Thirty Years of Change in Reef Fish Communities in the Florida Keys: Results from a Long-Term Monitoring Program

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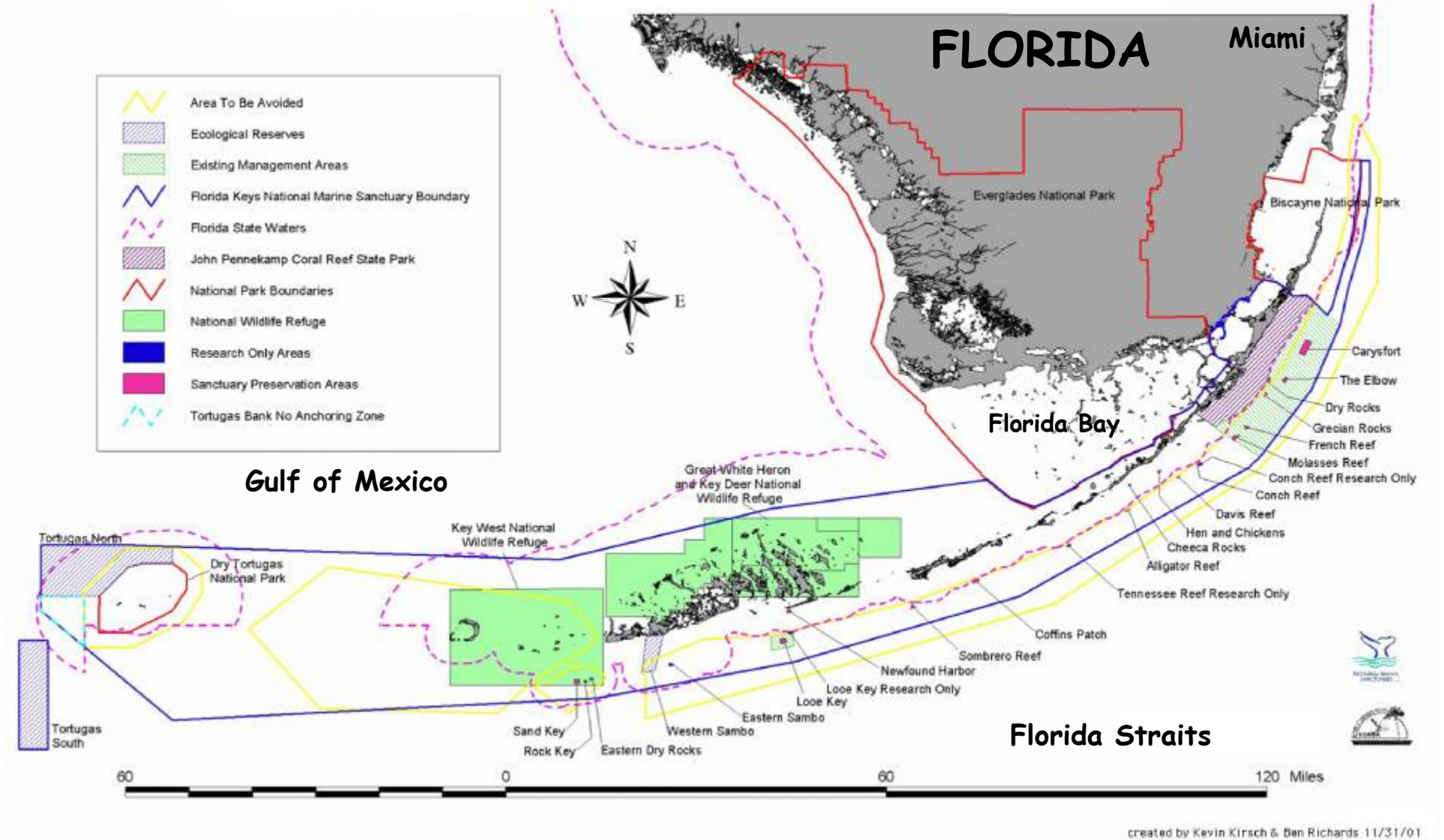
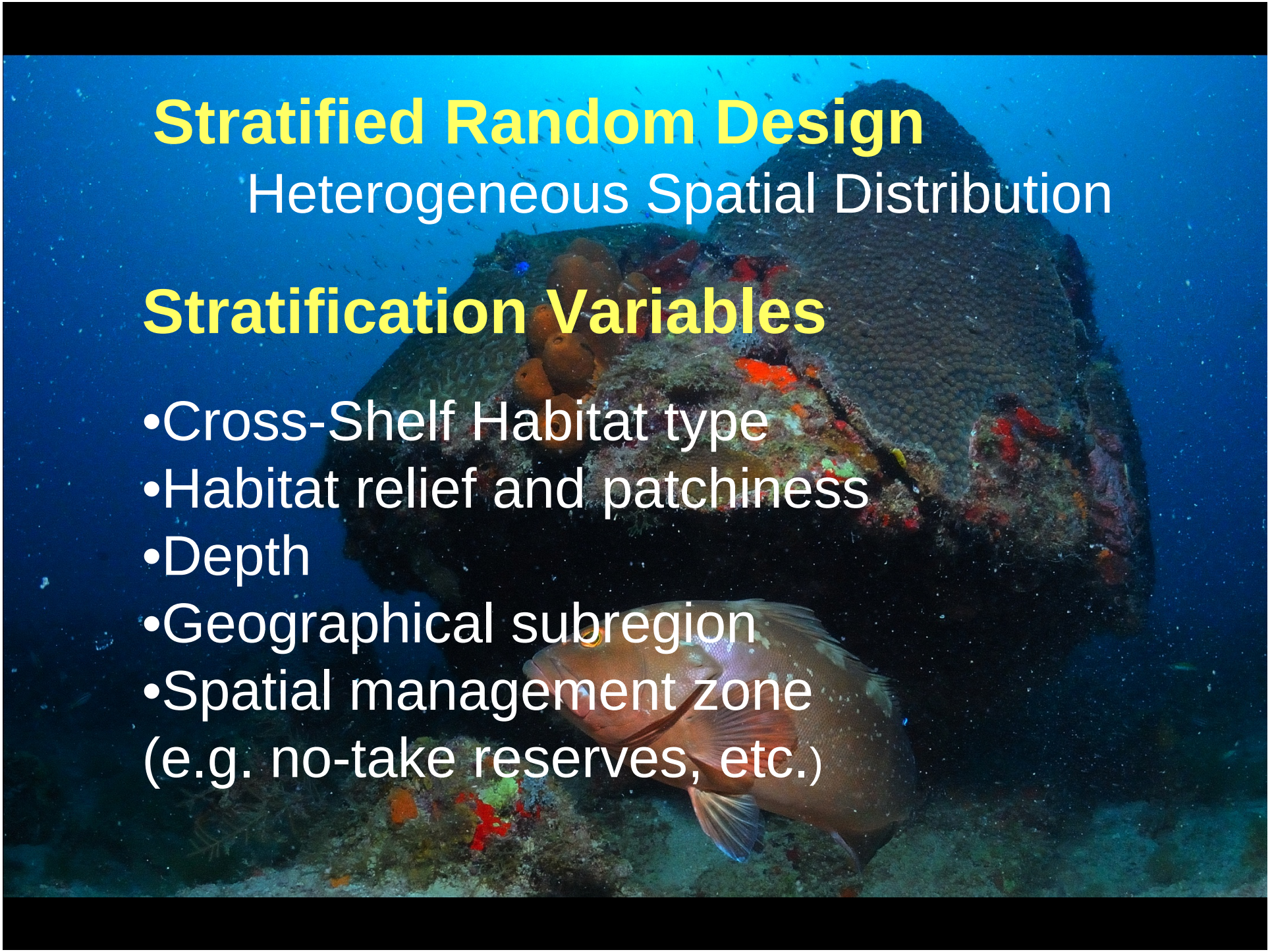
Reef Visual Census (RVC) program

- Describe status and trends of fish populations in the FL Keys
- Provide fisheries-independent data for stock assessments
- Evaluate management actions
- Allow synoptic analysis of large temporal and spatial scale changes in ecosystems
- Began 30 years ago and methodology is essentially unchanged

