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Science for Coastal Communities

Center for Coastal Fisheries and Habitat Research
CCFHR

Biology, ecology, control and management of invasive lionfish

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National Ocean Service, Beaufort, North Carolina

Talk outline

- Invasion chronology and status
- Reproductive biology
- Predation ecology
- Feeding ecology
- Potential impacts
- Life history and invasiveness
- Control and management

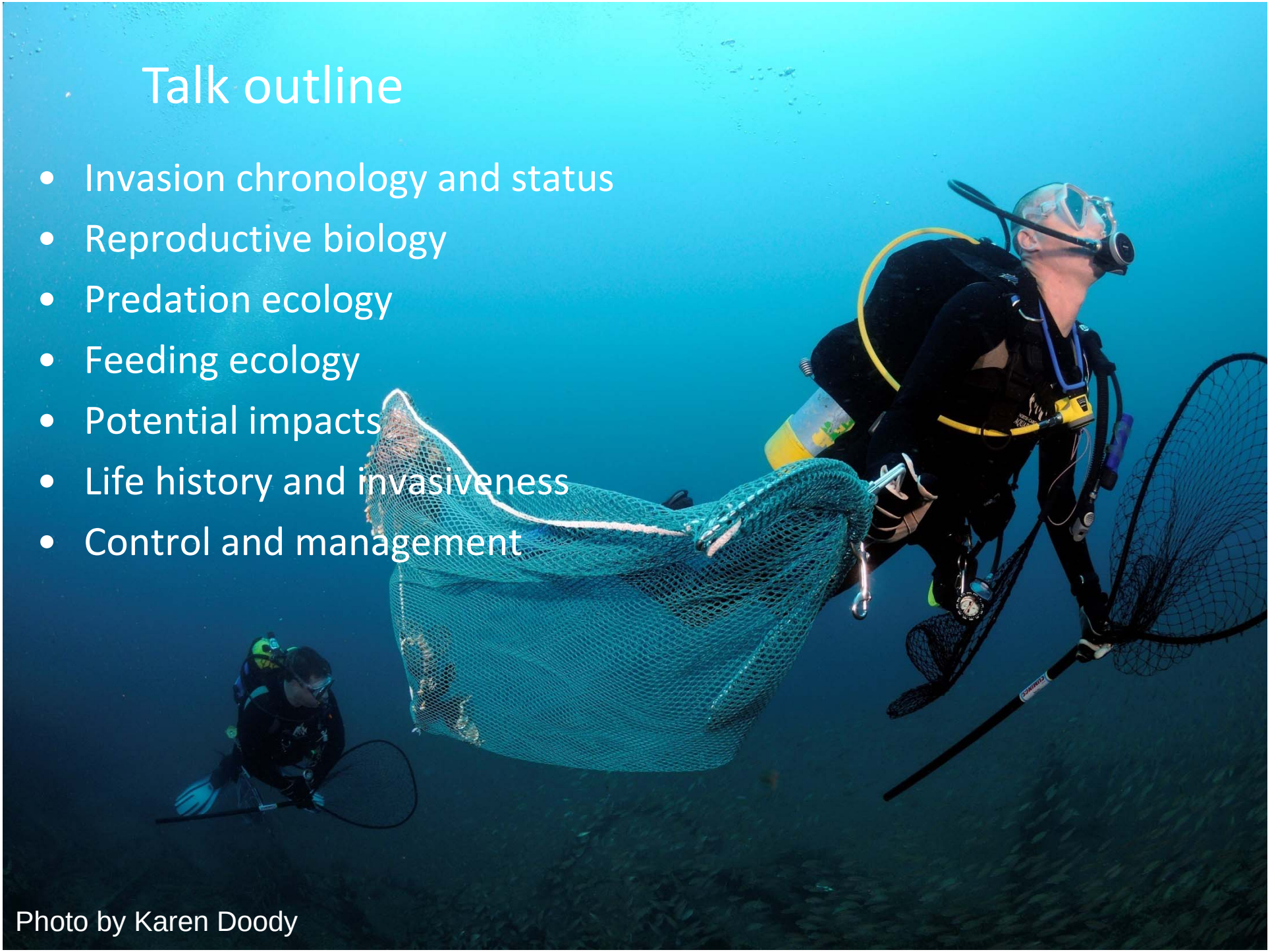
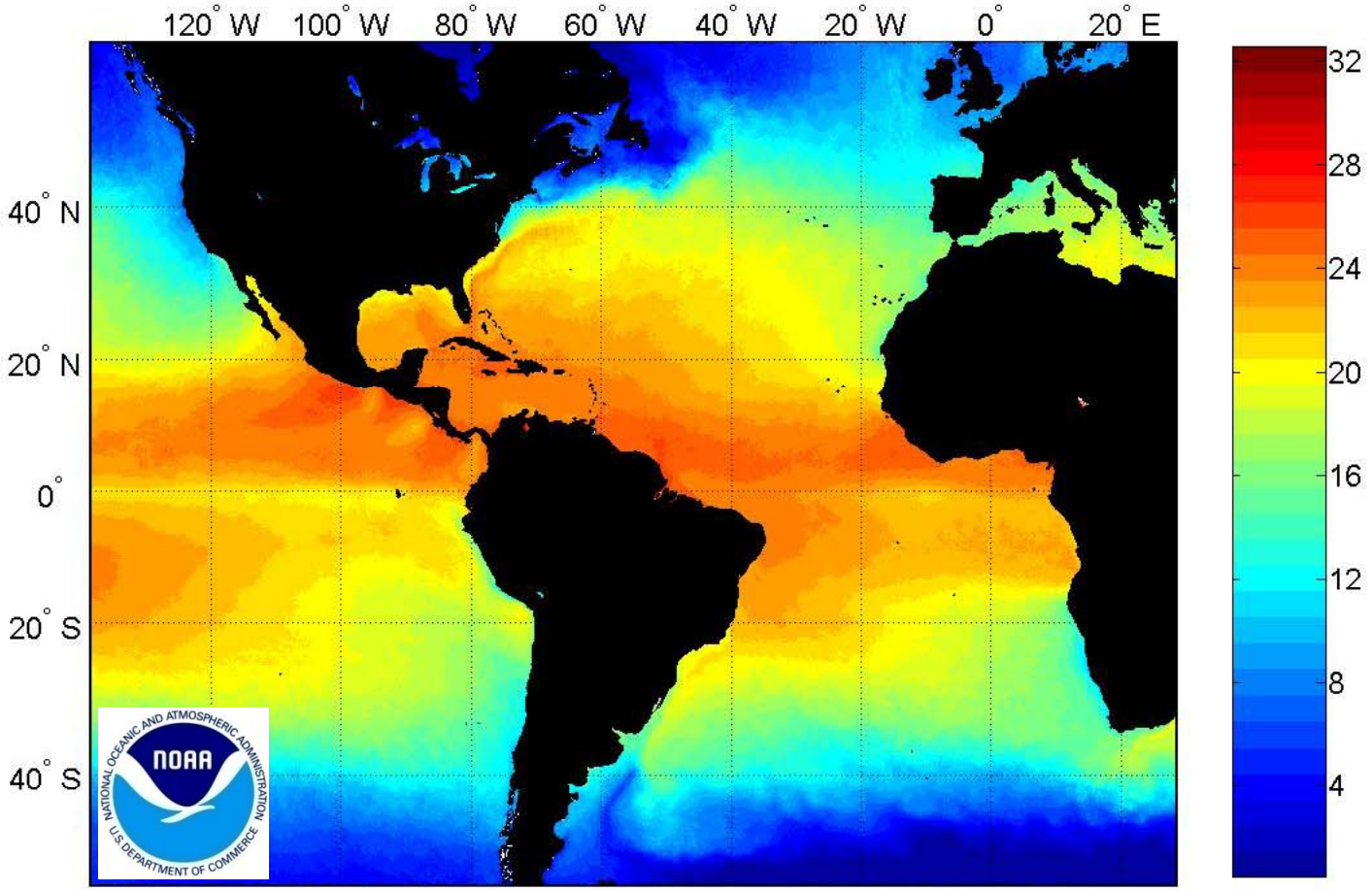


Photo by Karen Doody

Status of lionfish establishment (as of December 6, 2009)

Photo courtesy P. Whitfield

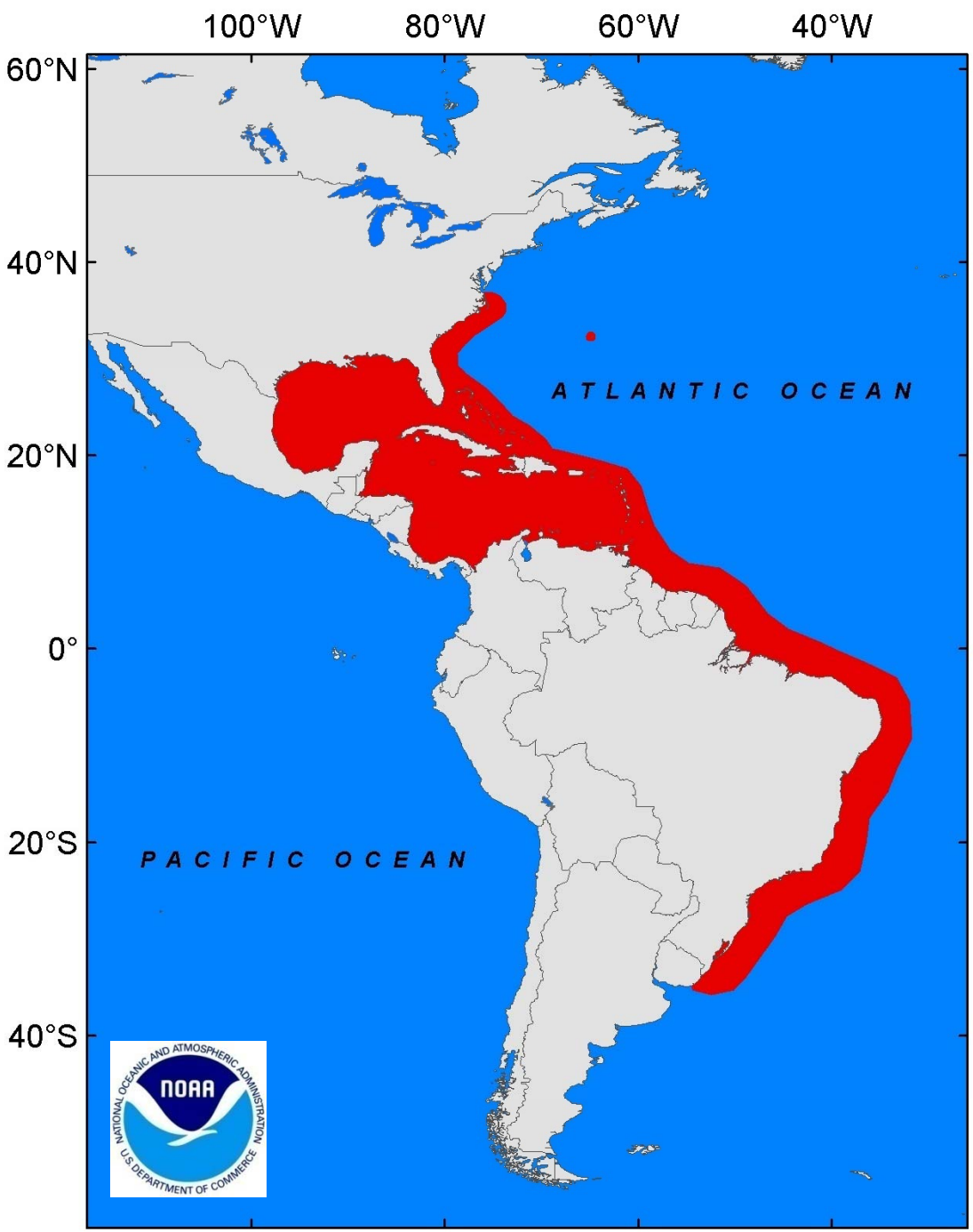
Schofield et al. 2009; Whitfield et al 2002; 2007, REEF



Sea Surface Temperature

Morris and Whitfield 2009

Lionfish thermal minimum ~ 10C (Kimball et al. 2004)



Morris and Whitfield 2009

Observed lionfish densities per acre!!!

