Ecological effects and management of invasive Lionfish in the Atlantic

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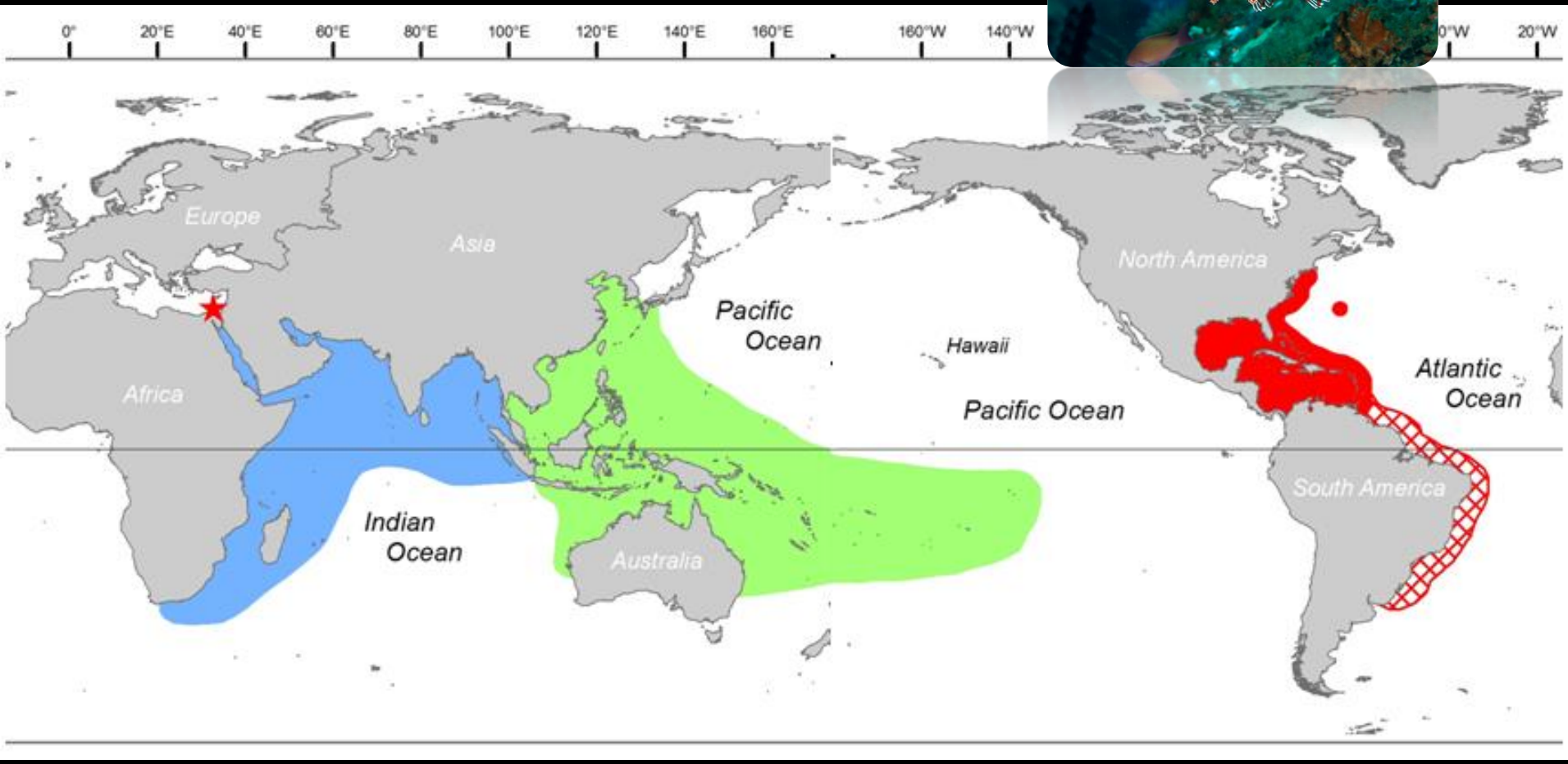
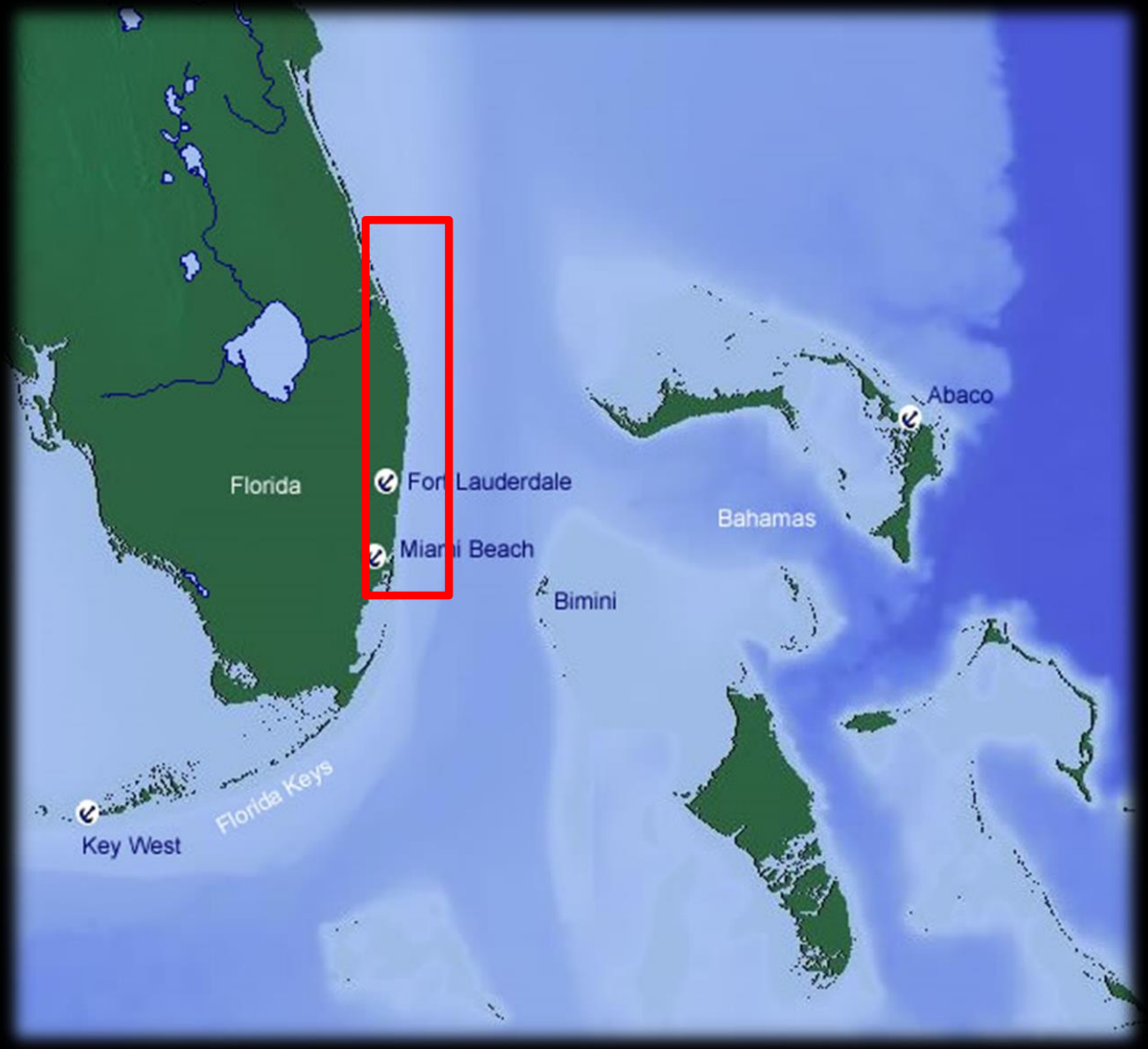
Distribution