The managed Florida Keys coral reef ecosystem




15 Meters



Stratified Random Design

Heterogeneous Spatial Distribution

Stratification Variables

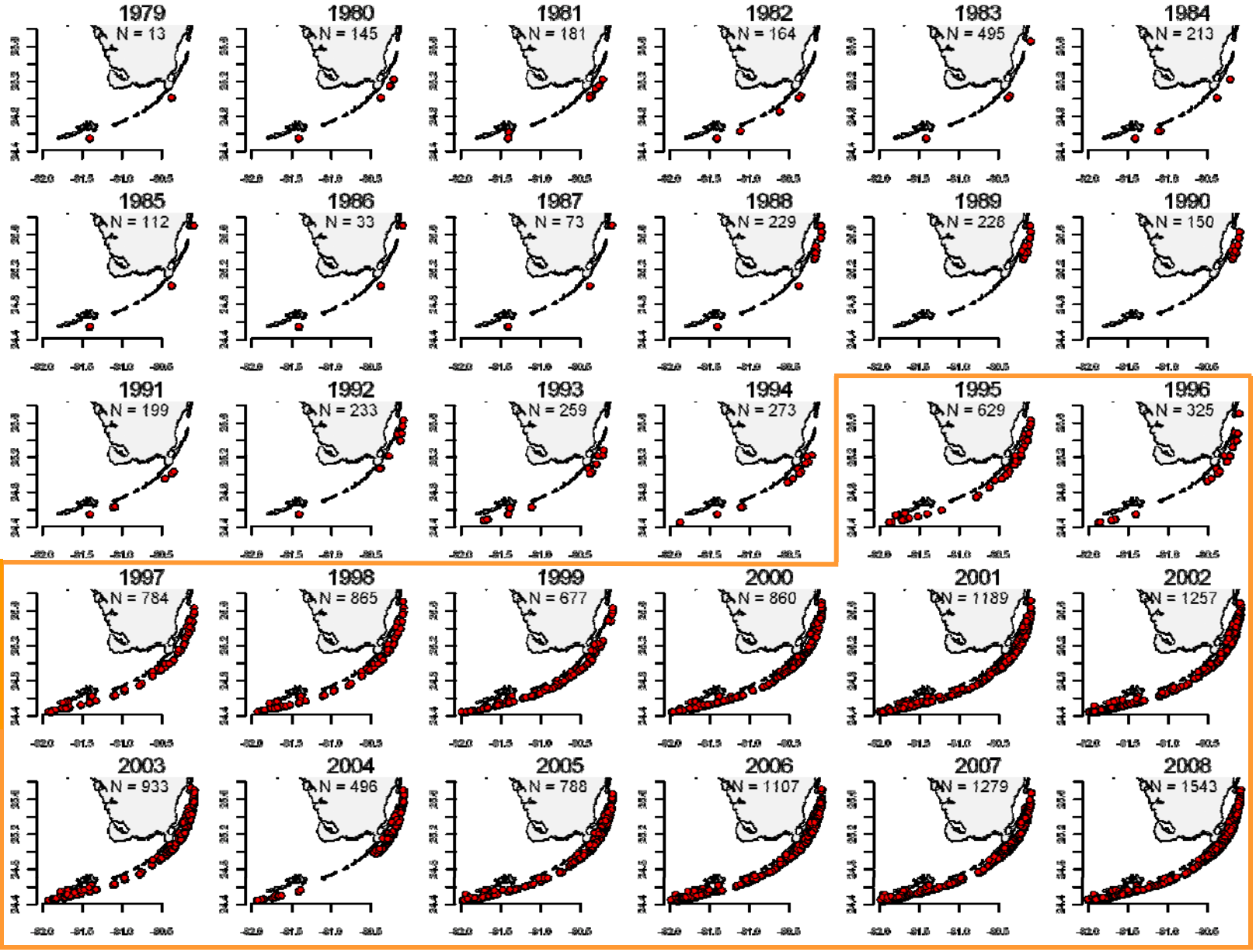
- Cross-Shelf Habitat type
- Habitat relief and patchiness
- Depth
- Geographical subregion
- Spatial management zone

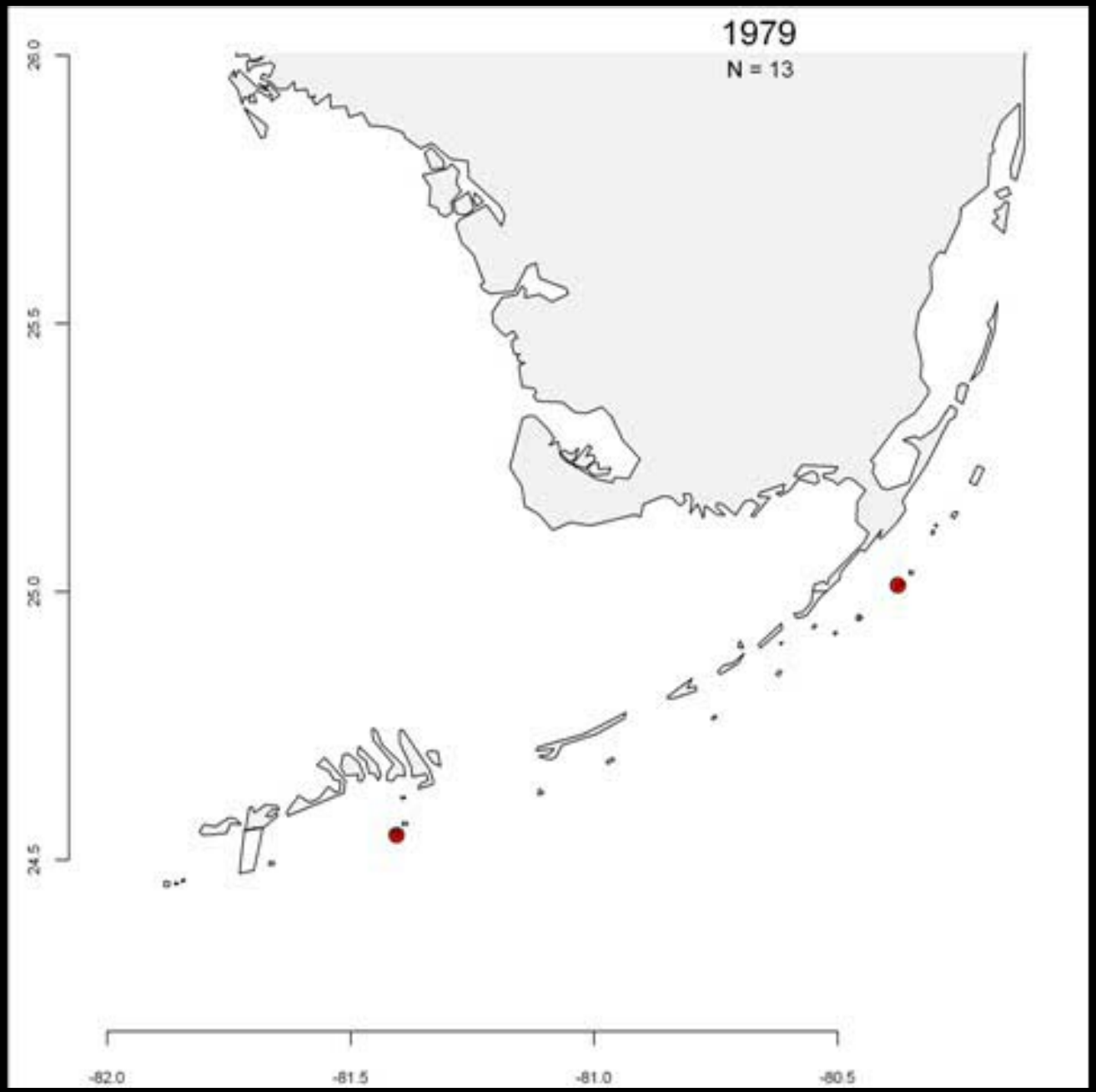
(e.g. no-take reserves, etc.)

