Lionfish update for GSARP
Nov 10, 2009

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Ecologist, NOAA National Ocean Service, Beaufort, North Carolina

What's new?

- Invasion chronology
- Reproductive parameters
- Ecological impacts
- Life history and invasiveness
- Control and management

New Publications in Last 6 months

Biology, Ecology, Control and Management of the Invasive Indo-Pacific Lionfish: An Updated Integrated Assessment

NOAA Technical Memorandum NOS NCCOS 99

Environ Biol Fish (2009) 86:389–398
DOI 10.1007/s10641-009-9538-8

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

James A. Morris Jr. · John L. Akins

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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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Keywords *Pterois* · Diet composition · Stomach content · Invasive species

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

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DOI 10.3391/ai.2009.4.3

Research article

Geographic extent and chronology of the invasion of non-native lionfish (*Pterois volitans* [Linnaeus 1758] and *P. miles* [Bennett 1828]) in the Western North Atlantic and Caribbean Sea

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Abstract

The Indo-Pacific lionfishes (*Pterois volitans* [Linnaeus 1758] and *P. miles* [Bennett 1828]; Family Scorpaenidae) are the first non-native marine fishes to establish in the Western North Atlantic. The chronology of the invasion is reported here using records from the US Geological Survey's Nonindigenous Aquatic Species database. Currently, lionfish are established off the Atlantic coast of the USA from the Florida Keys to Cape Hatteras (North Carolina), the Great Antilles, Bermuda, Bahamas, Cayman Islands and Turks and Caicos. The species have been reported from only one island in the Lesser Antilles (St. Croix), but it is not yet established there. Lionfish are established in Mexico, Honduras and Costa Rica. Reports have come from the Gulf of Mexico (Florida), Belize, Panamá and Columbia, although lionfish are not considered established in these localities at this time (August 2009), invasion is likely imminent.

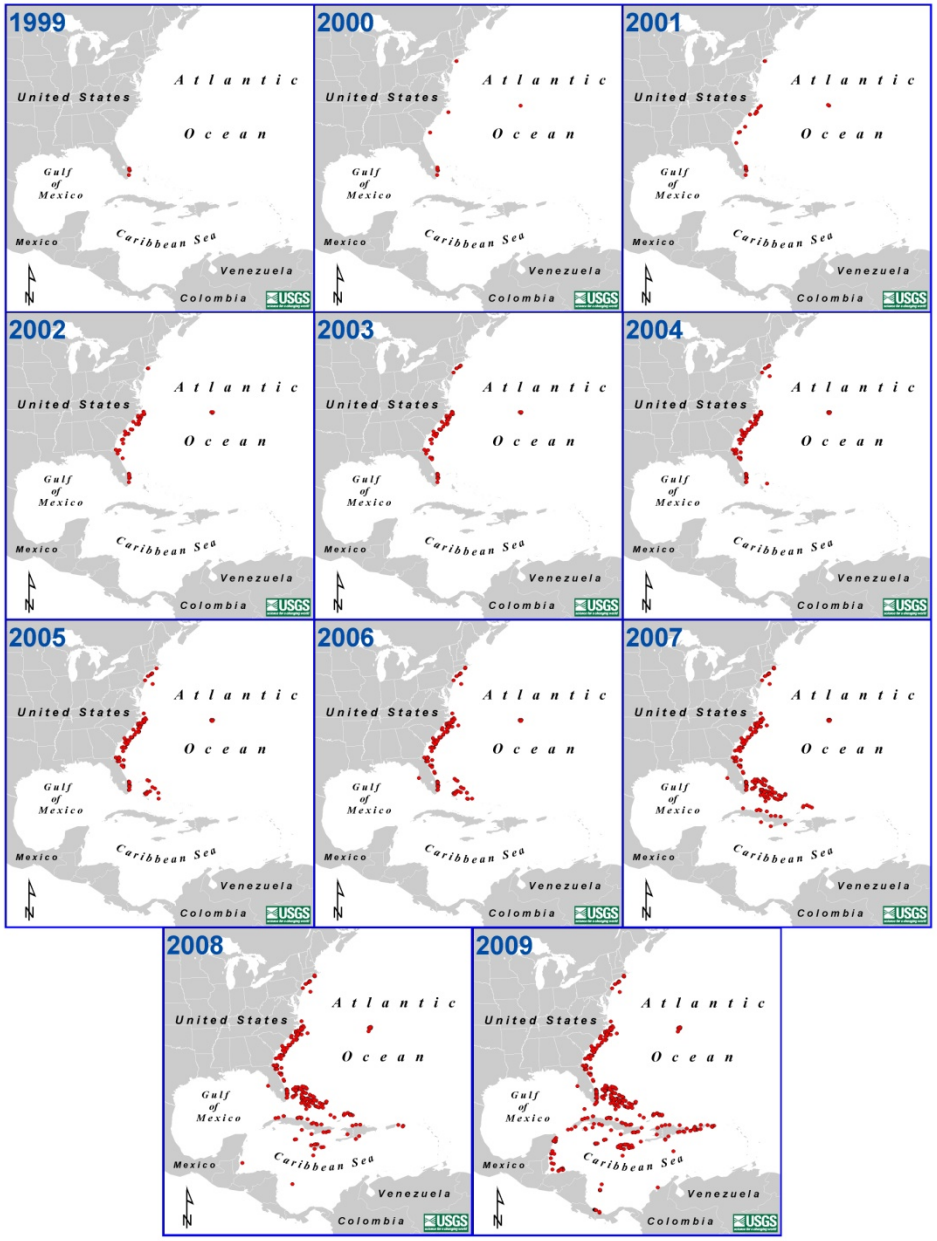
Key words: lionfish, *Pterois volitans*, *Pterois miles*, non-native marine fishes, Scorpaenidae

Introduction

The Indo-Pacific lionfish species (*Pterois volitans* [Linnaeus 1758] and *P. miles* [Bennett 1828]; Family Scorpaenidae) are the first non-native marine fishes to establish in the Western North Atlantic and Caribbean Sea. Although there are both confirmed and unconfirmed (anecdotal) reports of lionfish sightings from decades past, it is only recently (i.e., since 2000) that the species have considerably increased in numbers and spread through the Western North Atlantic (Whitfield et al. 2002, 2007; Freshwater et al. 2009a). At this time it is unclear what effects this new addition will have on native communities, and because the invasion is so recent there are few ecological studies of its impact (but see Albins and Hixon 2008). Nonetheless, there are several reasons to be concerned about their presence: Lionfish are predators that consume native species (Morris and Akins unpubl. data) and have venomous spines that could injure divers. In this paper, information on the chronology of invasion of the lionfish is provided using records from the US Geological Survey's Nonindigenous Aquatic Species database (USGS-NAS 2009).

