. Recreational fishing and crabbing are popular pursuits throughout the park, and the area boasts significant stocks of seatrout and redfish. Farther offshore, the waters of the Gulf of Mexico support commercial fisheries for grey snapper, gag grouper, blue crab, and shrimp—species which likely originate partly from the shallow waters of the park's seagrass estuaries.

### Current Management Efforts

Park personnel are presently unaware of any lionfish sightings within the national seashore, though it has been noted that sightings have been reported from Pensacola Bay and from reefs just offshore from the Florida district. Given the proximity of these sightings and the favorable habitat available within the waters of the national seashore, it is likely that lionfish are already in park waters. Consequently, the park is actively participating in a region-wide planning process to prepare for such an invasion. Plans are in the works to develop and install signage at beaches and boat ramps, and distribute information to local operations to raise awareness and facilitate reporting. The park is also in the process of developing an ecosystem monitoring program for the purposes establishing baseline conditions and document change. Language has already been included in research permits that requires investigators to report all lionfish sightings as a condition of their permit.

## ***Virgin Islands National Park***

### Park Resources

Virgin Islands National Park protects a diverse mix of terrestrial and marine environments on St. John and St. Thomas in the U.S. Virgin Islands. Approximately 40% of the park's total acreage comprises marine and coastal environments, including mangrove shoreline and a mosaic of seagrass flats, sand bottom, algal plains, and coral reef. Park waters host a variety of protected and regulated species including marine mammals, sea turtles, lobster, conch, grouper and a number of candidate species being considered for federal protection. The park also provides

designated critical habitat for communities of federally-listed elkhorn and staghorn coral. The park also protects a small sampling of largely low-profile submerged cultural resources.

### Visitor Experience

Between 800,000 and 900,000 people visit Virgin Islands National Park annually, with peak visitation occurring from December to April. Though local populations do frequent the park, the majority of traffic comes from off-island visitors arriving from local resorts, short-term rentals, organized tours, and cruise ships. Visitor use consists primarily of hiking through terrestrial habitats, enjoying the beach, or engaging in a variety of shore-based water sports.

Some extractive uses are allowed within park waters, including lobstering and the harvesting of conch. Fishing occurs primarily from shore, and specific sport fish (usually tarpon and bonefish) are sometimes targeted. Snorkeling is very popular; diving—though allowed in the park—is somewhat limited, only a half dozen dive moorings exist in the park and only a few business operations provide service. The moorings are utilized primarily by snorkel and dive groups. Spearfishing is not allowed in the park.

### Current Management Actions

The first confirmed lionfish in Virgin Islands National Park was observed in February of 2010, before being removed two months later. Since that time, just over 200 fish have been removed from disparate locations throughout the park. The park staff actively partners with CORE (a volunteer organization based on St. John) to assist in disseminating information about the lionfish invasion and help organize a successful mark and capture program. CORE personnel are responsible for removing the vast majority of lionfish captured thus far, under the auspices of a formal permit that allows them to utilize a pole spear in park waters. Park staff have also collaborated with the local government in coordinating response plans and activities across the island.

## ***Virgin Islands Coral Reef National Monument***

### Park Resources

Virgin Islands Coral Reef National Monument, which abuts the boundary of Virgin Islands National Park, was established in 2001 for the purpose of enhancing the protection of resources within the national park and protecting a broad spectrum of tropical marine systems from mangroves to algal plains. Like the nearby national park, the monument protects a diverse complex of both marine and coastal resources extending up to three miles from shore and considerably deeper—reaching a maximum depth of approximately 160 feet. The monument also preserves a number of modern wrecks and submerged cultural resources.

### Visitor Experience

Opportunities for visitor activities at Virgin Islands Coral Reef National Monument are entirely marine-based. Though non-consumptive uses are permitted within the monument, a prohibition on anchoring—coupled with a relative scarcity of available mooring buoys on the reef—limits the occurrence of snorkeling and diving. Visitors do regularly occupy day-use only moorings at Hurricane Hole, and are permitted extended use of specialized moorings during tropical storm events. Though harvesting is generally prohibited, exceptions exist in two distinct areas that permit the extraction of blue runners and baitfish. Visitors also experience the monument by cruising aboard private vessels or kayaking at Hurricane Hole.



### Current Management Actions

The first lionfish recorded in the monument was observed in 2010, and only a handful of lionfish have been removed since then. Proposed management efforts at the monument mirror those currently in place in the nearby national park. Furthermore, owing to its relative importance as a nursery area for commercially, recreationally, and ecologically important species, Hurricane Hole has been identified as a priority area for monitoring. Areas where lionfish have been previously recovered in higher numbers are likely to be similarly given higher priority for regular monitoring.



## Authorities and Policies

This document provides the framework and guidance to assist parks in developing a successful lionfish management program. These plans will comply with park-level enabling legislation and management objectives, NPS management policy regarding exotic animal management and Executive Order 13112<sup>4</sup> for invasive species. The following section provides an overview of relevant service-wide laws and policies.

### Legal Authorities

The National Park Service Organic Act (16 U.S.C. 1 et seq [1988], August 25, 1916, sc. 408, 39 Stat. 535) mandates the parks to “conserve the scenery and the natural and historic objects and the wild life therein... [to] leave them unimpaired for the enjoyment of future generations.” Changes to the natural communities from human actions in the parks, including the continuous and unabated invasion of exotic and feral species, are contrary to the intentions of the Act. Additionally, the NPS Organic Act, especially 16 U.S.C. 3, authorizes the Secretary of the Interior to destroy animals that may be detrimental to parks; therefore comprehensive control of exotics and their effects in the National Park System is strongly encouraged.

Executive Order 13112 was issued to prevent the introduction of invasive species; provide for their control; and minimize the economic, ecological, and human health impacts that invasive species cause. This order defines invasive species, requires federal agencies to address invasive species concerns and to not authorize or carry out new actions that would cause or promote the introduction of invasive species, and established the Invasive Species Council.

### Regulations

Title 16 of the United States Code provides the National Park Service with broad legal authority to manage all public and recreational use within parks, including the promulgation of regulations that may be more restrictive than State regulations or generally allowed in other NPS units. These regulations are found in Title 36 of the Code of Federal Regulations.

### National Park Service Management Policies

The *NPS Management Policies* (2006)<sup>5</sup> identify the responsibility of parks to manage nonindigenous, alien plant and animal species and to cooperate with other agencies with jurisdiction. *Management Policies* provide that exotic species will not be allowed to displace native species if displacement can be prevented and, “all exotic plant and animal species that are not maintained to meet an identified park purpose will be managed—up to and including eradication—if (1) control is prudent and feasible, and (2) the exotic species:

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<sup>4</sup> Executive Orders are available at: <http://www.nps.gov/applications/npspolicy/getEOs.cfm> (accessed February 24, 2012).

<sup>5</sup> Available at <http://www.nps.gov/policy/mp2006.pdf> (accessed February 24, 2012)

- interferes with natural processes and the perpetuation of natural features, native species or natural habitats, or
- disrupts the genetic integrity of native species, or
- disrupts the accurate presentation of a cultural landscape, or
- damages cultural resources, or
- significantly hampers the management of park or adjacent lands, or
- poses a public health hazard as advised by the U. S. Public Health Service (which includes the Centers for Disease Control and the NPS public health program), or
- creates a hazard to public safety.

High priority will be given to managing exotic species that have, or potentially could have, a substantial impact on park resources, and that can reasonably be expected to be successfully controlled. Lower priority is given to exotic species that have almost no impact on park resources or that probably cannot be successfully controlled. Where an exotic species cannot be successfully eliminated, managers will seek to contain the exotic species to prevent further spread or resource damage” (2006 *NPS Management Policies*, section 4.4.4.2).

Programs to manage exotic species will be designed and implemented using an integrated pest management (IPM) approach which is a decision-making process that coordinates knowledge of pest biology, the environment, and available technology to prevent unacceptable levels of pest damage by cost-effective means while posing the least possible risk by the pest and any related management activities to people, resources, and the environment (2006 *NPS Management Policies*, section 4.4.5.2, Integrated Pest Management Program).

The *NPS Management Policies* provide for the harvesting of invasive species, such as lionfish, by the public: “The Service may encourage the intensive harvesting of exotic species in certain situations when needed to meet park management objectives” (2006 *NPS Management Policies*, Section 4.4.3).

Legislation in Public Law 110-229, the Consolidated Natural Resources Act of 2008<sup>6</sup>, also provides the NPS with authority to use its resources and funds collaboratively on land outside park boundaries for activities benefiting park natural resources. It codifies aspects of *NPS Management Policies* that encourage superintendents to work cooperatively to protect and restore NPS natural resources.

## **Park Level Regulations and Compendia**

### ***Special Regulations***

Commonly called special regulations, park-specific regulations are found at 36 C.F.R. Part 7 and 13.7. Special regulations may be written to address activities that take place on federal or non-federal land or submerged lands and waters within park boundaries. (Park-specific regulations

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<sup>6</sup> Available at: <http://www1.nrintra.nps.gov/brmd/PL110legislation.cfm> (accessed February 24, 2012)

cannot be contrary to Federal statutory law or in derogation of park values.) Special regulations can be an effective way to protect the resources of ocean and coastal parks that are not sufficiently protected by general NPS regulations. One example is the Dry Tortugas National Park special regulation at 36 C.F.R. § 7.27 regarding fishing and vessel restrictions in the Research Natural Area (a no-take zone) of the park. However, the process of promulgating a special regulation includes a number of policy, procedural and timing considerations including National Environmental Policy Act compliance and public involvement.

### ***Park Compendia***

Pursuant to 36 C.F.R. §§ 1.5, 1.6, and 1.7(b), the Superintendent may put conditions on uses or activities in park units or even close areas to uses in an annual Superintendent's compendium. Examples of compendium restrictions on waterborne activities include location and permit fees for launching of vessels and of car-top boats and gear such as windsurfing equipment; fishing permits and limits; and access, weapons, and areas for waterfowl hunting in parks where such hunting is authorized by legislation. Compendium provisions have the force and effect of regulation. (Generally, the compendia may adopt local limits and conditions for activities that are otherwise allowable under the park's enabling legislation, the *NPS Management Policies*, and NPS regulations, but may not permit activities or uses that are inconsistent with those authorities.) The compendium is mainly for actions that are temporary in nature or may change from year to year (i.e., a closure for nesting eagles). Superintendents may take immediate action in the event of an emergency under 36 CFR § 1.5 to address threats to public safety or park resources. Some permanent actions, such as small area closures or visitor center hours, are permissible as long as they do not trigger any of the criteria in § 1.5(b) that require a special regulation. Compendium provisions generally require a written determination and justification by the Superintendent that is made available to the public for review.



## Management Actions

The National Park Service must respond to the extreme threat that invasive lionfish pose to ecological integrity and visitor safety and experience. This section of the plan advocates an aggressive and multi-faceted management strategy to monitor and suppress lionfish invasions, to communicate risks, and to ensure the safety of visitors, park staff and volunteers. Lacking this response, population levels may reach high densities and cause unacceptable impacts to native fishes, invertebrates and ecosystem function in ocean parks and risks to visitors. Parks should coordinate these efforts with adjacent marine protected areas and more broadly with state, territorial, and federal agencies. Ultimately, local and regional approaches will combine with an informed public to better understand and respond to the lionfish invasion.

The strategy for preventing and mitigating lionfish impacts to park resources includes the following elements: a) process and criteria to prioritize areas and park resources for lionfish control; b) approaches for setting control targets for reducing lionfish populations; c) methods for detecting and reporting the presence of lionfish, and available tools for their removal; d) approaches and methods for monitoring lionfish populations and for monitoring native species and potential ecological impacts, and e) adaptive management considerations. Although they can be flexibly applied to suit the particular habitats and logistical considerations of individual parks, all of these elements need to be addressed for the lionfish response strategy to be effective.

Similarly, the management strategy in this section provides a structure for assessing risks and mitigating hazards to employees, including safe wildlife handling practices, other safety standards, operational leadership processes and ways to incorporate lionfish concerns into public risk management and employee training programs. Finally, a comprehensive communication and outreach strategy is provided with recommended messages to communicate the impacts of lionfish and tools and media for delivering those messages effectively to the public.

### **Prevent or Mitigate for Lionfish Impacts on Park Resources**

#### ***Criteria and Processes to Prioritize Areas and Resources***

Although, protecting park resources across all marine habitats and cultural sites from invasive lionfish would be ideal, constraints on available capacity and logistical challenges will make this expansive approach impractical (see “Implementation Plans” below). Instead, managers will benefit from reviewing and prioritizing the most valuable and vulnerable areas for lionfish management actions. The criteria and steps necessary to identify priority areas for action follow.

#### **Park marine resource inventory and impact analysis**

This inventory and analysis is designed to provide the guidance needed to prioritize park resources and values for protection and assess their relative vulnerability to lionfish impacts. The overall process for conducting a lionfish impact analysis on park resources includes (1) gathering park resource information (2) assigning relative value to park resources that may be affected by lionfish (3) identifying the relative vulnerability of park resources to the threat of lionfish, and (4) identifying logistics and other challenges that may affect management decisions. The sections below identify the steps for accomplishing this review.

### Step 1. Gather geospatial, biological, and visitor use information

The park manager should gather all habitat information that may be useful for assessing the potential for lionfish impacts on park resources, including habitat maps, biological inventories, resource assessments, monitoring results, designations of Critical Habitat and marine reserves or other special designated areas or management zones. Where critical data (such as biological inventories) are not available for the park, the manager may consider adjacent locales or geographically similar habitats with relevant data to serve as a proxy that may yield comparable results.

### Step 2. Appraise relative value of areas/habitats

Before a plan for control can be developed, the manager must first decide where to deploy resources to most effectively accomplish goals. Assigning value to specific park resources is difficult and may be highly subjective. Use of prior economic valuation for resource damage assessment and restoration or other park resource impact events that have quantified the economic and ecological value of certain park resources may serve as a guide. Park resources can be categorized into two valuations—ecological and socio-economic.

**a. Ecological value.** Assigning ecological value is especially difficult as the marine ecosystems in parks are highly integrated and trophically linked. For example, coral reef ecosystems have high biological connectivity between reef zones and mangrove and seagrass habitats. However, some habitats that may be considered high in ecological value include those that support threatened or endangered species, nursery habitats, coral reefs with relatively higher rugosity and complexity, hard bottom communities or artificial reefs, essential fish habitats, marine reserve zones, or established hotspots of high biodiversity. The approaches in the literature and software decision tools for marine protected area design also may be useful when designating ecological value.

**b. Socio-economic and visitor use/experience values.** Park areas that are frequently used by recreational anglers, divers, snorkelers, swimmers and other watersports enthusiasts should be considered when prioritizing areas for lionfish control. These include popular fishing sites, dive sites and vessel moorings, shipwrecks, snorkeling sites (including underwater trails), areas where surface watersports (such as windsurfing and swimming) occur and other areas with higher frequency and intensity of visitor use that may be impacted by lionfish presence. The recreational values of these areas should be included in the lionfish resource impact review. For example, these values may include opportunities for divers and snorkelers to view a high diversity of fish, charismatic species such as sea turtles, large fish, and lobster, and areas with high percentages of live coral cover. Impacts on recreational fishing may occur as lionfish affect benthic fish communities including popular gamefish such as grouper and snapper. Quantifying the social and economic value of park resources that may be affected by lionfish is difficult, however, because of the lack of social science information on visitor use, and the economic value of natural resources.

### Step 3. Identify relative vulnerability of park resources to lionfish impacts

Creation of a map that identifies park areas that are most vulnerable to the lionfish invasion will help managers to effectively deploy control resources. Not all park resources will be invaded at the same levels, thus some are more vulnerable to lionfish impacts. Some habitat characteristics



that have been demonstrated to affect lionfish densities include habitat complexity (lionfish generally prefer high relief), food availability, and temperature regimes (lionfish temperature tolerance is approximately 11–35°C). The manager should as part of this analysis consider assigning zones where he/she may expect lionfish to invade.

Lionfish larvae settle in a broad variety of habitats, even though many adults aggregate at artificial structures and high-relief natural structures. Overall, the lionfish's affinity for structure suggests that they are more likely to colonize patch reefs or artificial structure more heavily than sea grass or sandy bottoms.

The original assessment of vulnerability should be periodically evaluated to determine if it is correct. If it is not, then the assessment should be adjusted.

#### Step 4. Consider Physical Hazards and Limitations

Prioritization of areas for removal must include consideration of the physical hazards and practical challenges associated with reaching these areas and in particular the safety of diving, snorkeling and vessel operations. Removal will be conducted primarily by using scuba or snorkeling. Accordingly, NPS dive operations are constrained by the depth certification level of the individual NPS diver which may further reduce the range of dive operations for that diver. Further, hazards of physical environment to safe vessel and underwater operations may further constrain where and when lionfish may be removed safely, such as surface conditions, currents and other hazards. Finally, the distance of removal sites from the base of operations may reduce the feasibility and cost-effectiveness of reaching those sites on a frequent basis. Because of these physical hazards and environmental factors at such depths, other options will likely need to be explored for effectiveness in dealing with the invasion (see “Available Control Techniques” and “Lionfish Monitoring” below).

#### **Setting Lionfish Control Targets for Natural Resource Protection**

As a general starting point, the number and biomass of lionfish in an area largely dictate the severity of their impacts on native species and habitats. One basic approach to setting removal targets is to simply control lionfish to the greatest extent possible. After establishing priority geographic areas for control, the manager should develop a control target based on the objective of reducing lionfish. The approaches used to develop control targets and spatial scales at which they are applied are at the manager's discretion. The amount of data, stage of the invasion (numbers observed, time since first observation, etc.), lionfish control resources available (logistics, removal tools and personnel), habitat types, and other factors will vary among parks and within parks.