	Max	Mean	Source
Bahamas	1,342.5	982.5	Green and Cote 2008
NC	1,125	375	Morris and Whitfield 2009
Red Sea	---	200	Fishelson 1997
Palau	---	5.5	Grubich et al. 2009

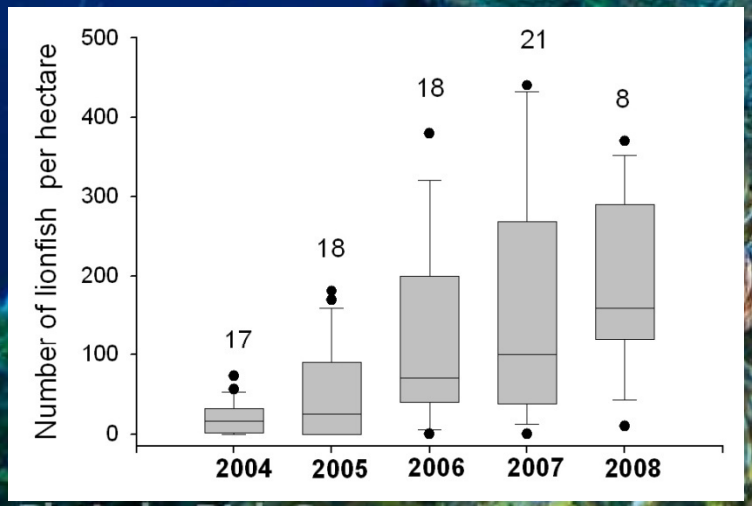
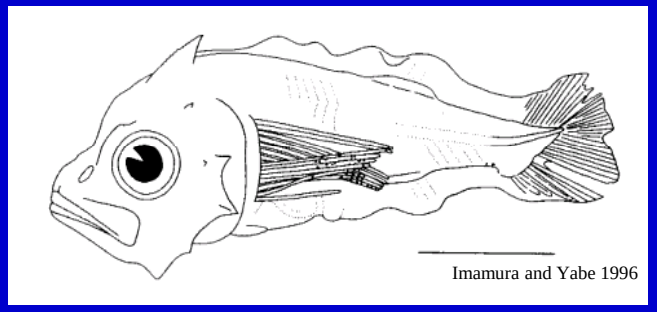
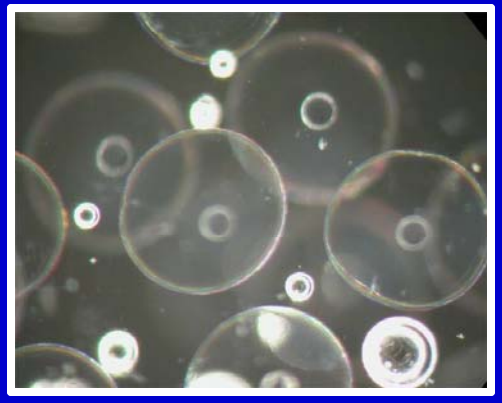


Photo by Rich Carey

Lionfish reproduction summary

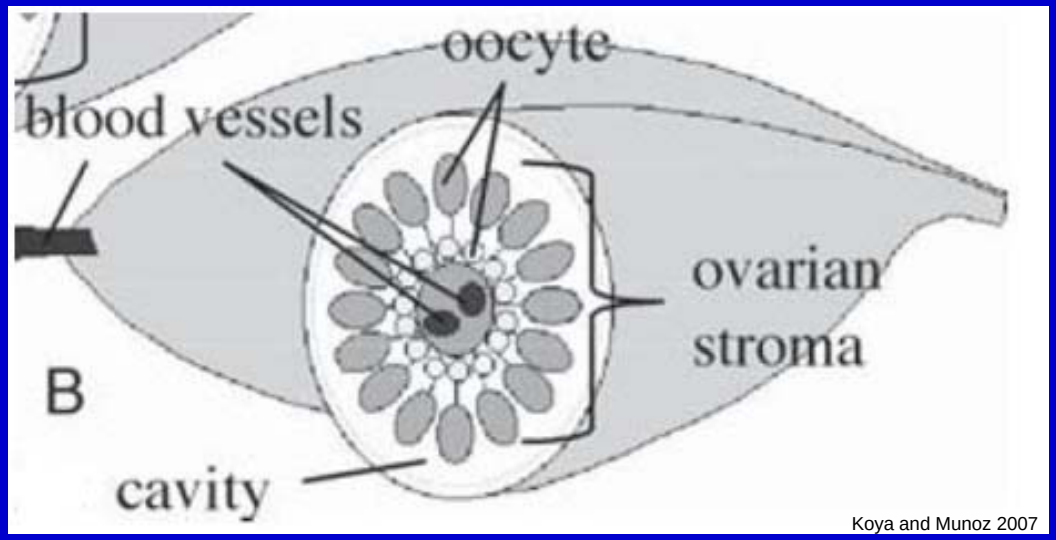
- Lionfish are gonochoristic, iteroparous, asynchronous, indeterminate batch spawners
- Each spawn consist of two buoyant egg balls
- Eggs are encased in gelatinous mucus
- Gelatinous mucus breaks down within 2-3 days
- Eggs hatch and release pelagic larvae
- Mean larval duration is ~26 days (Ahrenholz and Morris)



