

CRITICAL SITUATION ANALYSIS (CSA) OF INVASIVE ALIEN SPECIES (IAS) STATUS AND MANAGEMENT, THE BAHAMAS, 2013

*Under the project “Mitigating the Threats of Invasive
Alien Species in the Insular Caribbean”*



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ACRONYMS

| | |
|---------------------|--------------------------------------------------------------------------------|
| BEST | Bahamas Environment, Science and Technology Commission |
| BHA | Bahamas Hotel Association |
| BMTC | Bahamas Million Tree Campaign |
| BNGIS | Bahamas National Geographic Information Systems |
| BNNHC | Bahamas National Natural History Conference |
| BNT | Bahamas National Trust |
| BREEF | Bahamas Reef Environment and Education Foundation |
| CABI | Centre for Agricultural Bioscience International |
| CABI-CLA America | Centre for Agricultural Bioscience International for Central and Latin America |
| CARDI | Caribbean Agricultural Research and Development Institute |
| CBD | Convention on Biological Diversity |
| CEI | Cape Eleuthera Institute |
| CEP | Caribbean Environment Programme |
| COB-MESI | College of Bahamas Marine Environmental Studies Institute |
| CRISS | Caribbean Regional Invasive Species Strategy |
| DEHS | Department of Environmental Health Services |
| DOA | Department of Agriculture |
| DMR | Department of Marine Resources |
| ESP | Eco Schools Bahamas |
| FAO | United Nations Food and Agriculture Organization |
| FSP | Full Size Project |
| GBP | GloBallast Partnerships |
| GBPA | Grand Bahama Port Authority |
| GCFI | Gulf and Caribbean Fisheries Institute |
| GEF | Global Environment Facility |
| GEF-SGP | Global Environment Facility-Small Grant Program |
| GISP | Global Invasive Species Programme |
| GOB | Government of The Bahamas |
| GRAC | Gladstone Road Agricultural Complex |
| I3N | IABIN Invasives Information Network |
| IABIN | Inter-American Biodiversity Information Network |
| IAS | Invasive Alien Species |
| ICAO | International Civil Aviation Organization |
| IICA | Inter-American Institute for Cooperation on Agriculture |
| IMO | International Maritime Organization |
| IPPC | International Plant Protection Convention |
| ISSG | Invasive Species Specialist Group |
| IUCN | World Conservation Union |
| MEA | Multilateral Environmental Agreement |
| MTIASC | Mitigating the Threats of Invasive Alien Species in the Insular Caribbean |
| MOE | Ministry of Environment |
| NBS | National Biodiversity Strategy |
| NBSAP | National Biodiversity Strategy and Action Plan |

| | |
|----------------------------------|---------------------------------------------------------------------------------------|
| NEMA | National Emergency Management Agency |
| NGO | Non-Governmental Organization |
| NISP | National Implementation Support Partnership |
| NISS | National Invasive Species Strategy |
| OIE | Office International des Epizooties |
| PoWPA | Programme of Work on Protected Areas |
| PPG | Preparation Project Grant |
| PHMB | Pink Hibiscus Mealy Bug |
| Ramsar | Convention on Wetlands of International Importance especially as Waterfowl Habitat |
| REEF | Reef Environmental Education Foundation |
| RBDF | Royal Bahamas Defence Force |
| SIDS | Small Island Developing States |
| SPS | Agreement on the Application of Sanitary and Phytosanitary Measures |
| TNC | The Nature Conservancy |
| UNCLOS | United Nations Convention on Law of the Sea |
| UNCED | United Nations Conference on Environment and Development |
| UNEP | United Nations Environment Program |
| USDA | United States Department of Agriculture |
| USDA/APHIS Inspection Service | United States Department of Agriculture/Animal and Plant Health Inspection Service |
| WHO | World Health Organization |
| WTO | World Trade Organization Bahamas Maritime Authority (BMA) |
| ZNS | Bahamas Broadcasting Corporation |

GLOSSARY

Aggressive species – Those plants, animals or micro-organisms that overwhelm the landscape whether they are native or introduced.

Alien species – non-native, non-indigenous, foreign, exotic species occurring outside of their natural range and dispersal potential, and includes any part, such as seeds and larvae, that might survive and subsequently reproduce.

Ballast water – Fresh or salt water, sometimes containing sediments, held in tanks and cargo holds of ships to increase stability and maneuverability during transit.

Biodiversity – The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Short for biological diversity.

Biosecurity – Procedures intended to protect humans or animals against disease or harmful biological agents.

Control – Measures to eliminate or reduce the effects of invasive species, including eradicating infestations, reducing populations of invasive species, preventing their spread and mitigating their impact on the economy.

Detection – Surveillance for the existence and location of an invasive species that may have been introduced

Ecosystem - A dynamic complex of plant, animal, fungal, and microorganism communities and their associated non- living environment interacting as an ecological unit.

Endemic species – A species restricted to a specified region or locality.

Exotic species - Plant or animal species introduced into an area where they do not occur naturally, non-native species.

Harmful or dangerous – Plants and animals that sting, prickle, cause allergies, are poisonous to humans or other organisms or exclude other organisms from an ecosystem or habitat.

Feral animals – Animals that are untamed or wild.

Historic – Those plants and animals that were introduced long ago but now are accepted by most persons as “native”.

Information management – Activities to facilitate access to and exchange of information on invasive species, including information on distribution of invasive species.

Information management includes storage of data, providing access to invasive species databases and other forms of information.

Intentional introduction – An introduction made deliberately by humans, involving the purposeful movement of a species outside of its natural range and dispersal potential. Such introductions may be done legally or illegally.

Introduction – The movement by human agency of a species, subspecies or lower taxon outside its natural range. This movement can be either within a country or between countries.

Invasive alien species - Alien species that become established in a new environment, then proliferate and spread in ways that are destructive to native ecosystems, human health, and ultimately human welfare.

Monitoring – Ongoing research and surveys to track the presence and status of invasive species over time and at varying geographic locations to evaluate their impact on ecosystems and to evaluate the effectiveness of prevention and control activities.

Native species – A species occurring within its natural range and dispersal potential, i.e. within the range it occupies naturally or could occupy without direct or indirect introduction or by care of humans. Those plants and animals that occurred when Columbus arrived.

Naturalized – Plants and animals that have been introduced and now propagate on their own.

Prevention – Activities to prevent the introduction of invasive species. Includes monitoring the international and domestic movement of invasive species, evaluating individual species for invasiveness prior to introduction, and identifying and interdicting pathways for introduction.

Research – Developing scientific knowledge, methods and technologies to prevent, detect, control and monitor invasive species or to restore native species and habitats.

Sanitary or phytosanitary measure – Any measure applied:

- To protect animal or plant life or health within a country from the risks arising from the entry, establishment or spread of pests, diseases, disease-carrying organisms or disease-causing organisms;
- To protect human or animal life or health within a country from risks arising from additives, contaminants, toxins or disease-causing organisms in foods, beverages or feedstuffs;
- To protect human life or health within a country from the risks arising from diseases carried by animals, plants or their products or from the entry, establishment or spread of pests; or

- To prevent or limit other damage within a country from the entry, establishment or spread of pests.

SPS measures include all relevant laws, regulations, requirements and procedures; processes and production methods; testing, inspection, certification and approval procedures; quarantine treatments; risk assessment measures; and packaging and labeling requirements related to food safety.

Unintentional introduction – An unintended introduction made as a result of a species utilizing humans or human delivery systems as vectors for dispersal outside its natural range.

EXECUTIVE SUMMARY

This Critical Situation Analysis (CSA) provides a comprehensive view of the occurrence, trends and distribution of Invasive Alien Species (IAS) in The Bahamas. It evaluates gaps in existing institutional, legislative and policy frameworks. It also describes the profile of The Bahamas and includes The Bahamas National Protected Area System. The CSA contains information from the National Invasive Species Strategy (NISS) that was originally completed in 2003 and updated in 2013.

A total of 116 IAS have been identified for The Bahamas. They include plants, birds, terrestrial and aquatic species as well as microorganisms. Seven (7) plant and animal species have been targeted for eradication and 24 recommended for control. A management strategy has already been completed for the lionfish and a strategy is being developed for the newly identified cane toad, *Rhinella marina*.

For many years The Bahamas has realized the importance of the prevention and control/eradication of IAS. As such many governmental agencies, departments and non-government organization have worked to develop programs to educate the public about IAS and to mitigate the effects of IAS. This CSA highlights many of those efforts through the islands of The Bahamas as well as within The Bahamas Protected Area System.

Also highlighted is the effort to develop a regional strategy to combat the issue of IAS, a regional initiative entitled Mitigating Threats of Invasive Species in the Insular Caribbean (MTIASIC) was implemented. The Project is funded by the Global Environment Facility through the Centre for Agricultural Bioscience International – Caribbean and Latin America (CABI-CLA) acting as the Regional Implementing Agency, overseeing project activities in The Bahamas the Dominican Republic Jamaica St. Lucia and Trinidad & Tobago. Each country identified a high priority IAS and developed early detection and rapid response, control, eradication or preventative measures where applicable. With the MTIASIC project, The Bahamas developed control measures for the red lionfish, *Pterois volitans*. The project has five components: *Development of National Invasive Species Strategies (NISS)* but in the case of The Bahamas this CSA is being developed and the NISS updated, *Caribbean-wide Cooperation and Regional IAS Strategy (CRISS)*, *Information and Knowledge Generation, Management, and Dissemination*, *Prevention of IAS in Terrestrial, Freshwater and Marine Systems and Managing priority alien species invasions in pilot sites to ensure conservation and sustainable use of biodiversity*.

CONTEXT, OBJECTIVES AND SCOPE

Invasive Alien Species (IAS) are plants, animals, pathogens and other organisms that are introduced or spread in a new environment outside of their native range. They can include viruses, fungi, algae, mosses, ferns, higher plants, invertebrates, fish, amphibians, reptiles, birds and mammals. They negatively impact native ecosystems, human health and economic activities. These impacts include:

- Loss of genetic diversity through hybridization
- Competition with native species for food and space which results in displacement
- Introduction of diseases
- Physical changes to the environment. In many cases organisms can adapt to these changes or may actually cause the changes e.g. decreasing the amount of sunlight reaching an area (CABI 2010).

Exotic species are often introduced intentionally or unintentionally. Intentional introductions are often motivated by economic, environmental and social means, for example agricultural, landscaping and even environmental control measures (Box 1). Many introductions are unintentional through travel, trade and tourism. Many marine IAS for example, are transported in the ballast water of ships (Box 2). They can “hitchhike” and move from one place to another by imported vehicles, used tires, ships’ ballast water, ports in cargo holds, aircraft cabins, shipping containers, wood pallets and packaging material, and many other means. The increase in tourism allows IAS to arrive through human movement by air, land and sea attaching themselves to clothes, shoes or any object moved from one place to another. Humans also intentionally smuggle in pets, or plant material. The explosion of the pet trade has been a big part of invasive movement (CABI 2012).

The increase in globalization of markets and trading allows more species to move freely into new areas from all parts of the world, thus enhancing the possibility of becoming invasive. Some IAS migrate long distances from Africa to the Caribbean, for example the giant African snail, *Achatina fulica*. There are many alien species that exist peacefully in the environments and become naturalized where they are introduced. To become invasive, a species must display certain characteristics. These characteristics include: rapid growth and spread, high reproductive rates, high dispersal ability and the ability to adapt to environmental and physiological changes. Invasive Alien Species are also able to become established due to a lack of natural predators and diseases that would normally aid in controlling the species population growth. Invasive Alien Species have also been found to thrive in disturbed areas (Davis 2002).

The Convention on Biological Diversity (CBD) recognizes the importance of this global issue and calls on contracting parties to “*prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats and species*” (Article 8 (h)). The Conference of the Parties to the Ramsar Convention addresses IAS in coastal and inland wetlands. Resolution VIII/18 (Invasive Species and Wetlands) urges Ramsar Parties, and others “*to address the problems posed by invasive species in wetland ecosystems in a decisive and holistic manner...*”

Box 1: Casuarina, Australian Pine, *Casuarina equisetifolia*



Figure 1: Stand of Casuarina, Australian Pine, *Casuarina equisetifolia*

The Australian pine, *Casuarina equisetifolia* is a large vase-shaped tree that grows 100-150 ft (30.5-45.7 m) in height with wispy grey green twigs reminiscent of pine needles. The weeping branchlets look similar to jointed rushes and are ringed at their nodes by tightly overlapping little scale like leaves. The stout trunk is covered with thick pebbly textured brownish grey bark. The tree is supported by a dense, spreading, fibrous root system. Male flowers are borne in slender cylindrical spikes at the twig tips. The tiny brownish red female flowers grow in heads attached to the branchlets and are followed by 0.5 in (1.3 cm) diameter fruits that resemble pinecones and contain 70-90 winged seeds each. The Australian pine produces minor quantities of fruit constantly, but it usually goes through two major blooming and fruiting cycles each year. In Florida, there is a peak bloom period in April and a secondary one in September, with the largest numbers of seed becoming available in June and December. Australian pine often grows 5-10 ft (1.5-3.1 m) per year and has been known to reach 30 ft (9.1 m) in two years. In Florida, the usual life span of an Australian pine is 40-50 years, but there are reports that they can live hundreds of years in parts of their native range.

The Australian pine is native from Southeast Asia to northern Australia and the Pacific, but it has been planted and has established on beaches, berms, and similar open coastal sites in tropical areas throughout the world. In its native region, Australian pine occurs in habitats ranging from subtropical thorn scrubland to wet forest. The trees grow best in slightly uneven topography where holes and swales hold rainwater reserves. Recently disturbed places like cleared vacant lots and filled wetlands are ideal.

Australian pine trees prefer sandy soils, but saline, calcareous, rocky, volcanic, granitic, or just plain poor soils can also support growth. The pH can be anywhere between 5.0 and 7.7. Since this species forms symbiotic nitrogen-fixing associations with soil microbes, it can grow on nearly sterile sands, though it does appreciate fertilizer. It even appears to grow in some types of soil pollution, occurring around cement plants and on tin mine tailings.

The Australian Pine was introduced intentionally in the 1920's to make protective hedges along the coastline, but was not properly maintained. They have become well established along coastlines and beaches in The Bahamas and provide excellent shade and windbreaks. However, once it becomes established, it can radically alter the temperature, light and soil chemistry of beach habitats and inhibit the growth of native dune and beach vegetation, vital for coastal ecosystems. It also affects the habitat of nesting sea birds, sea turtles and highly endangered native Iguana species (CABI 2012).

In The Bahamas *Casuarina equisetifolia* devastates natural systems. It out competes native vegetation, causes erosion of dune systems allowing storm surge to reach further inland. There has been extensive loss of dunes in all national parks that it occurs including but not limited to Lucayan National Park, Exuma Cays land and Sea Park Clifton Heritage Park, Andros West Side park). There has been extensive loss of dune systems in areas outside of the national parks including the shorelines of Andros, Eleuthera, Grand Bahama, and New Providence. *Casuarina equisetifolia* severely reduces biodiversity wherever it occurs. It out competes native vegetation and creates monocultures. This species shades out the native shrubs and grasses, produces allelopathic compounds which retards growth of other species, and produces a thick ground litter which inhibits seedling germination. The root system is shallow but hard and woody reducing the ability of sea turtles to dig nests on shorelines.

While there is no quantitative data on the economic damage caused by Casuarinas there is anecdotal evidence. Casuarinas have shallow roots and tip over easily in tropical storms and hurricanes. When they tip over they tear up roads, snap powerlines and stop economic activity until they are cleared away. Additionally Casuarinas cause beach erosion. As areas lose their beaches they lose their ability to attract tourists and support the local economy.

The loss of beaches produces a direct social impact by reducing tourism. The

Bahamas has a tourist based economy and fewer tourists to an area means less money being put into the local and national economies.

There are few current programs to remove this species except in the Exuma Cays Land and Sea Park and small beach restoration projects throughout The Bahamas. Some limited time has been taken to remove invasive from Abaco National Park as well as Blue Hole National Park (Andros) with the help of TNC. Limited work has been done on New Providence (Freid 2008).

Box 2: Lionfish *Pterois volitans* and *Pterois miles* in The Bahamas



Figure 2: Lionfish, *Pterois volitans*

The red lionfish (Pteroinae) are from the subfamily of the scorpionfish (Scorpaenidae). Many species within the *Scorpaenidae* family, have large, venomous spines that protrude from the body, similar to a mane, giving it the common name of the lionfish. *Pterois volitans* and the closely related *P. miles*, share similar morphological resemblance; they are both native to the tropical waters of the Indo-Pacific, where they are carnivorous predators on coral, rocky and sandy substrates.

It is believed that both *P. volitans* and *P. miles* were most likely introduced in the early 1990s via aquarium releases or through ballast water and spread via ocean currents. *Pterois volitans* is a popular, relatively high priced fish in the global aquarium trade and is among the ten most valuable marine fish imported to the USA. The first documented introduction of *Pterois volitans* to the Western Atlantic occurred in Florida in August 1992. Since then *P.*

volitans has established in many parts of the western Atlantic, including the southeast coast of the USA, Bermuda, The Bahamas as well as parts of the northern Gulf of Mexico, most of the Caribbean, and parts of the Caribbean coasts of Central and South America (Figure 3 & 4). *P. miles* has still not been detected in The Bahamas.

- *P. miles*
- *P. volitans*
- Mixed
- Invasive *Pterois* sp.

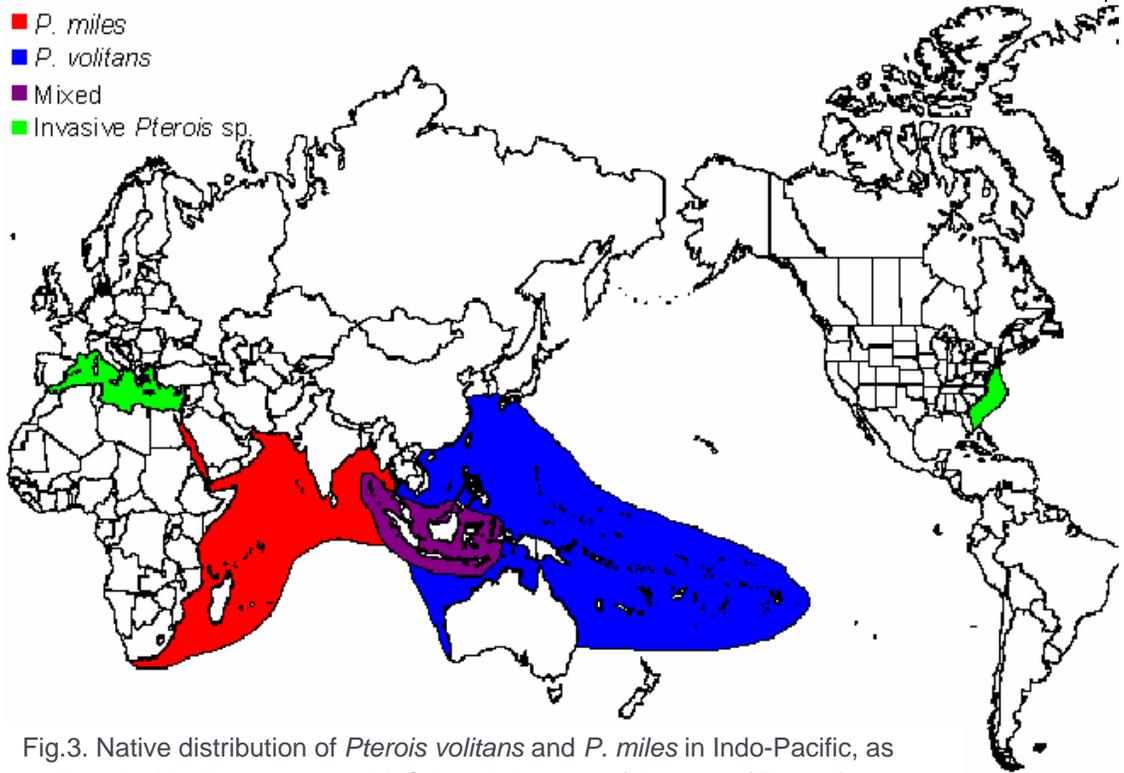


Fig.3. Native distribution of *Pterois volitans* and *P. miles* in Indo-Pacific, as well as the Mediterranean and US invaded range of the taxa. (Figure from

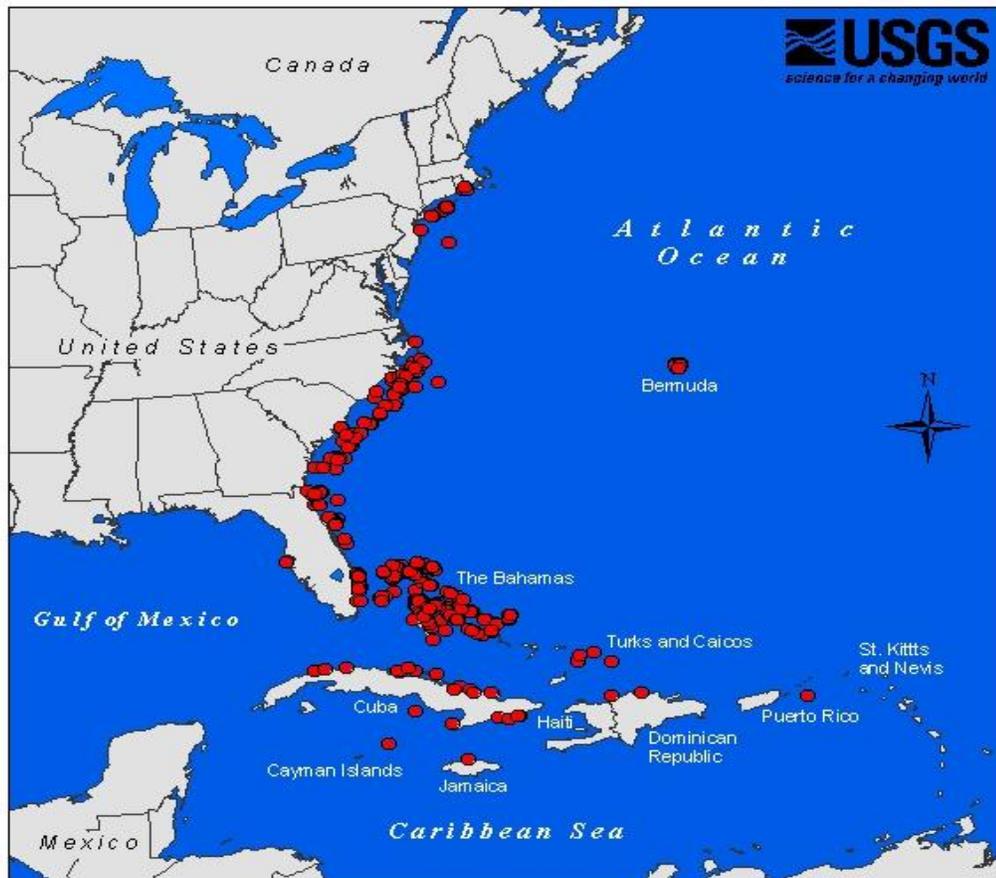


Figure 4: Atlantic distribution of *P.volitans* since 5 Sept.2008. (Figure from USGS NAS Database, 2008).