Material and Methods

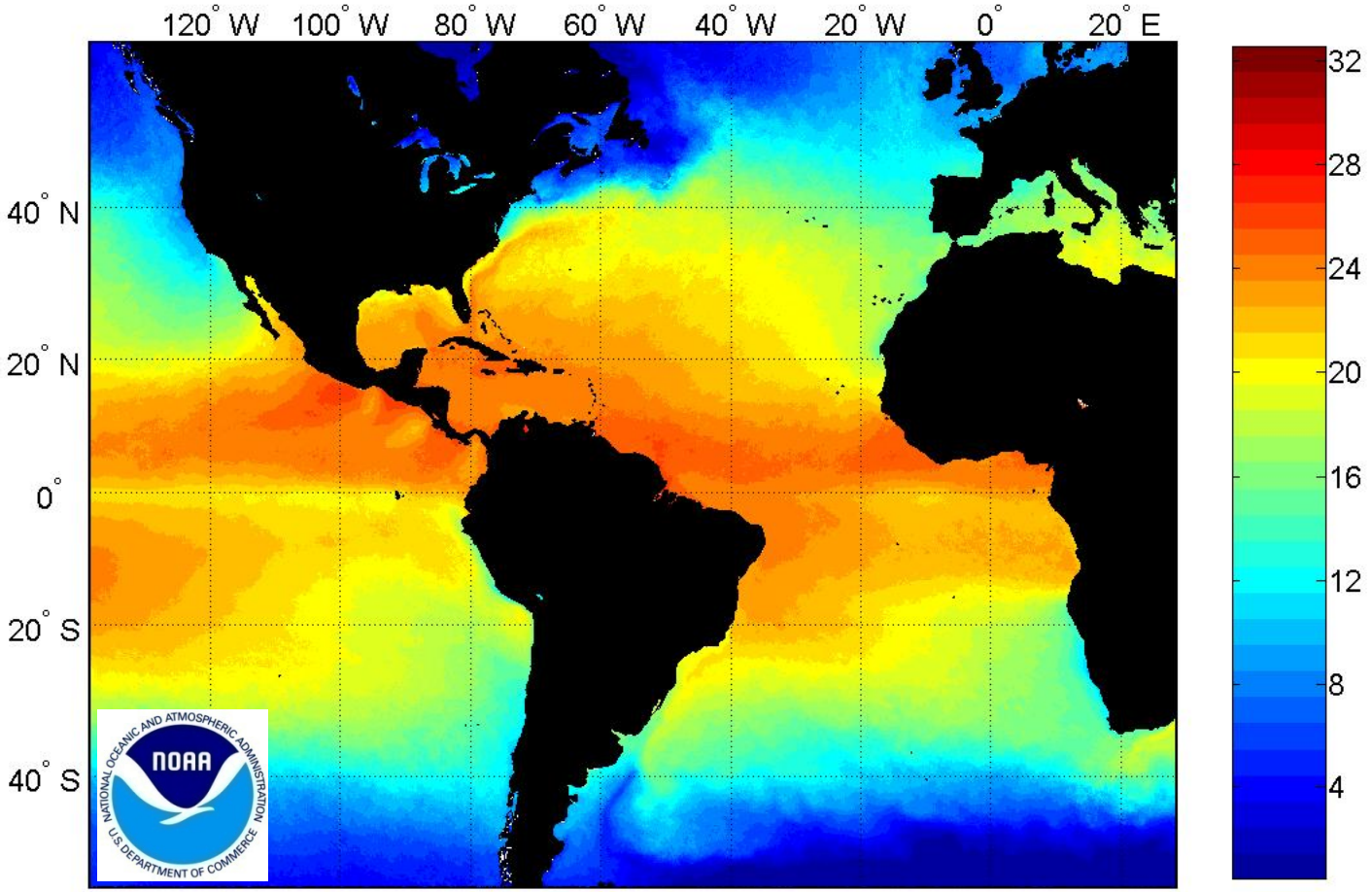
The USGS-NAS database is the national repository for spatially-referenced sightings information for non-native aquatic species in the USA (USGS-NAS 2009). The Reef Environmental Education Foundation database (REEF 2008) and National Oceanic and Atmospheric Administration (NOAA) are major contributors of lionfish data to the USGS-NAS database. Records in the USGS-NAS database are derived from a variety of sources, including scientific literature, published and unpublished reports, museum specimens and personal communi-



1040 records so far in 2009

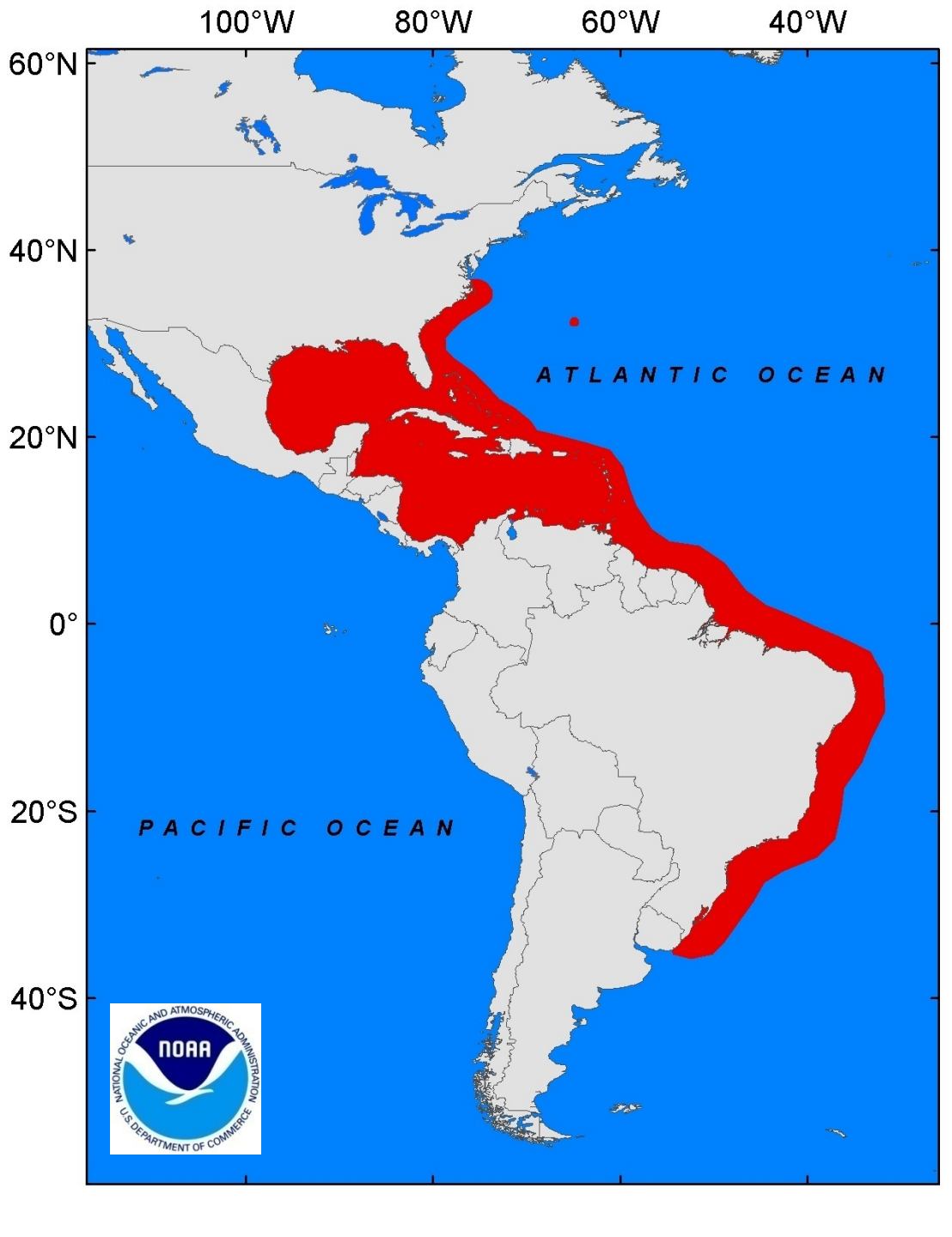
COUNTRY	No. of Records 2009	1st year
United States	297	1985 (FL)
Bermuda	79	2000
Bahamas	235	2004
Turks and Caicos	53	2007
Cuba	63	2007
Cayman Islands	24	2008
Jamaica	67	2008
Dominican Republic	24	2008
Haiti	10	2008
Puerto Rico (US)		2008
US Virgin Islands		2008
Belize	7	2008
Colombia	19	2008
British Virgin Islands	1	2008
Mexico	41	2009
Honduras	65	2009
Costa Rica	42	2009
Panama	6	2009
Netherlands Antilles	7	2009

Status of lionfish establishment



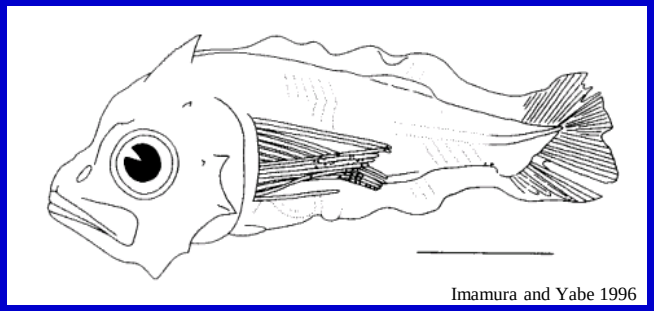
Sea Surface Temperature

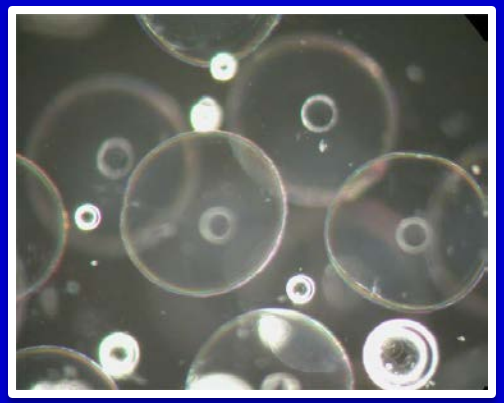
Lionfish thermal minimum ~ 10C (Kimball et al. 2004)


100°W
80°W
60°W
40°W
60°N
40°N
20°N
0°
20°S
40°S
ATLANTIC OCEAN
PACIFIC OCEAN
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