RVC Florida Keys Sampling Sites 1979-2009

Experimental sample design 1979-1994

Survey sample design 1995-2009




1979
N = 13
26.0
25.5
25.0
24.5
-82.0
-81.5
-81.0
-80.5

Program Summary

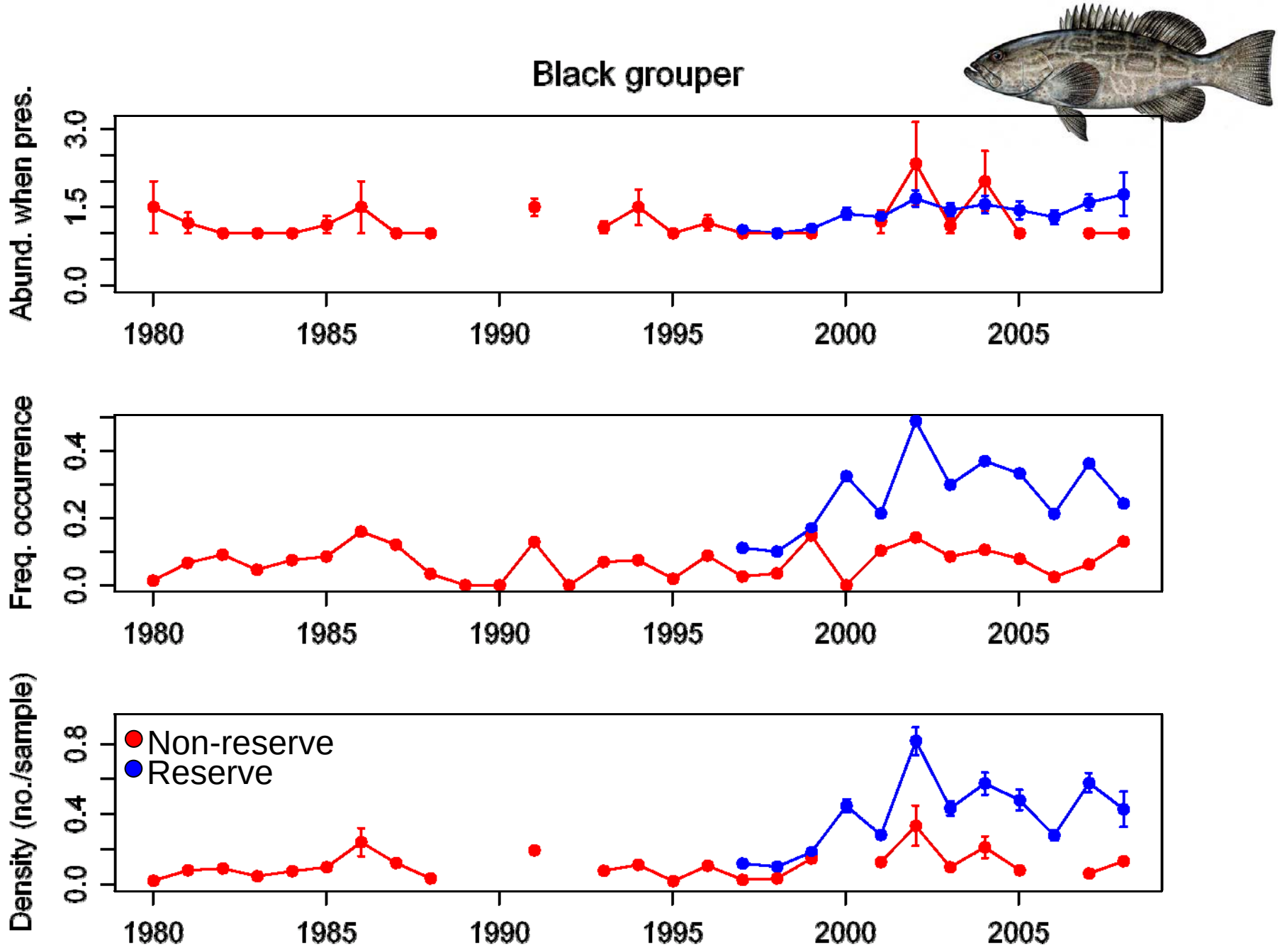
- 16,899 surveys conducted through 2008
- 366,511 records (species x survey) through 2008
- 161 divers used

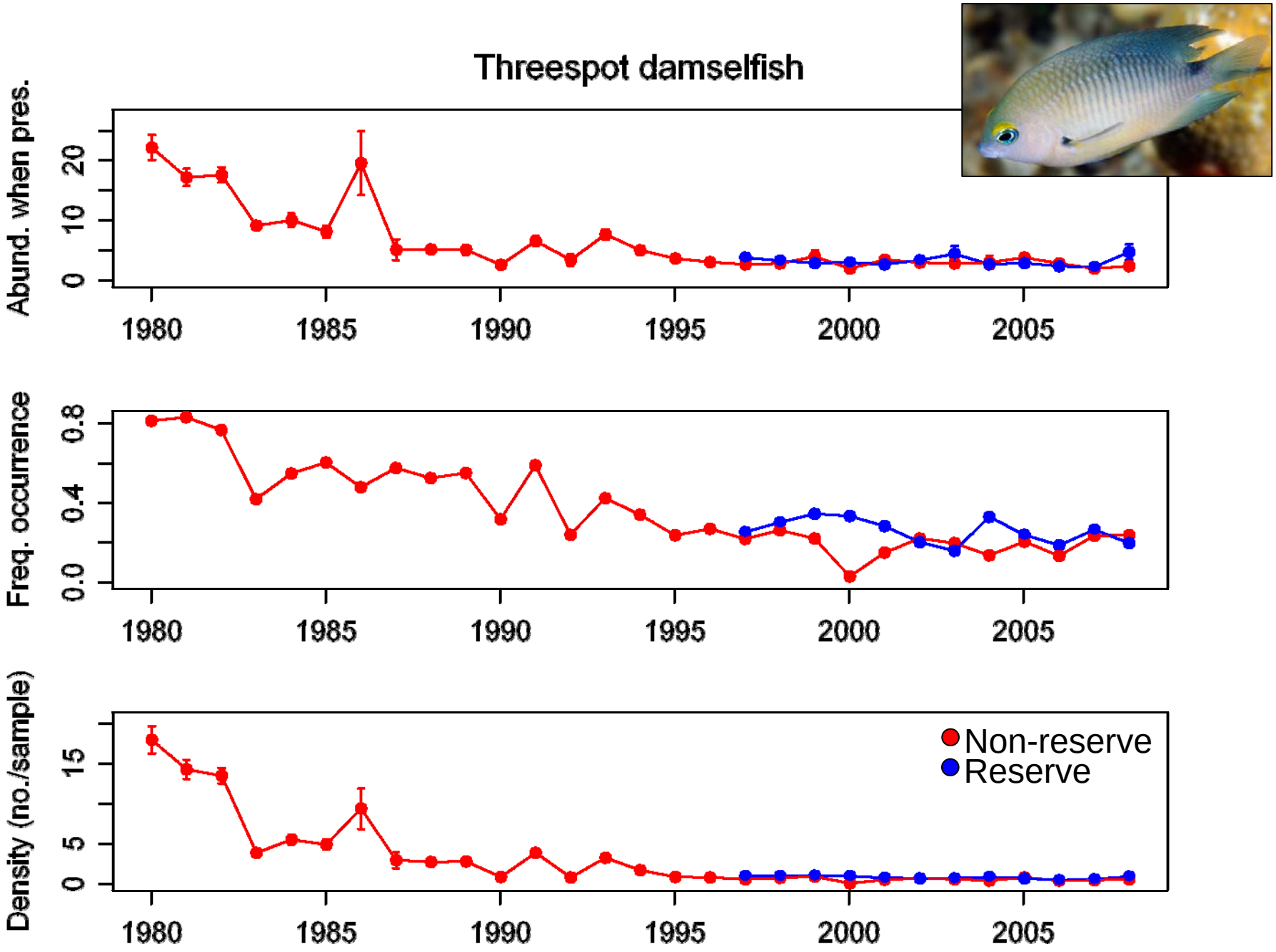
Rough Timeline

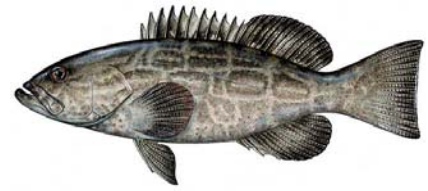
- 1950s-1970s (and before): Florida Keys overfished
- 1979-1980: Reef fish monitoring begins with experimental design
- Mid 1980s: Some fishery regulations implemented (size limits, bag limits)
- 1995: Modified to survey design; sampling intensified
- 1997: Marine reserves implemented in FL Keys
- 2001: Marine reserves added to Dry Tortugas bank
- 2007: Marine reserve added to Dry Tortugas National Park