In 2004 lionfish were first reported in The Bahamas but it was not until 2006 that their occurrence was officially documented in the scientific literature. Throughout The Bahamas both adult and juvenile lionfish have now been observed in waters surrounding every major island group. Lionfish are also held in captivity in public and private aquariums in The Bahamas. However, it is unknown whether lionfish were first introduced to The Bahamas via accidental or intentional releases associated with the aquarium trade, natural range expansion from US waters, a combination of both of the above, or some other means (e.g. ballast-water, though highly unlikely).

Due to the pelagic nature of the eggs and larvae, and recent sightings of lionfish just south of The Bahamas (e.g. Turks and Caicos, Cuba, Dominican Republic and Jamaica) strongly suggest that populations in The Bahamas are spreading southward throughout the wider Caribbean via natural range expansion.

Lionfish occur in many of the same habitat types in its invaded range of the Atlantic. However, some countries have also reported lionfish in unique habitats. These include:

1. The Bahamas appears to be the only place in which lionfish have been frequently observed in blue holes and mangrove creeks.
2. Bermuda is the only country in which a lionfish has been collected from a tide pool.
3. Long Island, New York, USA, is the only place in which lionfish have been reported in estuaries.

Lionfish are considered a high priority invasive species in The Bahamas due to: (1) their extensive geographic distribution; (2) a documented, adverse ecological impacts; (3) a potential threat to public health due to their venomous spines; (4) a potential threat to fisheries resources via predation on the juveniles of commercially valuable species and/or predation on the forage fish of commercially viable species; and (5) unprecedented size and density in their invaded range.

The full economic impact of lionfish has yet to be determined. However, if lionfish are shown to significantly reduce the abundance and/or distribution of commercially important species on sufficiently large scales, then subsistence and commercial fisheries are likely to be adversely affected by the invasion.

Lionfish have venomous dorsal, anal and pelvic spines, and are known to envenomate humans when threatened or harassed and reckless handling of recently dead specimens. Lionfish have envenomated a number of persons in the Bahamas, including fishermen and avid beach-goers. Moreover, the frequency of incidents of envenomation in the Bahamas is likely to increase as the fish becomes more widespread and abundant, particularly in shallow, nearshore areas frequently used by people therefore presenting a serious health threat.

Initially no formal efforts had been undertaken by the Government of The Bahamas to limit the establishment, spread and impact of lionfish. At a press conference in 2007, the Bahamas Minister of Agriculture and Marine Resources, urged fisherman and divers to kill lionfish when they encounter them. The paucity of existing information on the basic ecology and natural history of lionfish made it difficult at that time to initiate any type of realistic control efforts that would have been both biologically effective and financially feasible.

In response, the Bahamas Department of Marine Resources hosted a workshop for local stakeholders in November 2008. The workshop was held with the intent of relaying basic information about lionfish, research studies that have been conducted, and lionfish collection and handling techniques. At the workshop participants were provided with components of a draft plan

to review and comment on. As a result, the National Lionfish Response Plan (NLRP) was created in 2009. The goal of the NLRP was and still is to “maintain the distinctiveness and diversity of Bahamian marine communities, protect commercially important fisheries, safeguard public health, and reduce the growth and spread of lionfish populations.

Before the development of the NLRP a number of informal response efforts were initiated in The Bahamas in 2007 and 2008. For example, the College of the Bahamas Marine and Environmental Studies Institute in collaboration with the Department of Marine Resources began to systematically archive lionfish sightings and reports from the public as well as established an online lionfish sightings questionnaire (see www.bahamas.gov.bs or www.breef.org). A national lionfish specimen library containing specimens collected from various islands throughout the archipelago was also created to aid in future research related to lionfish genetics, aging and growth studies. Both organizations have also partially supported the zoology graduate research of a Bahamian student studying abroad whose thesis investigates the primary factors controlling lionfish establishment success in Bahamian nearshore waters. A series of town meetings and presentations about the lionfish invasion in The Bahamas were also conducted by the Department of Marine Resources, the College of the Bahamas Marine and Environmental Studies Institute, and the Bahamas National Trust in which the creation of a local commercial fishery for lionfish was also promoted. A number of lionfish tournaments and demonstrations have also been held as mitigation efforts and to increase public awareness.

In December 2009, the Government of the Bahamas signed a Memorandum of Understanding (MOU) with CAB International to ratify the Global Environment Facility (GEF) funded Full Size Project, Mitigating the Threats of Invasive Alien Species in the Insular Caribbean (MTIASIC). The MTIASIC Project was designed to establish a national and regional framework to address and mitigate Invasive Alien Species (IAS) that threaten marine, aquatic, and terrestrial ecosystems and their biodiversity through policies (Smith 2008).

Invasive Alien Species represent the second most significant cause of species extinction worldwide after habitat destruction. The impacts of IAS are immense, insidious, and usually irreversible. They cause significant damage to ecological, economic and health systems. Invasive Alien Species can compete with native species, act as pests or pathogens for cultivated or domesticated species, and in addition disseminate allergic or infectious agents.

Small Island Developing States (SIDS) like The Bahamas generally have high native species diversity and endemism counts due mainly to physical isolation from a mainland. This isolation also leaves small islands extremely vulnerable to IAS due to the lack of natural competitors, predators and gaps in ecological niche. The isolation of

SIDS may act against IAS establishment but can be an advantage since measures can more easily be taken by government agencies to prevent the arrival of an IAS. The prevention of IAS can be affected by improving both legislation and management capacity which can be further supported by quarantine and customs systems that are capable of identifying and intercepting IAS (Bahamas GreenSweep Manual 2012).

Climate change can create suitable conditions for the spread of IAS. It is expected the predicted warmer temperatures will facilitate the spread and establishment of IAS. Invasive Alien Species may be able to thrive in conditions that may become hostile to native species due to changes in environmental conditions. The lionfish *Pterois volitans* and *Pteroinae miles* are expected to establish areas outside their present range of distribution despite physical changes in the environment (Coté and Green 2012). Species are better able to expand their current range due to increasing temperatures and changes in weather patterns; for example, the disease carrying mosquitoes, *Aedes aegypti* has been able to thrive outside its natural range.



Dengue viruses are mainly transmitted by the bite of infected *Aedes aegypti* mosquitoes; an IAS with tropical and subtropical worldwide distribution that originated in Africa.

Figure 5: *Aedes aegypti* mosquito

The main emphasis of this document is to highlight the management and control mechanisms for IAS that negatively impact the native biodiversity of The Bahamas.

The main objectives of the Critical Situation Analysis is to:

- Review the efforts to prevent, eradicate and control/mitigate IAS in The Bahamas to date
- Assess gaps in existing legislative, policy and institutional frameworks including Multilateral Environmental Agreements (MEA) obligation and their fulfillment to prevent IAS introduction to the country as a baseline for strategic review under the Full Size Project (FSP) in line with the Global Invasive Species Programme

(GISP), the Convention on Biological Diversity (CBD) and Food and Agriculture Organization (FAO) guidance, *inter alia*

- Review the efforts during the Project Preparation Grant (PPG) phase of the UNEP/GEF project entitled Mitigating Threats of Invasive Species in the Insular Caribbean (MTIASIC).

BIODIVERSITY INVENTORIES

The Bahamas is an archipelago that extends 760 miles from the coast of Florida in the northwest almost to Haiti in the south east. It consists of 700 islands and 2400 cays, of which 30 islands are inhabited. The country is spread over approximately 100,000 square miles of the Atlantic Ocean. The total land area has been computed at 5,382 square miles by the Department of Lands and Surveys. The total population of The Bahamas is approximately 353,658. Andros Island is the largest land mass at 5,986 km² (2300 mi²) but one of the least populated of The Bahamas, while New Providence is 207 km² (80 mi²) and is the most densely populated. The Bahamas is part of the Caribbean Islands hotspot, which consists of three large groups of islands between North and South America: The Bahamas, the Lesser Antilles, and the Greater Antilles. The Bahamas is home to many marine and terrestrial species, making it an area significantly rich in biological resources. It boasts of beautiful coastlines with white and pink sandy beaches; and clear, shallow and sheltered waters, and the largest body of coral reefs; and other marine organisms in the Atlantic/Caribbean region, constituting the main focus of the country's tourism industry.

The climate is semitropical and has two distinct seasons, summer and winter. During the summer which extends from May through November, the climate is dominated by warm moist tropical air masses moving north through the Caribbean. Summer temperatures range from 21 to 34°C. During the winter months extending from December through April, the climate is affected by the movement of cold polar masses from North America. Temperatures during the winter months range from 15 to 24°C. The average rainfall totals 132 cm and is usually concentrated in November to June and September to October. The highest point is 206ft (63m), Mount Alvernia, on Cat Island. There are no rivers but brackish lakes (somewhat salty) are found on several of the islands (notably Andros and Grand Bahama) which are sources of potable freshwater. The natural terrestrial vegetation consists of Caribbean pine forests solely found on Abaco, Grand Bahama, Andros and New Providence and broadleaf evergreen forest locally called coppice forest. Rainfall is the sole source of fresh water in The Bahamas (Best 2005).

In 1999, the National Biodiversity Strategy and Action Plan estimated to have accounted for only 5% of The Bahamas biodiversity. Although knowledge of diversity is fragmentary there are many noteworthy aspects. They include but are not limited to:

- The Lucayan Caverns on Grand Bahama, reputedly one of the largest submarine cavern systems in the world, are known to possess a number of endemic species.
- Research on some of the blue holes of Andros on *Gambusia hubbsi*, a species of mosquitofish found only in The Bahamas, shows that populations between blue holes differ greatly in body size and sex ratios. These differences may reflect differences in predators-prey interactions, and research is continuing on these extremely complex ecosystems. The lakes of San Salvador contain four species of sympatric pupfish (*Cyprinodon*), a species known to exist in only one other place in the world.
- Insularity and an extensive shelf with productive coral reefs and other habitats, plus a large area of coastal wetlands, especially mangrove forests, contribute to the abundance and diversity of fish.

Correll and Correll (1982) reported that nearly nine percent (121 taxa) of plant species found in The Bahamas are endemic, but concludes that the Bahamian "flora has been derived mainly from that of the south and west, especially Cuba". Over 1350 species of flowering plants and ferns have been described, representing approximately 660 genera and 144 families and 21 varieties, subspecies and hybrids. There are 1,111 higher plants, 57 breeding birds, 53 reptiles, 5 amphibians and 248 fish has been identified in The Bahamas. Additionally 24 species of marine mammals are known to occur in The Bahamas. There is one species (*Geocapromys ingrahami*) and 3 subspecies (*Natalus micropus tumidifrons*, *Eptesicus fuscus bahamensis*, *Tadarida brasiliensis bahamensis*) of endemic mammals. There are 46 species of native herpetofauna in The Bahamas consisting of 3 frogs (including 1 endemic), 25 lizards (13 endemic), 11 snakes (7 endemic), 2 freshwater turtles, and 5 sea turtles.

Twelve species of bats live in The Bahamas with the Great Bahama bank supporting 9 species. In San Salvador 5 species of bats have been reported and on New Providence 4 species of bats have been reported. The most common of the bat species in The Bahamas is the Waterhouse's Leaf-nosed bat (*Macrotus waterhousii*.) Others include: the Bahamian funnel-eared bat (*Chilonatalus tumidifrons* (endemic)), Big Brown bat (*Eptesicus fuscus*), Buffy Flower bat (*Erophylla sezekorni*), Leach's single leaf bat (*Monophyllus redmani*), Gervais's funnel-eared bat (*Nyctiellus Lepidus*), Brazilian Free-tailed bat (*Tadarida brasiliensis*) among others. The Hutia (an endangered species protected under the Wild Animals Protection Act of 1968), along with bats, are the only land mammals native to The Bahamas. A historical predator to the hutia is the chickcharnie owl (*Tyto pollens*) which is now extinct.

A total of 24 species of Hesperidae have been found in The Bahamas, of which 14 are likely to be found on New Providence.

In San Salvador, 30 brown algae and 79 macro red algae species have been reported. In the warm waters of The Bahamas it is thought that Blue-green bacteria are abundant and form mats in the hypersaline lakes and blue holes. Presently, there are 56 species of plants and animals (see Table 1) listed in the IUCN Red List 2009 of Threatened Species for The Bahamas, ranging from extinct to least concern (BEST 2011).

Table 1: Endangered Species found in The Bahamas (CITES)

| Mammals | | Molluscs | |
|-----------------------------|----------------------------------------|---------------------------|---------------------------|
| Humpback whale | <i>Megaptera novangliae</i> | Queen Conch | <i>Strombus gigas</i> |
| Northern Right whale | <i>Eubalaena glacialis</i> | Corals | |
| West Indian Manatee | <i>Trichechus manatus</i> | Black Corals | <i>Anthipatharia spp.</i> |
| Birds | | Stony Corals | <i>Scleractinia spp.</i> |
| West Indian Flamingo | <i>Phoenicopterus ruber ruber</i> | Branch Corals | <i>Acropora spp.</i> |
| West Indian Tree Duck | <i>Dendrocygna arborea</i> | Brain Coral | <i>Platygyra spp.</i> |
| Sharp-shinned Hawk | <i>Accipter striatus</i> | Brain Coral | <i>Favia spp.</i> |
| Red-tailed Hawk | <i>Buteo jamaicensis</i> | Brain Root Coral | <i>Labophyllia spp.</i> |
| Marsh Hawk | <i>Circus cyaneus</i> | Birds Nest Coral | <i>Seriatopora spp.</i> |
| Osprey | <i>Pandion haliaetus</i> | Blue Coral | <i>Heliopora spp.</i> |
| Peregrine Falcon | <i>Falco peregrinus</i> | Brain Trumpet Coral | <i>Euphyllia spp.</i> |
| Merlin | <i>Falco columbarius</i> | Cactus Corals | <i>Pavona spp.</i> |
| American Kestrel | <i>Falco sparverius</i> | Cauliflower Corals | <i>Stylophora spp.</i> |
| Bahama Parrot | <i>Amazona leucocephala bahamensis</i> | Lettuce Corals | <i>Pectinia spp.</i> |
| Barn Owl | <i>Tyto alba</i> | Merulina Corals | <i>Merulina spp.</i> |
| Burrowing Owl | <i>Speotyto cunicularia</i> | Yellow Five Corals | <i>Milleporidae spp.</i> |
| Cuban Emerald Hummingbird | <i>Chlorostilbon ricordii</i> | Organpipe Corals | <i>Tubiparidae spp.</i> |
| Bahama Woodstar Hummingbird | <i>Calliphlox evelynae</i> | Brown Stem Cluster Corals | <i>Pocillopora spp.</i> |
| Ruby-throated Hummingbird | <i>Archilochus colubris</i> | Feather Corals | <i>Polyphyllia spp.</i> |
| Rufous Hummingbird | <i>Selasphorus rufus</i> | Plants | |

| | | | |
|----------------------------------------|-------------------------------------|--------------|-----------------------------|
| Reptiles | | Cacti | <i>Cactaceae spp.</i> |
| Bahamian Boa Constrictor | <i>Epicrates spp.</i> | Aloes | <i>Aloe spp.</i> |
| Pygmy Boa Constrictor | <i>Trophidophis canus</i> | Cycads | <i>Cycadaceae spp.</i> |
| Bahamian Rock Iguana | <i>Cyclura spp.</i> | Euphorbias | <i>Euphorbia spp.</i> |
| Cat Island & Eleuthera Island Terrapin | <i>Trachemys terrapen</i> | Orchids | <i>Orchidaceae spp.</i> |
| Inagua Terrapin | <i>Trachemys stejnegeri malonei</i> | Zamia | <i>Zamiaceae spp.</i> |
| American Crocodile | <i>Crocodylas acutus</i> | Lignum vitae | <i>Guaiaicum sanctum</i> |
| Marine Turtles | | Lignum vitae | <i>Guaiaicum officinale</i> |
| Leatherback Turtle | <i>Dermochelys coriacea</i> | Mahogany | <i>Swietenia mahagoni</i> |
| Loggerhead Turtle | <i>Caretta caretta</i> | | |
| Hawksbill Turtle | <i>Eretmochelys imbricata</i> | | |
| Green Turtle | <i>Chelonia mydas</i> | | |

Despite the fact that the Bahamas is a relatively small island nation that only covers approximately 100,000 square miles it has many terrestrial and marine ecosystems. These include: pine forest, coppice forest, mangrove forest, blue holes, inland ponds, rocky and sandy coastal zones, tidal flats and salt marshes, seagrass beds, coral reefs and open ocean (BEST 2011).

Terrestrial Biodiversity

- Pine Forests. Most pine forests (*Pinus caribaea*) are self-sustaining secondary growths. They protect the soil and the fresh water lens and provide habitats for many plants and animals--including the Bahama parrot in Abaco. This ecosystem is also known as “pineyards”, “pinelands” or “pine barrens”, and they may be “wetbarrens” or “dry barrens”. The pine forests of Abaco, Andros and Grand Bahama occupy about 6,185 km² (2,416 mi²).
- Coppice. This comprises the dense, upright and narrow-stemmed, regrowth of mixed hardwood tree species (*Bursera*, *Metopium* and *Swietenia*). It provides habitats for many orchids and bromeliads (both terrestrial and epiphytic), and for birds, snakes and crabs. Coastal coppice may occasionally flood, and on windward coasts receive salt spray which may lead to sculpting and wind-shaping.

