Prediction and Verification of Spawning Aggregations in the Gulf of Mexico

Will Heyman
LGL Ecological Research Associates

10 January 2017

Acknowledgements

- NOAA's Saltonstall-Kennedy Program
- RESTORE Act Science Program
- South Atlantic Fisheries Management Council
- Pew Charitable Trusts
- Gulf and South Atlantic Fisheries Foundation
- Scott Hickman, Buddy Guindon, Wayne Werner, Don DeMaria, Mark Marhefka, Jack Cox, Shin Kobara, Brad Erisman, Nick Farmer, Arnaud Grüss, and many others

Outline

- Multi-species spawning aggregations occur predictably in the Mesoamerican Reef and the US South Atlantic.
- Cooperative monitoring protocol used to characterize, monitor and protect FSAs in Belize, Mexico, and the US South Atlantic.
- The protocol and approach have been used to characterize FSAs in the GoM and can be used more broadly.
- Identify research priorities.

Objectives of this talk

- Show that transient multi-species fish spawning aggregations occur at predictable times and locations in the Gulf of Mexico
- Describe techniques and results RE: site prediction, verification, characterization and monitoring
- Illustrate knowledge gaps on FSAs in the Gulf of Mexico.
- Illustrate opportunities for research and management.
- Get feedback from SSC

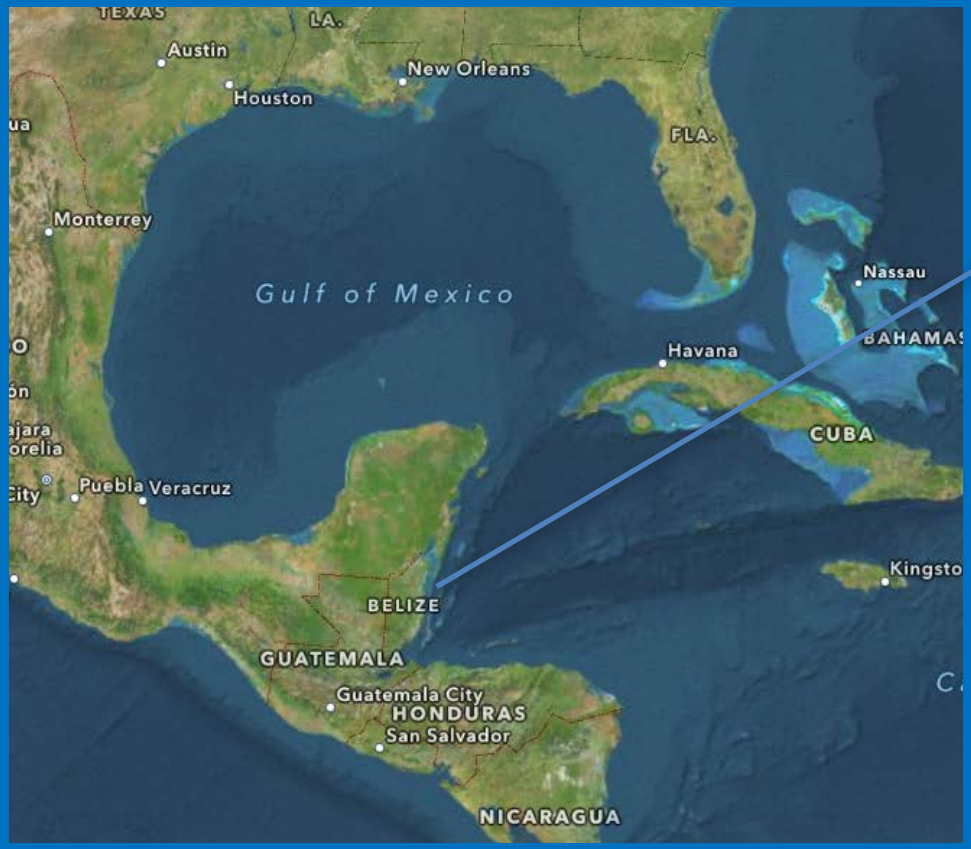
The snapper grouper complex

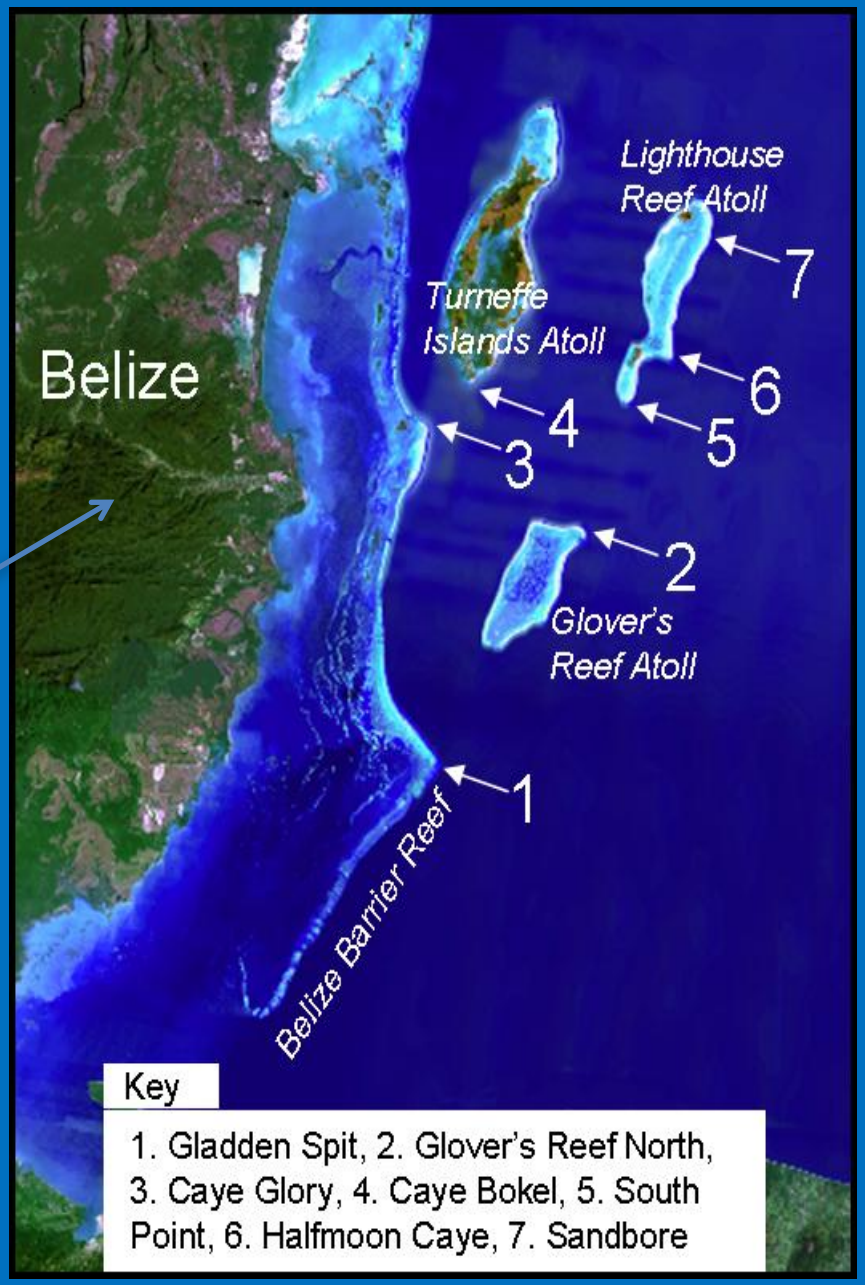
- Caught in multi-species fisheries
- Many overfished, threatened or vulnerable
- Many stocks transcend national and regional boundaries
- Many spawn in aggregations at reef promontories in the tropics

Photo courtesy of Scott Hickman

Photo courtesy of Eddie Toomer

Case Study: Belize spawning aggregations





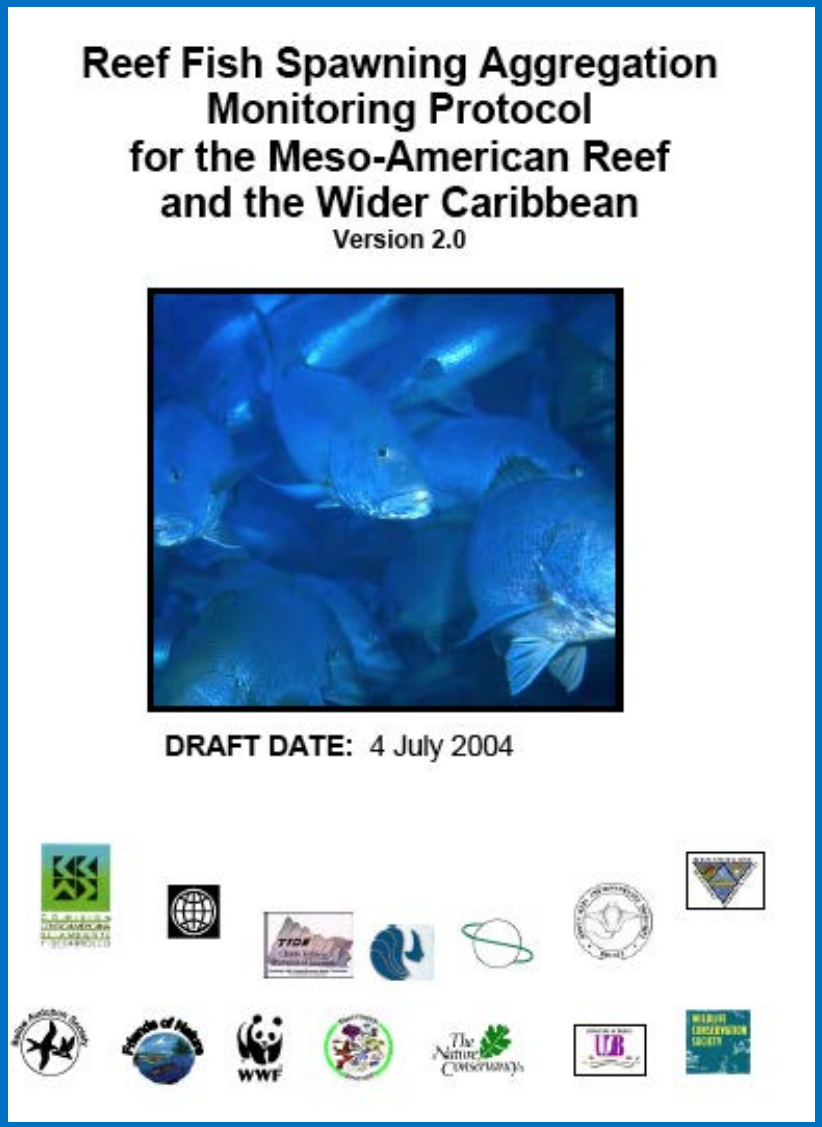
Mini Case Study: Belize

- National concern over declining Nassau Grouper stocks
- Many fishermen aware of various spawning sites
- National Study using Citizen Science characterized spawning sites

Heyman 2011

National Cooperative Study in Belize

- Developed and used standardized protocol
- Tens of institutions; hundreds of people involved



Reef Fish Spawning Aggregation Monitoring Protocol for the Meso-American Reef and the Wider Caribbean

Version 2.0

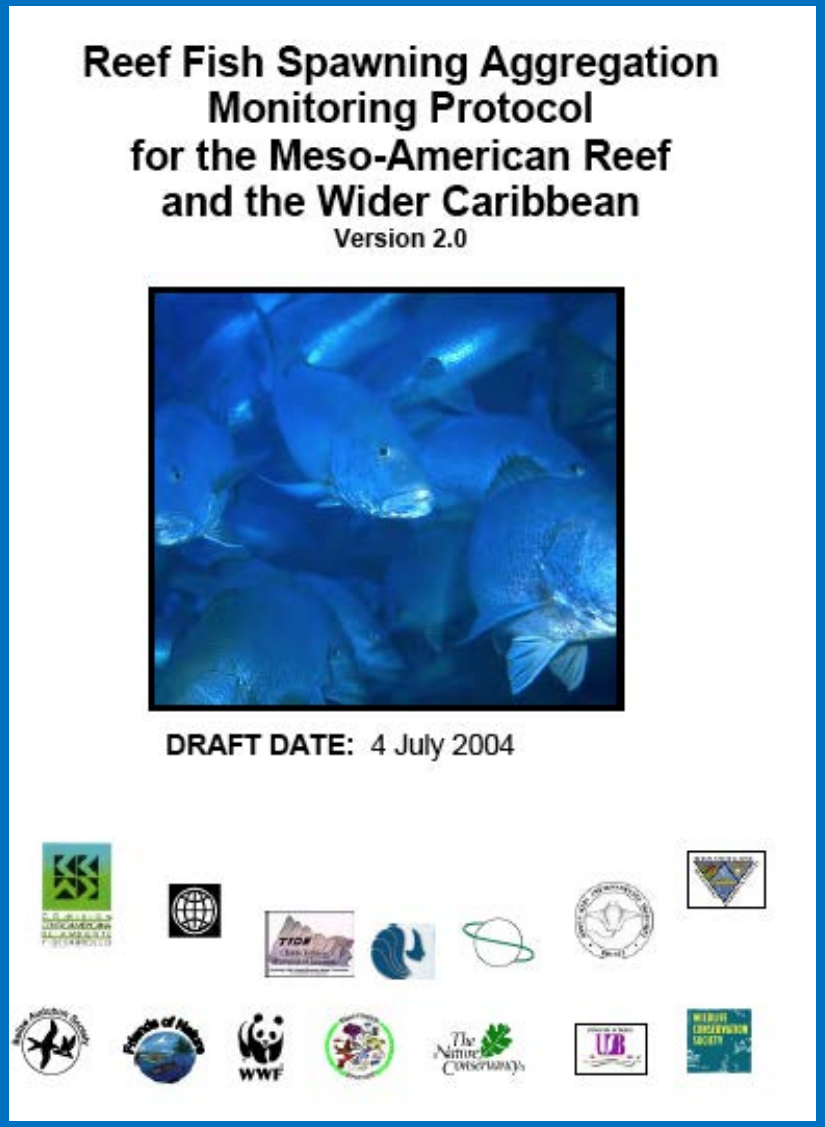
DRAFT DATE: 4 July 2004

Tested Hypothesis: Multi-species reef fish spawning aggregations occur at:

- Reef promontories (convex bending reef)
- Adjacent to shelf edges
- 30 – 50 m depth
- Top of dropoff into deep waters (> 500 m)

Techniques

- Fisher Interviews
- Bathymetric mapping
- Landings data
- Underwater Visual Surveys and video with SCUBA