- Red Lionfish – Pterois volitans
- Devil Firefish – Pterois miles



Source of the invasion



Aquarium imports and non-native fish sightings

Semmens et al. 2004

Invasion progression

USGS Non-indigenous Aquatic Species Database 2013

Invasion progression

USGS Non-indigenous Aquatic Species Database 2013

Invasion progression

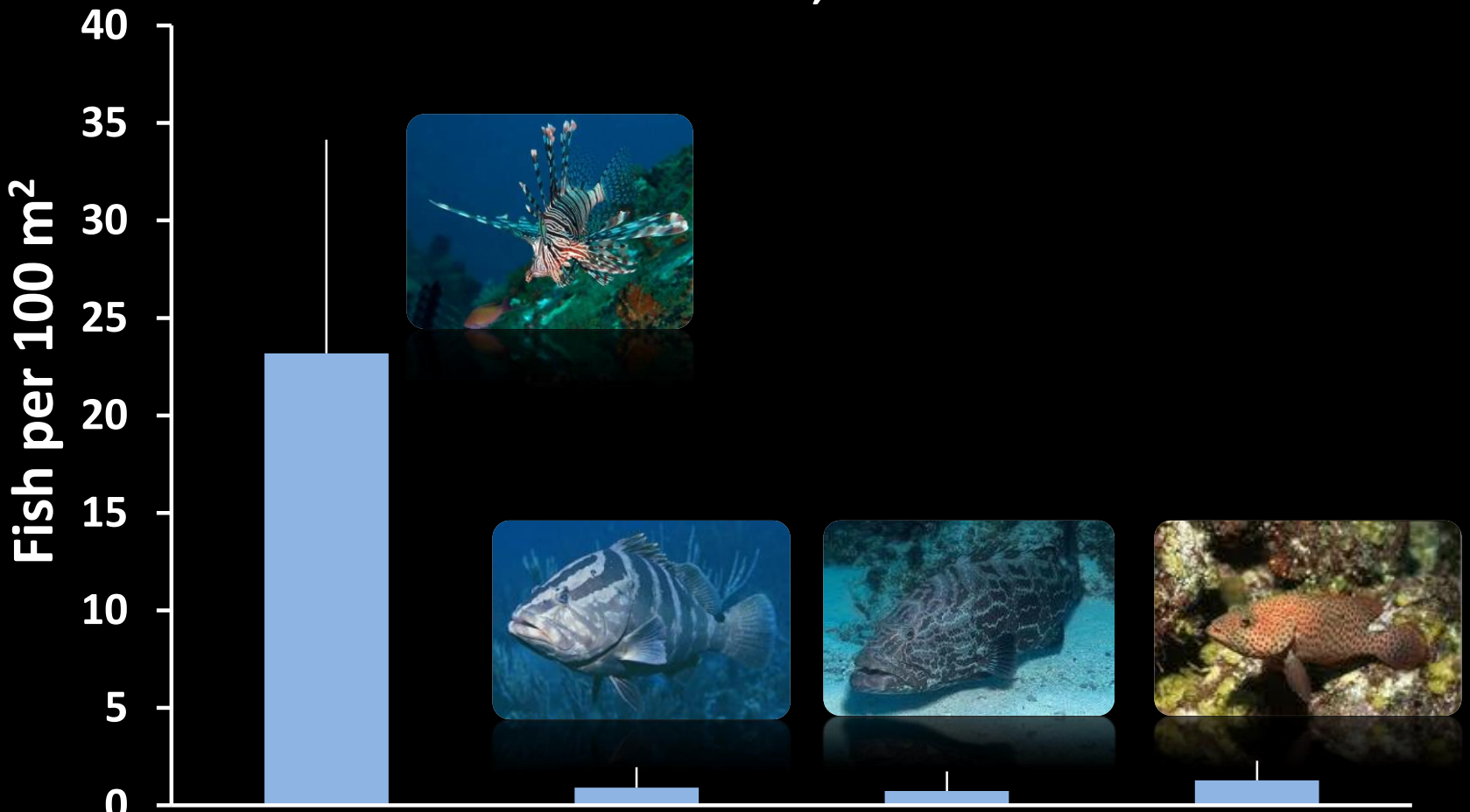
USGS Non-indigenous Aquatic Species Database 2013