- Inland ponds. Plant life may be restricted to micro-algae either dispersed or in mats along the edges. Salinity can vary widely, with some hypersaline ponds. Animal life in the latter includes crabs, insects, brine shrimps and wading birds. Anaerobic decomposition may release sulphides with unpleasant smells. Heavy rainfall or flooding with freshwater seriously disturbs hypersaline ecosystems.
- Mangrove Forests. These are dominated by one or more species of mangrove (*Avicennia*, *Laguncularia* and *Rhizophora*) with other plant species in drier areas. They encourage sedimentation, hold the sediments in place, and help build land. They also provide nursery habitats for many marine animals, including commercial fishery species, and habitat for water fowl and other fauna. Mangrove forests minimize flooding and erosion. They occur mainly in protected locations on leeward coasts. The Bahamas has about 4,286 km² (1,674 mi²) of mangrove forest and other wetlands.

Marine Biodiversity

- Blue holes. Ocean blue holes provide habitats for many marine animals, including commercially important fish. Inland blue holes comprise photosynthesizing cyanobacteria (often called blue-green algae) around the edges, and several different bacterial species at specific depths and levels of salinity. They are also home to several unique species of fish. The inland blue hole ecosystem is easily disrupted.
- Coastal rock. These ecosystems occur close to the sea, and comprise several low-growing and salt-tolerant shrubs, including *Strumfia*, many of which are most attractive. Iguanas may be found in this ecosystem.
- Coastal sand. These communities include beaches and strips among coastal rock ecosystems. Above the high water mark, the plants are typically vines and low-growing spreading perennial species and shrubs. Sea oats (*Uniola*) are often conspicuous.
- Tidal flats and salt marshes. These have saline soils which may be high in silt content, and are typically covered with rather succulent low-growing plants tolerant of salinity. Typical is *Salicornia*.
- Seagrass beds. These stabilize the sea-bed, are a primary source of food for many grazing marine reptiles, and provide nursery habitats for many commercial fisheries.
- Coral reefs. These protect low-lying coast-lines from wave action, provide habitat for numerous fish species and for other sea creatures, and have aesthetic value for Bahamians and tourists. They are the most diverse ecosystems in The Bahamas. The Bahamas may have as much as 4 to 5% of the world's coral reef biodiversity.

- Open ocean. This ecosystem abounds with numerous species of fish, marine mammals (such as whales and dolphins), jelly fish, octopus and squid, as well as seaweeds and an abundance of other organisms that provide food for the larger animals.

The fauna in The Bahamas includes an endemic mammal, commonly called Hutia (*Geocapromys ingrahamii*). Hundreds of rare and common bird species, endemic and migratory, use The Bahamas as a vital habitat or use it as a transit base including birds such as the White Crown Pigeon (*Columba leucocephala*), the Caribbean Flamingo (*Phoenicapterus ruber*) and the Kirtland's Warbler (*Dendroica kirtlandi*). The Bahamas also plays host to a fairly impressive number of reptile species ranging from the small Curly Tailed Lizard (*Leiocephalus carinatus*) found mostly in the Northern Bahamas to the much larger species of endemic Rock Iguanas (*Cyclura cyclura*, *Cyclura carinata*, and *Cyclura rileyi*) which are found more commonly in the Southern Bahamas. A great deal of the Bahamian biodiversity (both higher taxa of organisms and habitat types), exists in the marine environment, the majority of which remains unexplored and still virtually untouched. It is important to note that 94% of The Bahamas is marine territory. Reef systems form the backbone for this remarkable biodiversity, placing The Bahamas at the very core of ecologically significant yet sensitive nodes in global biodiversity. It is indeed noteworthy that many of the ecological relationships are distinctive and inimitable, thus bequeathing The Bahamas a greater abundance of marine biodiversity than the entire insular Caribbean.

Box 3

Some Rare Animal and Plant Species of The Bahamas

Rare species are those that have dwindled in numbers and distribution until there are only small populations dispersed over a large area. If the decline in numbers or in the number of populations continues, the species is said to be *vulnerable*. Further decline leads to population numbers falling below a critical level, and the species is then said to be *endangered*. The next stage is total decline and *extinction*.

The Bahamas has a number of animal and plant *rare* species, some of which are described below. In most instances these species have become rare because of habitat destruction as a result of land-clearing or direct exploitation for food or other uses.

The Bahamian Hutia (*Geocapromys ingrahamii*) is the only endemic land mammal in The Bahamas. It is a tail-less rodent somewhat larger than a rat (*Rattus norvegicus*). The hutia was considered at one time to be extinct within The Bahamas, but a colony was found on East Plana Cay, and small colonies have now been established on a number of Cays in the Exuma Land and Sea Park, where they have successfully multiplied. It remains rare because of the small number of colonies.

During the 1940s, numbers of the West Indian Flamingo (*Phoenicopterus ruber*) in the Wider Caribbean declined sharply, probably as a result of habitat destruction. A Reserve to protect this bird was first established in 1951, in Inagua: this became a National Park in 1963. A breeding colony, estimated to number around 60,000, is now located in Inagua, and flamingoes from Inagua are now beginning to recolonize other islands in The Bahamas.

The Great Barn Owl or Chickcharnie (*Tyto pollens*) has declined in numbers as its habitat, and probably its food supply, have dwindled as a result of land-clearing.

The Osprey or Fish Hawk (*Pandion halietus*) has also declined in numbers, probably as a result of coastal zone developments destroying nesting sites, and possibly also because of reductions in food supply as a result of commercial fishing. It is now found in only a few areas of The Bahamas.

The Inagua Turtle (*Pseudemys malonei*) and the Cat Island Turtle (*Pseudemys felis*) are found only near these two islands and are distinct species native to The Bahamas. Exploitation has probably led to their declines in numbers.

Three species of Ground Iguana are found in The Bahamas: *Cyclura cyclura*, *C. carinata* and *C. rileyi*. Each of these species has one or more sub-species, which are found only in certain islands or cays. *C. cycluracyclura* is found only in Andros, *C. cyclura inorta* is found only on the Allen Cays, and *C. cyclura figginsi* is found only in Exuma. *C. carinata bartschi* is found only in Mayaguana, while *C. rileyi nuchalis* is found only in Acklins and *C. rileyi cristata* only on White Cay. While the decline in numbers of all these species and sub-species is, no doubt, partly due to development, it is also due to poaching of live iguana for sale overseas as pets.

The Bimini Boa (*Epicrates striatus fosteri*), native to Bimini, has declined in numbers in part because of loss of habitat, but many have been, and continue to be, killed by people who find them in their houses or gardens, though the snake is non-venomous and not dangerous. Some are also poached and sold for the pet trade.

Agave species are related to the sisal plant—and known locally as “bamboo”. Several distinct and native species of *Agave* are found in Acklins, Exuma, Inagua and San Salvador. It is not clear why these species should be in decline but, no doubt, land-clearing is an important factor.

Ernodea gigantea is a shrub of coppice thickets on Acklins, Crooked Island and Mayaguana. It has no generally-recognized local name. It has become rare presumably as a result of land clearing.

Erythoxylum reticulatum is a rare shrub of both coppice and pineland habitats on Andros and Exuma. Again, it is not clear why it has become rare.

Psidium androsianum is related to the common guava and as the name suggests, is

native to Andros but is now rare.

Euphorbia brittonii is a low-growing perennial herb, rarely more than 7 cm high, is native to The Bahamas but now found only in Eleuthera and New Providence. Land-clearing may be responsible for its rarity in New Providence, but it is less clear why it appears to have declined in Eleuthera.

The Bahamas Protected Area System

Several agencies assist in the management of protected areas in The Bahamas. The DOA for the Wild Bird Reserves, the DMR for the Marine Reserves, the MOE for Conservation of Forests and the BNT for the system of National Parks. A list of the Protected Areas in The Bahamas including the IUCN Categories (Ia, Ib, II, IV and V) is presented in Table 2. Currently, there are no sustainable financing plans in place that support the national systems of protected areas except the National Parks that are under the management of The Bahamas National Trust receives \$1.25 Million annually from the GOB and raises the rest of its budget through grants, membership fees and private donations.

The existing marine protected areas in The Bahamas comprise approximately 154,011 hectares, spread over 10 national parks and three marine reserves. They include coastal and open ocean sites, inclusive of seabird nesting sites, turtle nesting beaches, coastal mangroves, seagrass beds, coral reefs and spawning aggregation sites. Species protected as a result of these areas include, but are not limited to, the Queen Conch (*Strombus gigas*), Nassau Grouper (*Epinephelus striatus*) and West Indian Flamingo (*Phoenicopterus ruber*) and endemic Rock iguanas (*Cyclura spp.*).

In 2000, the Minister responsible for Fisheries announced the creation of five marine reserve sites North Bimini, The Berry Islands, South Eleuthera, Exuma and Abaco. The intent of the marine reserves are for the maintenance of marine life and habitat in an undisturbed state and for the replenishment of fisheries while the marine parks were created primarily for the purpose of enhancing recreational use of coastal waters. The proposed areas, all fall under category IV, Habitat/Species Management Area, of the IUCN categories for protected area management.

In addition to the five marine reserves, The Bahamas has nine marine parks, which are managed by BNT, the Exuma Cays Land and Sea Park (1958); Moriah Harbor Cay, Exuma; Pelican Cays Land and Seas Park, Abaco; Black Sound, Abaco; Walker's Cay, Abaco; Union Creek, Inagua; West side of Andros National Park; Andros Barrier Reef National Park; and Bonefish Pond, New Providence. The Exuma Cays Land and Sea Park was designated a no take zone in 1986. Casual observation and scientific

research demonstrate that the fish are larger and more abundant within the park than outside of the park limits (Sluka et al.). To help sustain the marine resources, The Bahamas has committed to protect and manage 20% of the marine resources by 2020.

Table 2: Protected Areas of The Bahamas (Adapted from Best 2011)

| Protected Areas | Location | Established | Size Acres | Features | IUCN Designation | Classification | | | | |
|----------------------------------|----------------------------------------------|-------------|------------|------------------------------------------|------------------|----------------|--------------|------------------|--------|---------------|
| | | | | | | Agriculture | Inland Water | Marine & Coastal | Forest | Management By |
| Abaco Island | | | | | | | | | | |
| Tilloo Cay Reserve | Abaco | 1990 | 1b | Wild coast tropic bird nesting | II | | | X | | BNT |
| Abaco National Park | Southern Abaco | 1994 | 20,500 | Pine forest/Abaco Parrot | IV | | | X | X | BNT |
| Fowl Cays | Between Scotland and Man O'War Cay, Abaco | | | | | | | X | | BNT |
| Pelican Cays Land and Sea Park | 8 miles north of Cherokee Sound, Great Abaco | 1972 | 2,100 | Marine area | II | | | X | | |
| Black Sound Cay National Reserve | Located off Green Turtle Cay in Abaco | 1988 | 2 | Mangrove | Ia | | | X | | |
| Walker's Cay National Park | The northernmost island in The Bahamas. | 2002 | 3,840 | Marine area | V | | | X | | |
| No Name Cay Marine Reserve | South of Green Turtle Cay, Abaco | 2010 | 1.71 sqm | Mangroves, seagrass beds, bonefish flats | | | | X | | DMR |
| Crab Cay Marine Reserve | North of Green Turtle Cay, Abaco | 2010 | 1.6 sqm | Seagrass beds, patch reefs, beaches, | | | | X | | DMR |

| Protected Areas | Location | Established | Size Acres | Features | IUCN Designation | Classification | | | | |
|--------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------------|----------------------------------|------------------|----------------|--------------|------------------|--------|---------------|
| | | | | | | Agriculture | Inland Water | Marine & Coastal | Forest | Management By |
| | | | | hard bottom | | | | | | |
| Andros Island - Central Andros National Park Areas(5) | | | | | | | | | | |
| Northern and Southern Marine Parks | Andros Barrier Reef | 2002 | 64,834 | Barrier reef and marine areas | II | | | X | | BNT |
| West Side National Park | | 2008 | 185,032 | Pine forest, mangroves, creeks | II | | X | | X | BNT |
| Blue Holes National Park | Central Andros area 3 | 2002 | 33,235 | Blue holes, Pine Forest | II | | X | | X | BNT |
| Crab Replenishment Area | Andros area 2 | 2002 | 2,979 | Crab replenishment | II | | X | | | BNT |
| Berry Islands | | | | | | | | | | |
| The South Berry Islands Marine Reserve | The area from Chub Cay (twin islands of; Frazer's Hog Cay and Thompson Cay) to Whale Cay inclusive of Crab Cay, Bird Cay, Diamond Rock and Cat Cay, Berry Islands | 2010 | 72.6 sqm | Coral reefs, mangroves, seagrass | IV | | | X | | DMR |
| Bimini | | | | | | | | | | |
| North Bimini Marine Reserve | North Bimini | 2010 | 14.1 sqm | Sawfish, mangrove, lagoon | IV | | | X | | DMR |

| Protected Areas | Location | Established | Size Acres | Features | IUCN Designation | Classification | | | | |
|------------------------------------------------------------------------------------------------|--------------------------------|-------------------------|------------|-----------------------------------------------------|------------------|----------------|--------------|------------------|--------|---------------|
| | | | | | | Agriculture | Inland Water | Marine & Coastal | Forest | Management By |
| | | | | | | | | | | |
| Crooked Island | | | | | | | | | | |
| Hope Great House & Marine Farm | West coast of Crooked Island | 2002 | 3.6 | 18 th century ruins – Loyalist dwellings | III | | | X | | BNT |
| Eleuthera | | | | | | | | | | BNT |
| Leon Levy Native Plant Reserve | Governors Harbour, Eleuthera | 2009 | 25 | | | | | | X | private |
| Exuma | | | | | | | | | | |
| Moriah Harbour Cay National Park | Between Great and Little Exuma | 2002 | 13,400 | Beaches, dunes, mangroves, seagrass | Ib | | | X | X | BNT |
| Exuma Cays Land and Sea Park (First land & sea park in the world) (First marine fishery) | Exuma Cays | 1958 No take 1986 | 112,640 | No take marine zone | II | | | X | | BNT |
| The Exuma (Jewfish Cays) Marine Reserve | South-West portion of Exuma | 2010 | 56.2 sqm | Mangrove, sandy flats, spiny lobster | IV | | | X | | DMR |
| Grand Bahama Island | | | | | | | | | | |
| Lucayan National Park | East of Freeport, Grand Bahama | 1977 | 40 | Covers all vegetative | II | | X | | | BNT |

| Protected Areas | Location | Established | Size Acres | Features | IUCN Designation | Classification | | | | |
|------------------------------|--------------------------------------|-------------|------------|----------------------------------------------|------------------|----------------|--------------|------------------|--------|---------------|
| | | | | | | Agriculture | Inland Water | Marine & Coastal | Forest | Management By |
| | | | | zones in The Bahamas | | | | | | |
| Rand Nature Centre | Freeport, Grand Bahama | 1992 | 100 | Pine forest | II | | | | X | BNT |
| Peterson Cay National Park | Cay off Grand Bahama's leeward shore | 1968 | 1.5 | Island for seabird nesting | II | | | X | | BNT |
| Inagua | | | | | | | | | | |
| Inagua National Park | Great Inagua | 1965 | 183,740 | Ramsar site; West Indian Flamingos | II | | X | | | BNT |
| Little Inagua National Park | Little Inagua | 2002 | 31,360 | Uninhabited island – high biodiversity value | Ib | | | X | | BNT |
| Union Creek Reserve | Great Inagua | 1965 | 4,940 | Sea turtle research | Ia | | | X | | BNT |
| New Providence Island | | | | | | | | | | |
| The Retreat | New Providence | 1985 | 11 | Coppice forest/rare palm collection | V | | | | X | BNT |
| Harold and Wilson Ponds | South Central New Providence | 2002 | 250 | Brackish water wetlands area/IBA | II | | X | | X | BNT |

| Protected Areas | Location | Established | Size Acres | Features | IUCN Designation | Classification | | | | |
|------------------------------------|---------------------------------------|-------------|------------|--------------------------------------|------------------|----------------|--------------|------------------|--------|----------------------------|
| | | | | | | Agriculture | Inland Water | Marine & Coastal | Forest | Management By |
| Primeval Forest | Southwest portion of New Providence | 2002 | 5 | Old growth hardwood forest | II | | | | X | BNT |
| Clifton Heritage Park | New Providence | 2004 | 208 | Loyalists ruins, shoreline, wetlands | II & III | | | | | Clifton Heritage Authority |
| Bonefish Pond National Park | South central coast of New Providence | 2002 | 1,280 | Marine nursery area | II | | X | X | | BNT |
| Rum Cay | | | | | | | | | | |
| Conception Island National Park | North of Rum Cay | 1964 | 2,100 | Sea birds/sea turtle nesting beach | Ib | | | X | | BNT |
| Wild Bird Reserves | | | | | | | | | | |
| Adelaide Creek Wild Bird Reserve | Adelaide, New Providence | 1951 | 150 | | IV | | | | X | MOE |
| Betty Cay Wild Bird Reserve | | 1951 | 1 | | | | | X | | MOE |
| Big Darby Island Wild Bird Reserve | | 1951 | 202 | | | | | X | | MOE |
| Big Galliot Cay Wild Bird Reserve | Long Island | 1954 | 8 | | | | | X | | MOE |
| Big Green Cay Wild Bird | | 1965 | 210 | | IV | | | | X | MOE |

| Protected Areas | Location | Established | Size Acres | Features | IUCN Designation | Classification | | | | |
|-----------------------------------------------------------------------|----------------|-------------|------------|----------------|------------------|----------------|--------------|------------------|--------|---------------|
| | | | | | | Agriculture | Inland Water | Marine & Coastal | Forest | Management By |
| Reserve | | | | | | | | | | |
| Bottle Cay Wild Bird Reserve | | 1961 | 4 | | IV | | | | X | MOE |
| Cedar Cay Wild Bird Reserve | | 1961 | 2 | | IV | | | | X | MOE |
| Channel Cays and Flat Cay Wild Bird Reserve | | 1954 | 18 | | | | | | X | MOE |
| A rock within Exuma Land & Sea Park designated as a Wild Bird Reserve | | 1962 | 1 | | II | | | X | X | MOE |
| Finley Cay Wild Bird Reserve | Eleuthera | 1968 | 5 | Coppice forest | IV | | | | X | MOE |
| Goat Cay Wild Bird Reserve | | 1951 | 12 | | | | | | X | MOE |
| Goulding Cay WNR Wild Bird Reserve | San Salvador | 1968 | 2 | | IV | | | | X | MOE |
| Grassy Creek Cays & Rocks Wild Bird Reserve | Andros | 1954 | 172 | | | | | X | X | MOE |
| Guana Cay Wild Bird Reserve | | 1951 | 2 | | | | | X | X | MOE |
| Harvey Cay Wild Bird Reserve | Exuma | 1966 | 2 | | IV | | | | X | MOE |
| High Cay Wild Bird Reserve | | 1954 | 8 | | | | | X | X | MOE |
| Joulter Cays Wild Bird Reserve | Andros | 1968 | 117 | | IV | | | | X | MOE |
| Lake Cunningham Wild Bird Reserve | New Providence | 1968 | 70 | | IV | | | X | X | MOE |

| Protected Areas | Location | Established | Size Acres | Features | IUCN Designation | Classification | | | | |
|-----------------------------------------------|---------------------|-------------|------------|----------|------------------|----------------|--------------|------------------|--------|---------------|
| | | | | | | Agriculture | Inland Water | Marine & Coastal | Forest | Management By |
| Lightbourn Creek (Waterloo) Wild Bird Reserve | Grand Bahama | 1968 | 200 | | IV | | | X | X | MOE |
| Little Derby Island Wild Bird Reserve | Exuma Cays | 1951 | 136 | | | | | X | X | MOE |
| Little San Salvador Wild Bird Reserve | Little San Salvador | 1961 | 182 | | IV | | | X | X | MOE |
| Mammy Rhoda Cay Wild Bird Reserve | | 1955 | 1 | | | | | X | X | MOE |
| Paradise Island Wild Bird Reserve | | 1956 | 283 | | | | | X | X | MOE |
| Washerwoman's Cut Cays Wild Bird Reserve | | 1954 | 79 | | IV | | | X | X | MOE |
| Water Cay Wild Bird Reserve | | 1955 | 3 | | | | | X | X | MOE |
| Wood Cay Wild Bird Reserve | Abaco | 1955 | 6 | | IV | | | X | X | MOE |

Community consultations and site assessments continue to determine boundaries for Marine Reserves in the waters near Long Island and South Eleuthera. Consultations and site assessment continue on national park on San Salvador.