These control targets focus on actions at a local scale. Source populations of lionfish may occur outside of park boundaries. Setting a local control target will not necessarily affect external source populations of lionfish that aid in recruitment of lionfish into park waters.

#### Reduction/maintenance of CPUE

This approach is most easily applied to the earlier stages of invasion but may be applied at later stages. Under this control target, as many lionfish as possible are removed from the designated area while quantifying catch-per-unit effort (CPUE). “Catch” may be measured as either the number of lionfish captured per unit effort or the biomass of lionfish captured per unit effort.

–Effort” is the amount of effort expended towards lionfish capture, typically measured in number of dive hours.

The control target is set as either the reduction or maintenance of CPUE over time. Given consistent effort, the target is reached when the number of lionfish or the overall biomass removed, is reduced or maintained. As the number of lionfish per unit area is reduced, CPUE is reduced. If the catch rate increases over time, the control target is not being reached and it becomes necessary to increase effort. Ideally, the effort would be increased until the CPUE starts to decrease or remain stable over time. Depending on how quickly lionfish are invading the area it is possible that, during the initial portion of the effort, CPUE may actually increase before leveling off or dropping. When there are more lionfish to catch, CPUE increases until effort matches or exceeds the invasion rate and CPUE is maintained or reduced as lionfish subsequently become scarcer.

#### Success of response to sighting reports

This control target method should be utilized in the early stages of an invasion. The success-of-response control target utilizes reports of lionfish sightings to the NPS. The target is measured by the ratio of observations reported to the number of lionfish removed. The manager may set the target to a desired level of success, with the ratio approaching one-to-one as closely as possible (a lionfish is removed for each sighting report received). Guidelines are not available to identify a single target between 0 and 1. Accordingly, the manager should set that target as an increasing or stable percentage over time. Sighting reports can be provided by park staff, partner organizations, the public, or other sources as determined by the manager. However, this control target strategy may lose effectiveness due to potential breakdowns in reporting or increases in the lionfish invasion. For example, the public may become desensitized to seeing lionfish over time which lowers the rate of reporting, even while the number of lionfish continues to increase. By contrast, if the response is not keeping up with increasing lionfish sightings, the magnitude of the invasion is likely increasing beyond the “early” stage and a new strategy should be adopted.

#### Biologically-based targets

Setting precise numerical targets for lionfish control that yield predictable results in resource protection is not possible until additional knowledge is gained about how native species and community dynamics respond to changes in lionfish population levels. Recent lionfish management efforts are new and their results in reducing ecological impacts at local scales are not yet evaluated. The control targets provided here should be evaluated during implementation by monitoring the status of native species communities, in addition to monitoring lionfish population changes (see “Native Species Monitoring” below). For example, target thresholds based on the consumption rates of lionfish (D.S. Cerino, East Carolina University, pers. comm.; S. Green and I. Cote, Simon Fraser University, pers. comm.) and the productivity of the invaded habitat (S. Green and I. Cote, Simon Fraser University, pers. comm.), may enable the manager to adopt a biologically-based control strategy. Additional considerations include prey shifting. Smaller lionfish tend to prey on shrimp and other invertebrates and then switch to fish as they grow larger. In the Cayman Islands, systematic efforts to remove lionfish have reduced both numbers and average size of lionfish while leaving smaller individuals. As a result, control efforts may shift the balance of lionfish predation away from fish and toward invertebrates. (P. Schofield, USGS, pers. comm.) Information gained from monitoring will support research and

development of biological control targets for lionfish. As new information becomes available, the NPS will incorporate the most effective and feasible approaches for monitoring.

### ***Available Control Techniques***

#### Approaches

Lionfish removal will take place either actively (specifically targeting the removal of lionfish through organized efforts) or opportunistically. Given the limited resources of park staff, the manager may wish to encourage detection and control efforts by the public.

In addition to park staff, available means of detection and removal include supervised volunteers, contractors, derbies, fishing clubs, dive clubs, researchers engaged in lionfish-specific studies, NGOs, partner agencies, and unsupervised entities (not under park supervision or written agreements). Before entering into partnership agreements, the manager should evaluate the capacity and appropriate role of these entities to perform organized lionfish detection or control in park waters. Opportunistic removal efforts would include such user groups as park visitors (including recreational SCUBA divers and snorkelers), recreational and commercial anglers, researchers engaged in non-lionfish studies, NGO's and partner agencies, concessioners (report and/or remove), and subsistence fishers. All activities must comply with service-wide and park-level rules and regulations.

#### Detection and Reporting

If logistically feasible, park staff should assess for the presence, distribution, and density of lionfish either through systematic lionfish monitoring or in the course of other in-water work. Searches should be as detailed as possible to detect this cryptic species that tends to avoid open areas, preferring overhangs, caves, ledges, wrecks, and artificial habitat. However, small lionfish may be common in seagrass beds and other areas with limited structural shelter (M. Hixon, Oregon State University, pers. comm.). Additionally, detection efforts should account for the activity patterns of lionfish by searching during dawn and dusk periods when lionfish are more active and in darker areas such as caves and overhangs with flashlights. Information in park reporting systems should include:

- Park unit
- Date of sighting
- Location (preferably with GPS coordinates)
- Describe site location (on coral reef, inside wreck, etc.)
- Number and size of fish sighted
- Disposition (removed? killed and left? marker?)
- Contact information for follow up

These reporting systems could coordinate with larger scale reporting systems such as USGS nonindigenous aquatic species (NAS) system or the Everglades Cooperative Invasive Species Management Area (ECISMA). A local phone number can be provided for visitors to call to report a lionfish. This may require additional coordination with local governments to avoid reporting lionfish sightings to agencies that lack capacity or authority to respond in areas outside of their jurisdiction.

Another option for the early stages of the invasion is to use a lionfish location marker to enable visitors or volunteers to report sightings. Park staff distributes markers to snorkelers or divers

who leave the marker at the site where they see a lionfish, and report the site location to park staff. This method takes advantage of the high site fidelity of lionfish but requires a timely response to remove the marker and to quickly capture the lionfish. This method is not useful in areas of high currents since the marker may wash away. In high visitation areas visitors may think they are trash and remove them. As an alternative to placing a marker, providing GPS coordinates and/or the description of the general area to park staff is also useful. These markers can be produced easily in a small amount of time and at very low cost. An example is a weighted washer with a one-meter long yellow survey tape or fishing line attached with a float (or cork). Yellow is highly visible from a boat at depth. NPS should strive to have a consistent marker type.

A variety of tools exist for in-water containment and transport of lionfish. Table 1 shows the tools available, along with an evaluation of each tool's pros and cons, safety, cost and training needed.

The recommended characteristics of such tools include durability/puncture resistant, accessibility, ease of toting (streamlined), capacity adequate to handle the level of removal, ease of introduction and removal of fish, etc. Examples include vinyl dry bags, plastic buckets with a one-way lid, and heavy canvas bags. Once topside, lionfish are secured in coolers on ice or plastic tubs filled with ice. Devices to avoid include plastic bags, mesh bags, mask boxes, cotton tote or thin fabric tote bags, and stringers.

#### Ecosystem Resilience and Potential Predator Control

Additional efforts to protect native species and increase resilience of marine ecosystems may reduce impacts of lionfish. Although it is not yet clear if native predators will feed regularly on lionfish, natural predation may prove to be beneficial in reducing lionfish populations. Current and future efforts to restore depleted reef fish capable of preying on lionfish, such as groupers, particularly in marine protected areas such as National Parks, will increase the likelihood of top-down predator control of lionfish. By reducing impacts of fishing on the broader suite of species, marine reserves also should mitigate impacts of predation by lionfish on fish and invertebrate communities. Finally, management and restoration actions could be taken to increase ecosystem resilience and reduce other stressors such as poor water quality, marine debris, habitat damage, coral disease, and other impacts.

**Table 1.** Evaluation of tools available to control lionfish.

Tool	Pros	Cons	Safety	Cost	Training	User Group
Hand Nets	Effective for all sizes of lionfish; less likely to spook fish; live capture	Slower; cumbersome; difficult to maneuver	Minor sting risk exists at transfer of fish from net to bag	Low	Need training to avoid harming reef	All user groups; requires SCUBA/Snorkeling
Pole spears/Hawaiian sling	Fast; efficient; effective for larger & more elusive fish; easy to aim	Missed fish learn avoidance quickly; bad shot may harm corals sponges, and benthic community.	Misfires; potential for accidental buddy poke	Medium	Need training to master technique and safety	Park staff, permitted groups; requires SCUBA/Snorkeling
Spear guns	Semi-fast; efficient' effective for larger fish; easy aim	Missed fish learn avoidance quickly; bad shot may harm corals sponges, and benthic community; less control depending on model/type	Less control on larger models; accidental firing if safety not engaged	High	Need training to master technique and safety	Park staff, permitted groups; requires SCUBA/Snorkeling
Slurp guns	Live capture; maneuverable in small areas for small fish	Low effectiveness; low CPUE; easily spook fish; not suitable for large fish	Medium	High	None	Anyone; requires SCUBA/Snorkeling
Traps	Unmanned; can be placed deep; potential for high number caught	Non-specific; high bycatch; habitat damage from trap movement; may not be effective in high relief habitat; not effective for small lionfish	High	High	Very little	Park staff; permitted users

Tool	Pros	Cons	Safety	Cost	Training	User Group
Hook and Line	Live capture; no diving; access to deeper fish	Non-specific; slow; inefficient time use; not effective for small lionfish	High	Medium-High	None	Commercial and recreational anglers, subsistence fishers
Seine nets	Effective for large shallow soft-bottom area; can capture many fish at once; effective in areas of low visibility, high surf, or in areas that are difficult to snorkel	Requires a group of people; not effective around structure; non-selective; high bycatch; high potential to destroy benthos	High potential for sting with many fish in a mesh net	Medium	Limited	Park staff and volunteers
Chemicals	Very effective	Irreversibly harms all organisms in a widespread area; persistent in the environment for a long time	Depends on the chemical	Depends on the chemical	HAZMAT; MSDS sheets	Park staff; researchers; cooperators; requires SCUBA/Snorkeling
Biocontrol	Natural	Unknown effectiveness	High	Low	None	None

## ***Lionfish Monitoring***

### Overview

The purpose of lionfish monitoring is to assess lionfish abundance, distribution, habitat use, population demographics and invasion status, as well as any temporal changes in these topics, including changes attributed to organized removal efforts (see “Setting Lionfish Control Targets” above). A variety of metrics can be used to achieve this goal. Consistent collection of this data is critical and will afford for trend analysis over time. Data collection approaches can be broadly divided into “fishery independent” and “fishery dependent.” Metrics for each approach include:

#### *Fishery Independent*

- Density of lionfish populations
- Average size of lionfish
- Catch-per-unit-effort from lionfish-specific removal activities
- Encounter rates
- Habitat use

### *Fishery Dependent*

- Landing biomass
- Catch-per-unit-effort of recreational, commercial and subsistence fisheries
- By-catch rates and lengths from trap fisheries

### *Additional Data Sources*

- Envenomation events reported to park staff
- Visitor sightings
- Reports from concessioners

Monitoring efforts can be conducted either through passive/opportunistic or active/structured surveying. The activities of user groups who are conducting control (see “Available Control Techniques” above) can also provide some of the monitoring for quantifying the status of the lionfish invasion.

### Lionfish Monitoring: Early Stages of the Invasion

At the early stages of the lionfish invasion, sampling should focus on the target areas determined through the prioritization process described in the earlier section. At this stage, managers may rely on visitor and concessioner reports, and reports of lionfish from pre-existing monitoring programs and fishing activities. These data can inform the spatial colonization of lionfish, to prioritize for detection and removal later on. Maximizing the ability to detect the presence of lionfish in the park should be a top priority.

### Lionfish Monitoring: Advanced Stages of the Invasion

As the invasion progresses and targeted control activities begin, the sampling design of lionfish monitoring should focus on targeted areas determined by the prioritization process and similar habitats that are not prioritized for lionfish control. Comparisons of these areas (priority control areas and non-control areas) are useful for evaluating the success of control actions in preventing impacts to park natural resources and in facilitating adaptive management. Lionfish surveying efforts should be designed to be robust enough to detect statistical trends. Research has indicated that fisheries independent survey techniques for reef habitats are not optimized to detect lionfish because of their cryptic nature. Attempting to incorporate lionfish monitoring into pre-existing monitoring efforts has yielded very low detection rates, and therefore are not recognized as an appropriate method to surveying the density of lionfish (S. Green, Simon Fraser University, pers. comm.). Because of the patchy distribution of lionfish, the area needed to effectively detect lionfish may be very large. Methodologies need to be geared specifically towards detecting lionfish in different habitats. This may require, altering existing search protocols, but may be as simple as slowing search rate of existing search protocols.

Underwater data collection must consider low visibility, deep depths, high currents, and potential boat hazards. When one or more of these occur, sampling should be restricted to diver independent methods (e.g. trapping, seining, hook and line, or remotely operated vehicles; see page 27), although they are considered, at this time, less effective than active capture methods. The metrics to obtain from these methods would be size data, spatial distribution, and catch-per-unit-effort.

### Active In-water Monitoring

Active in-water monitoring should include consistency of time and area, and should be lionfish focused. An example of recommended survey efforts should plan for 5 minutes for every 50 square meters surveyed, with additional time added for more complex habitats (Best Practices Manual, S. Green, Simon Fraser University, pers. comm.). Reef habitats include patch reefs, fringing reefs, and hard bottom communities. These types of habitats are often complex in structure and require thorough search patterns that include exploring crevices and caves.

Seagrass habitats are shallow, soft bottom habitats that can be monitored by focusing on unique features that provide structure or cover, such as blow outs, prop scars, sponges, rock outcrops, etc. These areas are often locations for small, cryptic juvenile fish to hide.

Mangrove creek and shorelines are shallow complex habitats where search methods can be focused on the edges of creek walls and prop roots.

Man-made canals and natural channels often provide structure for lionfish settling, such as divots in limestone, dock pilings, sea walls, debris that are resultant of dredging, biota that provide structure on the bottom, etc.

Artificial structures, such as shipwrecks, pilings, lighthouses, sea walls, or any pile of man-made debris, are well known attractants for lionfish due to the large amount of structure. An effective way of monitoring these sites is to examine all areas that are safely accessible (avoiding areas that require penetration and may require advanced training).

### Data Collection and Management for Active In-water Monitoring

It is imperative that all parks use a minimum data collection standard that will provide for an easier Service-wide roll-up of lionfish data. If parks have the capacity and interest, additional data may be collected. A Microsoft® Access database should be used to ensure data standardization and integrity. Minimum data fields of monitoring data will include: location (latitude and longitude, UTM), date, time, park unit, observer name, dive buddy, depth, water temperature, visibility, habitat type (reef/hard bottom, seagrass/soft bottom, artificial, mangrove, canals and channels), area covered, time surveyed, weather (sunny, cloudy, etc.). Lionfish data to collect would include: length, number of individuals sighted, number individuals removed, disposition, collection method. A sample data sheet is provided in the appendix. For data collected prior to the creation of this database, information would be included to the maximum extent possible.

### ***Native Species Monitoring***

This section describes factors for managers to include in monitoring lionfish impacts on native species. Although existing resource monitoring or condition assessments may not have included these parameters in their original objectives or sampling design, existing information on native fish or invertebrate species may still be useful for evaluating lionfish impacts. Monitoring of lionfish prey species in priority areas where lionfish are removed and comparative sampling in similar habitats where lionfish are not removed, will assist with evaluating habitat-level changes and outcomes of control efforts. Recommended parameters for monitoring native species and their possible application follow.



Relevant attributes of native fish and invertebrate communities include lionfish prey base, prey species biodiversity, key functional species, and overall native species population demographics and densities. As a starting point, an assessment of the lionfish prey base is fundamental to understanding the impacts of lionfish on native fish and invertebrate communities. Lionfish have particular prey preferences consisting of small bodied fishes, juvenile larger fish, and crustaceans. Lionfish can grow as large as 42.4 cm and have been documented to consume prey as large as 50% of their total length. However, the average lionfish prey size is 2 cm, and requires dedicated sampling of small fish in addition to other size classes. Small size classes are typically not optimized in large scale fisheries independent monitoring methods.

#### In-Situ Monitoring Method

One method employed currently involves transect surveys (25 m x 2 m belt transect) focusing on a thorough search of all habitat features, using a dive light when necessary, recording the number and size of all fishes less than 15 cm total length observed, to the nearest cm. Minimum transect swim time is 15 minutes, but may be extended based on habitat complexity and fish density. Data is collected on a preformatted underwater data sheet with a predetermined species list based on local fish assemblages. All data is entered into an Access database (sample data sheet and database are available).

#### Lionfish Predation Analyses

Direct observations of lionfish predation can be made through gut content analyses of collected lionfish. It is recommended to dissect as soon as practical after collection to minimize additional digestion. Formalin may be used to fix the stomach contents through injection or removal. The potential for competition for prey between lionfish and native predators also could be measured through overlap analyses of gut contents of lionfish and of native predators. Finally, stomach content analyses of native fish also could be used to evaluate if native predators are feeding on lionfish, through various approaches involving creel survey landings, commercial landings, or other statistical means (e.g., regression and/or correlation analyses between lionfish and predator densities). Control of lionfish through predation may be a critical factor in reducing lionfish populations.

