Prediction and Verification of Spawning Aggregations in the US South Atlantic

Presented to:

South Atlantic Fishery Management Council

Snapper Grouper Committee

Presented by:

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LGL Ecological Research Associates, Inc.

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- South Atlantic Fisheries Management Council
- SC DNR MARMAP
- Gulf and South Atlantic Fisheries Foundation
- Pew Charitable Trusts
- Summit and Oak Foundations
- Sea Scouts Base Galveston
- NOAA Saltonstall Kennedy Program
- Commercial fishermen including Jack Cox, Mark Marhefka

Objectives

- **Develop and test methods** for **cooperative research with commercial snapper grouper fishermen for prediction and verification of spawning aggregations in the US South Atlantic**
- **Verify spawning aggregation sites** of anecdotally described multi-species spawning aggregations in the US South Atlantic
- **Foster a collaborative, participatory research and monitoring program to:**
  - Inform and improve SEDAR stock assessments
  - Identify, characterize, and design SMZs via an adaptive process
  - Ultimately provide a valuable data stream for the management of snapper/grouper
  - Instill participatory and adaptive, ecosystem based management practices

Context

- Declining Snapper Grouper Stocks in US South Atlantic
- Magnuson Stevens 2006 mandate to end overfishing
- Warsaw grouper and Speckled hind highly reduced with possible listing on ESA. (Nassau grouper is in the final stages of listing.)
- 240’ closure enacted and then removed
- Expert Workgroup recommendations modified and reduced
- “The hammer of regulation is still over our heads” Mark Marhefka
- What options are left? – SA AP decided to evaluate the possibility of SMZs to protect spawning habitat of snappers and groupers – particularly SH and WG

Spawning Aggregation

- Spawning – egg release
  - (could be pairs, small group or large aggregation)
- Spawning aggregation -
  - Conspecific fish that have migrated and grouped together for the purpose of reproduction, in densities 3x normal (Domeier et al. 1997)
- Fish aggregation –
  - group of fish (could be for feeding, breeding, or simply normal schooling behavior, i.e. jacks)

Prediction and Verification

- Collaborative approach
- Season
- General area
- Geomorphology
- Spawning signs
  - Gonad condition
  - Behavior
  - Coloration
  - Spawning

Photo: Douglas David Seifert

What Constitutes Verification?

Direct Evidence

- Photo/video documentation of spawning (gamete release)
- Hydrated oocytes in gonads of female fish
- Post ovulatory follicles in female gonads

Indirect Evidence

- Underwater observations and photo/video documentation of courtship behavior and coloration
- High percentage of female fish caught have late development stage gonads
- Anecdotal information

Technique application

In water on boat

- Observe gamete release (d)
- High percentage of late stage gonads (indirect and not very diagnostic)
- Photo/video of courtship (i) behavior and coloration
- Anecdotal information (i)

Laboratory

- Hydrated oocytes in gonads of female fish (d)
- Post ovulatory follicles in female gonads (d)

d=direct
i=indirect

Direct Evidence

Hydrated oocytes

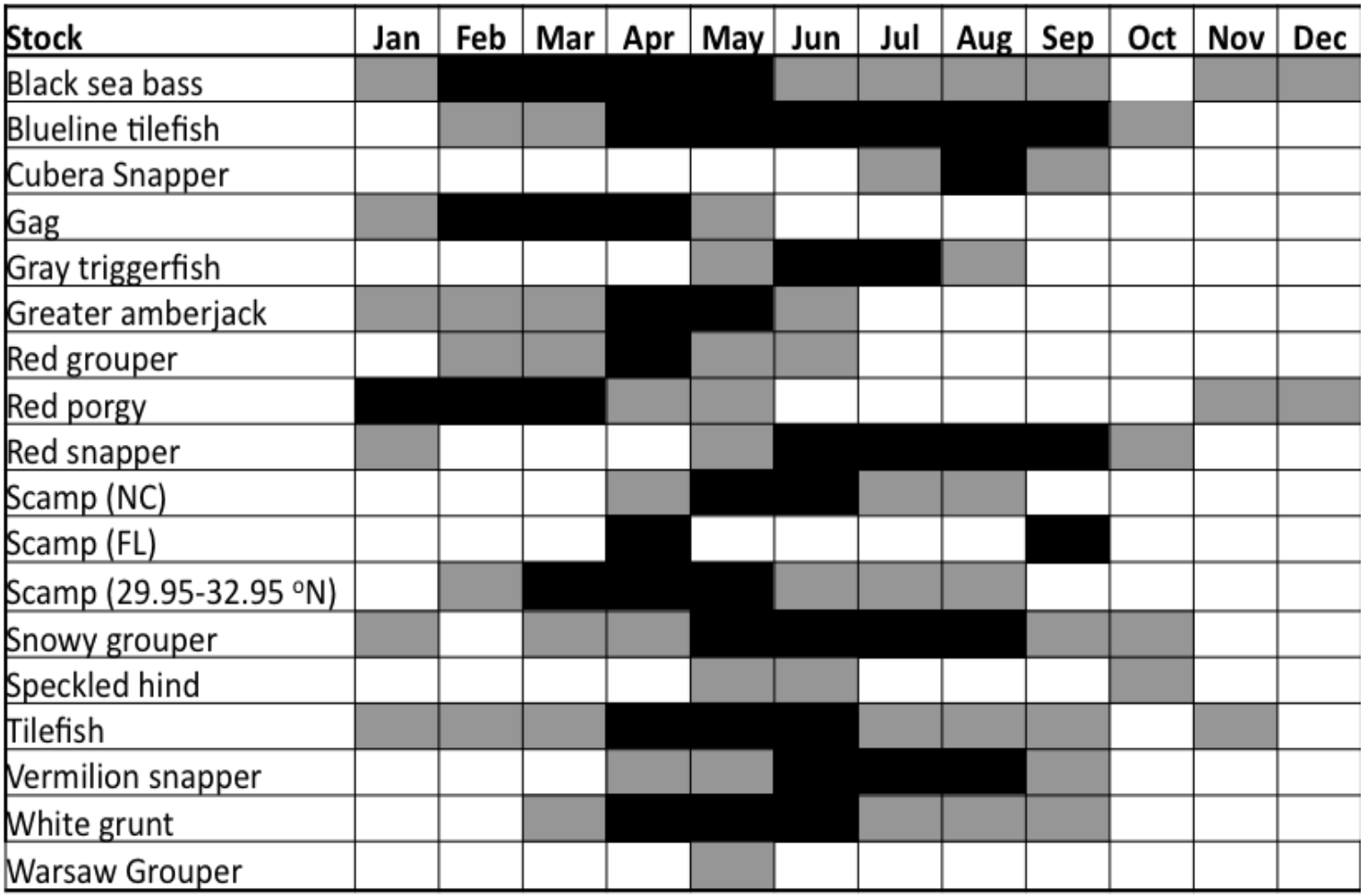
Snapper/Grouper spawning seasons based on Females in the US South Atlantic

Stock	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	References
Black sea bass													Sedberry et al. (2006); SEDAR-25 (2011)
Blueline tilefish													Harris et al. (2004)
Cubera Snapper													pers comm. SA fisherman to WDH
Gag													McGovern et al. (1998); Sedberry et al. (2006)
Gray triggerfish													Kelly (2014)
Greater amberjack													Harris et al. (2007)
Red grouper													Burgos et al. (2007)
Red porgy													Daniel (2003); Sedberry et al. (2006)
Red snapper													White and Palmer (2004); Seberry et al. (2006)
Scamp (NC)													Matheson et al. (1986); macroscopic
Scamp (FL)													Gilmore & Jones (1992); based on courtship behavior
Scamp (29.95-32.95 °N)													Harris et al. (2002), Sedberry et al. (2006)
Snowy grouper													Wyanski et al. (2000), SEDAR-36 (2013)
Speckled hind													Ziskin et al. (2011)
Tilefish													Erickson et al. (1985); Sedberry et al. (2006)
Vermilion snapper													Cuellar et al. (1996); Sedberry et al. (2006)
White grunt													Padgett (1997); Sedberry et al. (2006)
Warsaw Grouper													Sedberry et al. (2006)

Reference: Dave Wyanski developed this table. It will be included in a publication that is presently under development by Nick Farmer and others

This study

SC SC NC SC



Stock	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Black sea bass												
Blueline tilefish												
Cubera Snapper												
Gag												
Gray triggerfish												
Greater amberjack												
Red grouper												
Red porgy												
Red snapper												
Scamp (NC)												
Scamp (FL)												
Scamp (29.95-32.95 °N)												
Snowy grouper												
Speckled hind												
Tilefish												
Vermilion snapper												
White grunt												
Warsaw Grouper												

South East Reef fish Surveys

SERFS

Not many existing studies for South Atlantic spawning times/locations; some are:

Lindeman, K.C. R. Pugliese, G.T. Waugh and J.S. Ault. 2000. Developmental patterns within a multi-species reef fish fishery: Management applications and upper-slope habitats and protected areas. Bull Mar Sci 66(3): 929-956.