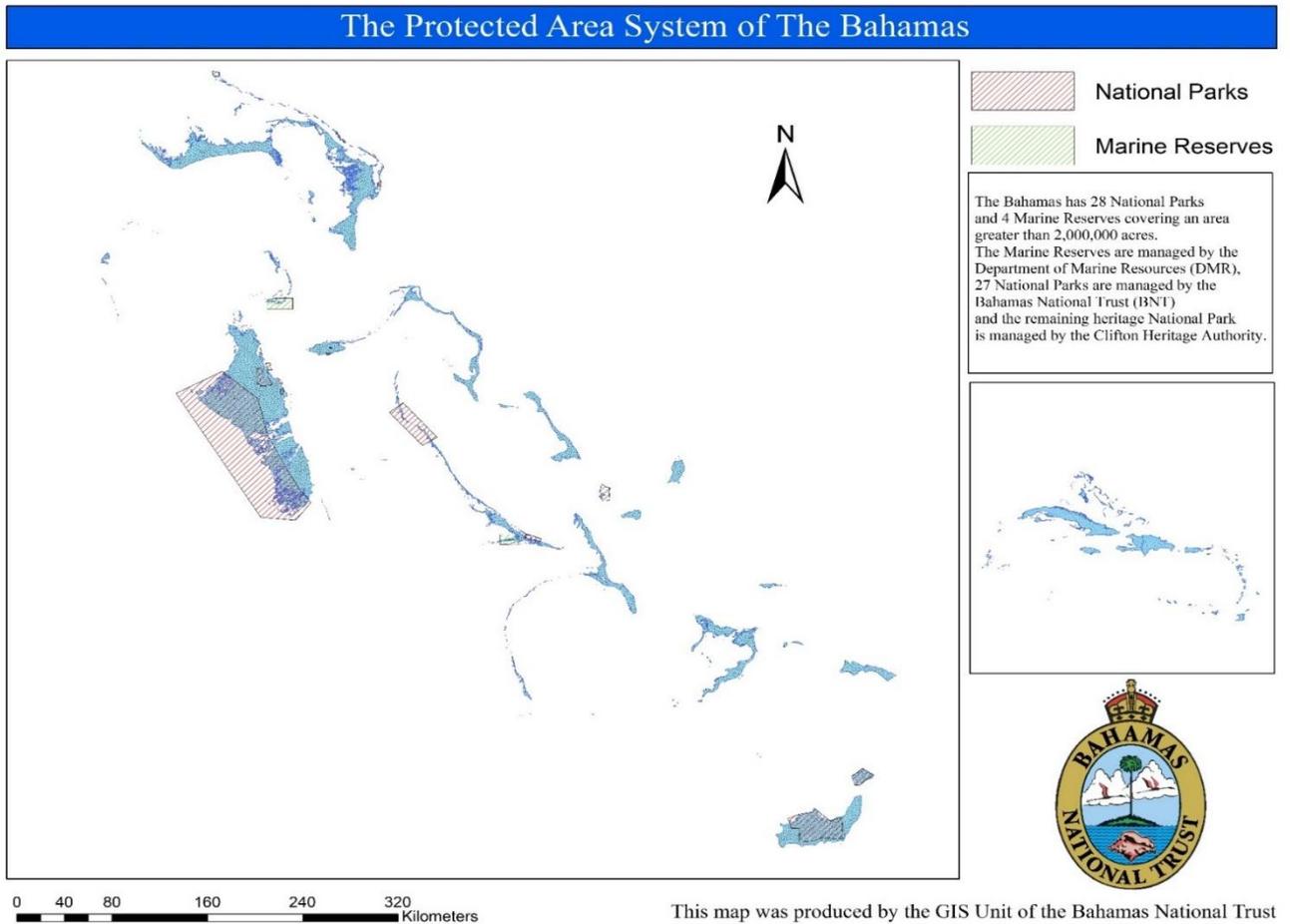


Figure 6: Map of The Bahamas Protected Area System.

IAS INVENTORIES

The National Invasive Species Strategy (NISS) was developed in 2003 and jointly funded by The Bahamas Government and the Environment Project Fund of the Foreign and Commonwealth Office of the British Government. The project facilitated the assessment of the mechanisms existing in The Bahamas to address the invasive species issue while enabling increased public awareness and involvement in the process. There were numerous stakeholder and public exercises during the project. The project developed awareness materials that hopefully benefited, not only to The Bahamas, but also to other Small Island Developing States (SIDS). The NISS was recently updated in 2013 and has identified 116 IAS that are found in The Bahamas or have the potential to become invasive.

List of Known Invasive Alien Species in The Bahamas (Adapted from NISS 2013)

Plant Species

| | |
|-----------------------------------|---------------------------------------------------------------------------------------|
| <i>Abrus precatorius</i> | Rosary pea |
| <i>Acacia auriculiformis</i> | Northern black wattle |
| <i>Acacia farnesiana</i> | Sweet acacia, Acacia |
| <i>Albizia lebbbeck</i> | Woman's tongue |
| <i>Antigonon leptopus</i> | Coral vine |
| <i>Asparagus densiflorus</i> | Asparagus fern |
| <i>Bauhinia variegata</i> | Poor man's Orchid, Orchid tree |
| <i>Bothriochloa pertusa</i> | Indian bluegrass, Barbados sour grass |
| <i>Calotropis procera</i> | Apple of Sodom |
| <i>Cardamine flexuosa</i> | Woodland bittercress |
| <i>Casuarina equisetifolia</i> | Australian Pine, Beefwood |
| <i>Casuarina glauca</i> | suckering Australian pine |
| <i>Cestrum diurnum</i> | Day jessamine |
| <i>Colubrina asiatica</i> | Lather leaf |
| <i>Dioscorea alata</i> | Winged yam |
| <i>Dioscorea bulbifera</i> | Air potato |
| <i>Eichhornia crassipes</i> | Water hyacinth |
| <i>Eugenia uniflora</i> | Surinam cherry |
| <i>Haematoxylon campeachianum</i> | Logwood |
| <i>Impomoea purpurea</i> | Morning Glory |
| <i>Jasminum fluminense</i> | Azores jasmine, Brazilian jasmine |
| <i>Lantana camara</i> | Lantana, Shrub verbena, angel lips, big sage, black sage, white sage, prickly lantana |
| <i>Launaea intybacea</i> | Bitter lettuce |
| <i>Leucaena glauca</i> | Jumbey |
| <i>Melaleuca quinquenervia</i> | Melaleuca, paper bark |
| <i>Nephrolepis multiflora</i> | Asian sword fern |
| <i>Neyraudia reynaudiana</i> | Burma reed |
| <i>Panicum repens</i> | Torpedo grass |
| <i>Passiflora foetida</i> | Fetid passion flower, Stinking passion flower |
| <i>Pennisetum purpureum</i> | Napier grass |
| <i>Pimenta racemosa</i> | Bay Rum |
| <i>Prunus amygdalus</i> | Almond |
| <i>Psidium guajava</i> | Guava |
| <i>Pteridium aquilinum</i> | Bracken |
| <i>Ricinus communis</i> | Castor Bean |
| <i>Ruellia brittoniana</i> | Mexican petunia |
| <i>Scaevola sericea</i> | Alternative: <i>Scaevola taccada</i> |
| <i>Scaevola taccada</i> | Asian Scaevola, Hawaiian seagrape, White inkberry |

| | |
|----------------------------------------------------|-----------------------------------------|
| <i>Schefflera actinophylla</i> | Schefflera, Queensland umbrella tree |
| <i>Schinus terebinthifolius</i> | Brazilian pepper, Bahamian holly |
| <i>Spathodea campanulata</i> | African tulip tree, flame of the forest |
| <i>Syngonium podophyllum</i> | Arrow head vine |
| <i>Syzygium cumini</i> | Black plum |
| <i>Thespesia populnea</i> | Seaside mahoe, cork tree, Spanish cork |
| <i>Thymophylla tenuiloba</i> var. <i>tenuiloba</i> | Bristleleaf, Dogweed, Dahlberg daisy |
| <i>Trachelosperumum jasminoides</i> | Star Jasmine |
| <i>Urochloa maxima</i> | Guineagrass |
| <i>Wedelia trilobata</i> | Wedelia, carpet daisy |
| <i>Ziziphus mauritiana</i> | Jujube, Chinese apple |

Bird Species

| | |
|------------------------------|------------------------|
| <i>Bubulcus ibis</i> | Cattle egret |
| <i>Columba livia</i> | Rock Dove |
| <i>Molothrus bonariensis</i> | Shiny Cowbird |
| <i>Myiopsitta monachus</i> | Monk parakeet |
| <i>Passer domesticus</i> | House Sparrow |
| <i>Streptopelia decaocta</i> | Eurasian Collared Dove |

Terrestrial Animals Species

| | |
|------------------------------------|----------------------------------------|
| <i>Aedes aegypti</i> | Yellow fever mosquito |
| <i>Anolis carolinensis</i> | Carolina anole |
| <i>Aphis spiraecola</i> | Spirea aphid |
| <i>Bos taurus</i> | Holstein |
| <i>Cactoblastis cactorum</i> | Cactus moth |
| <i>Canine</i> | Dogs (all breeds and types) |
| <i>Capra hicus</i> | Goat |
| <i>Cryptotermes brevis</i> | Powderpost termite |
| <i>Diaphorina citri</i> | Asian citrus psyllid |
| <i>Elaphe guttata</i> | Corn snake |
| <i>Eleutherodactylus coqui</i> | Caribbean tree frog, common coqui |
| <i>Equus asinus</i> | Donkey |
| <i>Euglandina rosea</i> | Rosy predator snail |
| <i>Felis catus</i> | Cats (all breeds and types) |
| <i>Gastrophryne carolinensis</i> | Eastern narrowmouth toad |
| <i>Herpestes auropunctatus</i> | Mongoose |
| <i>Maconellicoccus hirsutus</i> | Pink hibiscus mealybug |
| <i>Monomorium floricola</i> | Bicoloured trailing ant, Singapore ant |
| <i>Mus musculus</i> | Mouse |
| <i>Ovis aries</i> | Sheep |
| <i>Paratachardina pseudolobata</i> | Lobate lac scale |
| <i>Paratrechina longicornis</i> | Crazy ant, Long-horned ant |
| <i>Pheidole megacephala</i> | Big-headed ant |
| <i>Procyon lotor</i> | Raccoon |
| <i>Rattus norvegicus</i> | Norway rat |

| | |
|--------------------------------|----------------------------------|
| <i>Rattus rattus</i> | Ship rat |
| <i>Solenopsis geminata</i> | Tropical Asian fire ant, Red ant |
| <i>Solenopsis invicta</i> | Red imported fire ant |
| <i>Sus scrofa</i> | Pig |
| <i>Tapinoma melanocephalum</i> | Ghost ant |
| <i>Trachemys scripta</i> | Red-eared slider |
| <i>Loxosceles reclusa</i> | Brown recluse spider |
| <i>Wasmannia auropunctatus</i> | Little fire ant |

Aquatic Species

| | |
|----------------------------------|--------------------------------------|
| <i>Amphiprion sp</i> | Clown fish |
| <i>Artemia cysts</i> | Brine shrimp |
| <i>Callinectes sapidus</i> | Blue crab |
| <i>Callionymus lyra</i> | Dragonet |
| <i>Cherax quadricarinatus</i> | Red claw |
| <i>Chiloscyllium punctatum</i> | Banded shark |
| <i>Chkosoyllium piunctatum</i> | Brown Bamboo shark |
| <i>Chrysoara quinquechirra</i> | Sea nettle |
| Family Cichlidae | Cichlid fish |
| <i>Crassostrea virginica</i> | American oyster |
| <i>Dunaliella sp.</i> | Green algae |
| <i>Epinephelus lanceolatus</i> | Queensland grouper |
| <i>Euglandina rosea</i> | Cannibal snail |
| <i>Euxiophipops navarchis</i> | Blue-girded angelfish |
| <i>Euxiophipops xanthometapm</i> | Yellow-faced angelfish |
| <i>Hemiscylliidae</i> | Bamboo shark |
| <i>Heterodontus zebras</i> | Zebra Bullhead shark |
| <i>Nannochloropsis oculata</i> | Algae |
| <i>Oreochromis aureus</i> | Blue tilapia |
| <i>Oreochromis mossambicus</i> | Mozambique tilapia |
| <i>Oreochrommis ureblepis</i> | Tilapia |
| <i>Pterois miles</i> | Lionfish |
| <i>Pterois volitans</i> | Lionfish |
| <i>Radianthus</i> | Sea anemone |
| <i>Tubastraea coccinea</i> | Orange-cup coral, Colonial-cup coral |
| <i>Xiphophorus hellerii</i> | Swordtail, Red velvet |

Microorganisms

| | |
|---------------------------------------------------|----------------------------------|
| <i>Fusarium oxysporum</i> <i>f.sp. Cubense</i> | Panama disease of banana (fungi) |
|---------------------------------------------------|----------------------------------|

Plant and Animal Species Recommended for Eradication

| | |
|--------------------------------|---------------------------|
| <i>Casuarina glauca</i> | Suckering Australian Pine |
| <i>Melaleuca quinquenervia</i> | Melaleuca, (paper bark) |

| | |
|---------------------------------|------------------------------------------------------------------|
| <i>Mucuna pruriens</i> | Monkey Tamarind |
| <i>Scaevola taccada</i> | Asian Scaevola, White Inkberry, (Hawaiian Seagrape) |
| <i>Schinus terebinthifolius</i> | Brazilian Pepper, Bahamian Holly |
| <i>Molothrus bonariensis</i> | Shiny Cowbird |
| <i>Procyon lotor</i> | Raccoon (for all islands except New Providence and Grand Bahama) |

Plant and Animal Species Recommended for Control

| | |
|-------------------------------------|-----------------------------------------------|
| <i>Albizia lebeck</i> | Woman's Tongue |
| <i>Antigonon leptopus</i> | Coral Vine |
| <i>Bauhinia variegata</i> | Poor Man's Orchid |
| <i>Casuarina equisetifolia</i> | Casuarina, Australian Pine, (beefwood) |
| <i>Delonix</i> spp. | Poinciana |
| <i>Eichhornia crassipes</i> | Water Hyacinth |
| <i>Haematoxylon campeachianum</i> | Logwood |
| <i>Impomoea purpurea</i> | Morning Glory |
| <i>Leucaena glauca</i> | Jumbey |
| <i>Pimenta racemosa</i> | Bay Rum |
| <i>Prunus amygdalus</i> | Almond |
| <i>Ricinus communis</i> | Castor Bean |
| <i>Spathodea campanulata</i> | African Tulip Tree, Flame of the Forest |
| <i>Schefflera actinophylla</i> | Schefflera, Queensland Umbrella Tree |
| <i>Trachelosperumum jasminoides</i> | Star Jasmine |
| <i>Wedelia trilobata</i> | Wedelia, (carpet daisy) |
| <i>Columba livia</i> | Rock Dove |
| <i>Passer domesticus</i> | House Sparrow |
| <i>Pterois miles</i> | Lionfish |
| <i>Pterois volitans</i> | Lionfish |
| <i>Streptopelia decaocta</i> | Eurasian Collared Dove |
| <i>Canine</i> | Dogs |
| <i>Felis catus</i> | Cats |
| <i>Procyon lotor</i> | Raccoon (for New Providence and Grand Bahama) |

In the NISS it was determined that species-specific management plans need to be developed for high priority IAS as a matter of urgency. A response plan has been developed for lionfish which outlines management measures. The list below identifies species in immediate need of management plans:

- *Canine* Dogs
- *Casuarina glauca* Suckering Australian Pine
- *Casuarina equisetifolia* Casuarina, Australian Pine, (beefwood)
- *Felis catus* Cats

- *Molothrus bonariensis* Shiny Cowbird
- *Mucuna pruriens* Monkey Tamarind
- *Procyon lotor* Raccoon
- *Scaevola taccada* Asian Scaevola, White Inkberry, (Hawaiian Seagrape)
- *Schinus terebinthifolius* Brazilian Pepper, Bahamian Holly

The Case of The Cane Toad

During the development of this document The Bahamas was faced with the introduction of the Cane Toad, *Rhinella Marina*, which has the potential to become highly invasive. This species has been nominated as among 100 of the "World's Worst" invaders. There are two species of frogs on New Providence – the Cuban Tree Frog *Osteopilus septentrionalis* – and the Greenhouse Frog *Eleutherodactylus planirostris* but there are no native toads.

Cane toads were introduced to many countries as biological control agents for various insect pests of sugarcane and other crops. The cane toads have proved to be pests themselves. They will feed on almost any terrestrial animal and compete with native amphibians for food and breeding habitats. Their toxic secretions are known to cause illness and death in domestic animals that come into contact with them, such as dogs and cats, and wildlife, such as snakes and lizards. Human fatalities have been recorded following ingestion of the eggs or adults.

Cane toads are large, heavily built amphibians with a dry and warty skin. Their coloring ranges between grey and olive brown and their belly is pale with dark, irregular spots. Average-sized adults are 10-15 cm long, but they can grow up to 23 cm or more



Figure 7: Cane Toad, *Rhinella marina*

They breed in still or slow-flowing water often tangling the spawn around rocks or water plants. The appearance of cane toad spawn is unique and consists of long gelatinous strings with double rows of black eggs. Females lay 8,000 to 35,000 eggs at a time and usually breed twice a year. The eggs hatch in 48-72 hours into tadpoles. They develop into toadlets in between 17 days to 6 months. Cane toads need between 6 and 18 months to reach sexual maturity and have a lifespan of about 5 years.

The Cane Toad is native to southern Texas through Central America and tropical South America.

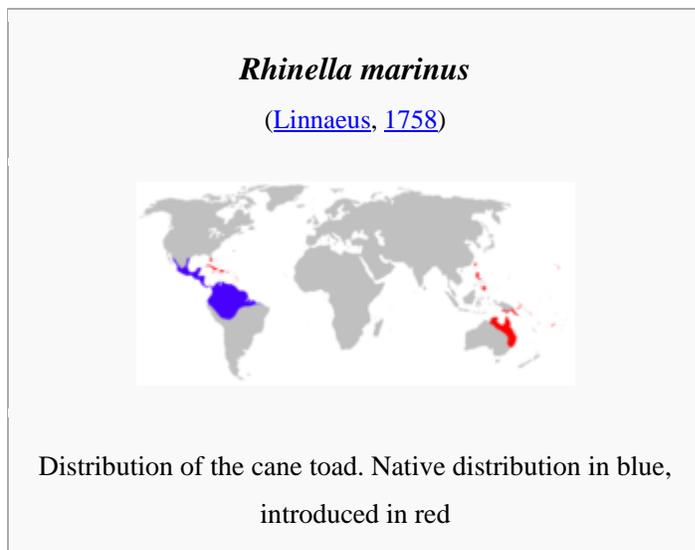


Figure 8: The native and introduced distribution the cane toad.

Cane toads forage at night in a wide variety of habitats. The cane toad is a ground-dwelling predator, primarily eating terrestrial and aquatic insects and snails. Toads will even take food left out for pets.

Cane toads need constant access to moisture to survive. Instead of drinking, they absorb water through the skin on their belly — from dew, moist sand or any other moist material. If forced to stay in flooded conditions, cane toads can absorb too much water and die. They can also die from water loss during dry conditions. Outside of its native range there are no specific predators or diseases that control cane toads (www.issg.org).

The Cane Toad has been unintentionally introduced widely on to many major islands in the West Indies. Although the Cane Toad has been present on many islands for over 150 years there have been limited to no efforts to control. In Jamaica it was viewed as beneficial until 2011 when Byron et al. have found numerous examples of cane toads poisoning Jamaican boas (*Epicrates subflavus*), large predatory snakes that are endemic to the island of Jamaica. The researchers now fear that the toads could pose a threat to the snake across its island range. They also worry that other species in Jamaica and on other Caribbean islands are at risk from bufotoxin poisoning.

Reports of Cane Toads were brought to the attention of the Bahamas National Trust and Ministry of Agriculture in early August 2013. The sightings all came from Lyford Cay, the most western end of New Providence, which is a private gated community. It was at that time that specimens were confirmed as the Cane Toad, *Rhinella marina*. Once the specimens were correctly identified the Bahamas National Trust, The Department of Agriculture and Mrs. Sandra Buckner (Herpetologist) organized an informational meeting for all relevant government agencies, NGO'S, private entities along with residents and staff of the Lyford Cay community. At the meeting, it was clear that a coordinator is needed to develop strategies going forward and to coordinate national efforts.