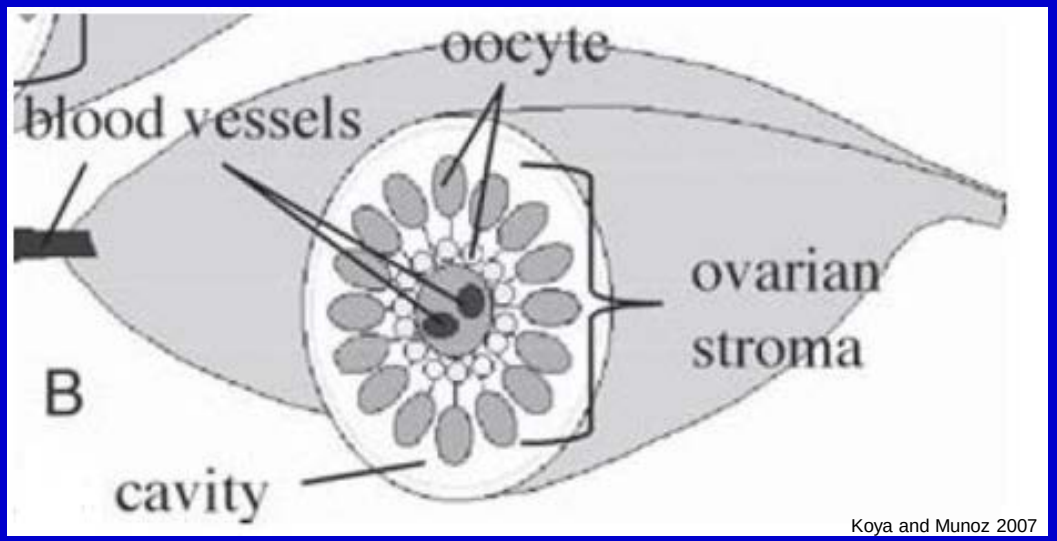
Reproductive strategy and early life history