#### Analysis of Impacts on Ecosystems and Habitats

Monitoring of native species and lionfish predation on key functional species will inform efforts to evaluate potentially severe ecosystem or habitat level changes. Certain native species perform specific functions in maintaining fish health and optimal conditions for coral growth in coral reef ecosystems. Monitoring of herbivorous fish species provides valuable information on this key functional group. Herbivorous fishes reduce abundance of macroalgae on reef substrates, enabling sponge and coral larvae to settle and grow. Reductions in juvenile herbivorous fishes from lionfish predation may, among other factors, contribute to higher algal abundance on reefs and declines in sponges or live coral cover. Similar reductions of symbiotic species that clean native fish of parasites, such as shrimp and gobies, could result in higher incidence of fish parasitism. Monitoring the number of lesioned or infected fishes may be useful in this regard.

#### ***Scientific Understanding of Lionfish and Adaptive Management***

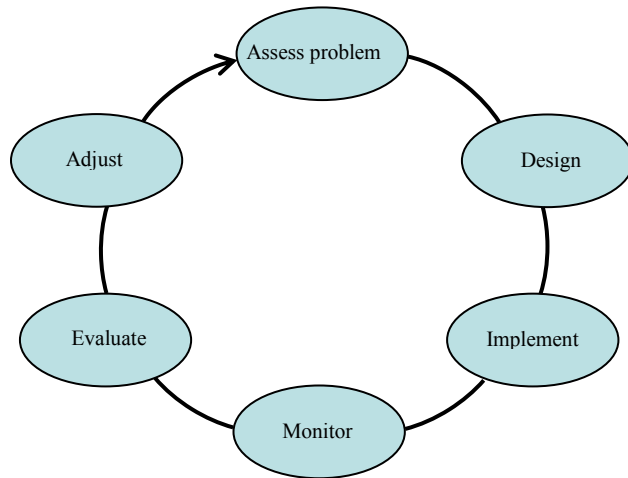
Adaptive management is a structured decision-making process that incorporates uncertainty about the potential responses of resources to management actions, and promotes flexible decision-making that can be adjusted as outcomes from management actions and other events

become better understood (Holling 1978, Walters 1986). The principles of adaptive management lend themselves to the circumstances surrounding the lionfish invasion and the challenges it presents to park managers and other resource managers. Although knowledge is growing, there is substantial uncertainty in the body of theories and knowledge about the lionfish invasion. As noted in this plan, prior to the invasion of lionfish in marine areas where parks are located, little information on their biology, ecology and control was available, and much of what has been learned so far in their invaded range is new information.

Recent management actions to control lionfish at various scales are equally new and their efficacy in reducing ecological impacts are not yet tested or understood. Most of all, managers need to know the impacts of lionfish predation on native species abundance and community composition, particularly as lionfish densities or biomass levels increase or decrease. Without this understanding, managers cannot accurately measure whether or not a chosen target level for removing lionfish is achieving objectives in terms of native species protected. How does the manager set lionfish control targets to accomplish his or her resource management mandates (i.e., to prevent or mitigate for lionfish impacts on park resources)? This response plan offers initial approaches but given the relative lack of experience and past observations to inform these decisions, this plan allows for substantial latitude for setting lionfish control targets and management practices. As a result, ample opportunities exist for learning from and evaluating different management approaches to lionfish in parks and other marine protected areas in an adaptive management decision framework.

Existing research and monitoring also greatly influence how effective this plan will be. The National Park Service and partners have committed substantial effort to implementing and evaluating the efficacy of marine reserves in protecting and restoring coral reefs, seagrass beds and interdependent species from the effects of fishing at Buck Island Reef National Monument, Dry Tortugas National Park, and Virgin Islands Coral Reef National Monument. The rising impacts of lionfish predation on native fish and invertebrates in these reserves add a new element of complexity to evaluating reserve performance. Ongoing habitat mapping, monitoring and research by the National Park Service, U.S. Geological Survey, National Oceanic and Atmospheric Administration, academia and other entities will inform development and implementation of lionfish response plans.

The U.S. Department of the Interior Technical Guide to Adaptive Management states: “Adaptive management requires stated management objectives to guide decisions about what to try, and explicit assumptions about expected outcomes to compare against actual outcomes” (Williams, et al. 2009) (Figure 2). Full application of adaptive management requires an explicit approach to determine whether or not the management action worked as expected. In addition, it requires scientific rigor, including models for comparing actual results to expected results of management actions, management flexibility, and commitment to carry out monitoring and re-evaluation of management goals over time. The workshop held to develop this plan included a wide range of park professionals and disciplines, including resource managers, interpreters, risk managers and safety experts, and external experts in lionfish biology and control, all of whom represent a community of practice for collaboration involving science and resource management agencies, academia and nongovernmental organizations. The work accomplished in developing this plan provides a foundation for an adaptive management approach to lionfish.



**Figure 2.** A schematic of the adaptive management approach from the assessment of the problem to the decision to adjust the management action (from Williams et al. 2009).

### ***Implementation Plans***

A detailed implementation capacity plan describes how various park assets will be used to achieve the management actions in the lionfish response plan. This implementation plan will assess total assets needed to conduct lionfish activities in relation to available park assets, to include the following components:

#### Assess Park Assets

##### *Budget*

Describe the overall level of funding needed to fully execute the desired management actions. This should take into account costs associated with staff salaries, expenses for contractors, interns, or other cooperators, travel, equipment and gear, overhead, training etc. Then, assess what funds (from base funds and/or other sources) are currently available to conduct the lionfish management activities.

##### *Human Assets*

Describe how park employees, park partners (e.g., cooperators, volunteers, contractors, researchers), and park visitors will be involved, the specific roles of each person/user group, and the time commitments needed for each to achieve the goals. Then, consider limitations on the availability of participants, or credentials such as certifications and/or authorizations (e.g. MOCC boat operations, NPS Blue-card for diving) required for project participants.

##### *Capital*

Consider boats and fuel (e.g., capacity, condition, availability, accessibility to various habitats and distances from park headquarters, usability as a dive platform etc.), SCUBA and snorkel equipment, and lionfish control gear (harvesting tools, personal protective equipment, and containers for transport, containers for long-term preservation and storage), as well as assets needed to complete outreach materials (media, printers, ink cartridges etc.). Compare these needs to the park's present capital assets and equipment.

### Conduct Gap Analysis

Based on the descriptions of proposed and actual park assets provided above, describe how potential gaps in current park assets will affect operational capacity to implement the response plan. Discuss whether adjustments (e.g., reduce area of effort, reduce staff involved, postpone activities until funding is received etc.) can be made to ensure an effective response until sufficient assets are obtained. Pursue opportunities (e.g., calls for proposals, partnerships with funded agencies or NGOs etc.) to address potential gaps between the current and desired implementation capacity.

## **Protect the Health and Safety of Visitors, Staff, Partners and Contractors**

### ***Safe Lionfish Handling Practices***

#### National Park Service Safe Handling Practices

As with all wildlife, there is an inherent risk to human health and safety with lionfish encounters. However, there are approaches to mitigate and reduce these risks. Proper planning, preparation and execution of prudent safety measures will help to ensure safety and reduce the chances of injury or illness associated with lionfish response measures. All lionfish removal, transport and dissection will follow under the human health and safety guidelines found in Reference Manual 50B section 4.15 Safe Work Practices for Employees Handling Wildlife (Appendix 3). Following these guidelines will provide a clear understanding of the potential hazards and mitigation measures associated with different activities performed by employees working with lionfish.

#### Job Hazard Analyses

As required by RM 50B, detailed Job Hazard Analyses (JHA) will be written, depending on the job description, to outline the steps of the specific task, the potential exposures and the proposed actions to avoid the hazards associated with lionfish response. Hazards may be grouped into three general categories: physical, chemical and biological. All three of these categories will be taken into consideration while preparing the JHAs. Once these hazards are identified, mitigation strategies may be implemented.

Potential risks for lionfish handling activities will include:

- Physical: stings, cuts, abrasions, equipment (i.e. biomedical sharps, vessels, spears)
- Chemical: chemicals used for specimen preservation (e.g. formaldehyde, ethanol, etc.)
- Biological: exposure to venomous spines, allergic reaction

Different tasks will require a variety of personnel to be involved with lionfish management and thus will require the development and use of a variety of JHAs. Job Hazard Analyses should be written and executed for tasks such as lionfish collection, handling, and dissections. The JHA form used is found in RM 50B, section 3.1, and should include Sequence of Job Steps, Identifying Potential Hazards/Injury Sources and Safe Actions or Procedures as a minimum. The JHAs should include the sequence of job steps and the management tools or resources used by different personnel. Examples of currently used JHAs for lionfish management activities can be found in the References and Resources section. Parks should create their own JHAs, using these examples as a template for each park's unique lionfish response activities. Also, JHAs should be modified and reviewed, corrected and updated by management on a regular basis.

### ***Safe Diving Practices***

#### National Park Service Dive Program

Many lionfish response activities require the use of scuba diving as a management tool. All NPS dives for the purpose of lionfish response activities will be performed in accordance with 485 DM, Director's Order 4, and Reference Manual (RM) 4 Diving Management. Compliance with OSHA Regulations (29 C.F.R., Part 1910, Subpart T, Commercial Diving Operations) is also required. According to RM 4, each park unit is required to have a separate Diving Safe Practices Manual and Emergency Operation Plan. Lionfish response activities specific to the park unit should be addressed in each of these plans.

### ***Safe Boating Practices***

#### Departmental Manual

Many lionfish response activities require the operation of boats. All NPS boat operations for the purpose of lionfish management will be performed in accordance with U.S. Coast Guard regulations and 484 DM 22, Watercraft Safety, which can be found at [http://elips.doi.gov/app\\_DM/act\\_getfiles.cfm?relnum=3912](http://elips.doi.gov/app_DM/act_getfiles.cfm?relnum=3912) (DM stands for Departmental Manual).

### ***Worker Training and Handouts***

Staff workers involved in lionfish management must receive training in safe work practices. This training should include a thorough review of the impacts of lionfish on park values, of the potential hazards associated with their specific work, of applicable JHAs and other pertinent information. This training must be completed before staff members are allowed to work on lionfish projects. To assist with this training, the NOAA Venomous Fish Handling Protocol is included in Appendix 5 along with examples of JHAs in Appendix 4.

### ***Sting Treatment Advice***

Although many injuries caused by lionfish can be non-life threatening, some injuries can develop into serious problems. Therefore, it is recommended that all lionfish injuries receive medical treatment by a physician. First Responders should be trained and equipped in the treatment and management of lionfish punctures and envenomations for visitors and employees. Lionfish injury treatment advice is included in Appendix 6.

### ***NPS Operational Leadership Application to Staff Behavior***

All organizations have a safety program that includes policies, procedures, rules, regulations, and safety training designed to provide employees with a safe work environment. NPS Operational Leadership introduces a new tool within the NPS Safety Management Program – a tool designed to prevent or mitigate risk associated with human errors when we are faced with threats and hazards.

Operational Leadership is a “special human factor tool” that is a part of the National Park Service safety management system. The program identifies key risk factors that affect individual and team performance, including leadership effectiveness, accident causation, mission analysis, capabilities, situational awareness and communications. Employees throughout the Service are receiving Operational Leadership training and should use the program's principles and techniques in accomplishing all aspects of lionfish management.

### ***Public Risk Management Program***

RM 50C requires the implementation of a Public Risk Management Program for park areas. As a part of that program, Regional Directors are expected to provide leadership and support for injury prevention initiatives, to assess the effectiveness of public risk management programs and to hold managers accountable for establishing and maintaining an active and appropriate public risk management program.

In addition, Superintendents have the most direct responsibility for addressing risks to visitor safety. They are expected to:

1. Exercise good judgment and discretion to promote a safe and enjoyable park visit while achieving the mandates of the NPS Organic Act.
2. Ensure that this DO 50C order and associated local procedures are implemented and enforced.
3. Advise employees of their role regarding how this order is to be implemented locally.
4. Where appropriate, appoint a tort claims officer to manage claims and provide assistance to the DOI Office of the Solicitor.
5. Strive to minimize the frequency and severity of preventable visitor incidents.
6. Develop, implement and keep current written, site specific public risk management work plans as necessary.
7. Maintain a written record of decisions affecting public safety and the policy financial and other reasons for those decisions.
8. Periodically conduct self-audits of public risk management programs when risks are identified develop and implement strategies to mitigate the risk or provide information to the public where possible and needed, consistent with NPS mission and authorities.
9. Provide training and orientation on public risk management as appropriate.
10. Support efforts in the park to identify means for collecting and analyzing visitor injuries.
11. Incorporate public risk management elements in performance standards and competencies for employees at all levels of NPS individuals parks as appropriate.
12. Ensure that risk reduction decisions that affect or are affected by natural or cultural resources considerations are based on interdisciplinary and scientifically sound information.
13. Ensure that concessionaires, commercial use authorization holders, lessees, special use permits, cooperating associations and contractors are compliant with contract or other legal documents provisions relating to visitor risk.
14. As appropriate identify methods (e.g., websites, wayside exhibits, brochures, interpretive programs, podcasts) to inform and educate members of the visiting public about park risk management and to inform them of their responsibilities for their own safety when visiting parks.

Superintendents should review existing public risk management programs to (1) ensure that hazards related to lionfish are considered within the context of the program and (2) ensure that appropriate management protocols or decision trees are developed, if warranted. The details of these programs and protocols will vary, depending on the kinds and intensities of visitor use.

### ***Orientation and Training for Visitor Contact Staff***

*NPS Management Policies* require that parks provide a safe environment for visitors and employees. Although park visitors assume a substantial degree of risk and responsibility for

their own personal well-being, the park must apply appropriate measures informing them of known hazards. The superintendent of each park will ensure an appropriate means of action to educate the visiting public about potential human hazards of lionfish by implementing relevant outreach methods (Ref. DO 50C, 3.10q). These educational methods would present the public with identification of lionfish, envenomation risks, and necessary first aid actions. Education methods could be incorporated into brochures, exhibits, websites, youth outreach programs, and interpretation programs.

Visitor contact staff, including interpreters and volunteers, shall be trained in the identification and potential hazards of lionfish to visitors. New visitor contact staff will be trained in lionfish safety during their orientation. Visitors should be made aware of all potential marine hazards as the potential exists for injury from sharp corals or poisonous stings from stingrays, spiny sea urchins, fire coral, jellyfish as well as lionfish. Sharks and barracudas may be encountered and although they are usually not aggressive they should be treated with caution. Visitors should also avoid contact with any unknown marine life. These messages will be integrated into the overall underwater safety message of the park. Examples of these safety messages can be found in the References and Resources Section.

### ***Lionfish Safety Messages***

There are numerous messages available that warn visitors of the possibility of being stung when handling lionfish. Since lionfish inhabit a wide variety of marine habitats (reefs, grass beds, jetties, bridge pilings, etc.) the chance also exists for people to be stung when entering, wading, swimming and diving in areas where lionfish are located. To reduce the chance of incidental envenomation, parks should incorporate information regarding the possible presence of LF in existing messaging regarding underwater hazards. Basic first aid information and treatment recommendations should also be available.

### ***Ciguatera Fish Poisoning***

Ciguatera fish poisoning (CFP) is caused by a toxic dinoflagellate (*Gambierdiscus* sp.) that occurs in tropical coral reef habitats. The occurrence of CFP and *Gambierdiscus* does not follow a consistent geographic pattern. Ciguatoxins have been found at various levels in more than 425 species of reef fish, and lionfish meat may contain ciguatoxins in some locations where CFP occurs. However, it is not known if lionfish present higher risks of CFP than native reef fish species. The Food and Drug Administration (FDA) regulates food safety including standards for consumption of marine fish. Testing is underway by FDA and NOAA to better determine the occurrence of ciguatoxins in lionfish. The suggested advisory levels for ciguatoxins are 0.10 ppb C-CTX-1 equivalent toxicity in fish from the tropical Atlantic, Gulf of Mexico and Caribbean.

### **Interpret the Significance of the Lionfish Invasion**

The National Park Service has long used interpretation to impart an appreciation for--and ethic of stewardship towards--the wealth of resources under its care. In recognizing that diverse audiences also have a role to play in the successful management of lionfish and other invasive species, the service also endeavors to engage all audiences through inreach and outreach efforts. To this end, this plan offers the following recommended objectives and strategies.

**Table 2.** Description of park audiences.

<b>Audience Segment</b>	<b>Examples</b>
Park Visitors	Short-term visitors whose primary goal is passive enjoyment
Park Users	Concessionaires, charter boats, tours, swimmers, snorkelers, divers, anglers, etc.
Media	Writers, reporters, producers, film makers and others who engage large markets
Park Partners	Other Governmental Agencies, Friends Groups, NGOs, Foundations, Volunteers, etc.
Virtual Visitors	Audiences that explore park resources through impersonal media
Government Officials	Elected and appointed officials, agency administrators, etc.
National Park Service	Employees across all park divisions and all relevant park units.
Researchers	Permitted investigators from universities, organizations, and government agencies
Students and Youth	Formal education institutions, community groups, scout troops, etc.