A rapid assessment of the Lyford Cay and neighboring areas was conducted by Vanessa Haley-Benjamin (BNT Director of Science and Policy), Mrs. Sandra Buckner (BNT Past President), Janeen Bullard (Consultant), Joe Wasilewski and Joe Burgess (Wildlife Biologists). The purpose of the assessment was to determine the distribution of the Cane Toads and inspect water bodies to determine if reproduction was evident. From our site assessment, we were able to determine that the cane toads seem to be confined to the Lyford area and there was evidence of reproduction within freshwater/brackish ponds.

News quickly spread about the presence of the Cane Toad so in an effort to ease public fears a press conference was held By Hon Kenred Dorsett the Minister of Environment.

The press conference was used to notify the public that the cane toad was identified and appears to be breeding in the Lyford Cay area. It also gave instructions on reporting any possible sightings, what to do in the event of contact with the animals toxins as well as proper methods of euthanasia. Informational fact sheet have since been created and training to identify and handle the animals have started with field staff from the Lyford Cay area, Department of Environmental Health Services, Bahamas National Trust and surrounding areas. Groups have been going out and collecting animals at night recording basic information and euthanizing them by refrigerating to cool down then freezing.

In order to control the species, our strategy addresses the capture and destruction of all life stages (including eggs, tadpoles and adults). Residents and staff of the Lyford Cay area have assisted greatly in this effort. Lyford Cay Security K9 unit have continued to cull and report any animals found. Notifications have gone out to residents and golf course to be vigilant, report any sightings and precautions they can take to reduce breeding. A Task Force of stakeholders has been formed and the group is working on the most effective strategy is being developed to handle the cane toad situation.

We are unable to definitively say how long the Cane toads have been here but there is one confirmed report dating back to 2011 and one anecdotal report to 2010. At this time, we are not sure how long the Cane Toad has been here or how many are within the Lyford Cay area. What we do know is that they are reproducing and we have to act swiftly to control and possibly eradicate the species. Despite anecdotal reports of possible Cane toad sightings outside of the Lyford Cay area (Charlotteville, Adelaide and St. Alban's Drive), these are all unconfirmed so we generally think they are still confined to the Lyford Cay area.

There is a more important message that this one incident has brought into question, are our borders effectively protected? As a country, what should be done to minimize such invasions? Based on the confirmed sightings from 2011 that were not reported a system of reporting needs to be developed and effectively communicated with the general public. As global travel and trade increases, the pathways for invasive species to establish themselves in new lands also increase. Such invasions undermine our economy and endanger our natural treasures. These stealth invaders, unchecked by natural controls, can spread across our islands and wreak havoc with already fragile native species and ecosystems.

HISTORIC OVERVIEW

Historically The Bahamas has worked in the following sectors to prevent, manage and control IAS:

- Agricultural sector - the Pink Hibiscus Mealy Bug (PHMB) (*Maconellicoccus hirsutus*), the coconut mite (*Aceria guerreronis*) and the citrus canker caused by the bacterium *Xanthomonas axonopodis*
- Biodiversity management – The Australian pine (*Casuarina equisetifolia*), the Hawaiian sea grape (*Scaevola taccada*), melaleuca (*Melaleuca quinquenervia*), Brazilian pepper (*Schinus terebinthifolius*) and lionfish (*Pterois volitans*)
- Human Health – Control of Dengue fever transmitted by the bite of infected *Aedes aegypti* mosquitoes

The Pink Hibiscus Mealy Bug (PHMB) (*Maconellicoccus hirsutus*) invaded the Caribbean in 1994, affecting citrus and other economically important species. Countries throughout the Caribbean were on high alert due to the destructive nature of this pest. The Bahamas was on high alert for PHMB and developed a national campaign in order to prevent its introduction. The campaign intensified to help control PHMB once the bug was reported in 2000. The Ministry of Agriculture created posters and flyers for distribution (Fig 7). Telephone hotlines were set up to report possible sightings. Radio and television shows and TV bulletins were broadcast to help the public identify PHMB and understand its possible affects. Town meetings and school visits were conducted and farmer education programs developed. Inspectors were trained to identify and treat infected areas.



Figure 9: Poster distributed by Department of Agriculture on the Hibiscus Mealy Bug.

Despite the best efforts to prevent the spread of PHMB failed. Due to the ineffectiveness of pesticides in treating PHMB it was treated biologically by releasing a wasp its natural enemy. To control the PHMB, exotic parasites, *Anagyrus kamali* and *Gyranusoidea indica* (both Hymenoptera: *Encyrtidae*) (fig 8), were introduced which were mass produced in San Juan, Puerto Rico by the local Department of Agriculture for local needs. These organisms were shipped and released in New Providence Island beginning in January of 2001. Additional parasite releases were made only at newly infested locations. By April of 2001 the mealybug's population density at the study sites had declined by an average of 71%. These parasitoids controlled the mealybug in Grenada, The Bahamas, Belize, Guyana, Mexico, the U.S. Virgin Islands, and Puerto Rico. Early detection and correct diagnosis is essential to minimizing widespread economic damage and/or prevent further establishment. Although this was not The Bahamas' first experience with an invasive, this was the first experience with a large scale prevention and public education component implementation.

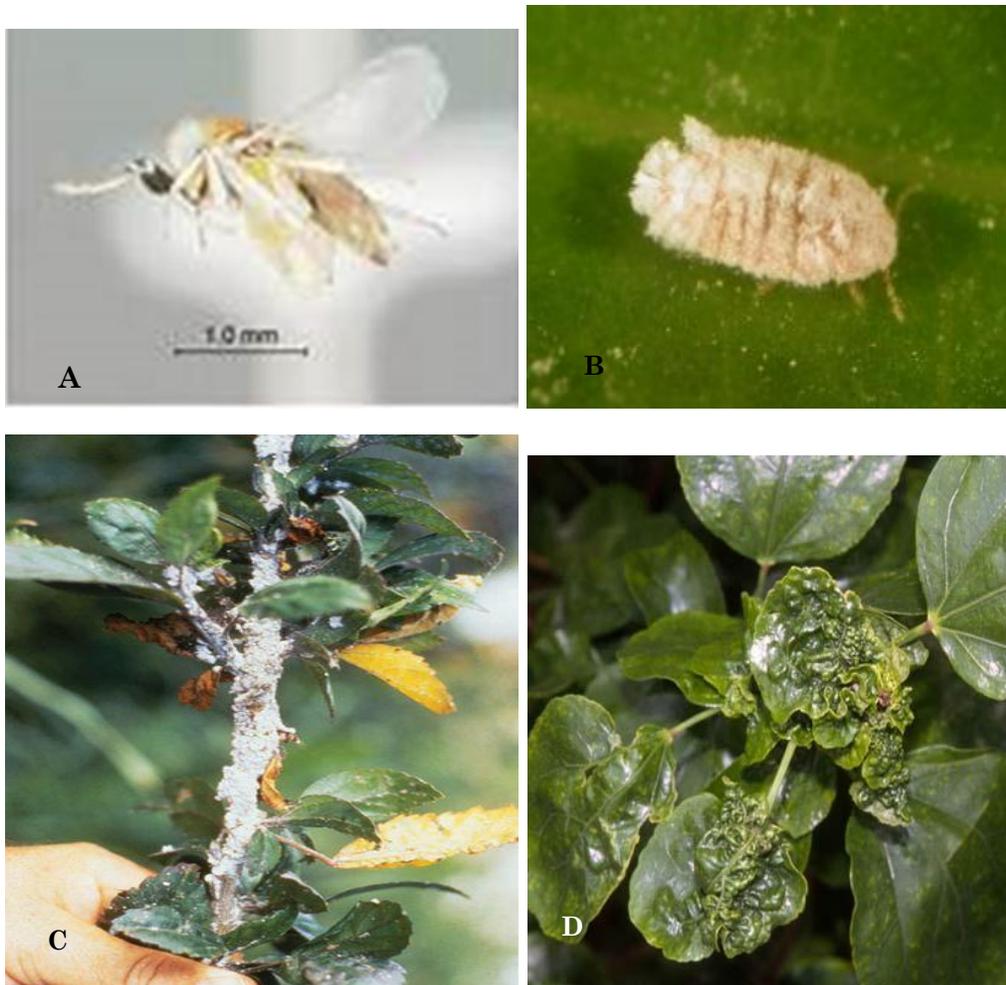


Figure 10: A. *Ansgyrus kamali* adult female wasp used as biological control against the Hibiscus Mealy Bug. B. The Pink Hibiscus Mealy Bug (PHMB) (*Maconellicoccus hirsutus*). C. Plant with established PHMB infestation and D. Leaf curling as a result of PHMB infestation.

In 2001, the IABIN Invasive Network (I3N) The Bahamas project was established to:

- Develop an inventory of invasive species information in The Bahamas
- Tie into the achievement of goals of the biodiversity subcommittee chaired by the BEST Commission. The goals were to recommend policy, legislation, mechanisms and other measures to facilitate the control of invasive species.

The project established the I3N working group consisting of representatives from the Biodiversity Subcommittee and the Research Unit of the College of The Bahamas. The

group collected and entered data, and conducted workshops and public consultations. Activities included:

- A workshop on invasive plant species in The Bahamas
- A lecture on invasive animal species in The Bahamas
- Newspaper articles on the concept of invasion and invasive species in general
- Interviews conducted in New Providence, Grand Bahama and Abaco to gather data for catalogues
- A literature search and examination of permits and licenses for importing plants and animals
- Public workshops on invasive species.

The *Building Partnerships to Assist Developing Countries to Reduce the Transfer of Harmful Aquatic Organisms in Ships' Ballast Water*, known as the **GloBallast Partnerships (GBP)** project aimed to help developing countries reduce the risk of invasion of aquatic organisms in ballast water and ships' sediments. The GloBallast partnership project aimed to:

- Reinforce governments' and ports' management capacities
- Promote legal, political and institutional reforms on a national level
- Establish systems ensuring sustainable management
- Encourage regional coordination and cooperation
- Simulate efforts on an international scale in view of developing technological solutions and improve knowledge management and information exchange in view of supporting initiatives linked to marine biosecurity.

A crucial component of the GBP was the partnership between the public and private sector. The expected results included: the improvement of knowledge acquisition, evaluation and adaptive management; the establishment of ballast water management strategies; the efficient use of knowledge management tools and marine environment monitoring systems; and the establishment of partnerships between the public and private sectors in order to stimulate the creation of technologies with good cost-efficiency for managing ballast water (CAR.SPAW.RAC 2013).

Background to Mitigating Threats of Invasive Species in the Insular Caribbean (MTIASIC)

In an effort to develop a regional strategy to combat the issue of IAS, a regional initiative entitled Mitigating Threats of Invasive Species in the Insular Caribbean (MTIASIC) was implemented. The Project is funded by the Global Environment Facility through the Centre for Agricultural Bioscience International – Caribbean and Latin America (CABI-CLA) acting as the Regional Implementing Agency, overseeing project activities in The Bahamas the Dominican Republic Jamaica St. Lucia and Trinidad & Tobago. Each

country identified a high priority IAS and developed early detection and rapid response, control, eradication or preventative measures where applicable. With the MTIASIC project, The Bahamas developed control measures for the red lionfish, *Pterois volitans*.

The Bahamas Department of Marine Resources is the national implementing agency and works in collaboration with local and international organizations including the BEST Commission, Bahamas National Trust (BNT), Bahamas Reef Environment Education Foundation (BREEF), Cape Eleuthera Institute (CEI), The Nature Conservancy (TNC) Northern Caribbean Program, Reef Environmental Education Foundation (REEF) (Key Largo, Florida) and Simon Fraser University, British Columbia, Canada.

The overall project goal is to conserve globally important ecosystems, the species and genetic diversity within the insular Caribbean. The project objective is to mitigate the threat to local biodiversity and economy from IAS in the insular Caribbean, including terrestrial, freshwater, and marine ecosystems.

The project has five components:

Development of National Invasive Species Strategies (NISS): At the end of the four-year project, each country is expected to have a NISS (policy document) and a permanent IAS working group to address IAS issues officially and in a sustainable manner. The Bahamas completed its NISS in 2003. Under this project it was reviewed and updated. The Bahamas Biodiversity Committee which was previously established serves as the IAS working group.

Caribbean-wide Cooperation and Regional IAS Strategy (CRISS): At the end of the project a regional IAS strategy for marine, terrestrial and aquatic IAS will complement the national efforts described under Component 1. The regional strategy aims to expand the draft CRISS document, which is currently primarily focused on agricultural pests and diseases, to cover also environmental IAS.

Information and Knowledge Generation, Management, and Dissemination: The threat posed by IAS is a cross-cutting issue. A multi-sectoral approach to knowledge management and dissemination is key to successful uptake of the project outputs. Public awareness campaigns will be implemented for each of the pilot projects, including the exchange of lessons learnt among the participating countries. The project will establish and strengthen several electronic networking initiatives that would be sustained after the project concludes.

Prevention of IAS in Terrestrial, Freshwater and Marine Systems: Prevention is the most cost effective measure for managing IAS and is a key component of the CBD Guiding Principles. The Bahamas' pilot project will evaluate removal frequencies that are most effective at controlling lionfish populations on marine habitats of ecologic and economic importance and monitor social impacts to address which lionfish removal frequency is the most successful in safeguarding critically important marine habitats and how much impact does the lionfish invasion have on human health.

Managing priority alien species invasions in pilot sites to ensure conservation and sustainable use of biodiversity also through Components 4 and 5, piloting prevention and response measures to biological invasions. The project is in line with Goal 6 of Convention of Parties (COP) 8 of the Convention of Biological Diversity (CBD): *Control threats to island biological diversity from IAS*, which calls for collaborative pathway analyses at the island, national, regional and global level, combined with the establishment of effective control systems at national and inter-island borders. It also calls for the development and implementation of measures for early detection of and rapid response to the introduction or establishment of IAS in both terrestrial and aquatic ecosystems and prevention, as well as eradication and management plans for long term management of priority IAS.

Table 3: The Bahamas’ achievements during the Project Preparation Grant (PPG) of the GEF-funded project “Mitigating Threat of Invasive Alien Species in the Insular Caribbean (MTIASIC)”

| <i>Activities under The Bahamas PPG</i> | <i>Outputs achieved</i> |
|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1. Increase national capacity to address potential risks posed to biodiversity of global significance from invasive alien species</p> | <p>The National Steering Committee was selected based on the existence of a standing committee, The Biodiversity Committee, responsible for identifying invasive species and making recommendations for their management. The committee consists of representative from Governmental and Non-Government Organizations and private entities, that has initiatives related to IAS under their portfolio; The Department of Marine Resources (DMR), The Bahamas Environment Science and Technology (BEST) Commission; The Bahamas National Trust (BNT), The Nature Conservancy (TNC) - Northern Caribbean Programme, Bahamas Reef Environment Educational Foundation (BREEF), Department of Agriculture (DOA) and Dolphin Encounters Limited (DEL).</p> <p>The National Invasive Species Strategy (NISS) was developed in 2003 under the mandate of the BEST Commission. One of the components of the project aims to update the contents of the NISS to incorporate the risks of climate change and associated IAS. A consultant was hired to facilitate the NISS update in which the process entailed stakeholder interviews and consultation workshop with the guidance of DMR and BEST to engage and incorporate input from twenty four (24) agencies. The final NISS was completed July 2013. The next steps include updating an existing draft Biosecurity Act to accompany the NISS for adoption by Government, which will provide IAS legislation that would mandate the relevant agencies to implement the NISS. A guide to invasive species in The Bahamas is being generated through the NISS development process geared towards guiding agencies to identify and properly remove or treat invasive plants or animals when capable.</p> |
| <p>2. Increased regional cooperation to reduce risk posed to biodiversity of global</p> | <p>The Bahamas has been actively involved in the Regional Consultations providing the baseline structure of the regional strategy, and the guiding principle for the completion of the strategy.</p> |

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| <p>significance from invasive alien species.</p> | <p>The Bahamas' NPC has held the secretariat position for the Marine Invasive Species Working Group, ensuring meetings are executed and documented, and compiling documents to guide the development of the marine invasive species strategy.</p> <p>The Bahamas hosted the final/3rd Regional Consultation to finalize the CIAS Strategy and the development of action plans for the respective working groups and country plans to guide the development of IAS Legislation for adoption of the regional strategy on the country level. The current CIAS Strategy although in its draft form, has been reviewed to guide the update of the existing NISS. The Bahamas has participated in the International Project Steering Committee (IPSC) Meetings from inception, and is expected to attend the upcoming IPSC to guide the progress of the overall project.</p> |
| <p>3. Access to data and best practice established, and public awareness of IAS strengthened.</p> | <p>The findings of the lionfish project have not been completed but results of the baseline surveys and site selections have all been documented to date. The preliminary results for the experiment will be completed by 30 December, 2011 which was presented at the 64th Gulf and Caribbean Fisheries Institute (GCFI) Conference in November 2011. Subsequent to the implementation of the project, NOAA, REEF and SPAW has since initiated the development of a regional lionfish control strategy. The Bahamas has been intimately involved in this process considering many efforts through research and control initiatives have been engaged in country. The Bahamas' National Lionfish Response Plan, removal techniques, control efforts, lionfish legislation review (in draft) and the NISS have been reviewed for the development of the regional strategy and The Bahamas Project Director has been identified as a reviewer for the strategy and best practice guidelines.</p> <p>A baseline public awareness survey was administered amongst approximately 1,100 persons throughout three (3) islands of which are pilot sites for demonstration experiments, Eleuthera, Exuma and New Providence. However, the final report has not been generated to capture the true sense of the level of</p> |

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| | <p>awareness on environmental issues and the impacts of lionfish and the invasion as a whole.</p> <p>Lionfish culinary demonstrations have been one of the major activities for education and outreach for the general public on the lionfish invasion and the impacts they pose. Approximately 10 lionfish demonstration have been conducted for the project through several means i.e. Expos, Food Shows, Seafood & Heritage Festivals, at Fish landing sites etc.</p> <p>An educational programme was developed in conjunction with Dolphin Encounters, highlighting the top 5 invasive species in The Bahamas. The infamous “Sea Rangers” explores Blue Lagoon Island identifying 4 plant invasives, then expanding to the marine invasive – lionfish, in a 15 minute segment. The national television station, ZNS, is currently airing the programme as fillers, and will be available in four 3-4 minute PSAs for posting on the regional website and you tube for wider circulation.</p> |
| <p>4. Increase capacity to strengthen prevention of new IAS introductions.</p> | <p>National capacity to prevent biological invasions strengthened: no action to be undertaken in The Bahamas under this project.</p> |
| <p>5. Increased capacity to respond, control and manage IAS impacting globally significant biodiversity</p> | <p>The project seeks to identify the most successful removal frequency based on lionfish densities and fish community structures. A total of 48 sites was selected on New Providence, Andros and within the Exuma Cays Land & Sea Park (ECLSP) for each habitat type: mangroves, artificial substrates and deep reefs (depth range 60-130ft). Lionfish was physically removed on SCUBA, with 5-inch paralyzer-tip pole spears and clear hand-held vinyl nets. At the control sites (24 in total), no lionfish was removed, however reef fish and lionfish surveys were maintained.</p> <p>There has been anecdotal evidence that points to marine invasive species being controlled naturally in marine protected areas due to larger predators found within the boundaries. This has been more of the focus on the lionfish</p> |

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| | <p>invasion, in that larger seabasses are preying on lionfish. A recent paper has been circulated to address this theory; however, there is still doubt as to natural predators in The Bahamas considering very few are found in its native range. Observational studies in The Exuma Cays Land and Sea Park have seen low abundance of lionfish with a small biomass as seen throughout the archipelago outside of MPAs.</p> <p>The project enabled formal establishment of a Lionfish Collection and Handling Protocol which stakeholders were trained in. The training functioned as a train-the-trainer program and two workshops produced at least 18 trainers who can conduct the training nationally.</p> <p>The National Lionfish Response Plan focused on identifying high biodiversity areas for designation as protected areas, in which management plans will address invasive species management through active removal and monitoring techniques. All protected area management plans address IAS management.</p> |
| <p>6. Effective project management and coordination; monitoring and evaluation (M&E)</p> | <p>Project deliverables produced on time and within budget.</p> <p>Effective M&E framework in place</p> |
| <p>7: Independent Evaluations</p> | <p>Independent evaluations completed in years two and four.</p> |



Figure 11: Participants during the MTIASIC Reef fish identification training.