- 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

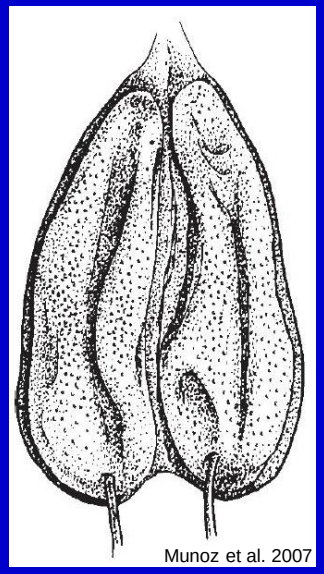

Imamura and Yabe 1996

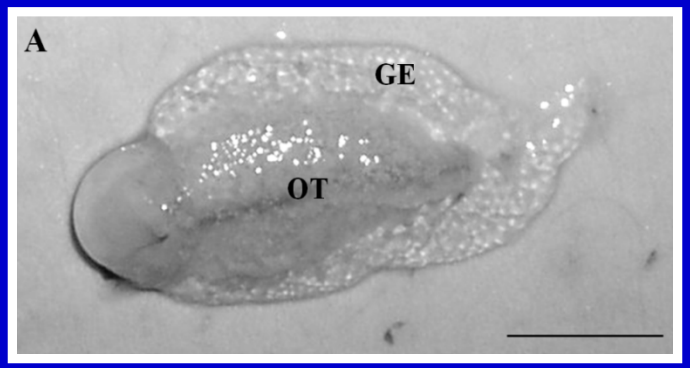


Lionfish ovarian morphology and oogenesis



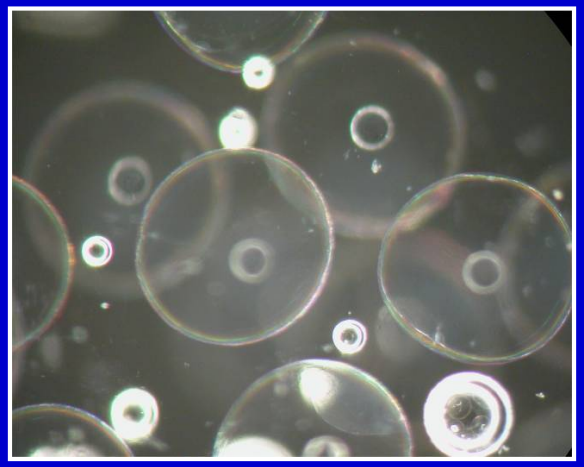
Koya and Munoz 2007


Munoz et al. 2007

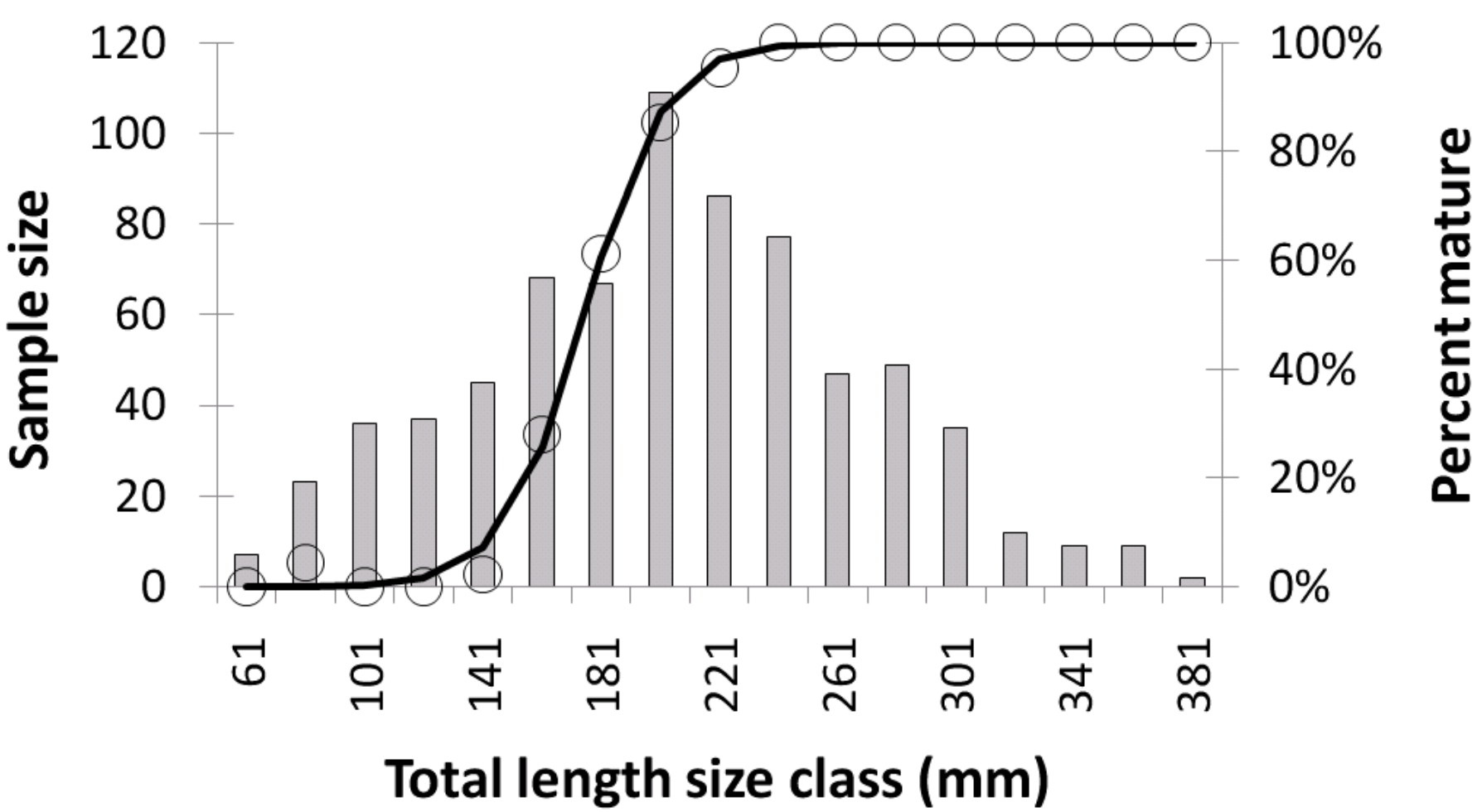


Reproductive dynamics

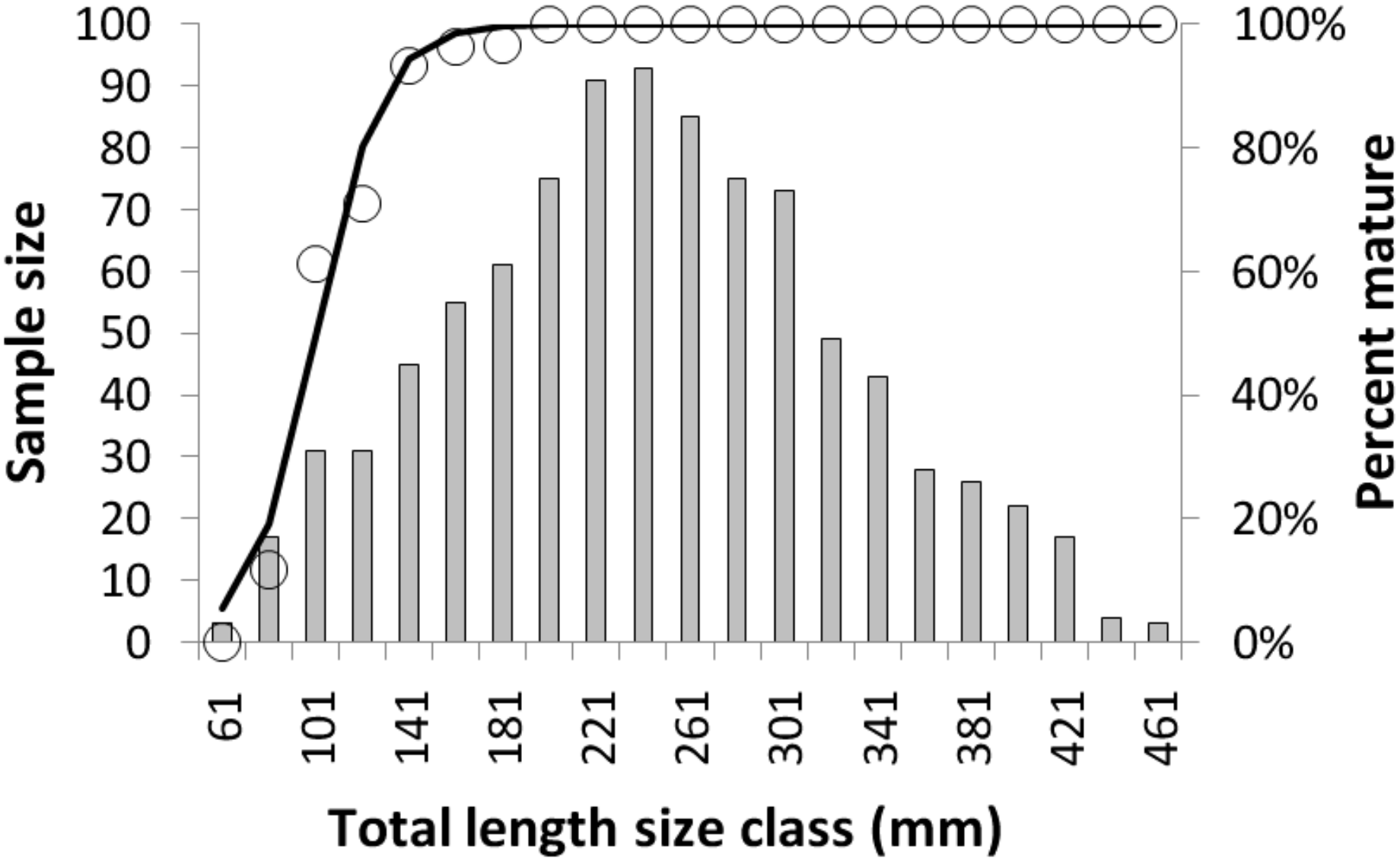
- Spawning seasonality
- Spawning periodicity
- Length at maturity
- Batch fecundity
- Annual fecundity



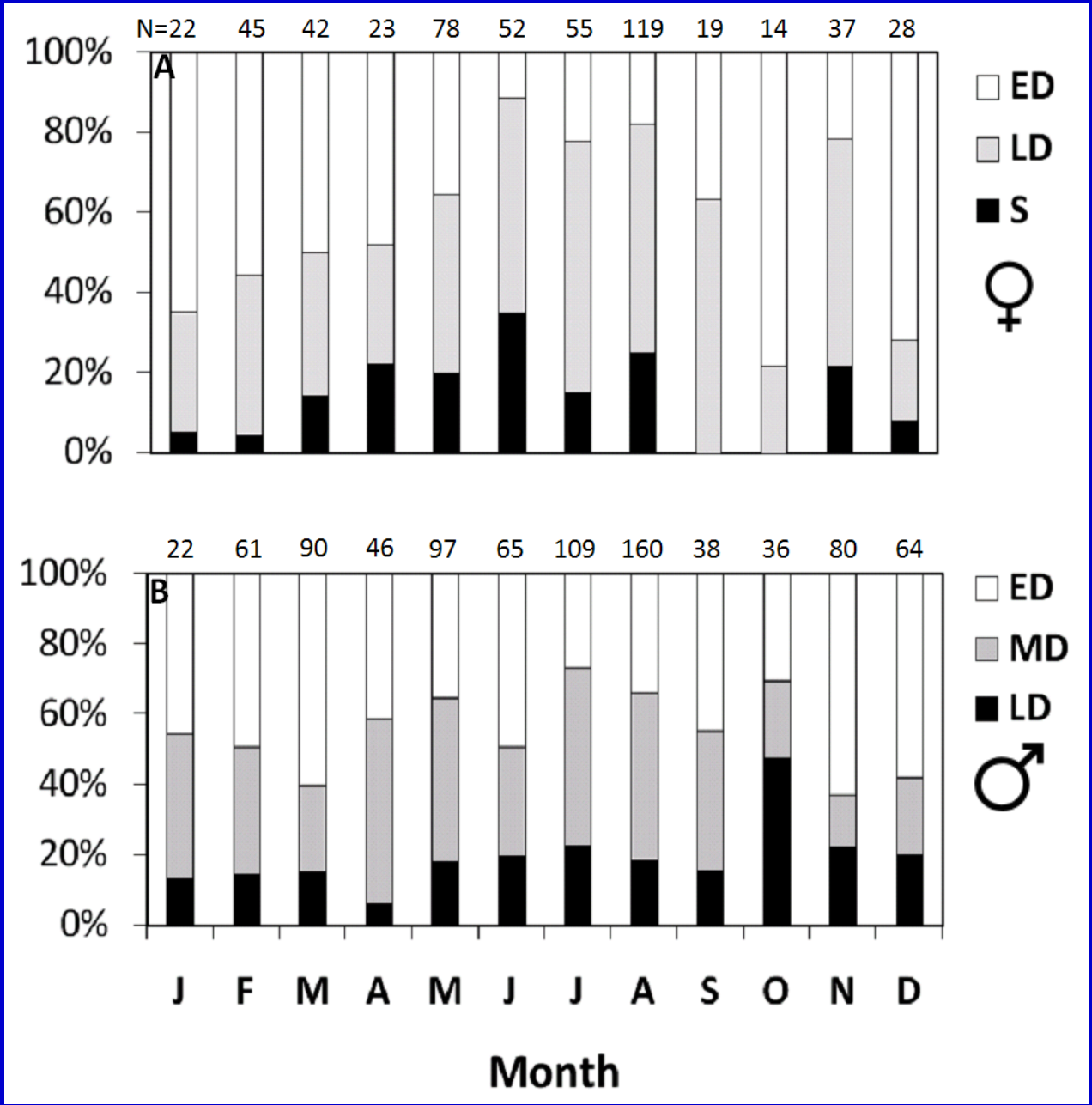
Female size at maturity is ~180 mm TL (less than 1 year old)



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

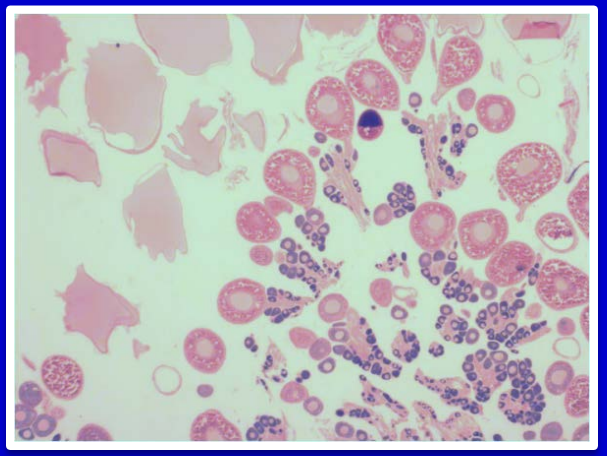


Lionfish spawn throughout the year!