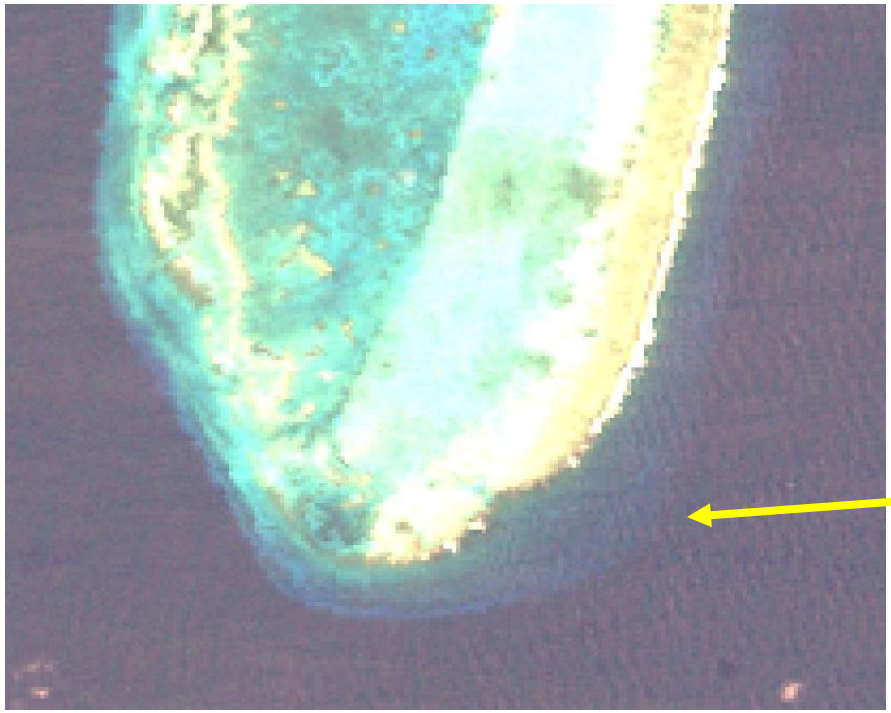
Schobernd, C.M., Sedberry, G.R., 2009. Shelf-edge and upper-slope reef fish assemblages in the South Atlantic Bight: Habitat characteristics, spatial variation, and reproductive behavior. Bull Mar Sci 84: 67–92.

Sedberry, G.R., O. Pashuk, D. M. Wyanski, J. A. Stephen, and P. Weinbach. 2006. Spawning locations for Atlantic reef fishes off the southeastern U.S. Proc. Gulf Carib Fish Inst 57: 463–514.

Geomorphology can be used to predict primary spawning aggregation sites

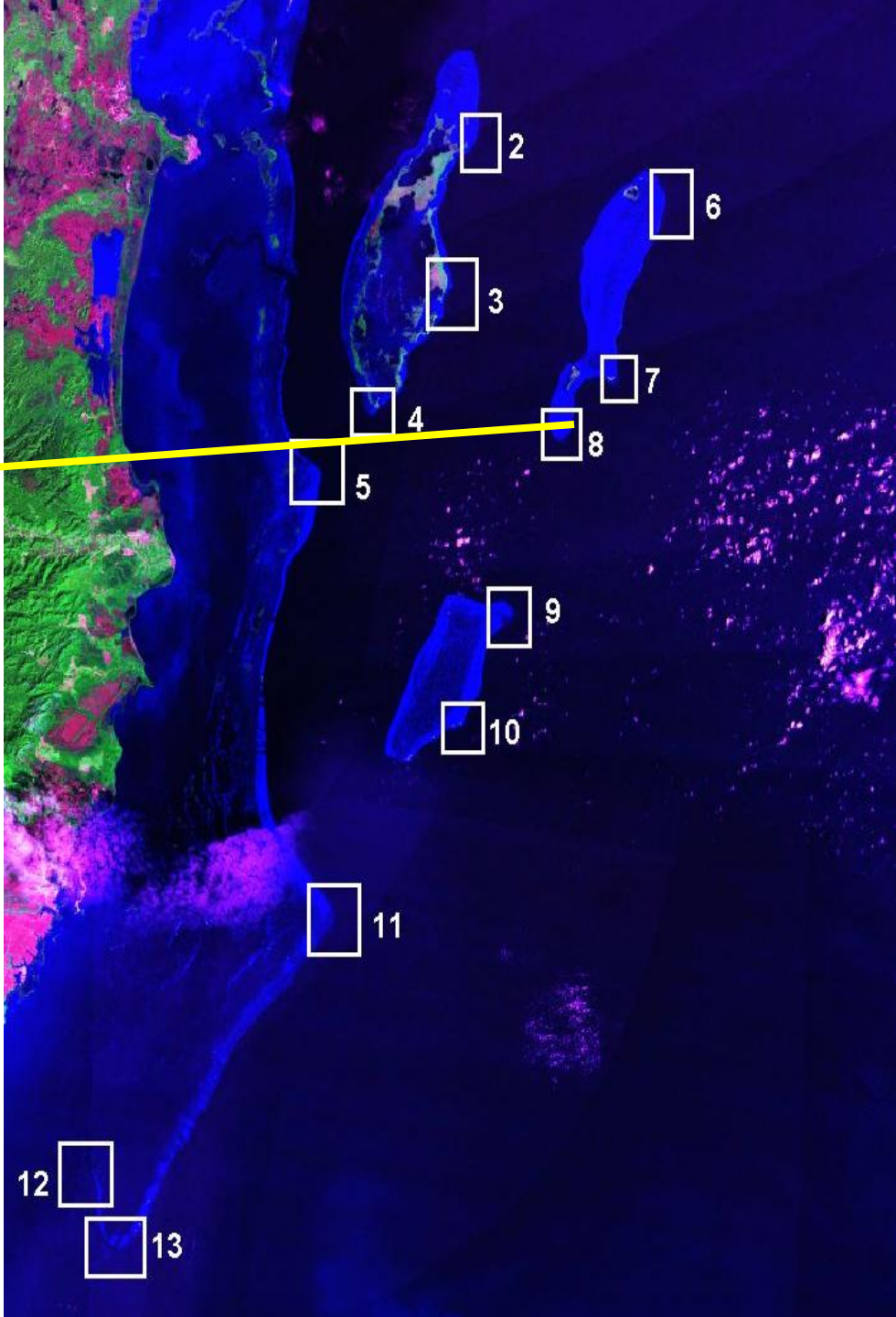
Primary Site: Every year, many species, many fish