Figure 12: MTIASIC Lionfish poster

PREVENTION

The Bahamas has recognized that the prevention and management of IAS is critically important to the economy and well-being of the country. The prevention of IAS would

be the most cost effective. Prevention refers to the exclusion of IAS from the country. A large scale prevention program would rely on import and trade regulations and restrictions, border controls and inspections. This proves to be extremely difficult for an archipelagic country like The Bahamas that has a population of over 300,000 people most of which are located on New Providence. The estimated illegal alien population is at 50,000. There are around 3.5 million tourists that visit annually by scheduled cruises or air travel as well as personal crafts. The Bahamas imports about 80% of its food and there is also a large population of pets including dogs, cats, tropical and marine fish, hamsters, rabbits, birds and others. The country also has at least 32 legal ports of entry with seven in New Providence alone (Bahamas Country Report EC-Cariforum, 2003).

One of the first steps would be to develop a predictive model to determine organisms that may potentially establish and flourish in the Bahamian environment. This model would also need to determine possible pathways of introduction. A list of potential pathways both intentional and unintentional needs to be identified along with the potential organizations of interest. Threat levels need to be assigned based on the threat to human, economic or ecosystem health.

Agricultural officers or packing house managers are stationed at various ports of entry on New Providence, Grand Bahama, Abaco, Andros, Exuma, Eleuthera and Long Island where established protocols for inspection exist. Currently, the DOA determines import limitations from a country based on the history and potential of native species becoming invasive. This is done by Orders under the Plants Protection Act. The imported goods, i.e. plant or animal materials require a license to import. If a shipment is approved it must be accompanied by a Phyto-Sanitary Certificate from the exporting country. Upon arrival, the shipment is inspected by agricultural officers. Additionally, there is monitoring and surveillance for pests that are known threats to The Bahamas. There are also weekly trappings for exotic fruit flies which are conducted jointly with the USDA. The animal import section also has established protocols and policies that consider invasive potential and possible damage to native wildlife and the environment prior to allowing the import of animals (DOA interview 2013).

Inspectors (DOA officers/Custom Officers) appointed by the Minister are required to conduct searches. Issues arise from the lack of training and sensitization to the IAS issue. Officers require training and additional material to assist with the identification of IAS. Additionally, on some islands there is a lack of facilities to detain and or quarantine items, as well as the challenge of finding a veterinarian to inspect animals (NISS stakeholder interview report 2011).

The Bahamas with assistance from the FAO has developed a five year plan for its agriculture sector. The plan calls for an ornamental research and development programme to be established within the Gladstone Road Agricultural Complex (GRAC) with the initial research priority being, to investigate possible invasive species pathways for importations from Florida and mites which affect the Ficus species. Recommendations from the research would be considered for improved legislation and regulatory protocols within the industry.

The agricultural sector is further supported by collaboration with the IPPC, FAO, IICA, CARDI, and USDA/APHIS.

EARLY DETECTION, RAPID RESPONSE AND IAS CONTROL

Early detection, coupled with a rapid assessment and a quick and effective response is viewed as one of the best and cost-efficient ways of dealing with IAS. Some potential IAS are bound to arrive in The Bahamas due to its geographical make up and many ports of entry.

Early detection and rapid response increases the likelihood that localized invasive populations will be found, contained, and eradicated before they become widely established. It can slow range expansion, and avoid the need for costly long-term control efforts. In order to be effective early response and rapid response is time sensitive. A successful process ensures that:

1. potential threats are being identified in time to allow risk-mitigation measures to be taken;
2. new invasive species are being detected in time to allow efficient and environmentally sound decisions to be made;
3. responses to invasions are effective and environmentally sound and prevent the spread and permanent establishment of invasive species;
4. adequate and timely information is being provided to decision-makers, the public, and to trading partners concerned about the status of invasive species within an area;
5. lessons learned from past efforts are being used to guide current and future efforts.

This process is only possible through monitoring being carried out by those who are regularly in the field, i.e. birdwatchers, landscape crews, researchers and the general public. There is a need for a national electronic database that can be assessed by inspectors and other field personnel that identifies existing and potential IAS. Access to a database would increase early detection capacity.

Once established, IAS should be targeted for management activities, research and innovative responses to minimize their long-term impacts and costs. Risk analysis, cost-benefit analysis and other tools can be used to identify and prioritize the most appropriate and cost-effective mitigation measures to be undertaken, including containment, control and eradication.

Unlike the prior three approaches, management approaches to established IAS tend to be costly and are reactive in nature. Eradication, containment and control of identified priority IAS can involve physical, chemical, biological or integrated strategies. Scientific research on methods and technologies for priority IAS are critical to effectively assign resource use and maximize effectiveness.

Control and management of invasive species is accomplished using modern resource management methods. Several complementary methods may be implemented in an overall strategy to protect ecosystems and aid in their recovery. Strategies are analyzed and adjusted as needed, and work (including follow-up and monitoring) is conducted for many years. Control efforts reduce invasive species to more acceptable levels, and management prevents their spread or re-emergence. Scientific advances can dramatically improve the outlook for the control of certain species.

SECTORIAL INVOLVEMENT

Inter-Ministerial Coordination

In July 2008, The Ministry of the Environment was established. It has the overall responsibility for coordination of environmental management activities in The Bahamas. Four departments within the Ministry share various responsibilities. The Bahamas Environment Science & Technology (BEST) Commission is responsible for protection, conservation and management of the environment and manages relations with the National and International organizations on matters relating to the Environment. The Department of Physical Planning is responsible for land use planning and review of environmental impact assessments. The Port Department is responsible for maritime affairs and the Department of Environmental Health Services (DEHS) is responsible for scientific research and environment control. However, several other government ministries, departments, statutory organizations and NGO's have varying responsibilities for different aspects of biodiversity management some of which are directly and indirectly involved in IAS management (Table 4&5).

Table 4: National Institutions and their responsibilities (NISS 2013).

| | Management Objective | NISS Framework Institutions |
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| | Coordinating Body (Data Centre) | Quasi-government agency led by Department of Agriculture with BNGIS as Data Centre Alternative: Specialists within each institution who meet regularly |
| 1 | Collaboration | Bahamas Maritime Authority (BMA) BEST Commission Department of Agriculture (DOA) Department of Marine Resources (DMR) Ministry of Foreign Affairs Ministry of Health National Emergency Management Agency (NEMA) Royal Bahamas Defence Force (RBDF) |
| 2 | Prevention | BEST Commission BMA Bahamas National Trust (BNT) Customs Department DOA DMR Forestry Unit, Ministry of the Environment Grand Bahama Port Authority (GBPA) Environmental NGOs Civic groups |
| 3 | Early Detection and Response | BMA Customs Department DOA Department of Environmental Health Services (DEHS) Department of Immigration DMR Forestry Unit, Ministry of the Environment GBPA Ministry of Health RBDF |
| 4 | Control | BMA Customs Department DOA DEHS DMR GBPA RBDF Department of Immigration Ministry of Health |
| 5 | Monitoring | BNT BMA BNGIS Customs Department DOA |

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| | | DMR DEHS Forestry Unit, Ministry of the Environment GBPA Ministry of Health RBDF |
| 6 | Education and Awareness | Bahamas Information Services BMA BNT Bahamas Reef Environmental and Education Foundation (BREEF) College of The Bahamas DOA DMR DEHS GBPA Ministry of Education Ministry of Health Ministry of Tourism Environmental NGOs Civic groups (e.g. Rotary and Kiwanis) All agencies involved in IAS management |
| 7 | Research | BNT Cape Eleuthera Institute COB DOA DMR FORFAR Field Station RBDF Ministry of Health Environmental NGOs Scientific community |
| 8 | Policy and Legislation | Attorney-General's Office Cabinet Parliament Senate All agencies involved in IAS management |
| 9 | Economic Tools | Attorney-General's Office Department of Physical Planning GBPA Ministry of Finance |

Table 5: Institutions and Legislation based on Biodiversity Management

| Subject Area | Name of Legislation | Institutions Responsible |
|---------------------|----------------------------|---------------------------------|
| Urban Planning | Town Planning Act | Dept. of Physical Planning |

| Subject Area | Name of Legislation | Institutions Responsible |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | Dept. of Local Government |
| Forestry | Penal Code Forestry Act | Forestry Section (Ministry of the Environment) Dept. of Agriculture Dept. of Local Government |
| Agriculture | Agriculture and Fisheries Act Animal Contagious Diseases Act Plant Protection Act | Dept. of Agriculture Dept. of Fisheries Forestry Section (Ministry of the Environment) Customs Dept. of Local Government |
| Crown Lands | Lands Surveyors Act Forestry Act | Dept. of Lands and Surveys Dept. of Agriculture Bahamas National Trust Bahamas Agricultural and Industrial Corporation Water and Sewerage Corporation Ministry of Housing Dept. of Local Government Office of The Prime Minister |
| Beaches | Town Planning Act Conservation and Protection of the Physical Landscape Act Coastal Protection Act | Dept. of Physical Planning Dept. of Lands and Surveys Port Department Dept. of Local Government DEHS |
| Protected Areas | Bahamas National Trust Act Wild Birds Protection Act Forestry Act Plant Protection Act Water and Sewerage Act Fisheries Resources and Jurisdiction Antiquities Monuments & Museums Act | Bahamas National Trust Dept. of Agriculture DMR Dept. of Lands and Surveys Water and Sewerage Corporation Dept. of Local Government AMMC Clifton Heritage Authority |
| Wildlife | Wild Animals Protection Act Wild Birds Protection Act Plant Protection Act Marine Mammal Protection Act Fisheries Resources and Jurisdiction Wildlife Conservation and Trade Act | Bahamas National Trust Dept. of Agriculture Dept. of Lands and Surveys Royal Bahamas Police Force Dept. of Local Government DMR |

| Subject Area | Name of Legislation | Institutions Responsible |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Marine Habitat | Agriculture and Fisheries Act Fisheries Resources (Jurisdiction and Conservation Act) Continental Shelf Act Merchant Shipping (Oil and Pollution) Act Conservation and Protection of the Physical Landscape Act | Dept. of Marine Resources Royal Bahamas Defence Force Royal Bahamas Police Force Bahamas National Trust Dept. of Lands and Surveys Port Department Local Government |
| Waste Management | Environmental Health Act Water and Sewerage Act | Dept. of Environmental Health Services Water and Sewerage Corporation Dept. of Local Government |
| Water | Water and Sewerage Act | Water and Sewerage Corporation Forestry Section (MOE) Dept. of Local Government |
| Land Use Development | Conservation and Protection of the Physical Landscape Act | Dept. of Physical Planning Dept. of Lands and Surveys Dept. of Agriculture Ministry of Public Works Dept. of Local Government |
| Fisheries | Agriculture and Fisheries Act Fisheries Resources (Jurisdiction and Conservation Act) Wildlife Conservation and Trade Act | Dept. of Marine Resources Bahamas National Trust Port Department Dept. of Lands and Surveys Royal Bahamas Defence Force Royal Bahamas Police Force Customs MOE DOA Dept. of Local Government |

Committees and Working Groups

The BEST Commission has instituted various committees to develop national policies and strategies specific to the various Conventions. The sub-committees are: National Implementation Support Partnership (NISP), Biodiversity, Climate Change, Science & Technology and Wetlands. The committees comprise representatives from all agencies with mandates affecting these thematic areas, as well as representatives from the

public. These committees are completely voluntary and their members generally have full-time jobs, while many committee members are very dedicated and contribute significant time and efforts to assigned tasks, others are sometimes unable or unwilling to do so. In spite of this several initiatives have been successfully completed regarding biodiversity including a National Invasive Species Strategy (NISS) and a National Biodiversity Strategy and Action Plan (NBSAP). Activities underway include a National Biosafety Framework (NBF) and National Biosecurity Strategy (NBS). A grant was received under the Ramsar Convention in June 2004 to assist the National Wetlands Committee in preparing a wetlands policy. Thus far, the Committee has held stakeholder consultations throughout most of The Bahamas. The National Climate Change Committee has prepared a draft policy document that is currently in the review stage. A workshop on land degradation was convened by BEST.

The National Biodiversity Committee is the task force that was formed to provide *inter alia* a forum for exchange of information among those agencies with responsibilities for conservation and biodiversity. The Committee is comprised of BEST Commission, BNT, TNC, DMR, BREEF, MOA and DEL. The committee was charged with the role of preparing and conducting the consultative process for the National Biodiversity Strategy and Action Plan (NBSAP). The committee is a means of information disbursement with all matters regarding Party to the Convention on Biological Diversity, biodiversity and the environment.

In December 2004, the Government of The Bahamas (GOB) represented by BEST Commission, BNT and TNC signed a National Implementation Support Programme (NISP) agreement to implement the Programme of Work on protected areas (PoWPA) that was adopted at the 7th meeting of the Conference of Parties to the Convention on Biological Diversity (COP-7). The NISP has established partnerships and has committed the partners to jointly implement a series of priority activities towards the establishment and maintenance of a comprehensive, effectively managed and ecologically representative system of Bahamian protected areas on land by 2010 and at sea by 2012. The Department of Marine Resources joined the NISP partnership in 2006.

The National Coastal Awareness Committee was established in 1998. It is a group of stakeholders from the private and public sectors, with an aim to educate the public on the threats to our coastal environment. Some of the activities of the project involve radio and television ads, national school competitions, field trips for children to various ecosystems, radio and television awareness programs and coastal clean-ups and exhibitions. These organizations include:

College of The Bahamas
Club Peace & Plenty Resort
Department of Environmental Health Service
Department of Marine Resources
Dolphin Encounters Ltd.
Ministry of Tourism & Aviation
Ministry of Education, Youth, Sports & Culture

Stuart Cove Dive Ltd.
The Bahamas Broadcasting Corporation (ZNS)
The Bahamas Hotel Association (BHA)
The Bahamas National Trust (BNT)
The Nature Conservancy
The Bahamas Environment Science & Technology Commission (BEST)
The Bahamas Reef Environment Educational Foundation (BREEF); and with support from Majestic Tours and other private and public sector contributors.

Sectoral Gaps and Deficiencies

The prevention, control and eradication of IAS spreads over a large sector of government ministries, departments, agencies and organizations. Although organizations continue to work at preventing and controlling IAS, they face many gaps and deficiencies at both an institutional and national level. These gaps and deficiencies include:

- Lack of adequate legislation
 - Existing legislation is not adequate to address the IAS issue. The draft Biosecurity Act in 2005 addresses many of the legislative gaps. To date the Act is still in draft but is expected to be reviewed and updated in 2013.
- No formalized institutional framework
 - There is no central agency with responsibility over IAS management. Agencies continue to work individually with no overall framework for IAS management. There are no clear responsibilities for tasks that has been agreed by all agencies involved.
- Limited inter-agency coordination
 - Agencies address IAS individually but there is limited coordination between agencies on IAS management. The best example of coordination has been seen with the NISP agencies (BEST, DMR, BNT and TNC) who are working together on the MTIASIC project and the GEF-MPA project.
- Limited capacity
 - There is limited human, institutional and financial capacity to enable proper IAS management. While agencies may have some technical capacity for addressing IAS, the numbers are severely limited and officers with technical expertise always have a myriad of issues they have to deal with, not only IAS. Agencies are limited in the resources (e.g. equipment, software, field gear, vehicles) they have available to manage IAS. Financial resources are stretched extremely thin for government agencies and IAS is usually not on the priority list when budgets are developed. Much of the funding for IAS work to date has come from external funding sources.

- Inadequate research
 - There is some research on IAS (e.g. lionfish, Melaleuca), but it is not sufficient to assist agencies in developing management plans for priority IAS. Under the MTIASIC project, research has increased on the lionfish, but much more is needed in order to effectively manage this issue.

- Lack of economic policies and tools to support IAS management
 - IAS management is not factored into economic policy development and there are no economic tools to facilitate management.

- Lack of Compliance and Enforcement
 - For existing regulations, there are not enough sufficiently trained officers (Customs, Agriculture and Fisheries, Wardens) to regulate and facilitate enforcement. The respective enforcement agencies also lack the necessary equipment, i.e. vehicles, boats etc. to perform their efficiently. A number of regulations are out of date and require modification and new regulations need to be implemented.

- Limited risk assessment
 - Some agencies conduct risk assessments for imported species (e.g. Customs, Agriculture and Marine Resources); however, this is not as comprehensive as it should be; nor is it done in a coordinated fashion with information shared between agencies.

- Limited information management
 - While agencies that collect IAS information have this stored internally, it is seldom available to or shared with other agencies to guide their management or decision-making with respect to IAS. In most cases, there is no proper system for filing, documenting or creating libraries.

- Limited public education and outreach
 - There have been several public education and outreach campaigns over the years, which have usually targeted specific species (e.g. lionfish, Casuarina, Scaevola and Brazilian pepper). There has been no regular outreach on IAS and limited coordination to develop a national program. Once an IAS has been introduced in many cases it takes too long before public education programs are developed and executed so the public usually relies on anecdotal stories.

- Lack of species-specific management plans

- Only 2 species-specific management plans have been developed since 2003 for Melaleuca and lionfish. There are many more species that have been targeted for eradication and control, and management plans need to be developed for these as well.
- Limited fulfillment of international and regional obligations and limited cooperation with international and regional organizations
 - The Bahamas has made limited progress in meeting its international and regional obligations under agreements like the Convention on Biological Diversity and the Cartagena Convention. It has also cooperated on a limited basis with agencies that also work on IAS, including GISP, IABIN and CABI.

LEGISLATION AND POLICY

There are only a few existing legislation that relate to IAS management and none adequately address current and future IAS issues. To fill many gaps, legislation was drafted to speak specifically to IAS. The act, however, is currently still in draft form.

The purpose of the Draft Biosecurity Act is:

To ensure the conservation and sustainable use of the biodiversity of the Commonwealth of The Bahamas;

To implement the National Invasive Species Policy and Strategy;

To develop regulations and mechanisms for management of and access to biological resources of The Bahamas;

To recognize the sovereign rights of The Bahamas over its natural resources;

To preserve and maintain the traditional knowledge, innovations and practices of the Bahamian people; and

To balance Intellectual Property Right issues with the need to regulate access to and benefits derived from biological and genetic resources in The Bahamas.

Although there is no single specific Act that addresses of invasive species there are several environmental acts that are relevant to the prevention and control of IAS (Table 5).

Table 6: National legislation relevant to IAS management in The Bahamas.

| Act Title | Year Enacted | Comments |
|--------------------------------------------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Water & Sewerage Corporation Act | 1976 | Provides regulatory framework for the management of water resources in The Bahamas |
| Environmental Health Act | 1987 | Provides the framework for environmental regulations that will ensure compliance for the Project. The Act authorized the DEHS to develop regulations that prevent and control air pollution, soil contamination and preserve water quality. |
| Agriculture and Fisheries Act | 1964 | Agriculture and Fisheries Department provides guidelines for the development of the area. Minister of Agriculture and Marine Resources may declare areas “protected”. |
| Fisheries Resources Act | 1977 | Fisheries Resources Act provides for conservation of fisheries resources of The Bahamas. Establishes exclusive fisheries zones and regulates harvesting of resources. The Act Authorizes protected areas within exclusive fisheries zones including land adjacent to it. Permission to fish within a zone is required: permission may include conditions necessary to conserve the resource. |
| Wild Animals Protection Act | 1968 | Prohibits the taking, capturing or hunting of any animal without a permit. |
| Wild Birds Protection Act | 1952 | Prohibits the taking, capturing or hunting of any animal without a permit. Protects birds and eggs during closed season. |
| Plants Protection Act | 1916 | Relates to plant disease and controls importation of plants to prevent outbreaks of exotic disease and establishment of unwanted species. |
| Conservation and Protection of the Physical Landscape of The Bahamas Act | 1997 | Protects physical landscape from environmental degradation, flooding and removal of hills; regulates filling of wetlands, drainage basins or ponds; prohibits digging or removing sand from beaches and sand dunes; prevents harvesting or removing protected trees. |

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| | | In order to perform activities that may affect the physical landscape of The Bahamas, permits must be obtained for these activities. The Department of Physical Planning issues the permits and enforces the regulations. |
| The Bahamas National Trust Act | 1959 | Directs the Bahamas National Trust to promote permanent preservation of lands, buildings, underwater areas of beauty, and areas of natural interest. The Act also allows the Trust to identify sites for protection, and to manage areas declared protected. |
| Planning and Subdivision Act | 2010 | This Act provides for: A land use planning based development control system led by policy, land use designations and zoning Prevention of indiscriminate division and development of land Promotion of sustainable development in a healthy natural environment Maintenance and improvement of the quality of the physical and natural environment Protection and conservation of the natural and cultural heritage of The Bahamas Planning for the development and maintenance of safe and viable communities |
| The Forestry Act | 2010 | Protects wetlands, water reserves, endemic flora and fauna and protected trees. It establishes a legal framework for the long-term sustainable management of forests, a governmental forestry agency and a permanent forest estate. It requires a license for timber cutting and other activities in the Forest Reserves. The Act mandates that a National Forest Plan be developed every five years to govern management activities, such as harvesting and reforestation measures, prescriptions for fire prevention, wildfire suppression and prescribed burning and soil and water conservation. |
| The Port Authority Act | 1962 | This Act provides for the regulation and control of ports, harbours and navigational aids throughout The Bahamas as well as pilots and pilotage. It also regulates dredging activities for harbours and ports. The Act prevents the dumping of ship ballast water in Bahamian harbours. This can prevent the introduction of |

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| | | exotic species and pollution of waters. |
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Regulations and Protocol

In the absence of legislation, several regulations and protocols have been initiated by the Bahamas Environment Science and Technology (BEST) Commission. A part of the duties of the commission is to provide guidelines and draft legislation for consideration by the government of The Bahamas. The BEST Commission recognizes the inadequacy of present legislation as it relates to protection of native plants. It has, therefore, proposed national strategies and suggested specific laws be enacted to address the same.