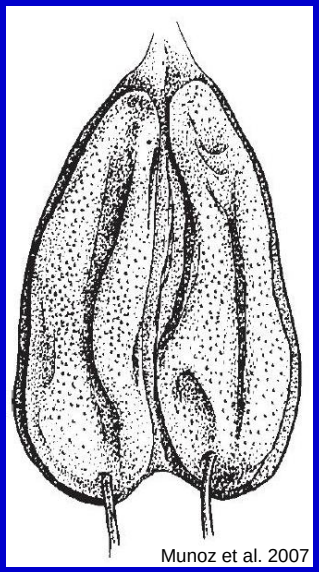


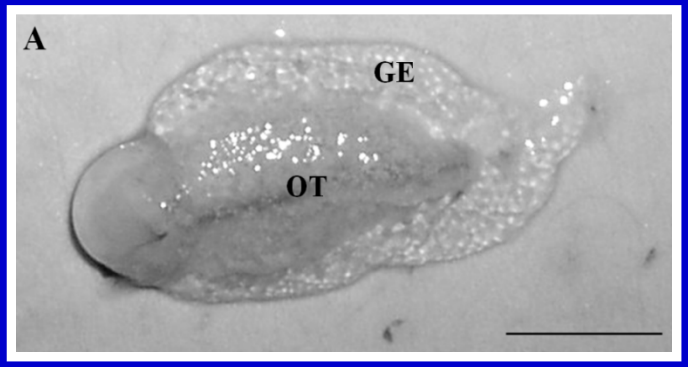
Morris, Sullivan, and Govoni

Lionfish ovarian morphology and oogenesis



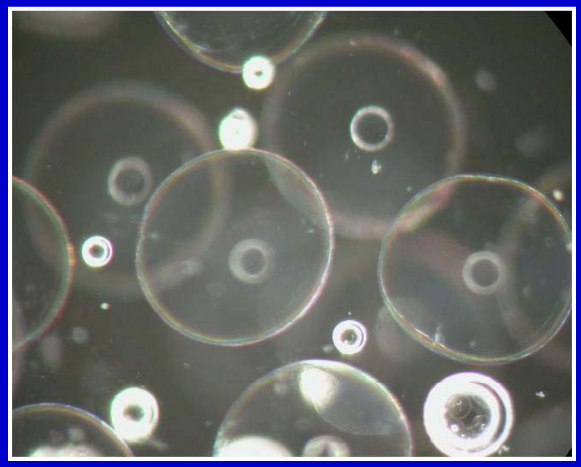
Koya and Munoz 2007


Munoz et al. 2007

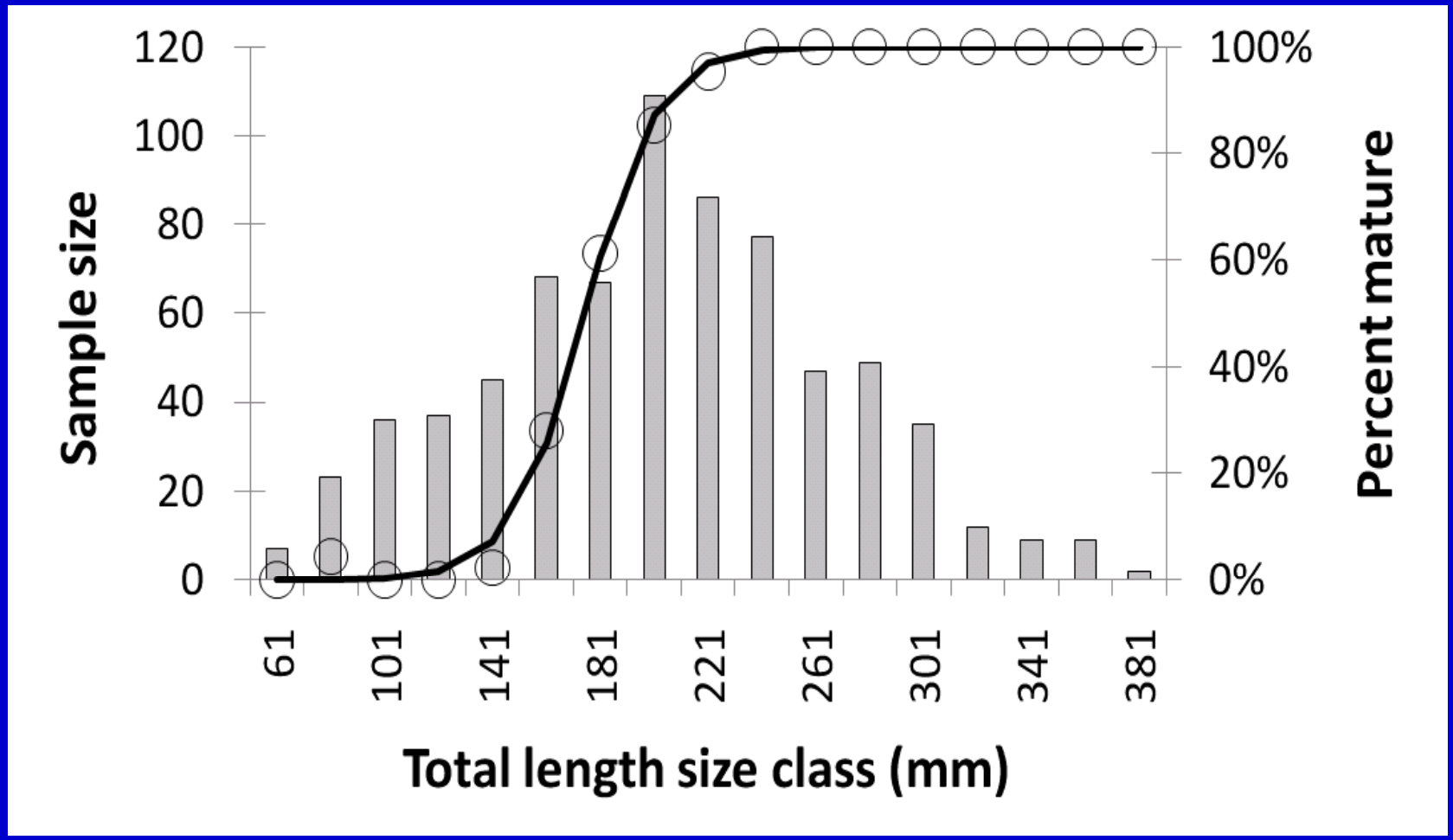


Reproductive dynamics

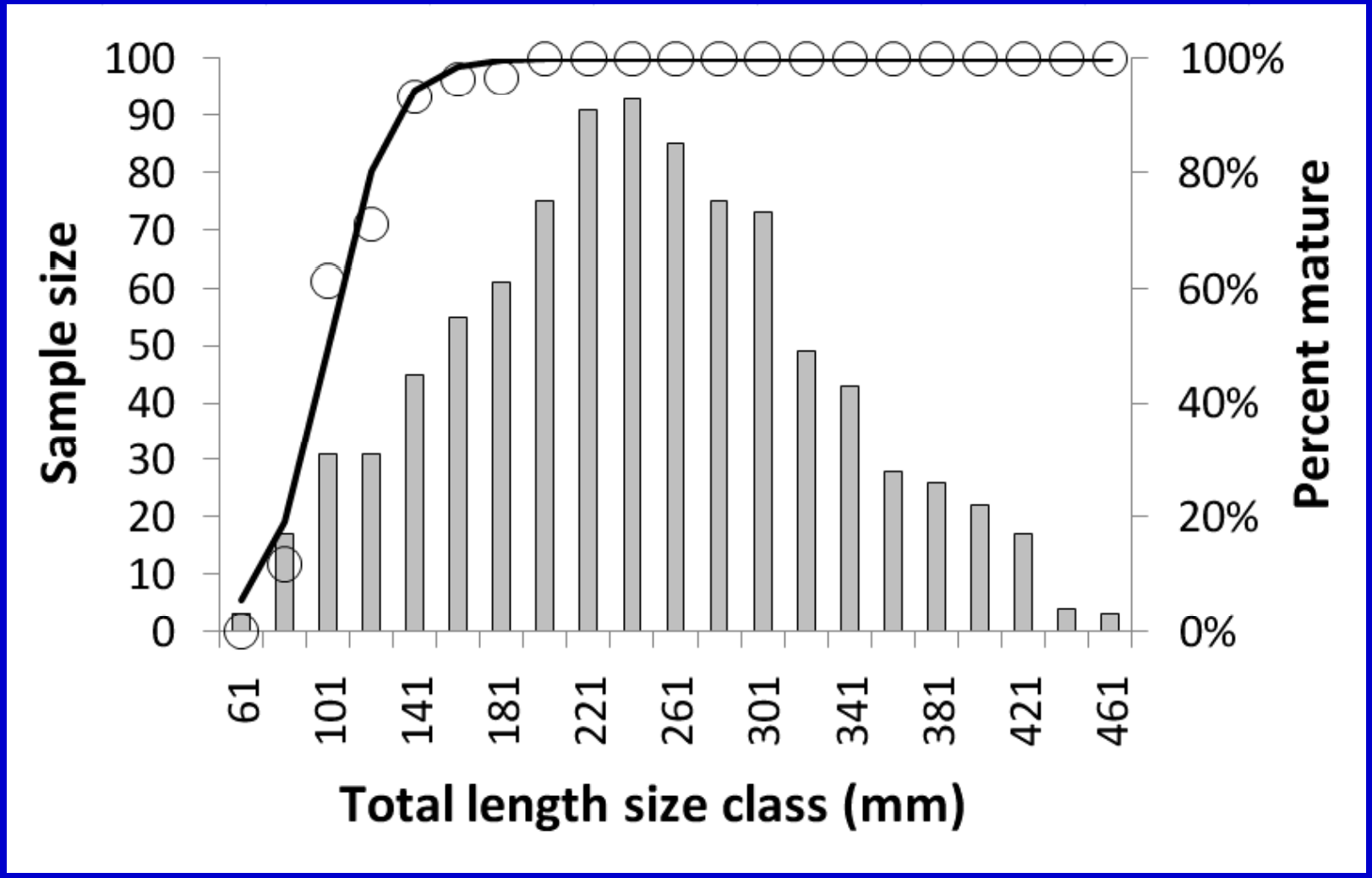
- Spawning seasonality
- Spawning periodicity
- Length at maturity
- Batch fecundity
- Annual fecundity



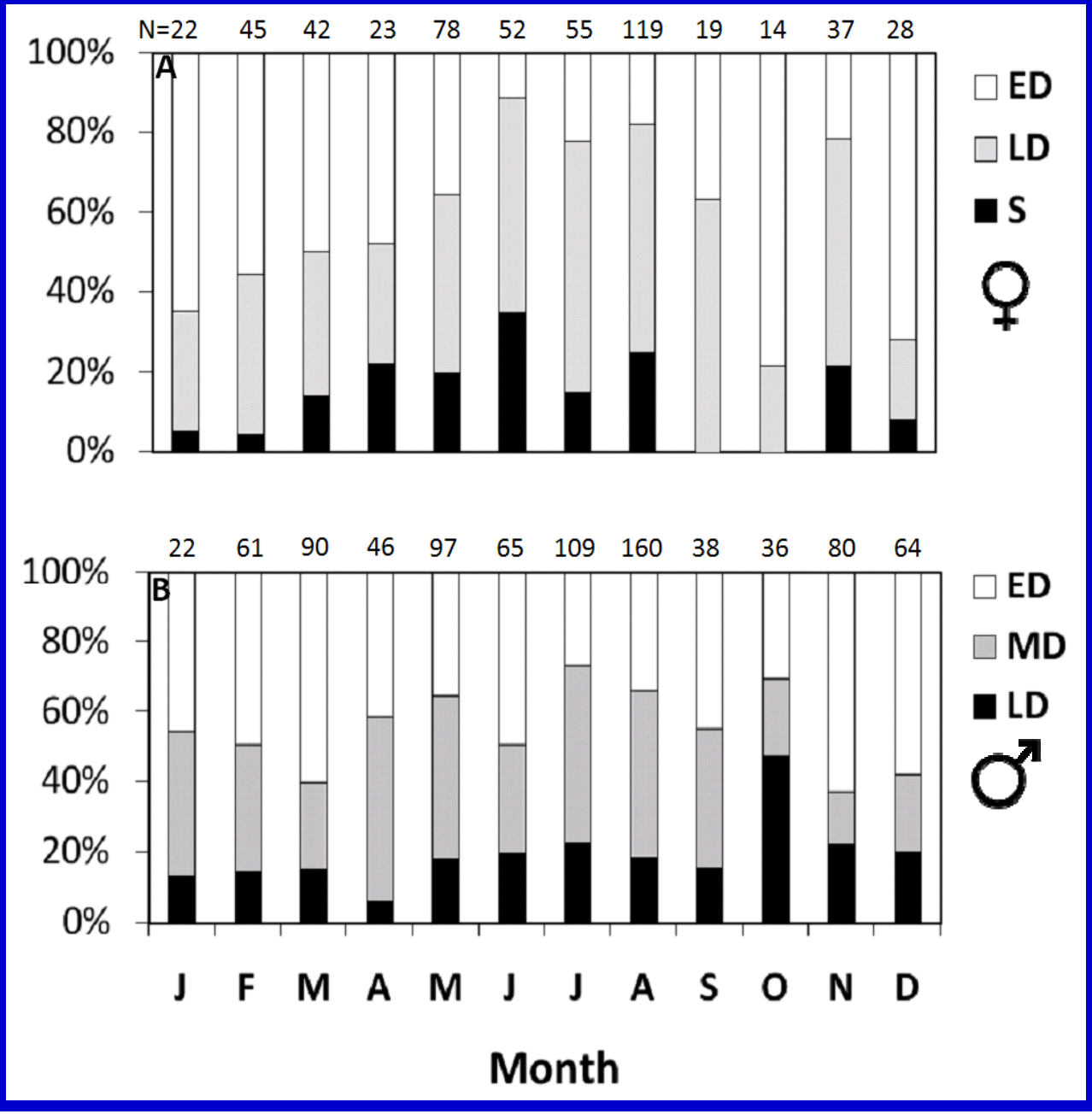
Female size at maturity is ~180 mm TL (less than 1 year old)



Male size at maturity is ~100 mm TL (less than 1 year old)



Lionfish spawn throughout the year!



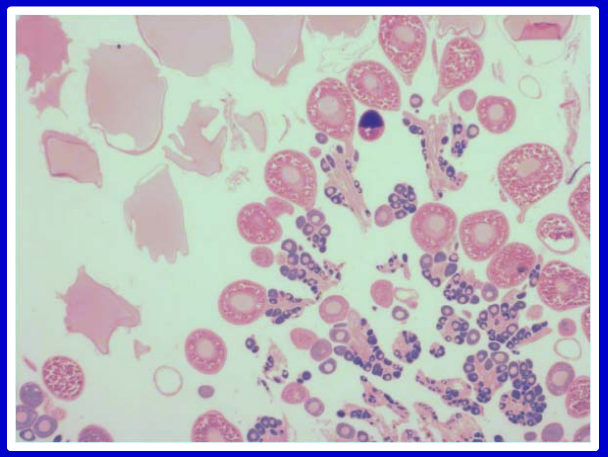
Spawning frequency

- Used final oocyte maturation as indicator of spawning
- 8 consecutive sampling days in the Bahamas
- 5 consecutive sampling days off North Carolina