Secondary Site: Some years, some species, some fish



Predicted spawning aggregation site

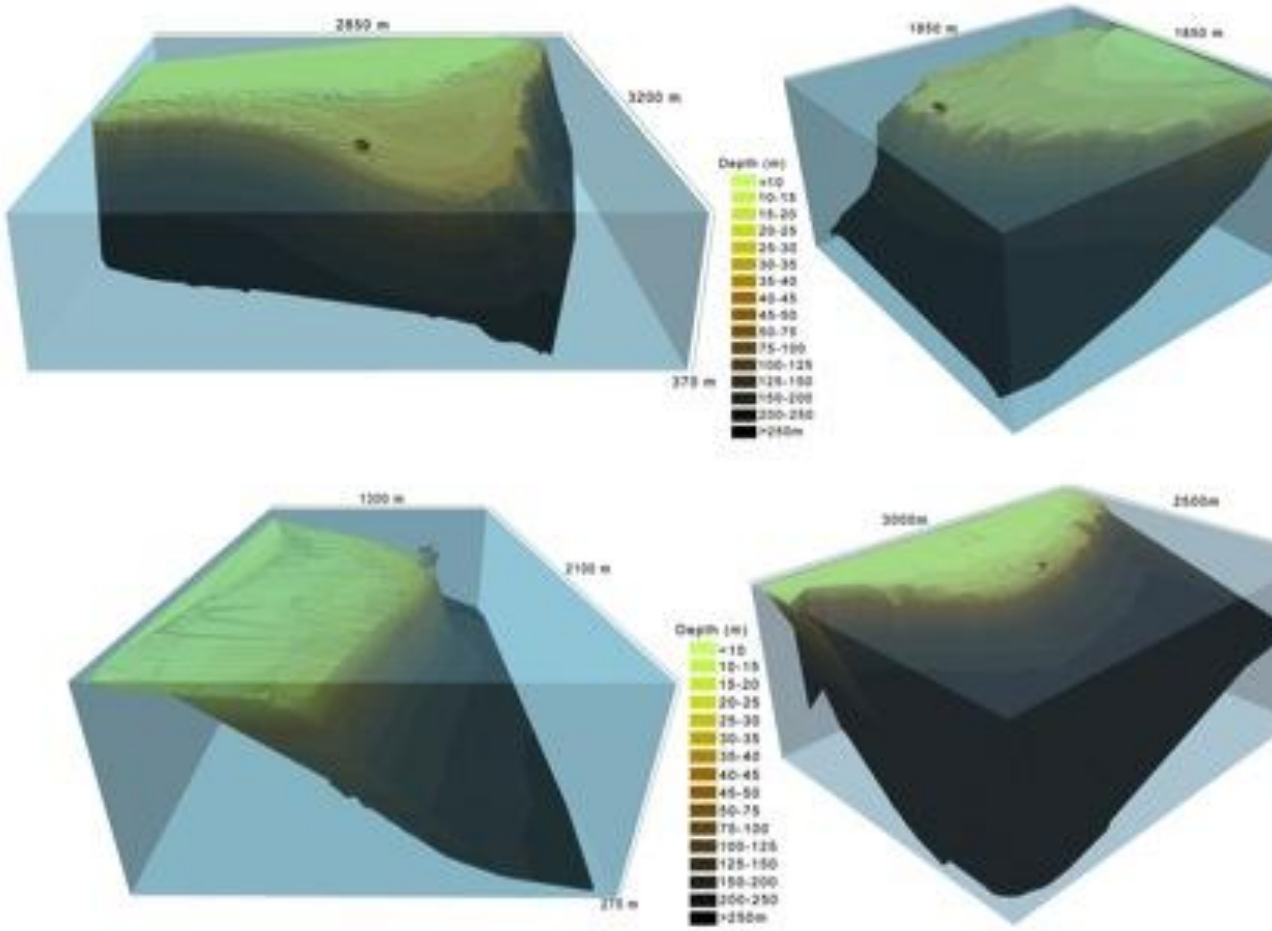
20 species of snappers, grouper and jacks



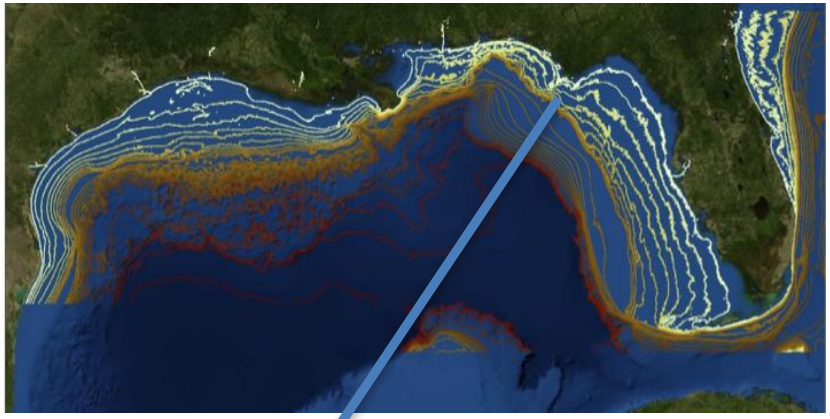
Belize and Cayman Islands: Multi-species aggregations at reef promontories in

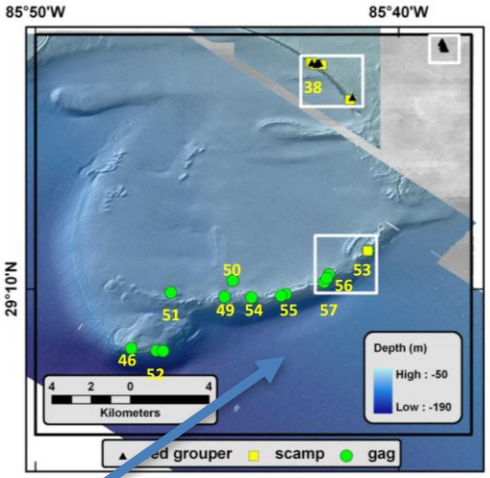
Nassau grouper
Black grouper
Yellowfin grouper
Tiger grouper

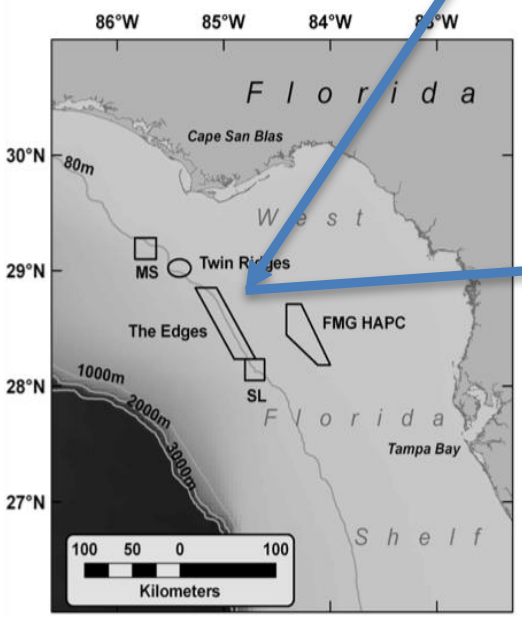
Cubera snapper
Dog snapper
Mutton snapper

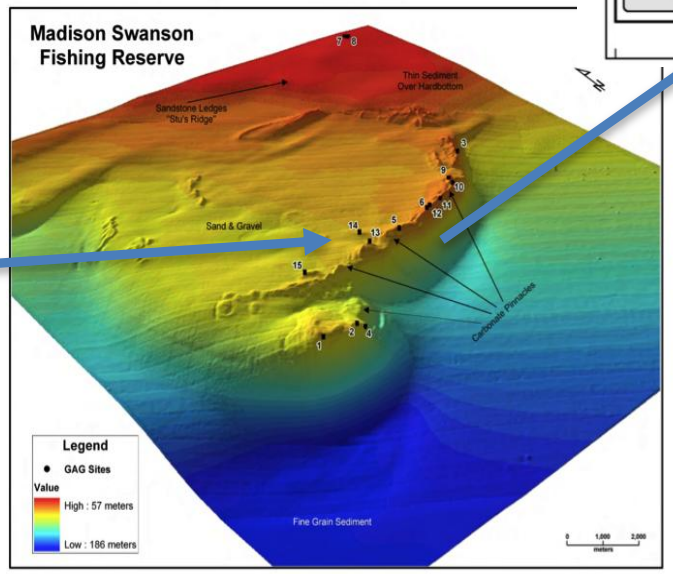


West Florida Shelf: Multi-species aggregations of gag and scamp at bumps on convex shelf edge