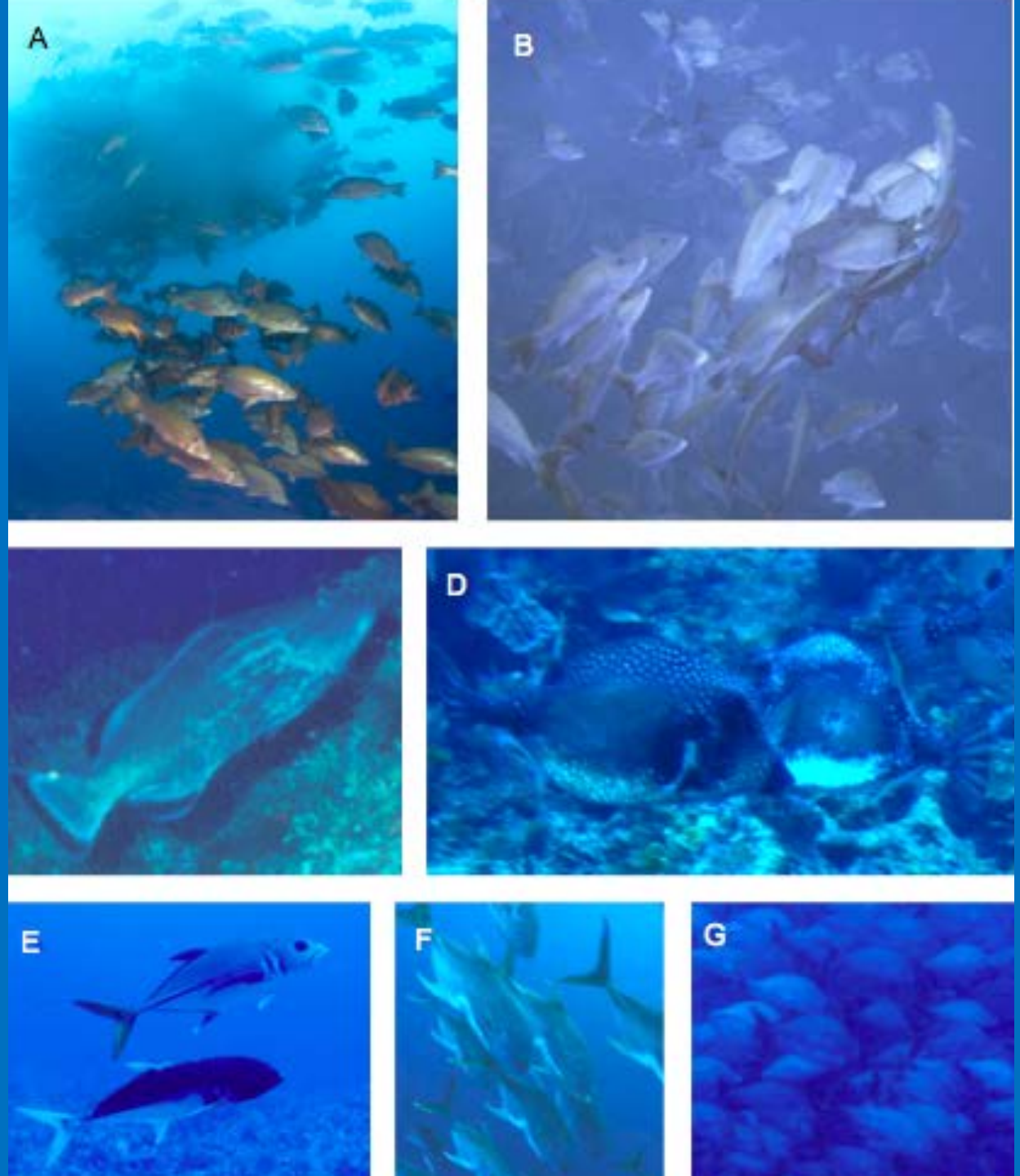
Reef Fish Spawning Aggregation Monitoring Protocol for the Meso-American Reef and the Wider Caribbean

Version 2.0

DRAFT DATE: 4 July 2004

RESULTS:

As many as 20 species spawning at each site including Nassau grouper, other grouper, snappers, and jacks



Heyman and Kjerfve, 2008; Kobara and Heyman 2010

Vol. 405: 243–254, 2010
doi: 10.3354/meps08512

MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser

Published April 29

Sea bottom geomorphology of multi-species spawning aggregation sites in Belize

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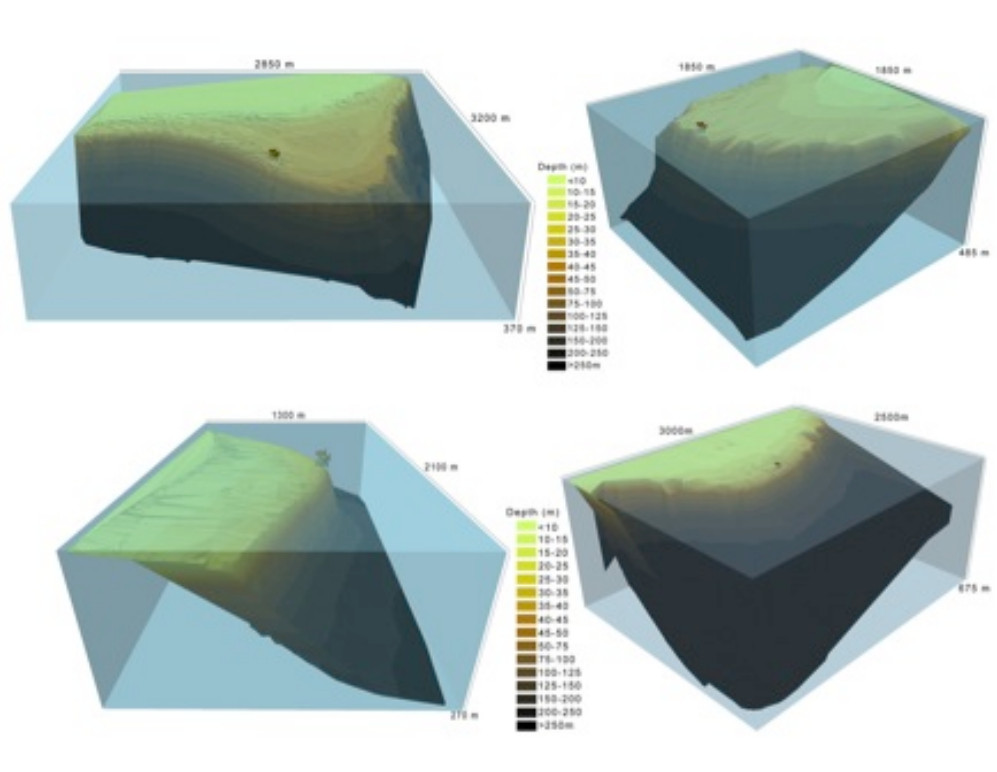
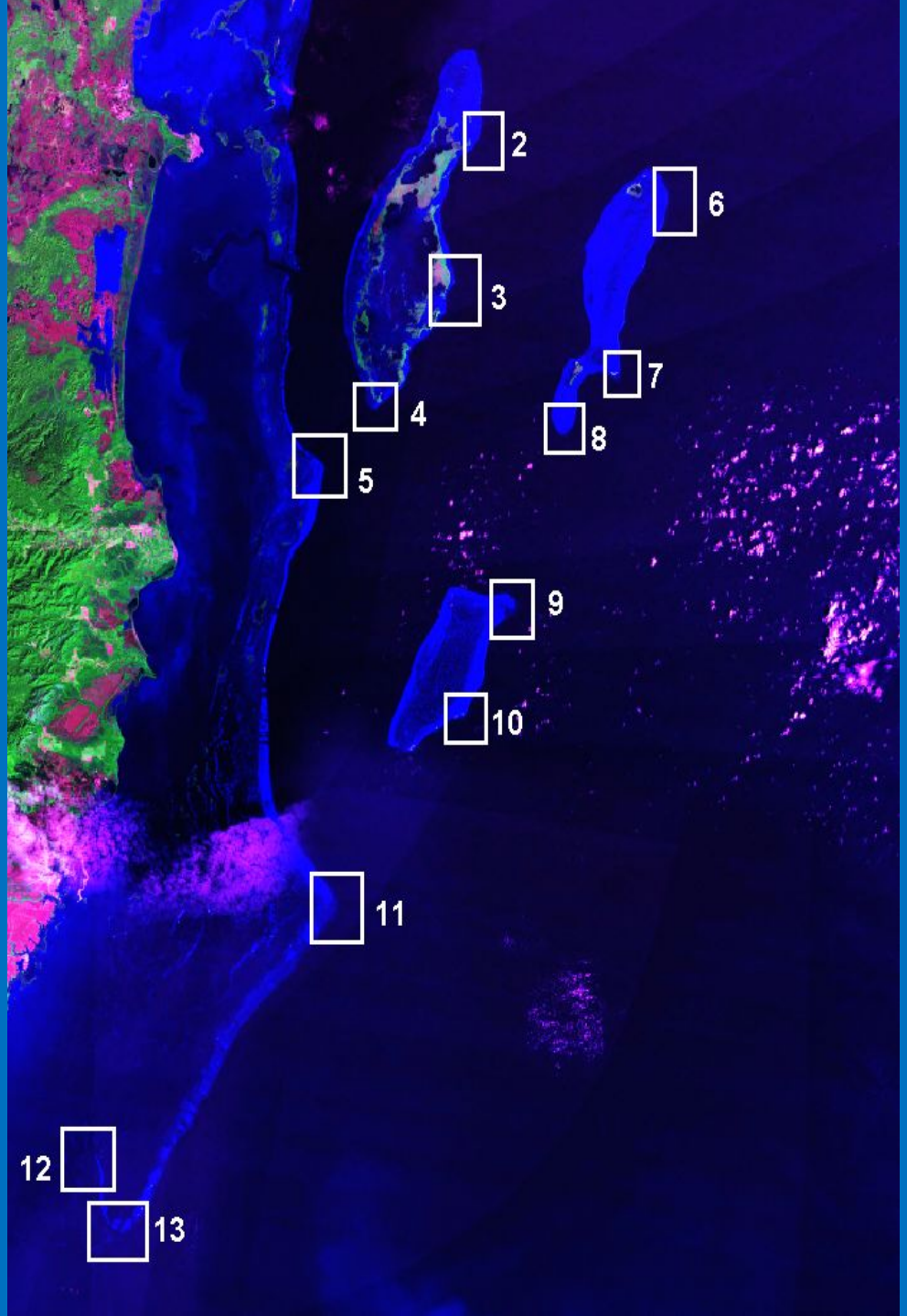
Department of Geography, Texas A&M University, College Station, Texas 77843-3147, USA



Fishermen took the results to Minister

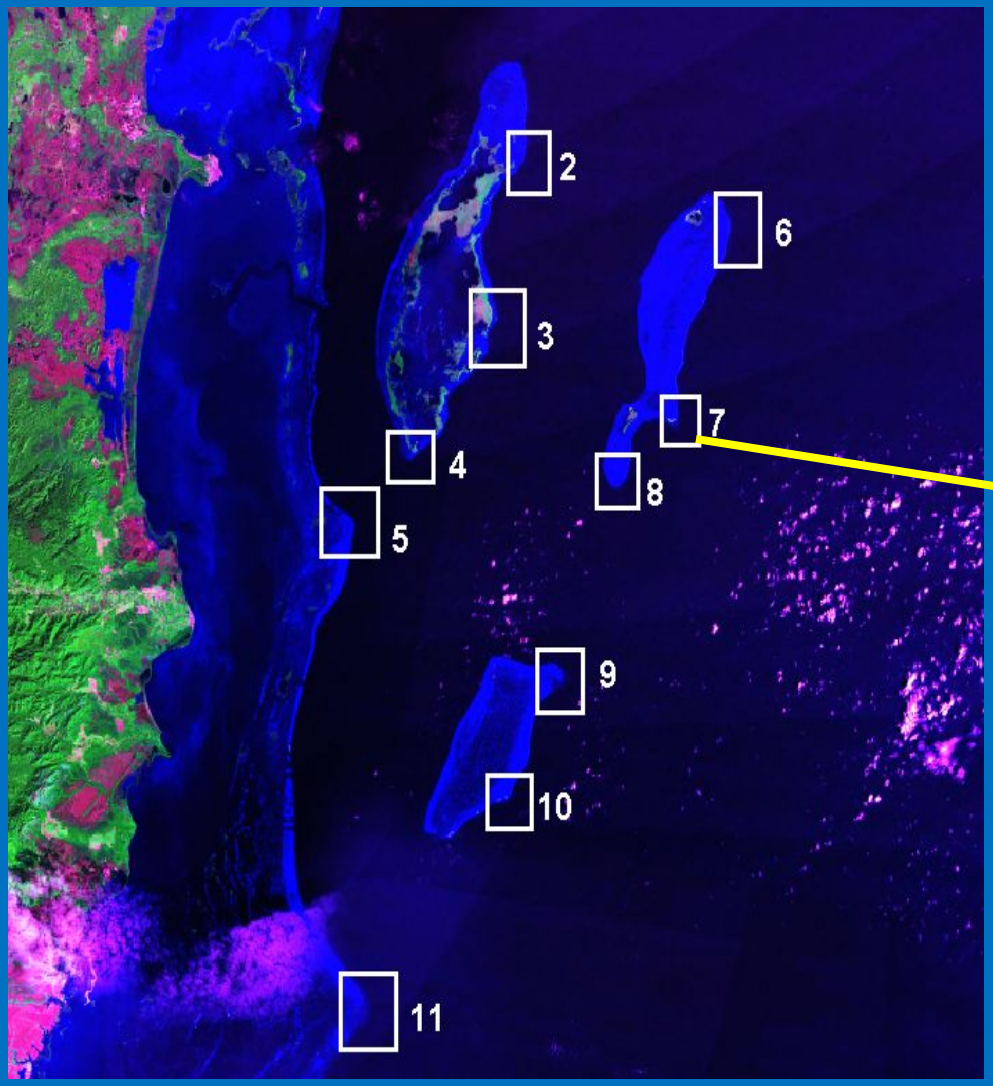
Minister created 11 new marine protected areas (MPAs) in 2003

