Regional Lionfish Abundance, Habitat Use, and Impact Utilizing an Existing Fisheries Monitoring Survey

WALTER BUBLEY, JOSEPH BALLENGER, DAWN GLASGOW, MARGARET WALKER & PETER KINGSLEY-SMITH

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES

NOAA Fisheries
National Marine Fisheries Service

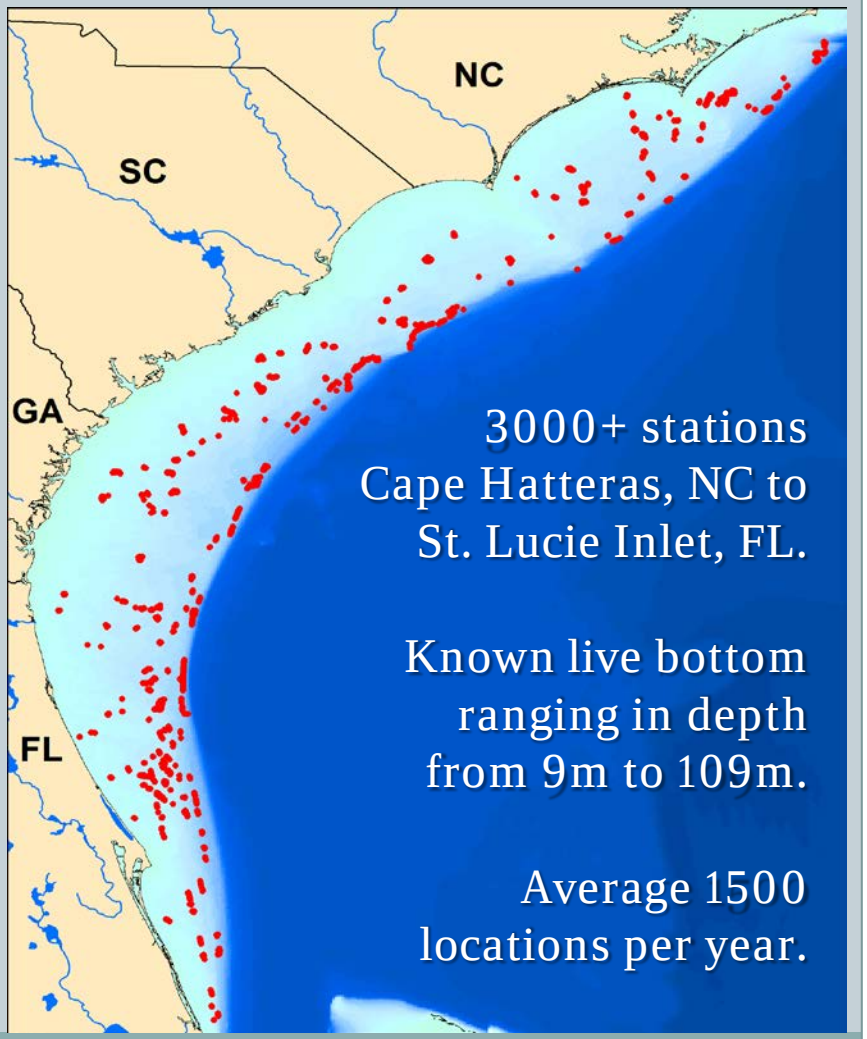
Southeast Reef Fish Survey

- SERFS - Long-term, regional, fisheries-independent monitoring program.
- The main goal of SERFS is to monitor long term changes in relative abundance, age composition, and length frequencies of reef fish found on hard bottom habitats.
- Recently applied to studying lionfish over broad spatial scale and across multiple years using a regionally standardized approach.
  - **Ma**rine **R**esources **M**onitoring, **A**ssessment, and **P**rediction
    - **MARMAP** (1972) – SCDNR: Charleston, SC
  - **S**outh**E**ast **A**rea **M**onitoring and **A**ssessment **P**rogram-**S**outh **A**tlantic
    - **SEAMAP-SA** (2009) – SCDNR : Charleston, SC
  - **S**outh**E**ast **F**ishery **I**ndependent **S**urvey
    - **SEFIS** (2010) – NOAA: Beaufort, NC

Southeast Reef Fish Survey

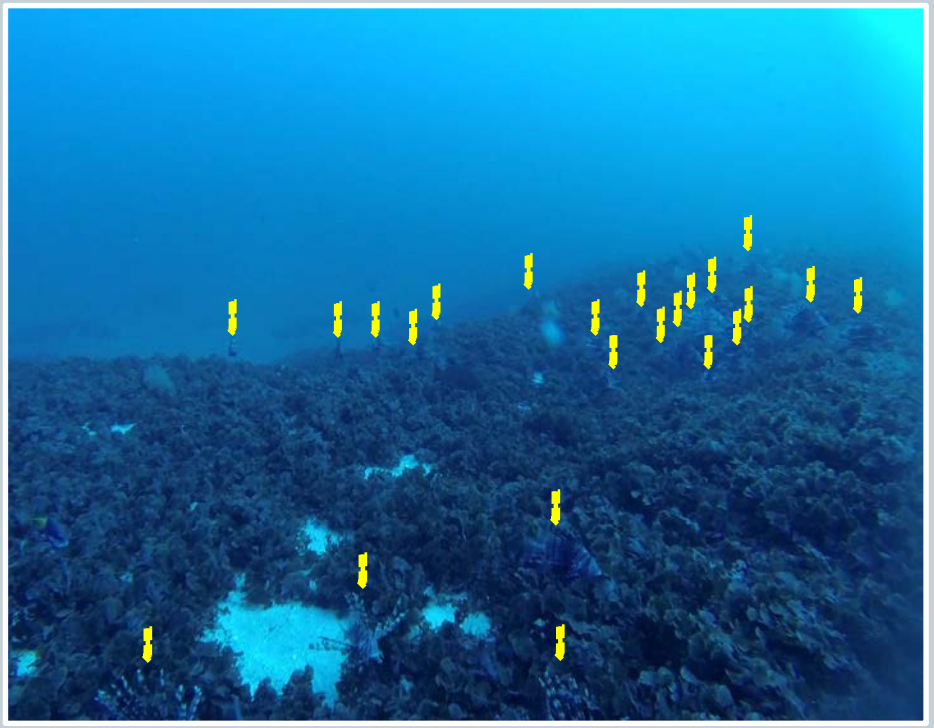
- Sampling locations (right)
- Chevron trap (1990)
- Video (2011)
- 90-min soak, CTD

1.7 m x 1.5 m x 0.6 m baited chevron trap



Video Data

- 20 minutes of video read– 1 frame every 30 seconds
  - 41 frames read per video
- Habitat characterized
- SumCount Lionfish
  - Total Lionfish seen in 41 frames
- MaxN Count
  - Most Lionfish in any frame



Objectives for Lionfish data

- Develop an index of abundance using video data
- Determine their effects on native fish assemblages