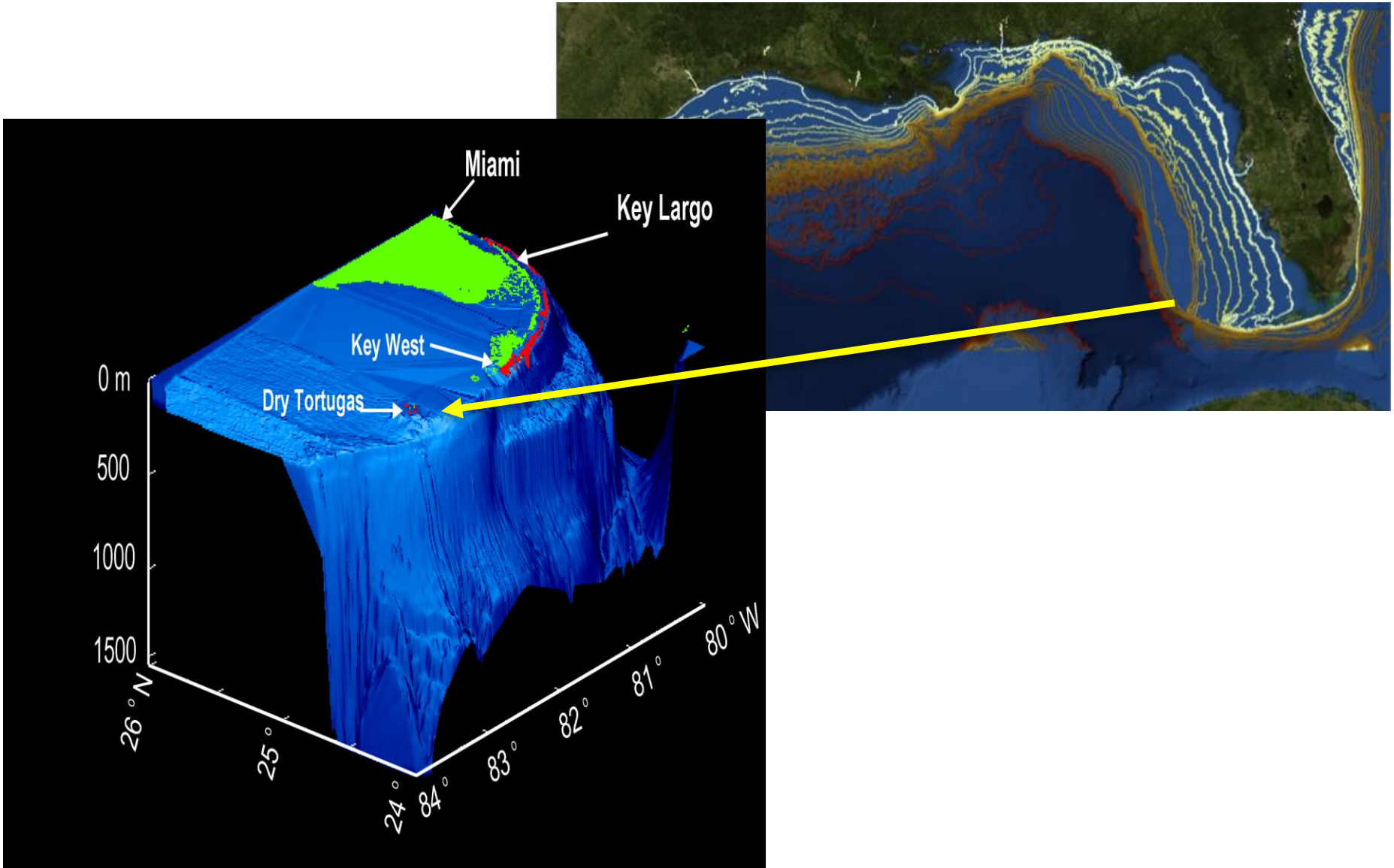






From F. Coleman and C. Koenig

Riley's Hump: Multi-species aggregations at areas of vertical relief near convex shelf edge



Anecdotal Information

- MPA Expert workgroup and follow up interviews indicate Georgetown Hole, Warsaw Hole, Western Dry Rocks, and other sites are multi-species spawning aggregation sites that harbor populations of Warsaw grouper and speckled hind.

- Worthy of investigation

Courtship and spawning coloration Nassau grouper

BULLETIN OF MARINE SCIENCE, 51(1): 83–103, 1992

COLOR VARIATION AND ASSOCIATED BEHAVIOR IN THE EPINEPHELINE GROUPERS, *MYCTEROPERCA MICROLEPIS* (GOODE AND BEAN) AND *M. PHENAX* JORDAN AND SWAIN

R. Grant Gilmore and Robert S. Jones

Gag courtship coloration

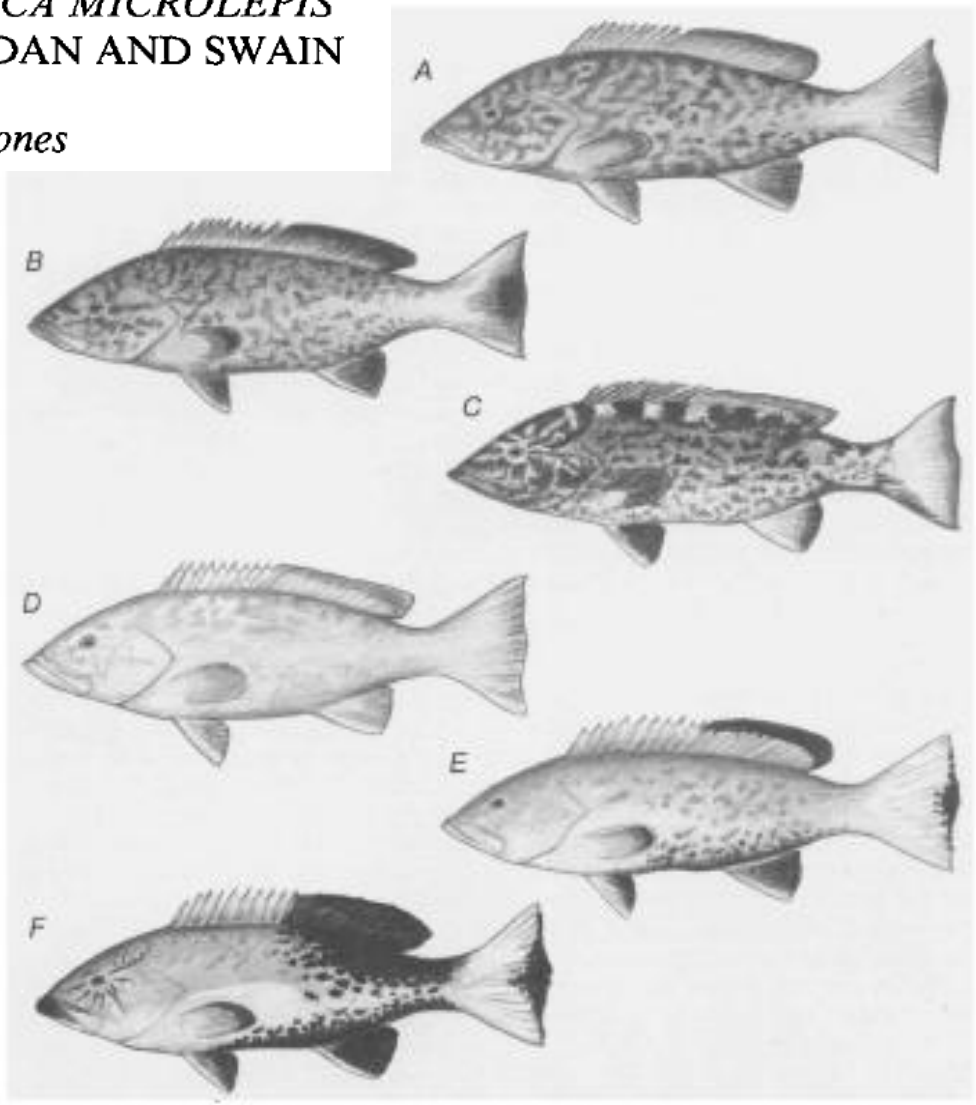
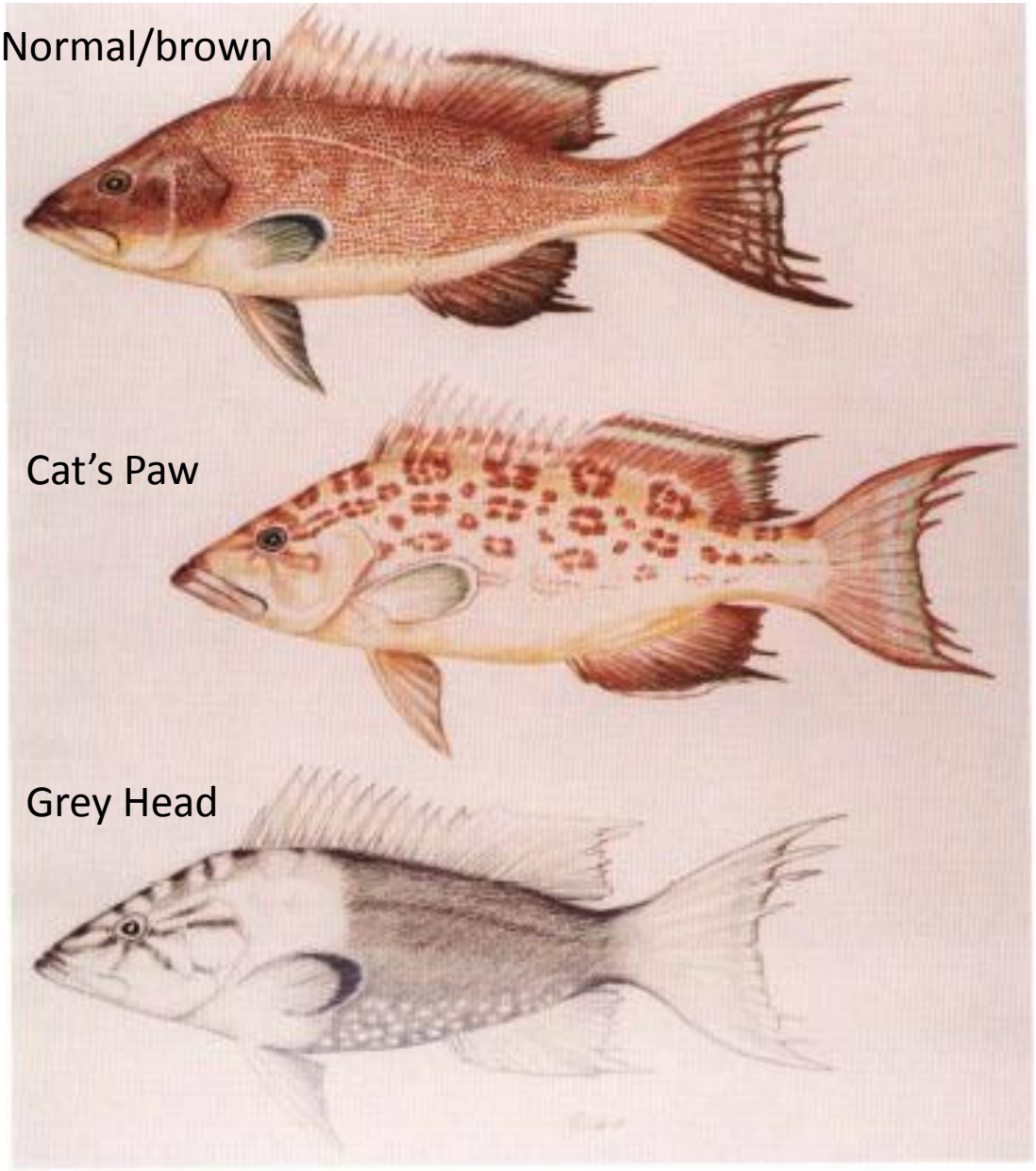