Lionfish abundance has increased rapidly

Green et al. 2012 PLoS ONE

Relative predator abundance

Eleuthera, Bahamas



Green et al. 2012 PloS ONE

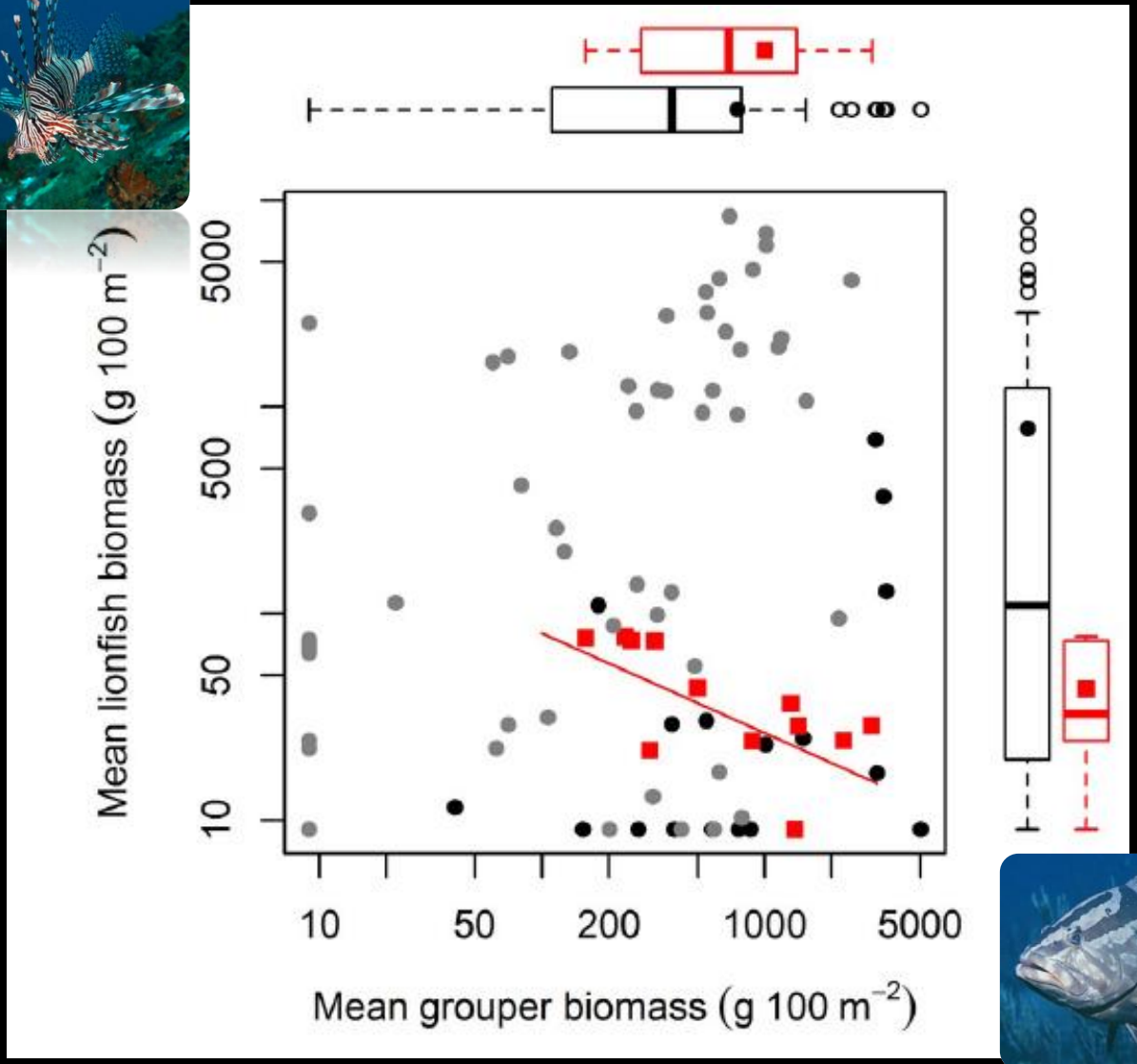
Potential lionfish range

Morris & Whitfield 2009

Lionfish in the Loxahatchee River

Judd and Layman 2012

Predators do not control lionfish



Valdivia, Green et al. 2014 PeerJ

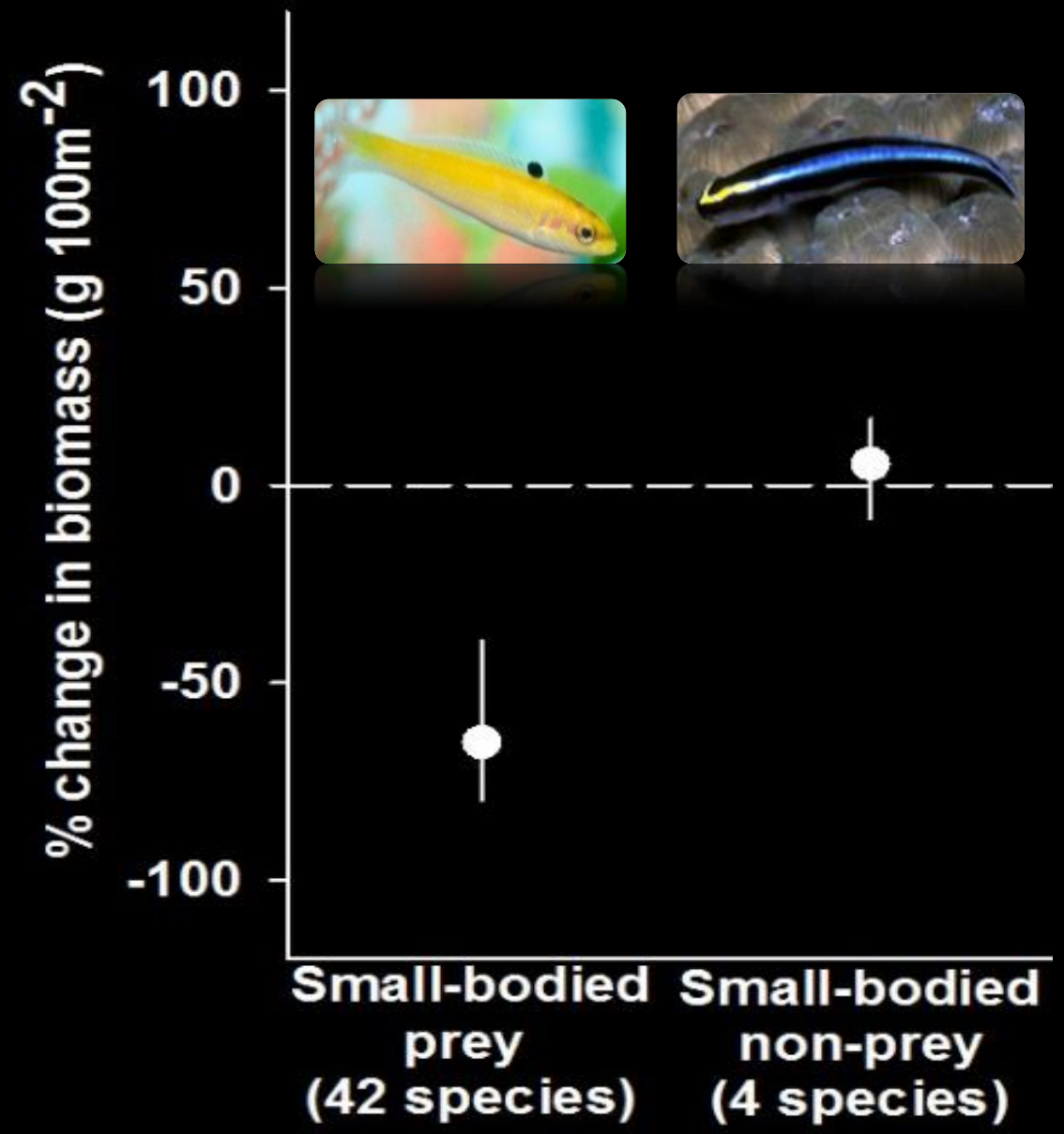
Gape-limited predators

Avoided

Preferred

Green & Côté J Animal Ecol 2014

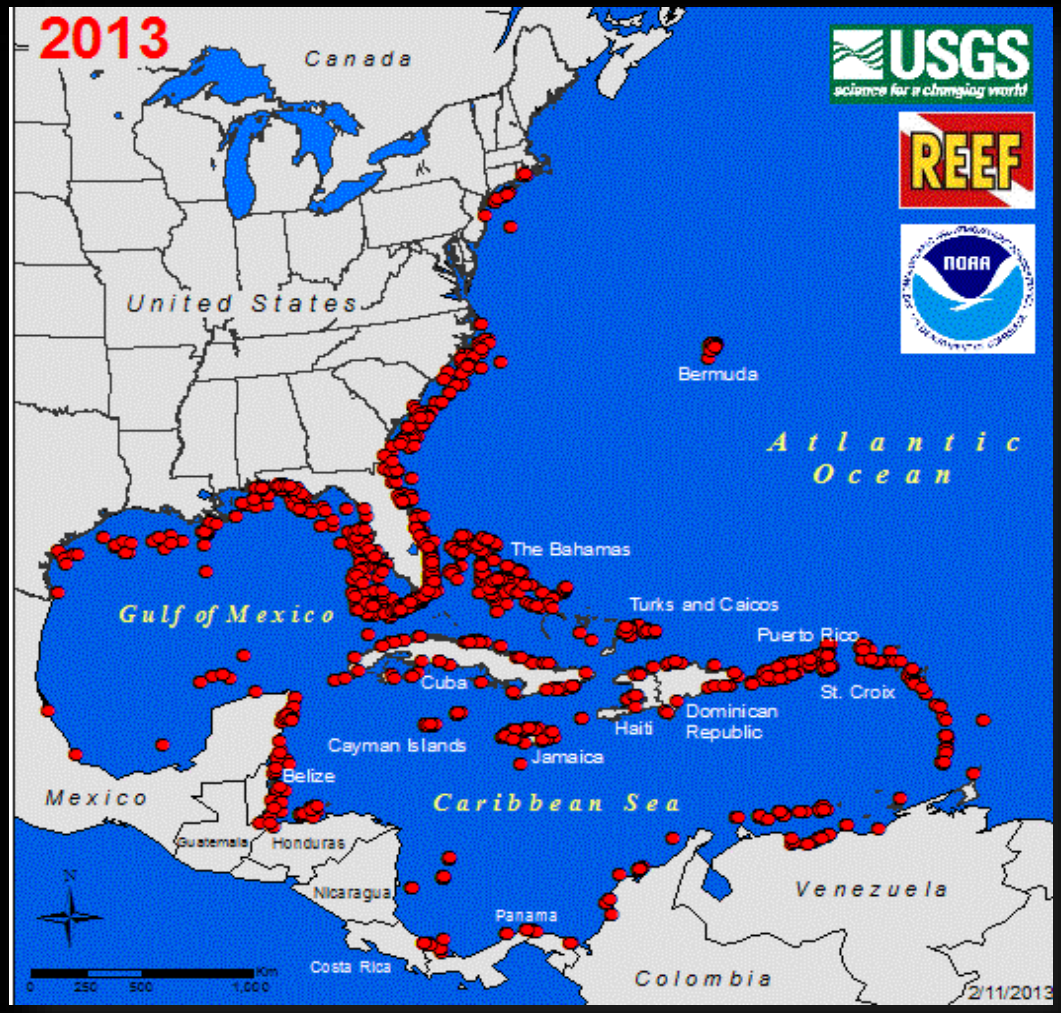
65% reduction in prey biomass over two years



Green et al. 2012
PLoS ONE

What have we learned so far?