The National Invasive Species Strategy (NISS, 2003)

This strategy is a broad overview of the IAS issue. It suggested that in order to manage IAS prevention, early detection and response, eradication and control were most important. It recognized that for the strategy to succeed, customs officers, agriculture and fisheries officers and enforcement officers would have to be trained to identify and properly handle IAS. Areas proposed for regular monitoring were public places, protected areas and national parks. The committee working on the invasive species document advised that an inventory of all alien species be performed. In addition, it categorized species and recommended them for eradication and others for control.

A National Invasive Species Policy and voluntary codes for conduct, for managing invasive species includes the commitment to enact legislation, prepare and implement management plans for the control of invasive species and the reestablishment of native species was drafted and adopted by the government agencies. The need for research in best management practices was highlighted and it was agreed to participate in regional and international efforts to control and eradicate IAS.

The National Action Plan to Combat Land Degradation in The Bahamas (2006)

This plan determined that invasive alien plant species is one of the main causes of land degradation throughout The Bahamas. The Plan calls for of improved stakeholder participation, innovative projects to restore degraded land, funding, collaborative research, coordinated activities and added participation from a more informed public to assist in the process of reducing land degradation.

The Bahamas National Biodiversity Strategy and Action Plan (1999)

The plan spoke to the biodiversity of The Bahamas. Emphasis was placed on the fact that IAS are a serious threat to biodiversity loss, therefore the need to control or eradicate these species are critical to ecosystems health. The plan further suggested that risk assessments be done on each alien species, implementation of a public education program and interregional cooperation be utilized to reduce biodiversity loss.

It also recommended an integrated ecosystems approach to biodiversity conservation because of interdependence of these systems.

National Environmental Policy

The goal of this policy is the sustainable use of the environment of The Bahamas to meet the needs of the present and future generations through the following specific objectives:

- to prevent, reduce, or eliminate various forms of pollution to ensure adequate protection of the environment and the health of its citizens;
- to conserve the biological diversity of the country and the stability, integrity, resilience and productivity of ecosystems; and
- to provide for the environment to be fully integrated into policy, plans, programmes and development project decisions that might be detrimental to the continued health safety and productivity of the country’s environment.

MULTILATERAL ENVIRONMENTAL AGREEMENTS AND PROTOCOLS

The Bahamas has signed on to several multilateral environmental agreements relevant to its sustainability. Among the agreements were the UN Convention on Biodiversity, the UN Convention on Biodiversity Cartagena Protocol and the Convention on International Trade on Endangered Species and wild Flora and Fauna (Table 7). These conventions provide the framework for individual member states to develop plans to address the concerns outlined in the documents. In most instances, The Bahamas has complied with the various agreements and has produced its national action plans to address issues in the UN documents on biodiversity and invasive species. Table 8 outlines various international organizations involved in IAS management.

Table 7: Multilateral Environmental Agreements The Bahamas has signed.

| Conventions/Agreements/ Protocols | Objective | Concluded | In force |
|------------------------------------------|--------------------------------------------------------------------------------------------------|------------------|-------------------|
| Convention on Biological Diversity | To develop national strategies for the conservation and sustainable use of biological diversity. | 5 June, 1992 | 29 December, 1993 |
| Cartagena Protocol on | To protect biological | 29 January, | 29 January, |

| | | | |
|-----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|--------------|
| Biosafety | diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. It establishes an advanced informed agreement (AIA) procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory. | 2000 | 2000 |
| Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) | To protect certain endangered species from over-exploitation via a system of import/export permits. | 3 March, 1973 | 1 July, 1975 |

Table 8: International Organizations and IAS Management (Adapted from NISS 2013)

| Instrument | Enforcement | Website | IAS Engagement | IAS Focus |
|-----------------------------------------------------------------------------------------|-------------------------|--------------------------------------------------------------------------|-----------------------|------------------|
| Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) | Regulatory | www.cites.org | Active | Species Pathway |
| Codex Alimentarius Commission | Regulatory | www.codexalimentarius.net | Potential | Species Pathway |
| United Nations Food and Agriculture Organizations (FAO) | Voluntary | www.fao.org | Very Active | Species Pathway |
| International Airline Transport Association (IATA) | Voluntary | www.iata.org | Active | Pathway |
| International Civil Aviation Organisation (ICAO) | Voluntary | www.icao.int | Active | Pathway |
| International Maritime Organization (IMO) | Regulatory Voluntary | www.imo.org | Very Active | Pathway |
| International Plant | Regulatory | www.ippc.net | Very Active | Species |

| | | | | |
|----------------------------------------------------------------------------------------------------|------------|----------------------------------------------------|-------------|---------------------------------|
| Protection Convention (IPPC) | | | | Pathway |
| International Union for the Conservation of Nature (IUCN) | Voluntary | www.iucn.org | Very Active | Species Pathway Ecosystem |
| Office International des Epizooties (OIE) – World Organization for Animal Health | Regulatory | www.oie.net | Active | Species |
| Ramsar Convention on Wetlands | Regulatory | www.ramsar.org | Active | Ecosystem |
| United Nations Framework Convention on Climate Change (UNFCCC) | Regulatory | unfccc.int | Potential | Ecosystem |
| World Customs Organization (WCO) | Voluntary | www.wcoomd.org | Potential | Pathway |
| World Health Organization (WHO) | Voluntary | www.who.int | Potential | Species Pathway |
| World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures | Regulatory | www.wto.org | Potential | Pathway |
| World Tourism Organization (UNWTO) | Voluntary | unwto.org | Potential | Pathway |

PUBLIC AWARENESS AND EDUCATION

Without public awareness and sensitivity to the IAS issue all other efforts will prove futile. The community is the most important stakeholder and should be involved in the management of IAS. Partners throughout the country have developed and executed several public outreach efforts. These efforts include specialized training for various professionals, radio and television public service announcements, school programmes, national competitions, newspaper articles, special outreach events and the production of educational materials.

Protected Area IAS Management

- Both marine and terrestrial IAS have been observed within protected areas and managers have been taking steps to combat the problem. The issue of dealing with IAS has been added to the protected area management planning process and cases are handled on an area by area basis. To date management plans have been developed for four protected areas within The Bahamas.
- Staff of the BNT has completed training with Chris Berg of the Nature Conservancy on treating and handling invasive plant species. Park specific management plans have been developed for Brazilian pepper, cattails, scavoela, melalueca and casuarina.
- There are active trappings of feral animals including cats (*Felis catus*) in the Abaco National Park to protect the Bahama Parrot (*Amazona leucocephala bahamensis*).
- From 2011 to 2012 the GEF-Small Grants Project was developed to improve the quality of specified areas within Bonefish Pond and Moriah Harbour Cay National Parks. The project's objectives included increasing public knowledge of the impact of invasive species on coastline ecosystems, increasing the public's knowledge levels of invasive species, to raise awareness of the impacts on coastal ecosystems in nearby communities and to improve the impacted coastline areas by removing invasive species and planting native trees. Staff from BNT along with volunteers successfully removed about 18 acres of Casuarina trees and planted one acre of young Red Mangroves (*Rhizophora mangle*). There were also presentations about IAS at town meetings, local schools and Garden Clubs.
- A partnership consisting of seabird specialist Dr. Will Mackin, Iguana, Island Conservation, and invasive eradication specialist Dr. John Iverson, and the Bahamas National Trust began a project on Allen Cay in 2011 to help restore the ecology of Allen Cay, an island in the Central Bahamas that is infested with invasive mice (*Mus musculus*) and has seen a marked decline in the population of the Audubon's Shearwater (*Puffinus lherminieri*) since 2000. Each year, hundreds of adult shearwaters are found dead at Allen Cay, and almost all are

killed by Barn Owls and left to be eaten by hermit crabs. The death rate at this colony is twice the rate at other colonies nearby that do not have mice. The project eradicated mice that disrupted the favored nest sites and daytime roost sites for owls. The project is expected to save hundreds of shearwaters each year and allow the population to increase from around 300 pairs to nearly 1,200 pairs. Allen Cay is also home to about 20 Allen Cay Rock Iguanas. The mice also disrupted the nesting sites for the iguanas. The removal of the mice is expected to double the breeding population of the endemic subspecies named for the Allen Cays.



Figure 13: Allen Cay Rock Iguana



Figure 14: Participants in the Allen Cay house mouse eradication project from Bahamas National Trust and Island Conservation

Professional Training

The BREEF conservation teacher training workshops and professional development seminars to date have reached over 600 educators. Issues related to the identification and control of terrestrial and marine IAS. Highlighted species include Melaleuca, Casuarina, Scavaela, Brazilian pepper and Lionfish. Since 2009 training presentations on lionfish biology ecological impacts and research findings have been delivered to over 120 teachers and to visiting groups at the Gerace Research Centre in San Salvador, Bahamas at BREEF's annual summer teacher workshops.

In February 2010 ECOMAR also received a grant from the Gulf & Caribbean Fisheries Institute (GCFI) through the Caribbean Environment Programme (CEP), UNEP (United Nations Environment Programme) and CaMPAM, for the Belize Bahamas Fishermen Exchange whereby fishermen from Belize were able to travel to the Bahamas for a workshop on lionfish handling and preparation techniques. Delegates from Belize included representatives from the Fisheries Department, Northern Fishermen Producers Cooperative, National Fishermen Producers Cooperative, Placencia Fishermen Producers Cooperative, the Rio Grande Fishermen Producers Cooperative, Coral Reef Alliance and ECOMAR. The workshop included a classroom training session, field networking with Bahamian fishermen, capturing lionfish and preparing lionfish for consumption. The Belizean fishermen also had opportunity to liaise with the fishermen and organizations involved in managing the lionfish populations in Bahamas. Due to the widespread invasion of lionfish, The Bahamas Department of Marine Resources is now developing creative strategies to promote lionfish as a commercial fishery in the hopes of controlling their population. The GCFI Belize & Bahamas Fishermen Exchange has served as an invaluable opportunity to share lessons learned from the Bahamas lionfish status and management efforts.

The primary goal of the MTIASIC professional training component is to build national capacity in long-term monitoring and research in fish communities in a variety of habitat types, necessary to evaluate their status and address present and future environmental concerns. Training involved intensive one to two-week long workshops led by international researchers actively involved in lionfish ecological studies in the Tropical Western Atlantic. Additionally, some skills like native fish identification and underwater estimation of fish lengths were consistently reinforced in the field via a series of monthly, group proficiency dives during the first year of training. By the end of professional training, more than half of project participants obtained "expert level" status, the highest level of certification, in the REEF Fish Survey Program (see www.reef.org). This represents one of the greatest achievements of MTIASIC Bahamas to date. Prior to the project, no Bahamian had achieved beyond "novice level" certification in the REEF program. These seven people are now members of REEF's Advanced Assessment Team for the Tropical Western Atlantic, and some are certified

to teach the course up to expert level status to others. The following manuals were developed to assist in training and management of lionfish:

- Under the MTIASIC Project, the Bahamas adopted James Morris' lionfish collection and handling protocol "Invasive Lionfish A Guide to Control and Management". James Morris' Lionfish Guide to Control and Management is observed as a best practices manual and as such is being widely distributed amongst resource managers in the Bahamas.
- Nicola Smith, MTIASIC Experiment Coordinator, crafted and submitted the "MTIASIC Adopted and Revised Field Survey Protocol". The revised protocol is based in part on NOAA's Technical Memorandum (NOSNCCOS, 136) and "Lionfish dissection: technique applications" by Green et. al.



Figure 15: MTIASIC training to dissect lionfish and examine stomach contents.



Figure16: BESS intern during lionfish removal exercise.

School Programmes

In 2009 DEL – Project Beach hosted a poster competition under the theme “The Pirates of The Carribean: Invasives in The Bahamas”. The competition was nationwide and was open from Kindergarten to grade 12. The application featured information on three of the main IAS in The Bahamas and what can be done to prevent them. Staff held Assemblies at various schools that also provided information about IAS in a fun and entertaining way. The competition brought in over 500 posters.



Figure 17: Winners of the DEL Project Beach 200 poster competition. A. K2 to 2, B. 3 to 5, C. 6 to 8 and D. 9 to 12.

The Eco-Schools Bahamas (ESB) Programme is an international programme aimed at raising students' awareness of global and local sustainable development issues through classroom study, as well as school and community action. Schools follow a simple, seven-step process to actively engage students in assessing and improving use of resources on their campuses, related to six core themes - *energy, waste, water, biodiversity, litter and school grounds*. The ESB was piloted in 2009 with 7 schools, and in 2013 includes 19 registered schools on three islands, with Deep Creek Middle School and Hope Town Primary becoming our first two schools to receive the international Green Flag Award in 2010 and 2012, respectively. In 2012, BREEF received funding from the Global Environment Facility Small Grants Programme (GEF-SGP) under the biodiversity topic to increase awareness of native and invasive plants. By creating native plant gardens on schools campuses, schools are encouraging the preservation of native plants and raising awareness of their value to our local culture and economy. They are also increasing awareness of invasive plants and their impacts within their communities.

In 2012, native and invasive plant teacher workshops were conducted in Abaco and New Providence. Six schools have created native plant gardens on their campuses,

completed native and invasive plant survey with a minimum of 20% of their students and have done awareness campaigns with students and within their communities.

Special Events and Programmes

While ridding the country of invasive species is important, it is also essential to biodiversity and its conservation that the ecosystem be repopulated with important native species. One initiative which aspired to do so is The Bahamas Million Tree Campaign (BMTC) which was officially launched in 2008 with a native tree planting at Doris Johnson High, a local senior high school. As a spinoff from The United Nations Environment Programme's Billion Tree Campaign, the programme aimed to plant 1,000,000 native/indigenous trees throughout the country while encouraging the use of natives and illuminating IAS for landscaping. It also aimed to discourage the importation and propagation of IAS.

Educational organizations have incorporated IAS into their ongoing school based and public education programmes throughout the country. These activities include general IAS campaigns about lionfish, casuarina, brazilian pepper, etc. Presentations to groups include lionfish dissection to show stomach contents, safe handling practices, and taste samples.

From 2004 to 2011 The Ministry of Education and special committee developed a draft marine science curriculum, in which the topic 'Invasive species' was included in the grade twelve unit: '*Human impact on the marine environment*'. Special focus was given to lionfish, but it also referred to the impact of Casuarina and Scaevola on coastal areas.

The Bahamas Environmental Steward Scholars (BESS) Programme is a year-long academic and work experience programme for graduating high school students in The Bahamas interested in the environment, conservation and sustainable systems/development. Participants take part in a four-month paid internship with a conservation-related organization which may either precede or follow the 14-week academic course of study at The Island School, Cape Eleuthera. Since its inception in 2008, 24 scholars have participated in the programme. Of these, 16 have had the opportunity to participate in invasive species control activities with BREEF, the Bahamas National Trust, Friends of the Environment, The Cape Eleuthera Institute or the National Coastal Awareness Committee.

April of every year is celebrated as National Coastal Awareness Month. The activities highlight the importance of the coastal environment, and increase public awareness of the threats to our coast (including invasive species) and what each person can do to make a positive difference. In 2013, the school competition entitled 'Our Bahamas...2Our Native Plants', invites students of grades 4-12 to create a 60 second PSA to increase awareness of any of the following: *Identification of native and invasive plants, the value of native plants: threats posed by invasive plants, encourage the public to take action to preserve native, and reduce the number of invasives.*

In 2009, DMR in conjunction with the College of The Bahamas Marine Environmental studies Institute (COB-MESI) developed a National Lionfish Response Plan which has been incorporated as an activity into the 5 year strategic plan for marine resources. Through GEF funding, studies will be conducted on the effects to lionfish populations and other marine species populations in areas where lionfish will be captured and removed. An educational and outreach programme will also be undertaken to educate people about the policies and regulations that will be developed to manage Lionfish in The Bahamas.

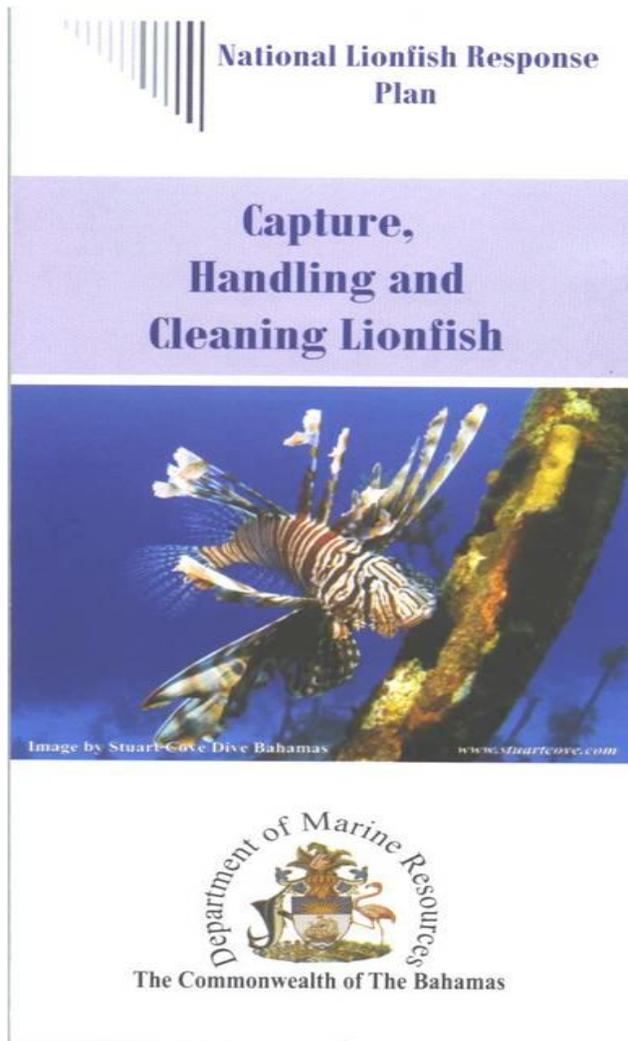


Figure18: NLRP brochure that has been distributed throughout The Bahamas.

Since 2009 various organizations including Bimini Sands & Resorts, LAD/REEF (Green Turtle Cay Tournament), Friends of the Environment (North Abaco), Joelle/Staniel Cay Divers (Staniel Cay Tournament) and Rachel Lightbourne (NP Lionfish Round-up) have hosted lionfish tournaments throughout the islands including Long Island, New Providence, Abaco, Exuma and Bimini. Participants pay a fee and set out to catch as

many lionfish fish as possible. At the end of the day prizes are given for the largest fish as well as the boat with the greatest number of fish caught. Spectators at the tournaments are treated to lionfish tastings. Throughout the years these tournaments have helped to remove thousands of lionfish from surrounding waters as well as increase awareness to the general public.