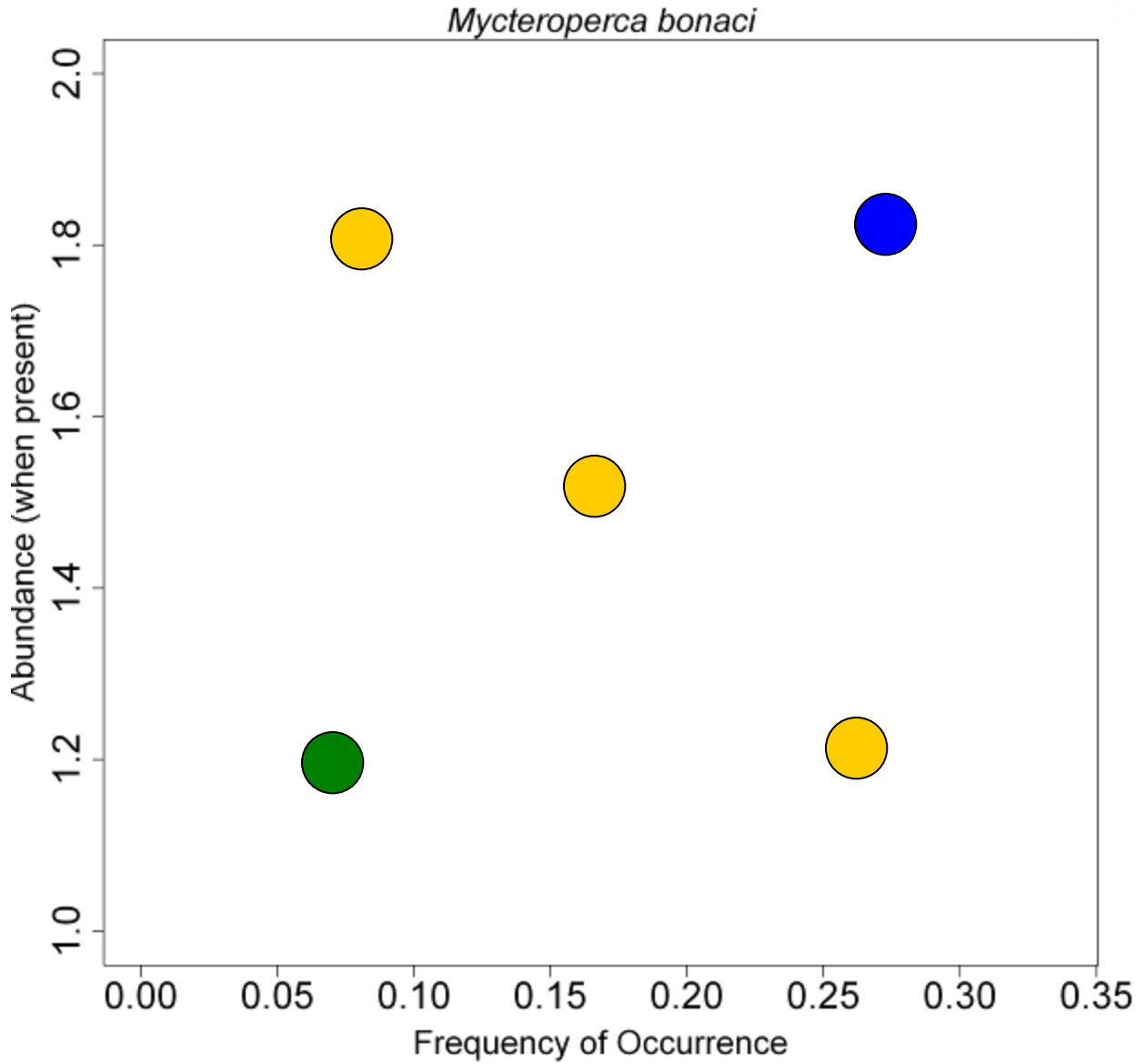
This analysis

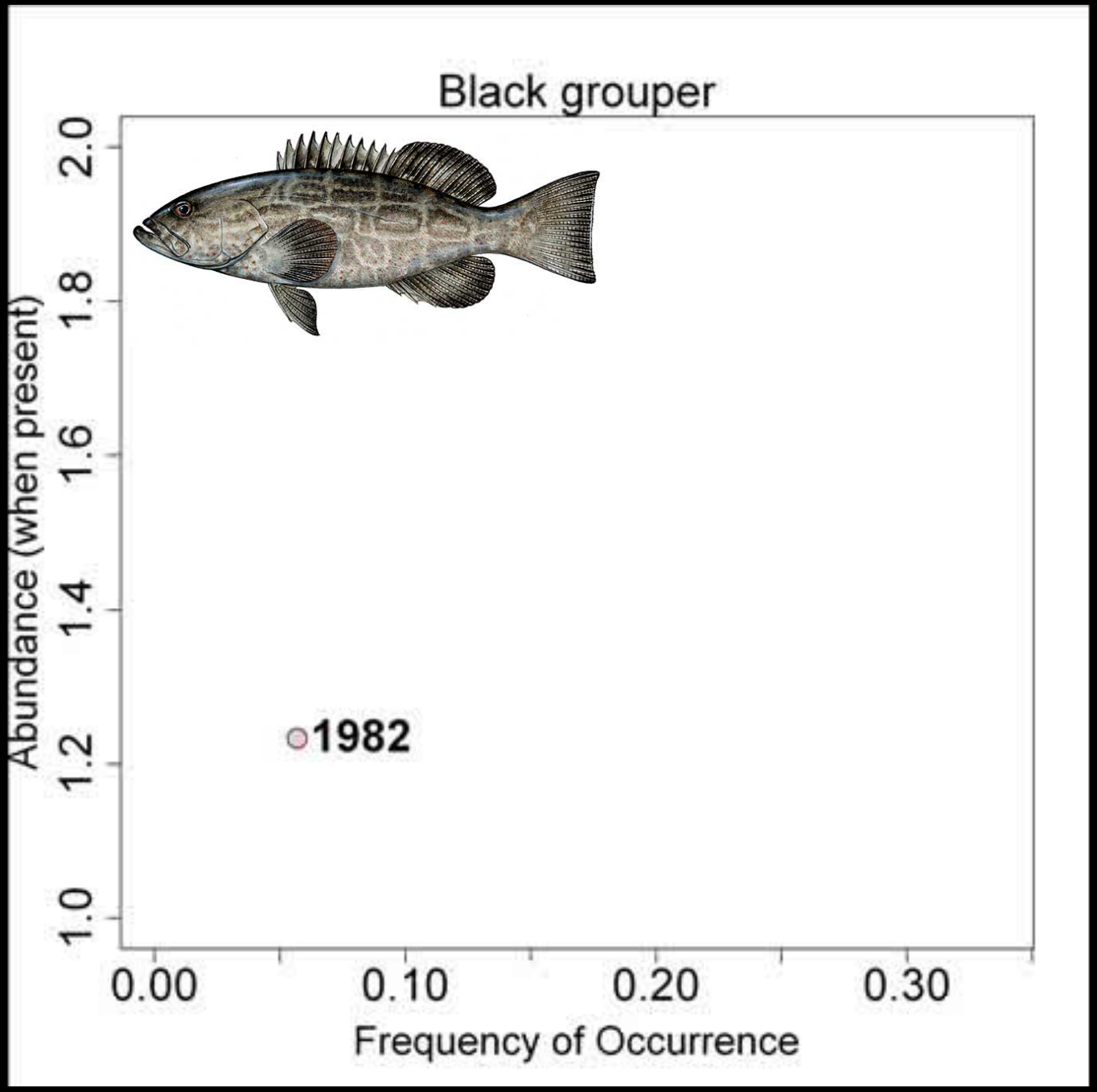
- Restricted to high-relief spur & groove forereefs
- Sanctuary Preservation Areas (no-take reserves; SPAs) implemented in 1997
  - ‘Reserve’ analyses: only areas that became reserves pre-1997
  - ‘Non-reserve’ analyses: all areas pre-1997 and only areas open to fishing after 1997
- Response variables include:
  - Biomass
  - Abundance when present (i.e. excludes zeros)
  - Frequency of occurrence
  - Density (i.e. includes zeros)

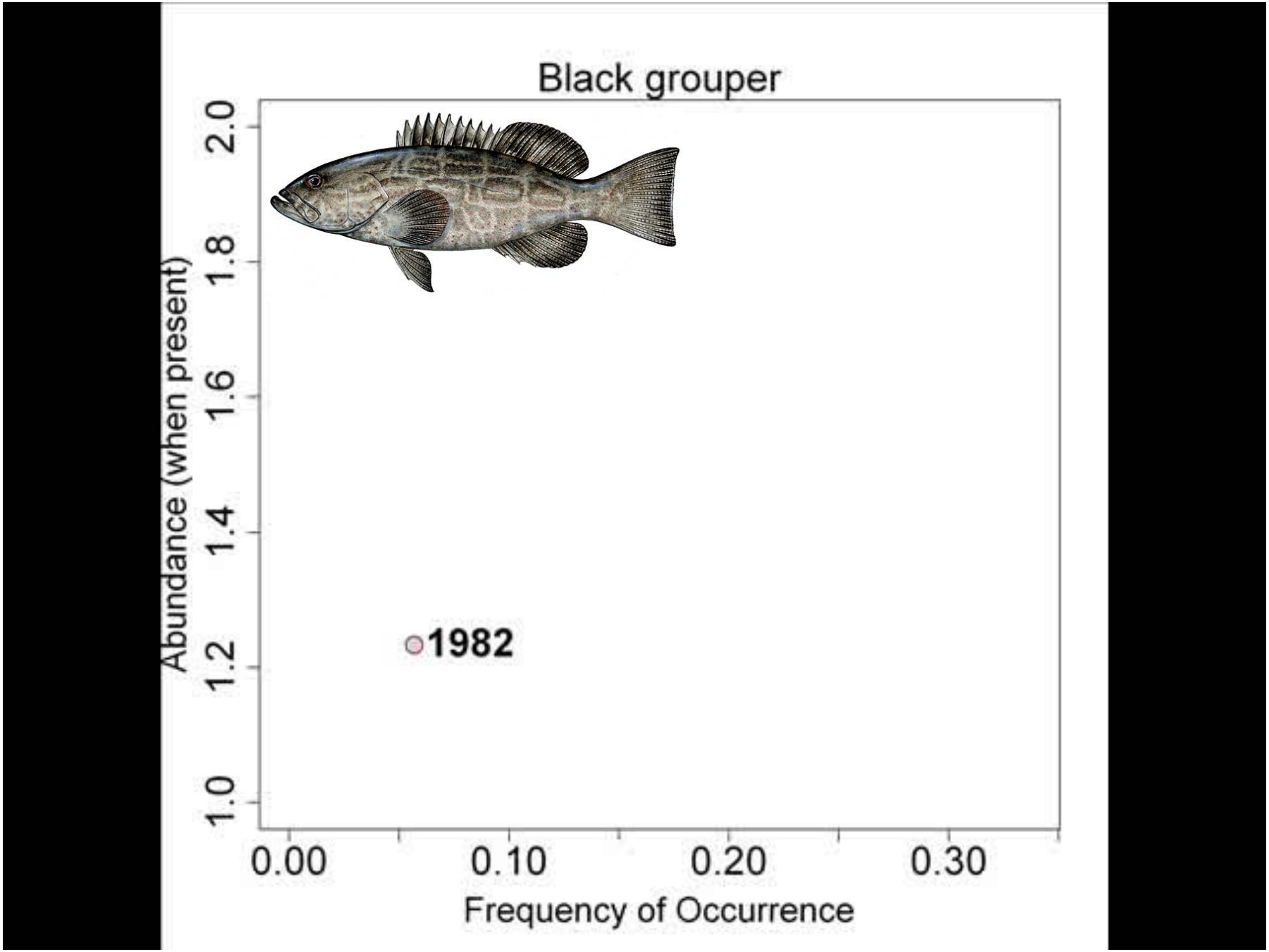

Black grouper
Abund. when pres.
0.0
1.5
3.0
1980
1985
1990
1995
2000
2005
Freq. occurrence
0.0
0.2
0.4
Density (no./sample)
0.0
0.4
0.8
Non-reserve
Reserve