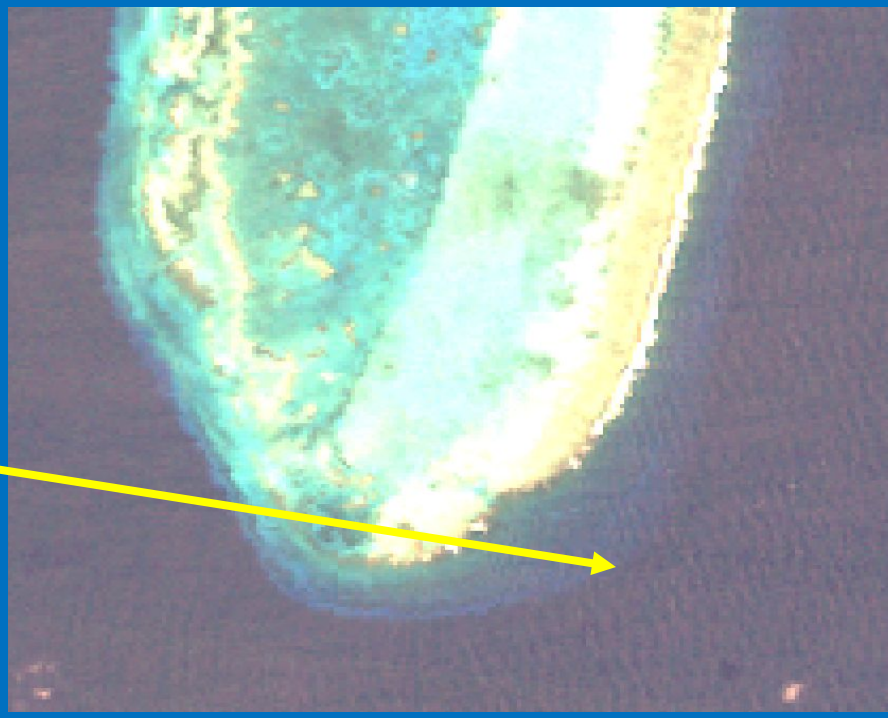
- Sites monitored through 2017
- Some sites are recovering
- Source of National pride



Heyman, 2011

Predict and Verify: Lighthouse Reef, Belize





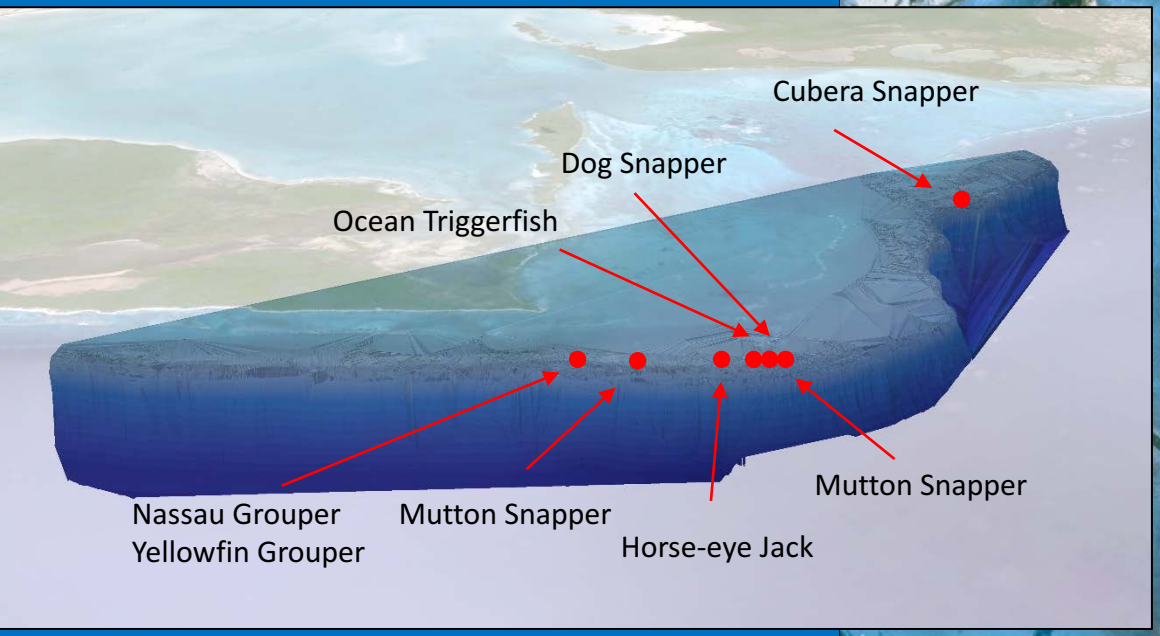
Predicted spawning aggregation site

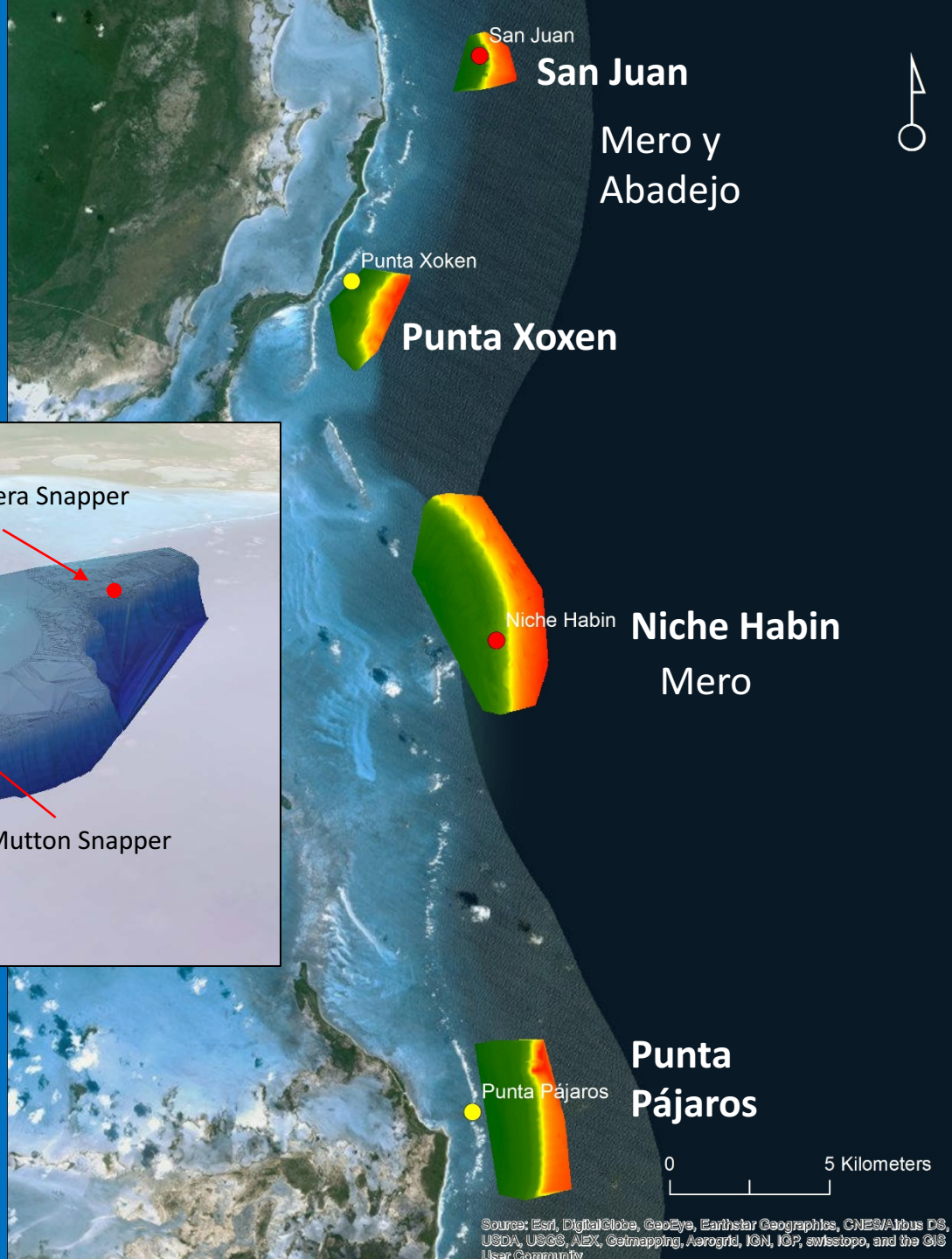
20 species of snappers, groupers and jacks

Mexico

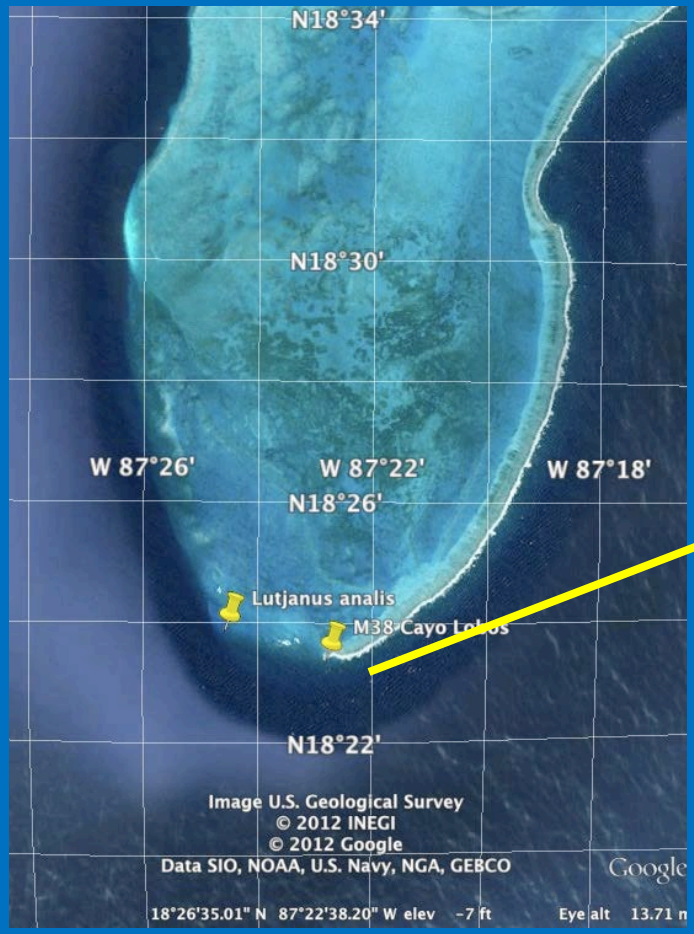
- NGO COBI trained fishermen in aggregation monitoring
- Used standardized protocol to characterize, map and monitor FSAs
- Documented multi species FSAs at reef promontories
- 5 sites protected at request of fishermen

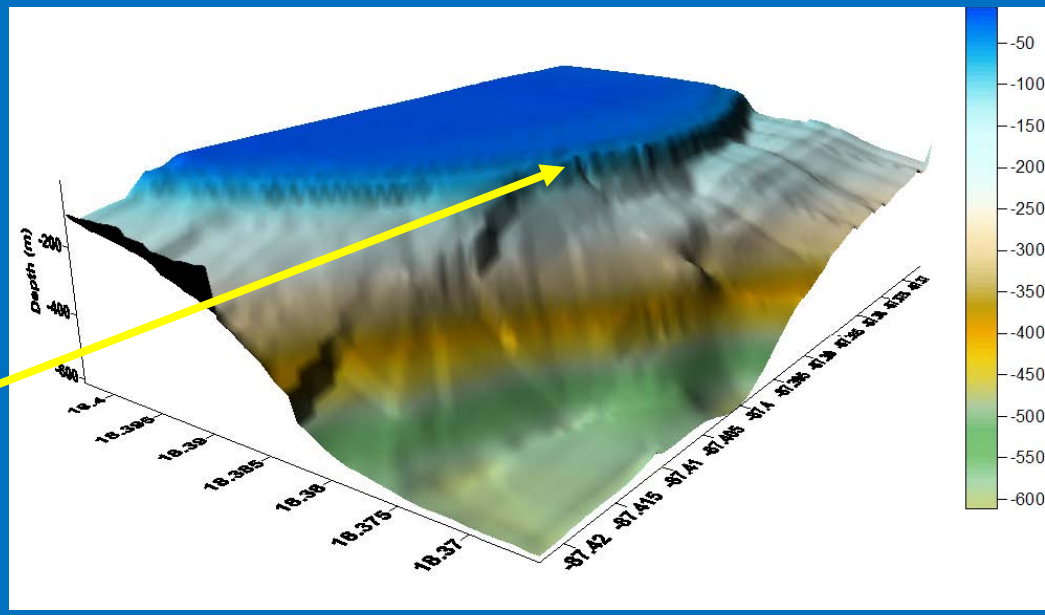
Mexico


Cubera Snapper
Dog Snapper
Ocean Triggerfish
Nassau Grouper
Yellowfin Grouper
Mutton Snapper
Horse-eye Jack
Mutton Snapper


San Juan
San Juan
Mero y
Abadejo
Punta Xoken
Punta Xoxen
Niche Habin
Niche Habin
Mero
Punta Pájaros
Punta
Pájaros
0
5 Kilometers
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Predict and Verify: Chinchoro Atoll, Mexico





mutton snapper spawning aggregation verified

Heyman et al., 2014

Cuba FSAs

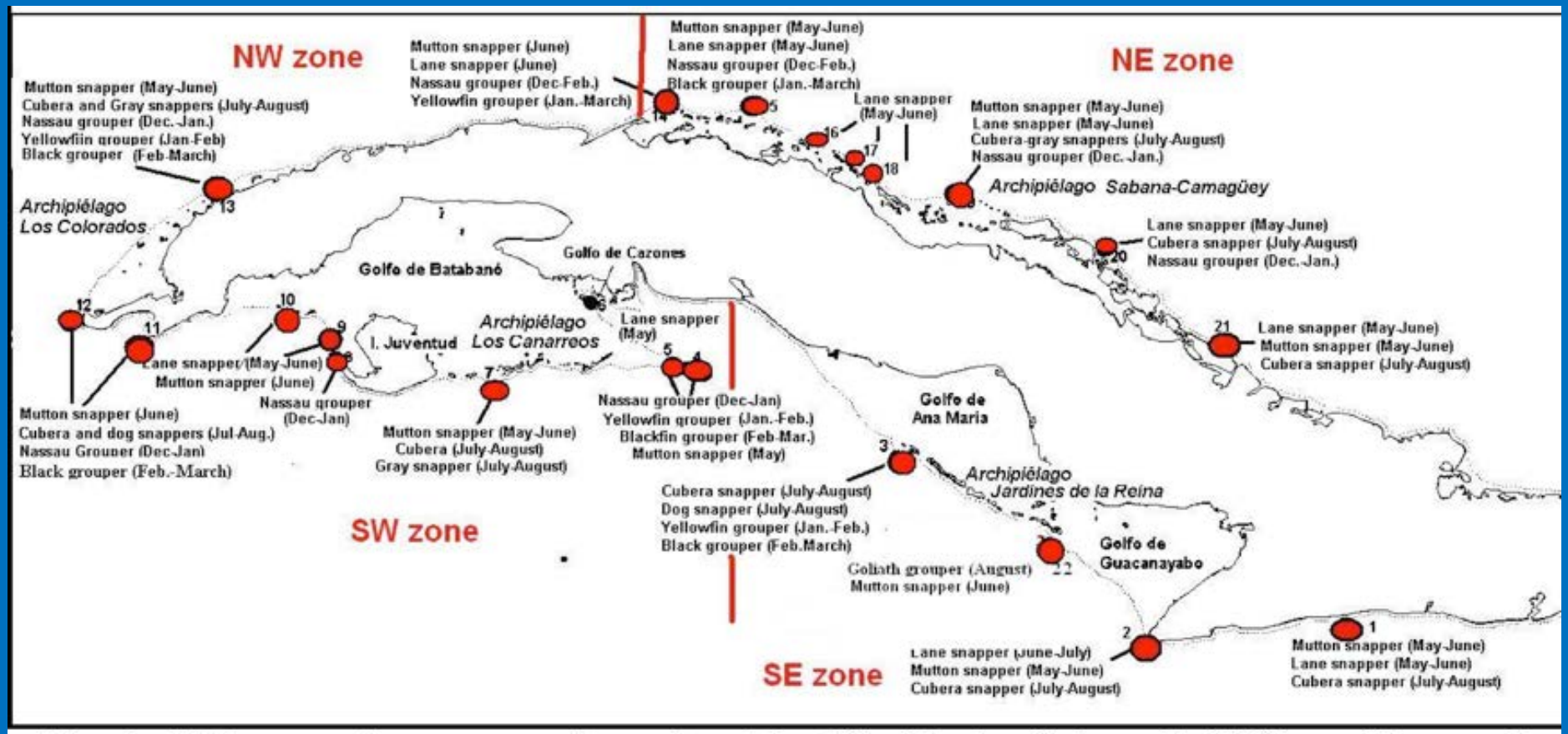


Fig. 1. Fish spawning aggregations sites identified in the Cuban shelf (from Claro and Lindeman, 2003)