***Communicate the Impacts of Lionfish***

Messages

Use the following Service-wide messages regarding the lionfish invasion:

- The introduction, establishment, and spread of invasive species challenge the mission and the purposes for which most parks are protected. History reveals a long litany of examples where introduced species have threatened to compromise the values for which national parks have become synonymous.
- The lionfish is a venomous predatory fish native to the Indo-Pacific waters that was introduced into Atlantic waters as early as the 1980s. Lionfish have the potential to impact many of our most treasured marine landscapes. The proliferation of lionfish may have the potential to significantly impact commercially, recreationally, and ecologically important species, and result in changes to the community composition and ecological function of various marine ecosystems. Consequently, the National Park Service is actively attempting to assess the implications of the lionfish invasion and minimize risks to the resources under our care.
- The invasion of lionfish is unique as it is currently the only known marine invasive fish species recognized to have established itself throughout the Caribbean and the coastal waters of the southeastern United States. Currently, twelve units of the National Park Service stand to be impacted by the lionfish, as well as many additional wildlife refuges and sanctuaries administered by related agencies. Management and control may require novel management strategies and close coordination across jurisdictional boundaries.
- Our nation’s coastal resources are degraded by a variety of natural and human-caused stressors, including hurricanes, fishing pressure, pollution, disease, rising seas, and



warming waters. Impacts from lionfish may exacerbate these stressors and threaten the continued existence of critically imperiled species, such as Federally-listed staghorn and elkhorn corals.

- Exploring the lionfish story reveals a tragic realization that mistakes inflicted upon our terrestrial landscapes similarly threaten our oceans. At the same time, discussions about this unprecedented invader might also provide inspiration to ensure similar invasions are prevented in the future.

### Methods

Each park should consider developing, or linking to, a standardized web page that serves as a clearinghouse to share important lionfish messaging, efforts, and data to all audiences. Sites should be linked to other affected units to convey the broad scale of NPS efforts. All new media developed about lionfish efforts should adhere to NPS Graphic Identity guidelines to help convey a unified effort, using templates provided by the NPS Graphic Identity project and boilerplate language in the development of interpretive lionfish products.

### ***Communicate National Park Service Plans to Manage the Lionfish Invasion***

#### Messages

Use the following Service-wide messages regarding National Park Service plans to manage the lionfish invasion:

- While eradication is unrealistic, the National Park Service is exploring active management efforts to monitor and suppress lionfish populations that include assessment, control strategies, and measures of success. To that end, parks are working collaboratively with numerous organizations, across jurisdictional boundaries, to plan response efforts that minimize the risk of harm.
- Parks are spreading awareness and stimulating a dialogue on many aspects of the invasion story. Materials are also being developed to help instill an appropriate level of caution in park visitors, encourage reporting, and help convey safe removal practices.

### Methods

Parks should consider making planning documents, relevant data, and statements on management efforts available to all audiences on each park's standardized web page. In addition, parks may develop a series of site-specific fact sheets identifying Frequently Asked Questions (FAQs) that address the status and management of lionfish at each respective unit, including:

- What is the venomous nature of the fish? What parts? How does envenomation work? What are the symptoms and treatments? Are they edible and, if so, how are they prepared?
- What is the source of the invasion and how are they being dispersed?
- What are the impacts? What do they eat? How much?
- What are the potential control methods?

## ***Create an Active Public***

### Potential Audiences

Parks should work to create an active public, across a variety of stakeholder groups, in responding to the lionfish invasion. This public may include park users, media, partners, National Park Service employees and volunteers, researchers and others.

### Potential Methods

Parks should consider developing and disseminating visual aids and materials through multiple media to instruct on accurate identification, safe removal techniques and to facilitate reporting, such as:

- Develop all-weather field identification card decks that feature lionfish and species often mistaken for lionfish that furnishes reporting numbers
- Develop online training modules that deliver content on identification and reporting at the convenience of the audience.
- Institute a “lionfish marker” program at high visitor use areas to facilitate reporting.

Parks can highlight how standing park policies and regulations relate to the capture and removal of lionfish, and communicate specific regulations unique to lionfish if applicable.

- Integrate lionfish-specific information into site bulletins, signage, etc. that currently conveys fishing regulations.

Parks can promote unified avenues of reporting across partners and the public that encourage participation, foster data sharing, and help coordinate a management response.

- Identify a shared database to be used across jurisdictions (i.e., USGS NAS reporting system) and promote its use through integration.

Parks can explore options for engaging recreational users in control efforts as volunteers or as part of an authorized agent program.

- Engage in active recruitment for a formal volunteer control crew and provide ongoing training and oversight.

Parks can encourage collaboration with organized groups and park partners who can assist NPS efforts in lionfish control, education, and funding.

- Facilitate data sharing from organized groups not operating in an official NPS volunteer capacity.
- Earmark fee demo money to help fund control efforts.
- Utilize friends groups and trusts to help coordinate fund raising efforts to aid in research and management efforts and to coordinate or organize fishing derbies.

Parks can explore opportunities to engage the larger community through organized events (trainings, lecture series, derbies, etc.) to raise awareness and activism in the effort.

- Target outreach programs to coastal communities and hobbyist groups.

Parks can integrate lionfish messaging in larger efforts currently in existence that encourage responsible consumerism, pet ownership, and environmental stewardship.

- Habitattitude and Stop Aquatic Hitchhikers (National Aquatic Nuisance Species Task Force supported campaigns)
- Include lionfish information in the *Don't Let It Loose* campaign and curriculum guide
- Use the lionfish example to encourage responsible aquaculture

Parks can encourage assistance in management efforts from park researchers through messaging and authorization disseminated via research permit or cooperative agreement.

- Develop materials and guidelines that permit coordinators can include in research permits to encourage lionfish detection or removal.

### ***Use the Lionfish Invasion as a Case Study***

#### Case Study

Broadly emphasize preventing species invasions and minimizing the damage from all existing invasions. Use the invasion of the lionfish as a case study to show the public how the species were introduced and how they have expanded, highlighting the problems caused by invasive species. This case study would conclude with messages designed to cultivate a responsible stewardship ethic.

#### Potential Methods

Parks should consider developing materials and programs that tell the story of the lionfish and cultivate a greater stewardship ethic, using these or similar techniques:

- Use the lionfish opportunistically to draw audiences into broader discussions about larger topics of invasive species, sustainability, and environmental ethics.
- Use the lionfish story to highlight the importance of prevention, early detection and rapid response, thereby encouraging audiences to report observations of all invaders.
- Provide reporting avenues in all communications materials to facilitate reporting
- Utilize the national parks as outdoor classrooms to have audiences explore multiple viewpoints and values at play in the lionfish invasion.

### ***Information Sharing Across Parks and Divisions***

#### Share Information

Parks should work to facilitate the flow of current, accurate information (reviewed through a process of vetting) and resources between parks and all divisions within the parks.

#### Potential Methods

Parks should consider appointing a point person to validate lionfish information and facilitate the information flow, including the following:

- Develop and present online and/or in-person briefings or trainings to familiarize park personnel with park efforts, materials, and safety protocols to ensure a consistent and accurate message.
- Supervisors can identify personnel eligible and available to participate in training opportunities and/or support their participation in control efforts.
- Tie lionfish management actions to objectives outlined in larger NPS planning initiatives (i.e. the Call to Action) to encourage buy-in and participation across all park personnel.
- Gauge the success of communication efforts at the park level through annual program reviews and implement changes as appropriate.

## **Developing a Park Specific Plan**

Parks need to develop a plan specific to their situation. If the park, in consultation with the Regional Environmental Coordinator, determines that a Categorical Exclusion (CE) under NEPA is sufficient, it is suggested that parks follow this plan outline:

### ***Suggested Park Lionfish Plan Outline***

1. Introduction
  - A. Problem Statement and Objectives
2. Current Park Situation Analysis
  - B. Park Overview
    - 1) Natural and Cultural Marine Resources
    - 2) Visitor Use Patterns
  - C. History and Current Status of Invasion in Park
  - D. Park Resource Impacts and Risks
    - 1) Regional Oceanographic Setting
    - 2) Ecological Impacts and Risks
    - 3) Visitor Experience Impacts and Risks
  - E. Current Park LF Activities and Management Actions
  - F. Authorities and Policies (Refer to Authorities and Policies section)
3. LF Management Actions
  - A. Management Alternatives – Post Invasion
    - 1) Prioritization of Areas (refer to Criteria and Processes to Prioritize Areas and Resources section)
    - 2) Control Targets (refer to Control Targets section)
    - 3) Control Techniques (refer to Control Techniques)
    - 4) Monitoring Plan (refer to LF and Ecological Monitoring sections)
    - 5) Adaptive Management
  - OR
  - A. Management Alternatives – Pre Invasion
    - 1) Prioritization of Areas Vulnerable to Colonization (refer to Criteria and Processes to Prioritize Areas and Resources section)
    - 2) Early Detection Monitoring Plan (refer to LF and Ecological Monitoring sections)
    - 3) Public Education and Reporting
3. Health and Safety (Refer to Health and Safety Section)
  - A. Employee Safety - Operational Leadership
  - B. Public Safety and Risk Management
4. Public Education and Outreach (refer to Public Information and Outreach Section)
5. Implementation Plan
  - A. Budget
  - B. Organizational Assets
    - 1) Funding
    - 2) Human (staff, partners, visitors)
    - 3) Capital (boats, equipment, etc.)

- C. Partnerships
- D. Periodic Evaluation of Response Plan Activities

Parks should consult with their Regional Environmental Coordinator to determine if an EA or EIS is required. The DO-12 Handbook suggests that a combined plan and EA (or EIS) can be used as a planning tool to expedite both implementation and compliance. It is suggested that parks follow this combined plan/EA outline:

***Suggested Park Lionfish Plan/Environmental Assessment Outline***

1. Introduction
  - A. Purpose of and Need for Proposed Action
  - B. Problem Statement and Objectives
2. Current Park Situation Analysis
  - A. Park Overview
    - 1) Natural and Cultural Marine Resources
    - 2) Visitor Use Patterns
  - B. History and Current Status of Invasion in Park
  - C. Current Park LF Activities and Management Actions
  - D. Authorities and Policies (Refer to Authorities and Policies section) (including NEPA)
  - E. Public Involvement
3. LF Management Actions and Alternatives
  - A. No Action Alternative
  - B. Management Alternatives – Post Invasion
    - 1) Prioritization of Areas (refer to Criteria and Processes to Prioritize Areas and Resources section)
    - 2) Control Targets (refer to Control Targets section)
    - 3) Control Techniques (refer to Control Techniques)
    - 4) Monitoring Plan (refer to LF and Ecological Monitoring sections)
    - 5) Adaptive Management

OR

  - B. Management Alternatives – Pre Invasion
    - 1) Prioritization of Areas Vulnerable to Colonization(refer to Criteria and Processes to Prioritize Areas and Resources section)
    - 2) Early Detection Monitoring Plan (refer to LF and Ecological Monitoring sections)
    - 3) Public Education and Reporting
4. Affected Environment/Existing Conditions
  - A. Park Resources and Risks
    - 1) Regional Oceanographic Setting
    - 2) Ecological Risks

- 3) Visitor Experience Risks
  - B. Health and Safety (refer to Health and Safety Section)
  - C. Employee Safety – Operational Leadership
  - D. Public Safety and Risk Management
- 5. Environmental Consequences
  - A. Park Resources Impacts and Risks
    - 1) Regional Oceanographic Setting
    - 2) Ecological Impacts and Risks
    - 3) Visitor Experience Impacts and Risks
  - B. Health and Safety (Refer to Health and Safety Section)
  - C. Employee Safety – Operational Leadership
  - D. Public Safety and Risk Management
- 6. Implementation Plan
  - A. Budget
  - B. Organizational Assets
    - 1) Funding
    - 2) Human (staff, partners, visitors)
    - 3) Capital (boats, equipment, etc.)
  - C. Partnerships
  - D. Periodic Evaluation of Response Plan Activities
- 7. Consultation and Coordination
  - A. Federal Agencies (including, but not limited to)
    - 1) USFWS (Endangered Species Act)
    - 2) NOAA/NMFS ([Magnuson Fishery Conservation Act](#)/Essential Fish Habitat)
    - 3) NOAA (Marine Mammal Protection Act)
  - B. State and Local Agencies (including but not limited to)
    - 1) State fish and wildlife agency
    - 2) SHPO (National Historic Preservation Act)
    - 3) Local government/ordinances
- 8. References

## Moving Forward

The National Park Service must implement this plan as soon as possible at a level commensurate with the severity and scale of the lionfish invasion. Parks must keep pace with rapid increases in lionfish populations by assessing their presence and safely removing them in targeted park areas. This requires both immediate action to develop park-level response plans, and organizational capacity to support sustained monitoring and removal in the long-term. NPS should develop funding and organizational capacity for park-level response plans to be fully operational no later than 2013. In addition, NPS should pursue partnerships to accomplish lionfish control, research and outreach needs, including state and federal agencies, non-governmental organizations, foundations, universities, volunteers, and other sources.

As noted, research into lionfish ecology will improve understanding of their impacts on native fish and invertebrate communities, and enable managers to set control targets based on risks associated with certain population thresholds of lionfish. Models that incorporate lionfish size, prey consumption rates, water temperature, prey diversity and productivity will enable biologically based control targets. The need for research notwithstanding, monitoring, removal and outreach all must go forward without delay to address the immediate, three-fold threat to ecological integrity, visitor experience and visitor safety in parks. Observations gained from monitoring and removal during these initial response efforts should yield valuable information to support research and adaptive management.

Finally, the challenges from aquatic nuisance species (ANS) argue for a more consistent and sustained response generally from NPS. Lionfish are not the first ANS to threaten parks. Two previous service-wide response plans were recently developed for quagga mussels and viral hemorrhagic septicemia (VHS). Resource managers have been contending with a multitude of exotic fish and invertebrates for many years in freshwater and marine environments. Aquatic resources in parks are no less vulnerable than terrestrial ecosystems to invasive species and require NPS to sharpen its focus on the profound ecological impacts of ANS. “Hundreds of introductions have occurred and nonindigenous species now inhabit many coastal marine communities from the Hawaiian Islands to New England. Every assessment indicates that the rate of marine introductions in U.S. waters has increased exponentially over the past 200 years and there are no signs that these introductions are leveling off. New introductions are occurring regularly on all coasts, producing immediate and damaging impacts, and leading to millions of dollars in expenditures for research, control, and management efforts” (Carlton 2001).





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## **Appendices**

1. Lionfish Fact Sheet
2. Staff, Partner and Volunteer Training Resources
3. Safe Work Practices for Handling Wildlife
4. Sample Job Hazard Analyses
5. NOAA Venomous Fish Handling Protocol
6. Lionfish Injury Treatment Advice
7. Outreach Resources
8. Summary of Lionfish Response Plan Workshop, September 13-16, 2011



## Appendix 1. Lionfish Fact Sheet



### Invasive Lionfish Facts

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#### Ecological impacts

- Impacts to biodiversity and resilience of coral, hardbottom, and artificial reefs.
- Potential reduction of ecologically important species such as cleaners, herbivores, and forage fishes.
- Interactions with other reef stressors could exacerbate lionfish impacts (e.g., ocean acidification, fishing impacts, etc.)
- Cascading impacts across food webs is possible (e.g., predation on herbivores, increased macroalgae, decreased coral biomass).
- Potential impacts to species of concern (Nassau grouper, Warsaw grouper, speckled hind, striped croaker, key silverside).
- Scale of ecological impacts is high in magnitude and geographically broad (North Carolina to the Caribbean and the Gulf of Mexico).

#### Socio-economic impacts

- Potential impacts to stock rebuilding efforts for commercially important species.
- Economic losses for commercial fishermen include loss of fishing days when envenomation occurs and reduction of native species catch rates.
- Potential economic loss in the trade of native marine ornamental species.

#### Human health impacts

- Lionfish sting symptoms include tachycardia, hypertension, hypotension, seizures, chest pain, abdominal pain, swelling, pain, and subdermal necrosis at the sting site, and temporary paralysis to all extremities.
- Long term health impacts of repeated envenomations are unknown.
- Divers, fishermen, and swimmers are at increased risk of envenomation at locations where lionfish have reached high densities.
- Envenomation risk to bathers/swimmers increases at locations with structure such as piers, breakwaters, and confined tidal swimming pools.
- Lionfish, similar native reef fish, may cause ciguatera fish poisoning in some locations.

#### Control

- Control plans that support sustained removals can significantly reduce local lionfish densities.
- Tools for local lionfish control include commercial harvesting as a food fish, harvesting juveniles for the aquarium trade, sport tournaments, and adopt-a-reef and other citizen-based removal efforts.
- Based on current technology, lionfish eradication at the regional scale is likely not feasible given the expansive depths and geography of lionfish habitat.

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Updated May 1, 2011

## Appendix 1 (continued)



### Invasion history

- Lionfish was first documented as established off the coast of North Carolina in 2000.
- Two visually identical species (*Pterois miles* and *P. volitans*) of lionfish were introduced into the Atlantic via the U.S. aquarium trade beginning in the 1980's.
- Lionfish are widespread throughout the Southeast U.S., Caribbean, and are presently invading the Gulf of Mexico.
- Lionfish are expected to invade South America as far south as the northern coast of Argentina.
- Lionfish have established throughout most of the Caribbean in less than five years.

### Biology

- Lionfish may live decades and reach sizes up to 47cm (19 inches).
- Lionfish inhabit all marine habitat types and depths (shoreline to over 1000').
- Lionfish possess venomous spines capable of deterring predators and inflicting serious stings and reactions in humans.
- Lionfish temperature tolerance is approximately ~10 – 35C.
- Lionfish become sexually mature in less than one year and spawn in pairs.
- A single female lionfish spawns over ~2 million eggs/year.
- Lionfish eggs are held together in a gelatinous mass and are dispersed by currents.
- Lionfish larval duration is ~25 days.

