RESILIENCE SOURCEBOOK

Inspired by the 2013 Milstein Science Symposium
Understanding Social and Ecological Resilience in Island Systems
Informing Policy and Sharing Lessons for Management

CASE STUDIES OF SOCIAL-ECOLOGICAL RESILIENCE IN ISLAND SYSTEMS

American Museum of Natural History
Center for Biodiversity and Conservation

A PLATFORM FOR COLLABORATION SPURS EFFORTS TO COMBAT THE INVASIVE LIONFISH

Bermuda

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Setting

A limestone island totaling 53.2 square kilometers in the middle of the Atlantic Ocean, Bermuda is a British territory. It is located about 1,070 km off the coast of North Carolina at 32.3 N, 64.783333 W; Bermuda's subtropical climate is maintained by the Gulf Stream. Bermuda is densely settled, with a population of about 65,000, with little migration as immigration laws are strict and well enforced.

Bermuda ranks in the top ten countries in terms of cost of living. This is primarily driven by international business in the banking and reinsurance industries, which are the primary industries in Bermuda (followed by tourism). A large population of expatriates from around the world works in Bermuda in banking and reinsurance, as well as locally trained Bermudians. Almost all products and resources are from external sources. Having no freshwater reserves on land, Bermuda must rely exclusively on rain for freshwater.

Bermuda has a history of seafaring people. They have traditionally extracted marine resources to feed and support the growing population, and that tradition continues today; Bermudians tend to be passionate about local seafood. Bermudians rely on the sea for subsistence and thus the economy is also dependent on a healthy marine ecosystem. The government has played an integral role in protecting the marine environment. For example, a fish pot ban was enacted in 1990. Fish pots are traps for catching fish and were the most common method of fishing prior to the ban. This effective and comprehensive enforcement has likely played a role in the current health of Bermuda's reefs, in contrast to the health of nearby reefs in the Caribbean and Florida. Commercial fishermen (mostly serving the local restaurants and markets) initially resisted the changes but now seem to recognize that the strict enforcement protected their livelihoods in the long run.

Map Data: ©2016 Google

While the government has effectively managed the threat of overfishing, other threats remain. For example, dredging the harbor in order to accommodate increasingly large cruise ships destroys reefs. Another important threat is from eutrophication from fertilizer runoff from the many golf courses on the island.

The Disturbance

The first lionfish (*Pterois* spp.) sighting in Bermuda was made in 1999. Lionfish were first detected in the Western hemisphere in 1985 near the southeast coast of North America. The introduction likely occurred through release from the aquarium trade. The initial invasion spread northward along the east coast of the United States. By 2000–2001, Lionfish were identified as an established invader in the offshore waters of North Carolina.

Since 2004, the population has successfully spread southward with established populations now existing throughout the Caribbean Sea, the Gulf of Mexico and as far south as Brazil. Lionfish are

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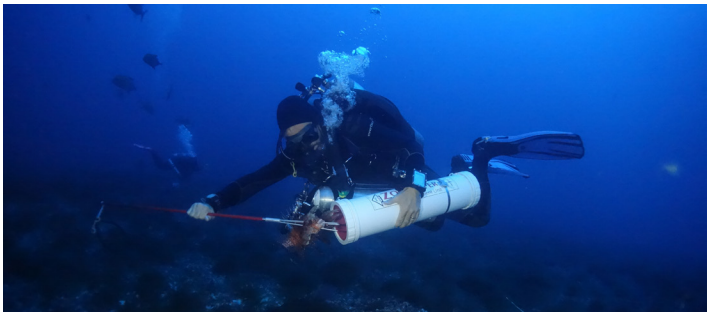


DarwinPlus research team diver, A. Chequer, collecting lionfish from a reef at 60 meters. Photo credit: OSF

now ubiquitous throughout the Caribbean, having established themselves in a variety of marine habitats, including coral reefs, mangroves, sea grass beds, coastal estuaries and deep waters up to 300 meters. In the Bahamas lionfish populations are documented to exceed 390 fish per hectare compared to 80 per hectare in their native range.

Lionfish are voracious predators. Divers in the Bahamas have observed a single lionfish consume over 20 juvenile reef fish in just 30 minutes! In Bermuda we are just beginning to monitor associated declines in reef fish as the invasion intensifies. Other regions however, have shown declines in prey fish by up to 65% in just two years. Likewise, the presence of lionfish on a reef has been shown to reduce recruitment of juvenile fishes by 79%. The lionfish most negatively affects small prey fish species including wrasses, gobies, basslets, and also crustaceans such as shrimp and crabs. Prey fish species include over 40 species from 20 families.

Through removal of juveniles, the lionfish invasion has potential ramifications all the way up the food chain. For example, lionfish compete with native predators for prey species, which can lead to declines in native predator populations. Likewise, if herbivore populations are removed through lionfish predation we could see a bloom in algal growth and associated declines in coral health as macroalgae overgrows and outcompetes corals. Thus the lionfish has the potential to affect all aspects of reef health.

The Response

In 2012 the Ocean Support Foundation (OSF) held a lionfish workshop, in which the Bermuda Lionfish Taskforce was initiated with the aim of developing a control plan and creating a collaborative front to stop the invasion. From the Taskforce, a group of researchers from OSF, Bermuda Institute of Ocean Sciences (BIOS), Bermuda Aquarium, Museum & Zoo (BAMZ), Bermuda Department of Environment and Natural Resources, and University of Massachusetts applied and received funding from United Kingdom's DarwinPlus Initiative through the Department of Environment Food and Rural Affairs. The grant supported work to assess the lionfish population abundance and distribution, feeding and reproductive ecology, and recruitment as well as to develop tools for long-term control.

