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Lionfish in the Caribbean: Past and Present
Lessons learnt from the UKOTs

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INFOPESCA/FAO/WCAFC

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UK Overseas Territories Programme

UK Overseas Territories in the Wider Caribbean Region: Anguilla, Turks & Caicos Islands, Cayman Islands, Montserrat, British Virgin Islands and Bermuda

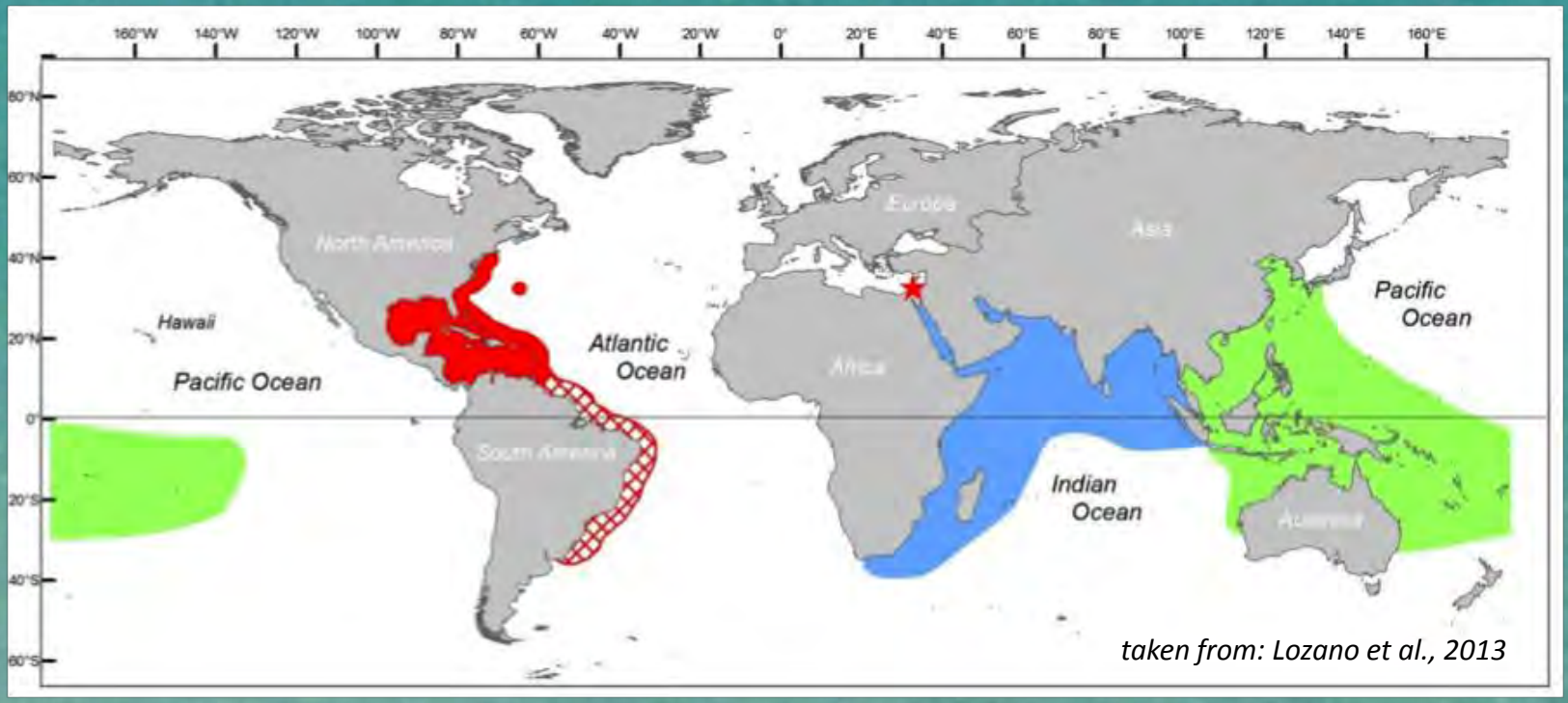
Red Lionfish (*Pterois volitans*) and Devil Firefish (*Pterois miles*)

- Native to Indo-Pacific region
- Scorpaenids family- scorpionfish mistakenly identified as lionfish by fishers and general public
- Fist marine fish to successfully invade the western Atlantic region
- Mostly referring to *P. volitans* as found to be more common (Hamner *et al.,* 2007)
- *P. volitans*- different in presence of horn-like projections on head
- Venomous- highly developed venom apparatus (13 dorsal spines, 2 anal spines and 2 pelvic spines- venom glands are located along grooves of each spine and extend ¾ of distance from base of spine towards the tip.
- Toxin contains acetylcholine which affects neuromuscular transmission and causes cardiovascular and neuromuscular effects in animals and humans (Morris, 2012).

Photo: Ned Deloach

Venomous characteristic causes concern in the invaded range of the species and poses challenges to control measures.