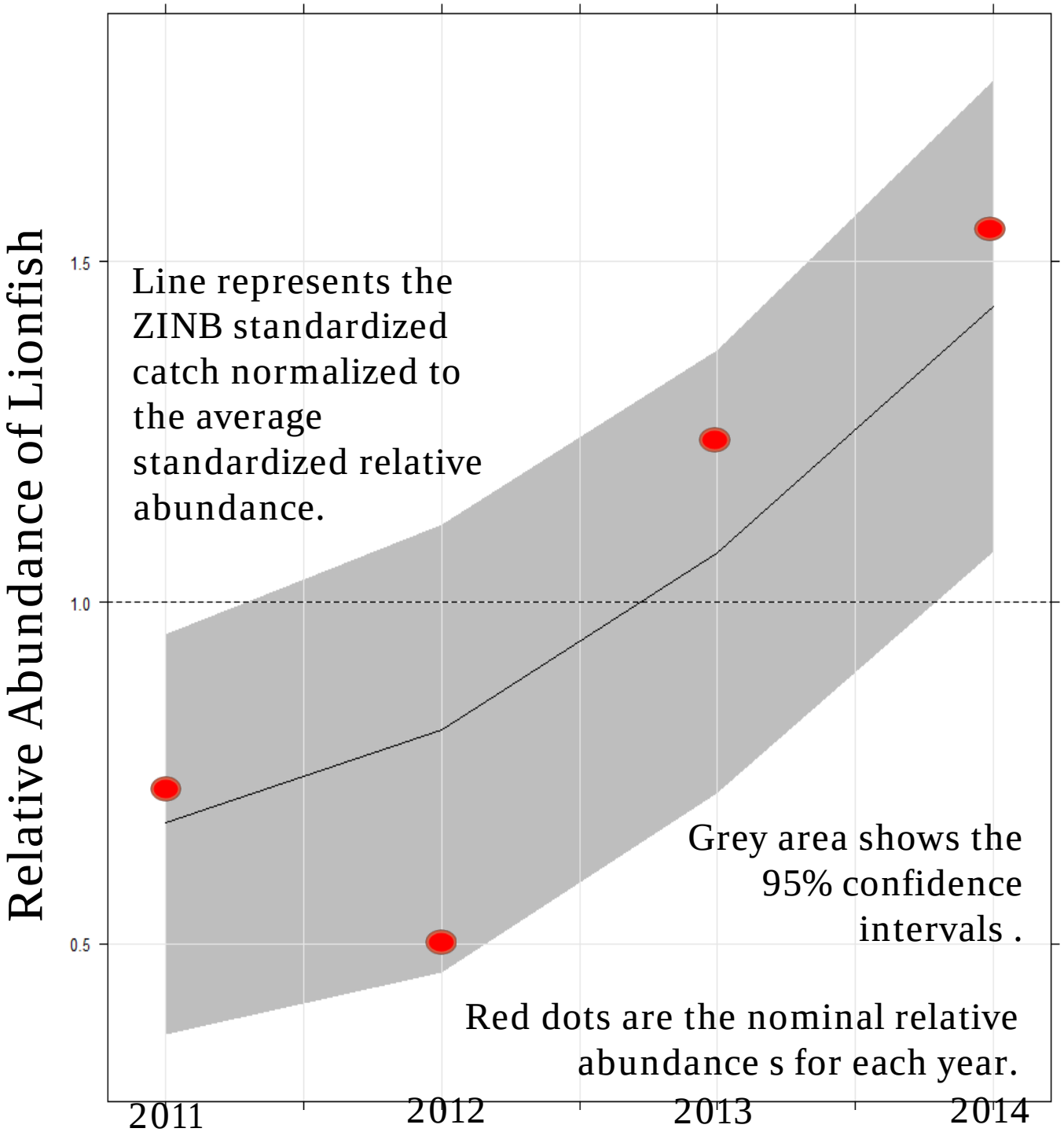
Methods - Abundance

- Zero-Inflated Negative Binomial Model was used to determine the relative abundance of lionfish.
- The best model was chosen using BIC (Bayesian Information Criterion) values and this model was used to determine a relative abundance index.
- Index normalized to series mean.

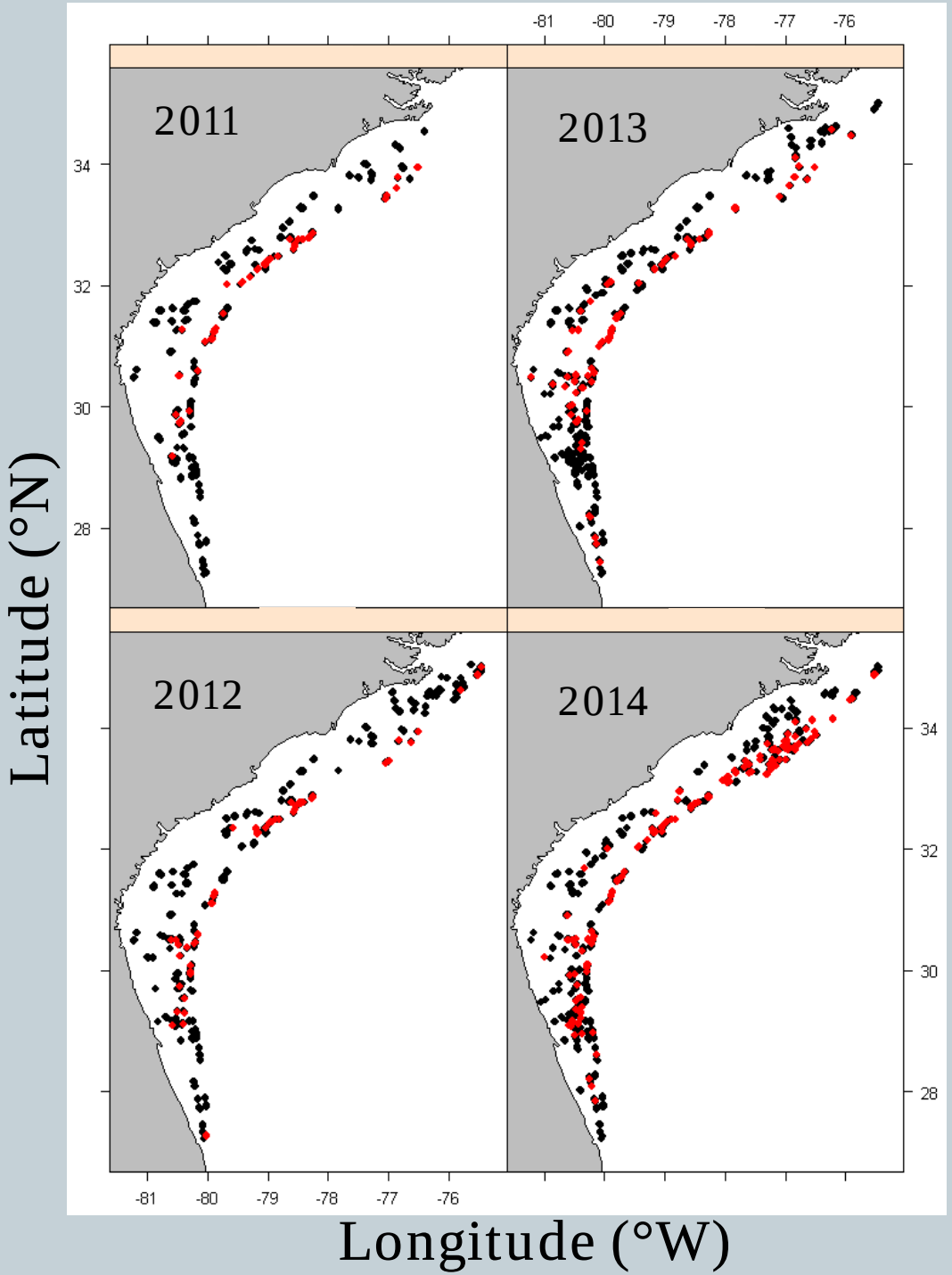
Results - Abundance

Year	Videos (n)	Prop. Positive LF
2011	675	0.0741
2012	1222	0.0597
2013	1396	0.0795
2014	1415	0.1449