Threespot damselfish
Abund. when pres.
0
10
20
1980
1985
1990
1995
2000
2005
Freq. occurrence
0.0
0.4
0.8
1980
1985
1990
1995
2000
2005
Density (no./sample)
0
5
15
1980
1985
1990
1995
2000
2005
Non-reserve
Reserve

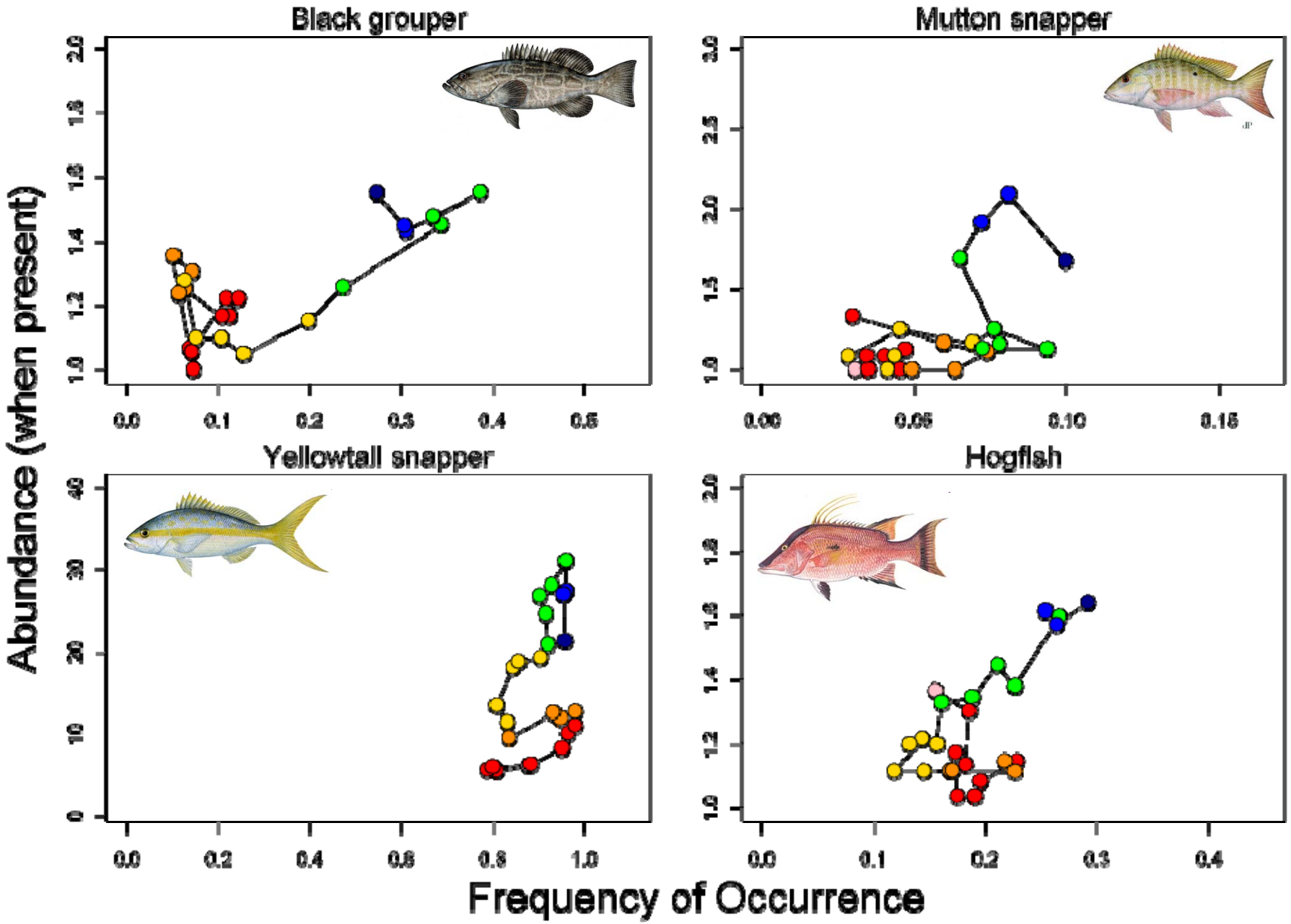



Mycteroperca bonaci
Abundance (when present)
2.0
1.8
1.6
1.4
1.2
1.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Frequency of Occurrence

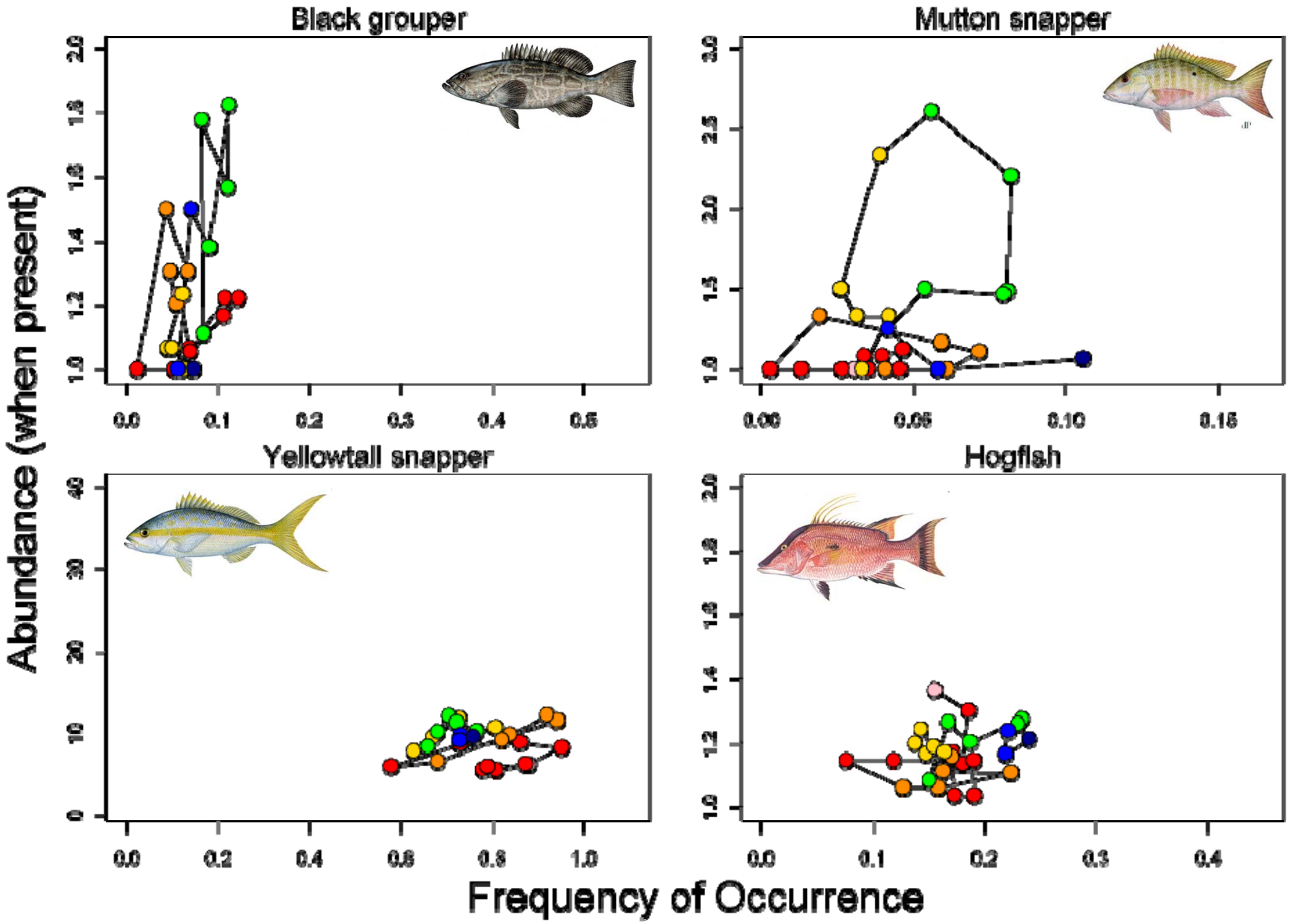

Black grouper
Abundance (when present)
2.0
1.8
1.6
1.4
1.2
1.0
1982
0.00
0.10
0.20
0.30
Frequency of Occurrence