Native and non-native range of *Pterois volitans* and *Pterois miles*



Native range- *Pterois volitans* (green) and *Pterois miles* (blue)
The star in the Mediterranean Sea -migration of *P. miles* via the Suez Canal (Golani and Sonin, 1992).
Non-native range of *P. volitans* and *P. miles* (red) (from Schofield *et al.,* 2012).
Predicted future distribution of lionfish along coastal South America is shown in red hatching (Morris and Whitfield, 2009)

Dispersal of lionfish populations of the Caribbean

From 1985 to 2011. Ref: http://nas.er.usgs.gov

The first outstanding characteristic of this invasion is the speed at which it has spread

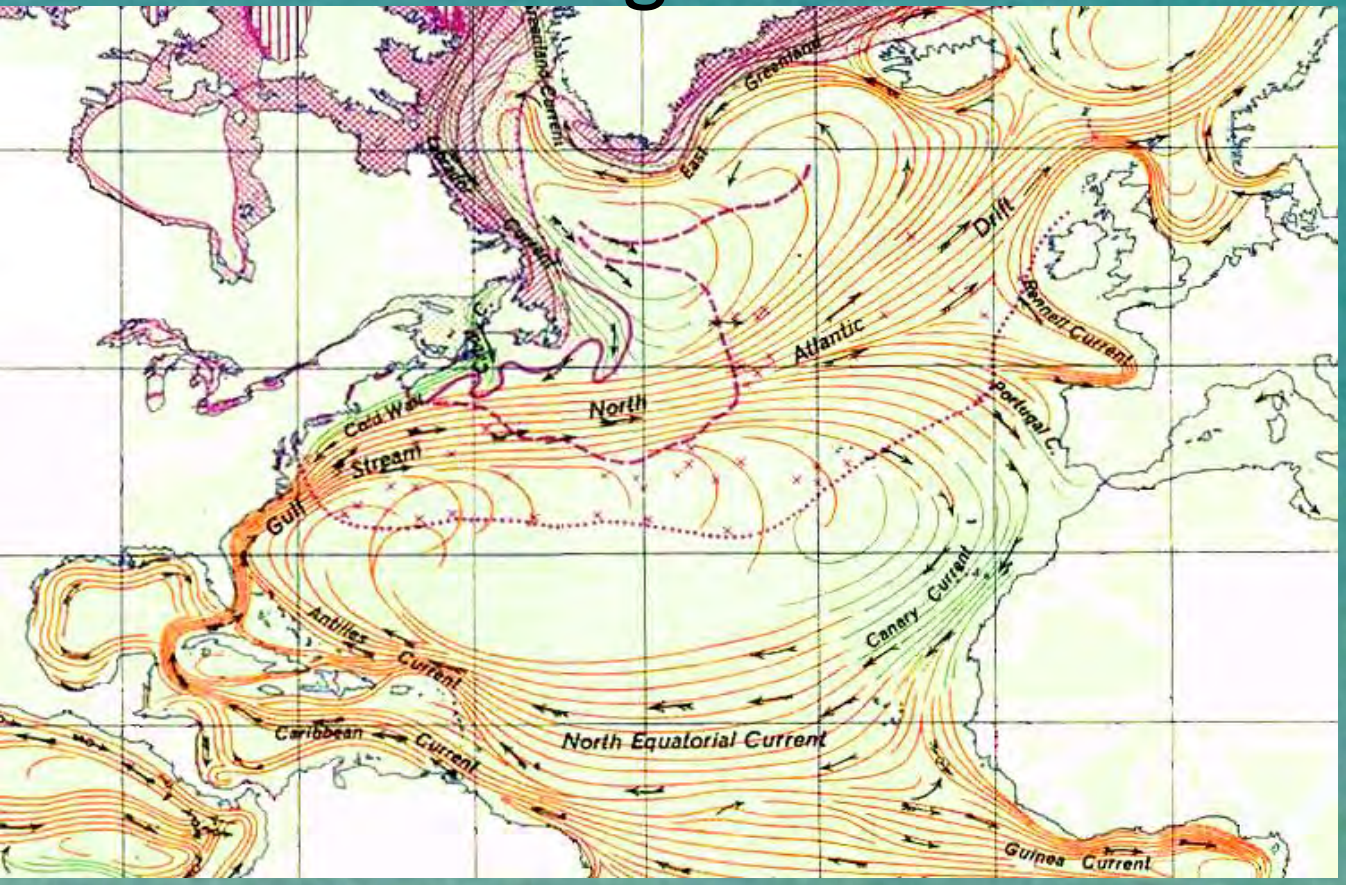
1985- First report in Florida waters

2011- spread across the Atlantic to Bermuda, Caribbean Sea, and south to Colombia and Venezuela.

Recorded in The Bahamas, Turks and Caicos Islands, Cayman Islands, Cuba, Jamaica, Dominican Republic, Puerto Rico, Mexico, Honduras, Costa Rica, Haiti, Virgin Islands, Belize, Panama and Colombia.

Future- Possible (and likely) expansion of their current range to South America

Invasion Range



(*taken from* :Johnson and Richardson, Anguilla government)

Occupancy range

limited by sea water temperature, affecting survival and reproduction:

- mean chronic lethal temperature of 10.0°C, and
- mean temperature of feeding cessation at 16.1°C (Kimball *et al*., 2004).