- Zero-Inflation Sub-Model:
  - Year + Current Magnitude + Depth^3 + Depth^2 + Depth + Latitude^2 + Latitude + Biota Density^2 + Biota Density
- Count Sub-Model:
  - Year + Water Clarity + Substrate Size + Depth^3 + Depth^2 + Depth + Latitude + $\text{Bottom Temperature}^3$ + $\text{Bottom Temperature}^2$ + Bottom Temperature + Day of Year + Biota Density


Relative Abundance of Lionfish
1.5
1.0
0.5
Line represents the ZINB standardized catch normalized to the average standardized relative abundance.
Grey area shows the 95% confidence intervals .
Red dots are the nominal relative abundance s for each year.
2011
2012
2013
2014

- SERFS sampling distributions from 2011 to 2014 for the chevron traps.
- Black dots represent no lionfish; red dots represent at least one lionfish.
- Presence/absence only; not abundance.
- Minimal change in latitudinal range but increase in proportion of positive locations.



Methods - Species Assemblages

- **Video data for Federally managed species**
  - Priority species enumerated
    - Mostly large, piscivorous species (Snapper/Grouper/Jacks)
    - No significant differences between presence/absence of Lionfish in video alone (lack of niche overlap, too large to be eaten by lionfish)
- **Chevron Trap Catch Data**
  - ID, count, and measure all species
    - Includes smaller, forage species
    - Few Lionfish caught (only 17 since 1990 in ~15,000 traps; all of which were caught in the last 3 years)
- **Supplemented Lionfish abundance data using from video cameras affixed to trap**
  - Representative of presence/absence of lionfish
- **Multi-variate analysis (PRIMER-E software)**

Methods - Species Assemblages

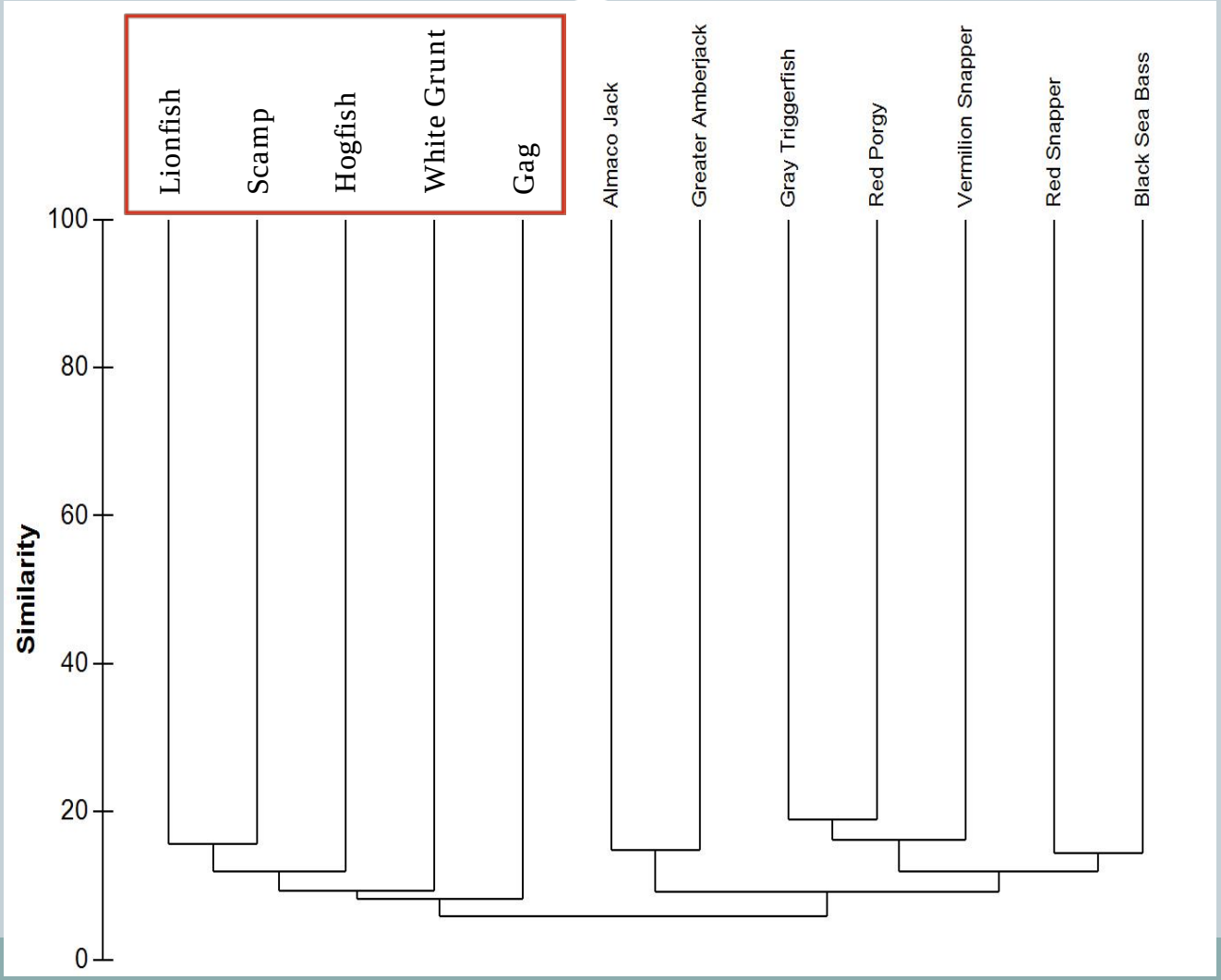
- **Two-way crossed Analysis of Similarity (ANOSIM: multi-variate equivalent to ANOVA)**
  - Account for year and latitude effect
  - Depth held constant (30-55m); core of lionfish abundances
  - Results – Effects on species assemblage difference between sites:
    - Lionfish presence: Significant ($R = 0.04$; $p = 0.018$)
    - Year and Latitude: Significant ($R = 0.16$; $p = 0.001$)
- **Similarity Percentages Analysis (SIMPER)**
  - Determine which individual species contribute most to assemblage differences between sites with and without lionfish present.
- **Cluster Analysis**
  - Identify which species occur most frequently in assemblages in which lionfish were present
    - Potentially vulnerable species (competition and/or predation?)