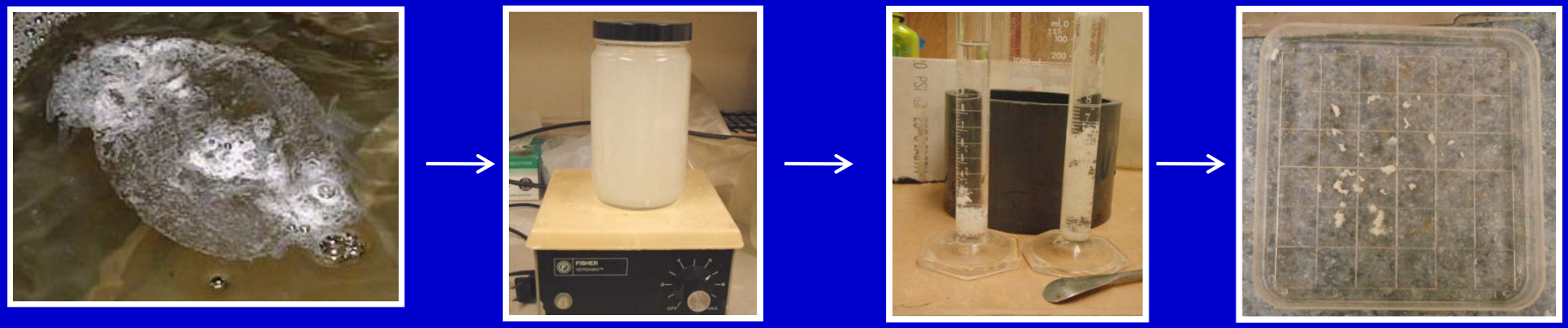
Spawning frequency (days) = (# spawning/total #)/1
(Schaefer et al. 1986)

North Carolina = 3.58 days
Bahamas = 4.15 days

(Within range observed for other tropical reef fishes)

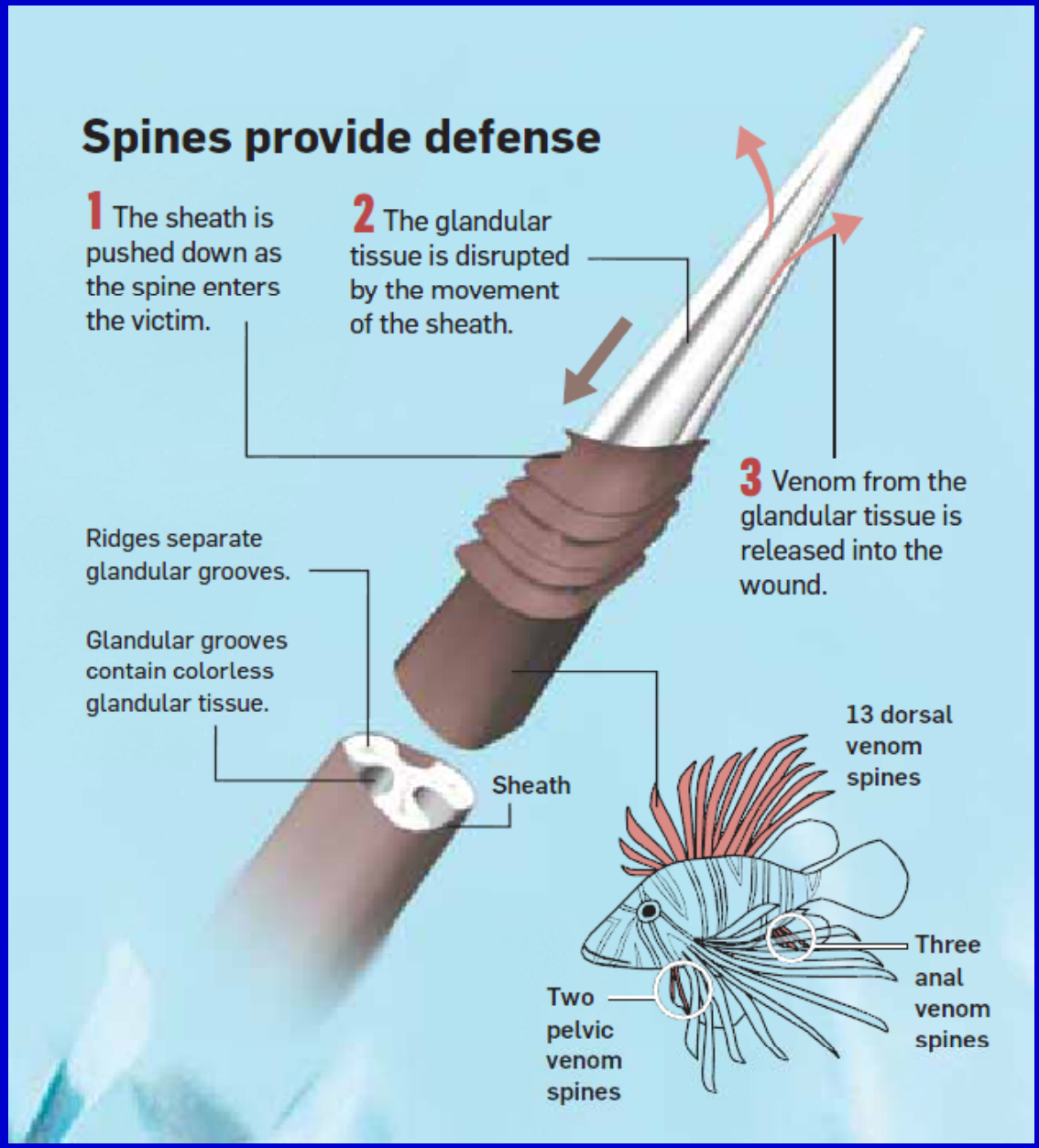


Fecundity estimates



Batch fecundity	24,630 ± 11,867
Monthly fecundity	194,481
Annual fecundity	2,335,052

(Assuming year round spawning every 3.85 d)

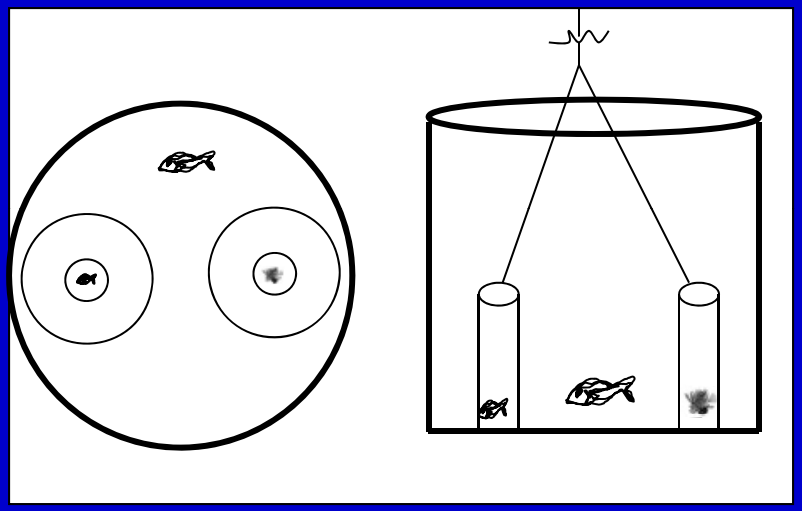

Spines provide defense
1 The sheath is pushed down as the spine enters the victim.
2 The glandular tissue is disrupted by the movement of the sheath.
3 Venom from the glandular tissue is released into the wound.
Ridges separate glandular grooves.
Glandular grooves contain colorless glandular tissue.
Sheath
13 dorsal venom spines
Three anal venom spines
Two pelvic venom spines

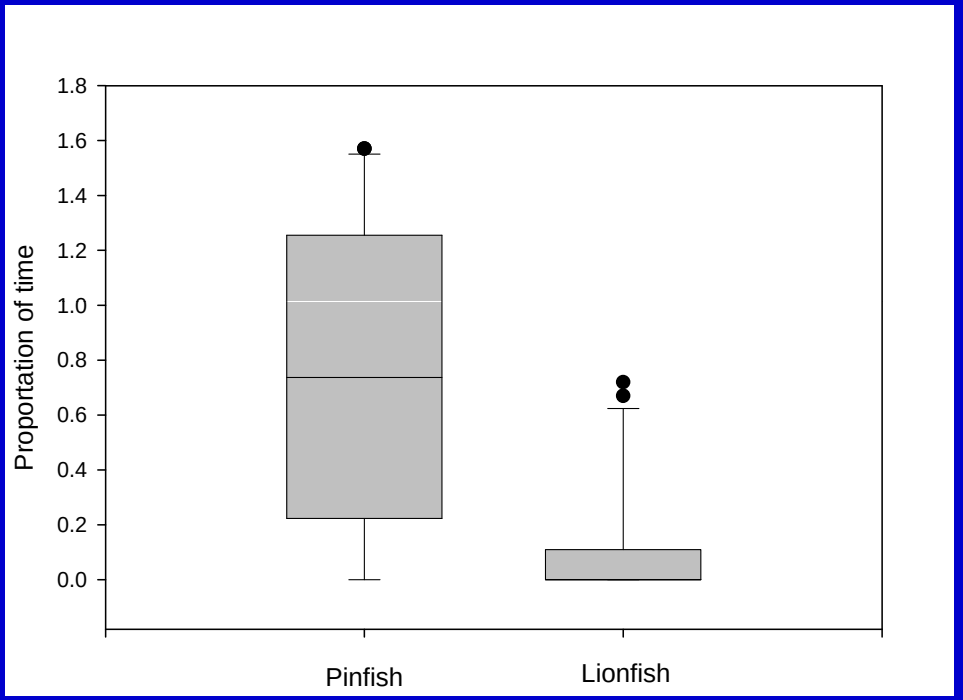
What eats lionfish?

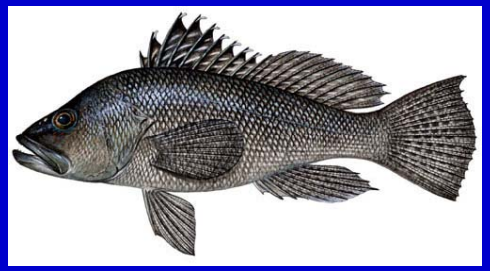
Literature
Cornetfish (Bernadsky 1991) – questionable….

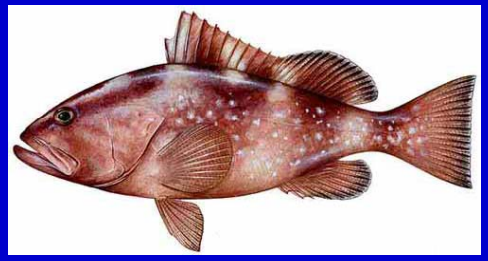
Anecdotal
Sharks?
Greater amberjack
Goliath grouper
Humpback scorpionfish
Cannibalism (Fishelson 1975, Morris 2009)

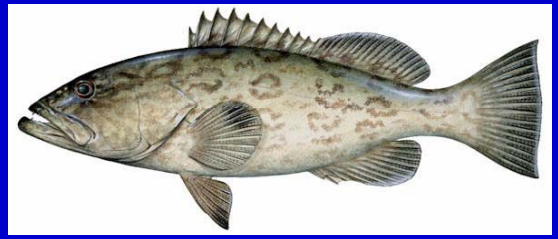
Laboratory results for predation on lionfish











Morris and Rice

Predation on the invasive red lionfish, *Pterois volitans* (Pisces: Scorpaenidae), by native groupers in the Bahamas

Received: 7 March 2008 / Revised: 11 March 2008 / Accepted: 11 March 2008

Fig. 1 Nassau grouper, *Epinephelus striatus*, with red lionfish, *Pterois volitans* dissected from stomach following capture on 5 March 2008. The lionfish was orientated in the stomach as shown

Fig. 2 Red lionfish, *Pterois volitans*, photographed on 2 March 2008 south of New Providence, Bahamas

On 26 January 2008, a tiger grouper, *Mycteroperca tigris* (472-mm standard length [SL]), was caught off New Providence (25°04.6′N, 77°20.6′W), Bahamas and found to contain a single red lionfish, *Pterois volitans* (61-mm SL) in its stomach. This observation was considered an anomaly given both the venomous nature of lionfish, and their relatively recent introduction to the Bahamas (Snyder and Burgess 2007).