Figure 7. Color phases of the gag, *Mycteroperca microlepis*. (A) and (B) are grey and brown reticulate phases; (C) camouflage phase; (D) solid grey; (E) black-belly phase; (F) black-back phase.

Mycteroperca microlepis

From Gilmore and Jones, 1992

Scamp courtship coloration



From: Gilmore and Jones, 1992

Gilmore and Jones 1992

“ . . courtship and other display behavior was observed during the same period in ripe individuals of the black sea bass*, snowy grouper, and speckled hind, . .* with the gag and scamp aggregations.

The return of specific individuals to the same reef formation to spawn was also observed. Two scamp, with diagnostic scar patterns . . . 28 February 1979; 7 March and 9 April 1980

Gonad Development Stages (mutton snapper)

Male

Female

Figures from M. Meadows (2012); original photos by Ariel Poholek (FWC & FAU)

Late development
Eggs not clearly visible
Edible

Hydrated eggs
Eggs easily visible
Not edible; too watery

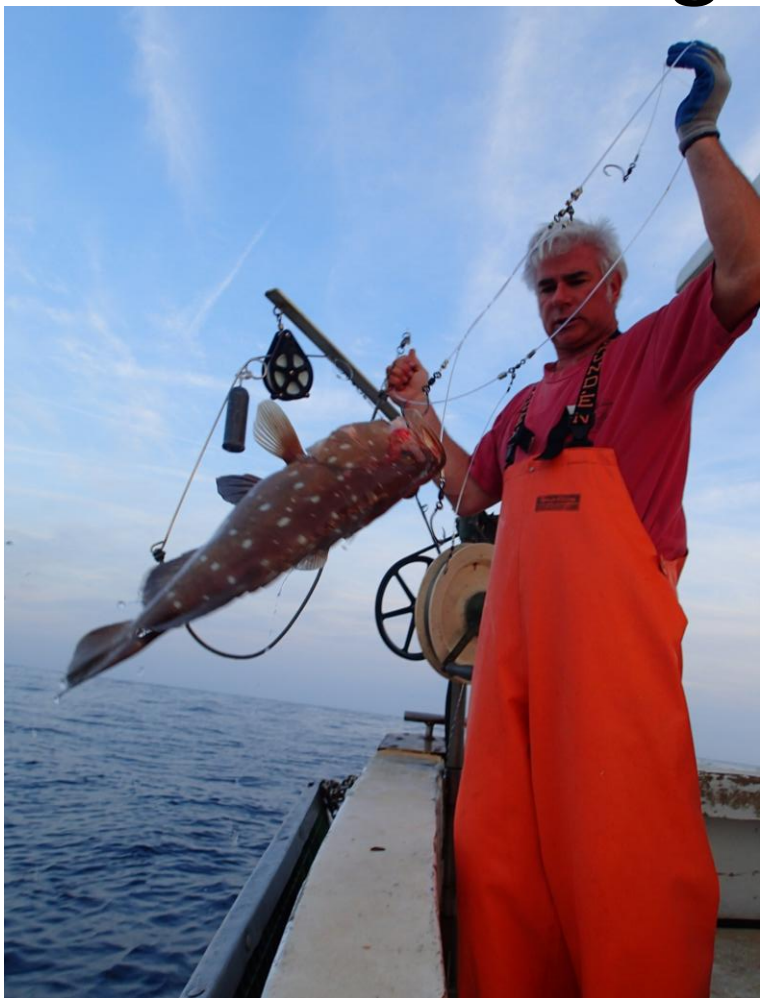
Source: Mascareñas I., G. Hinojosa, B. Erisman, O. Aburto-Oropeza. 2013. Manual de Monitoreo biológico-pesquero de curvina golfina (*Cynoscion othonopterus*). CBMC-SIO. 28 pp.

Techniques Developed and Tested

- Commercial landings: gonad development phase, CPUE, age and growth
- GoPro cameras deployed on fishing gear
  - SERFS video data could be mined for this purpose 2200 hours/yr
- Mapping sampling sites using sonar and GPS
- Fisher interviews