Black grouper
Abundance (when present)
2.0
1.8
1.6
1.4
1.2
1.0
1982
0.00
0.10
0.20
0.30
Frequency of Occurrence

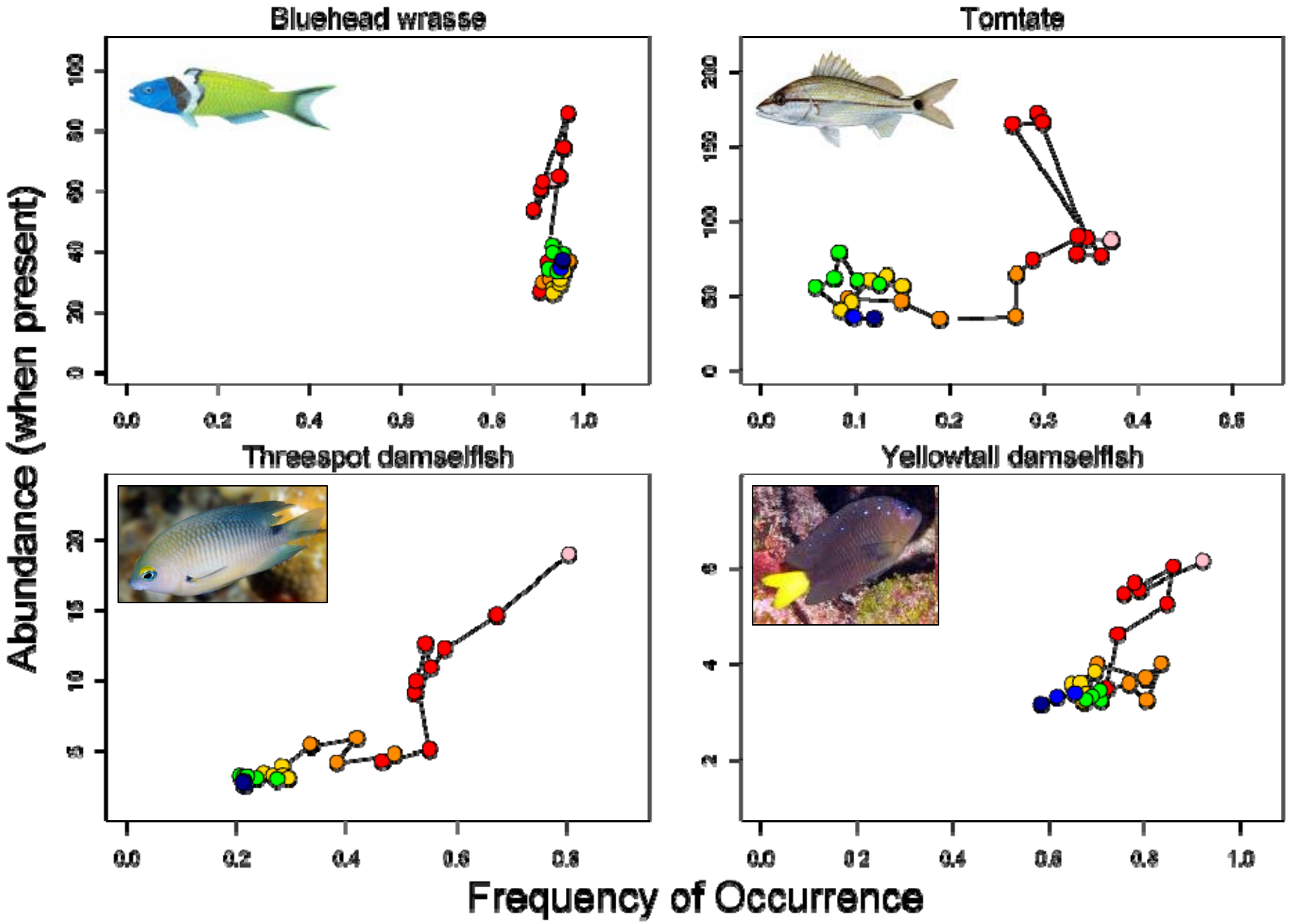
Reserves only (after 1997)