Spawning frequency

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

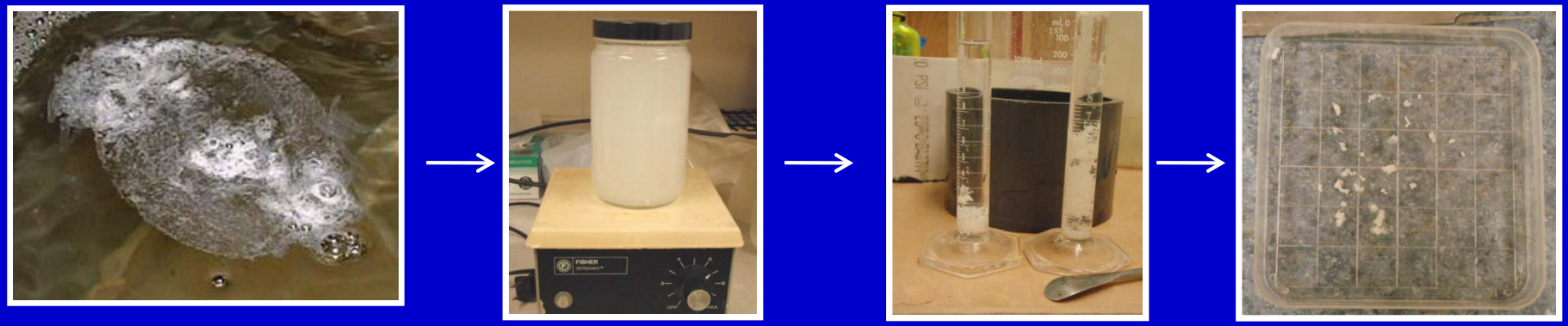


Spawning frequency (days) = (# spawning/total #)/1
(Schaefer et al. 1986)

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)

Top rankings

1

Masked goby (Gobiidae)

2

Yellowhead wrasse (Labridae)

3

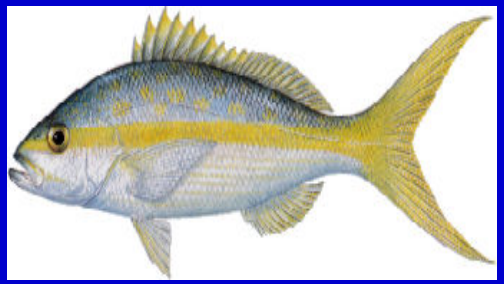
Royal gramma (Grammatidae)

4

Belted cardinalfish (Pomacentridae)

Economically important species

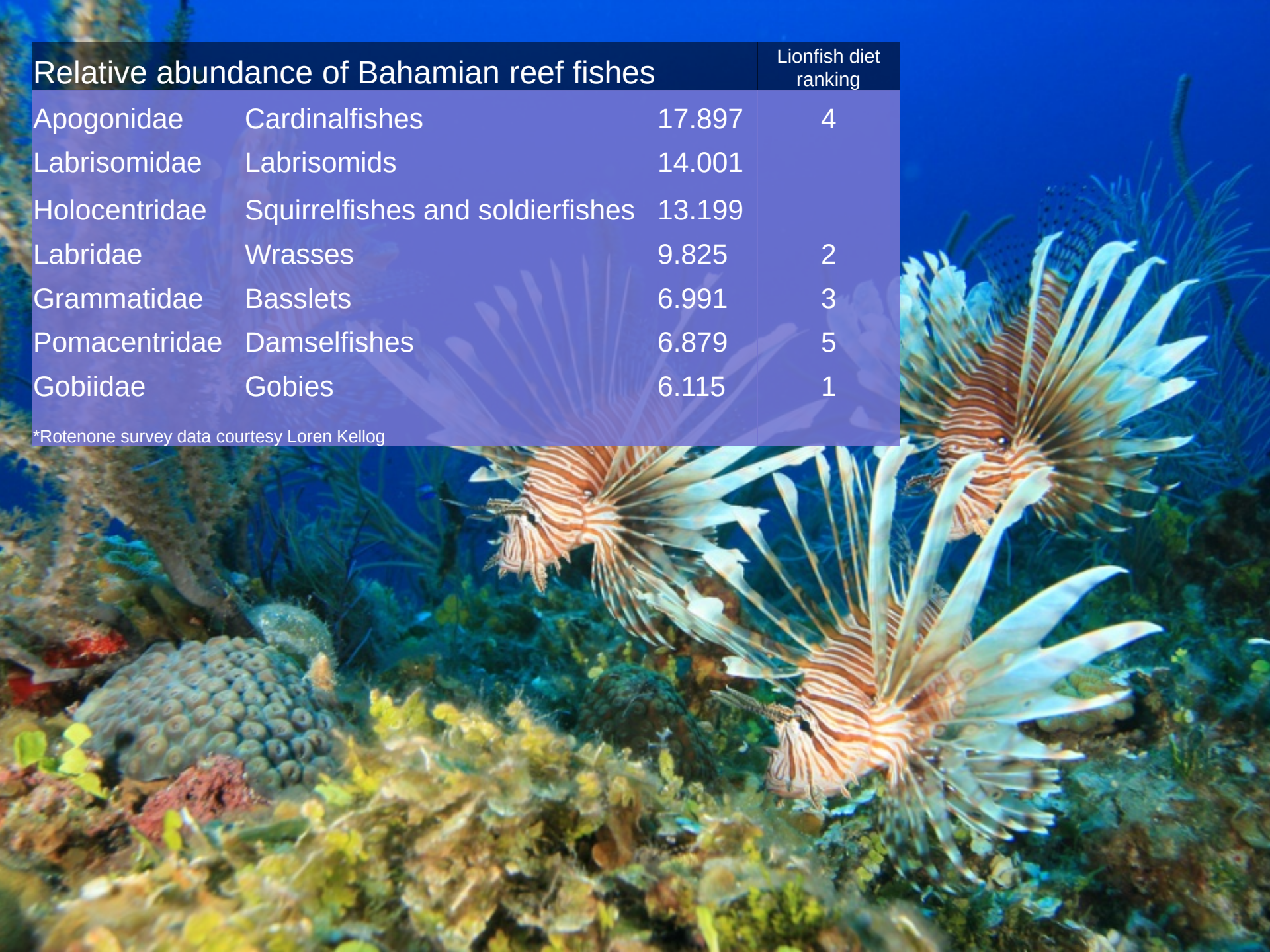
Nassau grouper



Yellow tail snapper

Vermillion snapper

Banded coral shrimp



Relative abundance of Bahamian reef fishes			Lionfish diet ranking
Apogonidae	Cardinalfishes	17.897	4
Labrisomidae	Labrisomids	14.001	
Holocentridae	Squirrelfishes and soldierfishes	13.199	
Labridae	Wrasses	9.825	2
Grammatidae	Basslets	6.991	3
Pomacentridae	Damselfishes	6.879	5
Gobiidae	Gobies	6.115	1

*Rotenone survey data courtesy Loren Kellog

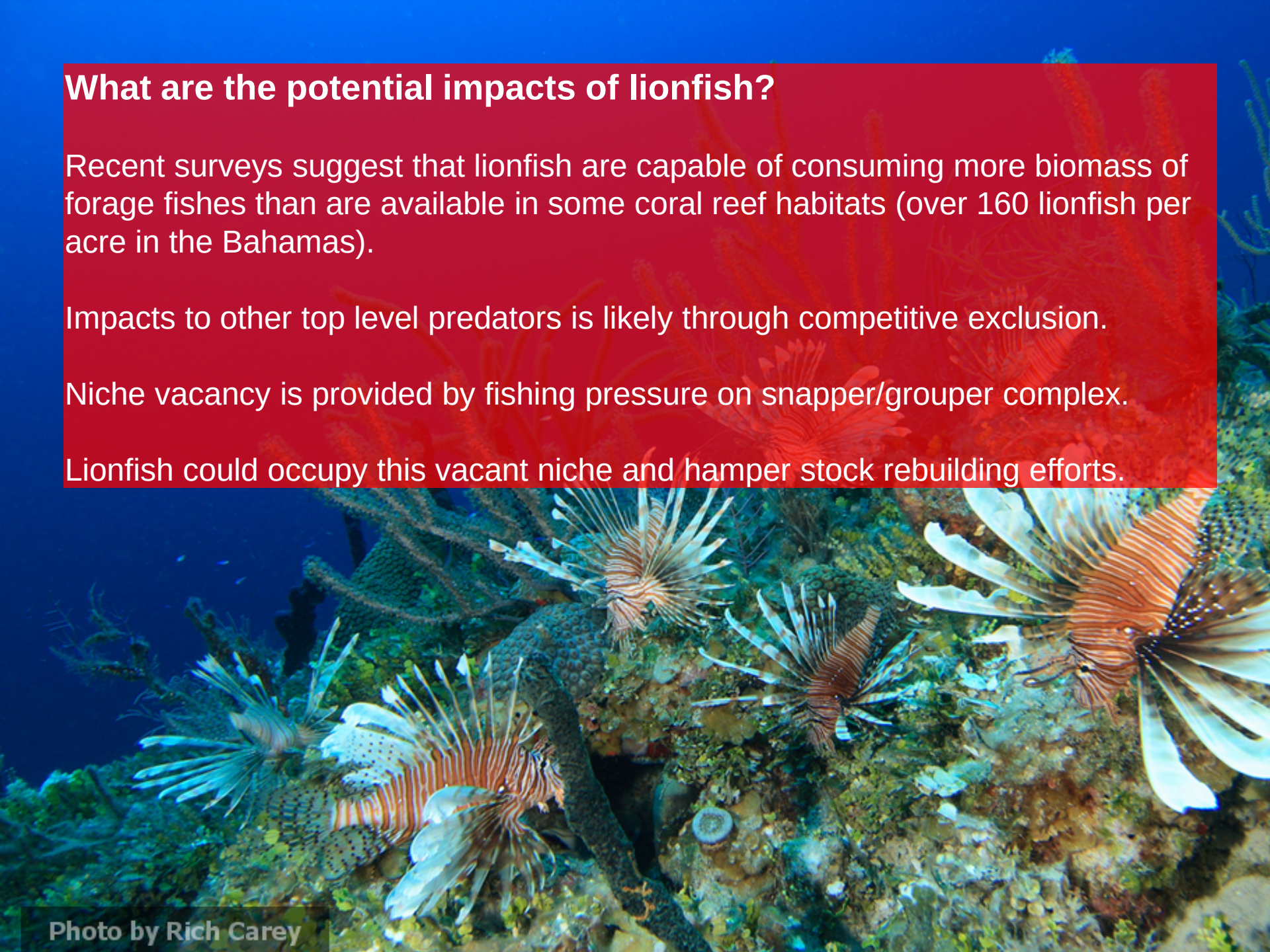
What are the potential impacts of lionfish?