Anecdotal evidence provided by fishers, however, suggested that native grouper species were preying on red lionfish with some regularity. Subsequently, five Nassau groupers, *Epinephelus striatus*, caught off Eleuthera Island (25°10.0′N, 76°14.0′W) at an approximate depth of 14 m on 5 March 2008, were dissected. Two of the stomachs contained red lionfish. The first grouper (477-mm SL) contained a partially digested lionfish, identifiable only by the morphology and multiplicity of the remaining fin rays. The second slightly larger grouper (482-mm SL) contained a red lionfish of 137-mm SL which was in almost pristine condition (Fig. 1).

The successful invasion and establishment of the piscivorous red lionfish in western Atlantic waters (Fig. 2) (Whitfield et al. 2002; Snyder and Burgess 2007) have lead to concerns over its potential impact on native fish biotas. To our knowledge, this is the first documented evidence of introduced red lionfish being preyed upon by native species within their novel range.

Acknowledgments We thank Marco Fox and Johran Hanna. Sally Thomson and Stuart Cove's Fin Photo provided Figures 1 and 2. This study was supported by a Sidney Hogg Memorial Scholarship to A. Maljković.

References

Snyder DB, Burgess GH (2007) The Indo-Pacific red lionfish, *Pterois volitans* (Pisces: Scorpaenidae), new to Bahamian ichthyofauna. Coral Reefs 26:175

Whitfield PE, Gardner T, Vives SP, Gilligan MR, Courtenay Jr WR, Ray GC, Hare JA (2002) Biological invasion of the Indo-Pacific lionfish *Pterois volitans* along the Atlantic coast of North America. Mar Ecol Prog Ser 235:289–297

A. Maljković (✉) · T. E. Van Leeuwen
Tropical Marine Ecology Lab, Department of Biological Sciences, Simon Fraser University, 8888 University Drive, Burnaby,


Photo courtesy J. Jeffries

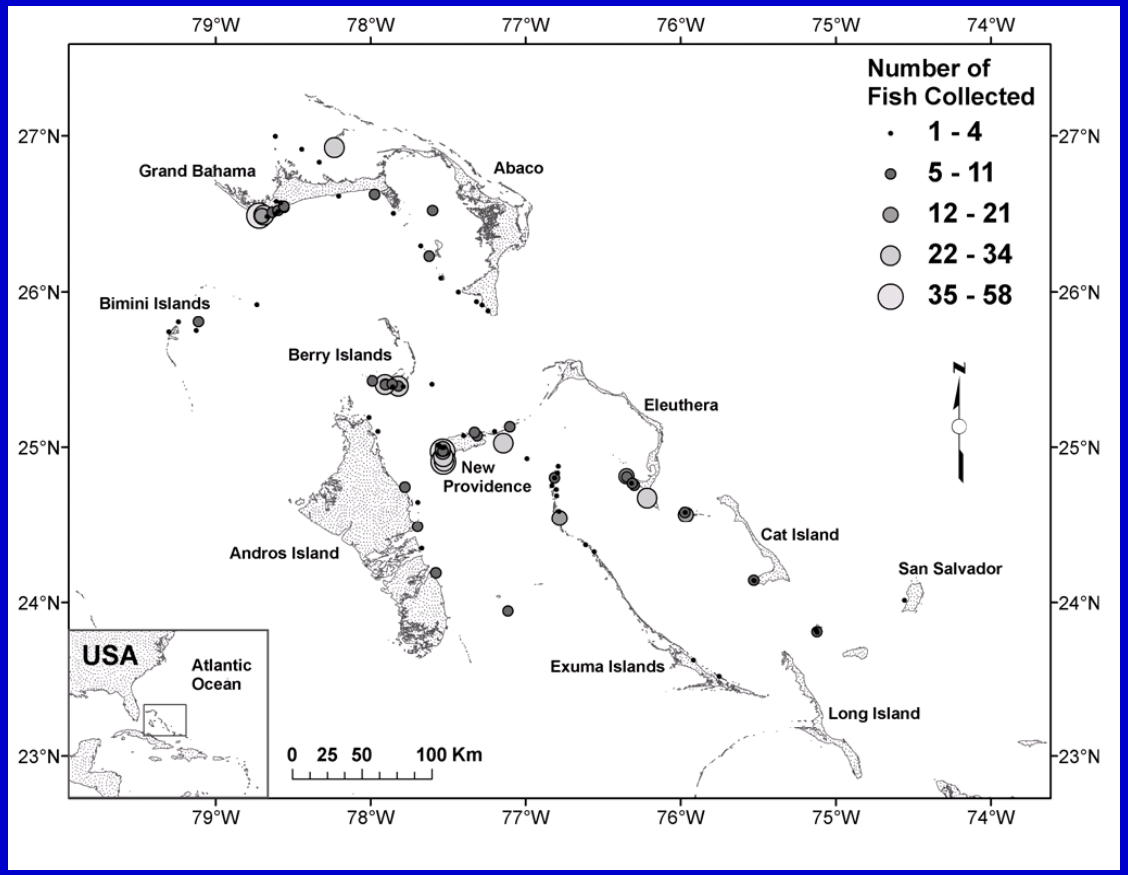
Indo-Malayan octopus mimics lionfish!!

Octopus (above) mimicking a lion-fish

Norman et al. 2001

Lionfish diet analysis

- Processed 1,200+ lionfish stomachs from the Bahamas
- Sampled throughout the calendar year
- ID, measured length and volume
- Determined relative frequency (%F), number (%N), volume (%V) of each prey type



Morris and Akins 2009

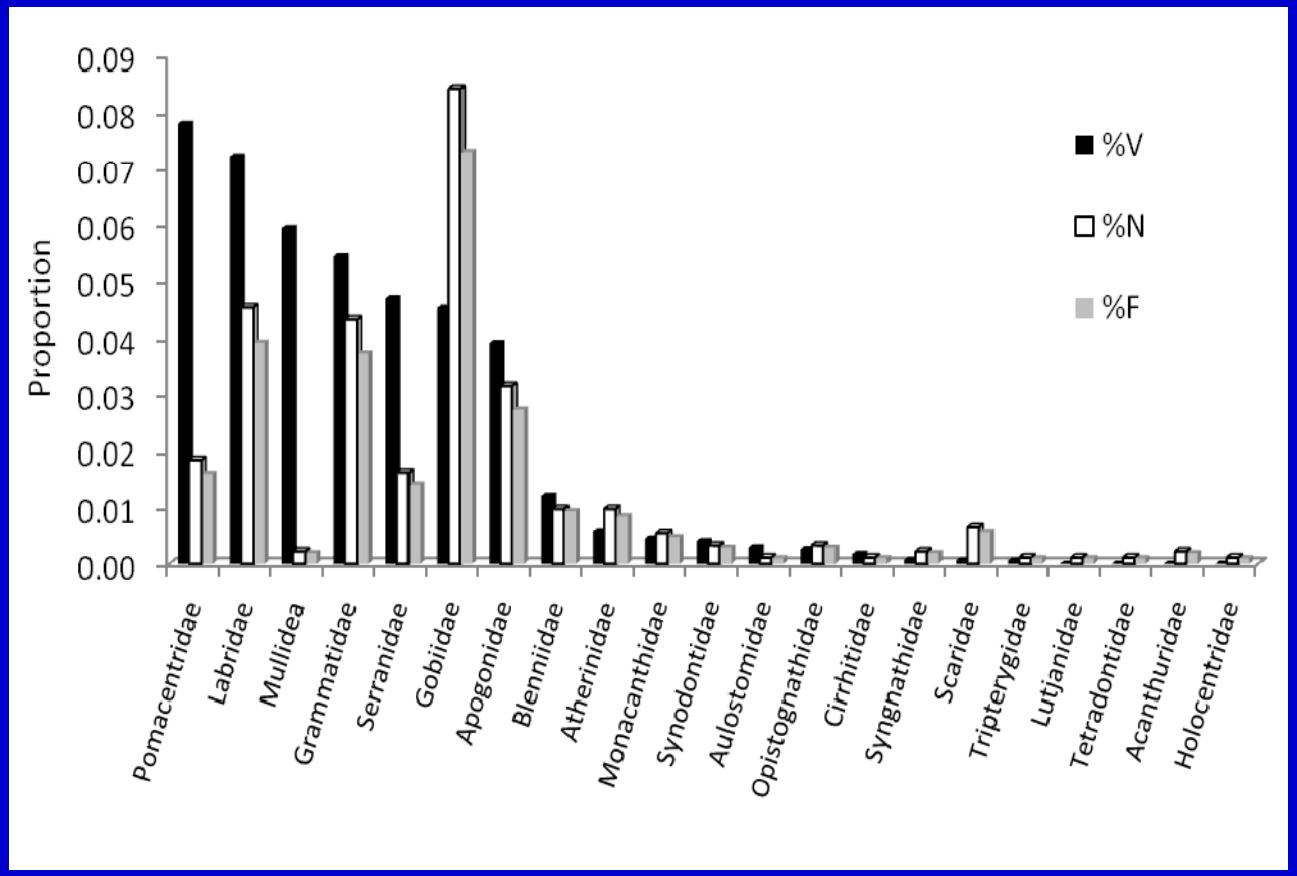


Photo credit REEF

Top rankings

1

Masked goby (Gobiidae)

2

Yellowhead wrasse (Labridae)

3

Royal gramma (Grammatidae)

4

Belted cardinalfish (Pomacentridae)