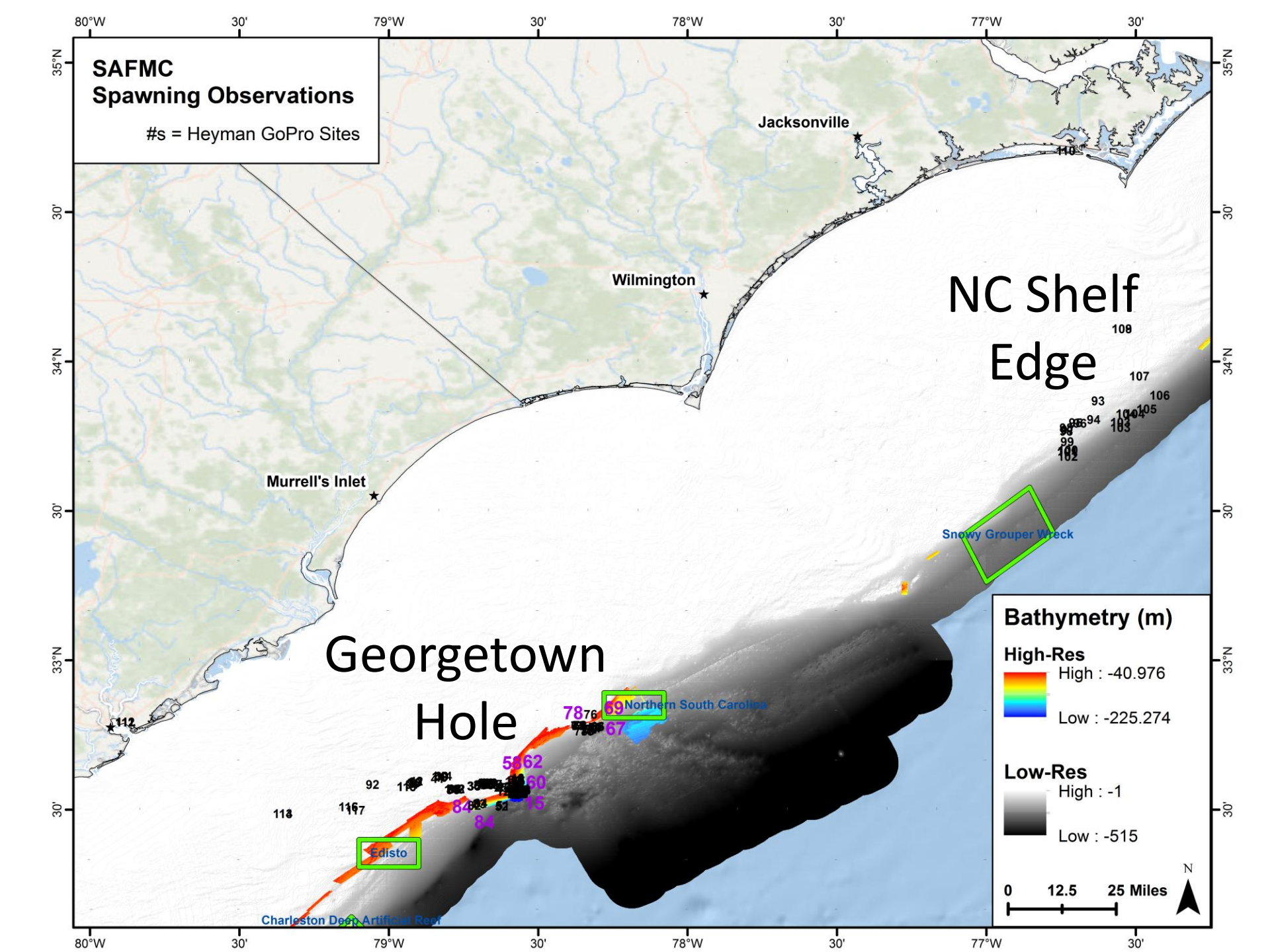
Drop Camera Setup

On commercial gear



Sites and Times Evaluated

- Georgetown Hole area off South Carolina
  - February 2014
  - April 2014
  - July 2014
- NC Shelf edge
  - July 2014


SAFMC
Spawning Observations
#s = Heyman GoPro Sites
Jacksonville
Wilmington
Murrell's Inlet
NC Shelf
Edge
Georgetown
Hole
Snowy Grouper Wreck
Northern South Carolina
Edisto
Charleston Deep Artificial Reef
Bathymetry (m)
High-Res
High : -40.976
Low : -225.274
Low-Res
High : -1
Low : -515
0 12.5 25 Miles
N
80°W
79°W
78°W
77°W
35°N
34°N
33°N
30'

Initial Results for Georgetown Hole

- Local knowledge of fishing
- Multi-beam mapping
- Sampling and bottom type
- Gonad observations
- Courtship coloration
- NEW maps and possible spawning locations
- Possible SMZ boundaries

The Devil's Hole

Barry was a friend of mine who I had gotten to know in our home church in the mid-1980s. He knew I was a licensed fishing boat captain and loved getting me to tell deep-sea fishing stories. One of Barry's longtime dreams was to catch a giant Warsaw grouper. In my years as a commercial fisherman, I had caught more giant grouper on hook and line than about any other fisherman on the East Coast. In fact, in the 1970s and '80s, I caught over 100 of these monstrous fish, which averaged about 175 pounds; ten were over 300 pounds, and one was a 450-pounder. To catch that one, I used a live 15-pound mahi mahi for bait, on a 300-pound test wire line.

In the early 1990s, Barry started to hound me, "Jack, will you take me out to catch one of those Warsaw grouper?"

There are several good spots for Warsaws right off Myrtle Beach, near where we live; one of them, Georgetown Hole, is 62 miles offshore. As commercial fishermen in the 1970s, we called that place the Devil's Hole because of the number of boats and fishermen who had disappeared without a trace while fishing there, including some friends of mine. Barry knew that I once had caught 28 grouper that totaled 5,000 pounds in one night at Devil's Hole. On another night I caught 14, and on still another, 9.

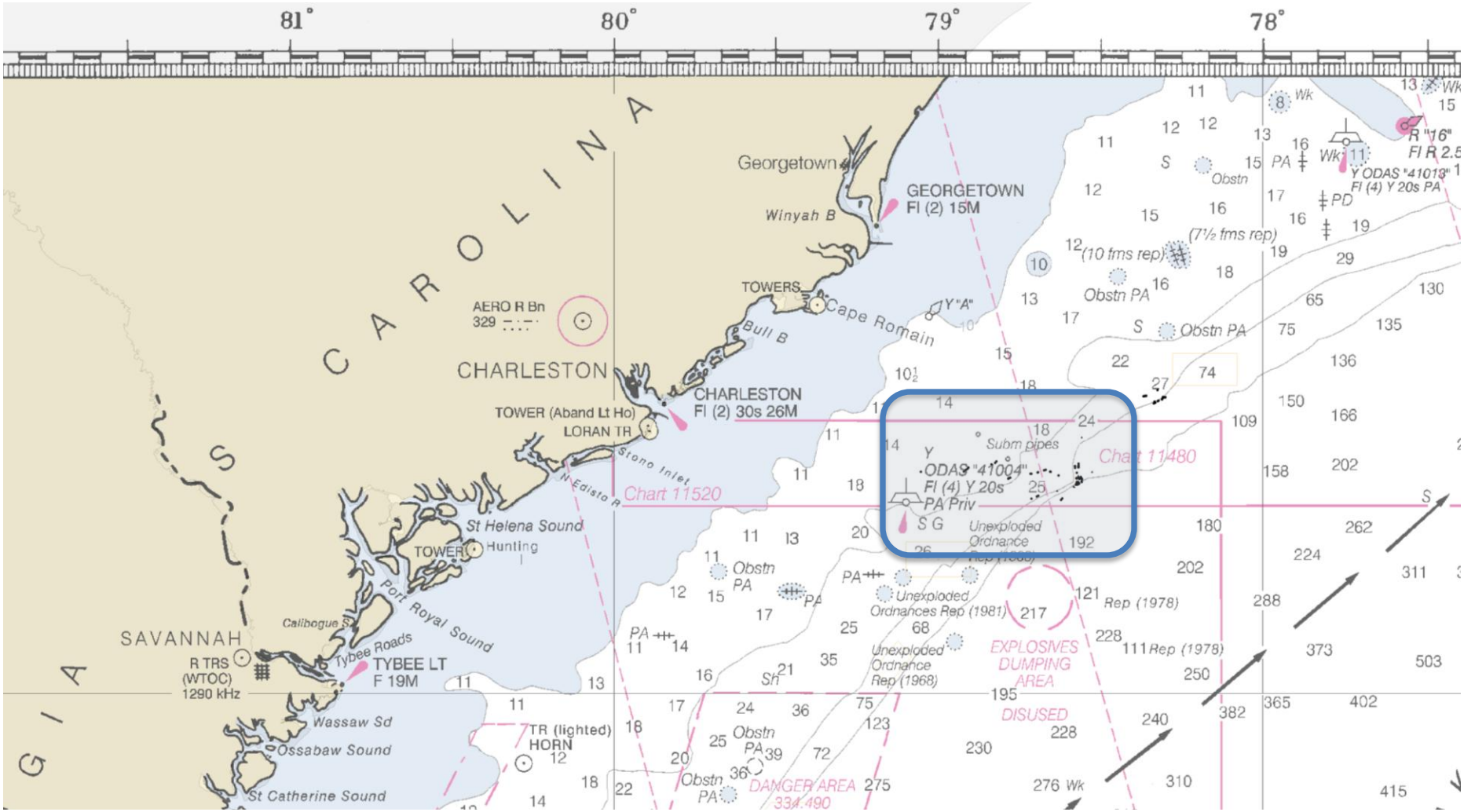
From: Frost, J. 2006. *Spiritual Slavery to Spiritual Sonship. Destiny Image Publishers, Inc.*