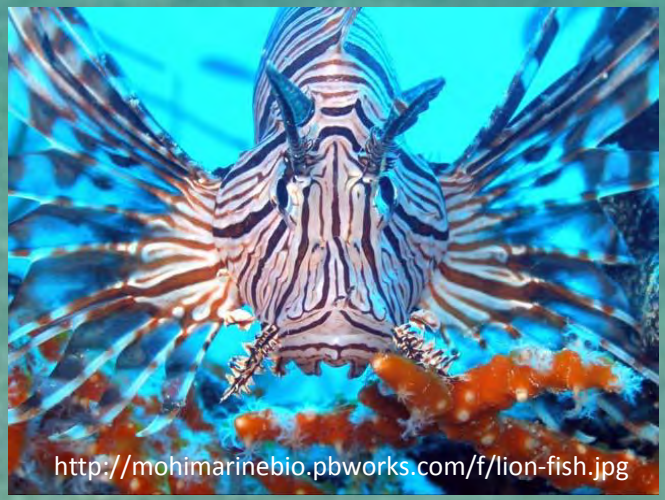
Several stages to invasion

- First driven by large currents, namely the Gulf Stream- spread across the Atlantic to Bermuda and south to Caribbean
- Second, radial and proximity based- leading to proliferation of species in invaded area

Characteristics of species facilitating invasion

Voracious predator- 40 species of fish and crustacean species from over 20 families (Albins and Hixon, 2011). Can consume up to 6% body weight , and prey can be up to 2/3 body size.

Various predation strategies- Camouflage, static movement, ambushing, corralling prey, positioning through altering its centre of buoyancy. Pectoral fins are also used to flush benthic invertebrates (crabs and juvenile spiny lobster) from the substrate by palpation (Fishelson, 1975).



Venomous- deter predators and additional means of catching prey

Characteristics of species facilitating invasion

•**Unique reproduction mechanisms** with a rapid turnover- can reproduce year round and females reproduce every 4 days (enables dramatic population increase in a short time)

•Relatively **resistant to parasites**, giving them another advantage over native species.

•**High survival rate-** Up to 45 days without eating (enabling the species to be transported over vast distances, without food).

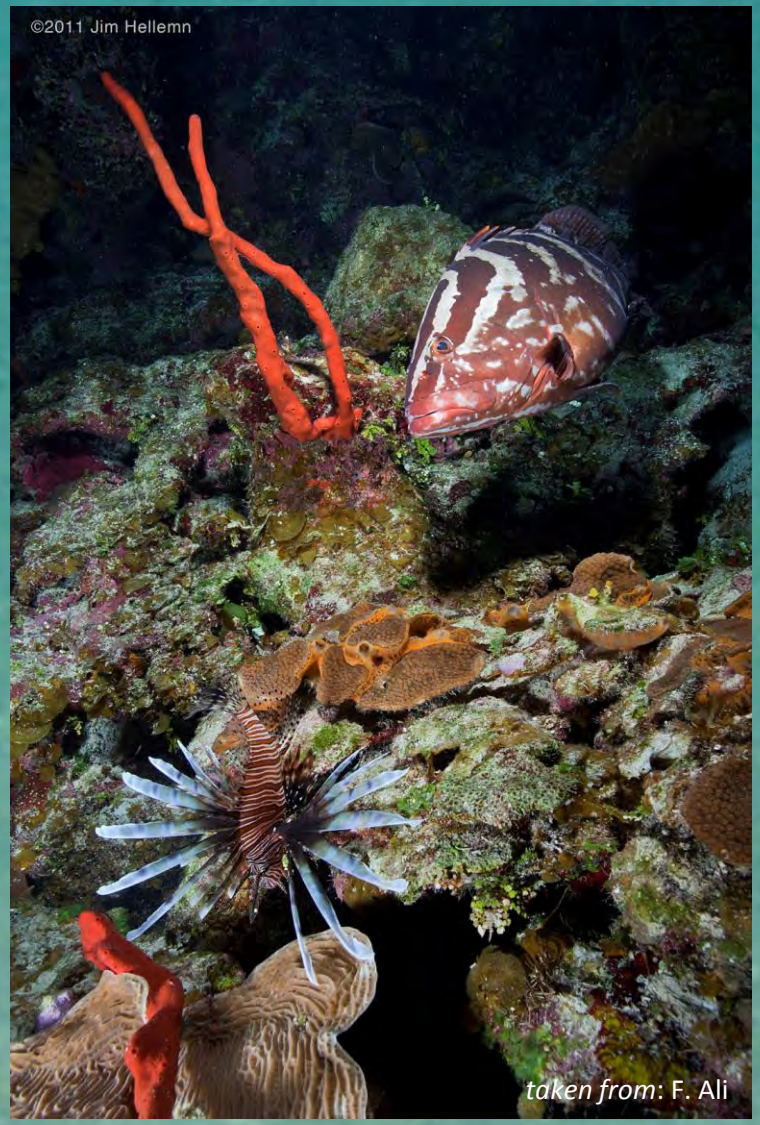
•**Rapid growth rate**, able to outgrow native species

•No native predators in the **Atlantic** ocean.

Native area population equilibrium

- **Indo-Pacific** conditions: population size control by natural predators such as groupers, sharks and eels (Green *et al*, 2011).

- **Caribbean** conditions
  - an abundance of prey, previously not exposed to lionfish predatory behaviour, and
  - lack of effective predation on lionfish by Atlantic species (Albins and Hixon, 2011).