### Ecology

- Lionfish can reach densities higher than 200 adults per acre.
- Lionfish are generalist carnivores that consume >56 species of fish and many invertebrate species, with prey exceeding half the lionfish's body size.
- Many lionfish prey are commercially, recreationally, and ecologically important.
- Native predators have been observed to exhibit avoidance for lionfish.
- Lionfish have very few parasites compared to native species.
- Lionfish exhibit site fidelity.
- Lionfish have high affinity for structure and feed primarily during dawn and dusk time periods.



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Updated May 1, 2011

## **Appendix 2. Staff, Partner and Volunteer Training**

<http://inside.nps.gov/index.cfm?handler=training>

<http://www1.nrintra.nps.gov/wrd/marine/>

<https://doilearn.doi.gov>





## Appendix 3. Safe Work Practices for Employees Handling Wildlife

### ***NPS RM 50B, 4.15 SAFE WORK PRACTICES FOR EMPLOYEES HANDLING WILDLIFE***

#### Purpose

The purpose of this document is to provide guidance that will assist National Park Service (NPS) staff in identifying and mitigating risks associated with handling wildlife so that important natural resource management and visitor protection activities can be performed in a safe manner.

***Even if only brief and incidental to primary duties, any park unit employee may come into contact with live or dead animals. All employees are encouraged to review this document and consider when and how to protect themselves from the potential hazards of handling wildlife.***

#### Background

NPS staff handle a wide range of wildlife species under a variety of circumstances in efforts to manage park resources, maintain park facilities, provide for visitor experiences, and protect human health and safety. Wildlife biologists may be the most recognized animal-handlers due to their work in wildlife capture, tagging, sampling, monitoring, translocation, and research. In addition to handling live animals, biologists also may handle dead animals for diagnostic submission, necropsy, or disposal. These investigations on both live and dead wildlife are critical because they contribute to a better understanding of park resources and help managers make informed decisions.

While biologists may handle wildlife most frequently, they are not the only employees who come into contact with wildlife. Maintenance workers and others deal with wildlife as well, often for removal from structures or for disposal. In fact, the mission of the NPS to conserve natural resources while providing for their enjoyment inherently brings wildlife and people, both staff and visitors, into closer proximity in parks than most other areas. These management activities and human-wildlife interactions often are vital to meeting park objectives and fulfilling NPS mandates; however, they are not without some risk.

Although an inherent risk to human health and safety exists with each wildlife encounter, this risk should be viewed in perspective with other hazards and a comprehensive approach to occupational safety used to reduce a variety of risks. This prudent approach to minimizing risks of injury or illness includes an understanding of basic safety measures and disease transmission, common sense, and awareness of surroundings. Basic safety measures may mean implementing the use of proper protective equipment for a particular job, or traveling in pairs and informing a supervisor of activities, especially if traveling alone. An understanding of potential zoonotic diseases – those diseases that can be transferred between humans and animals – not only can help prevent illness, but also aid in the identification of symptoms that can lead to timely medical attention.

### Appendix 3 (continued)

Equally important to implementing basic safety measures and becoming informed on potential zoonotic disease risks, is having an awareness of the general environment. Planning for expected terrain, weather, or wildlife interactions, informs decisions on what personal protective equipment (PPE) to bring to the field. Although it is unreasonable to contain all risks or control the natural environment, deliberate **P**lanning, **P**reparation, and **E**xecution of safety measures, as appropriate for the situation, can reduce the chances of illness or injury.

#### Objectives

To assist NPS staff in preparing Job Hazard Analyses (JHA) for handling wildlife by:

- Identifying types of risks that may be encountered when handling wildlife, *and*
- Introducing appropriate levels of precautions based on specific activities.

A thorough understanding of potential hazards associated with different activities performed by employees working with wildlife is essential in providing a safe work environment. When conducting wildlife studies, analyzing and mitigating risks are integral parts of every job.

A JHA is a multi-step process designed to study and analyze a job in a particular working environment. It breaks a task down into steps, identifies potential risks associated with each component, and may reveal ways of reducing or eliminating these hazards. JHAs result in a detailed written procedure for safely completing a particular job. (See Reference Manual 50B Section 3.1 Job Hazard Analysis)

***The key to a successful Job Hazard Analysis is avoiding a “one size fits all” approach. The process is meant to stimulate constructive conversation between supervisors, employees, and others involved in the task. The outcome is a written document outlining the steps of the job, the potential hazards, and proposed actions to avoid or mitigate these hazards.***

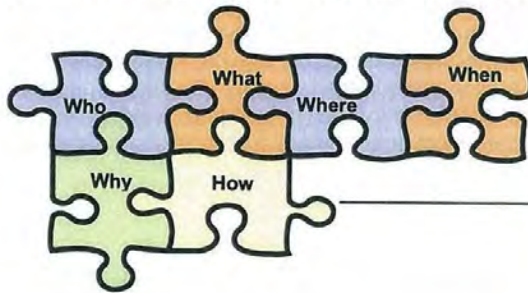
## Appendix 3 (continued)

### Visual Guide for Safe Work Practices

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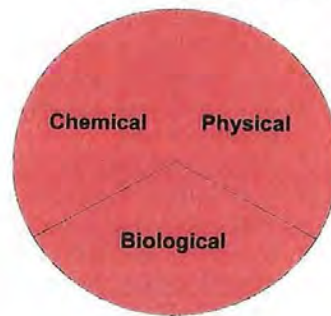
#### Plan

(Define the task and the context in which it will occur)



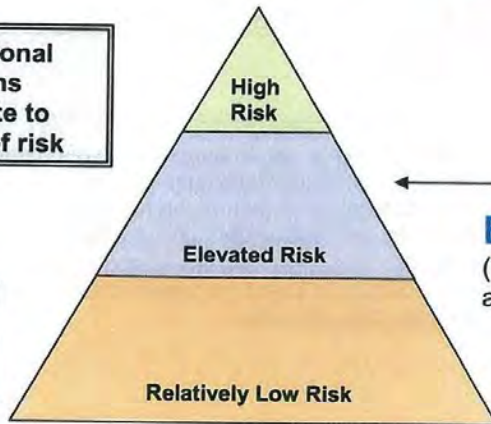
#### Prepare

(Understand the hazards; this may require outside assistance)



Use additional precautions appropriate to the level of risk

Use Standard Precautions



#### Execute

(Carry out the protective actions appropriate to the level of risk)

## Appendix 3 (continued)

### **Plan**

A number of physical, chemical, and biological risks are present in everyday field work, but these threats can be increased when focus is being placed on handling wildlife. Handling wildlife is inherently risky to human health and safety in part due to the level of uncertainty and unpredictability associated with the activity. To better understand, prepare for, and moderate these risks, the tasks must be well defined and each component carefully considered. This may be accomplished by describing who, what, where, when, why, and how each part of the job will be completed (see Table 1). By clearly explaining each of these components, as well as identifying the equipment and personnel needed to complete them, the analysis can uncover potentially hazardous situations and allow for appropriate mitigation.

**Table 1.** Defining the task

Who	<ul style="list-style-type: none"><li>• who assumes responsibility for supervision of the overall project</li><li>• who completes the collection, transport, or shipping of an animal, or of wildlife samples</li></ul>
What	<ul style="list-style-type: none"><li>• what parts of animal collection, sampling, or transport present a hazard</li><li>• what training is necessary</li><li>• what recourses are available for additional information</li></ul>
When	<ul style="list-style-type: none"><li>• when are these actions appropriate (does the benefit outweigh the potential risks)</li><li>• when should specific actions be performed</li></ul>
Where	<ul style="list-style-type: none"><li>• where should these tasks be completed</li><li>• where should animals/samples be transported to</li></ul>
Why	<ul style="list-style-type: none"><li>• why is the task necessary</li><li>• why is the task potentially hazardous</li></ul>
How	<ul style="list-style-type: none"><li>• how should the task be completed (a detailed explanation)</li><li>• how breaches in safe work practices will be handled</li></ul>

### **Prepare**

Perhaps the most critical element of the JHA is having an appreciation of potential hazards of working with wildlife. Hazards may be grouped into three general categories: physical, chemical, and biological. Examples of each hazard type may be found in Table 2. While chemical and physical hazards may be relatively easily identified, biological hazards are more likely to be unrecognized or misunderstood. Therefore, this document provides proportionately more information and resources to assist managers in identifying biological hazards, primarily sources of infectious zoonotic disease.

## Appendix 3 (continued)

**Table 2.** Potential Risks

Category	Specific Risk
Physical	<ul style="list-style-type: none"> <li>• Environmental               <ul style="list-style-type: none"> <li>-Uneven or extreme terrain (e.g., slips, trips, falls, avalanche, wind)</li> <li>-Elevation (e.g., altitude sickness)</li> <li>-Climate (e.g., dehydration, drowning)</li> <li>-Weather (e.g., lightning, exposure to heat, cold, UV radiation)</li> </ul> </li> <li>• Animals               <ul style="list-style-type: none"> <li>-Predators</li> <li>-Handled animal (e.g., kicks, bites, crushing, strains)</li> <li>-Associated animal (e.g., attack from another member of the group)</li> </ul> </li> <li>• Equipment               <ul style="list-style-type: none"> <li>-Firearms</li> <li>-Helicopters</li> <li>-Biomedical sharps (e.g., needles, scalpels, necropsy knives)</li> <li>-Vehicles, live-capture traps, transport cages</li> </ul> </li> <li>• Man-Made               <ul style="list-style-type: none"> <li>-Traffic</li> <li>-Noise</li> <li>-Electrical</li> </ul> </li> </ul>
Chemical	<ul style="list-style-type: none"> <li>• Task Specific               <ul style="list-style-type: none"> <li>-Pharmaceuticals (e.g., anesthetics, antibiotics)</li> <li>-Chemicals used for specimen preservation (e.g., formalin)</li> <li>-Disinfectants (e.g., bactericides, viricides)</li> </ul> </li> <li>• Environmental               <ul style="list-style-type: none"> <li>-Toxins (e.g., pesticides, herbicides)</li> <li>-Gases (e.g., hydrogen sulfide, sulfur dioxide)</li> <li>-Chemical spills (e.g., gasoline, oil)</li> </ul> </li> </ul>
Biological	<ul style="list-style-type: none"> <li>• Infectious zoonotic disease</li> <li>• Exposure to venomous animals or allergic reaction to any animal</li> <li>• Poisonous</li> </ul>

### A. Physical

Employees working outdoors are exposed to many types of physical hazards depending on the type of work, geographic region, season, and duration of time spent outside. In addition, man-made hazards such as electrical overhangs, utilities, canals, and various types of infrastructure, should be identified and assessed prior to work.

#### *1. Injury (due to animals or equipment)*

Wild animals can inflict injury on humans unintentionally or as an act of aggression or defense. While mammalian predators and venomous reptiles often are thought of as dangerous, most wildlife can injure humans through biting, kicking, scratching, stomping, or crushing. An understanding of animal behavior is essential for safely handling wildlife.

## Appendix 3 (continued)

In addition to hazards associated with direct animal handling, much of the equipment, if improperly used, can be dangerous to humans. Traditional firearms, remote delivery systems (i.e., dart guns), traps, and snares can cause trauma to humans. Knives, needles, and other sharps can also cause injury. Use of aircraft for animal capture and monitoring poses an additional risk. Department of the Interior policies on use of firearms by non-law enforcement personnel and ACETA (Aerial Capture, Eradication, and Tagging of Animals) are under development.

### 2. Injury (due to environment)

Although the allure of working outdoors attracts many people to the NPS, there are unique hazards employees encounter when working outdoors. The basic hazards that need consideration when working outside are:

Exposure to:

- Heat Stress
- Cold Stress
- Dehydration
- UV Radiation (Sun)
- Lightning
- Wind (falling trees/limbs)

Topography:

- Elevation
- Water hazards

### B. Chemical

Chemical hazards can be divided into those associated directly with wildlife capture or handling, and those already part of the environment. Chemicals related to handling wildlife include pharmaceuticals (e.g., anesthetics), reagents used to preserve biological samples (e.g., formalin), and disinfectants (e.g., bleach). Pharmaceuticals used to immobilize wildlife can be dangerous and potentially life-threatening. Exposure to drugs may occur through accidental injection, ingestion, or absorption through mucous membranes or breaks in the skin. See Kreeger et al., 2002, for an overview of human safety associated with chemical immobilization; see Draft Director's Order #77-4, Use of Pharmaceuticals for Wildlife, for NPS requirements on use of wildlife pharmaceuticals. Material safety data sheets (MSDS) for many chemicals used in laboratory analysis of samples can be found at MSDS Search ([www.msdssearch.com](http://www.msdssearch.com)).

Environmental chemical hazards may be either naturally occurring (e.g., sulfur dioxide), may be intentionally applied (e.g., pesticides, herbicides), or could be accidentally spilled (e.g., gasoline, oil). Exposure to these substances from dermal contact (either direct or indirect) or inhalation may result when working in contaminated environments. If the substance is known, obtain an MSDS and evaluate the activity to be conducted and determine the likely risk exposure.

### Appendix 3 (continued)

#### *C. Biological*

There are a variety of biological hazards associated with handling wildlife. Some of the most common are exposure to venomous animals (e.g., snakes) and hypersensitivity type allergic reactions due to contact with any plant or animal a person is responsive to (e.g., bee stings, pollen, poison ivy). While less common and potentially less well understood, transmission of infectious diseases between wildlife and humans also poses an important biological hazard. Diseases that are shared between animals and humans are termed zoonotic diseases. Zoonotic diseases are generally uncommon; however, the consequences of disease may be high. This can lead to an increase in concern and dread about infection. There are a number of established zoonotic diseases of importance (see the ZED website at <http://inside.nps.gov/publichealth/zed/zed.htm>) and new zoonotic diseases continue to emerge (e.g., highly pathogenic avian influenza Asian strain H5N1). Concern at some level is prudent. Further, many zoonotic diseases (e.g., plague, West Nile virus, brucellosis, bovine tuberculosis, and in most areas, rabies) are exotic to park systems and impart negative impacts not just on human health, but also on the health of native wildlife species. Therefore, management of these diseases may be warranted.

Transmission of zoonotic diseases requires three elements: an infection source, a susceptible host, and a route of transmission for the pathogen (Siegel et al., 2007). Potential zoonotic infection sources include animals, carcasses, body fluids (e.g., blood, urine, and saliva), feces, aborted fetuses, and environments (e.g., water, soil, burrows) contaminated by infected animals. Besides humans, susceptible hosts can include other species or animals of the same species. Transmission routes for zoonotic diseases are varied and depend on many factors, including the biological properties of the pathogen and the way in which the pathogen leaves the infected host.

There are three main routes of transmission for zoonotic pathogens: contact, through the air, and via vectors (see Table 3). It is possible for the same pathogen to be transmitted by multiple routes. Contact transmission occurs when pathogens enter the human host by ingestion, mucous membrane contamination, or through breaks in the skin. Direct contact transmission occurs when the pathogen is transferred after handling infected animal or biological samples from an infected animal. Indirect contact transmission may occur by handling contaminated objects, touching contaminated surfaces, or from the environment. Transmission via air occurs when pathogens from animals or their environments travel through the air and are inhaled or deposited on mucous membranes. Pathogens may become aerosolized when an infected animal coughs or sneezes, when contaminated dust particles are disturbed, or through aggressive handling of infected animal tissues. Some pathogens (e.g., plague) may be transmitted by respiratory droplets or splashing of contaminated fluids. These pathogens travel only short distances through the air in droplet form and require close proximity (<2 m) to the infected animal or environment. Other pathogens (e.g., hantaviruses) may be transmitted as ultra-small particles and can travel longer distances by air currents. Vector-borne transmission occurs when a biting arthropod (e.g., mosquitoes, ticks, fleas) transfers the pathogen from an infected animal to a human host. Vectors may be encountered when handling wild animals and when working in field settings.

## Appendix 3 (continued)

**Table 3.** Disease Transmission Routes

Transmission Route	Entry Into Body	Risk Activity Examples	Disease Examples
<b>Contact-Direct</b>	Ingestion, mucous membrane contamination, breaks in the skin	Trapping, handling, sampling live or dead animals; handling animal samples (e.g., blood)	Rabies, <i>Salmonella</i> , plague, tularemia, brucellosis, anthrax, scabies
<b>Contact-Indirect</b>	Ingestion, mucous membrane contamination, breaks in the skin	Handling contaminated equipment such as traps, lab or field equipment, needles, pencils, soiled laundry, vehicle interiors, countertops	Rabies, <i>Salmonella</i> , plague, tularemia, brucellosis, anthrax, scabies
<b>Aerosol</b>	Inhaled small particles or droplets deposited on mucous membranes	Disturbing contaminated dust particles (e.g., cleaning buildings), close contact with animals	Small particulate: hantaviruses, highly pathogenic avian influenza Droplet: Plague
<b>Vector-borne</b>	Bite of infected invertebrate animal (e.g., tick, flea, mosquito)	Working in environment with vectors; handling carcasses infested with vectors	Lyme disease, plague, tularemia, Rocky Mountain spotted fever, relapsing fever, West Nile virus

### ***Execute (applying strategies for mitigation)***

Once potential chemical, physical, and biological hazards are identified, mitigation strategies may be implemented. Excellent communication between supervisors, employees, and others participating in the task, is the first step in mitigating a hazard. Each party plays a role in taking responsibility for creating and maintaining a safe working environment. Part of this communication requires a working knowledge of potential hazards, familiarity with appropriate working conditions, and recognition of the need for additional training. Management support for training, clear description of the scope of work, development of standard operating procedures (SOPs), and on-the-job monitoring are necessary to reap the benefits of JHAs. It is important to remember that familiarity with an activity or expertise in a subject area can lead to complacency by employees and supervisors. The key is to always think through the task, identify the potential hazards, and provide for reasonable safety precautions, no matter how often a job has been performed. For resources related to mitigating general hazards, see Table 4.