Recent surveys suggest that lionfish are capable of consuming more biomass of forage fishes than are available in some coral reef habitats (over 160 lionfish per acre in the Bahamas).

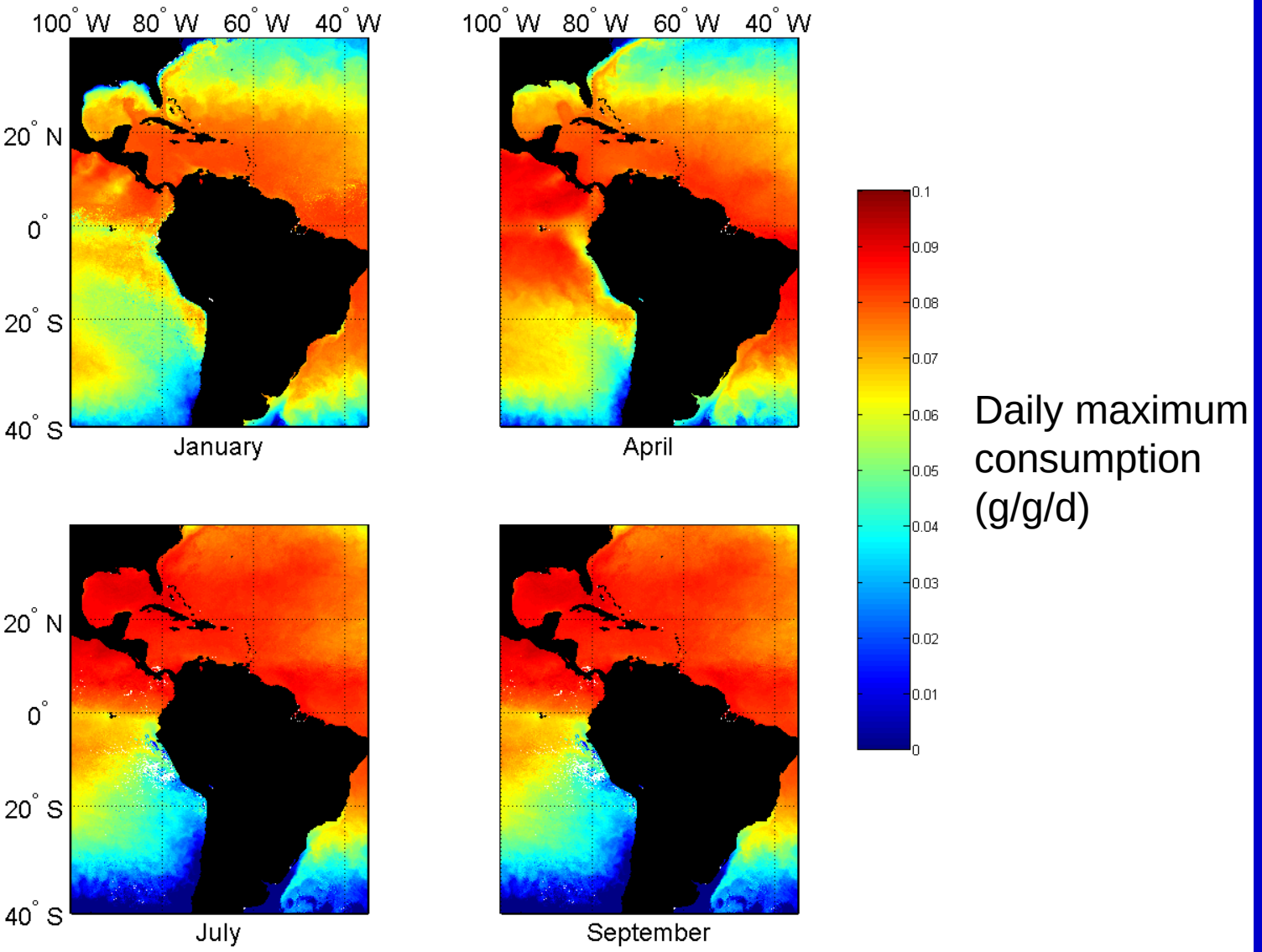
Impacts to other top level predators is likely through competitive exclusion.

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

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

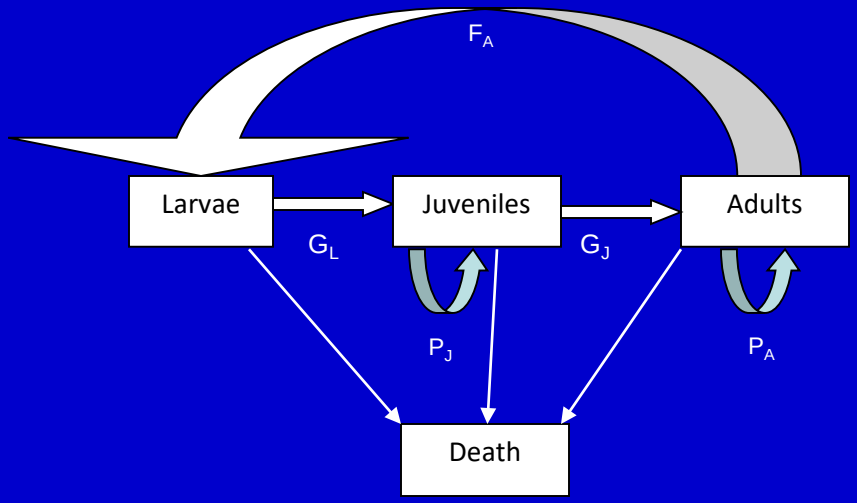


Lionfish trophic impacts



A STAGE-BASED MATRIX POPULATION MODEL OF INVASIVE LIONFISH WITH IMPLICATIONS FOR CONTROL

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



Elasticity and sensitivities of matrix elements and lower-level parameters

$$e_{ij} = \frac{a_{ij}}{\lambda} \frac{\partial \lambda}{\partial a_{ij}}.$$

$$\frac{\partial \lambda}{\partial x} = \sum_{ij} \frac{\partial \lambda}{\partial a_{ij}} \frac{\partial a_{ij}}{\partial x}$$

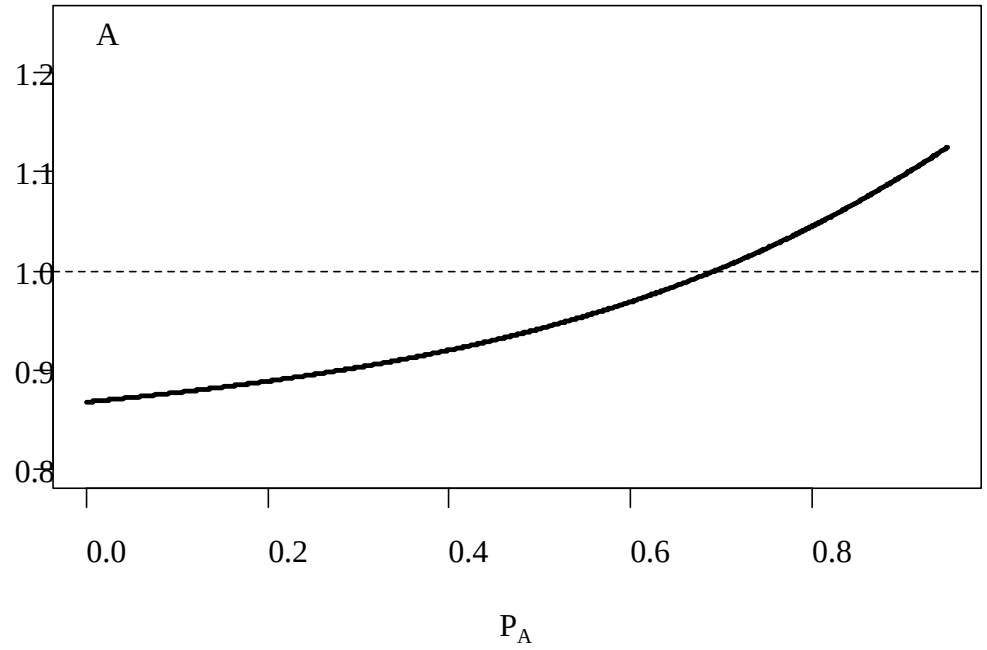
(Caswell 2001)