Note: There are some reports on Caribbean predators (groupers) with lionfish in stomach content, confirmed by a study in Bahamas (Makjovic and Leuwen 2005); this may indicate potential shift in Caribbean predator behaviour

Lionfish densities in Caribbean

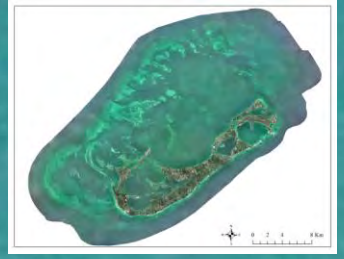
- Lionfish found:
  - All habitat types
  - From shoreline to over 1000 ft deep
  - In densities orders of magnitude greater than in native range (maximum 80 lionfish per hectare, Shiel *et al.,* 1986; Fishelson, 1997)

Reported Caribbean Densities:

- 390 lionfish per hectare (Green and Côté, 2011),
- up to 600 fish per hectare in Little Cayman (Frazer *et al.,* 2013)

5-15 times densities recorded in native range

Cayman Islands-1st sighting 2008
Shallow waters less than 20m (60')
Spearing by SCUBA



(32°N, 64°W)

Bermuda-1st sighting 1999 . Majority in depths greater than 150'
Developing lionfish specific trap

Turks & Caicos Islands- 1st sighting in 2007- shallow waters in marine parks <15m- population remaining stable/Increased population in deep reef wall in S. Caicos
Potential breeding ground

British Virgin Islands- 1st sighting in 2010- mostly offshore in 70 m (200')depth- much less inshore. – entering lobster traps

Montserrat- 1st sighting 2010- not many reefs or sheltered harbour- mainly deep waters in 70 m (200')

Anguilla- 1st sighting- 2010-near shore reefs 3-70m (10'-200' of water) – Majority in 70 m (200') and up to 17 miles off the coast. They remain solitary and have not been seen in groups.

Risks

Lionfish broad diet
Direct predation, of native species (juvenile yellow tail snapper and Nassau grouper) as well as competing for food resources (Morris and Akins, 2009)

Feeding on ecologically important species such as parrotfish and other herbivorous fishes (Albins and Hixon, 2008).

taken from S. Manuel (Bermuda government)

Level to which lionfish populations can grow before drastically altering the ecosystem is uncertain

Impacts

Fisheries Industry
Affecting recruitment of commercially important species (including spiny lobster). Evidence seen in Turks & Caicos Islands recording reduction in standard length and size class of commercially landed grouper and snapper species.

Resilience of coral reef ecosystem
Affecting services provided by coral reefs (fisheries as habitat/coastal protection/ beach formation/tourism)

Risks

7 of the 20 top **ornamental species** collected in the Western Atlantic are being **preyed** upon by lionfish and will be less abundant (Bruckner, 2005; Morris and Akins, 2009).

taken from S. Manuel (Bermuda government)

Impacts

Aquarium fish trade Increased pressure on ornamental species

Decline of other mid-sized predators (via predation or competition) creates a destabilising effect and modifies the trophic cascade.

Survival of native reef fishes declines by about 80 percent once lionfish settled in an area.

Loss of biodiversity Extinction in the long term of certain small-bodied fish and loss of species richness, (Albins and Hixon, 2011). Evidence-Percent change measured in the Bahamas (Green *et al.,* 2012).

Affecting Livelihoods- Fisheries Industry

NEGATIVE IMPACTS

Decline in native commercial and recreational fisheries

Supplying and promoting an exotic species to the detraction of native fish species; a "Green Image"?

Venomous -health risks to fishermen and restaurant staff

Ciguatera toxicity concern- need to assess and adopt appropriate regulatory measures

POSITIVE IMPACTS

Creating a new fishery offer of a new product, and a potential opportunity

Additional revenue to governments and new employment (such as a specific lionfish processing plant).

Control measure for lionfish population

Affecting livelihoods: Fisheries Industry

- Florida reported commercial lionfish landings in 2012 of about 5,000 kilograms

- Lionfish is the number two by-catch in Florida's lobster fishery, and it fetches one of the highest prices per pound.

Question: Will there be any long term consequences on the industry if successful at reducing lionfish population and this niche fishery collapses? Will the lionfish fishery become a "boom and bust" fishery?

Affecting livelihoods- Tourism Industry

POSITIVE IMPACTS

Licensing of dive operators – Development of "Green Tourism"

-new product to the industry
-an environmental benefit
-generated additional revenue for the cost of the license
-Divers can fish in different habitats, nearer to shore, and spend less fuel.
-Stimulating local economy
- an alternative fishery

taken from :Johnson and Richardson (Anguilla government)

Affecting livelihoods: Tourism Industry

NEGATIVE IMPACTS

- Potential risk to human health associated with the venomous characteristic of this fish

- Culling activity is not approved by all tourist divers, and a balance has to be achieved on dive operator boats.

- Potential repercussions, (witnessed in Cayman Islands), where native top predators attack lionfish cullers

- Loss of coral reefs, loss of key tourism asset- On average, half of Caribbean countries GDP from the tourism industry
  - diving is a key component of reef tourism and recreation
  - 2-5% loss of growth in the Caribbean diving industry would result in a region-wide loss of annual net benefits of between 100 and 300 million USD (Burke and Maidens, 2004)

Regional Responses

The Ad Hoc Committee for the **Caribbean Regional Response to the Lionfish Invasion** (known as 'Regional Lionfish Committee') was established in November 2010

-Combines efforts of UNEP- Caribbean Environment Programme (UNEP-CEP) and Regional Activity Centre for Protocol on Specially Protected Areas and Wildlife of Cartagena Convention (SPAW-RAC)