The types of approaches used to prevent human injury or illness during wildlife capture and/or handling vary with factors such as the species, sex, age of the animal, behavior of animal (wild, habituated, food-conditioned), reason for animal handling, level of employee experience, and presence of enzootic zoonotic disease(s). In general, handling devices (e.g., squeeze chambers in traps and other restraint mechanisms) and/or animal anesthesia can decrease the risk of physical injury from animals that are not easily restrained; however, training and familiarity are required



### **Appendix 3 (continued)**

for the safe use of these tools. These techniques may not be appropriate under all conditions or may not be sufficient for hazard reduction if used alone. Reducing biological risks generally requires an appropriate barrier between the animal, or animal samples, and the handler (e.g., gloves, coveralls, or eye/respiratory protection). Additional methods for hazard reduction may include the following:

- Development and review of protocols or SOPs on animal handling
- Daily or periodic project safety briefings and post-handling debriefing
- Training on appropriate techniques for chemical or physical restraint
- Awareness of intentional or accidental trauma from animals
- Awareness of potential zoonotic diseases in the area or handled species
- Vaccination against potential pathogens as appropriate to the level of risk (e.g., rabies, tetanus)
- Training on when and how to use PPE
- Contingency plans (e.g., escape route, contact information for medical advice)

While human safety is the primary goal, these techniques should not be used in a manner that puts animals at undue risk of injury, excessive stress, or capture-related death.

Training employees in the essential components outlined in this document is critical to protecting workers from injuries and illnesses when conducting wildlife management or research, nuisance animal removal, and pest control. Training is an important part of the NPS safety and health program. If employees are unfamiliar with specific job hazards and proper work practices, this may be a cause for higher injury rate, and training may provide a solution. The NPS regularly produces a variety of training courses that can be useful in providing information for working safely. Information may be found on the DOI Learn website at <https://doilearn.doi.gov>, and the ZED website.

SOPs are appropriate for jobs where the same basic actions will be repeated regularly, and are particularly helpful when consistency is needed to ensure suitable outcomes. They need not be onerously detailed or prohibit deviations for unique circumstances in the field. SOPs are often indirectly incorporated into wildlife capture or management plans. For example, an SOP for necropsy procedures may be particularly helpful to direct use of PPE, ensure consistent sampling, explain correct shipping, provide for adequate sanitation, and describe situations that may indicate high risk wildlife mortality events. For sample submission instructions, see the NPS Wildlife Health website.

#### A. Mitigating General Hazards

There are general safe work practices that provide protection against a variety of the most common hazards (see Table 4).

## Appendix 3 (continued)

**Table 4.** General Hazard Mitigation

Hazard	Exposure	PPE and Safe Work Practices
Physical	Contact	<p>NOAA's National Weather Service Heat Index                      Heat Stress Facts                      Protect Yourself from the Sun                      Cold Stress Facts                      Cold Card                      Hazard from Mudslides                      Landslides                      Flashflood Warning System                      NIOSH Slips, Trips, Falls                      Work Zone Traffic Safety                      RM 50 B Section 4.2                      Hearing Loss Prevention                      Lightning                      Proper Biomedical Sharps Disposal</p>
Chemical	<ul style="list-style-type: none"> <li>• Inhalation</li> <li>• Ingestion</li> <li>• Dermal absorption</li> <li>• Injection</li> </ul>	<p>RM 50 B Section 4.4 Hazard Communications                      OSHA Hazardous Communication Standard                      MSDS Search                      NIOSH Pocket Guide to Chemicals                      NIOSH Respirator Topic Page                      Formalin MSDS</p>
Biological	No high risk exposure anticipated	<p><u>Standard Precautions:</u>                      Hand Hygiene – <b>Hand washing with soap and water is the single most important measure for reducing the risk of disease transmission.</b> Alcohol-based sanitizers can be used as an adjuvant to hand washing (particularly when running water is not available), but is not a substitute for hand washing.                      Promptly disinfect soiled equipment, environmental surfaces, and other contaminated items using an appropriate disinfection agent; dispose of biological waste properly.                      Do not eat, drink, or smoke when handling animals.                      When working with wildlife indoors, be sure to work in a well-ventilated area.                      Avoid needle sticks or cuts during handling; report injuries.                      Take care to avoid and/or use physical barriers for protection from wildlife defense mechanisms (e.g.,</p>

Hazard	Exposure	PPE and Safe Work Practices
		<p>bites, scratches, stings).</p> <p>Transport, ship, and store samples according to applicable regulations (do not store samples with food).</p> <p>Discuss need for prophylactic vaccination (e.g., rabies, tetanus) with physician.</p> <p>Carry appropriate medications/tools to treat allergic hypersensitivities and mitigate venomous bites (e.g., epinephrine auto-injector, snake bite kit).</p> <p>Seek medical attention if concerned about an exposure to a zoonotic disease or if ill, inform physician of potential exposures.</p>
	Contact	<p><u>Add to Standard Precautions:</u></p> <p>Disposable gloves should be readily available and worn when touching blood, body fluids, secretions, excretions, mucous membranes, and non-intact or diseased skin.</p> <p>Coveralls, lab coat, or dedicated clothing.</p> <p>Goggles if splash risk exists.</p> <p>Impermeable gloves (e.g., leather) if handling animals that may bite or scratch.</p>
	Aerosol	<p><u>Add to Standard and Contact Precautions:</u></p> <p>Mask (droplet hazards) or respirator (inhaled particulate hazards). Use of respirator requires specific program elements (See Reference Manual 50 B Section 4.3 Respiratory Protection)</p> <p>Eye protection: Goggles appropriate to the disease risk.</p>
	Vector	<p><u>Add to Standard Precautions:</u></p> <p>Insect repellents on body and clothing.</p> <p>Wear light colored long-sleeved clothing and long pants.</p> <p>Wear coveralls or dedicated clothing if ticks or fleas are a concern.</p> <p>Minimize activities at dawn and dusk if mosquitoes are a concern.</p> <p>Tick checks.</p> <p>Bag animal carcass with insecticide if arthropods observed.</p>

## Appendix 3 (continued)

### B. Mitigating Specific Zoonotic Disease Risks

Standard Precautions (Table 4) are infection control measures that should be applied at all times by all persons when working with or exposed to wildlife. Standard precautions alone are likely adequate protective measures for low-risk situations, such as working with apparently healthy animals in areas without enzootic disease.

Beyond these Standard Precautions, certain situations may present additional risks for zoonotic disease transmission that require other protective work measures and practices. The first step in mitigating disease hazards is to identify if a zoonotic pathogen may exist in the species of wildlife being handled and in the region of the country where the work is being done. Additionally, it is important to assess the relative likelihood of pathogen presence. An abbreviated list of zoonotic disease pathogens is available on the ZED\_website. This website also contains links and reprints of publications on specific safe work practices for some of the most serious zoonotic diseases. Several zoonotic disease handbooks also are available (e.g., Heymann 2004). Additionally, consultation with a wildlife disease professional is warranted and encouraged if there are questions or uncertainty about zoonotic disease risk in a given area or species. Once a disease risk has been recognized, a transmission route(s) can be determined and appropriate safe work practices and PPE selected for the job. See Table 5 for recommendations on appropriate PPE for specific tasks and conditions.

*The keys to preventing exposure to zoonotic diseases are:*

- 1. Use available resources to identify potential zoonotic pathogens.*
- 2. Determine potential route(s) of transmission (contact, aerosol, vector-borne).*
- 3. Determine appropriate safe work practices and PPE to prevent exposure.*
- 4. Implement these measures when working in potential exposure situations.*

## Appendix 3 (continued)

**Table 5. Specific Activities with Exposure to Zoonotic Disease Pathogens and Protective Practices**

<b>Activity</b>	<b>Conditions</b>	<b>Activity Risk</b>	<b>PPE</b>	<b>Work Practice</b>
1. Handling apparently healthy live animals.	No substantial local zoonotic disease concerns or vectors.	Zoonotic disease risk from casual contact is minimal.	<ul style="list-style-type: none"> <li>• Clothing appropriate to the nature of the operation</li> </ul> <i>Except:</i> <ul style="list-style-type: none"> <li>• Disposable gloves and eye protection when handling healthy birds<sup>1</sup></li> </ul>	1. Use Standard Precautions.
2. Handling biological samples from apparently healthy live animals.	No substantial local zoonotic disease concerns or vectors.	Zoonotic disease risk may increase with contact of body fluids or biological samples from animals.	<ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Coveralls, lab coat, or dedicated clothing</li> </ul>	1. Use Standard and Contact Precautions.
3. Handling apparently healthy live animals (or samples) from areas with known zoonotic disease risks.	Disease exists (or spills into) handled species or vectors associated with handled species.	Risk increases if a zoonotic disease is known to be present in the area, a species, or vector (e.g., plague, rabies, brucellosis).	<ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Coveralls, lab coat, or dedicated clothing</li> <li>• Eye and respiratory protection as appropriate to the level of disease risk</li> </ul>	<ol style="list-style-type: none"> <li>1. Use Standard and Contact Precautions plus appropriate precautions for transmission routes of diseases of concern.</li> <li>2. Become familiar with symptoms of the disease in humans and seek medical attention if symptoms occur (inform health care provider of occupation and potential exposure).</li> </ol>
4. Handling sick or injured live animals.	For euthanasia, sampling, or transportation.	Risk increases because cause of illness may be zoonotic and sources of contaminations may increase (e.g., diarrhea)	<ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Coveralls, lab coat, or dedicated clothing</li> <li>• Eye and respiratory protection as appropriate to the level of disease risk</li> </ul>	<ol style="list-style-type: none"> <li>1. Use Standard and Contact Precautions plus appropriate precautions for transmission routes of diseases of concern.</li> <li>2. Submit diagnostic samples (if ill).</li> <li>3. Prevent visitors or others from contacting a sick or injured animal.</li> </ol>
5. Handling for disposal or submission of animal found dead.	Single dead animal in area with no substantial local zoonotic disease or vectors.	<p>Small animal: Risk is minimal if barrier is used.</p> <p>Large animal: Risk is limited but may increase with size of animal being handled due to potential for contamination</p>	<p>Small animal:</p> <ul style="list-style-type: none"> <li>• Disposable gloves or inverted bag for collection</li> </ul> <p>Large animal:</p> <ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Coveralls, lab coat, or dedicated clothing</li> <li>• Eye and respiratory protection as appropriate to the level of disease risk</li> </ul>	<ol style="list-style-type: none"> <li>1. Use Standard and Contact Precautions plus appropriate precautions for transmission routes of diseases of concern.</li> <li>2. Transport outside passenger area of vehicle (i.e., bed of truck or trunk).</li> <li>3. Bag carcass tightly if it must be placed in passenger compartment or to avoid leakage of blood or other body fluids into the environment.</li> <li>4. Cover all carcasses.</li> </ol>
6. Handling for disposal or submission of	Multiple dead animals in any event or single	Risk may differ if the mortality event is	<p>Small animal:</p> <ul style="list-style-type: none"> <li>• Disposable gloves or inverted bag for</li> </ul>	<p>Follow work practices described in #5 above.</p> <p><i>In addition:</i></p>

<sup>1</sup> DOI memorandum on: Employee Health and Safety Guidance for Avian Influenza Surveillance And Control Activities in Wild Bird Populations

## Appendix 3 (continued)

**Table 5. Specific Activities with Exposure to Zoonotic Disease Pathogens and Protective Practices**

<b>Activity</b>	<b>Conditions</b>	<b>Activity Risk</b>	<b>PPE</b>	<b>Work Practice</b>
multiple animals found dead.	dead animal in an area of substantial zoonotic disease or vector risk.	recurring (e.g., juvenile birds washed ashore) vs. unexpected.	collection Large animal: <ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Coveralls, lab coat, or dedicated clothing</li> <li>• Eye and respiratory protection as appropriate to the level of disease risk</li> </ul>	<ol style="list-style-type: none"> <li>1. Inform wildlife biologist of finding and consult with wildlife disease professional for potential causes of illness.</li> <li>2. In an unexpected mortality event: Submit 1-5 animals for diagnostic evaluation and dispose of remaining carcasses in landfill or other approved means.</li> <li>3. Store samples in approved locations according to protocols.</li> <li>4. Become familiar with symptoms of diseases of concern in humans and seek medical attention if symptoms occur (inform health care provider of occupation and potential exposure).</li> </ol>
7. Handling dead animal for necropsy, dissection, or food processing.	Healthy appearing animal that is collected for management or research or animal found dead with no known zoonotic disease risk.	Risk is increased due to closer contact with a variety of body fluids and tissues, but no reason to suspect presence of pathogens or vectors.	<ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Coveralls, lab coat, or dedicated clothing</li> </ul>	<ol style="list-style-type: none"> <li>1. Use Standard and Contact Precautions.</li> <li>2. If an animal has received any drugs (anesthetics, euthanasia agent), it is unfit for human consumption and must be removed from the human food chain.</li> </ol>
8. Handling dead animal for necropsy or dissection.	Animal found dead, animal that has been observed ill, or species with known zoonotic risk (e.g., bat, ground squirrel).	Risk is increased due to closer contact with a variety of body fluids and tissues and unknown cause of death.	<ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Coveralls, lab coat, or dedicated clothing</li> <li>• Eye and respiratory protection as appropriate to the level of disease risk</li> <li>• Shoe covers or boots which can be disinfected</li> </ul>	<ol style="list-style-type: none"> <li>1. Consult with public health prior to use of carcass or carcass parts for display or educational purposes.</li> <li>2. Become familiar with symptoms of the disease in humans and seek medical attention if symptoms occur (inform health care provider of occupation and potential exposure).</li> <li>3. Become familiar with warning signs for unusual mortality events: <ul style="list-style-type: none"> <li>- Multiple dead animals</li> <li>- Blood coming from body orifices (nose, rectum) without obvious signs of trauma</li> <li>- Animals displaying neurologic signs prior to death.</li> </ul> </li> </ol>
9. Collection of biological samples from the environment for management or research.	Collection of samples (feces, urine, fetuses) from the environment where no known zoonotic enzootic disease occurs.	Risk from contact with body fluids and tissues, but no known disease is present.	<ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Coveralls, lab coat, or dedicated clothing</li> </ul>	<ol style="list-style-type: none"> <li>1. Use Standard and Contact Precautions. <i>In addition:</i></li> <li>2. Store samples in approved and dedicated specimen storage location according to protocols.</li> </ol>

## Appendix 3 (continued)

Table 5. Specific Activities with Exposure to Zoonotic Disease Pathogens and Protective Practices

Activity	Conditions	Activity Risk	PPE	Work Practice
10. Collection of biological samples from the environment for management or research.	Collection of samples (feces, urine, fetuses) from the environment where zoonotic disease or vectors occur.	Risk from contact with body fluids and tissues from potentially infected animals or their parasites.	<ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Coveralls, lab coat, or dedicated clothing</li> <li>• Eye and respiratory protection as appropriate to the level of disease risk</li> <li>• Shoe covers or boots which can be disinfected</li> </ul>	<ol style="list-style-type: none"> <li>1. Use Standard and Contact Precautions plus appropriate precautions for transmission routes of diseases of concern.</li> </ol> <p><i>In addition:</i></p> <ol style="list-style-type: none"> <li>2. Consult a wildlife health professional for potential causes of illness.</li> <li>3. Become familiar with symptoms of the disease in humans and seek medical attention if symptoms occur (inform health care provider of occupation and potential exposure).</li> <li>4. Consult with public health prior to use of samples for display or educational purposes.</li> </ol>
11. Cleaning areas of animal excreta and handling rodents in traps.	Indoor or field locations with significant accumulation of organic matter.	Mouse excreta or large quantities of bird or bat guano are of considerable concern, particularly in indoor facilities.	<ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Disposable coveralls</li> <li>• Eye and respiratory protection as appropriate to the level of disease risk</li> <li>• Shoe covers or boots which can be disinfected</li> </ul>	See: NPS worker protection recommendations for <u>hantaviruses</u> .
12. Incidental exposure as a result of other duties.	Indoor or outdoor.	Briefly handling or contact with live or dead animals incidental to any work assignments.	<p>Small animal:</p> <ul style="list-style-type: none"> <li>• Disposable gloves or inverted bag for collection</li> </ul> <p>Large animal:</p> <ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Coveralls, lab coat, or dedicated clothing</li> </ul>	<ol style="list-style-type: none"> <li>1. Communicate with Natural Resources, Risk Management, or Public Health staff as appropriate.</li> <li>2. Transport outside passenger area of vehicle (i.e., bed of truck or trunk).</li> <li>3. Bag carcass tightly if it must be placed in passenger compartment or to avoid leakage of blood or other body fluids into the environment.</li> <li>4. Cover all carcasses.</li> </ol>

## Appendix 3 (continued)

### References

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8. Material safety and data sheets for many chemicals used in laboratory, [www.msdssearch.com](http://www.msdssearch.com).
9. A number of established zoonotic diseases of importance, ZED website at <http://inside.nps.gov/publichealth/zed/zed.htm>

### Definitions

*Aerosol* – Solid particles or liquid droplets suspended in a gas (generally air).

*Aerosolized* – When liquid droplets or solid particles become suspended in air.