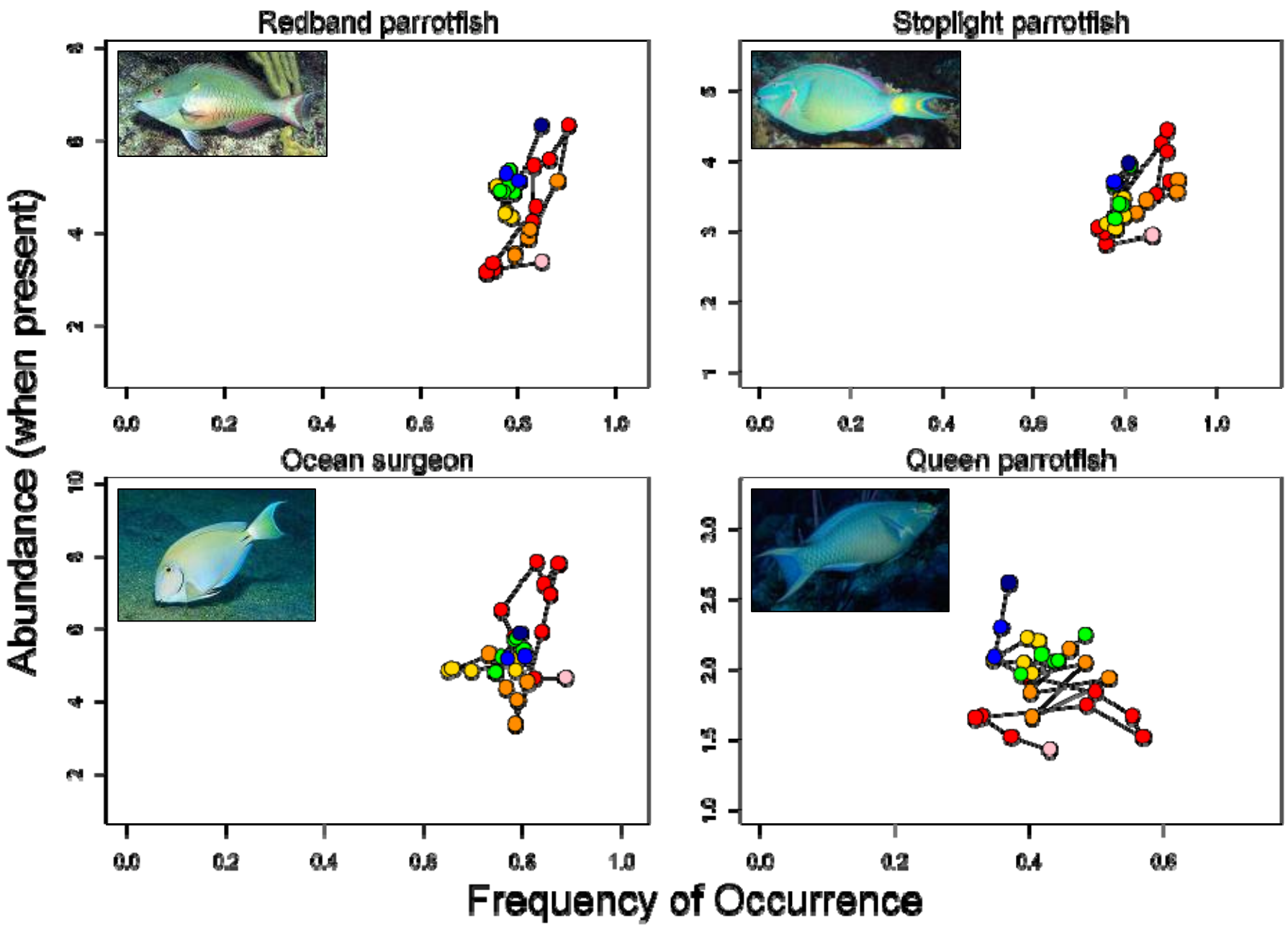


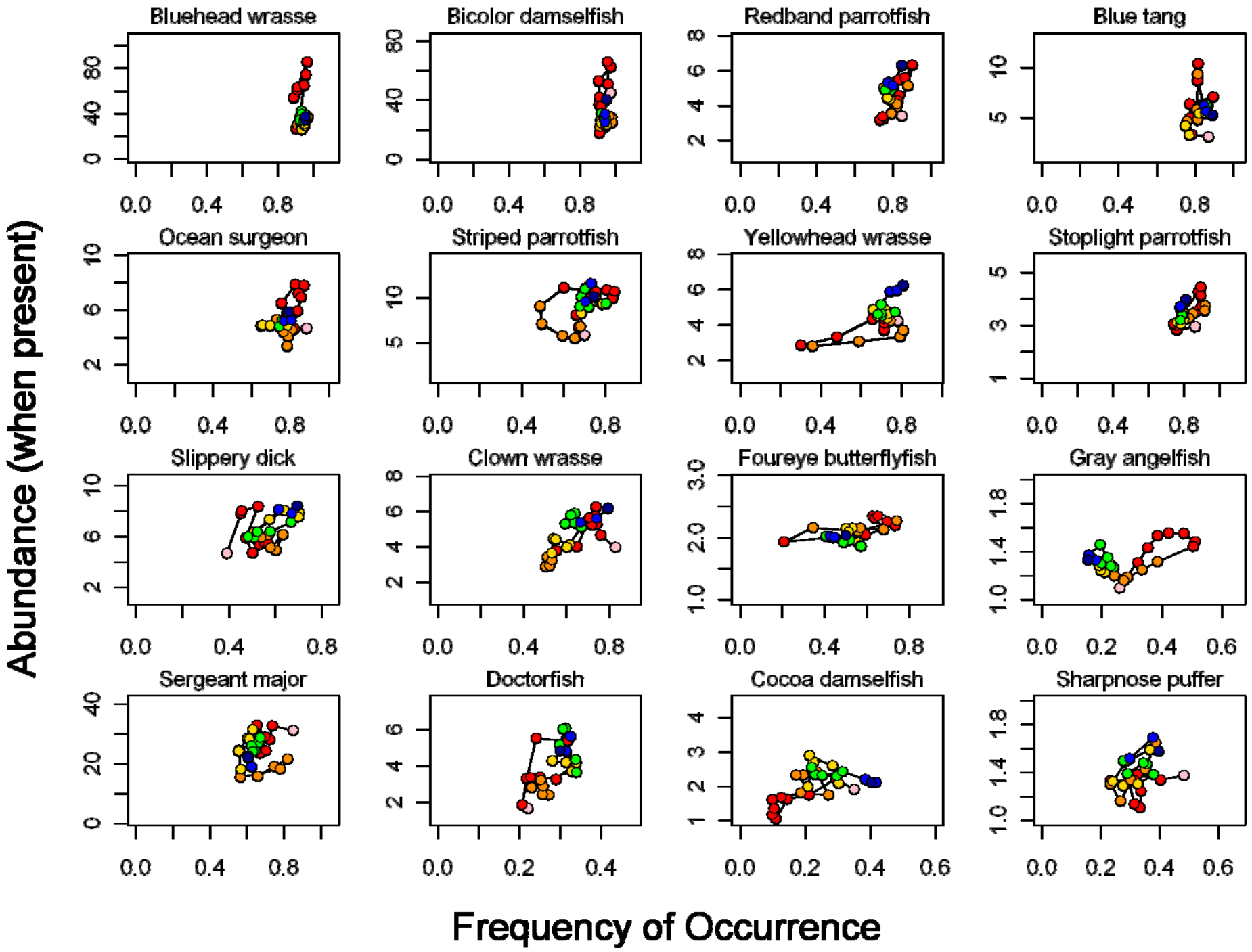
Non-reserves only (after 1997)

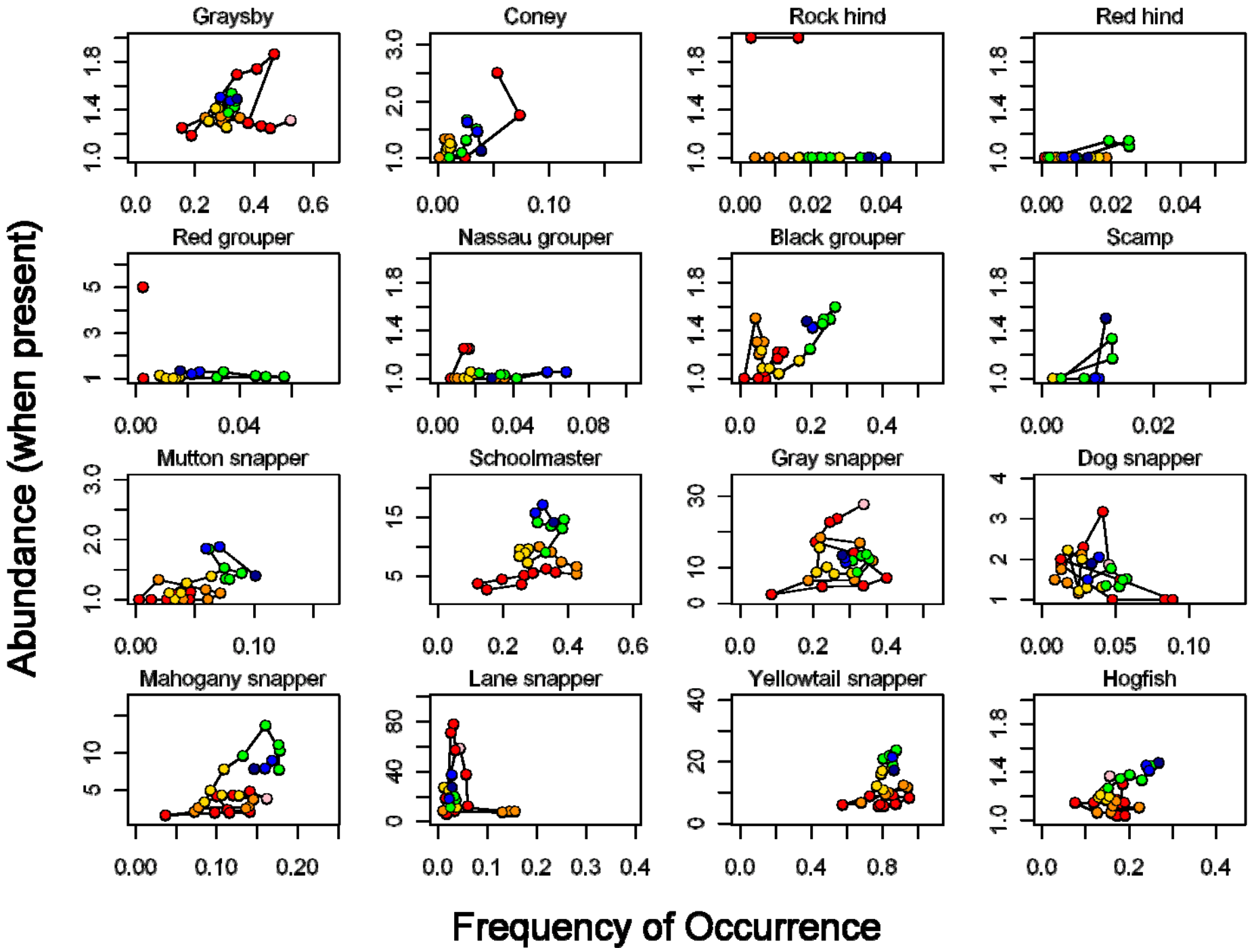


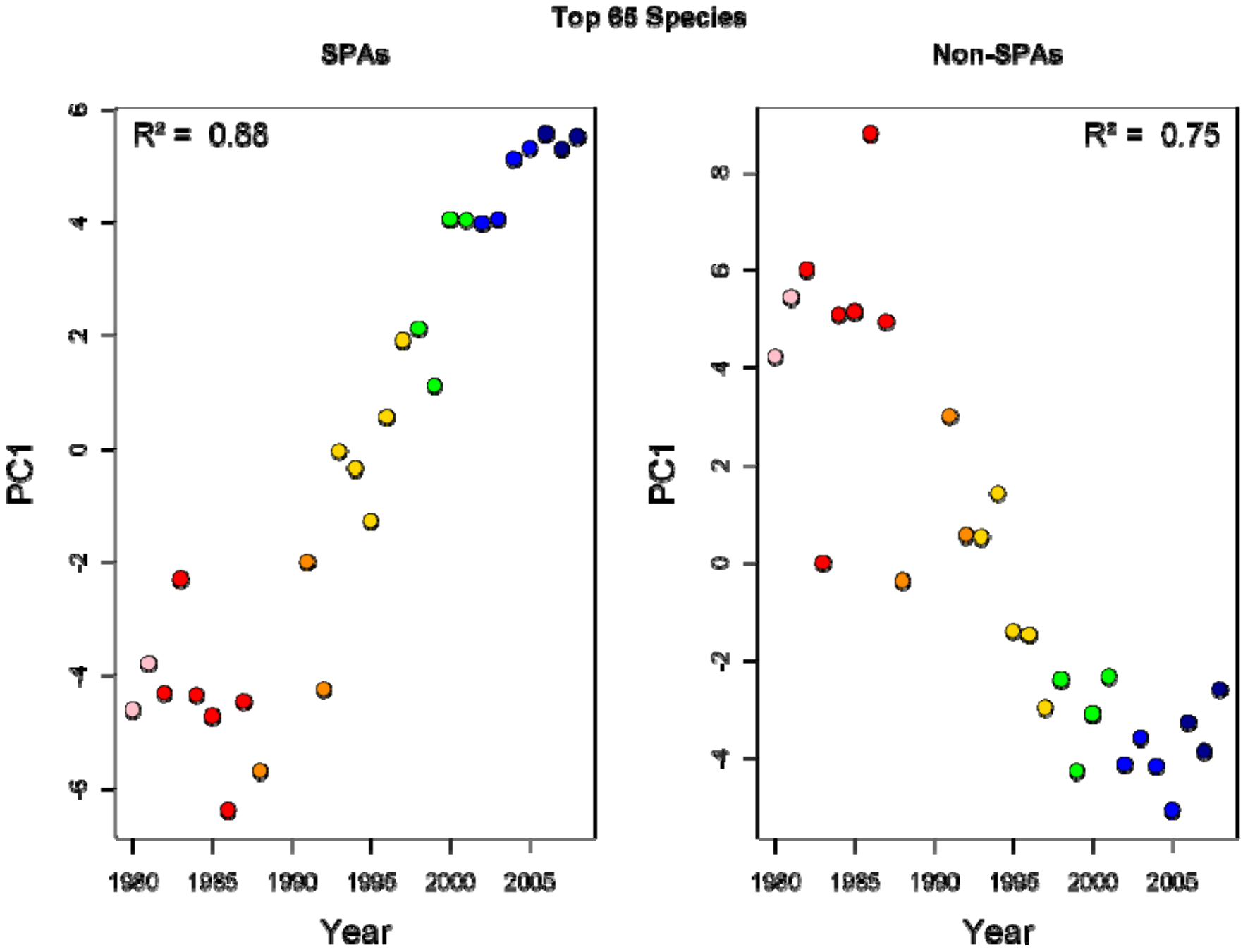
All data (reserves and non-reserves)