SIMPER Analysis Results

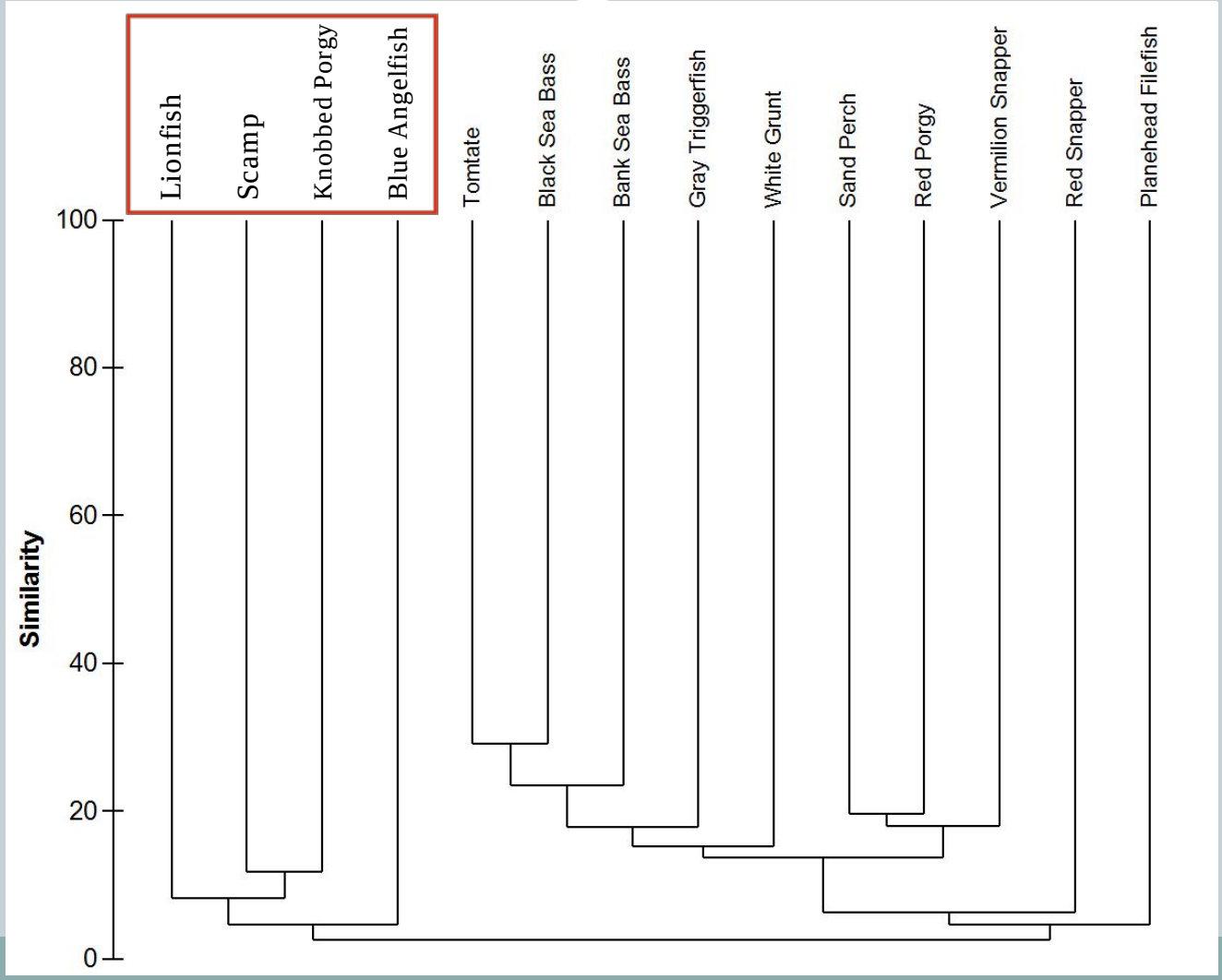
	Lionfish Absent	Lionfish Present	Difference
Species	Average Abundance	Average Abundance	
Black Sea Bass	2.99	0.98	↓
Tomtate	1.59	1.53	
Red Porgy	0.76	0.98	
Gray Triggerfish	0.55	0.85	↑
Vermilion Snapper	0.49	0.45	↓
Bank Sea Bass	0.49	0.11	↓
Scup (*Stenotomus* spp)	0.53	0.06	↓
White Grunt	0.26	0.38	↑
Knobbed Porgy	0.03	0.13	↑
Red Snapper	0.21	0.1	↓
Sand Perch	0.19	0.04	↓
Scamp	0.04	0.13	↑