*Arthropod* – Animals belonging to the phylum Arthropoda which includes insects (e.g., mosquitoes, fleas, gnats) and arachnids (e.g., ticks, mites).

*CDC* – Centers for Disease Control and Prevention, a part of the U.S. Department of Health and Human Services, is the primary Federal agency responsible for conducting and supporting public health activities in the United States.

*Dedicated clothing* – Garments worn only during specific work activities which are not to be worn for office/personal activities (e.g., in offices, at home, in public venues).

*Dermal* – Referring to the skin. For example, dermal absorption means passing through the skin.

*Enzootic* – A disease that occurs at a regular, predictable, or expected rate in an animal population or area.



### **Appendix 3 (continued)**

*Job Hazard Analysis (JHA)* – A JHA is a multi-step process designed to study and analyze a job.

*Mask* – A barrier worn over the nose and mouth to prevent droplet contamination of mucous membranes.

*Respirator* – A barrier worn over the nose and mouth that filters particulates of certain sizes from inhaled air. Particulate respirators are also known as "air-purifying respirators."

*Pathogen* – A biological agent that causes disease or illness to its host (e.g., bacteria, viruses, or fungi)

*PPE* – Personal protective equipment.

*Vector* – For the purpose of this document: An arthropod capable of transmitting an infectious agent to other host species

*Zoonoses* – Infectious diseases that can be transferred between domestic or wild animals and humans

### **Consultation**

#### **Risk Management Division**

1201 Eye Street, NW  
11th Floor Washington, DC 20005  
Office: (202) 513-7214  
Fax: (202) 371-2226

#### **Public Health Program**

1201 Eye Street, NW 11th Floor  
Washington, DC 20005  
Office: (202) 513-7217  
Fax: (202) 371-1349

#### **Biological Resource Management Division**

1201 Oak Ridge Drive #200  
Fort Collins, CO 80525  
Office Number: (970) 225-3592  
Fax: (970)225 -3585



## **Appendix 4. Sample Job Hazard Analyses**

The following pages contain three sample Job Hazard Analyses (JHA). The staff of each park must create their own JHAs so that they appropriately consider the conditions and activities that exist at that workplace. These JHAs are provided to demonstrate the format and content of a well written JHA.

The samples are:

Lionfish Dissection JHA

Lionfish Handling by Non-Resource Management Staff JHA

Spear Handling JHA

More information about preparing JHAs can be found in Section 3.1 of National Park Service RM 50B, found at <http://www.nps.gov/policy/RM50Bdoclist.htm>.

**Appendix 4 (continued)**

<b>JOB HAZARD ANALYSIS (JHA)</b>		Date: 9/15/11	<input type="checkbox"/> New JHA <input type="checkbox"/> Revised JHA
Park Unit: Biscayne National Park	Division: Resource Management	Branch: Fish, Wildlife, Inventory and Monitoring Program (FWIMP)	Location: Convoy Point
TASK TITLE: Lionfish Dissections		JHA Number:	Page <u> 1 </u> of <u>     </u>
Job Performed By: FWIMP Staff and volunteers	Analysis By: Safety Committee	Supervisor: Vanessa McDonough	Approved By: Elsa Alvear
Required Standards and General Notes:	Be familiar with lionfish anatomy and aware of potential stinging and chemical hazards		
Required Training:	Orientation and observation of other staff performing the duties at least once		
Required Personal Protective Equipment:	latex gloves, puncture proof gloves, goggles, lab coat		
Tools and Equipment:	scissors, vials, dissection scissors, scalpels, forceps, dissection tray, ethanol, ruler, electronic weight, plastic trays, pencils, clipboard, paper, Mylar paper, Ziploc plastic bags, squeeze bottles		
<b>Sequence of Job Steps</b>		<b>Potential Hazards</b>	<b>Safe Action or Procedure</b>
1. Retrieve lionfish from cooler 2. Defrost frozen lionfish 3. Pour ethanol into vials 4. Weigh and measure individual lionfish 5. Spine removal		1. CW-Envenomation by spines 2. CW- Envenomation by spines 3. E-Spill, splash or inhale ethanol 4. CW- Envenomation by spines 5. CW- Envenomation by spines	1. Wear proper PPE (puncture proof gloves) when moving lionfish from cooler to bucket or lab. 2. Retrieve bucket from Marine Storage, fill with tap water halfway and place bagged lionfish in water. Leave till they thaw. Wear proper PPE (puncture proof gloves) when removing lionfish from bucket. 3. Move large container of ethanol to hood and turn hood on. Pour ethanol into small squeeze bottles using funnels. Squeeze bottles are used to then transfer smaller amount of ethanol into vials after specimen has been collected. When finished, put away ethanol. 4. Wear proper PPE (puncture proof gloves) when moving lionfish from bag to weight and for collecting measurement. 5. Wear proper PPE (puncture proof gloves) when using scissors to cut off venomous spines. Dispose of spines in specific trash bag to be removed immediately from lab

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**JHA - CONTINUATION SHEET**

JHA Number: \_\_\_\_\_

Page \_\_\_\_\_ of \_\_\_\_\_

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
<p>6. Dissection analysis</p> <p>7. Placing gut contents in vials</p> <p>8. Proper disposal of lionfish</p>	<p>6. CW-Cutting oneself with scissors or scalpels</p> <p>7. E- Spilling ethanol</p> <p>8. CW- Envenomation by spines</p>	<p>6. Wear proper PPE (latex gloves) when cutting open fish, removing head and removing stomach or gonads from lionfish</p> <p>7. Wear proper PPE (goggles) when placing gut content into vials</p> <p>8. Wear proper PPE (puncture proof gloves) when disposing of spines and lionfish remains. All trash bag containing remains should be removed from lab and placed in outside dumpster immediately.</p>

Text Description of Task When it is Done Safely

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**Authorized Employee Information**

Employee ID	Last Name	First Name	Qualifications/Remarks

## Appendix 4 (continued)

### INSTRUCTIONS FOR COMPLETING THE JOB HAZARD ANALYSIS FORM

Job Hazard Analysis (JHA) is an important accident prevention tool that works by finding hazards and eliminating or minimizing them *before* the job is performed, and *before* they have a chance to become accidents. Use your JSA for job clarification and hazard awareness, as a guide in new employee training, for periodic contacts and for retraining of senior employees. as a refresher on jobs which run infrequently. as an accident

investigation tool, and for informing employees of specific job hazards and protective measures. Set priorities for doing JHA's: jobs that have a history of many incidents, jobs that have produced disabling injuries, jobs with high potential for disabling injury or death, and new jobs with no accident history. Here's how to do each of the three main parts of a Job Hazard Analysis:

#### SEQUENCE OF JOB STEPS

Break the job down into steps. Each of the steps of a job should accomplish some major task. The task will consist of a *set* of movements. Look at the first *set* of movements used to perform a task, and then determine the next logical *set* of movements. For example, the job might be to move a box from a conveyor in the receiving area to a shelf in the storage area. How does that break down into job steps? Picking up the box from the conveyor and putting it on a hand truck is one logical set of movements, so it is one job step. Everything is related to that one logical set of movements is part of that job step.

The next logical *set* of movements might be pushing the loaded hand truck to the storeroom. Removing the boxes from the truck and placing them on the shelf is another logical set of movements. And finally, returning the hand truck to the receiving area might be the final step in this type of job.

Be sure to list *all* the steps in a job. Some steps might not be done each time checking the casters on a hand truck, for example. However, that task is a part of the job as a whole, and should be listed and analyzed.

#### POTENTIAL HAZARDS

Identify the hazards associated with each step. Examine each step to find and identify hazards – actions, conditions, and possibilities that could lead to an accident.

It's not enough to look at the obvious hazards. It's also important to look at the entire environment and discover every conceivable hazard that might exist.

Be sure to list health hazards as well, even though the harmful effect may not be immediate. A good example is the harmful effect of inhaling a solvent or chemical dust over a long period of time.

It's important to list *all* hazards. Hazards contribute to accidents, injuries, and occupational illnesses.

In order to do part three of a JHA effectively, you must identify potential and existing *hazards*. That's why it's important to distinguish between a hazard, and accident and an injury. Each of these terms has a specific meaning:  
HAZARDS – Potential danger. Oil on the floor is a hazard.

ACCIDENT – An unintended happening that may result in injury, loss or damage. Slipping on the oil is an accident.

INJURY – The result of an accident. A sprained wrist from the fall would be an injury.

Some people find it easier to identify possible accidents and illnesses and work back from them to the hazards. If you do that, you can list the accident and illness types in parentheses following the hazard. But be sure you focus on the *hazard* for developing recommended actions and safe work procedures.

#### SAFE ACTION OR PROCEDURE

Using the first two columns as a guide to decide what actions are necessary to eliminate or minimize the hazards that could lead to an accident, injury, or occupational illness.

Among the actions that can be taken are, 1) engineering the hazard out; 2) providing personal protective equipment; 3) job instruction training; 4) good housekeeping; and 5) good ergonomics (positioning the person in relation to the machine or other elements in the environment in such a way as to eliminate stresses and strains).

List recommended safe operating procedures on the form, and also list required or recommended personal protective equipment for each step of the job.

Be specific. Say *exactly* what needs to be done to correct the hazard, such as, "lift using your leg muscles." Avoid general statements like, "be careful."

Give a recommended action or procedure for *every* hazard.

If the hazard is a serious one, it should be corrected immediately. The JSA should then be changed to reflect the new conditions.

**Appendix 4 (continued)**

<b>JOB HAZARD ANALYSIS (JHA)</b>		Date: 9/15/11	<input type="checkbox"/> New JHA <input type="checkbox"/> Revised JHA
Park Unit: Biscayne National Park	Division: Interpretation and Law Enforcement Staff	Branch:	Location: Convoy Point
TASK TITLE: Lionfish Handling		JHA Number:	Page __1__ of __1__
Job Performed By: Non- RM Staff	Analysis By: Safety Committee	Supervisor: Vanessa McDonough	Approved By: Elsa Alvear
Required Standards and General Notes:	Be familiar with lionfish anatomy and aware of potential stinging hazards		
Required Training:	Orientation and training from Resource Management Staff		
Required Personal Protective Equipment:	puncture proof gloves		
Tools and Equipment:	Plastic bags, Mylar paper and cooler or freezer		
<b>Sequence of Job Steps</b>	<b>Potential Hazards</b>	<b>Safe Action or Procedure</b>	
1. Retrieve lionfish from visitor  2. Place in plastic bag with Mylar label  3. Place bag in cooler or freezer and alert Resource Management Staff	1. CW-Envenomation by spines  2. CW- Envenomation by spines  3. CW- Envenomation by spines	1. Wear proper PPE (puncture proof gloves) when handling lionfish.  2. Wear proper PPE (puncture proof gloves) when moving lionfish into bag with the Mylar label.  3. Wear proper PPE (puncture proof gloves) when moving lionfish into freezer or cooler.	



**JHA - CONTINUATION SHEET**

JHA Number: \_\_\_\_\_

Page \_\_\_\_\_ of \_\_\_\_\_

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure

Text Description of Task When it is Done Safely

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**Authorized Employee Information**

Employee ID	Last Name	First Name	Qualifications/Remarks

## Appendix 4 (continued)

### INSTRUCTIONS FOR COMPLETING THE JOB HAZARD ANALYSIS FORM

Job Hazard Analysis (JHA) is an important accident prevention tool that works by finding hazards and eliminating or minimizing them *before* the job is performed, and *before* they have a chance to become accidents. Use your JSA for job clarification and hazard awareness, as a guide in new employee training, for periodic contacts and for retraining of senior employees. as a refresher on jobs which run infrequently. as an accident

investigation tool, and for informing employees of specific job hazards and protective measures. Set priorities for doing JHA's: jobs that have a history of many incidents, jobs that have produced disabling injuries, jobs with high potential for disabling injury or death, and new jobs with no accident history. Here's how to do each of the three main parts of a Job Hazard Analysis:

#### SEQUENCE OF JOB STEPS

Break the job down into steps. Each of the steps of a job should accomplish some major task. The task will consist of a *set* of movements. Look at the first *set* of movements used to perform a task, and then determine the next logical *set* of movements. For example, the job might be to move a box from a conveyor in the receiving area to a shelf in the storage area. How does that break down into job steps? Picking up the box from the conveyor and putting it on a hand truck is one logical set of movements, so it is one job step. Everything is related to that one logical set of movements is part of that job step.

The next logical *set* of movements might be pushing the loaded hand truck to the storeroom. Removing the boxes from the truck and placing them on the shelf is another logical set of movements. And finally, returning the hand truck to the receiving area might be the final step in this type of job.

Be sure to list *all* the steps in a job. Some steps might not be done each time checking the casters on a hand truck, for example. However, that task is a part of the job as a whole, and should be listed and analyzed.

#### POTENTIAL HAZARDS

Identify the hazards associated with each step. Examine each step to find and identify hazards – actions, conditions, and possibilities that could lead to an accident.

It's not enough to look at the obvious hazards. It's also important to look at the entire environment and discover every conceivable hazard that might exist.

Be sure to list health hazards as well, even though the harmful effect may not be immediate. A good example is the harmful effect of inhaling a solvent or chemical dust over a long period of time.

It's important to list *all* hazards. Hazards contribute to accidents, injuries, and occupational illnesses.

In order to do part three of a JHA effectively, you must identify potential and existing *hazards*. That's why it's important to distinguish between a hazard, and accident and an injury. Each of these terms has a specific meaning: HAZARDS – Potential danger. Oil on the floor is a hazard.

ACCIDENT – An unintended happening that may result in injury, loss or damage. Slipping on the oil is an accident.

INJURY – The result of an accident. A sprained wrist from the fall would be an injury.

Some people find it easier to identify possible accidents and illnesses and work back from them to the hazards. If you do that, you can list the accident and illness types in parentheses following the hazard. But be sure you focus on the *hazard* for developing recommended actions and safe work procedures.

#### SAFE ACTION OR PROCEDURE

Using the first two columns as a guide to decide what actions are necessary to eliminate or minimize the hazards that could lead to an accident, injury, or occupational illness.

Among the actions that can be taken are, 1) engineering the hazard out; 2) providing personal protective equipment; 3) job instruction training; 4) good housekeeping; and 5) good ergonomics (positioning the person in relation to the machine or other elements in the environment in such a way as to eliminate stresses and strains).

List recommended safe operating procedures on the form, and also list required or recommended personal protective equipment for each step of the job.

Be specific. Say *exactly* what needs to be done to correct the hazard, such as, "lift using your leg muscles." Avoid general statements like, "be careful."

Give a recommended action or procedure for *every* hazard.

If the hazard is a serious one, it should be corrected immediately. The JSA should then be changed to reflect the new conditions.

**Appendix 4 (continued)**

<b>JOB HAZARD ANALYSIS (JHA)</b>		<b>Date: 9/15/11</b>	<input type="checkbox"/> New JHA <input type="checkbox"/> Revised JHA
Park Unit: Biscayne National Park	Division: Resource Management	Branch: Fish and Wildlife Inventory and Monitoring Program	Location: On the water, Biscayne National Park
TASK TITLE: Pole Spear Handling		JHA Number:	Page __1__ of __1__
Job Performed By: FWIMP Staff	Analysis By: Safety Committee	Supervisor: Vanessa McDonough	Approved By: Elsa Alvear
Required Standards and General Notes:	Familiarization and knowledge of pole spears and potential safety hazards		
Required Training:	Orientation and training from Resource Management Staff		
Required Personal Protective Equipment:	Dive gloves, dive or snorkel gear, bag or bucket for collection, puncture proof gloves for lionfish handling		
Tools and Equipment:	Pole spear, extra bands, tip covers		
<b>Sequence of Job Steps</b>	<b>Potential Hazards</b>	<b>Safe Action or Procedure</b>	
1. Removed spear(s) from dive locker and place on boat.	1. CW- Puncture from spear tip	1. Keep spear tips covered when not in use. Be aware of where spear is pointed at all times.	
2. Storing spears on boat	2. CW- Puncture from spear tip	2. Keep spear tips covered when not in use. Lay spear along gunnels with spear tip pointed away from general traffic	
3. Entering water with spear	3. CW- Puncture from spear tip, CO - Band entangled on boat cleats, dive gear, person etc.	3. Keep spear clear of all potential entanglement objects. Keep spear tip on until ready to use. Point spear away from you and other divers when entering the water. Consider having topside person hand spears down once divers are in the water.	
4. Spearing a lionfish	4. CW- Puncture from spear tip, CW – Envenomation from lionfish	4. When a lionfish has been spotted, pull spear band towards the tip of the spear, aim the spear at the head of the lionfish and release shaft. Make sure your spear is not pointed towards any other person. Make sure your buddy's spear is not pointed at you. Wear proper PPE (dive gloves) when using spears.	

**JHA - CONTINUATION SHEET**

JHA Number: \_\_\_\_\_

Page \_\_\_\_\_ of \_\_\_\_\_

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
5. Removing lionfish from spear	5. CW – Envenomation from lionfish	5. Place spear with lionfish on it into bag or bucket, using the lid to pull lionfish off the spear. Keep hands away from lionfish spines and spear tip.
6. Getting spear back on boat	6. CW – Puncture from spear tip	6. During safety stop, be aware of where spear tip is pointed. Place cap back on spear tip. Do not draw band for any reason. Hand spear up to topside person or place in a secure location before getting on boat. Once on the boat, ensure spear tips are covered and pointed away from traffic.
7. Storing spear	7. CW – Puncture from spear tip	7. Remove spear from boat. Make sure spear tips are covered. Place spears in dive lockers.