-Partners- Governments (Mexico, USA, DR), CABI, REEF

Regional Strategy for the Control of Invasive Lionfish in the Wider Caribbean **ICRI** (Lozano *et al.,* 2013)

UK Overseas Territories JNCC workshops To develop Lionfish Response Strategy: 2 reports with UKOT specific lionfish status and strategy. www.jncc.gov.uk

Invasive Lionfish: A Guide to Control and Management Morris (2012) http://lionfish.gcfi.org/manual/InvasiveLionfishGuide_GCFI_SpecialPublicationSeries_Number1_2012.pdf

Country Responses and Control Measures

Dependent on lionfish population hotspots characteristics, existing legislation, and community engagement

Shallow water Culling- Hunting parties/bounty on lionfish

- Using modified spears by local stakeholders and volunteers SCUBA/snorkeler) – some examples, Bonaire, Cayman, Bermuda, Turks & Caicos Islands, BVI, Montserrat
- Engagement of dive operators- leading culling expeditions with tourists (Cayman)

Recreational hunting-
Engagement of dive operators, tourists are allowed to buy a permit to spear lionfish.

Cayman Islands: Culling Effort for shallow populations of lionfish

Cayman Islands Government

DARWIN INITIATIVE

Licensed Non spearing (Cullers):

Grand Cayman: 1,485 individuals
Cayman Brac: 62 individuals
Little Cayman: 58 individuals

Licensed Spearing: (Dive Companies)

Grand Cayman: 76 individuals
Cayman Brac: 5 individuals
Little Cayman: 12 individuals

Licensed Spearing: (local residents)

Grand Cayman: 294 individuals
Cayman Brac: 36 individuals
Little Cayman: 5 individuals

taken from : B. Johnson (Cayman government)

Marine Protected Areas main focus of lionfish extraction

Culling Efforts for Lionfish populations at depths beyond SCUBA: Trapping

Lionfish by-catch in the lobster trap fishery, Bermuda (J. Pitt, Department of Environmental Protection)

	2009-10	2010-11	2011-12	2012-13
Total number caught offshore (reported)	608	200	371	487
Total number caught inshore (reported)	6	2	5	6

Note: Based on 50% of fishermen reporting

Bermuda- Lionfish most commonly caught by catch in lobster traps

British Virgin Islands- reports of 100 lbs of lionfish caught per boat per trip with lobster traps

Challenges:

1)Minimise by-catch during trapping

2) Educate- Many fishers still concerned regarding handling, and throw lionfish overboard

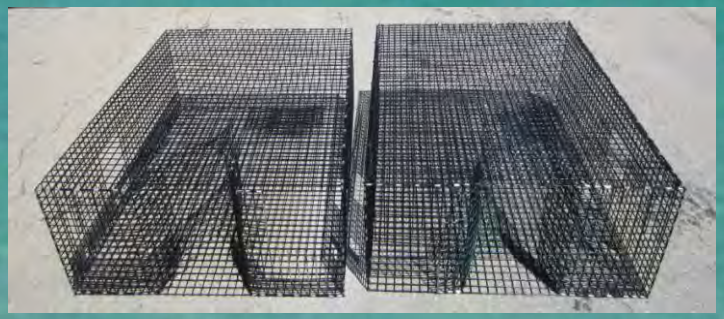
3) Appropriate legislation

Government Response in Bermuda:

1) Change in legislation Initially illegal to sell by-catch; provision made for lionfish caught in lobster traps
2) Design lionfish specific traps

Country Responses- Lionfish specific Traps

Bermuda: Designing lionfish specific traps and camera fitted for monitoring and assessment



Funnel with pvc Ring (taken from J. Pitt, Bermuda government)

Modified lobster traps

- Several parameters tested (shade, funnel type)

Camera characteristics

-GoPro Hero2 camera with Cam-Do external controller card and Group B ScoutPro HH2 housing rated to 5,000'.
-Controller card allows GoPro to take 5 photographs every 15 minutes, and turns it off in between to save battery life
- attached to the float line ~8' about the trap.
- Field of view includes trap plus immediate surroundings.
- 20 days of battery life. Rated to 250' / 76 m depth.

(taken from: J. Pitt, Bermuda government)

Other Control Measures by Countries

- *Creating awareness of the problem*-Engagement of government and of the community (divers, fishers, restaurateurs)
- *Foster predators to eat lionfish*- Divers catch lionfish and offer the wounded or dead lionfish to these predators to train them in eating the lionfish. Eg. British Virgin Islands fishermen feeding lionfish to sharks
- *Attraction for tourists*- promoting serving in restaurants as a delicacy favoured by tourists. The species has higher levels of omega-3 fatty acids than other commonly consumed Caribbean fishes
- *Scientific Research*- engage dive operators and volunteers to assist in data collection/prioritise research required

Other Control Measures by Countries

Conservation of lionfish predators

- Protection of groupers and sharks through the establishment of Marine Protected Areas.
- Thirty-eight countries in the Caribbean and tropical North-Western Atlantic are now protecting their coastal areas from fisheries (Sealey and Bustamente, 1999).
- Limit excessive fishing of commercial species- such as sharks, yellowtail snapper , (Nassau) groupers, porgies, triggerfish, jacks, tilefishes, grunts, spadefishes, wrasses and sea basses. Excessive fishing reduces interspecific competition leaving a niche vacancy in the reef fish community (Huntsman *et al.,* 1999).