Two-tailed T-Test: $p < 0.05$

Video – Species associated with lionfish

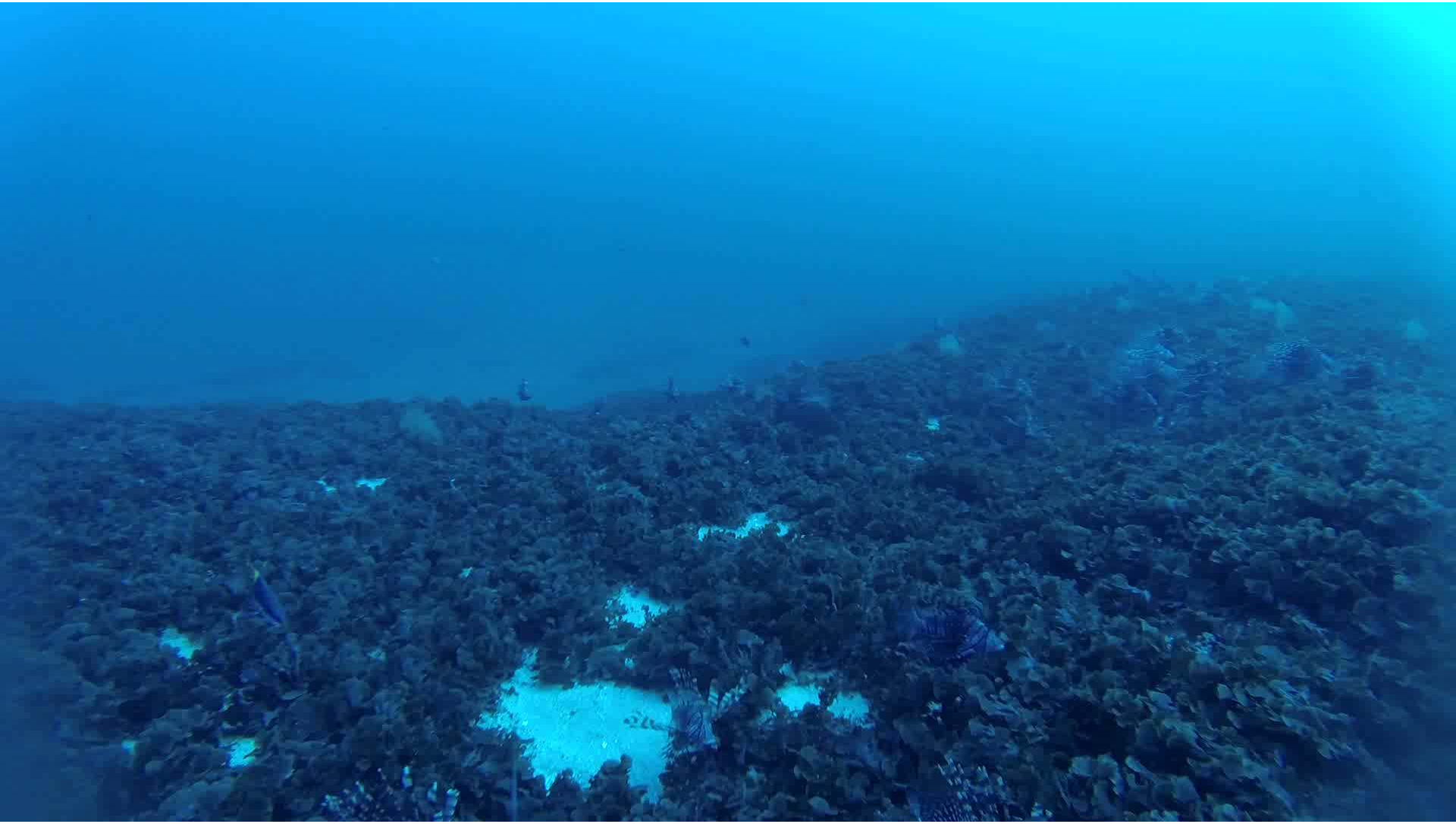


Chevron Traps – Species associated with lionfish



CONCLUSIONS

- First large scale study of Lionfish abundance and distribution in this region.
- Relative abundance of Lionfish has been increasing steadily since 2011 (based on ZINB model).
- Increase in number of sites with Lionfish.
- Lionfish presence correlates with species assemblage differences on a region wide level (based on hybrid video/trap data).
- Potentially susceptible species have been identified to guide future monitoring efforts to look for lionfish abundance-related impacts.

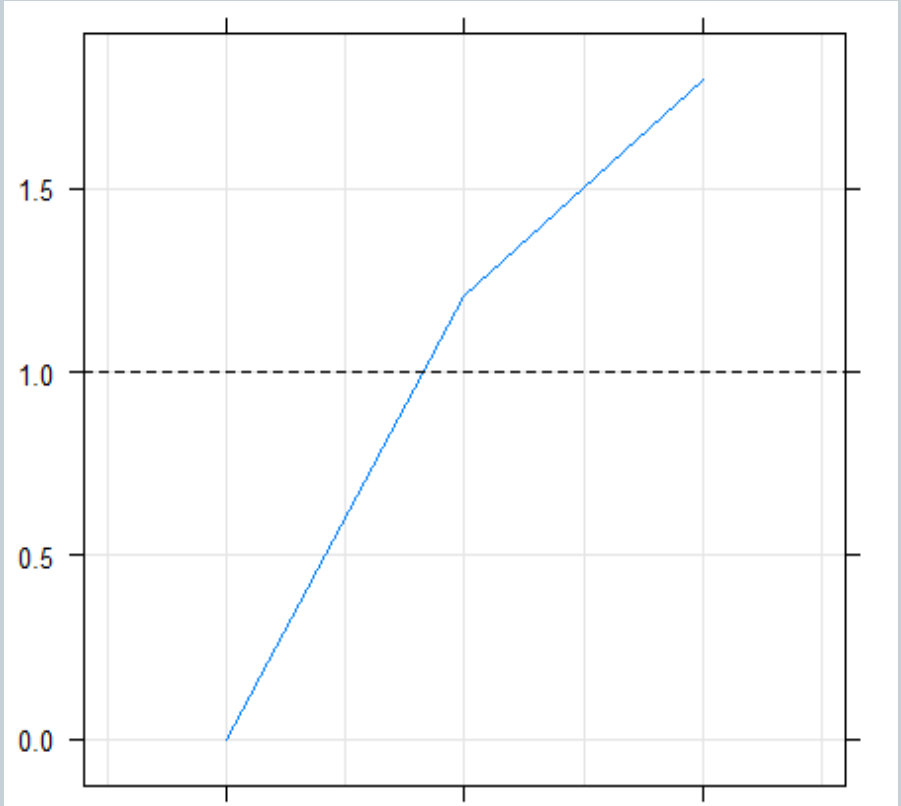


Acknowledgements

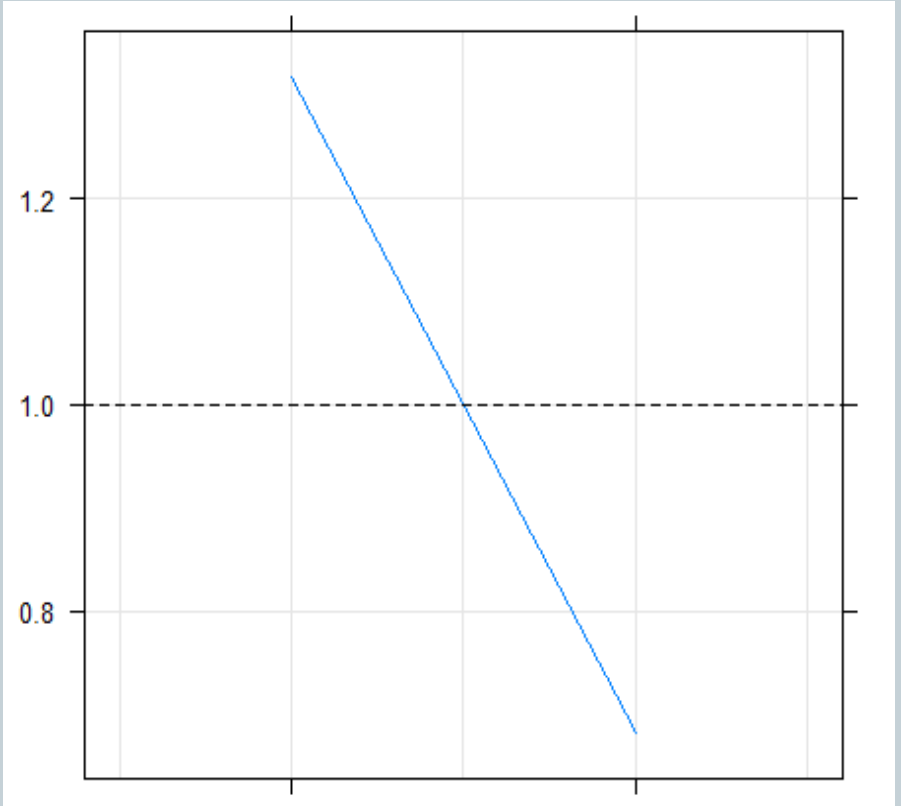
- Video Readers
  - Beaufort and Charleston
- Funding
  - USFWS SC State Wildlife Grant
  - NOAA fisheries
  - South Carolina DNR