Oceanography and Marine Biology: An Annual Review, 2013, **51**, 281-326
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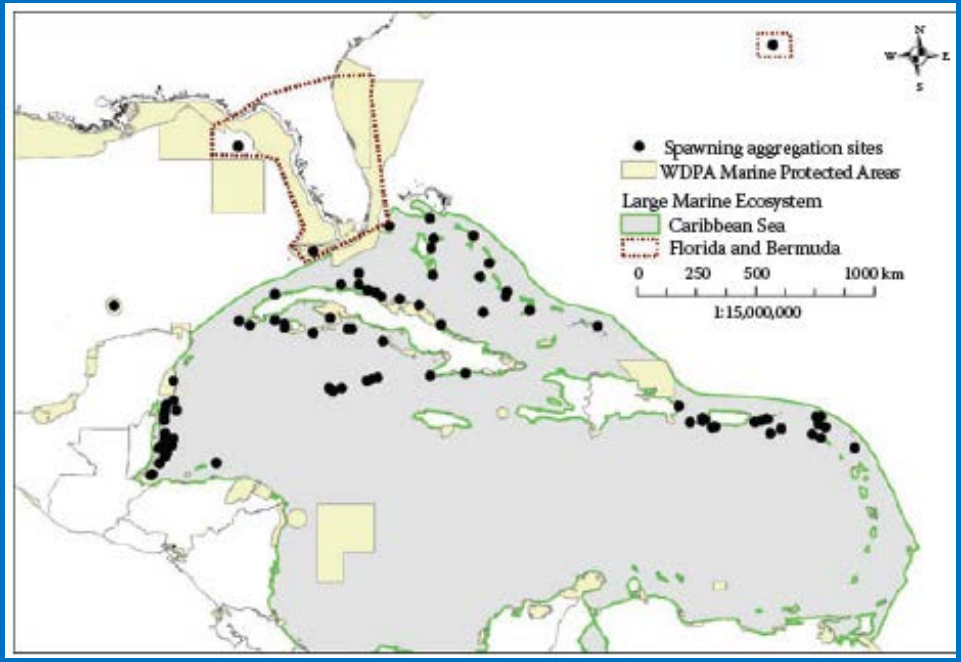
Taylor & Francis

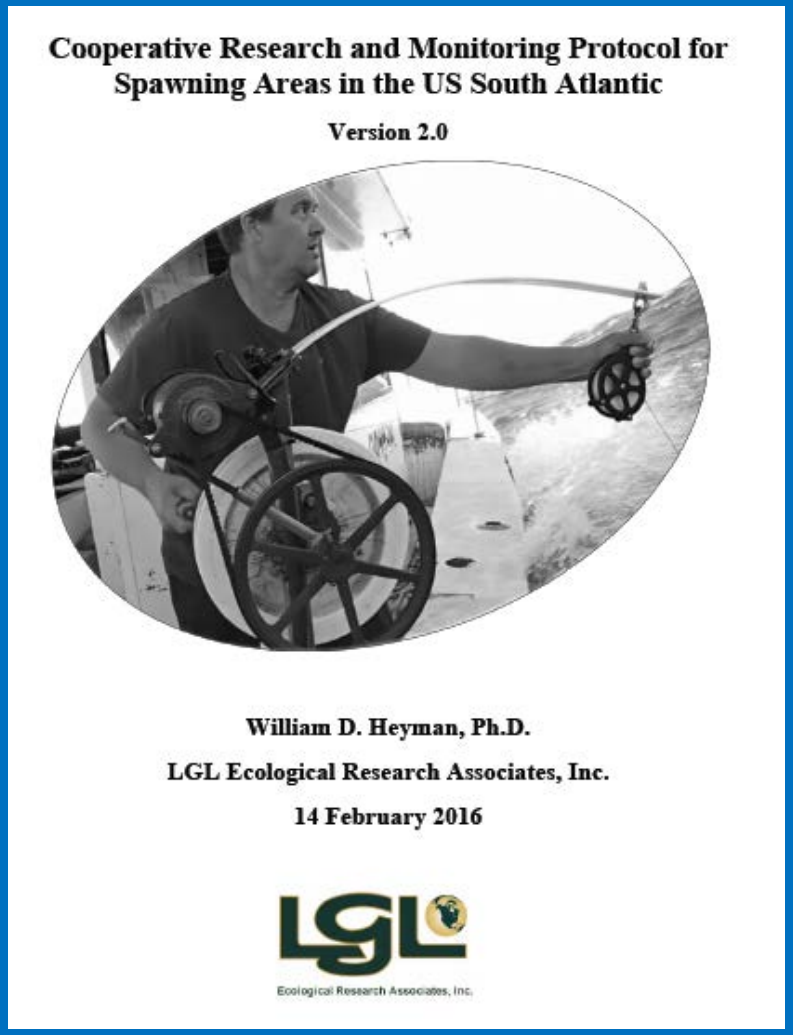
BIOGEOGRAPHY OF TRANSIENT REEF-FISH SPAWNING AGGREGATIONS IN THE CARIBBEAN: A SYNTHESIS FOR FUTURE RESEARCH AND MANAGEMENT

SHINICHI KOBARA[1], WILLIAM D. HEYMAN[2],
SIMON J. PITTMAN[3,5] & RICHARD S. NEMETH[4]

108 confirmed sites evaluated



Techniques applied in the US South Atlantic



Cooperative Research and Monitoring Protocol for Spawning Areas in the US South Atlantic

Version 2.0

William D. Heyman, Ph.D.

LGL Ecological Research Associates, Inc.

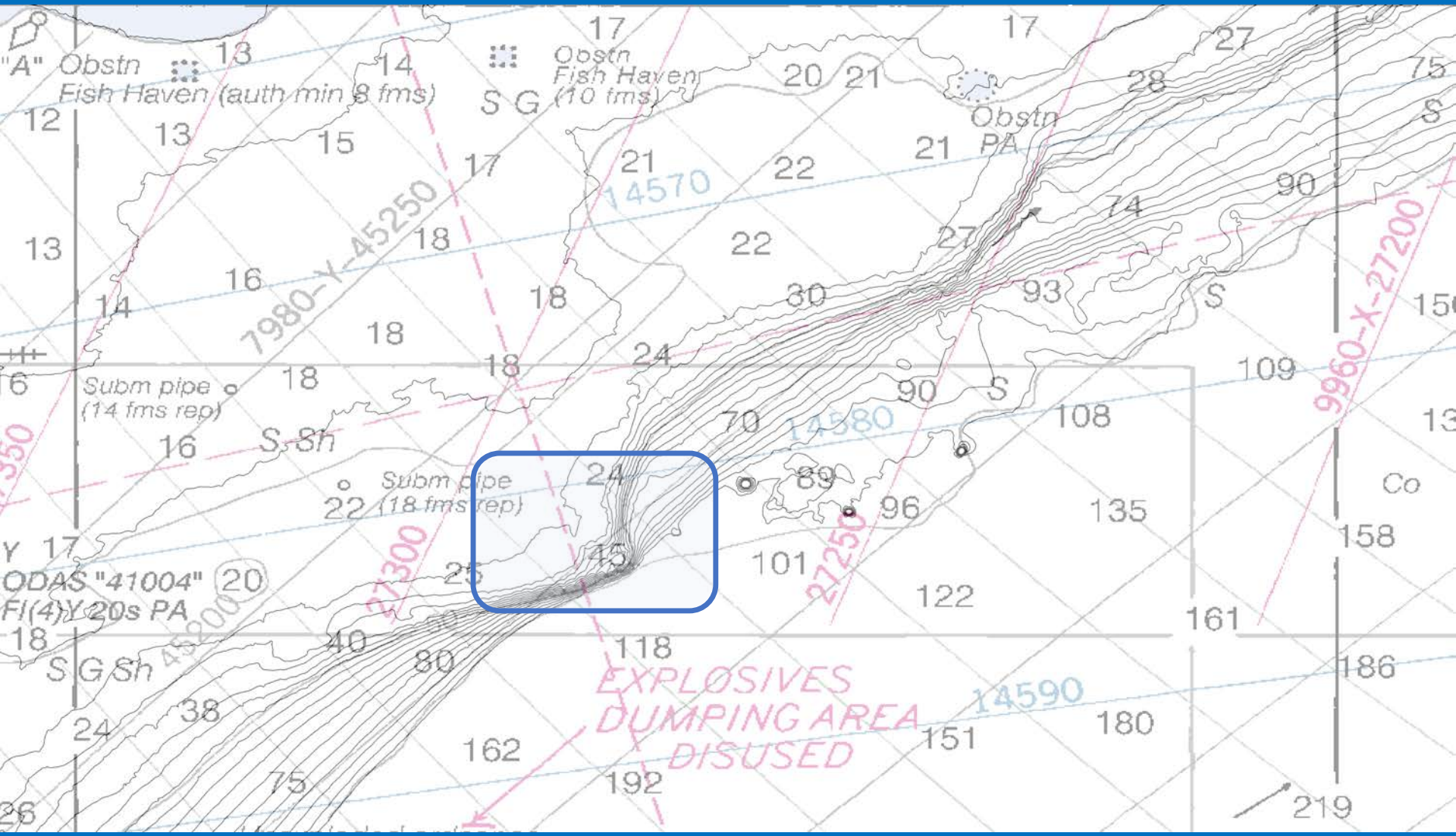
14 February 2016

Ecological Research Associates, Inc.

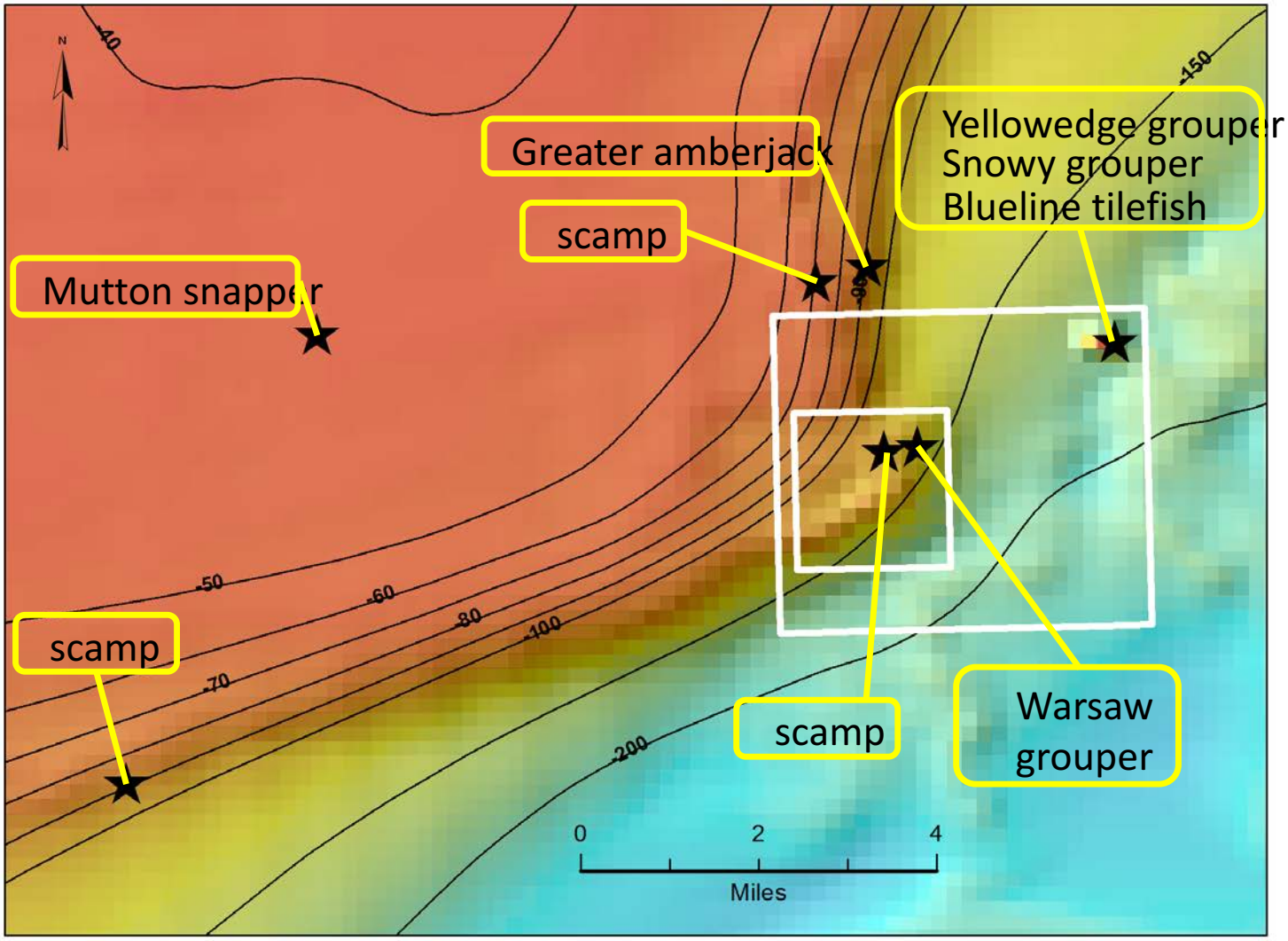
Biological data collection

Go Pro cameras

Results 2014: Georgetown Hole



Georgetown Hole FSAs



SAFMC Amendment 36 to Snapper Grouper FMP

- Establishes management framework to create new Spawning Special Management Zones
- Established network of 5 initial spawning SMZs, including Georgetown Hole