Photo credit Fishbase

Economically important species

Nassau grouper

Yellow tail snapper

Vermillion snapper

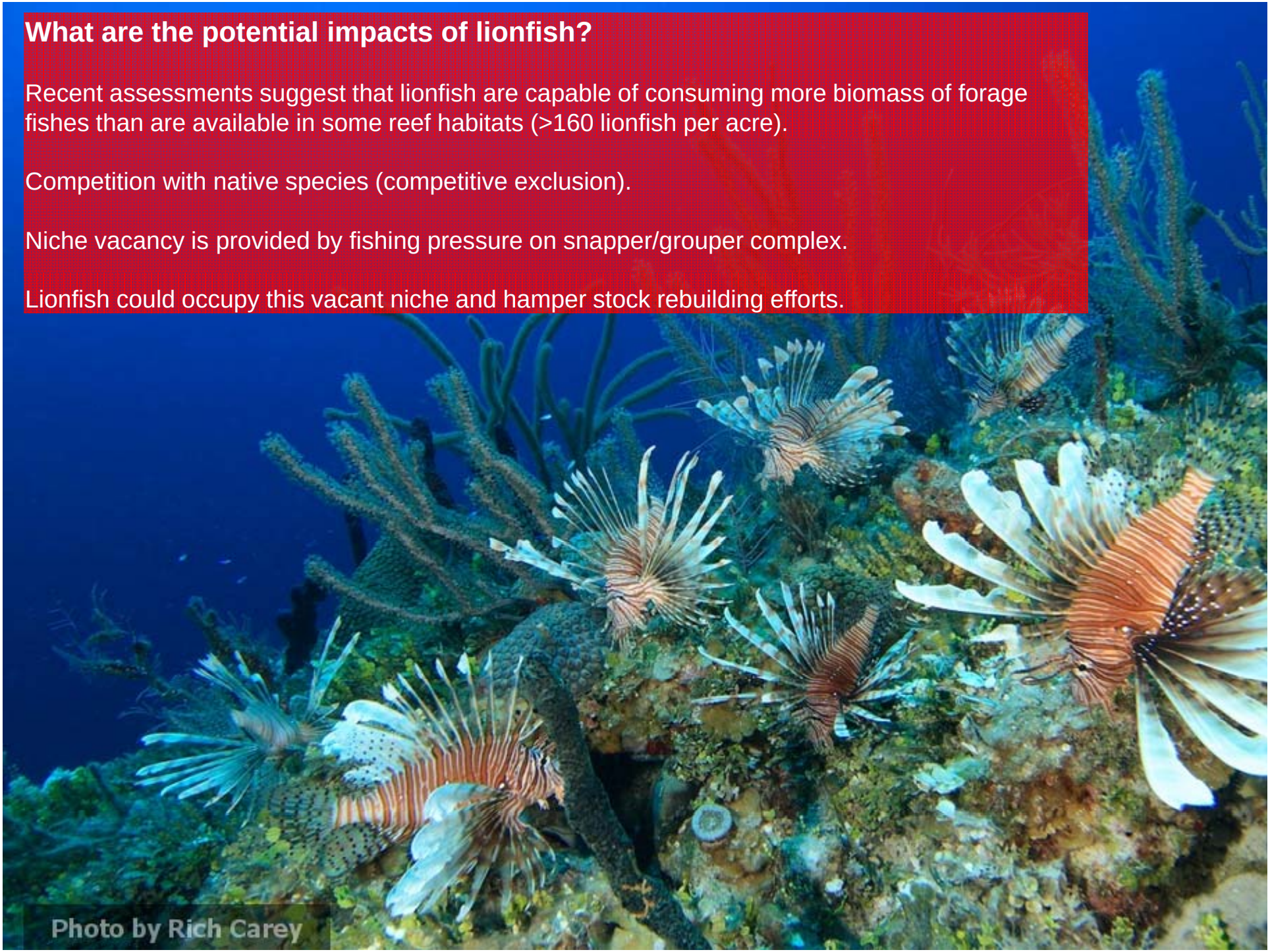
What are the potential impacts of lionfish?

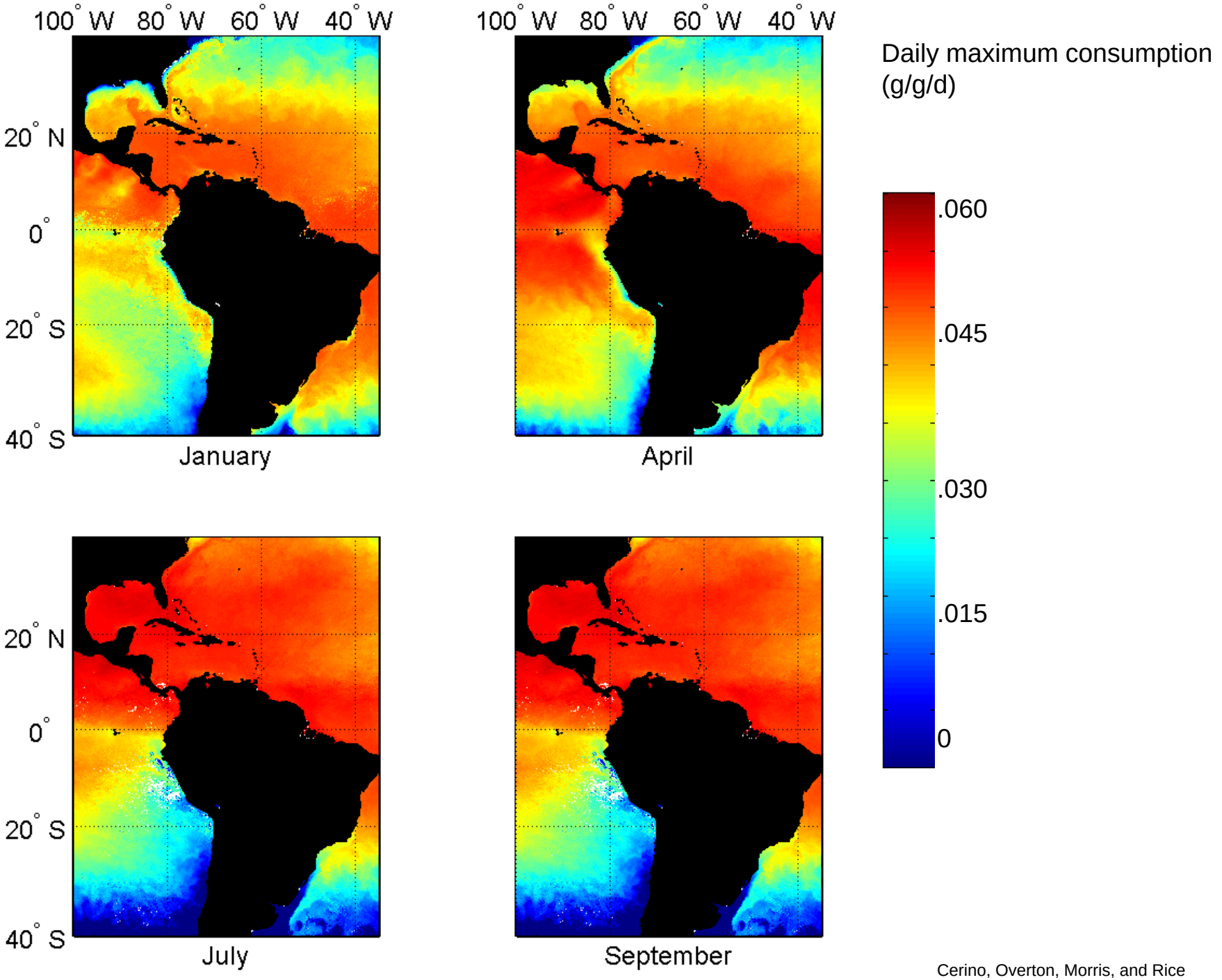
Recent assessments suggest that lionfish are capable of consuming more biomass of forage fishes than are available in some reef habitats (>160 lionfish per acre).

Competition with native species (competitive exclusion).

Niche vacancy is provided by fishing pressure on snapper/grouper complex.

Lionfish could occupy this vacant niche and hamper stock rebuilding efforts.



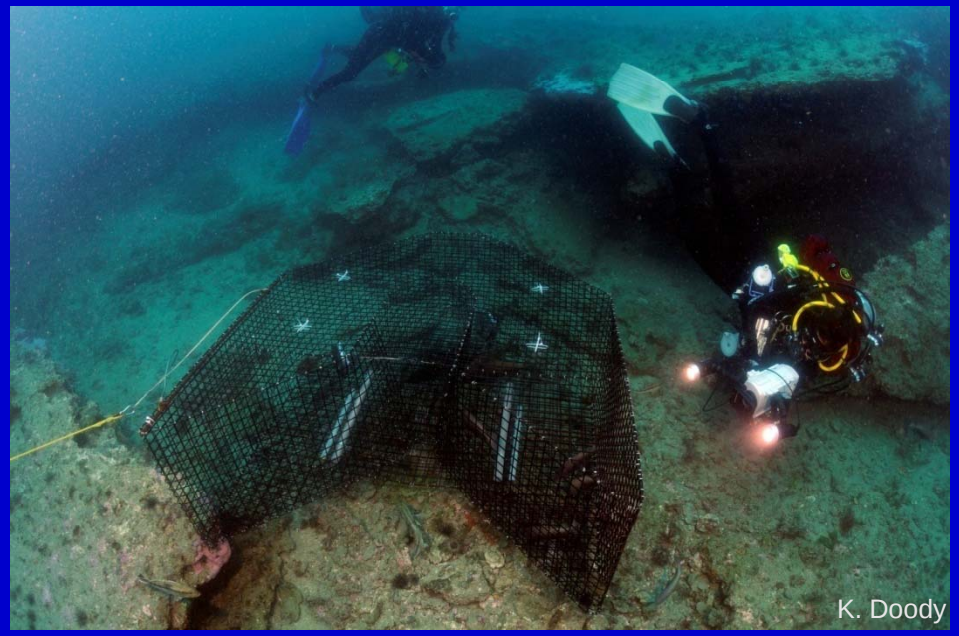


Cerino, Overton, Morris, and Rice

Why are lionfish so invasive?

Main predictor	Reference	Lionfish	Reference
Broad diet	1,7	Y	Morris 2009
High physical tolerance	1,2,3,8	Y	Kimball et al. 2004
Prior invader	1,2,3,10	Y	Golani and Sonin 1992
Fast growth	1	Y	Morris, unpub. data
Large native range	2,3	Y	Schultz 1986
High adult trophic status	2	Y	Morris 2009
High propagule pressure	2,3,5,6	Y	Ruiz-Carus et al. 2006
Long life span	3	Y	Morris, unpub. data
High fecundity	6,8	Y	Morris 2009
Large egg diameter	6	Y	Morris 2009
Long reproductive season	4	Y	Morris 2009
Young age at maturity	8	Y	Morris 2009
Large body size	2,9,10,5	Y	Morris 2009
Short distance to native source	2,10	N	Schultz 1986
Parental care	2,3,6	N	Morris 2009

Harvest strategies



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Lionfish sensory (tasting) trials

Credits:
Barry Nash (NC Sea Grant)
Joyce Taylor (NCSU Seafood Laboratory)
NCSU Seafood Laboratory Staff
James Morris NOAA lionfish researcher


Sea Grant

ALMOND BROILED LIONFISH FILLETS RECIPE

Might not look like it, but this could be dinner tonight! Photo from NEDN Stock.

The almond broiled lionfish fillets is a very affordable dish. Delicious, simple, and easy recipe. Can be ready in 15 minutes.

Serves/Makes: 6

Ingredients:

2 1/2 pounds Lionfish fillets
1/4 cup butter
1/4 cup all purpose flour
2 tablespoons lemon juice
1/2 cup sliced almonds
4-6 drops hot pepper sauce
1 tablespoon chopped parsley
1 teaspoon paprika
1 teaspoon seasoned salt

Cut fish into 6 serving portions.

Combine flour, paprika, and salt.

Roll the Lionfish fillets in mixture and place in single layer, skin side down, in well greased baking pan.

Drizzle 2 tablespoons of melted butter over the lionfish fillets.

Broil 10-15 minutes or until fish flakes easily with a fork.

Meanwhile, sauté almonds in remaining butter until golden brown.

Remove from heat.

Add lemon juice, hot pepper sauce and parsley.

Pour over the almond broiled lionfish fillets and serve at once.

Hints:

Don't be afraid to substitute, pollock, cod, red snapper, whiting or any firm-fleshed fish for the lionfish.