Redband parrotfish
Stoplight parrotfish
Ocean surgeon
Queen parrotfish
Abundance (when present)
Frequency of Occurrence


Bluehead wrasse
Bicolor damselfish
Redband parrotfish
Blue tang
Ocean surgeon
Striped parrotfish
Yellowhead wrasse
Stoplight parrotfish
Slippery dick
Clown wrasse
Foureye butterflyfish
Gray angelfish
Sergeant major
Doctorfish
Cocoa damselfish
Sharpnose puffer
Abundance (when present)
Frequency of Occurrence


Graysby
Coney
Rock hind
Red hind
Red grouper
Nassau grouper
Black grouper
Scamp
Mutton snapper
Schoolmaster
Gray snapper
Dog snapper
Mahogany snapper
Lane snapper
Yellowtail snapper
Hogfish
Abundance (when present)
Frequency of Occurrence


Top 65 Species
SPAs
Non-SPAs
R² = 0.88
R² = 0.75
PC1
Year
1980
1985
1990
1995
2000
2005

Principal components loadings

Non-SPAs

Species	PC1	Trophic Group
Threespot damselfish	0.22	Herbivore
Yellowtail damselfish	0.21	Herbivore
Rock beauty	0.21	Invertivore
Bluehead wrasse	0.20	Invertivore
Foureye butterflyfish	0.20	Invertivore
Beaugregory	-0.20	Herbivore
Harlequin bass	0.19	Invertivore
White grunt	-0.19	Invertivore
Spanish hogfish	0.19	Invertivore
Yellow goatfish	0.18	Invertivore
Tomtate	0.18	Invertivore
Sergeant major	0.17	Planktivore
Cocoa damselfish	-0.17	Herbivore
French grunt	-0.17	Invertivore
Bicolor damselfish	0.16	Herbivore

SPAs

Species	PC1	Trophic Group
White grunt	0.22	Invertivore
French grunt	0.22	Invertivore
Harlequin bass	-0.20	Invertivore
Blue angelfish	-0.20	Invertivore
Yellowtail snapper	0.20	Planktivore
Foureye butterflyfish	-0.19	Invertivore
Threespot damselfish	-0.19	Herbivore
Tomtate	-0.19	Invertivore
Schoolmaster	0.19	Carnivore
Porkfish	0.19	Invertivore
Gray angelfish	-0.18	Invertivore
Caesar grunt	0.17	Invertivore
Bluestriped grunt	0.17	Invertivore
Rock beauty	-0.17	Invertivore
Black grouper	0.17	Top predator

Summary

- Able to summarize complex data in a meaningful way
- Provides synoptic view of 30 years of trends
- Generates a variety of testable hypotheses about factors that control fish abundance in the FL Keys
- Shows consistent change in community structure over 30 years in FL Keys, both in and out of marine reserves
- Provides information to managers about management actions (e.g. reserves), fishery status, and other impacts (e.g. hurricanes)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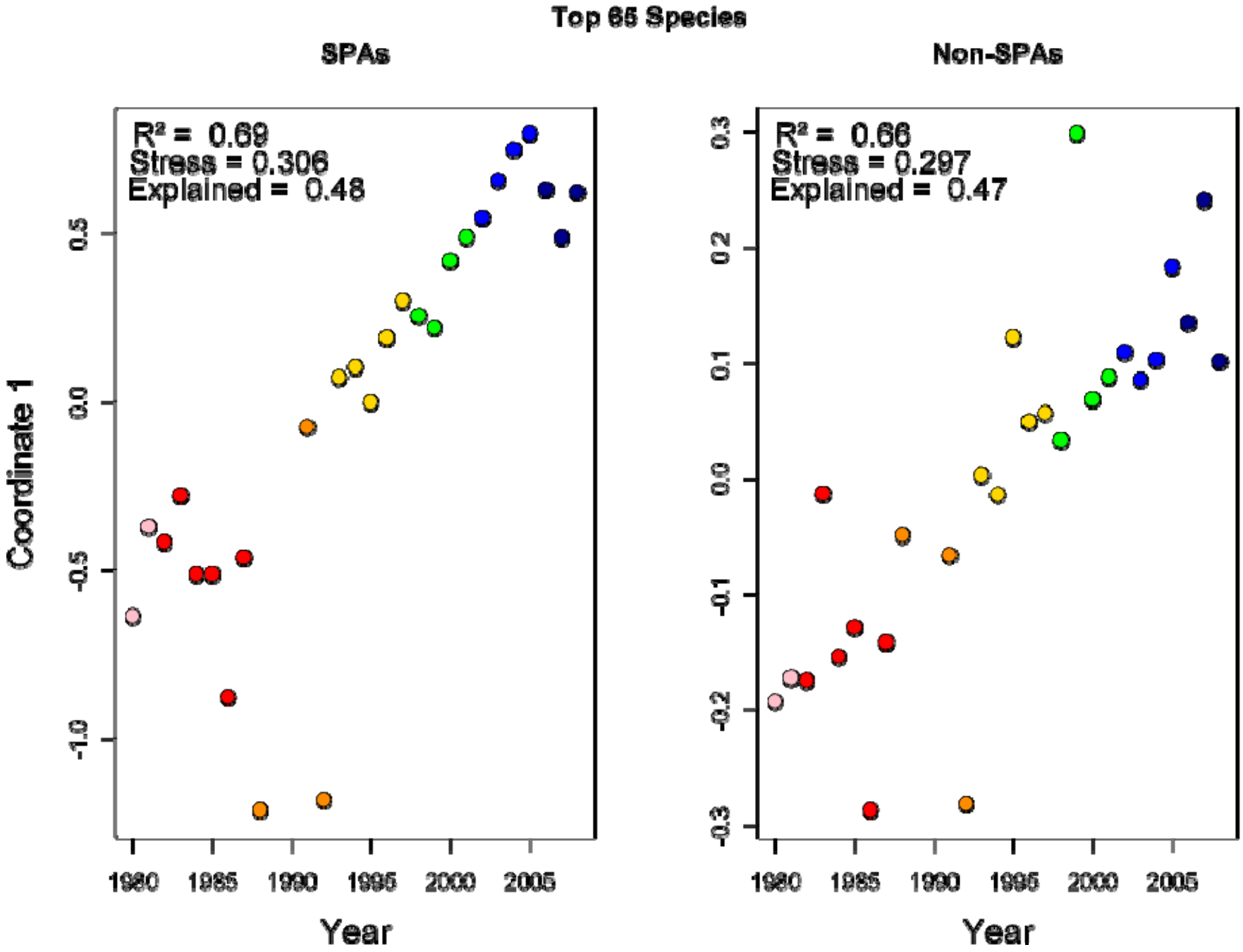
U.S. DEPARTMENT OF COMMERCE
NOAA
CORAL REEF
CONSERVATION PROGRAM
FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION
ROSENSTIEL SCHOOL OF MARINE AND ATMOSPHERIC SCIENCE
RSMAS
UNIVERSITY OF MIAMI
NATIONAL PARK SERVICE

Hogfish reproduction in the FL Keys

	Marine Reserve	Fished Area
Survey effort	7 hrs	19 hrs
Area surveyed	2.5 ha	9.6 ha
Number of spawns	55	0

Muñoz, Burton, et al. 2009


Top 65 Species
SPAs
Non-SPAs
R² = 0.69
Stress = 0.306
Explained = 0.48
R² = 0.66
Stress = 0.297
Explained = 0.47
Coordinate 1
Year
Year
1980
1985
1990
1995
2000
2005
-1.0
-0.5
0.0
0.5
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3

1957

McClenachen 2009

2007

McClenachen 2009