MPAs may be the most effective way to manage or mitigate the lionfish invasion (Albins and Hixon, 2011).

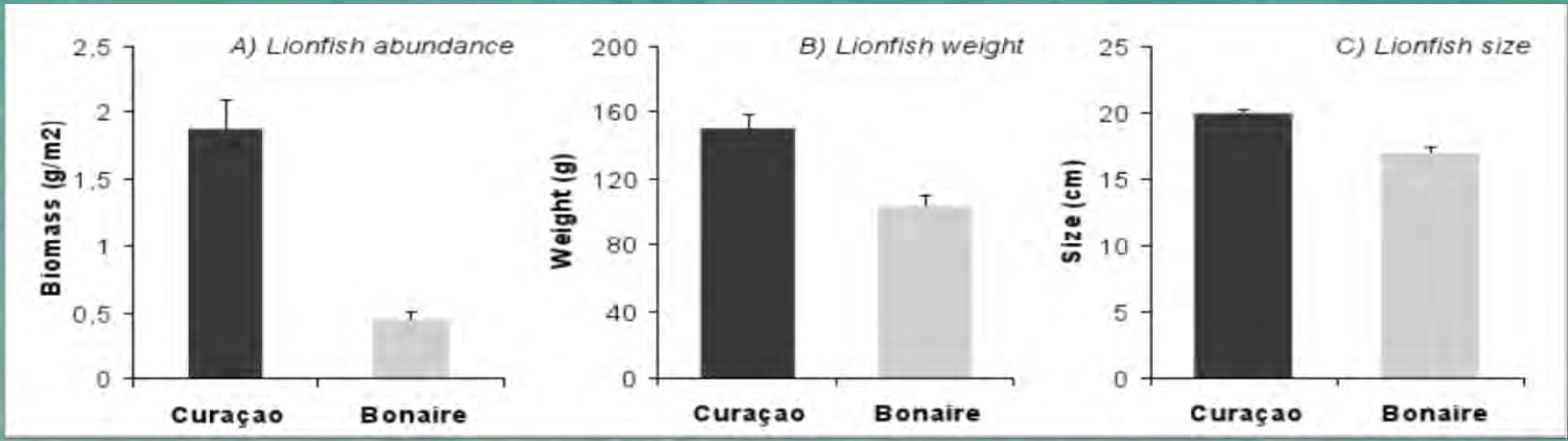
Effective conservation of predatory fish and other large-bodied size fish by MPAs has been documented (Halpern, 2003).

Effectiveness of measures

Effectiveness of culling by spearing (de León *et al.*, 2012)

Study comparing culled (Bonaire) and non-culled (Curacao) after 2 years of eradication on Bonaire

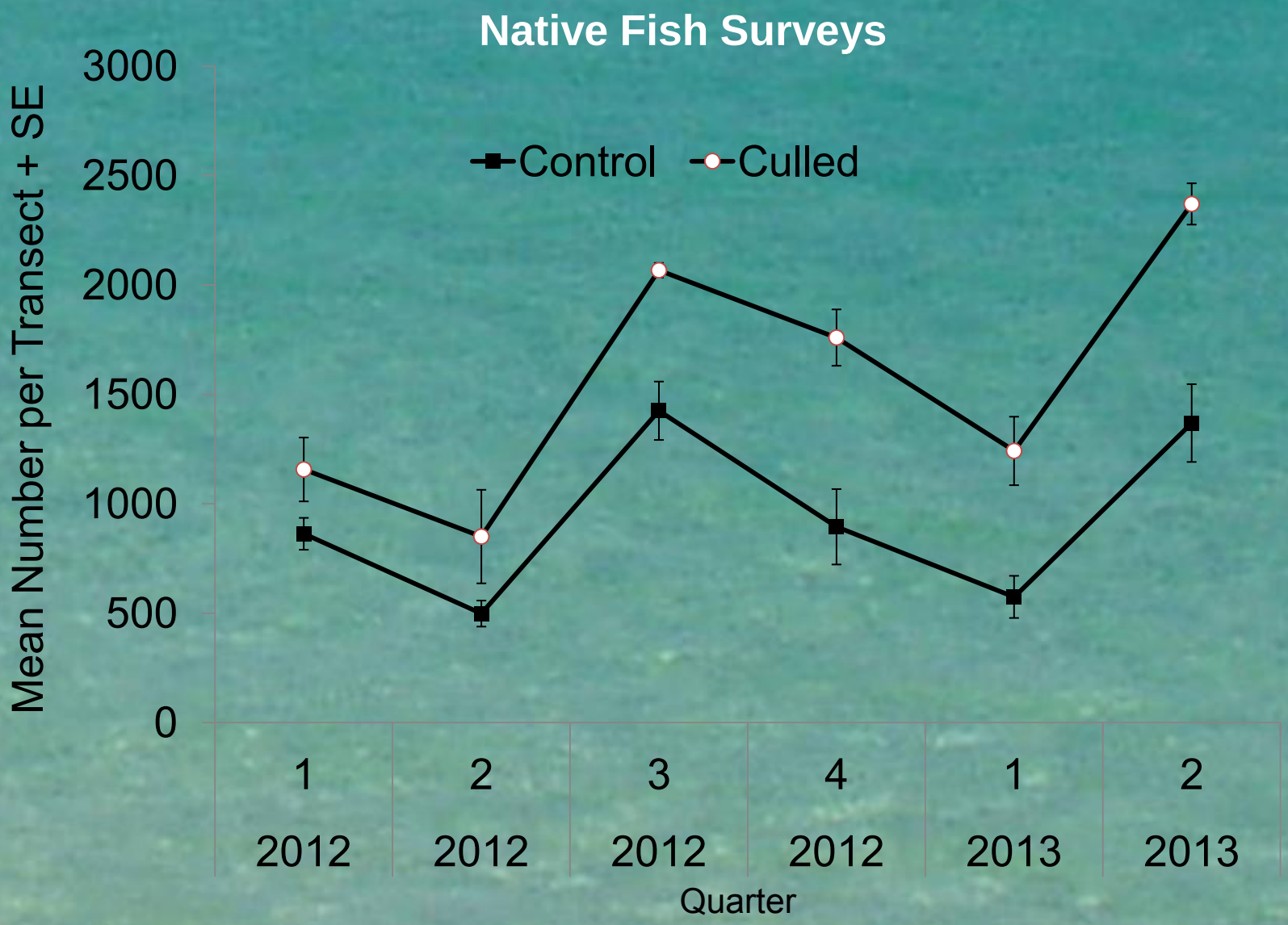
Bonaire- 4.2 times less, with a density approximating 0.45g/m^2, 33% less lionfish weight and 15% smaller