Complete eradication is unlikely



Controlling the lionfish invasion

~~Eradication~~ → Population suppression

Planning control

Minimize ecological impacts in priority areas

Juvenile fish habitat

Marine Protected Areas

How many lionfish to remove?

How many lionfish can a reef tolerate?

How many lionfish can a reef tolerate?

$$P - C = N$$

Prey fish production ($kg\ ha^{-1}yr^{-1}$) - **Lionfish prey consumption ($kg\ ha^{-1}yr^{-1}$)** = **Net prey fish production ($kg\ ha^{-1}yr^{-1}$)**

Prey decline if $N < 0$

Green et al. *2014* Ecol. App.

How many lionfish can a reef tolerate?

$$\bar{N}_x = \underbrace{\frac{1}{z}\sum_{\forall_z}\sum_{\forall_i}\sum_{\forall_v}\left(\frac{jW_{v,i,z}{}^{q}}{e^{\frac{E}{kT}}}\right)W_{v,i,z}}_{\text{Prey fish production}} - \underbrace{\bar{d}_x\overline{W}_x\bar{p}(0.006e^{0.16T}\overline{W}_x{}^{c})y}_{\text{Lionfish prey consumption}}$$

Green et al. *2014* Ecol. App.

How many lionfish can a reef tolerate?

$$\bar{d}_x = \frac{\frac{1}{z}\sum_{\forall_z}\sum_{\forall_i}\sum_{\forall_v}\left(\frac{jW_{v,i,z}{}^{q}}{\frac{E}{e^{kT}}}\right)W_{v,i,z}}{\overline{W}_x\overline{p}\left(0.006e^{0.16T}\overline{W}_x{}^{c}\right)y}$$

Surveys of fish biomass

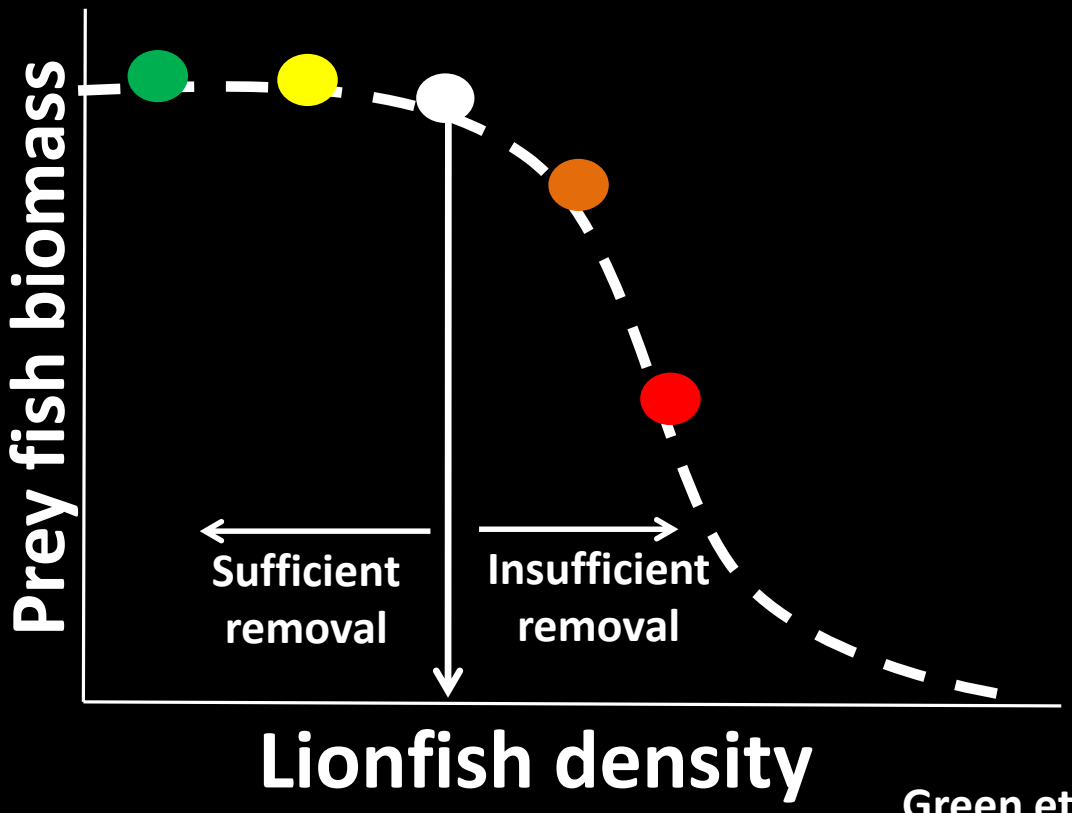
Predation rates

Lionfish densities and body sizes

Green et al. *2014* Ecol. App.

How many lionfish can a reef tolerate?

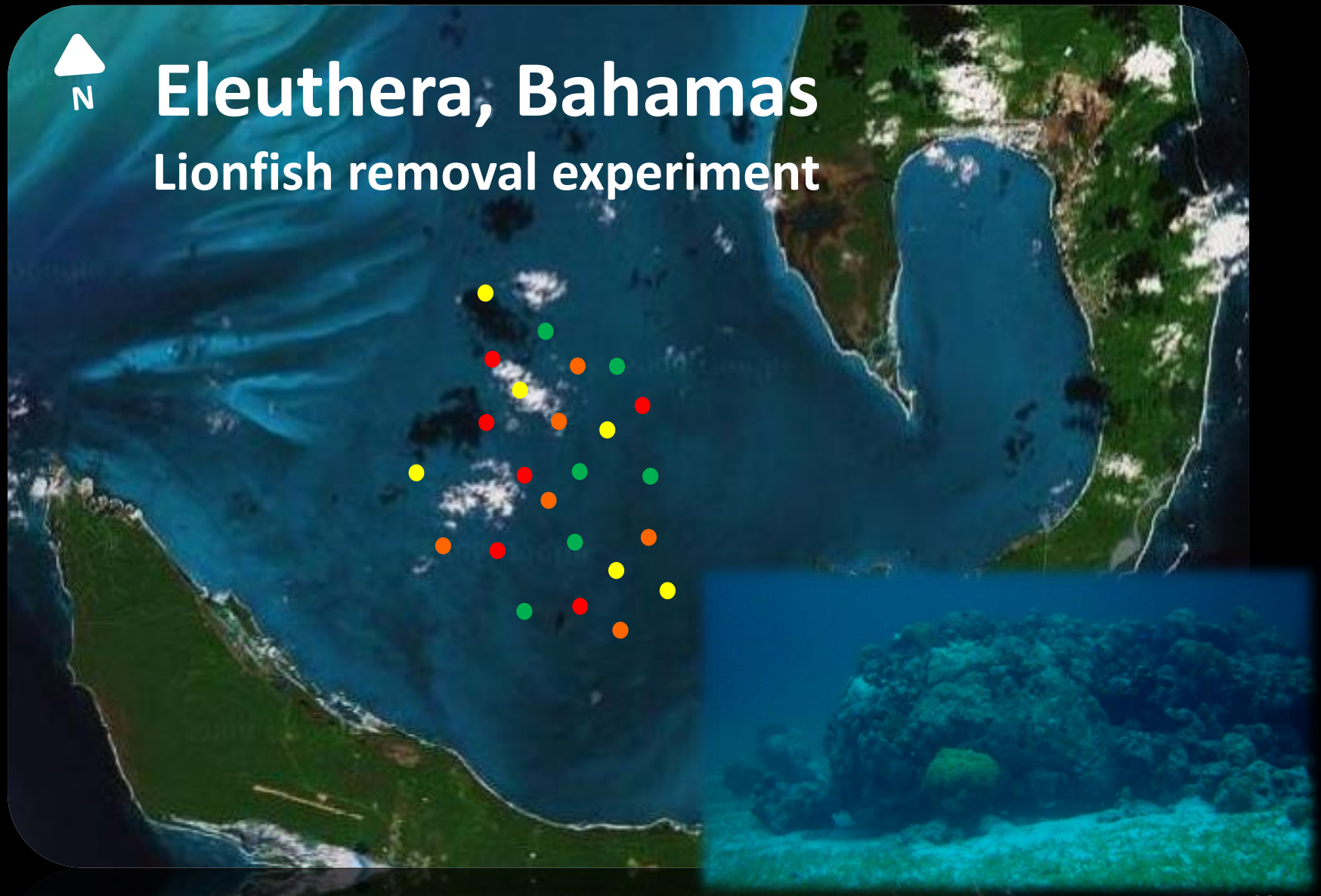
$$\bar{d}_x = \frac{\frac{1}{z}\sum_{\forall z}\sum_{\forall i}\sum_{\forall v}\left(\frac{jW_{v,i,z}{}^{q}}{e^{\frac{E}{kT}}}\right)W_{v,i,z}}{\overline{W}_x\overline{p}(0.006e^{0.16T}\overline{W}_x{}^{c})y}$$