And of course because this is a white fish you may want to pair it with a Chardonnay or a Riesling. (Our Art Director loves the German Rieslings)

We recommend a nice side of leafy greens and a simple vinegrette. However, rice or roasted potatoes pair wonderfully with the almonds and hot sauce - especially on a cooler night.

LIONFISH ARE A HIT WITH CHICAGO, NEW YORK CHEFS

By Bob Sterner

Lionfish got rave reviews from chefs in New York City and Chicago who received test samples of the venomous alien species that were caught in a lionfish roundup off of North Carolina.

Divers caught 131 fish in the first roundup that was conducted in June by Discovery Diving Co., Beaufort, N.C., and Olympus Dive Center, Morehead City, N.C. After local divers had a feast, the remaining fish were packed into boxes of ice and shipped to restaurateurs.

"The fish arrived pristine, cold and as fresh as any I've ever seen," Bruce Sherman said. Besides creating culinary masterpieces at North Pond Restaurant, Chicago, he also chairs the Chicago Chef Cooperative. "The colors and patterns of the fish were very impressive along with their elaborate fins."

Sherman used filets for plated servings and the heads and bones for soup stock, so virtually nothing was wasted. Like the other chefs, he said he is eager to get more.

Chef Dave Pasternack at New York City's ESCA restaurant described lionfish as similar to rascas, a scorpionfish traditionally used in France for bouillabaisse, a seafood stew.

Marc Meyer, chef and owner New York's Cookshop, saw a new opportunity for culinary presentation. After scaling them, he dipped the whole fish, fins and all, into hot oil. He said it looked beautiful and tasted even better.

All chefs agreed that the flesh is delicate with a sweet, clean flavor. They also noted that patrons took special interest in the fish after being told by their servers where the fish came from and why.

Lionfish, native to Indo-Pacific waters, have no real predators since they arrived here and started a reproducing population during the past decade. They have been decimating native species from the Carolinas south to Key West, Fla.

"They're eating everything," said Lisa Mitchell, executive director of the Florida-based Reef Environmental Education Foundation. "They could wipe out entire reefs."

"They're absolutely everywhere, said Paula Whitfield, a researcher at the National Oceanic and Atmospheric Administration's North Carolina facility. "If you go deeper than 100 feet, they're ubiquitous now."

Catching them is labor intensive. They rarely bite on fishing lines. To ensure that only lionfish were being harvested, divers used hand nets and spears, and a few got stung in the process. Reactions ranged from mild to intense pain, which was treated with hot packs.

The dive charter operators are scheduling regular lionfish roundups. For $350, divers get a seminar on catching techniques, charter boat rides, and are supplied with nets, spears, gloves and catch bags. Roundup weekends wrap up with a fish dinner. For information visit *www.DiscoveryDiving.com* or *www.OlympusDiving.com.* ■

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 this **threat** to our marine environment.

Place stamp here.

TO:

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.

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

Bahamas Reef Environment Educational Foundation

Department of Marine Resources

The Nature Conservancy
Protecting nature. Preserving life.™

Marine & Environmental Studies Institute

Science & Technology

Conservation and cookery

Eat for the ecosystem

Oct 15th 2009

From *The Economist* print edition

A heartening tale of business and the environment

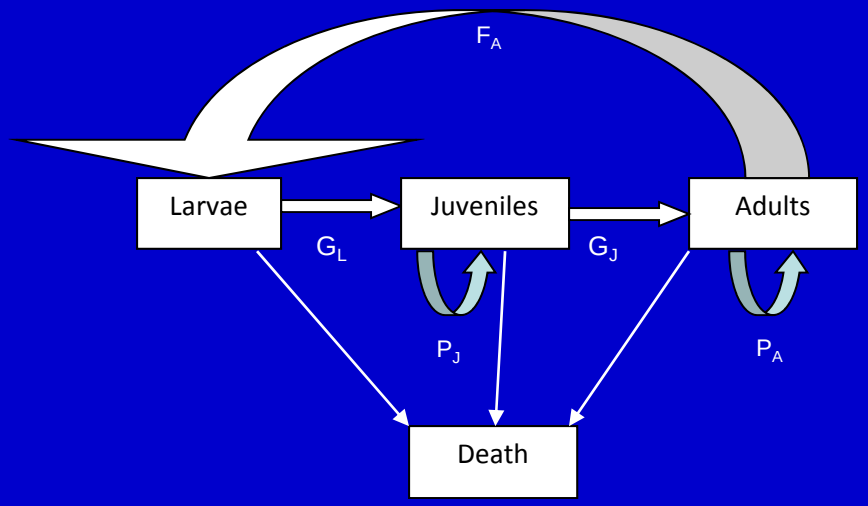
Science Photo Library

RED lionfish are pretty, but they are also greedy. A single one of them, introduced into a coral reef where the species is not native, can reduce the number of other small fish by 80% in just a few weeks, according to Mark Hixon, a marine biologist at Oregon State University. To make matters worse, lion fish are top predators. Though their size would make them an easy mouthful for a shark or a grouper, their poisonous spines mean they are more or less invulnerable.

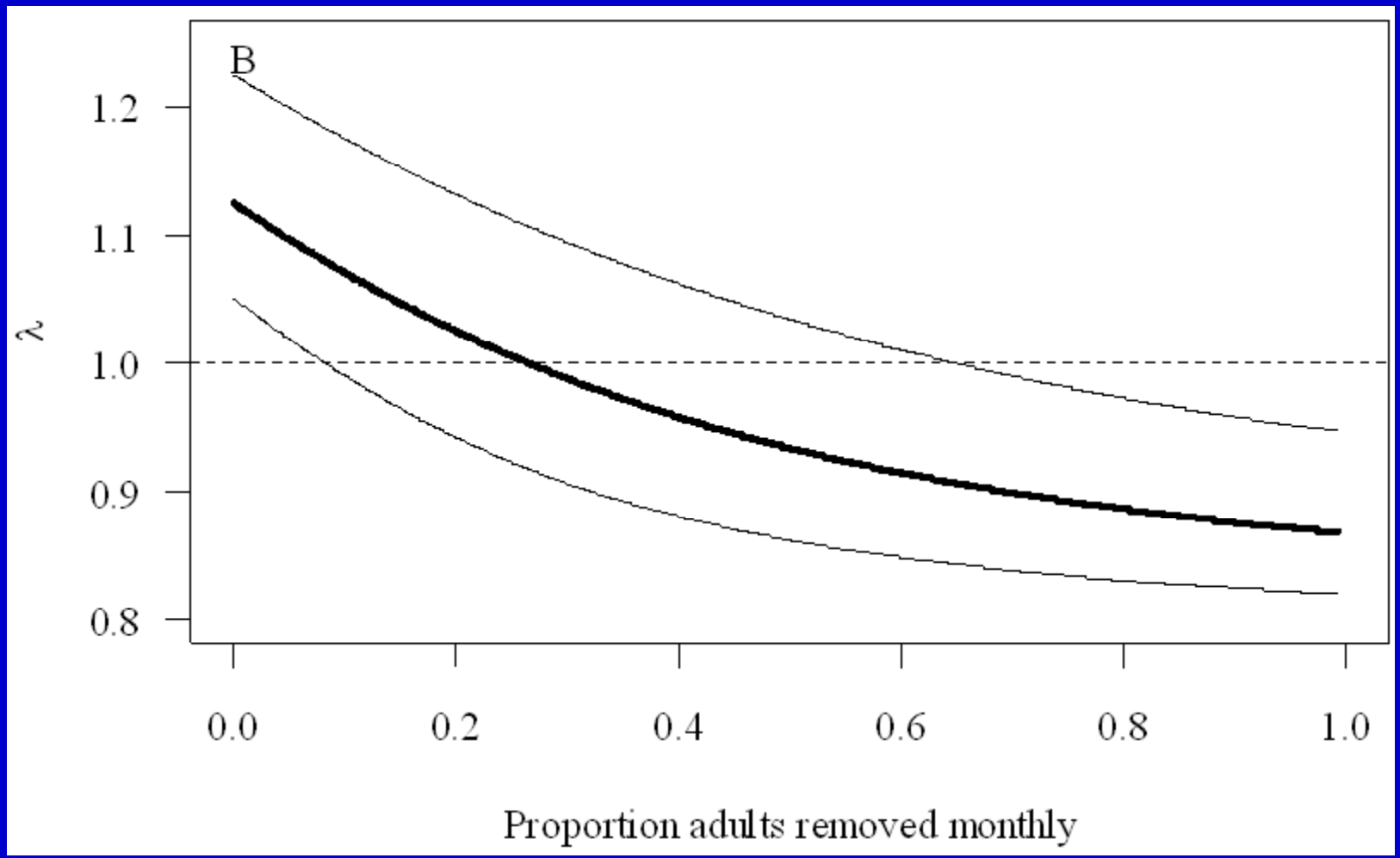
In the lionfish's native waters, the western Pacific Ocean, the local ecosystem has adjusted to such predatory behaviour. In the Caribbean, though, the lionfish is a novelty—and a destructive

Population modeling – stage-based matrix model

$$\begin{bmatrix} L_{t+1} \\ J_{t+1} \\ A_{t+1} \end{bmatrix} = \begin{bmatrix} 0 & 0 & F_A \\ G_L & P_J & 0 \\ 0 & G_J & P_A \end{bmatrix} \begin{bmatrix} L_t \\ J_t \\ A_t \end{bmatrix}$$