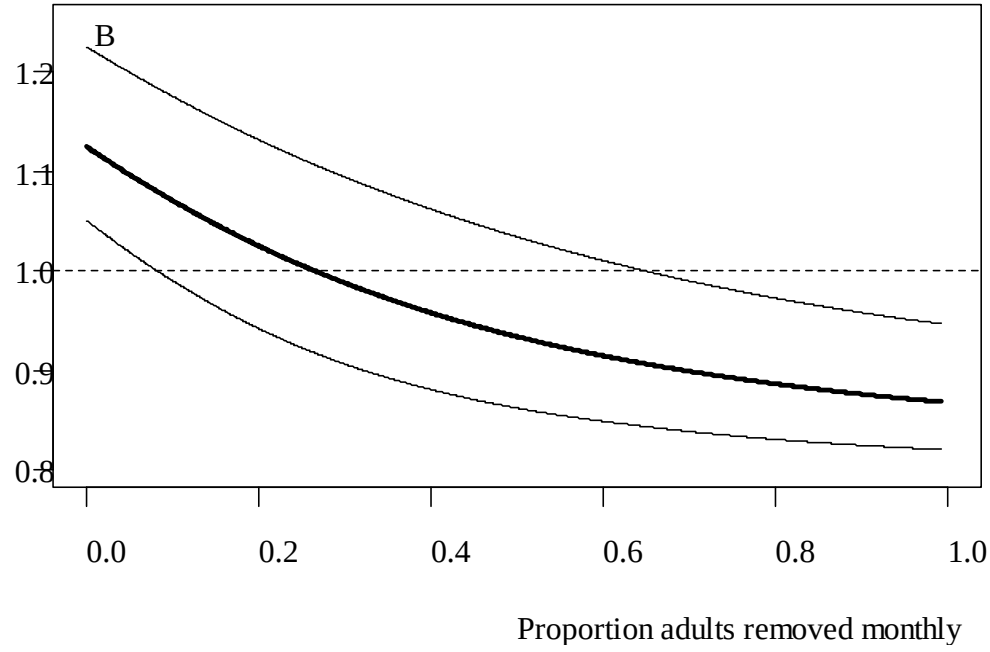
Table 8.2 Matrix element value, computation, and elasticity of λ.

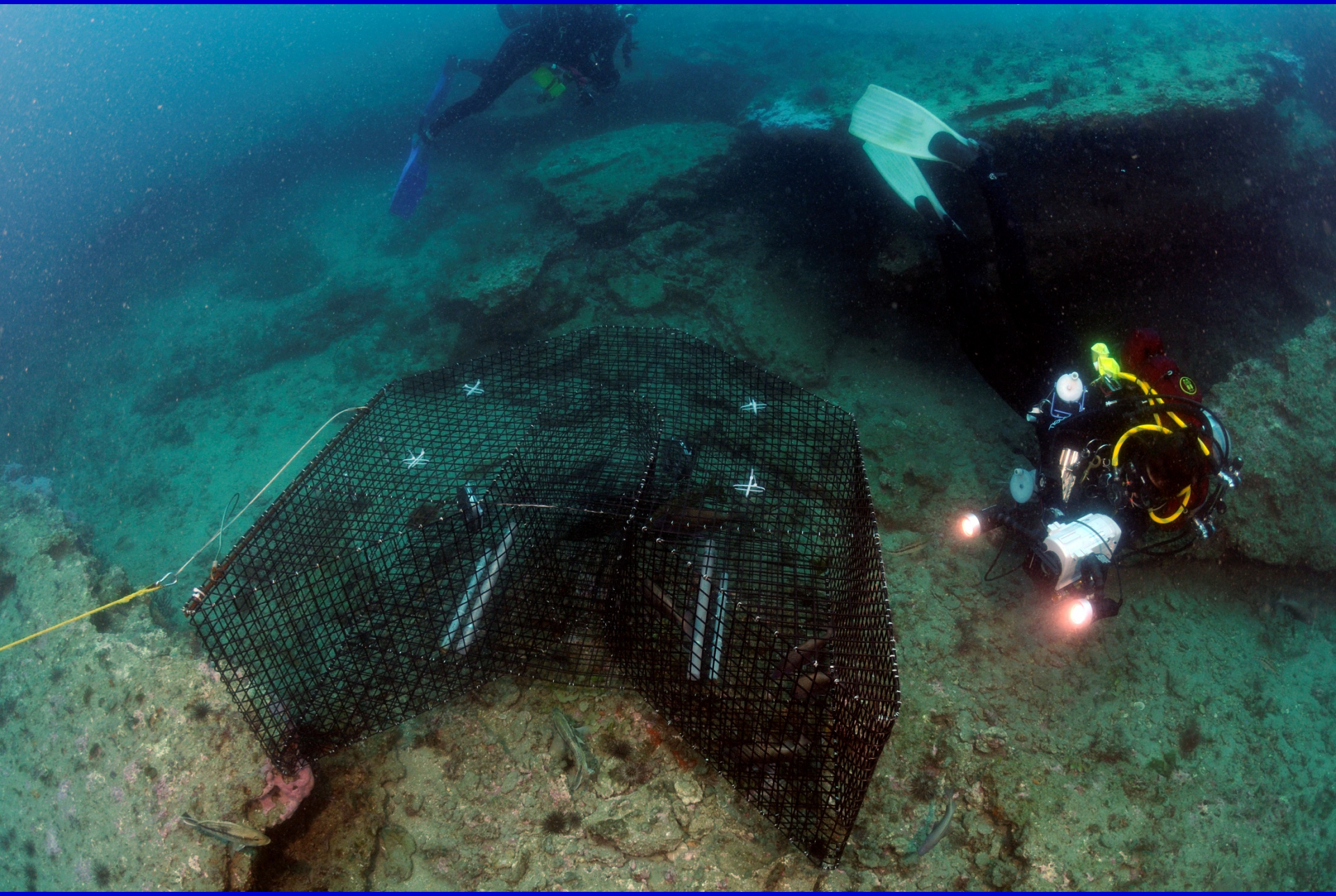
Element	Value	Computation
P_A	0.951	e^{-M_A}
P_J	0.787	$11/12\ e^{-M_J}$
G_L	0.00003	$e^{-M_L D_L}$
G_J	0.072	$1/12\ e^{-M_J}$
F_A	11,837	$\rho F e^{-M_E D_E}$

Table 8.1 Values of lower-level parameters, their sources, and the sensitivity of λ to each of them. The matrix element in which the lower-level parameter was used is provided in parentheses. Mortality is expressed as instantaneous rate.

Parameter	Value	Units	Reference
Larval mortality M_L (G_L)	0.350	$month^{-1}$	McGurk 1987
Adult mortality M_A (P_A)	0.052	$month^{-1}$	Lorenzen 1996
Juvenile mortality M_J (P_J, G_J)	0.165	$month^{-1}$	Lorenzen 1996
Proportion female ρ (F_A)	46%	---	Morris, unpub. data
Larval duration D_L (G_L)	30	days	Morris, unpub. data
Egg mortality M_E (F_A)	0.310	day^{-1}	McGurk 1987
Fecundity F (F_A)	194,481	$month^{-1}$	Morris, unpub. data
Egg duration D_E (F_A)	3	days	Morris, unpub. data


A
1.2
1.1
1.0
0.9
0.8
0.0
0.2
0.4
0.6
0.8
P_A


B
1.2
1.1
1.0
0.9
0.8
0.0
0.2
0.4
0.6
0.8
1.0
Proportion adults removed monthly



Center for Marine Sciences and Technology
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Phone: 252-222-6334
Fax: 252-222-6335

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

Results (~10 tasters- mean score of 5.0 is the highest score possible)

Tasters' Comments on Lionfish Recipes

Pan-Fried Lionfish, Evaluation 4.8:

Loved this—I like mild fish, and this is excellent

The only reason this didn't get a 5 is that I prefer baked to fried. The fish was nice and flaky and the batter was flavorful. Bonus: It wasn't rubbery.

Very tasty.

Lionfish with Fresh Herb Mayonnaise, Evaluation 5.0:

Gave it a 5, but thought mayonnaise overpowered fish a bit, but great.

Fish was moist! Fresh herb mayonnaise was delicious. Herbs were subtle but added just a little punch.