A comparison of the abundance, weight and size of Lionfish populations between Curacao and Bonaire after two years of eradication on Bonaire (de León *et al.*, 2012)

Effectiveness of measures

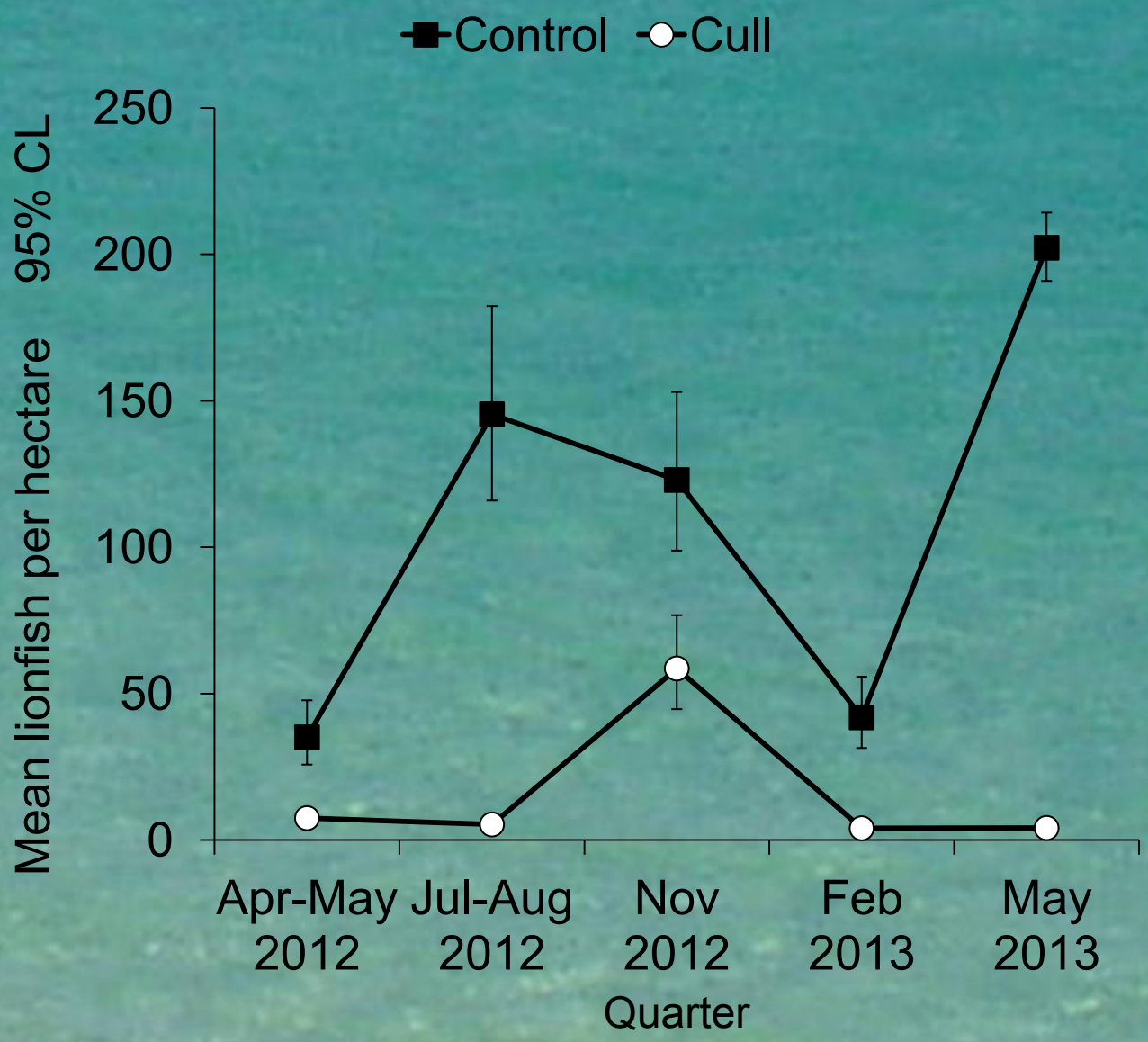
Frazer *et al.* (2014) Little Cayman- Comparing native fish populations in culled vs not culled reefs



Effectiveness of measures

- Targeted removals of lionfish shifted the size frequency distribution of remaining lionfish toward smaller lionfish whose stomachs contained less prey and fewer fish (Frazer *et al.,* 2014- Little Cayman).