“ We used to catch Warsaw out there (Georgetown Hole) the size of Volkswagons”

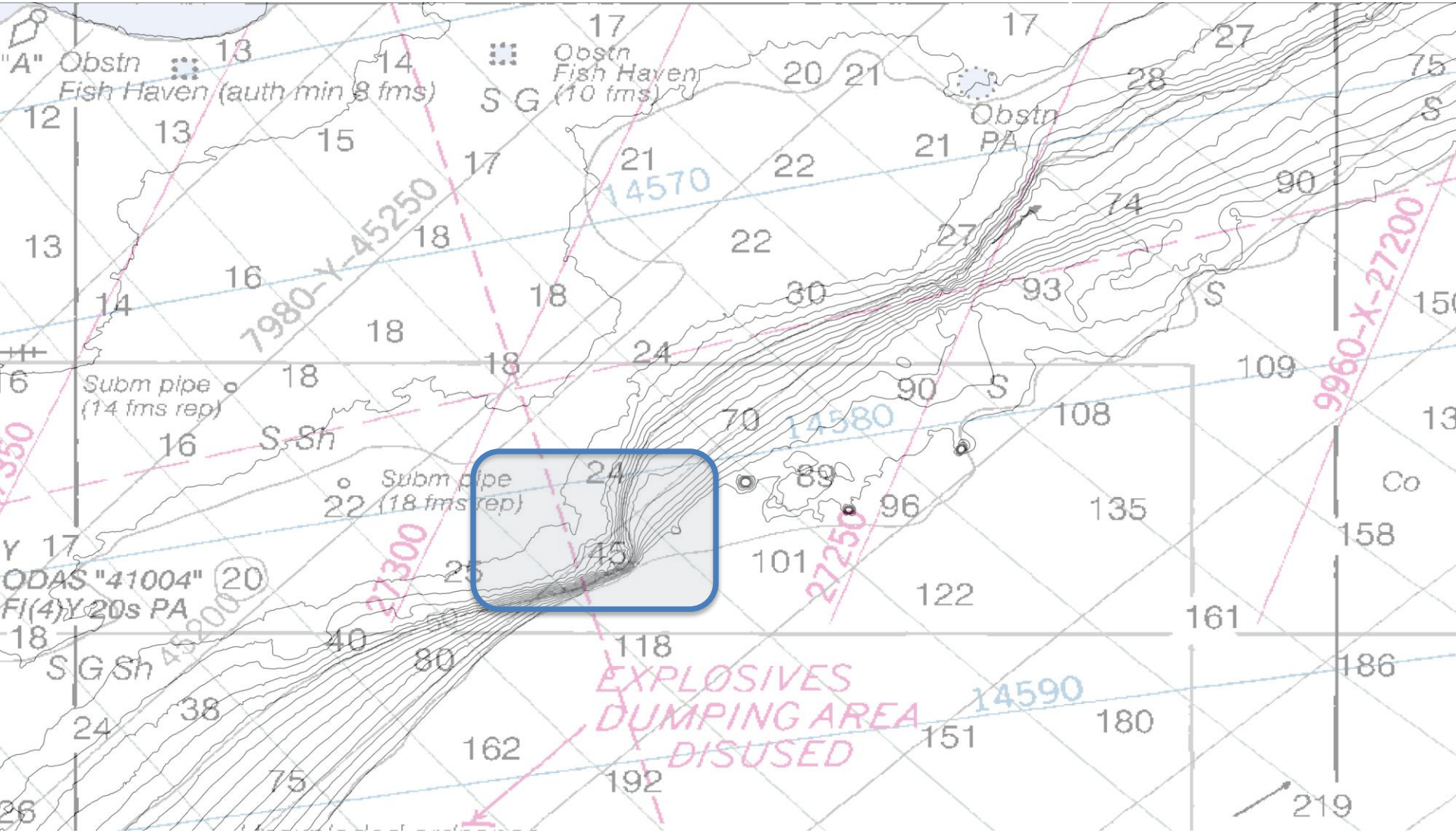
Phil Conklin

LINK to Video: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CCcQtwIwAQ&url=http%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DEMAfKOxQwXQ&ei=hg92VL2nI4SoNvzXgvAF&usg=AFQjCNHCg48UdQktPiZsOd-kSb3poKIuhw&sig2=Rg2q0rjb1gKy6ySHpk4pww