RESTORE: Mapping known FSAs in the GoM

- Surveyed literature of over 800 references
- Examined historical histology collections
- Collected reliable accounts and personal observations from fishermen's logbooks
- Used data collected by the authors.
- Mapped known sites

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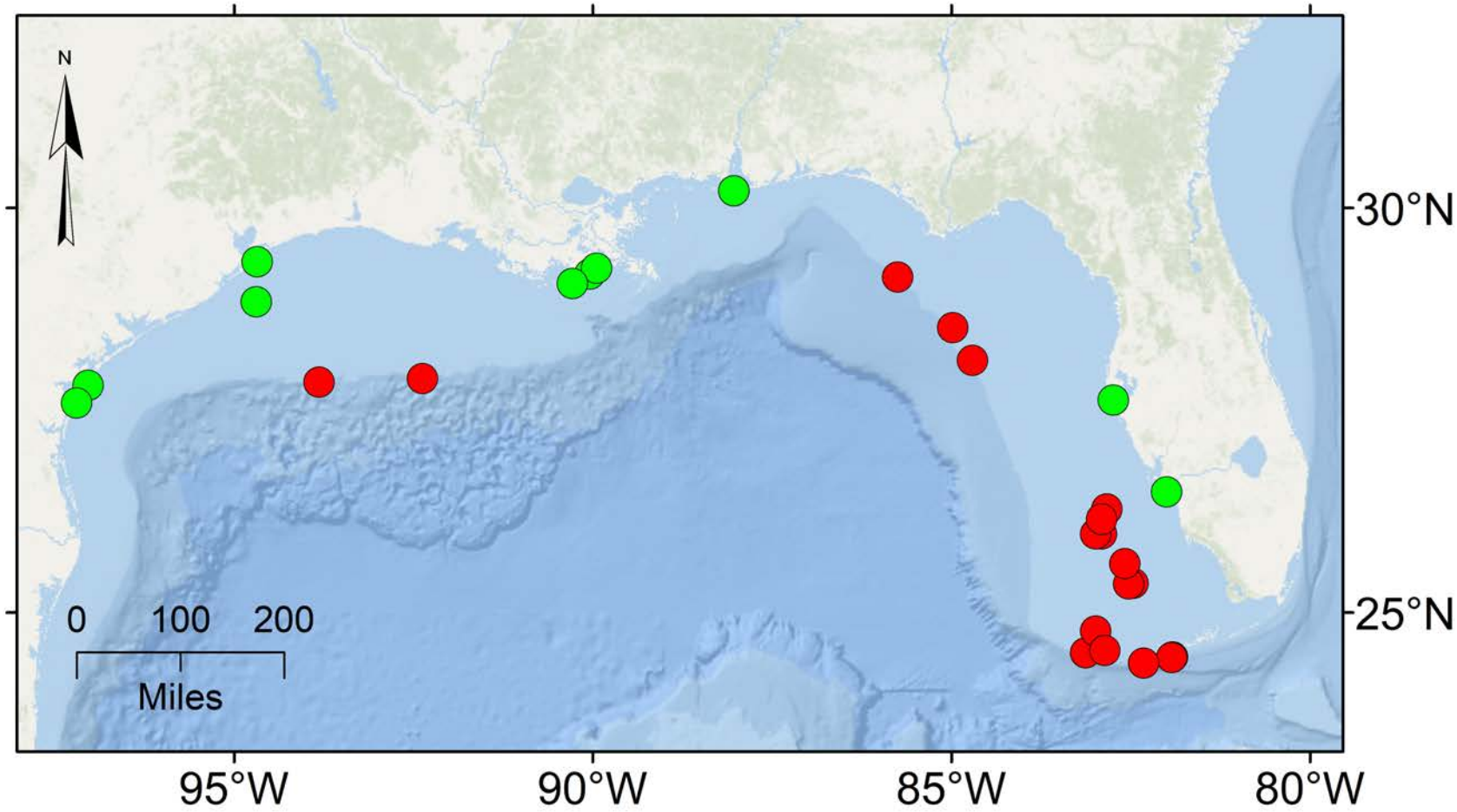
Documented Spawning sites

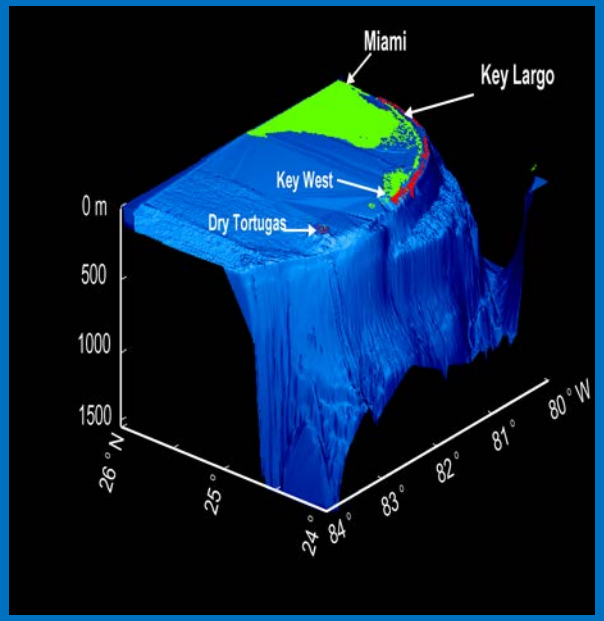


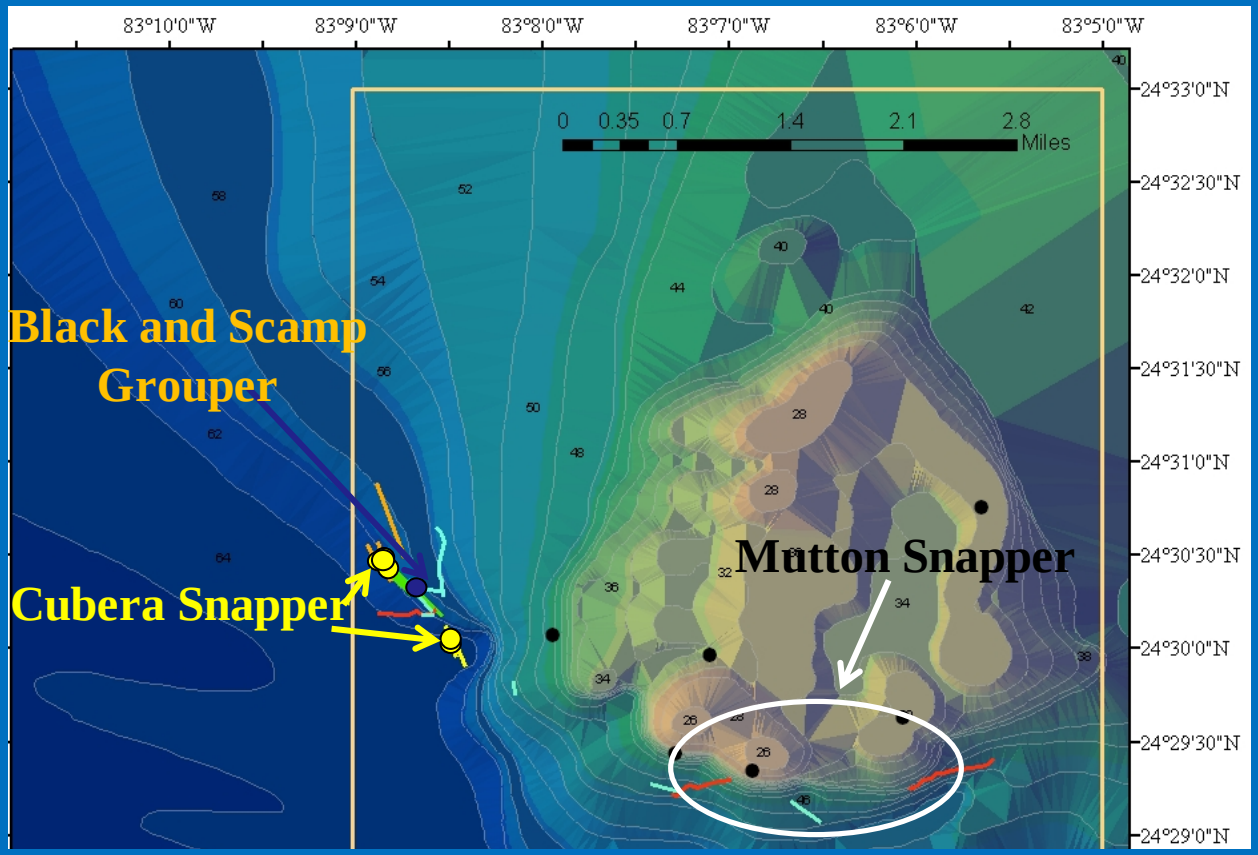
All Species

Riley's Hump

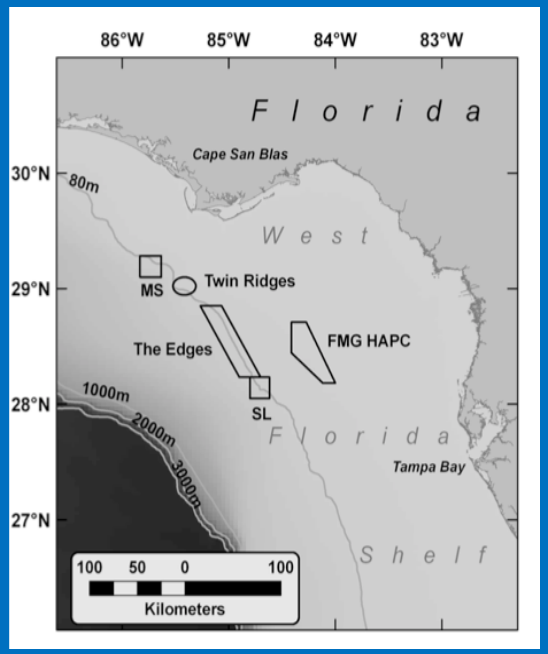
Preliminary evidence of increased spawning aggregations of mutton snapper (*Lutjanus analis*) at Riley's Hump two years after establishment of the Tortugas South Ecological Reserve

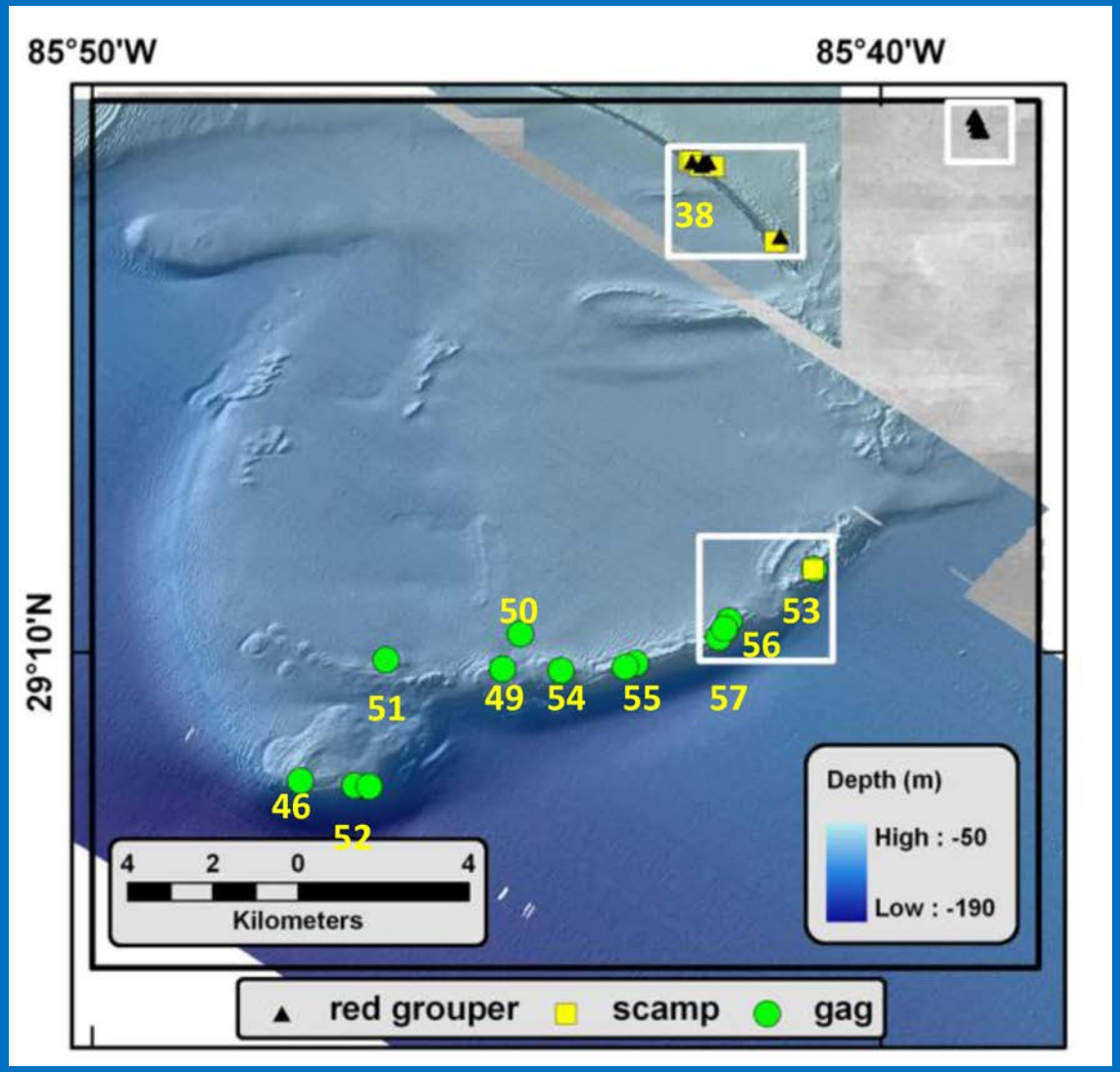
Michael L. Burton
Kenneth J. Brennan
Roldan C. Muñoz
Richard. O. Parker Jr.