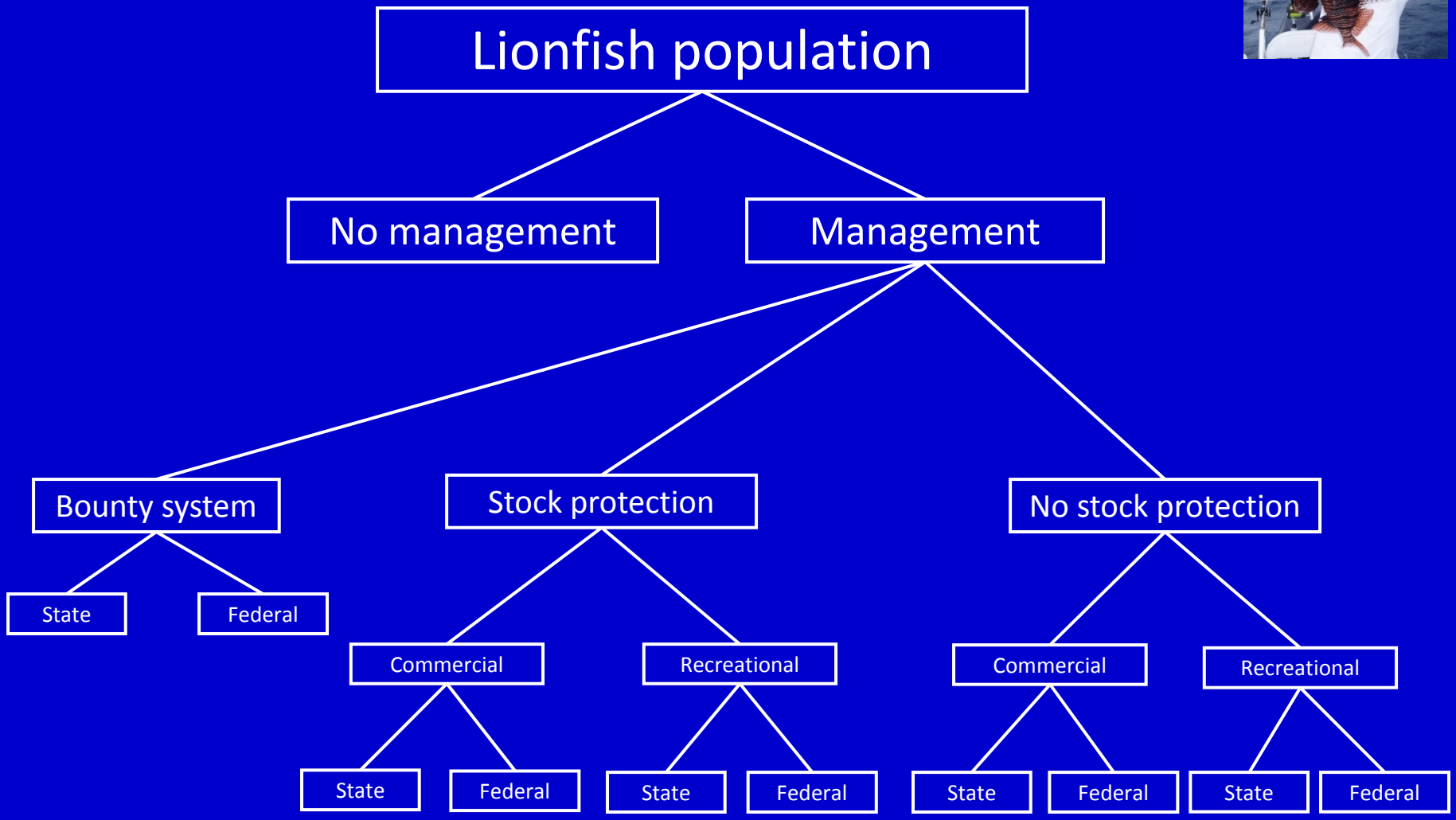


Morris, Shertzer, and Rice



Morris, Shertzer, and Rice

Lionfish management options



Morris and Whitfield 2009

Discussion topics

- Management options and future actions (or no action)
- Magnuson-Stevens issues
- Harvest strategies and impacts
- Impacts on stock rebuilding plans and future management of Snapper-Grouper

The lionfish story – Unprecedented outreach on invasive species

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Feeding ecology of invasive lionfish (*Pterois volitans*) in the Bahamian archipelago

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Abstract Feeding ecology of the lionfish (*Pterois volitans*), an invasive species in the Western North Atlantic, was examined by collecting stomach content data from fishes taken throughout the Bahamian archipelago. Three relative metrics of prey quantity, including percent number, percent frequency, and percent volume, were used to compare three indices of dietary importance. Lionfish largely prey upon teleosts (78% volume) and crustaceans (14% volume). Twenty-one families and 41 species of teleosts were represented in the diet of lionfish; the top 10 families of dietary importance were Gobiidae, Labridae, Grammatidae, Apogonidae, Pomacentridae, Serranidae, Blenniidae, Atherinidae, Mullidae, and Monacanthidae. The proportional importance of crustaceans in the diet was inversely related to size with the largest lionfish preying almost exclusively on teleosts. Lionfish were found to be diurnal feeders with the highest predation occurring in the morning (08:00–11:00).

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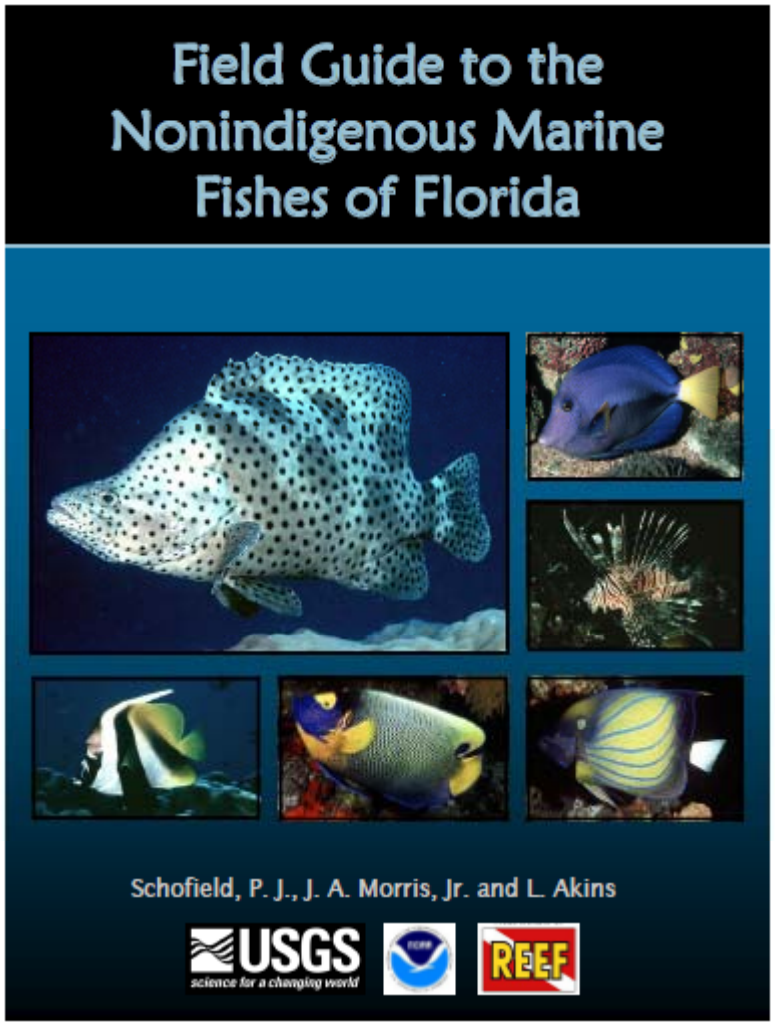
Introduction

The lionfishes, *Pterois miles* and *P. volitans*, (Hamner et al. 2007; Morris 2009) are the first non-native marine fishes to become established along the Atlantic coast of the U.S. and the Caribbean. Adult lionfish specimens are now found along the U.S. East Coast from Cape Hatteras, North Carolina, to Florida, and in Bermuda, the Bahamas, and throughout the Caribbean, including the Turks and Caicos, Haiti, Cuba, Dominican Republic, Puerto Rico, St. Croix, Belize, and Mexico (Schofield et al. 2009). The first documented capture of lionfish in the Atlantic was in 1985 off Dania Beach, Florida (J. Bohnsack, NOAA NMFS, pers. comm.). Additional sightings occurred in 1992 following an accidental release of six lionfishes from a home aquarium into Biscayne Bay, Florida (Courtenay 1995). Many other reports of lionfish were documented in southeast Florida between 1999 and 2003 by Semmens et al. (2004), who attributed many of these sightings to releases by home aquarists.

Recreational divers reported the first sightings of lionfish in the Bahamas in 2004 (REEF 2009). Snyder and Burgess (2007) published the first record of lionfish in the Bahamas, suggesting that lionfish were widely distributed throughout Little Bahama and


Field Guide to the
Nonindigenous Marine
Fishes of Florida
Schofield, P. J., J. A. Morris, Jr. and L. Akins
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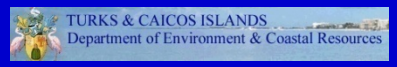

Many, many, more…

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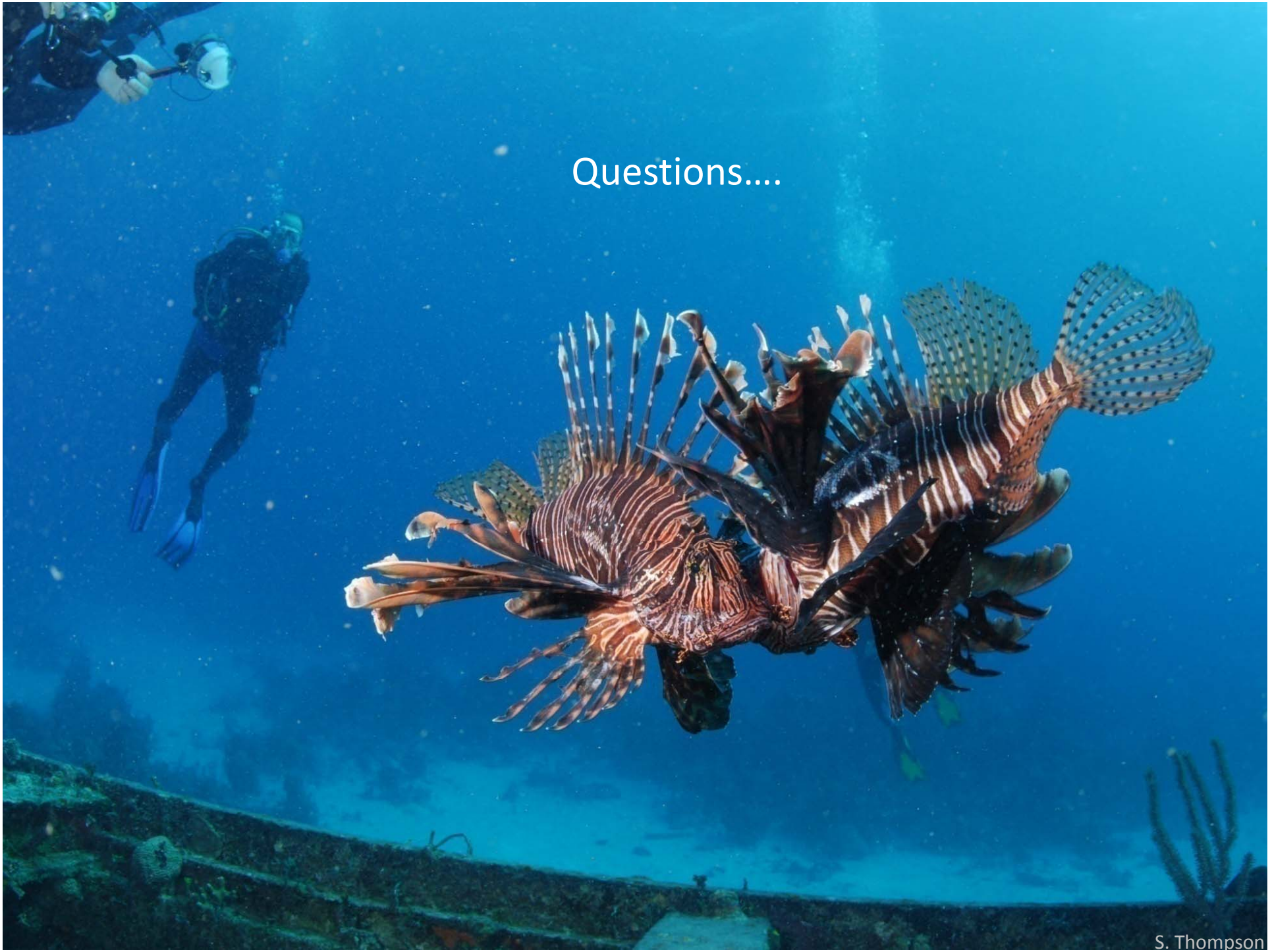
Questions….
S. Thompson