Green et al. *2014* Ecol. App.

The Bahamas

Testing targets for lionfish control

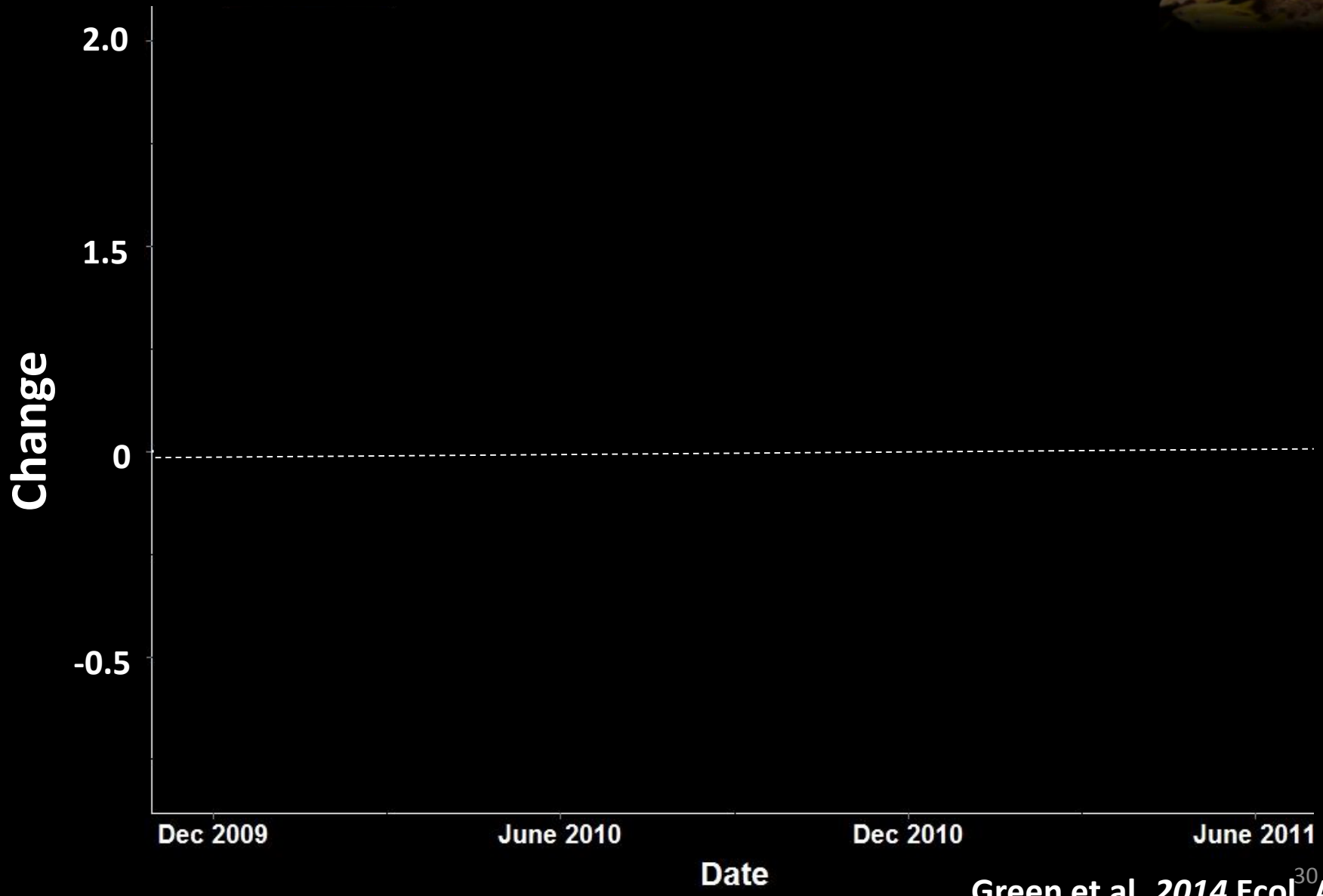


Testing targets for lionfish control

Two year removal experiment:

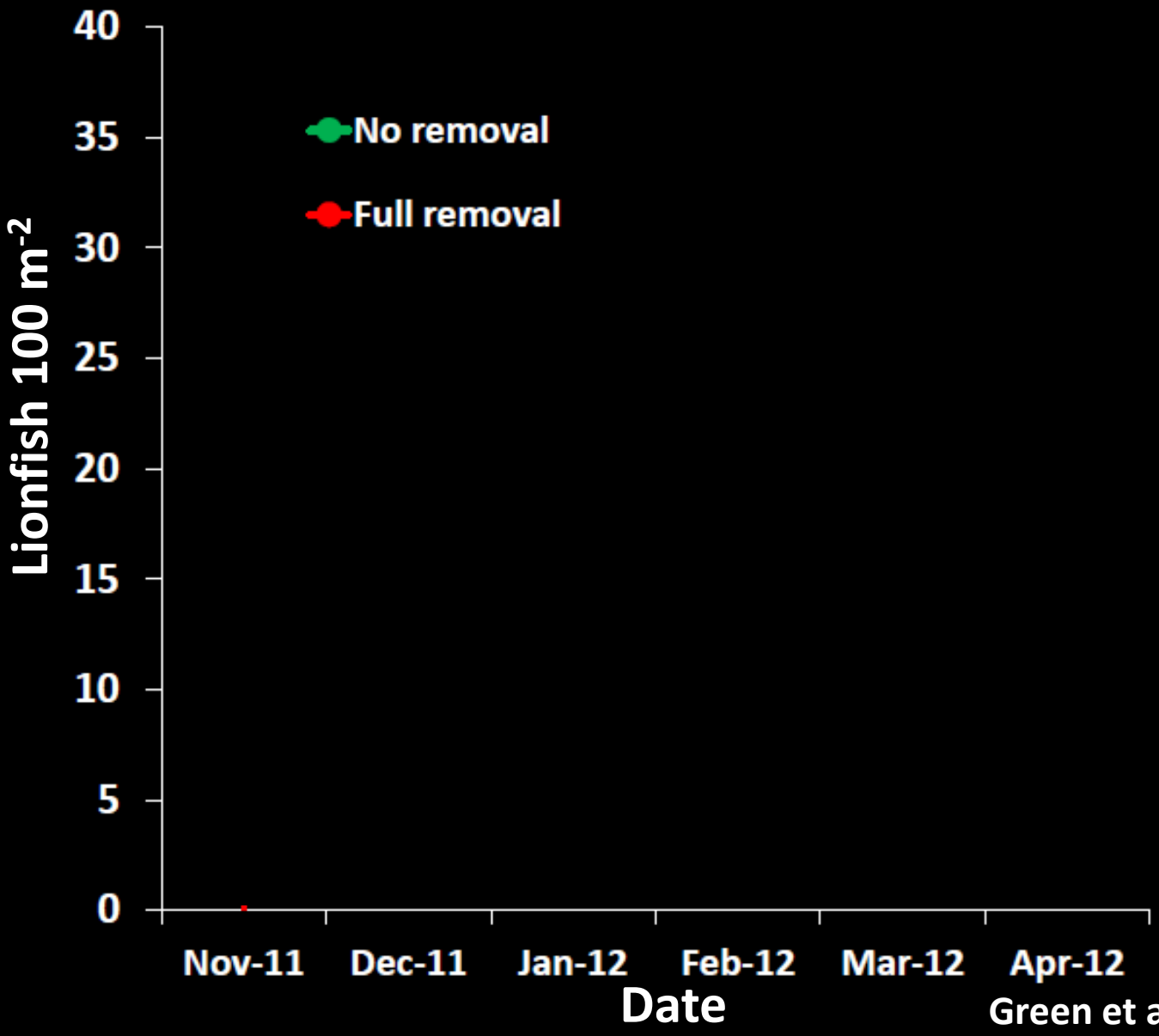
- **Removed lionfish monthly to maintain four treatment groups**
- **Surveyed native fish community every six months**

Change in prey-sized fish (<15cm)



Green et al. *2014* Ecol. App.

Recolonization happens rapidly



Green et al. in preparation

How often to remove?

What is the cost and effort needed for control?

Lionfish removal project

Florida Keys

St Croix, USVI

FLORIDA 4 REEF Protect Our Reefs

Sea Grant Florida

NOAA CORAL REEF CONSERVATION PROGRAM

NATIONAL MARINE SANCTUARIES

FLORIDA PARK SERVICE ENVIRONMENTAL PROTECTION

NATIONAL PARK SERVICE

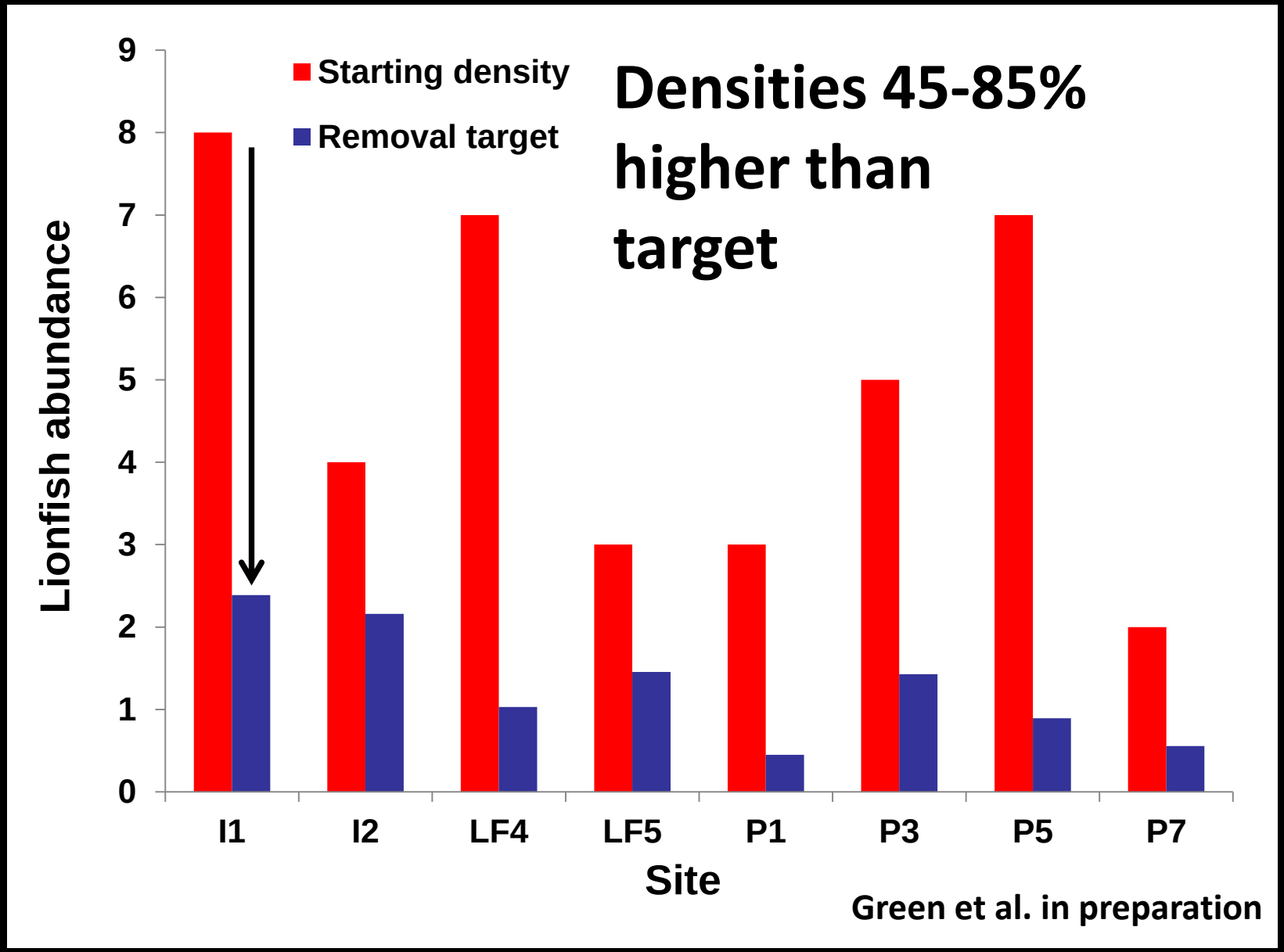
OSU Oregon State University

NOVA SOUTHEASTERN UNIVERSITY

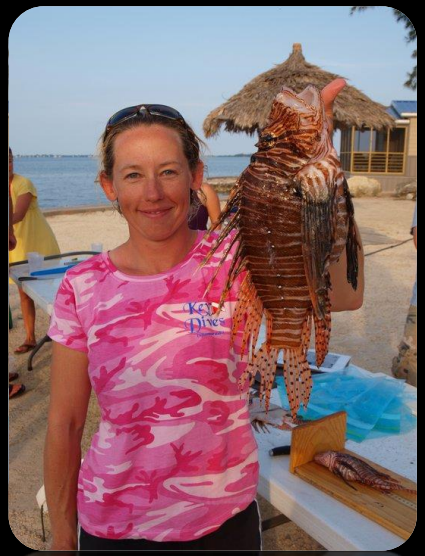
REEF

Bi-monthly dives to survey and remove lionfish

How many lionfish to remove?



Tools to achieve control



Derbies

Diver removal

Traps

Where do we get the manpower to achieve control?