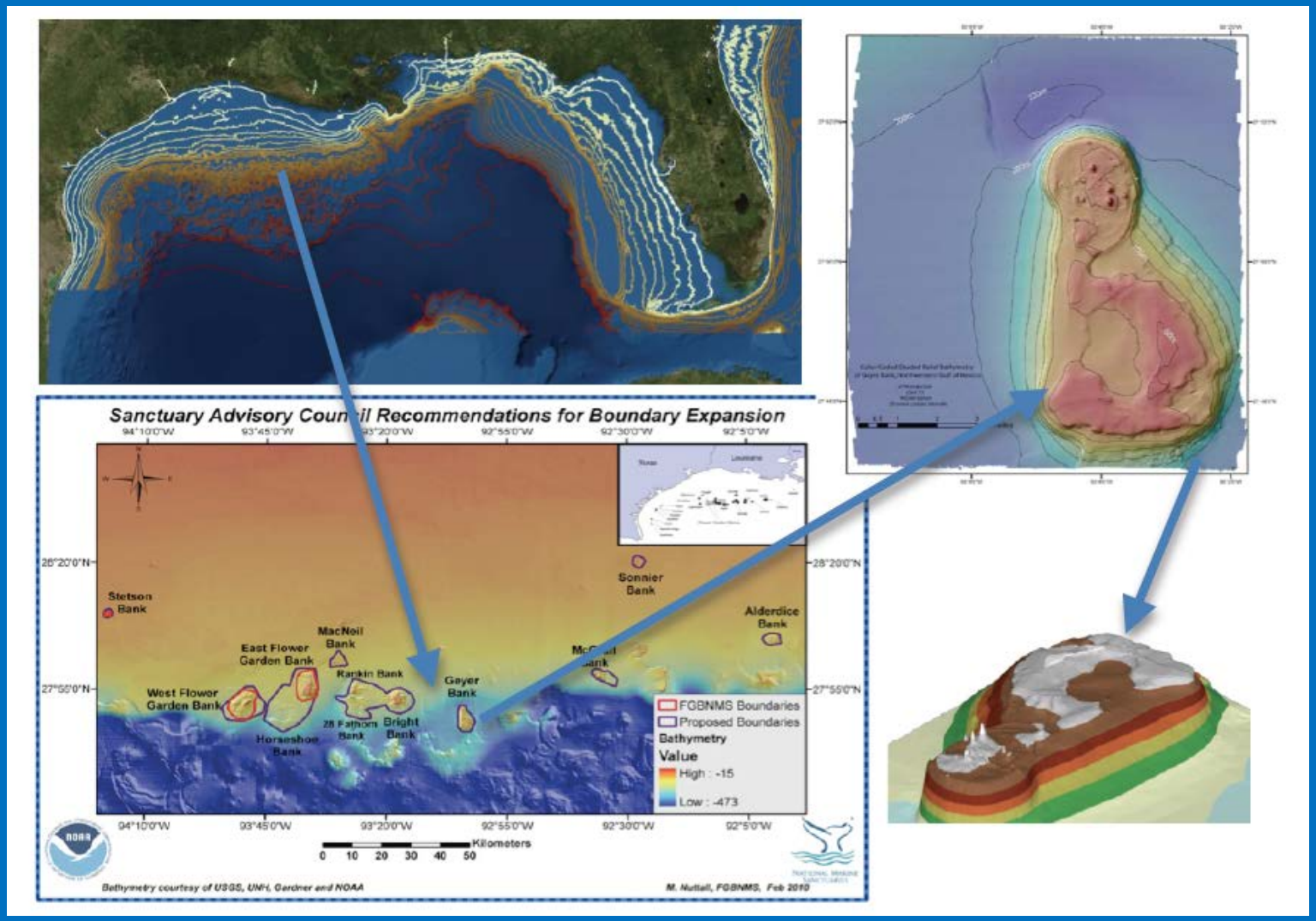


West Florida shelf edge





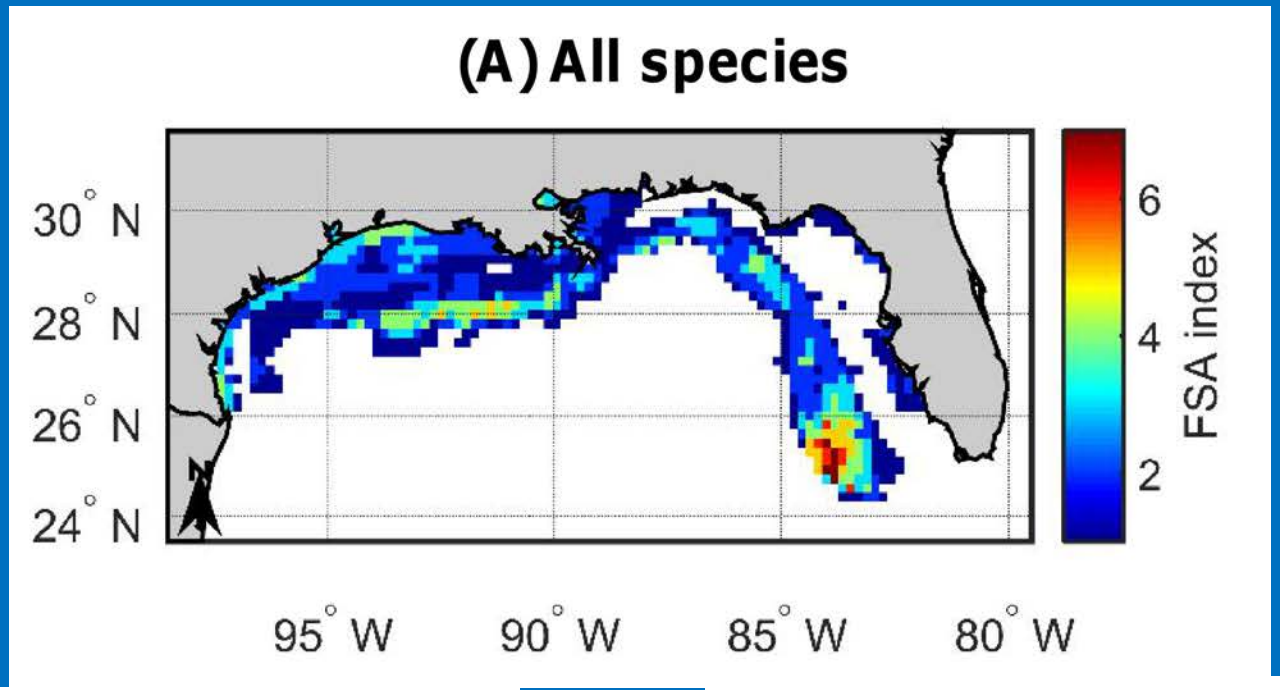
Research 2015: Possible spawning aggregations on banks in the NW Gulf of Mexico

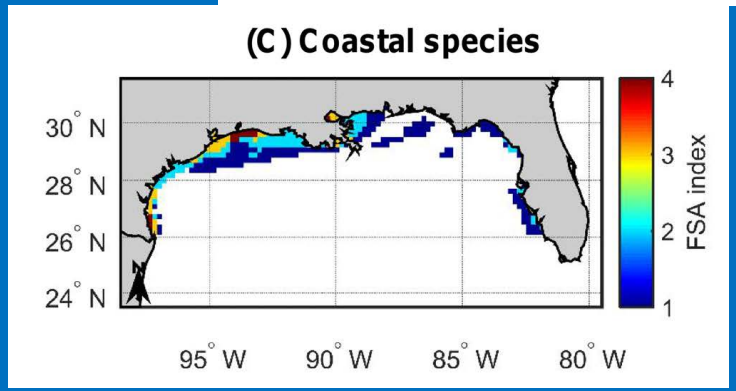


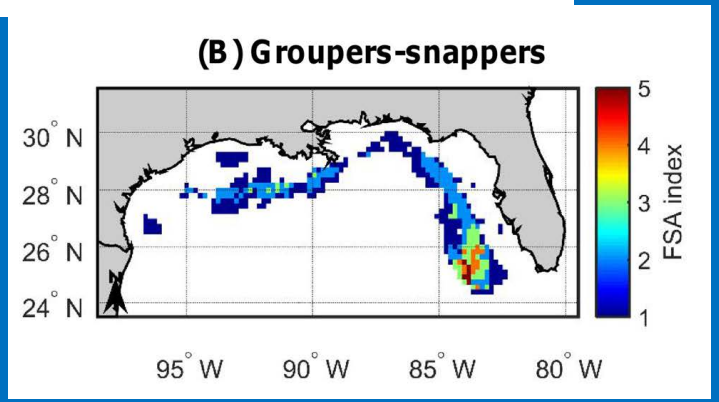
Prioritizing monitoring and conservation efforts for fish spawning aggregations in the U.S. Gulf of Mexico

Arnaud Grüss, Christopher Biggs, William D. Heyman, and Brad Erisman

(*In Review*: Scientific Reports)







RESTORE: Techniques refined and applied in the Gulf

UF IFAS UNIVERSITY of FLORIDA

The Nature Conservancy

NOAA

COBI

Cooperative Research and Monitoring Protocols for Fish Spawning Aggregations in the Wider Gulf of Mexico

LGL Ecological Research Associates, Inc.

GULF OF MEXICO COASTAL OCEAN OBSERVING SYSTEM GCOOS

March 2017

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Protocols, data sheets, database

Table 1: Protocols with their purpose, appropriate conditions, data sheets and target user. A key to the abbreviations is below the table.

Type of Method	Protocol #	Protocol Name	Purpose and expected outcome	Type of Use (P,V,C,M,R)	Depth (S,M,D)	Water clarity (L, M, H, VH)	Data Sheet	Target Users
Field Expedtion		Trip Summary	To provide a summary of the location, timing and equipment used on a CRMP trip.	V, M, C			Trip Summary Data Sheet	Trained data collector
Fisher interviews	1	Fisher interviews	To capture and quantify anecdotal information that can be used to predict the time and location of fish spawning aggregations.	P, V, C	S, M, D	L, M, H, VH	Anecdotal Observation Data Sheet	Trained data collector, fishermen
Fishery Dependent Methods	2a	Landings and catch per effort	To provide detailed site-specific landings and effort during CRMP sampling trips and to collect biological samples.	P, V, C, M	S, M, D	L, M, H, VH	Landings and Catch per Effort Data Sheet	Trained data collector, trained fishermen
	2b	Dockside sampling surveys	To document the size:frequency and gonad condition of fishes being processed at landing sites and thus illustrate spawning seasons.	P	S, M, D	L, M, H, VH	Citizen Science Dock Sampling Data Sheet	Trained fishermen
	2c	Biological sampling	To determine age, growth, and reproductive status from individual fish.	V, M, C	S, M, D	L, M, H, VH	Biological Sampling Data Sheet	Trained data collector, trained fishermen
Fishery Independent Methods	3a	Preliminary site mapping	To sketch the location of fish spawning aggregation sites in relation to known landmarks and bathymetry.	C	S, M, D	L, M, H, VH	Sketch map and Description	Fisherman or trained data collector
	3b	Adaptive bathymetric mapping	To create bathymetric maps with single beam sonar showing spawning areas by species.	V, C	S, M, D	M, H, VH	GIS Map	Trained data collectors, trained fishermen, and GIS operator
Underwater Visual Assessment	4a	Underwater visual census (UVC)	To verify and quantify the number and size composition of fishes in spawning aggregations; to document courtship and spawning behaviors.	V,C,M	S, M	H, VH	Underwater Visual Census	Trained data collector
	4b	Diver underwater video survey	To record courtship and spawning behavior and to verify abundance and size ranges collected via UVC.	V, C, M	S, M	M, H, VH	Video Camera Data Sheet	Trained data collector, fisherman, divers
	4c	Drop cameras	To record position and times and file names for drop camera videos.	V, C, M	M, D	M, H, VH	Video Camera Data Sheet	Trained data collector, fisherman, divers
Emerging Technologies	5a	Passive hydroacoustics	Quantitative assessment of species' timing and level of participation in spawning event; possible direct evidence of FSA	C, M, R	S, M	L, M, H, VH	To be developed	Trained researcher
	5b	Acoustic telemetry	To document spawning site utilization and site fidelity, residency time, migration routes and distances; possible indirect evidence of FSA	C, M, R	S, M	L, M, H, VH	To be developed	Trained researcher
	5c	Split-beam sonar mapping	To quantify fish density and biomass using sonar	C, M, R	M, D	M, H, VH	To be developed	Trained researcher