Text Description of Task When it is Done Safely

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**Authorized Employee Information**

Employee ID	Last Name	First Name	Qualifications/Remarks

## Appendix 4 (continued)

### INSTRUCTIONS FOR COMPLETING THE JOB HAZARD ANALYSIS FORM

Job Hazard Analysis (JHA) is an important accident prevention tool that works by finding hazards and eliminating or minimizing them *before* the job is performed, and *before* they have a chance to become accidents. Use your JSA for job clarification and hazard awareness, as a guide in new employee training, for periodic contacts and for retraining of senior employees. as a refresher on jobs which run infrequently. as an accident

investigation tool, and for informing employees of specific job hazards and protective measures. Set priorities for doing JHA's: jobs that have a history of many incidents, jobs that have produced disabling injuries, jobs with high potential for disabling injury or death, and new jobs with no accident history. Here's how to do each of the three main parts of a Job Hazard Analysis:

#### SEQUENCE OF JOB STEPS

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#### SAFE ACTION OR PROCEDURE

Using the first two columns as a guide to decide what actions are necessary to eliminate or minimize the hazards that could lead to an accident, injury, or occupational illness.

Among the actions that can be taken are, 1) engineering the hazard out; 2) providing personal protective equipment; 3) job instruction training; 4) good housekeeping; and 5) good ergonomics (positioning the person in relation to the machine or other elements in the environment in such a way as to eliminate stresses and strains).

List recommended safe operating procedures on the form, and also list required or recommended personal protective equipment for each step of the job.

Be specific. Say *exactly* what needs to be done to correct the hazard, such as, "lift using your leg muscles." Avoid general statements like, "be careful."

Give a recommended action or procedure for *every* hazard.

If the hazard is a serious one, it should be corrected immediately. The JSA should then be changed to reflect the new conditions.





## Appendix 5. NOAA Venomous Fish Handling Protocol

### Venomous Fish Handling Protocol Center for Coastal Fisheries and Habitat Research, National Ocean Service, Beaufort, NC

**PURPOSE:** Establish specific procedures and training requirements for NOAA divers assigned to the **Center for Coastal Fisheries and Habitat Research (CCFHR)** when diving where encounters with venomous fish are likely to occur.

**Background:** Venomous fish are commonly found in waters of the Southeastern United States, the Gulf of Mexico, and US territories in the Caribbean Sea. NOAA Scientific Divers are increasingly being asked to capture venomous fish, specifically the invasive Indo-Pacific lionfish, for research aimed at understanding and potentially controlling the rapid spread of these species.

**SCOPE:** This document provides operational guidance to CCFHR divers when capturing or handling venomous fish in the water when using SCUBA or while skin diving.

**POLICY:** All divers diving on a CCFHR project shall use protective gear and equipment when working with and around venomous fish.

#### Responsibility

**Diver:** Each diver shall evaluate his or her risk and complete training prior to conducting dives to collect venomous fish.

**Divemaster (DM):** The DM shall brief the boat crew, divers, and topside support personnel on the risks of handling venomous fish and basic first aid for venomous fish incidents. Further, the DM shall verify that each diver has the appropriate personal protective equipment (PPE) available and agrees to use their PPE prior to allowing dives to commence.

**Unit Diving Supervisor (UDS):** The UDS shall ensure DMs and Divers have the appropriate training, PPE, and appropriate first aid supplies at the dive site prior to authorizing dives.

#### GUIDANCE

**Personal Protective Equipment (PPE):** Whether capturing live or spearing venomous fish, divers should wear at least one **puncture proof glove** and **full wet suits**. Some divers wear a puncture proof glove on one hand and a regular wet suit glove on the hand they use to control their spear. The buddy diver carrying the **catch bag** shall wear 2 puncture proof gloves. A wetsuit reduces risk but fish spines can penetrate a wetsuit. Thick, clear plastic bags made for use as dry bags are preferred to opaque catch bags, because solid materials resist punctures and because they are clear the diver can observe the fish (Figure 1), and because they might contain

## Appendix 5 (continued)

some of the fish scent. Canvas material is sometimes used but does not offer the advantages of the heavy clear plastic bags. There is a list of places to acquire protective gear in the Resources Section following the Figures below.

**Capturing Methods:** Most stings occur when a diver is distracted and not watching the fish when it is captured or bagged, when allowing the bag to hang near the body or leg, or when not wearing proper gloves, or trying to handle a fish by grasping the body. Divers should constantly monitor the location of the bag relative to themselves and other nearby divers, the condition of the bag, the fish in the bag, and the fish being hunted (maintain situational awareness). The dive boat should provide a weighted hang line on which to clip the bag near the safety stop so the divers can finish the ascent unencumbered. When “live boat” diving, divers should hang the catch bag from a line attached to a surface marker buoy or lift bag. A small weight can be added to the catch bag to ensure the bag remains vertical and doesn’t drift up during ascent when the fish bladders swell and the fish lose buoyancy control. Good buoyancy control reduces the likelihood of a leg or torso puncture (Figure 2).

**Live captures:** Nets can be used effectively to capture venomous fish. Most venomous species do not seem to fear divers and do not hurry away from one or two careful attempts to capture them. Closed, clear plastic nets have been effectively used for smaller fish and mesh landing nets for larger specimens. The following 2 different methods are being used:

For smaller fish, one commonly used strategy is to equip one diver with two nets (one for herding and one for collecting (Figure 3) and the other diver with a collecting bag. Once the first diver captures a fish between the nets, both divers should move to a suitable area to transfer the fish. The preferred area will be protected from strong currents and allow space for equipment and bags without disturbing the nearby benthic habitat. The (bagger) diver with the collection bag places the bag on the bottom, opens the bag and vents any remaining air from the bag. The diver with the netted fish should place both nets on the bottom, collapse the nets to prevent movement of the fish, firmly grasp the fish by the head (and away from the spines- Figures 4 & 5) from the outside of the net, then turn the net inside out and place the fish into the open bag. The diver with the bag should then close the entrance of the bag around the diver’s arm who will then release the fish into the bag. The bag can then be closed and secured. To introduce additional fish into the bag, herd and secure previously captured fish towards the bottom of the bag prior to adding the new fish.

Another commonly used method is as follows: Net the fish, trap it by overturning the net onto the bottom, grasp the cod end of the net (on the thick mil plastic right above the mesh) and with the other hand grasp the net at the opening end trapping the fish between both hands. The bagger then opens up the collection bag, which is held vertically, and the collector the puts the opening of the bag over the top of the collection bag and releases the hand closest to the collection bag. Use the hand closest to the cod end to push forward and move the fish into the bag. The fish want to swim down escape by swimming up is unlikely.

## Appendix 5 (continued)

**Spear captures:** Divers should use spears with paralyzer tips to immobilize the fish when speared (Figure 4). Once speared, the fish should be removed by grasping the fish by the head, away from the venomous spines (Figure 5). Place the fish into collection bags in the same procedure as with nets. Collection bags may also be equipped with a trap door so the fish can be pulled off the spear when placed in the bag. Bags equipped this way reduce handling time and risk. Some divers pith the fish after removing it from the spear tip to immobilize it. To pith a fish, press the tip of a spear point (or a tool like a marlinspike or ice pick) into the head behind the eyes through the brain.

**Other Safeguards:** Each diver and the DM should assess the potential for and presence of predators, availability of proper gear, the planned methods, each diver's ability and experience. For any method, divers should agree on the method before diving, practice the method in "dry runs" on the surface, and consult with more experienced divers for additional recommendations. No diver should agree to dive unless he or she is comfortable performing the required tasks. The DM should not allow dives to commence unless he or she is absolutely comfortable the dives can proceed without unnecessary risk.

### FIRST AID

**Signs and Symptoms:** Signs and symptoms vary from mild swelling and pain to tachycardia, hypertension, hypotension, seizures, chest pain, abdominal pain, sub dermal necrosis at the sting site, and temporary paralysis to the extremities. Symptoms will vary depending on the severity of the sting. For an average sting, the pain, which may be excruciating, will usually lessen after a few hours. Generalized symptoms can be severe. The distress caused by the pain may advance to a state of delirium in severe cases. The generalized weakness that may develop can involve the cranial nerves, facial muscles, vision, speech, and cause respiratory distress. If stung, the diver should ascend immediately following normal procedures.

**Treatment:** An envenomated diver should ascend without delay; continuing the dive places the diver at greater risk that a severe reaction would occur while still in the water.

As soon as practical after the diver is out of the water, apply heat to the affected area, either by soaking the affected part in non-scalding hot water up to 45° C (113 °F) or by using a heat compress for 30-90 minutes or until the pain no longer recurs when removed from the water. Avoid burning the victim, who may not be able to detect burn causing temperatures above 120 °F. The wound site should be cleaned with soap and water or rinsed with sterile saline. If a spine or spines have broken off the fish and are still lodged in the skin, it should be gently extracted. Small amounts of bleeding may help to flush some of the venom, but profuse bleeding (rare in these cases) should immediately be controlled. Once heat therapy is ended, the extremity should be immobilized and elevated.

If the victim shows signs of an allergic reaction, simple medications containing anti-histamines may be administered if the victim has no allergies to the medications and they are not

## Appendix 5 (continued)

nauseated or showing signs of shock. If an epinephrine injector (epi-pen) is onboard, and a person qualified in the use of an epi-pen recommends it be used, an injection might benefit the injured diver with a severe allergic reaction.

Monitor for signs of shock. If the victim's respirations become weak, rapid, or labored or their pulse becomes weak or rapid, immediately initiate the Dive Emergency Assistance Plan (DEAP), provide 100% Oxygen, and be prepared to transport the victim to advanced medical care.

### *Other Information*

Antivenoms may be available for some venomous species in areas where these species and humans interact with some frequency. Many proteinaceous toxins, including those of the Indo-Pacific lionfish species, become less potent after ice or heat are applied. However, when cleaning fish precautions should always be taken to prevent punctures since other toxins, allergens, or pathogens might also be present.

In all cases, envenomations require cessation of future dive activities until the consulting medical practitioner indicates the medical emergency is over and the diver is fit to resume diving.



Figure 1: Collecting Bag (Photo courtesy of Gray's Reef NMS)

## Appendix 5 (continued)



Figure 2: Good Buoyancy Control (Photo courtesy of Gray's Reef NMS)



Figure 3: Use of 2 Capture Nets (Photo courtesy of Gray's Reef NMS)

**Appendix 5 (continued)**



Figure 4: Pole Spear or Hawaiian Sling with Paralyzer Tip (Photo courtesy of Gray's Reef NMS)



Figure 5: Removing an Indo-Pacific Lionfish from a Pole Spear (Photo courtesy of Gray's Reef NMS)

## **Appendix 5 (continued)**

### Resources

(Check with your purchasing agent to ensure compliance with purchasing guidelines prior to making purchases)

[http://www.REEF.org/catalog/83/field\\_supplies](http://www.REEF.org/catalog/83/field_supplies)

<http://www.jblspearguns.com/polespears.php?id=Polespears>

<http://www.hexarmor.com/technology/>

<http://traveloasis.com/glaccleardry.html>

<http://www.westmarine.com/1/3/west-marine-dry-bags>





## **Appendix 6. Lionfish Injury Treatment Advice**

The following treatment advice is from Scott A. Gallagher, M.D., FACEP (available at: <http://emedicine.medscape.com/article/770764-treatment>).

### **Prehospital Care**

1. Prehospital care should address and recognize the injury as a potential envenomation, gentle removal of visible spines, direct pressure to control bleeding, administration of analgesia, and transport for definitive medical evaluation.
2. Recognition of serious systemic symptoms and proper institution of approximate lifesaving procedures such as CPR and treatment for anaphylaxis should be paramount in the prehospital care setting.

### **Emergency Department Care**

1. Emergency Department management of Scorpaenidae envenomations involves addressing the venom exposure as well as the accompanying inflicted trauma. General rules of therapy include prompt analgesia, wound management antivenom administration, and supportive treatment for significant envenomations.
2. CPR and advanced cardiac life support procedures are rarely indicated but always take absolute precedence.

### **Wound Debridement**

3. Gentle manual removal of spines prevents future penetration or breakage
4. With proper anesthesia, surgical removal of embedded spines is indicated when they are in proximity to joints, nerves, or vessels.
5. Weight bearing surfaces may require removal of spines to prevent chronic pain.
6. Always irrigate copiously after adequate anesthesia.

### *Hot Water Immersion Techniques*

7. Heat treatment is widely recommended as effective initial treatment for envenomation by Lionfish.
8. The affected limb should be immersed in water no warmer than 114 degrees Fahrenheit, or 45 degrees Celsius.
9. Be careful not to infect thermal burns by placing an insensate limb (as a result of local anesthesia or decreased sensitivity as a result of pain) into scalding water.
10. Local or regional anesthesia, if available, is a suggested means of adjunctive analgesia.

## **Appendix 6 (continued)**

### **Analgesia**

1. Methods of recommended analgesia vary depending upon the reference cited and range from immersion techniques to local or regional anesthesia to parental analgesics.
2. Most references recommend that initial therapy consist of immersion in non-scalding hot water after removal of visible spines and sheath, in order to inactivate the thermo labile components of the venom that might otherwise cause a severe systemic reaction.
3. Adjunctive regional or local anesthesia offers several benefits that are not conferred by immersion techniques with analgesia. In addition to the absence of the rise of thermal injury, reliable, prompt, and prolonged analgesia allows for simultaneous debridement of the wound.
4. Parenteral analgesics and/or sedatives may be needed for patients who have wounds that are difficult to immerse or anesthetize, or for persons exhibiting significant anxiety reactions to the envenomation.

### **Wound Management Principles**

1. Wound management principles include identification of foreign materials, adequate debridement, tetanus prophylaxis, and appropriate referral for retained fragments that are not easily accessible in the Emergency Department.
2. Although the spines rarely break off into the skin, debridement of loose spines should be undertaken promptly, because retained spines continue to envenomate. Embedded structures should be pulled straight out with forceps to avoid breaking.
3. Ultrasound and plain radiography may help locate retained fragments, many of which require referral for consideration of operative removal. Retained fragments act as foreign bodies, causing inflammation and eventually becoming encapsulated into granulomata, which may lead to delayed healing and secondary infection.
4. Tetanus prophylaxis is indicated in all patients who have experienced traumatic marine injuries and who have insufficient immunization histories.
5. Severe to life threatening systemic symptoms of envenomation most commonly result from envenomations by lionfish.

## **Appendix 7. Lionfish Outreach Resources**

To facilitate reaching all park audiences (internal and external), the following interpretive and outreach templates and products have been developed and are available at:

<http://www.nature.nps.gov/water/marineinvasives/index.cfm>.

- Fact Sheets
- Site Bulletins
- Frequently Asked Questions
- PowerPoint Presentation
- Posters
- Rack Cards
- Deck/Identification Cards

These products may be tailored to address the status and management of lionfish at each respective unit. Another outreach product could be a "lionfish-in-a-jar" that could be available for viewing at visitor centers or at lionfish or other park events.



## **Appendix 8. Summary of Lionfish Response Plan Workshop, September 13-16, 2011**

In order to respond to the threat that invasive lionfish pose to ecological integrity as well as risks to visitor safety in parks, the National Park Service (NPS) held a four day workshop to develop a service-wide response plan to address this invasion. Twenty-nine participants, including natural and cultural resource managers from affected NPS units, Washington D.C. and regional NPS offices, and selected external partners from National Oceanic and Atmospheric Administration, Universities, and NGOs, attended the four-day workshop. The workshop was facilitated by staff from the U.S. Institute for Environmental Conflict Resolution.

During the workshop, participants reviewed and discussed technical information on lionfish biology, status of park-level responses, efforts by other south Florida and Caribbean marine resource managers, and best management practices. The majority of the workshop was devoted to establishing service-wide goals, objectives and strategies for responding to the lionfish threat, and to drafting a more detailed Lionfish Response Plan to assist each of the parks with establishing a park-specific Lionfish Management Plan.

The participants first discussed service-wide objectives, broad statements of desired future conditions, and possible strategies to address the lionfish invasion, which included a laundry list of approaches for individual parks to choose from in order to accomplish specific park-level objectives. One of the first subjects that workshop participants discussed was to what degree the NPS should eradicate or control lionfish in the park system. There was a consensus among NPS workshop participants to adhere to NPS mission and mandates with respect to addressing the lionfish invasion. It was agreed that the NPS should strive to protect natural resources for current and future generations to experience, address invasive species to the degree possible, and limit interference with natural habitats, public safety, and natural ecology. Participants agreed that the lionfish response will vary by park, and that each park will need to prioritize highly sensitive and critical habitats when responding to the lionfish threat. Participants concluded that the eradication of lionfish was not feasible given the nature of the invasion, and therefore the goal of the NPS should be control of the species to minimize deleterious impacts within park units, especially high-priority areas.

Participants then broke out into three groups to discuss the three main objectives for responding to lionfish: preventing or mitigating resource impacts, maintaining the health and safety of park staff and visitors, and providing appropriate public information and outreach. Participants worked in the three groups and in smaller groups to write specific sections of the plan.

The entire group met in plenary throughout the four days to determine if there was group consensus around the general objectives and strategies for the three sections, to provide status updates, and to determine group consensus on any major decisions for the response plan. Participants were able to develop and write a substantial amount of the draft response plan. An NPS lionfish technical team, consisting of representatives from the Ocean and Coastal Resources Branch, Southeast Regional Office, Biscayne National Park, and contract specialists, provided further edits and coordinated external peer review and completion of the final document.



The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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**National Park Service**  
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