USGS Non-indigenous Aquatic Species Database 2012

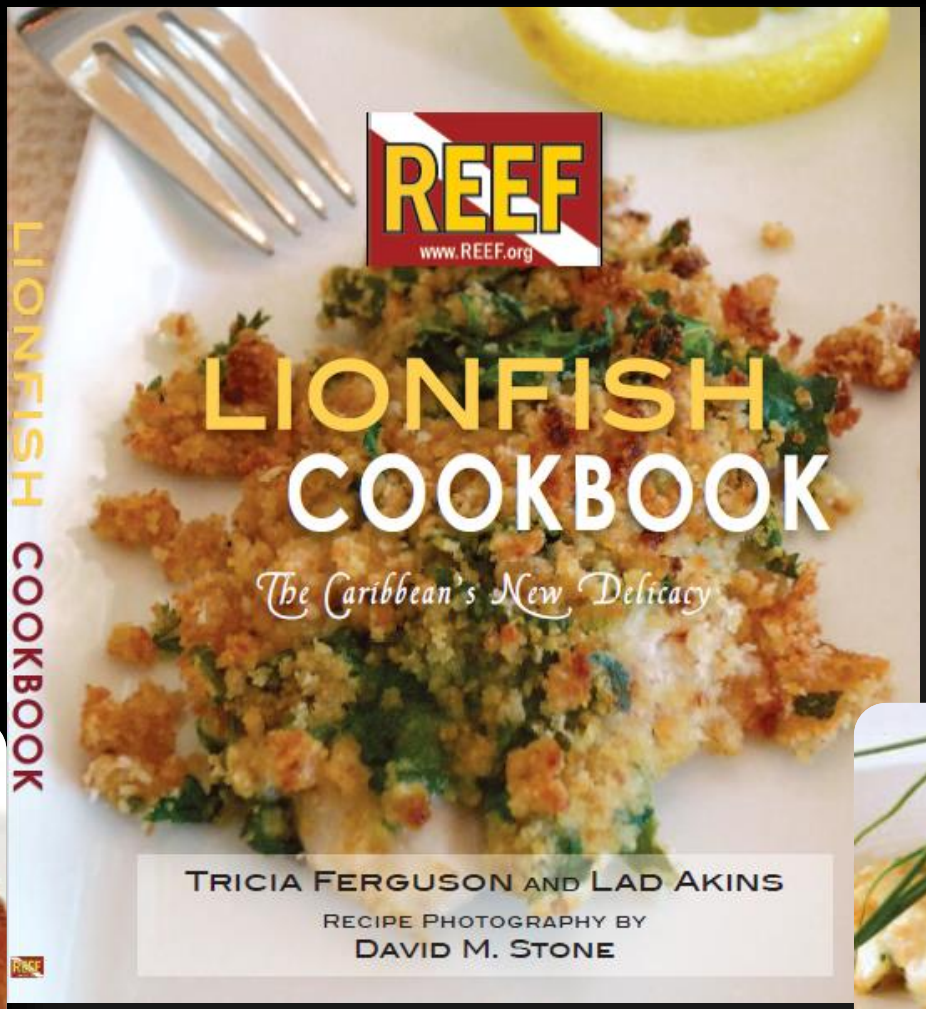
Tools for lionfish control

Primarily caught by spear and hand-net

Tools for lionfish control

Food fishery

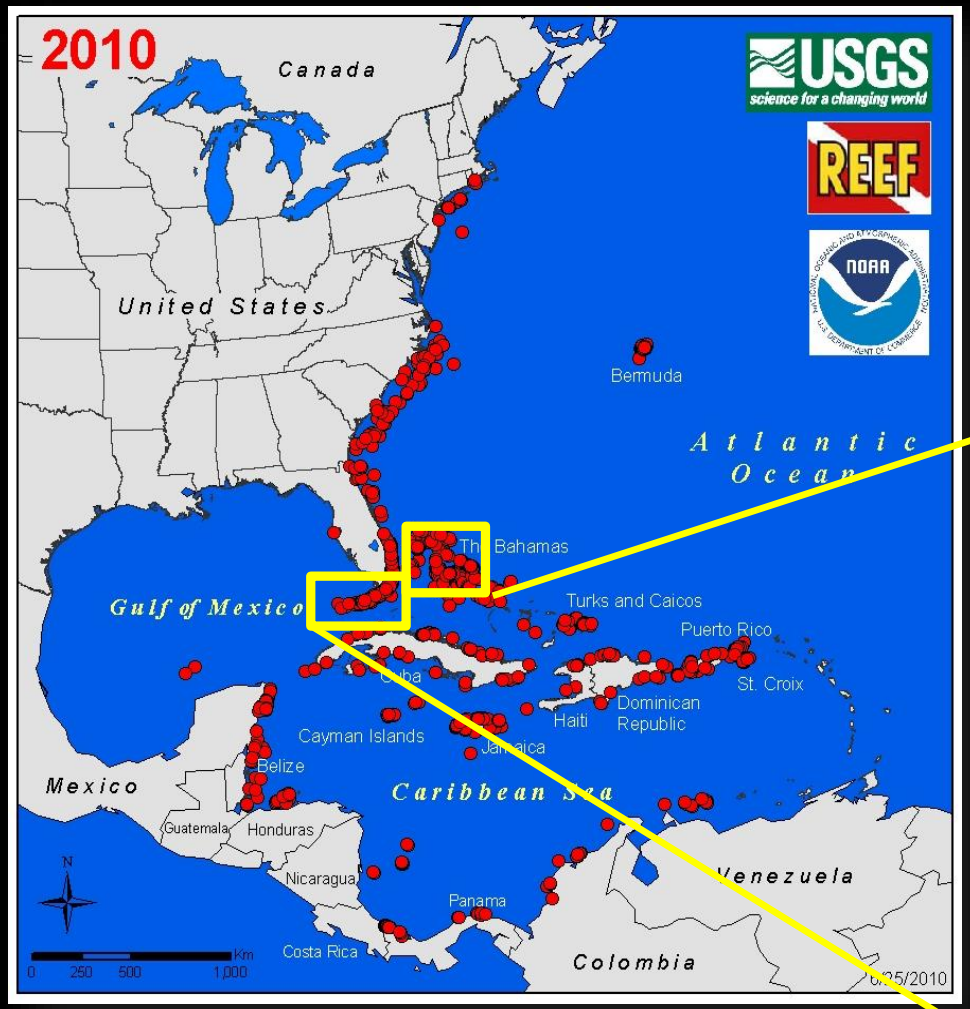
Eat ‘em to beat ‘em!



Lionfish derbies

Green et al. in preparation

Derby effectiveness study underway



Green Turtle Cay, Bahamas

Key Largo, Florida

Global Invasive Species Database 2014

Population control

Single-species population models identify mortality rate needed to cause population decline

Population control

ERADICATION

When is eradication successful?