Individual Variables - Abundance

Water Clarity

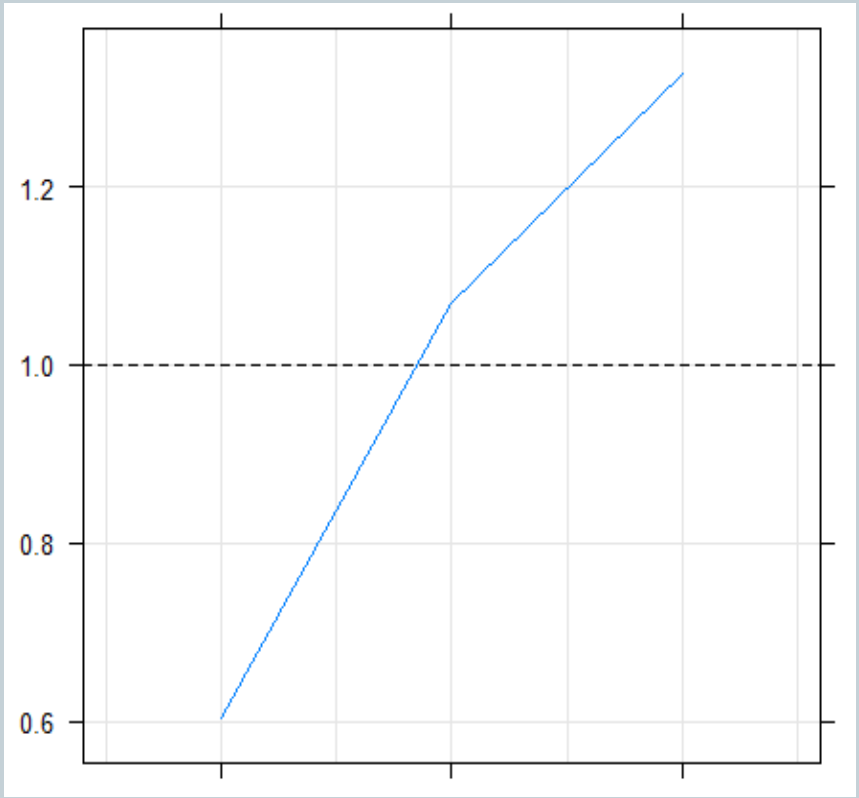


Current Magnitude



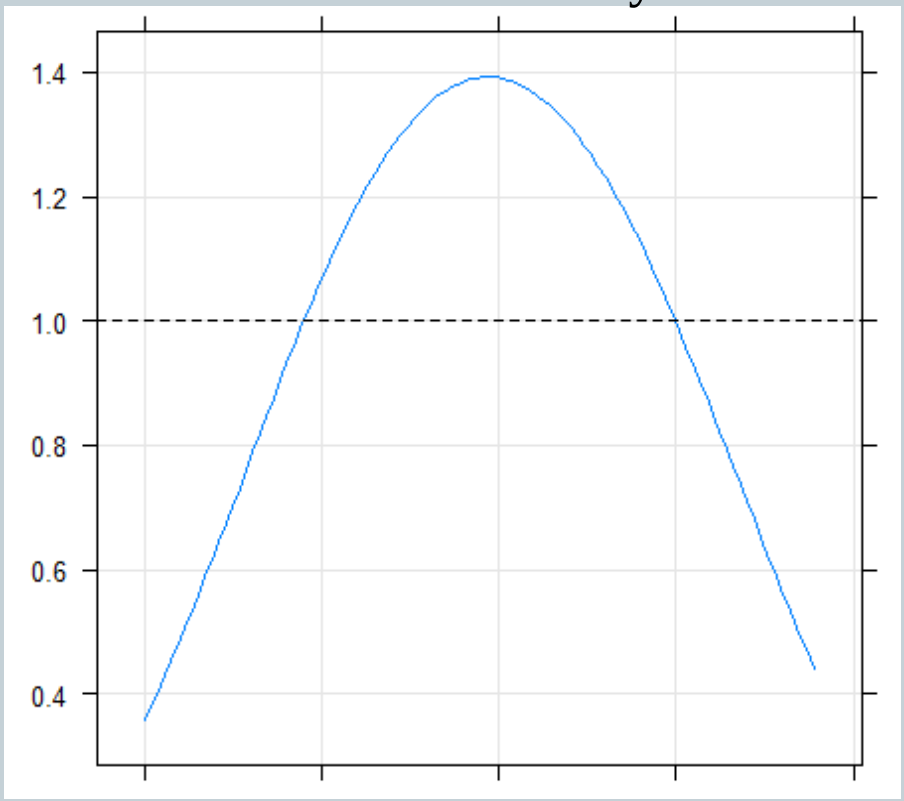
Individual Variables - Abundance

Substrate Size



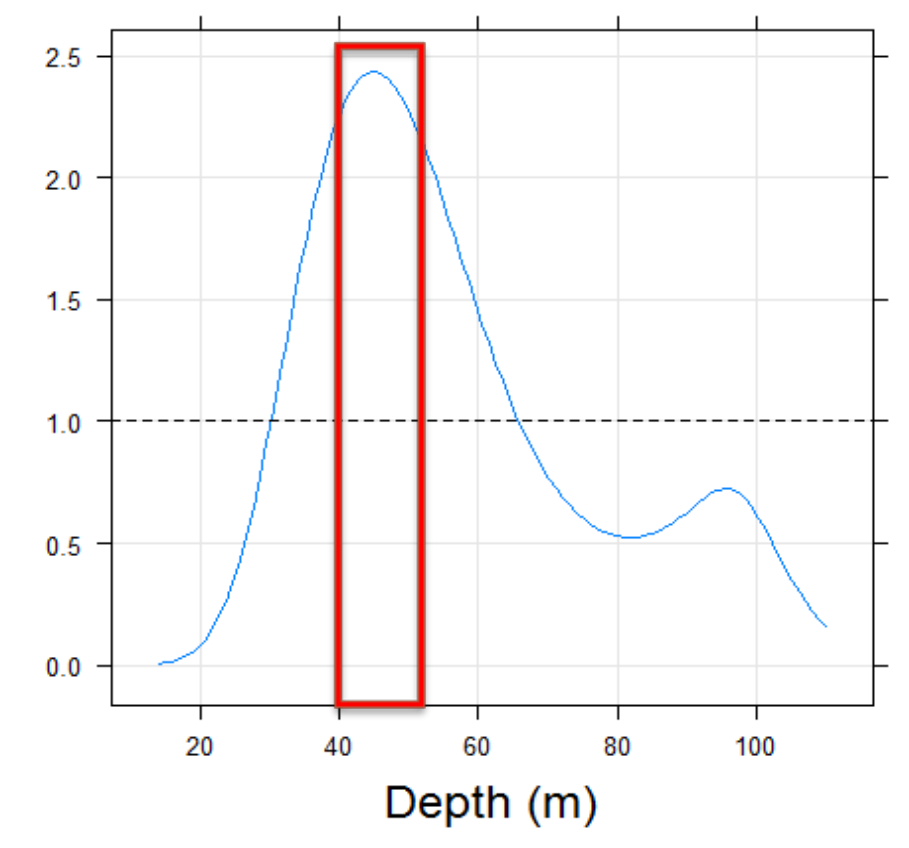
Small ----------> Large

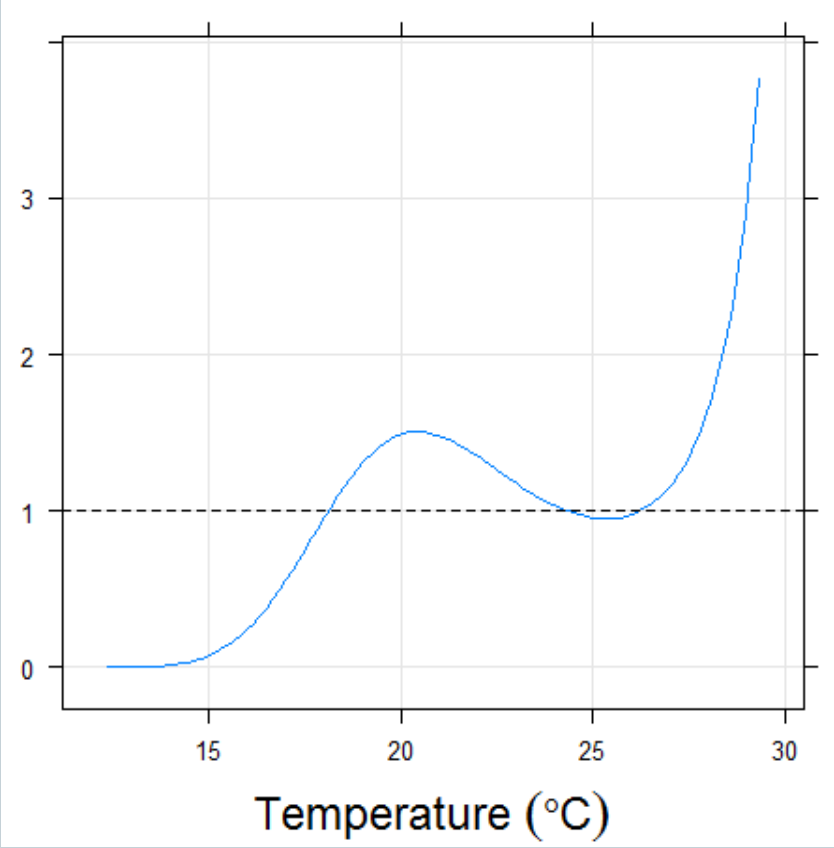
Biota Density



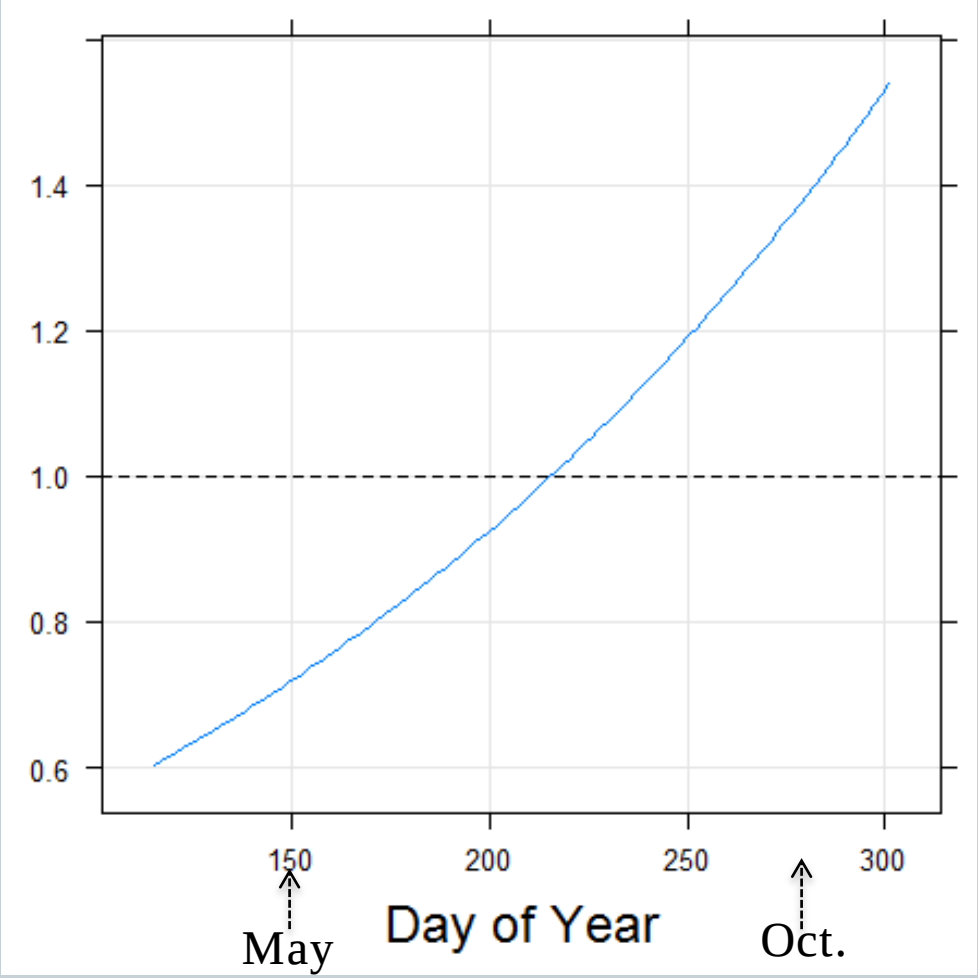
Low ----------> High

Individual Variables - Abundance





Individual Variables - Abundance



Spatial/Temporal Changes

- **Explanation of species assemblage by environmental variables**
  - **BIO-ENV analysis**
    - **Latitude and depth were largest explanatory variables**
      - **Rho = 0.213; p = 0.002**

Spatial/Temporal Changes

- Explanation of species assemblage by environmental variables
  - BIO-ENV analysis
    - Latitude and depth were largest explanatory variables
      - Rho = 0.213; p = 0.002
- **Latitudes with minimal samples removed**
  - **27° and 35°**
- **Held depth constant**
  - **30-55 m**

Spatial/Temporal Changes

- **Only latitudes at the extremes of the survey had significant differences**

Latitude	Pairwise significant differences	Lionfish Contribution (%)
28	2010, 2014	2.19
29	none	-
30	none	-
31	none	-
32	none	-
33	none	-
34	2012, 2014	2.55