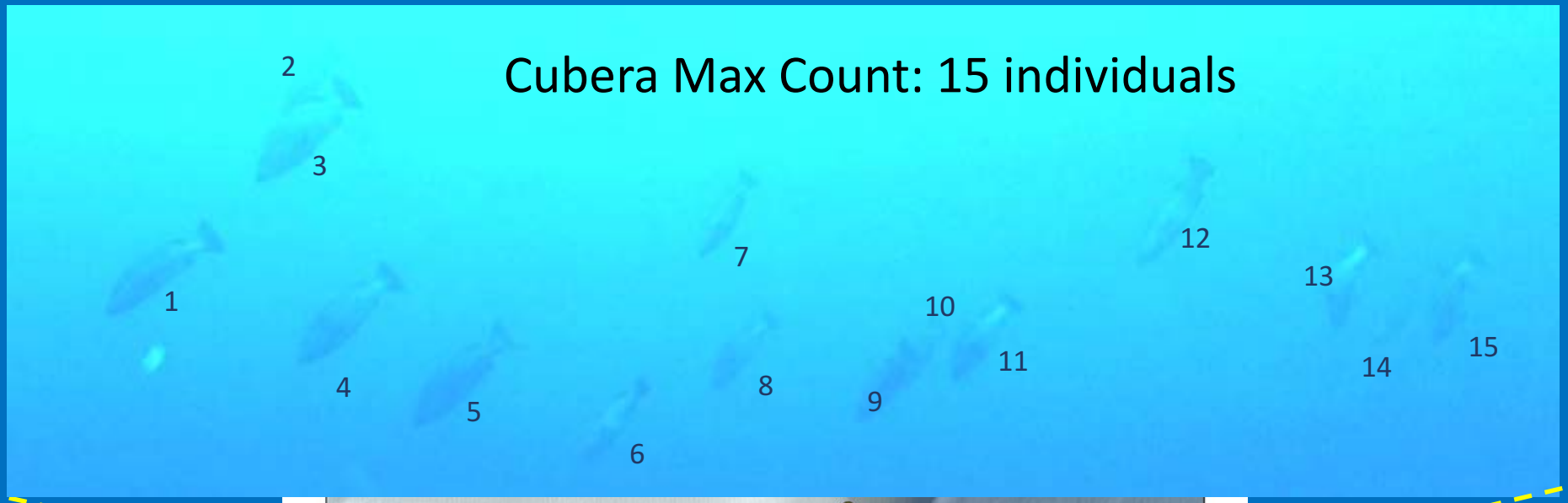
Key

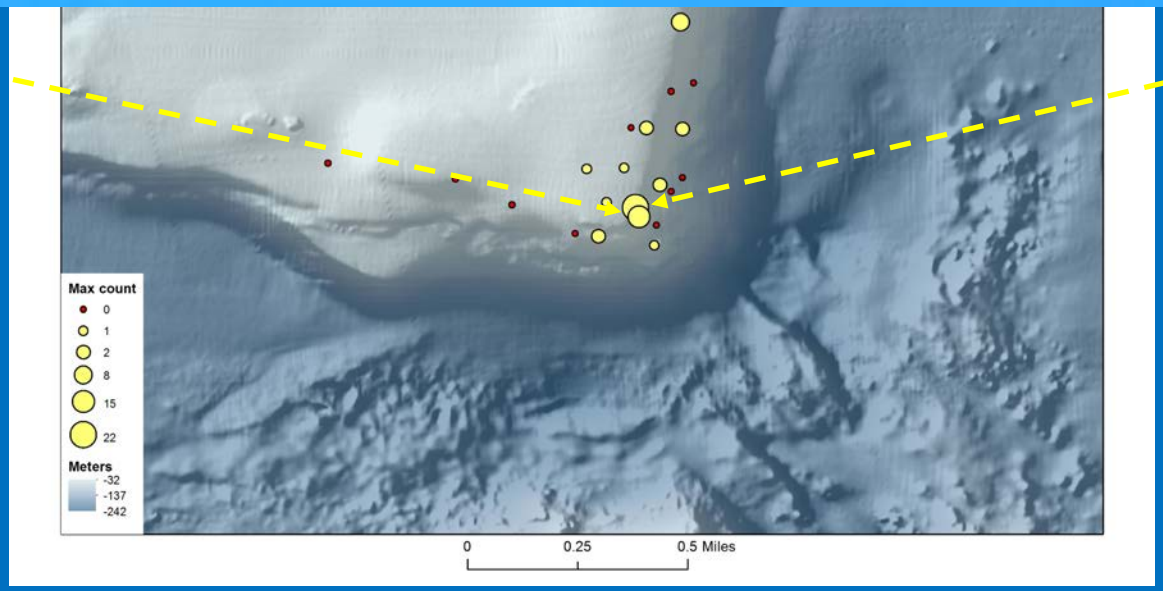
Type of Use: **P**rediction, **V**erification, **C**haracterization, **M**onitoring, **R**esearch

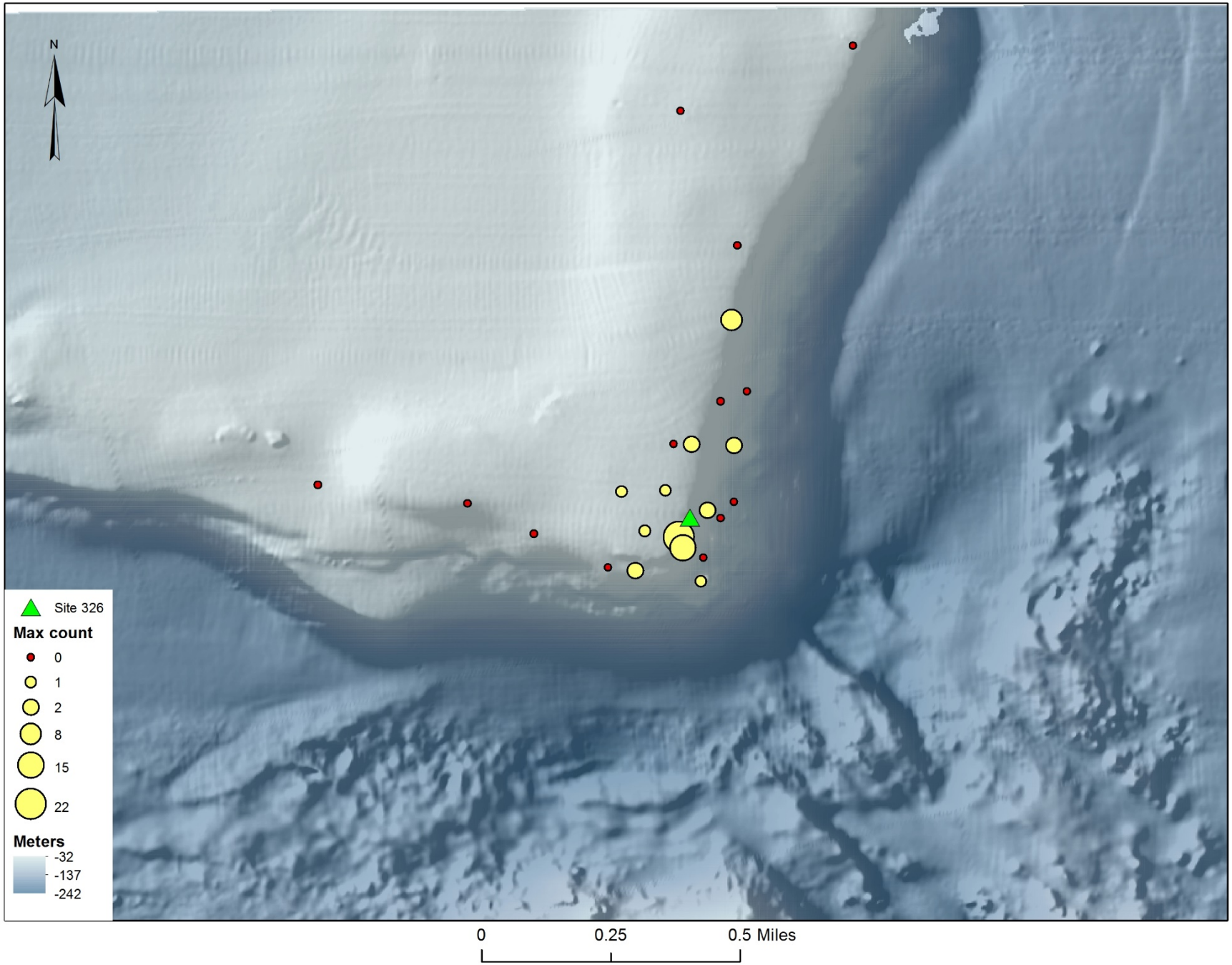
Depth: **S**hallow (<10m), **M**edium (10 – 30m), **D**eep (>30m)

Water Clarity: **L**ow (<1m), **M**edium (1 – 5m), **H**igh (5-15m), **V**ery **H**igh (>15m)

New Results: Wayne's Lump



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Site 326
Max count
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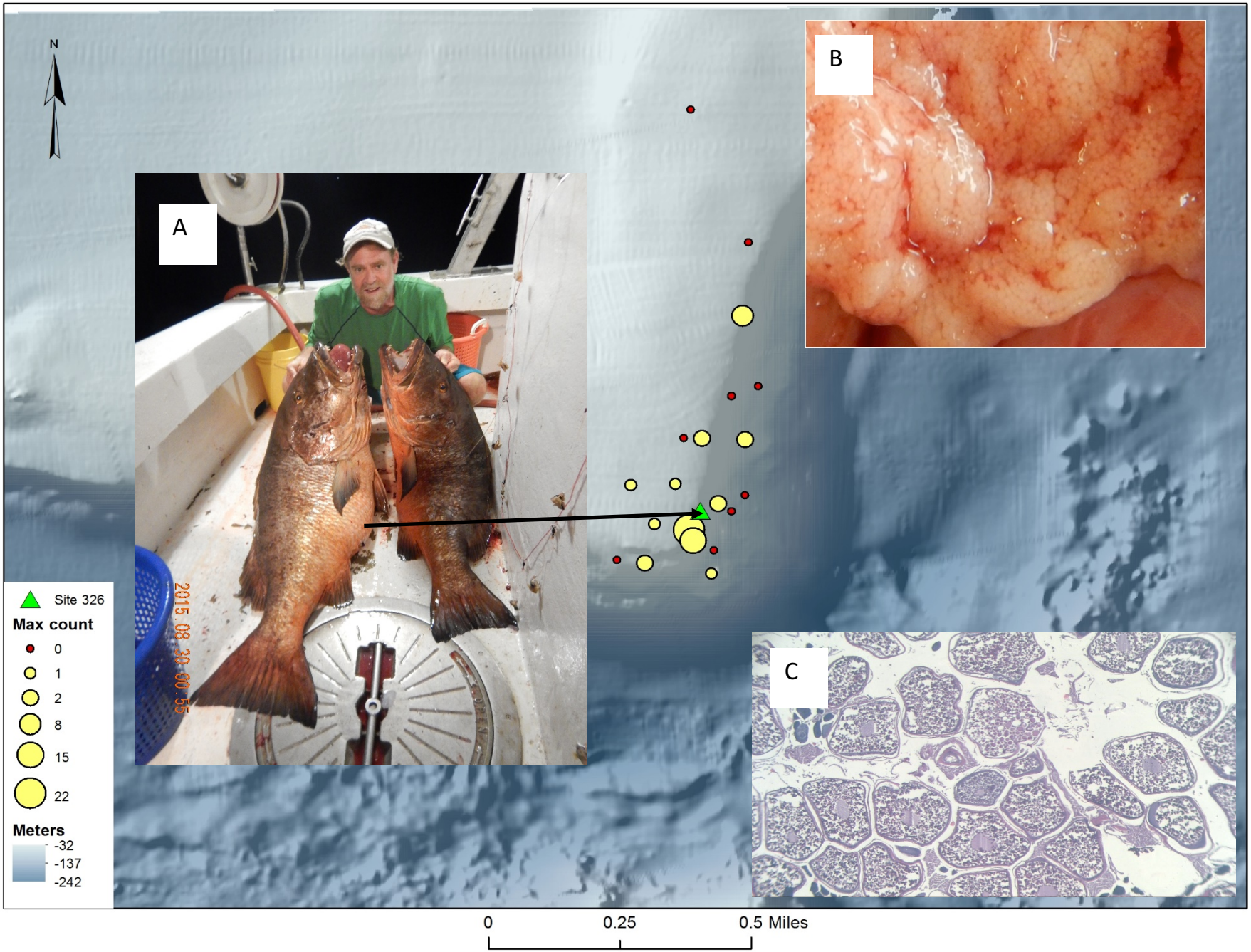
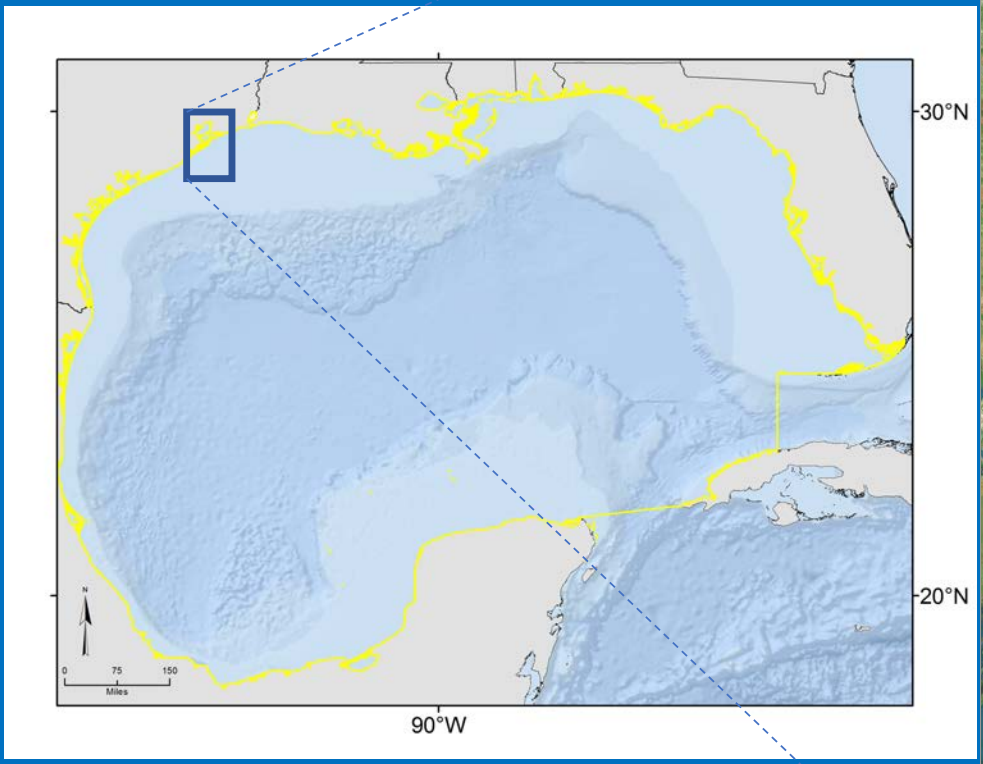
1
2
8
15
22
Meters
-32
-137
-242
0
0.25
0.5 Miles


N
A
B
C
2015.08.28 00:55
Site 326
Max count
0
1
2
8
15
22
Meters
-32
-137
-242
0
0.25
0.5 Miles