Restricted geographic range

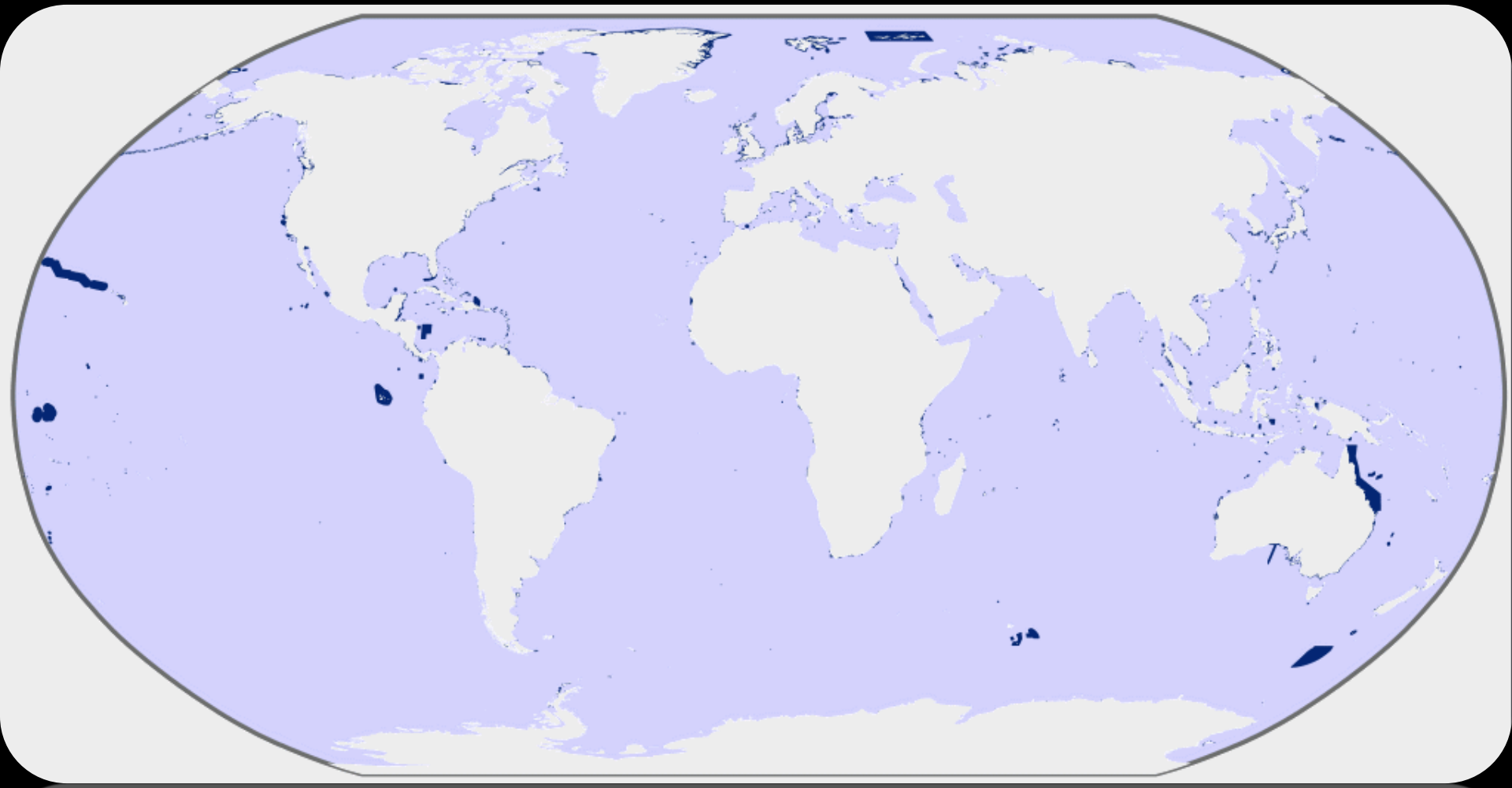
Small population size

Occupied habitats readily accessible

Invader easily removed

Invasions in the sea

Marine conservation occurs at a local scale



MPA Global
A database of the world's Marine Protected Areas

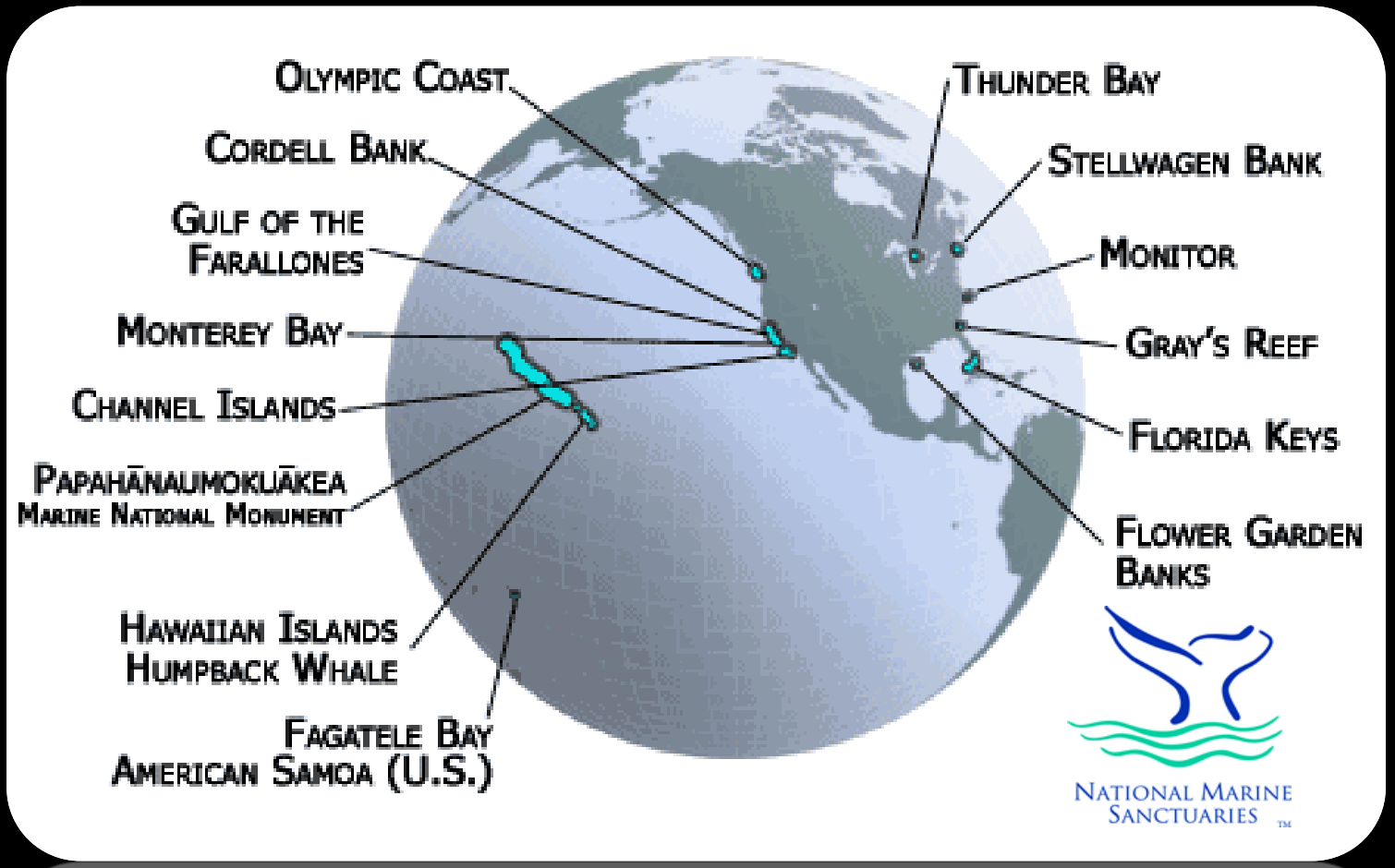
SEA AROUND US PROJECT WWF UNEP WCMC IUCN The World Conservation Union

A new approach to invasive species management

Numerical eradication → ‘Functional’ eradication

Green et al. in preparation

Invasion & US marine protected areas



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Which marine invasions can be functionally eradicated?

Aim 1: Identify predictors of eradication success

Aim 2: Determine candidates for functional eradication

Aim 3: Apply a functional eradication framework

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Summary

- Eradication-focussed invasion management yields limited success in the sea

- Need alternative mechanistic approaches focussed on mitigating impacts in high priority locations

- Invasive lionfish are having significant effects on native fish community structure

- Controlling lionfish below predicted 'thresholds' densities can prevent ecological effects

Green 2014

Collaborators and funders

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NSERC CRSNG

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

PE Eleuthera Institute

The Government of The Bahamas

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Thank you

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