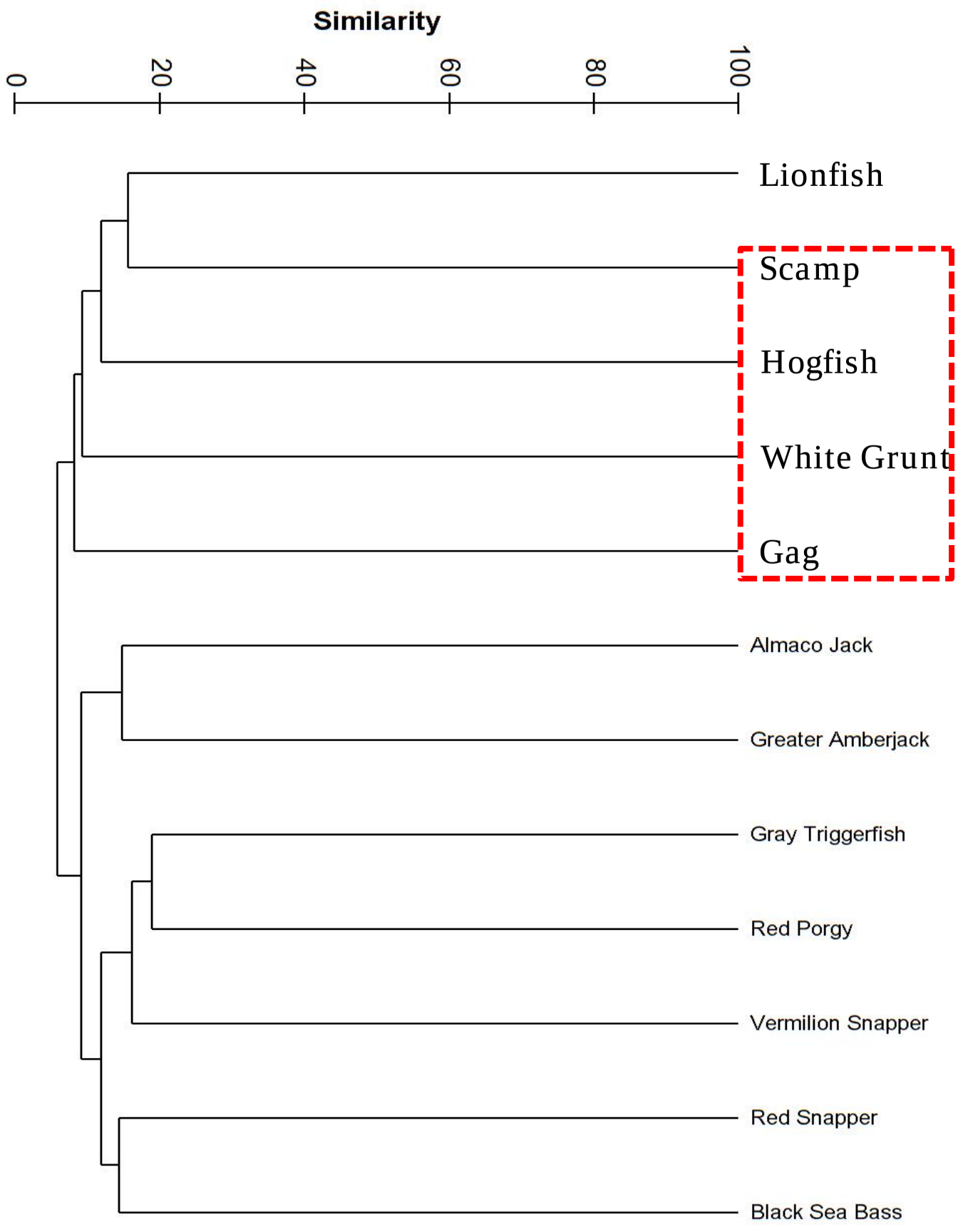
Presence/Absence of Lionfish

- **Removed 2010 data**
- **Two-way crossed ANOSIM**
  - **Account for year and latitude effect**
  - **Depth held constant**
  - **Results**
    - **Lionfish presence: Not significant (R = 0.01; p = 0.267)**
    - **Year and Latitude: Significant (R = 0.15; p = 0.001)**
- **SIMPER**

SIMPER analysis

	Lionfish Absent	Lionfish Present	Difference
Species	Average Abundance	Average Abundance	
Vermilion Snapper	0.98	1.23	↑
Red Porgy	0.87	1.08	↑
Gray Triggerfish	0.5	0.74	↑
Almaco Jack	0.27	0.38	↑
Scamp	0.15	0.39	↑
Greater Amberjack	0.26	0.3	
Black Sea Bass	0.33	0.16	↓
Red Snapper	0.37	0.21	↓
White Grunt	0.13	0.29	↑
Hogfish	0.07	0.17	↑

Two-tailed T-Test: $p < 0.05$

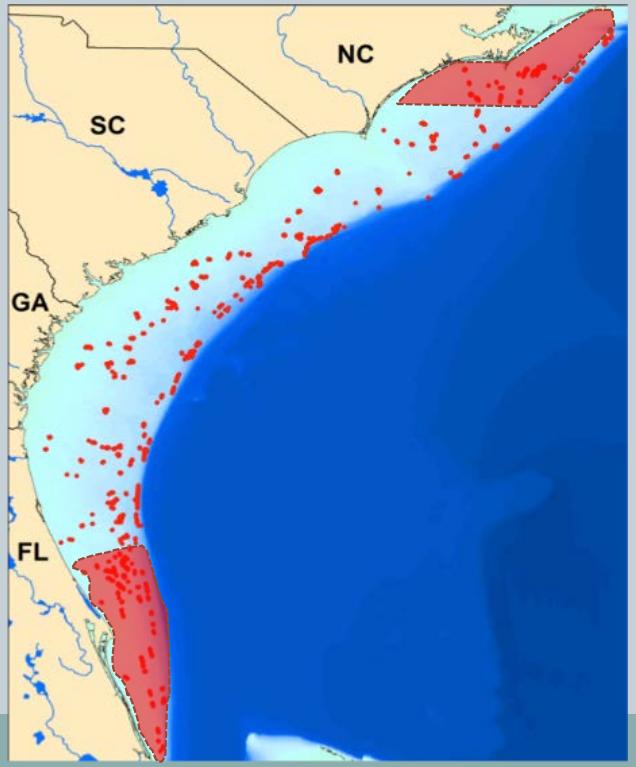

Similarity
0
20
40
60
80
100
Lionfish
Scamp
Hogfish
White Grunt
Gag
Almaco Jack
Greater Amberjack
Gray Triggerfish
Red Porgy
Vermilion Snapper
Red Snapper
Black Sea Bass

Overview

- **Temporal/spatial differences**
  - At extremes of survey area
- **Lionfish presence**
  - No significant difference
  - Increase in most species

Explanations

- **Temporal/spatial differences**
  - At extremes of survey area → Narrow shelf
- **Lionfish presence**
  - No significant difference
  - Increase in most species



Explanations

- **Temporal/spatial differences**
  - At extremes of survey area → Narrow shelf
- **Lionfish presence**
  - No significant difference → Larger species
  - Increase in most species

Explanations

- **Temporal/spatial differences**
  - At extremes of survey area → Narrow shelf
- **Lionfish presence**
  - No significant difference → Larger species
  - Increase in most species → Habitat

Spatial/Temporal Changes

- **Almost all latitudes had significant differences**

Latitude	Pairwise significant differences	Lionfish Contribution (%)
28	2010, 2014	2.44
29	2010, 2014	3.34
30	2011, 2014	2.92
31	2011, 2014	3.97
32	2011, 2014	4.86
33	none	-
34	2012, 2014	0