Galveston Jetties



2015 Results: Galveston Channel

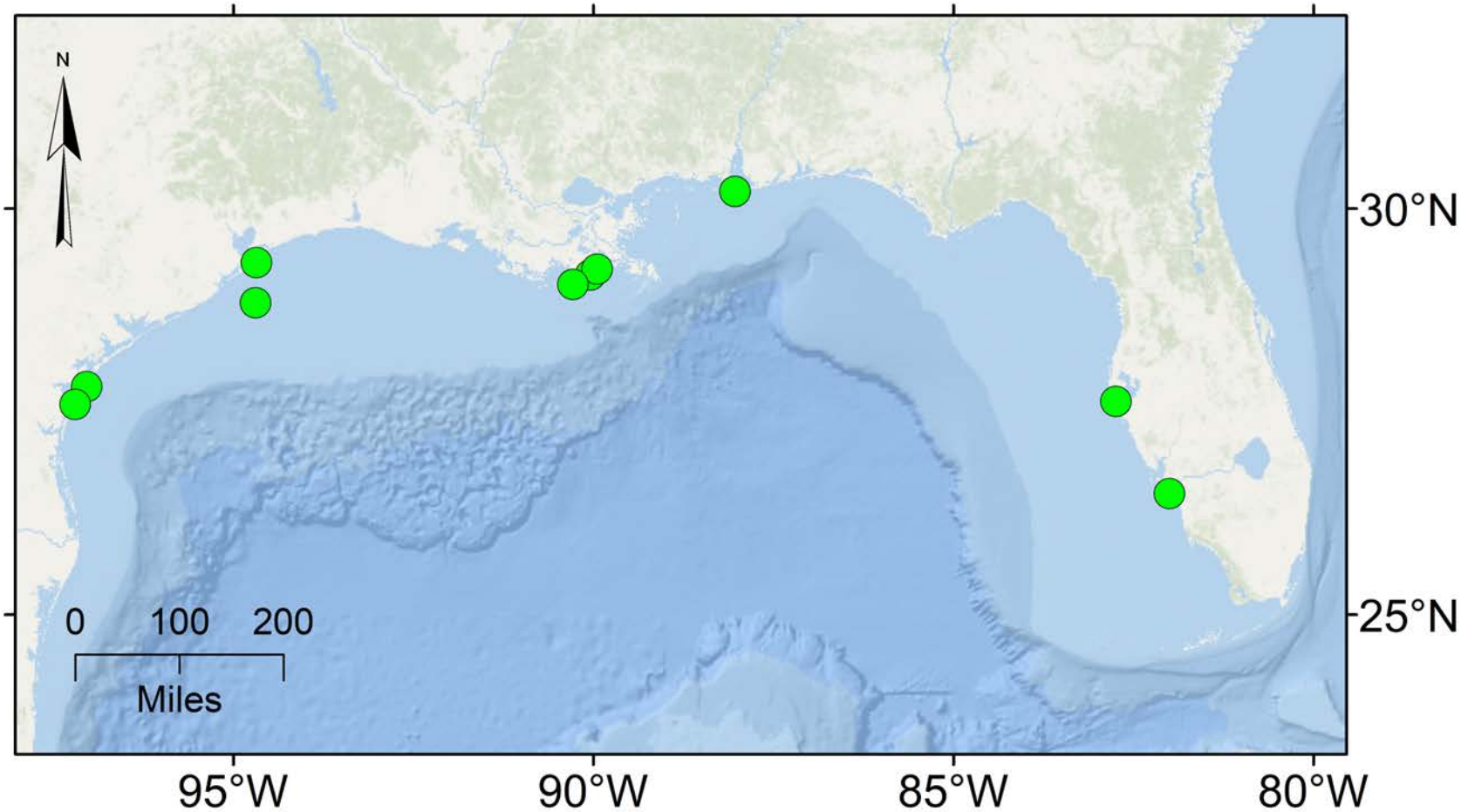
2015.03.17 13:59

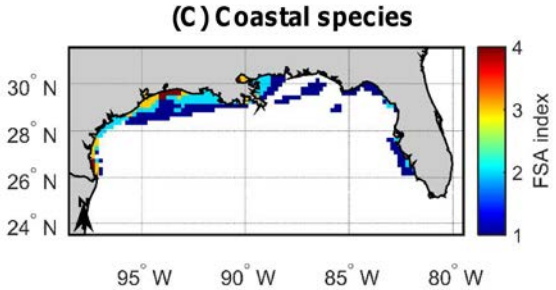
Sheepshead Aggregation

Coastal multi-species FSAs

- Sheepshead spawn at the Galveston jetties during 4 – 6 weeks, spawning daily until they stop abruptly.
- Galveston channel and jetties serve as multi-species spawning habitat
- Other jetties and passes (including Aransas Pass) show similar spatio-temporal patterns

Documented Spawning sites

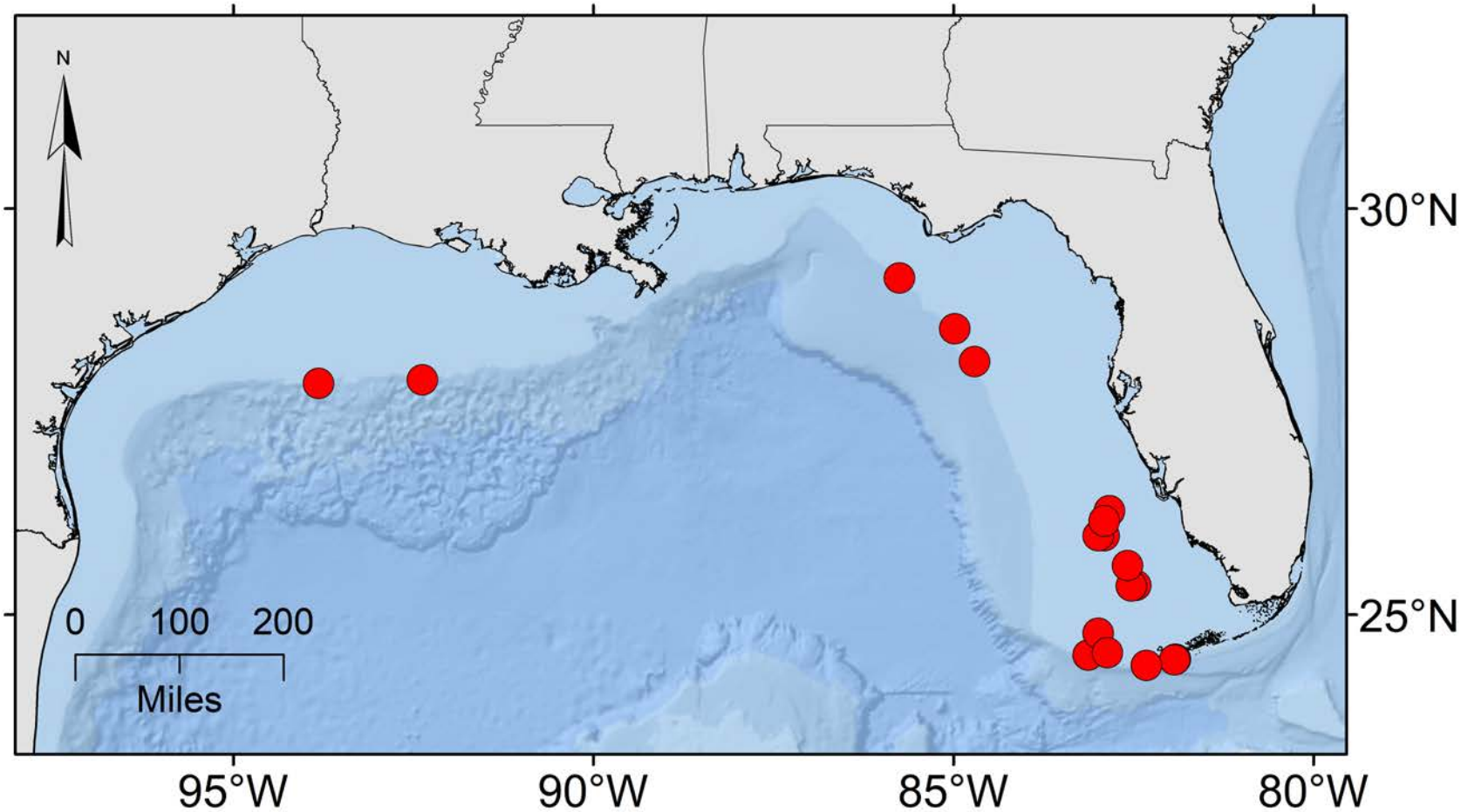


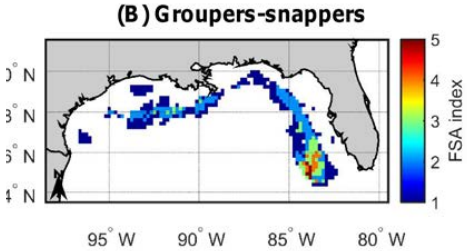


Coastal Species

(seatrout *Cynoscion nebulosus,* red drum *Sciaenops ocellatus,* black drum *Pogonias cromis,* and sheepshead *Archosargus probatocephalus*)

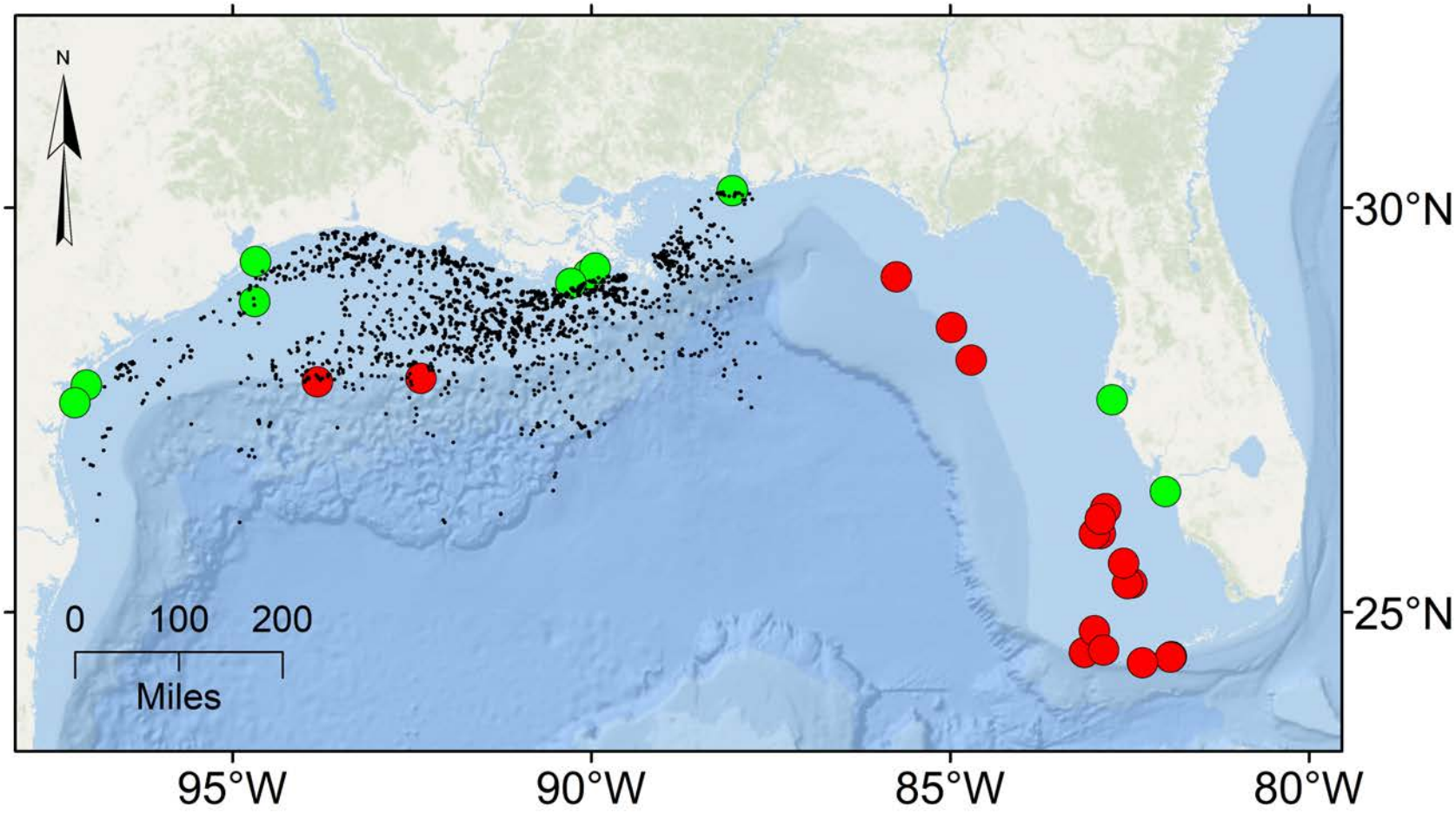
Documented Spawning sites





Snapper Grouper Species

Mutton snapper *Lutjanus analis*, Cubera *L. cyanopterus*, Dog snapper *Lutjanus jocu*, Yellowtail snapper *Ocyurus chrysurus*, Grey snapper *Lutjanus griseus*, Gag *Mycteroperca microlepis*, Yellowmouth grouper *Mycteroperca interstitialis*, Scamp *Mycteroperca phenax*, Black grouper *Mycteroperca bonaci*, Goliath grouper *Epinephelus itajara*, Greater amberjack *Seriola dumerili*, Crevalle jack *Caranx hippos*, Horse eye jack *Caranx latus*, Permit *Trachinotus falcatus*, and Ocean triggerfish *Canthidermis sufflamen*



All species with oil and gas platforms

Research: Possible spawning aggregations at Oil and Gas Platforms

Data Gaps

1. With the exception of a few coastal species, there is a near total lack of information on the location of FSAs for most focal species in the Gulf of Mexico, which greatly impedes monitoring, assessment, and management efforts.
2. Data on the behavioral dynamics of spawning aggregations (e.g. timing, dimensions, durations, abundance, fish movements) and fine-scale, spatio-temporal interactions between spawning aggregations and fisheries is lacking for many species but critical for management.
3. A unified bathymetric coverage for the Gulf of Mexico is still lacking but would enhance our ability to predict, characterize, monitor and manage important multi-species sites.

Recommendations for spatial research

1. Locate and characterize multi-species spawning areas for key species and prioritize them for protection or management.
2. Engage stakeholders from all sectors to improve understanding of reef fish spawning ecology and the fisheries significance of spawning aggregations.
3. Use Cooperative Monitoring Protocol to characterize sites.
4. Evaluate Platforms as FSAs.

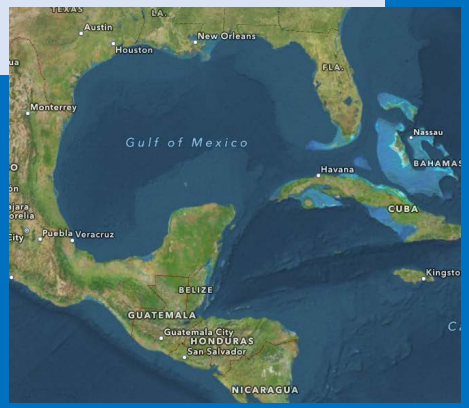
Opportunities to improve stock assessments

1. Improve metrics that allow for integration of productivity parameters associated with spawning aggregations (e.g. spawning potential ratio, total egg production) with stock assessments.
2. An additional data stream for biological samples.

Vision: A regional network of protected and cooperatively monitored FSA sites

Long-term (3-10 yrs @ $1m/yr)

- Develop a network of fishermen, scientists and managers who cooperatively predict, characterize, and monitor multi-species FSAs throughout the GOM
- Develop methods to integrate FSAs into regional stock assessments
- Establish long-term monitoring sites for FSAs in the wider GOM
- Utilize advanced technologies to improve efficiency & quality of FSA monitoring
- Assess the importance of petroleum platforms as suitable FSA sites
- Model the potential effects of climate change and fishing pressure on the phenology, distribution, and productivity of FSAs



Questions for SSC?

- What is the importance of documenting and monitoring multi-species FSAs in the GoM?
- Do you think that the Cooperative Monitoring Protocol will produce data that can be used to characterize and monitor sites? How could it be improved?
- How can monitoring data from FSAs
  - inform stock assessments?
  - Inform regional management of stocks?
- Should additional spatial protections be considered for key FSA sites?