This group of collaborators, along with the Bermuda Lionfish Taskforce, is working vigilantly to control this species through spearing and trapping. Recent evidence has shown that local culling by divers can reduce the population of lionfish on reefs. The Bermuda Lionfish Taskforce is working to get as many people permitted to spear lionfish as possible so as to increase our culling efforts. The Ocean Support Foundation also has a designated team of technical divers that target "hotspots" at 45-60 meters in depth for culling lionfish. Likewise a local group of citizen scientists, Bermuda Ocean Explorers, is extremely active in culling efforts on shallow reefs. For long-term control the taskforce is working on developing a lionfish-specific trap from a modified lobster trap. With the help of commercial lobstermen, the taskforce aims to

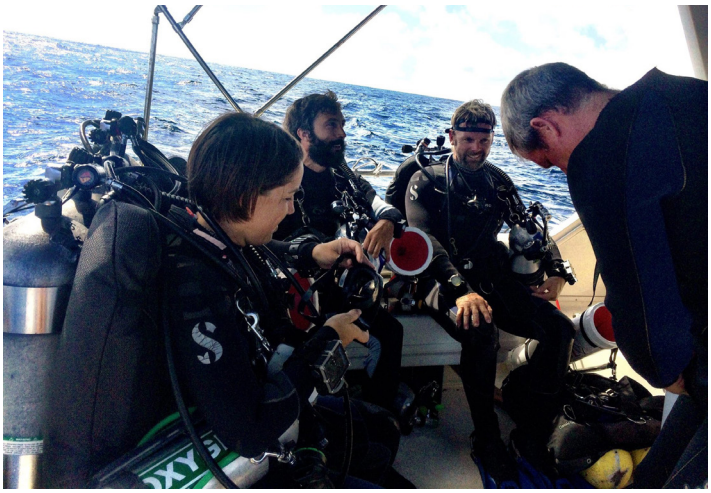
A. Chequer assists visiting collaborator, H. Pinheiro (California Academy of Sciences), to analyze collected lionfish specimen. Photo credit: OSF

create a trap that will target lionfish with minimal by-catch that can remove lionfish from reefs inaccessible to divers.

Increasing demand for lionfish on the menu is another strategy the taskforce is using to manage the lionfish invasion. Luckily the lionfish is delicious and not difficult to prepare (although preparation does require some care due to venomous spines in their fins). In Jamaica, local demand for lionfish has driven population declines in the species on local reefs. To increase interest in lionfish as a food source, Groundswell hosts an annual Lionfish Tournament at BIOS that encourages capture and consumption of lionfish, provides lessons on preparing fish and offers lionfish samples to all the patrons. It's a great way in increase local awareness.

Lessons Learned

- *Collaboration and cooperation between groups from different sectors is key to responding to a large-scale disturbance like the lionfish invasion*. The Lionfish Taskforce enabled individuals from all sectors and the community together, enabling a broader understanding of the threat and facilitating a proportional response. Without collaboration and cooperation between groups the full extent of the invasion would not have been understood. Working with citizen scientists like the Bermuda Ocean Explorers and community-based environmental groups like Groundswell enabled mobilization of many more people to help on this important issue. Ultimately it will take the entire community to control the invasion, so raising public awareness was key.



DarwinPlus technical dive team prepares to collect lionfish from a deep reef "hot spot" (left to right: G. Goodbody-Gringley, C. Eddy, A. Chequer, G. Maddocks). Photo credit: OSF

As told to Georgina Cullman.

Collaborating Investigators

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Lead Organizations

- The Bermuda Lionfish Taskforce http://www.lionfish.bm

Partner Organizations

- Bermuda Institute of Ocean Sciences http://www.bios.edu
- Ocean Support Foundation http://www.oceansupport.org
- Bermuda Aquarium, Museum & Zoo (BAMZ) http://www.bamz.org
- Bermuda Fisheries https://www.gov.bm/department/environment-and-natural-resources
- Groundswell http://www.reefspect.com
- Bermuda Ocean Explorers http://bermudaoceanexplorers.org

Funding Summary

- Department for Environment, Food & Rural Affair Darwin Plus https://www.gov.uk/guidance/darwin-plus-applying-for-projects-in-uk-overseas-territories

Resources

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The Milstein Science Symposium

The collection of this case study and others like it results from the April 2013 Milstein Science Symposium, Understanding Ecological and Social Resilience in Island Systems: Informing Policy and Sharing Lessons for Management. Held at the American Museum of Natural History, the Milstein Science Symposium convened local resource managers, researchers, educators, island leaders, policy makers, and other leading conservation practitioners to examine characteristics, qualities, and processes that may foster resilience for coastal and marine systems as well as explore interactions, linkages, and feedback loops in complex social-ecological systems and what this means for management. The Milstein Science Symposium was organized in collaboration with The Nature Conservancy, the Gordon and Betty Moore Foundation, the National Science Foundation, The Christensen Fund, the Coral Reef Alliance (CORAL), the Scripps Institution of Oceanography at the University of California San Diego, the University of California Santa Barbara, the United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries, and Small Island Developing States (UN-OHRLLS), and the Wildlife Conservation Society.

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