Excellent! My favorite!

My favorite.

Broiled Lionfish with Garlic-Basil Butter, Evaluation 5.0:

Wonderful texture!

The first thing I noticed about this one was the smell—delicious!

Good-Good!

Garlic flavor is great.

General Comments:

Excellent fish. I would order this at a restaurant if on the menu. The bones are the only problem. Very good texture, firm and moist!!

Excellent preparations and taste. Great chefs.

Texture is similar to flounder, mild flavor.

Mean score

Taster comments

End of slide show

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

Bahamas National Trust

The Nature Conservancy
Protecting nature. Preserving life.™

Marine & Environmental Studies Institute

Science & Technology

Conservation and cookery

Eat for the ecosystem

Oct 15th 2009

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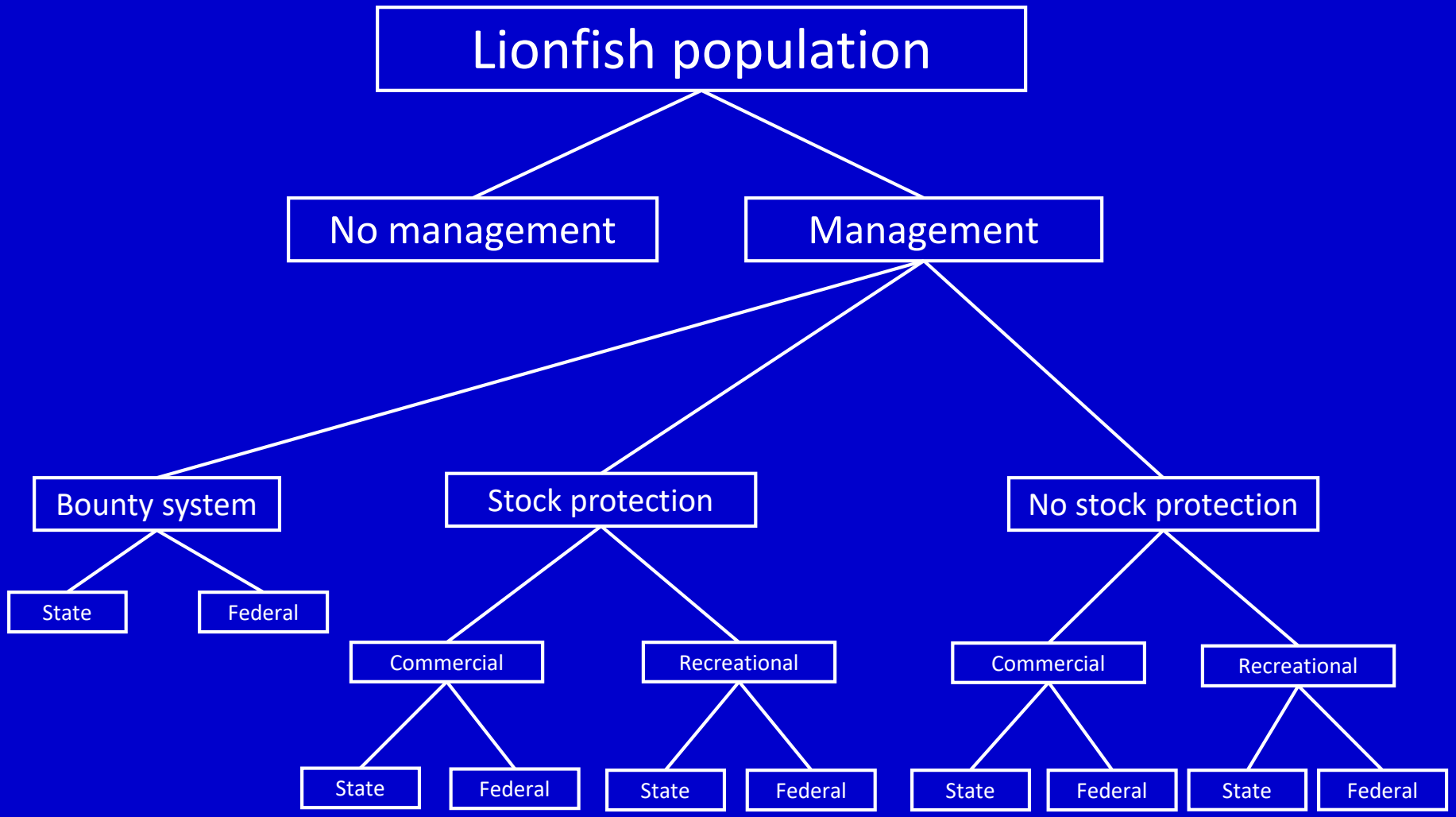
A heartening tale of business and the environment

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

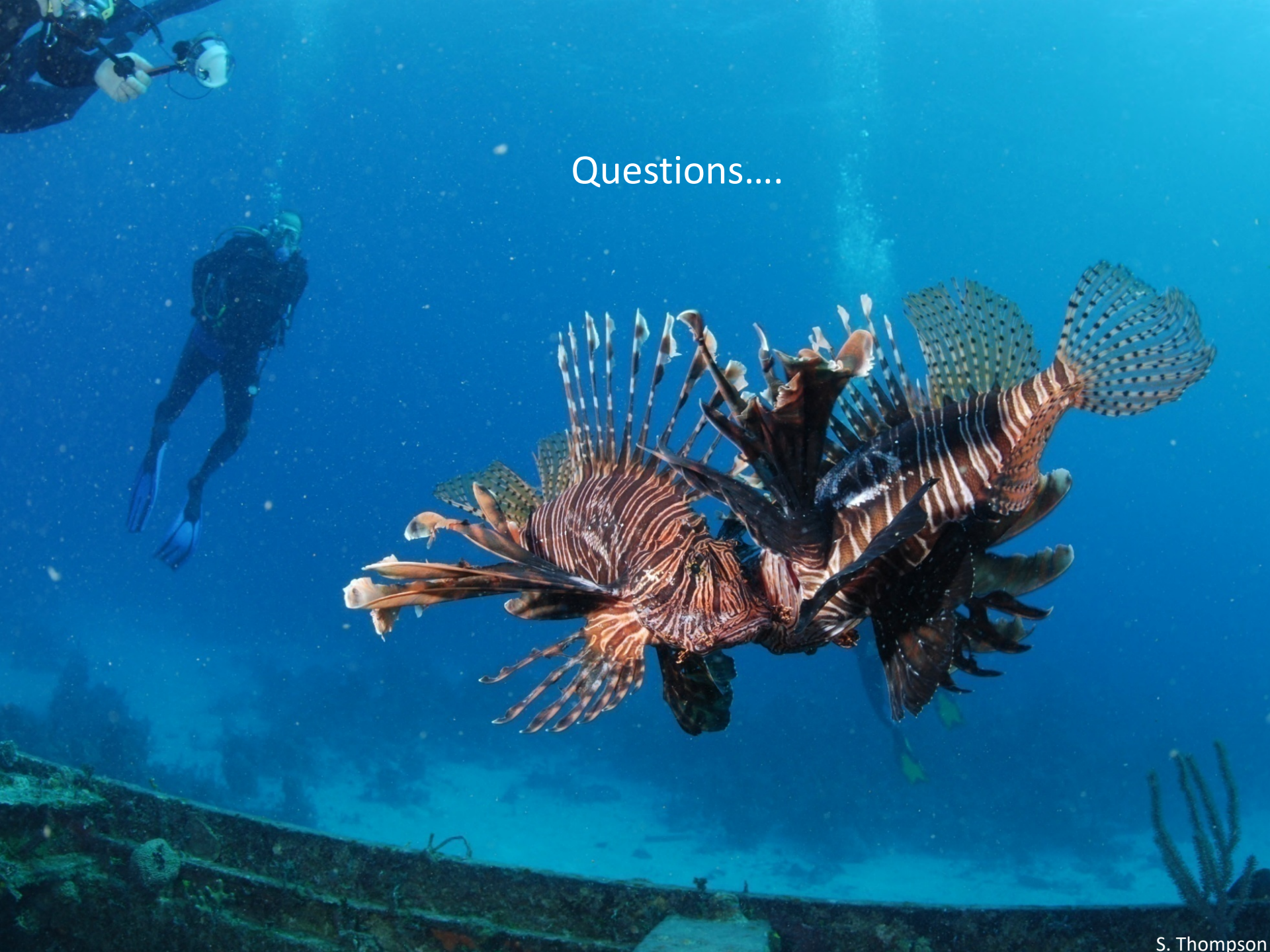
Lionfish management?



What 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

KW Fantasy Fest 2009


Questions….
S. Thompson

Field Guide to the Nonindigenous Marine Fishes of Florida

Schofield, P. J., J. A. Morris, Jr. and L. Akins

USGS science for a changing world

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