Friends of the Environment along with Michael Parotti from Sugarland Nursery, 18 eager helpers from JA Pinder Primary, members of the Sandy Point community and grant support from The Nature Conservancy combined efforts to restore a section of shoreline near the community's Government Dock that has been experiencing erosion and had no native vegetation.

A cleanup was done to make sure the area was pristine. Then native plants were planted along the top of the beach to help prevent erosion and beautify the area. A local plant nursery provided plants for the restoration. Examples of plants that will be utilized in the restoration include: Buttonwood (*Conocarpus erectus*), Cocoplum (*Chrysobalanus icaco*), Seagrape (*Coccoloba uvifera*), Orange Geiger (*Cordia sebestena*), Periwinkle (Sailor Cap), Autograph trees, fever grass, yellow elder and coconuts. The students were very enthusiastic and did a great job carefully placing and watering the plants! The plants chosen for the restoration are representative of those found in Bahamian coastal environments. Some of them, including the seagrape and cocoplum trees, will even provide fruit in the future.

FRIENDS provided two picnic tables (built by a Sandy Point carpenter), so that the community can further enjoy the area.



Figure 19: Students from JA Pinder participating in restoration project.

Friends of the Environment started a project to restore the beach at The Crossing, Marsh Harbour. The beach had been overtaken by invasive casuarinas and Hawaiian seagrape, which prevented many native plants from growing. With permission from local government, the invasive plants were removed. The historic dune was reformed and planted with native vegetation. Today, the beach is flourishing and has become a popular recreational area.



Figure 20: Before and After of The Crossing, Marsh Harbour, Abaco

Lionfish culinary demonstrations has also been modeled to facilitate control measures by promoting lionfish as a food source, thus enabling fishers to target lionfish more consistently to control their populations. Lionfish tournaments have also included culinary demonstrations to educate the general public on cleaning techniques for lionfish for personal consumption, while encouraging restaurants to itemize lionfish on their menus. These measures have been quite effective as it has proven to increase awareness of the existence of lionfish in The Bahamas, and their venomous nature which ideally makes them safe to handle once properly de-spined, and safe to eat. The Bahamas Marine Exporters Association has been collaborating with project partners in advertising the purchase of whole lionfish to sell on the seafood market, thus supplying lionfish fillets to 12 customers throughout the country.



Figure 21: Preparation of lionfish for demonstration.

Educational Material

A variety of multimedia educational resources have been produced to support classroom instruction and raise public awareness on conservation issues. These include audio and video PSAs, brochures/fact sheets, booklets, short films, posters, and lesson plans/activities. The following resources make direct mention of invasive species. These include:

- The Nassau grouper 08-09 closed season flyer encourages the public to eat lionfish instead of Nassau grouper during the closed season. 10,000 copies were printed and distributed to the public.

Nassau grouper populations are in decline throughout the Caribbean.
Support the Closed Season so that we may have a plentiful supply for generations to come.



Nassau Grouper Spawning Season — November - March

A grouper we save today lives to spawn another day . Support our fishermen, CHOOSE another fish during the Closed Season.

Protect the Nassau grouper during their spawning season November – March

The closed season protects the Nassau grouper during part of their **breeding** season. This is when they are most **vulnerable** because they aggregate in large numbers to spawn at predictable times and locations.

There are several species of grouper in The Bahamas. The Nassau grouper can be identified by: (see photo overleaf)

- 5 olive/brown bars on the body
- A band across the eye
- A black saddle-shaped spot on the base of the tail

During the closed season, other grouper species must be landed intact to allow for easy identification.

We encourage you to try lionfish as an alternate fish this season.

Lionfish are an **invasive**, non-native species that are rapidly reproducing in our waters. They are voracious predators, competing with our local fish for food and consuming some of our valuable fishery species. Lionfish have very few predators, although Nassau grouper have been known to eat them. Targeting the lionfish as a food fish would help to combat the **threat** to our marine environment.

Lionfish on the Menu

- Lionfish are tasty. They can be filleted or pan-fried whole.
- Lionfish flesh is safe to eat.
- Lionfish venom is located in the spines and is deactivated by heat.
- Lionfish are sold as a food fish in the Pacific region.
- **GO GREEN**—Eat Lionfish!

SAFETY FIRST!

Lionfish spines are venomous but the fish can be safely handled once the spines have been removed. If you catch lionfish, use caution to avoid a puncture wound.

First Aid: Apply hot water (as hot as is safe) and seek immediate medical care.

TO:



For more information, contact
Dept. of Marine Resources, Tel: 242 393 1777 or
BREEF, Tel: 242 327 9000, www.breef.org, breef@breef.org



Figure 22: BREEF Eat Lionfish poster.

- In 2011 under the GEF SPG a poster was created to increase the awareness of Casuarina as an invasive and steps the public can take to help.

Why is the Casuarina an **Invader?**

Australian Pine
Casuarina equisetifolia

This fast-growing tree was introduced to The Bahamas in the early 20th century as an ornamental, and also used as a windbreak to protect residential areas along coastlines. Time proved the species to be unsuitable for either purpose. The shallow spreading roots are disruptive to beaches, lawns and sidewalks, and the tree is easily blown over in storms. This guest has become a major pest, and the National Invasive Species Strategy identifies *Casuarina equisetifolia* as a high priority for control and eradication.

The Casuarina's ability to colonize disturbed and nutrient-poor sites makes it a highly successful invader. These large fast-growing trees thrive in open coastal habitats, including beaches, dunes and rocky shores. Casuarinas cover the ground with a thick layer of "needles" containing chemical compounds that discourage the growth of native shoreline species. Large stands of casuarinas crowd out native vegetation and offer little in the way of food or habitat to native wildlife. Casuarinas are easily toppled because of their shallow root systems. Wind-blown trees intensify beach erosion and inhibit nesting by sea turtles and roosting by endangered birds like the Piping Plover. The intrusion of Casuarinas into coastal mangroves can reduce nursery habitat for important marine species, as well as contribute to the loss of nesting and roosting habitat for birds.

How You Can Help – a **3-STEP PLAN**

- 1. Remove Casuarina seedlings or saplings whenever possible.**
- 2. Plant recently disturbed beach habitat with native vegetation such as**

These coastal plants have strong and deep root systems, which help hold the sand dune together during storms.
- 3. Contact the Bahamas National Trust to learn more about Casuarina removal in your community.**

Improving Coastal Habitat Through removal of invasive species

gef
SGP The GEF Small Grants Programme
BNT

The Improving Coastal Habitats through the Removal of Invasive Species Project focuses on invasive species removal at Norman Harbour City National Park and Borealis Forest National Park. If you would like to organize a group casuarina removal activity, contact **BNT Parks Department** at 242-383-1317 or email bntr@bnt.bs

Figure 23: Educational poster on Australian Pine under the GEF-SGP.

- In 2012 BREEF's Virtual Coral Reef Field Trip combines film, poster, and an educator's guide to explore the lionfish as a threat to reef biodiversity. The film shows the lionfish, defines the term 'invasive species', and discusses the threat that lionfish pose to marine biodiversity. It also encourages fishermen to catch them and the public to eat them. The film is based on the learning objectives of the Biology curriculum, this subject is mandatory for high school students. Three

hundred copies have been distributed to Biology teachers throughout the country. Each public school and most private school Biology teachers have received a personal copy with an additional copy provided for the school's inventory. The film is currently in rotation on local television stations.

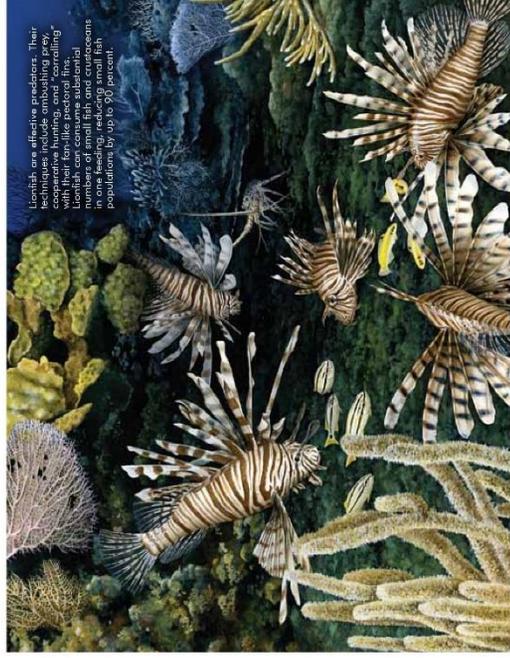
- FRIENDS is currently focusing efforts on Hawaiian seagrape and address this issue by working with:
 1. Local communities to reduce Hawaiian seagrape in residential areas. They have created a "Go Native" guide which identifies IAS and recommends native species that can be used as an alternative.
 2. Abaco businesses to reduce Hawaiian seagrape on commercial properties
 3. Local plant nurseries to offer native plants for landscaping and discourage the import or propagation of invasive plants. They are encouraged to follow the Bahamas Voluntary Code of Conduct.

- Under the Andros West Side Expansion Project TNC reproduced poster on the life cycle of lionfish. The posters have been distributed to schools throughout The Bahamas.

Portrait of an Invasion



- **Lionfish were introduced by humans** into the Indo-Pacific Ocean. Their high fecundity and ability to tolerate a wide range of salinities with lionfish for prey may have set the stage for proliferation.
- **Lionfish are formidable.** Their appearance may deter potential predators and make them unrecognizable as prey.
- **Lionfish reproduce quickly.** They spawn every 4-5 days, and mature at 8 young days.
- **Lionfish may out-compete** native species, such as snappers and groupers, for food and habitat.
- **Lionfish can decimate reefs.** With voracious appetites, they can reduce populations of juvenile and small fish on coral reefs by up to 90 percent. Lionfish may also graze on and consume grazing parrotfishes, which normally prevent algae from growing over corals.



Lionfish are effective predators. Their techniques include ambush hunting, camouflage, and hunting along with their tentacles. Lionfish can consume substantial numbers of small fish and coral polyps, and their populations may increase by up to 90 percent.

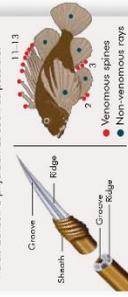
Life Cycle



As frequently as every 4 days throughout the year, the female releases two egg masses that are fertilized by the male. Juveniles spend most of their lives in a small area but can live in a wide range of habitats.

The Venomous Spines

Lionfish have two grooves on each spine. These grooves contain venom glands. After the spine punctures the skin, the glandular tissues release a potent neurotoxin that travels up the spine to the wound. Take a pain reliever and seek the wound in hot water. Consult a physician as soon as possible.



How to Help

- Never release aquarium fish into the wild.
- Report lionfish sightings to the Florida Fish and Wildlife Conservation Commission regulatory agency.
- Participate in lionfish tournaments to reduce local lionfish populations. Their white, fleshy meat is delicious.
- Use gloves when handling to prevent injury. Venomous spines can be removed by carefully cutting with a sterile scalpel. Consider wearing a wetsuit to handle the fish safely.



RED Lionfish

Pterois volitans

The red lionfish is an invasive species native to the Indo-Pacific Ocean. Their high fecundity and ability to tolerate a wide range of salinities with lionfish for prey may have set the stage for proliferation. Introduction and subsequent population increase are now causing negative impacts on marine ecosystems in the southeastern seaboard of the U.S. and the Caribbean Sea. Lionfish are efficient predators invading a variety of natural and artificial habitats, competing with native predator fish and consuming smaller fishes, including the young of large species. A similar species, the devil firefish, *Pterois miles*, has also been introduced in the Atlantic.

Affected Areas

Observations of red lionfish have been recorded on continuous coral reef tracts, patch reefs, deep reefs (up to 1000 feet deep or 305 meters), wrecks, mangroves, and other habitats in the southeastern U.S. and Bermuda to the western Gulf of Mexico and throughout the Caribbean Sea.



What Do Lionfish Eat?

Lionfish are indiscriminate predators that will consume a wide variety of prey, including the young of important fishery species such as groupers and snappers and ecologically important species such as snappers and groupers. Lionfish prey on many populations, which may affect local ecobalance.



Protecting nature. Preserving life.SM
Turrell, Hall & Associates, Inc.
marine & environmental consulting



Loxahatchee River District
"Preserving Nature by Design"SM
Poster Series, No. 7
www.loxahatchee.org



Figure 24: Lionfish lifecycle poster reproduced by the Andros West Side Expansion Project

Life on the Bahamian Coral Reef

Coral Reefs cover less than 1% of the sea floor, but contain 25% of all marine species. These species depend on each other for their survival. Some organisms that live on our reefs are:

- | | | | | |
|-------------------------------------|-----------------|------------------------------------------|--------------------------------|--------------------------|
| 1. Zooxanthellae | 5. Sponge | 9. Long-Spined Urchin | 15. Butterflyfish (coralivore) | 20. Green Moray Eel |
| 2. Phytoplankton/ Microscopic Algae | 6. Soft Coral | 10. Queen Conch | 16. Grunts | 21. Barracuda |
| 3. Marine Algae/ Seaweed | 7. Hard Coral | 11. Silversides/Pilchards | 17. Snappers | 22. Nurse Shark |
| 4. Seagrass | 8. Sea Cucumber | 12. Parrotfish | 18. Black Grouper | 23. Caribbean Reef Shark |
| | | 13. Queen Angelfish | 19. Nassau Grouper | 24. Hawksbill Turtle |
| | | 14. Spiny Lobster/Crawfish (detritivore) | 25. Seastar | |

● Producer ● Herbivora/Omnivora ● Carnivore



Benefits of Reefs

Reefs provide:

- a habitat for marine organisms
- a supply of seafood
- shoreline protection
- employment through fishing and tourism
- sand and beaches
- recreation for locals and tourists
- opportunities for scientific research
- medicinal and commercial products

Coral Reef Conservation in The Bahamas

Coral Reef Education – BREEF and other conservation partners raise awareness of coral reefs through school programmes, field trips, public campaigns and teacher training workshops.

Protection of Connected Habitats – Marine habitats are interconnected; many reef species need several different habitats, including coral reefs, wetlands, seagrass beds, beaches, tidal flats and deep sea areas, to complete their life cycle. Protected areas, land use planning, proper waste disposal and removal of invasive species, help to protect these habitats.

Scientific Research – Scientists collect useful data to guide management efforts. Coral reef surveys, coral propagation activities, conch, grouper and crawfish studies, invasive species (Herfist) research and removals are being conducted in The Bahamas.

Legislation to Protect Important Species – The harvest of coral, sea turtles and commercial shark fishing is prohibited in The Bahamas. Closed seasons, size limits, gear restrictions, bag limits for sport-fishing and restricted entry into the fishery area designed to prevent over-exploitation of marine resources.

Marine Protected Areas (MPAs) – Marine Parks and Reserves protect critical marine habitats. National Parks are managed by The Bahamas National Trust. Marine Reserves are managed by the Department of Marine Resources. The Government of The Bahamas has committed to expand the protected area network by protecting 20% of the Bahamas' marine environment by 2020.



MPAs that protect Coral Reefs (2012)

- | | |
|------------------|--------------------------------------------|
| Abaco | 1. Muller's Cap National Park |
| | 2. Nicholas Cay Marine Reserve |
| | 3. Sand Cay National Park |
| | 4. Pollack Cay Land and Sea Park |
| Andros | 5. North and South Marine Parks |
| Eleuthera | 6. Grouper Cay Land and Sea Park |
| | 7. Montserratian Cay National Park |
| | 8. The Grouper (Parrot) Cay Marine Reserve |
| Exumas | 9. The Conception Island National Park |
| | 10. Little Inagua National Park |
| | 11. South Inagua Island Marine Reserve |

Tiny colonial animals called polyps secrete a limestone skeleton which builds the structure of the reef. Microscopic algae called zooxanthellae live symbiotically inside the polyp's tissues.



Reefs provide us with food, jobs, recreation and storm protection. Let's do our part to protect our precious Coral Reefs.

www.breef.org

Figure 25: Poster of the virtual coral reef tour created by BREEF

- Native Plant Garden Manual for Schools is a publication produced by BREEF with funding from GEF-SGP for the Eco-Schools Bahamas programme, promotes native plant biodiversity and environmental sustainability. This manual was distributed to schools to increase awareness of native plants and assist with the implementation of native plant gardens on their campuses. The manual encourages schools to remove invasive plants from their campuses, where feasible, includes photos of invasive plants to assist with identification and explores the impacts of the five plants of greatest concern: Casuarina, Scaevola, Brazilian pepper, Melaleuca and Wedelia.
- The Greensweep Manual was written to assist BNT with park IAS management. The manual helps volunteers and managers to identify plant IAS as well as proper procedure to handle and dispose of plant material.
- In 2013 BREEF participated in a one hour talk show on lionfish, which aired on the Bahamas Sports radio station 103.5 FM. The show launched Chef Alfred's cookbook which includes lionfish recipes.
- The "Conservation Makes Sense" PSAs were produced by a local high school. They have been aired on local stations and are available on Youtube. The PSAs have also been distributed to participants of BREEF workshops for use in schools. These PSA's with invasive species content include:
 - Tasty Lionfish – Grouper man
 - Lionfish on the menu
 - Nassau grouper red alert
- In 2011 an educational programme was developed in conjunction with Dolphin Encounters, highlighting the top 5 invasive species in The Bahamas. The infamous "Sea Rangers" explores Blue Lagoon Island identifying 4 plant IAS, then expanding to the marine invasive – lionfish, in a 15 minute segment. The program airs on ZNS the local television station and is available on youtube. It teaches the audience to identify IAS and explains their harmful effects on the environment.



Figure 26: Sea Rangers Sophie and Ray in front of Brazilian Pepper tree during the taping of the IAS PSA.

- In an effort to increase public awareness on the prevention and management of IAS there has been extensive media coverage of information and activities.

Research

In order to manage the effects of IAS and to inform decision makers there is a need for continued research on IAS in The Bahamas. Research has increased in the past several years especially on targeted species such as lionfish and melaleuca, more is needed to fill information gaps. Priority areas need to be identified for the IAS that have been identified by the NISS for urgent eradication and control (see list on page37). The NISS requires that management plans be developed for these species but there is a need for proper research to lead this process.

There is also a need to ensure that once the research has been completed it is communicated to environmental managers, decision makers and the Bahamian public. Environmental organizations such as BNT and BREEF have translated scientific data to layman terms in educational materials and print media such as Treasures of the Sea and others. Other avenues include the various scientific conferences that are held in the Bahamas. During these conferences, local and international scientists deliver presentations on the problems IAS pose to the Bahamas and the work being executed to address IAS. These conferences are outlined below:

- Since 1984, scientists utilizing the Gerace Research Centre have taken part in biennial meetings to promote a better understanding of the investigations being conducted on San Salvador, The Bahamas, and the wider Western Atlantic. The material presented at these meetings covers a broad range of topics, including marine conservation, archaeology, invasive species, and plant-insect interaction.

- The Bahamas' first Annual Bahamas National Natural History Conference (BNNHC), was held 4th-8th March, 2013. The mission of this conference was to create a forum for natural scientists to present their work to each other and the Bahamian Public and to build relationships that encourage interdisciplinary research and conservation in the Bahamas. Going forward, this forum should inspire new avenues of research and cooperation across disciplines while highlighting the benefits of research to the environment, economy and human society of The Bahamas.
- The Abaco Science Alliance Conference, started by FRIENDS in 2004, was designed as a biennial forum for sharing research being conducted in The Bahamas. It helps to bridge the gap between scientists and the community making data about The Bahamas more accessible to everyone, including students.

There needs to be an assessment of research gaps especially for those IAS that are recommended for eradication or control. Priority needs should be determined and communicated with the scientific community. Under the MTIASIC project scientific needs were developed for the lionfish and has led to a better understanding of the effects and behaviors of the lionfish. Those areas are identified below:

- Ecology and impact of lionfish in mangrove, seagrass and deep sea communities.
- Distribution and movement of lionfish across and between coral reefs, mangroves, seagrass and deep sea habitats.
- Ontogenetic shifts in habitat use and distribution.
- Larval distribution, settlement patterns and cues.
- Evaluating the catch per unit effort associated with a lionfish commercial fishery required to evaluate the effect on local lionfish populations.
- Socioeconomic impacts of the invasion, and the identification of socioeconomic factors to develop a commercial lionfish fishery.
- Predicting the rate and pattern of lionfish spread throughout The Bahamas and the Caribbean based on oceanographic features, current lionfish abundances and distribution, and lionfish reproductive biology and behavior.
- Effect of outreach and education initiatives on local lionfish populations.

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