Frazer *et al.,* 2014 Little Cayman. Comparing lionfish Populations in culled vs. not culled areas



Effectiveness of measures?

Study

McCoy *et al.,* 2014. Cayman Islands "Lionfish (*Pterois volitans*)Population Dynamics ,Local Community Culling effectiveness, habitat usage and diets-Cayman Islands, Caribbean" (Bangor University, UK)

Results

- Results indicate differences in population dynamics of fish species between culled and un-culled areas
- Smaller lionfish (<25cm) had a higher percentage (approximate 2 fold the frequency of occurrence) of crustaceans in their diets than larger individuals within each island
- Frequency of crustaceans in lionfish diet differs among sites

What can be derived from this?

•Prey density and composition are key elements to lionfish diet –i.e. Lionfish diet reflects prey density composition at site. Prey community biomass (calculated from fish species and sizes), predation rates and diet information, and lionfish densities (sizes, abundance and density) required for assessment of predation impacts.

•For effective control measures, nursery habitats of important (commercial and ecological species) need to be identified and understood

•Nursery habitats of important species need to be protected from lionfish

Efforts for control measures should be focused on identified nursery habitats

Achieving sustainable control of lionfish

- It is important to address control in a manner that makes most effective use of limited resources.
- Prioritise locations for control efforts
  - Nursery habitats,
  - Marine Protected Areas
  - Areas of high visitation or tourism value
- Address thresholds and capacities of lionfish in these areas through modelling
- Develop tools to maximise efficiency while still protecting the resources
  - Use of environmental economics to assess impact of lionfish on key industries (Study recently completed in Cayman Islands on economic impact of lionfish on Tourism industry- van Beukering *et al.,* in prep.)

Complete removal of lionfish from a site is unlikely and would incur high unsustainable removal costs.

Removal target?

According to J. Morris (2012) models suggest that at least 27 percent of adult lionfish must be removed monthly to bring about meaningful decline in targeted areas.

Challenges faced by territories for sustainable and effective control measures

- *Limited manpower-* affects capacity for surveys on lionfish population densities, nursery habitats, predation evaluation in several Territories, necessary to focus control measures.

- *Lack of information on nursery habitats* of commercially important species and/or ecologically important species- limits ability to focus efforts on critical habitats.

- *Gaps in data-* Accurate fisheries statistics or poor management system for analysis and use hinder assessment of impact of lionfish on fisheries

- *Funding for understanding impacts, implementing control measures, and monitoring* is a major limiting factor in many territories.

- *Lack of dedicated coordinator* in Territories for lionfish programme inhibits response success. Examples: Cayman Islands and Bermuda where coordinator in former and Task Force in latter have capacity to assess and implement measures more effectively than in other Territories.

Challenges faced by territories for sustainable and effective control measures

Legislative

- special licenses to take lionfish while using SCUBA
- Prohibit use of speargun (Turks & Caicos Islands)
- Spearfishing forbidden in Marine Parks (Bonaire passed a law)
- No spearfishing within one mile of shoreline
- Size restrictions lifted (Cayman islands amended legislation to take small lionfish <8” in fork length)
- Recreational fishermen cannot sell their catch
- Prohibit use of traps for fin fish (Bermuda)

Regional Strategy…a must for long term sustainable response strategy

Photo: S. Sarkis

- Use of **standard methods throughout**
  - Enables comparison and pooling of data for a better evaluation of control measure focus and effectiveness

- **Available toolkits**
- A 'toolkit' providing standard data sheets, methods for dissection guide and survey protocols http://www.reef.org/reef_files/_LF_dissection_final.pdf and see NOAA Technical Memorandum 139 - *Lionfish Dissection: Techniques and Applications*

- Economic valuation toolkit for assessment of lionfish impact on fisheries and tourism industry http://www.jncc.org.uk Cayman Islands Final Report includes 1) Tourist Exit Survey Template and 2) Business Survey Template

taken from : Green *et al.,* 2012
NOAA Technical Memorandum NOS NCCOS 139

- **Sharing of expertise through technical workshops**
  - Improves data collection

- **Lionfish database**
  - Consensus for development of a lionfish web portal at regional level, and/or lionfish database for UKOTs- access to scientific information and enables better analysis, management and utilisation of data

Funding Sources

- Darwin + for UK Overseas Territories (UKOTs)
  - www.darwin.defra.gov.uk
- Life + for European Overseas Territories (OCTs)
  - www.ec.europa.eu/environment/life/funding/lifeplus.htm
- The Caribbean Regional Fisheries Mechanism (CRFM) has 17 member states; funding access includes:
  - European Development Fund (EDF)- assistance to ACP states and OCTs
  - Governments of Canada (Canadian International Development Agency – CIDA
  - International Development Research Centre – IDRC,
  - Japan International Cooperation Agency – JICA

  www.caricom-fisheries.com

Need to pool resources and develop **cross-territory proposals** to maximise resources and efforts, and strategise responses for effective results in long term

THANK YOU MUCHAS GRACIAS