Georgetown Hole



Georgetown Hole



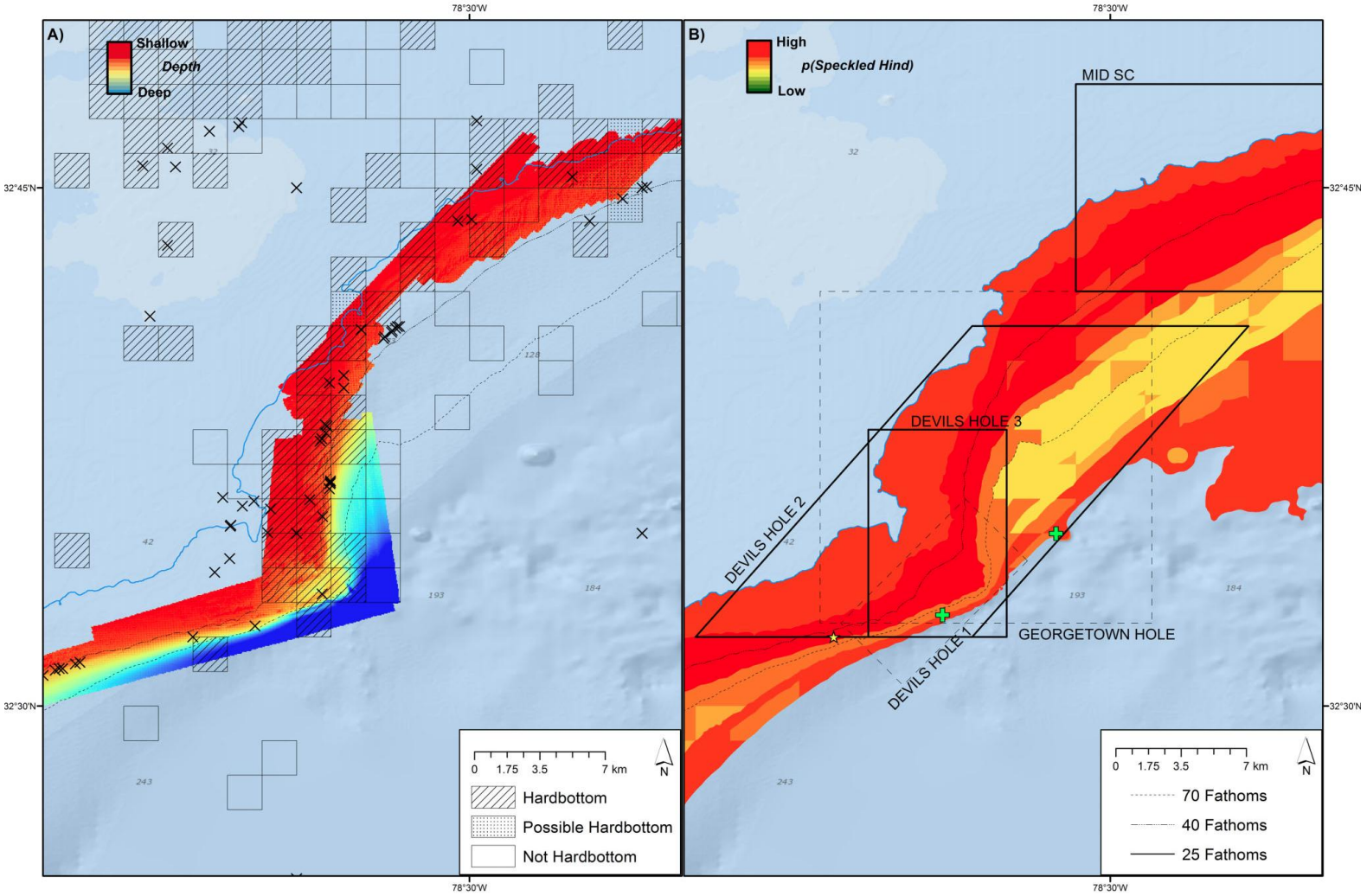
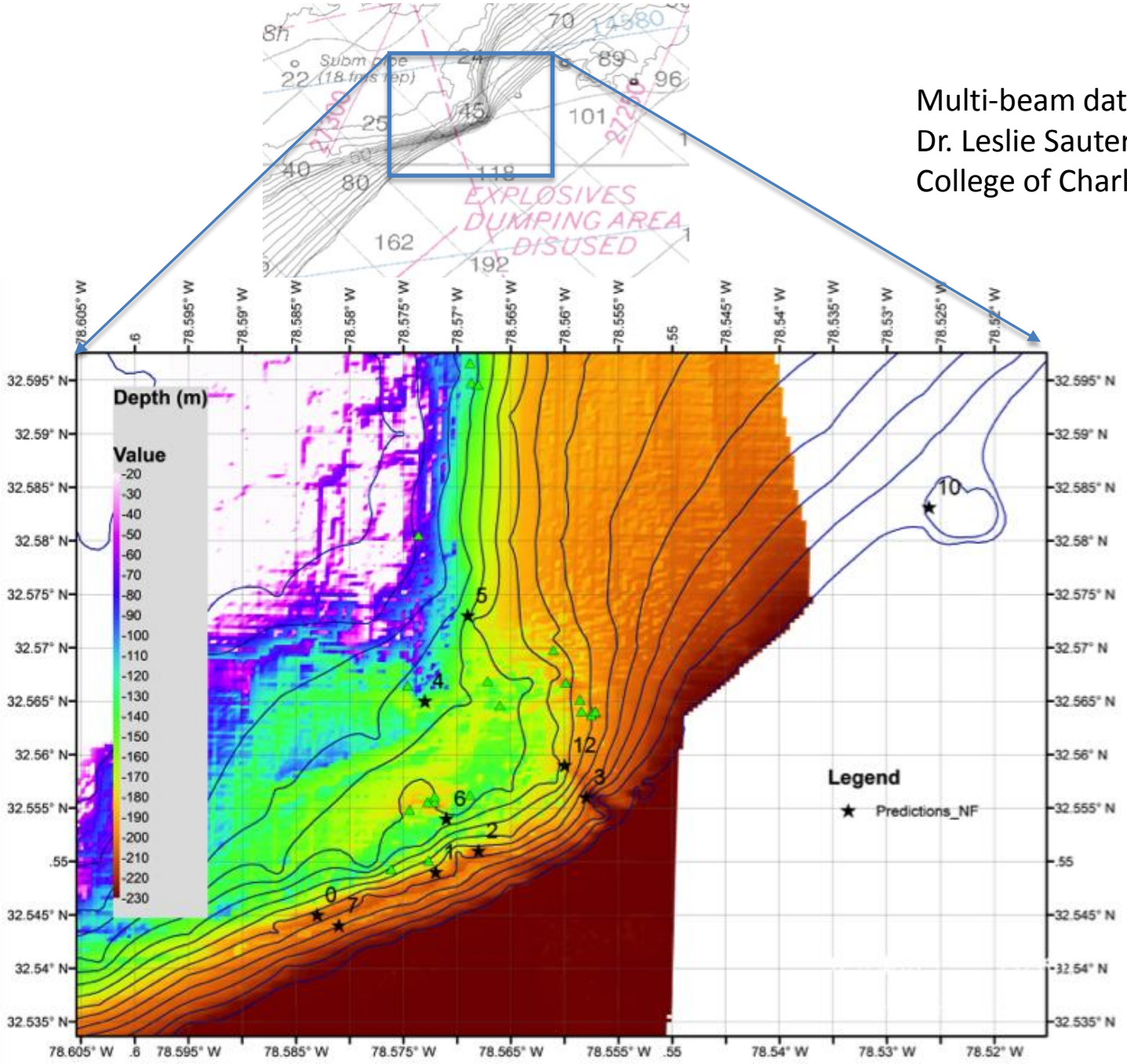
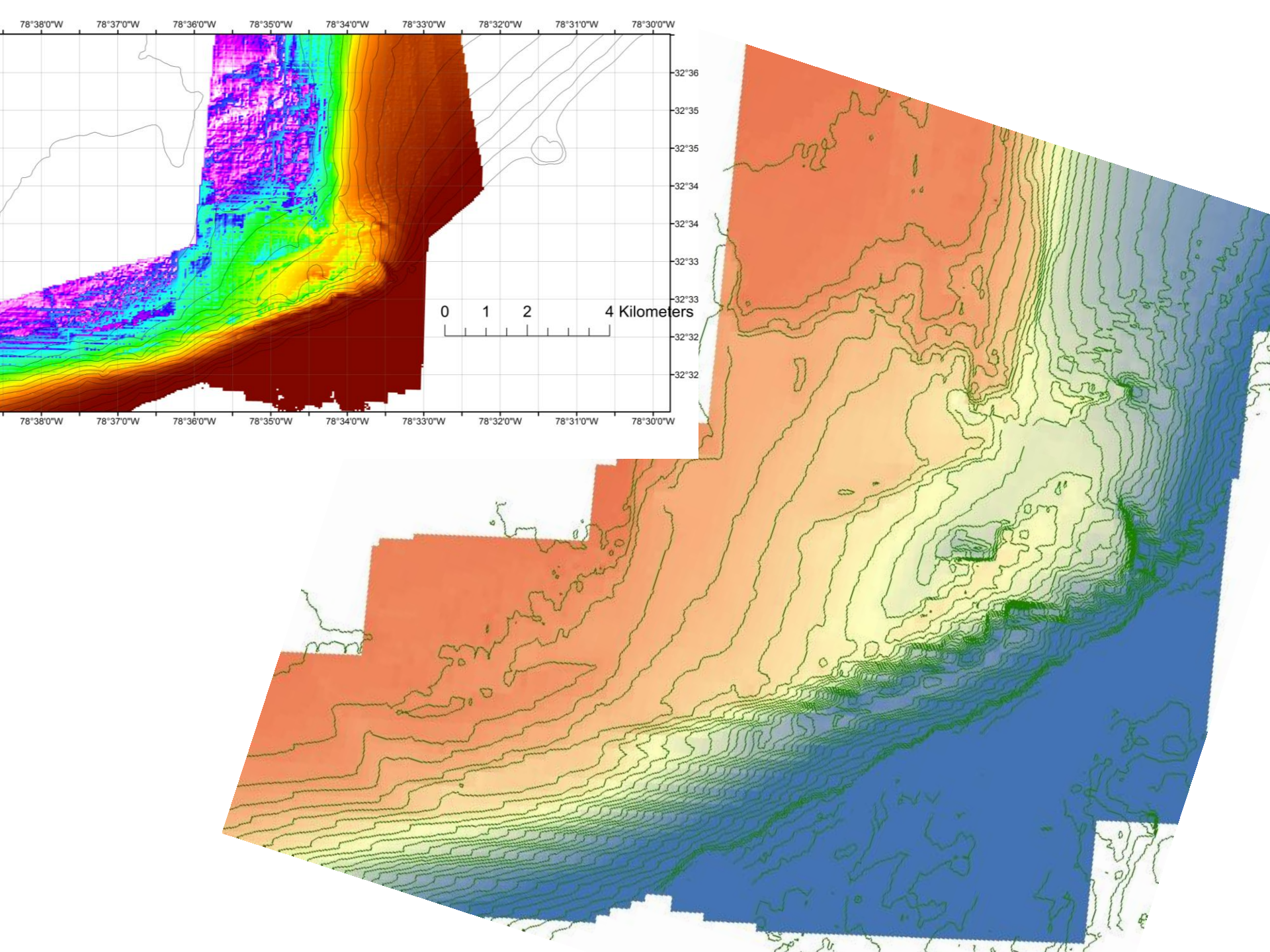


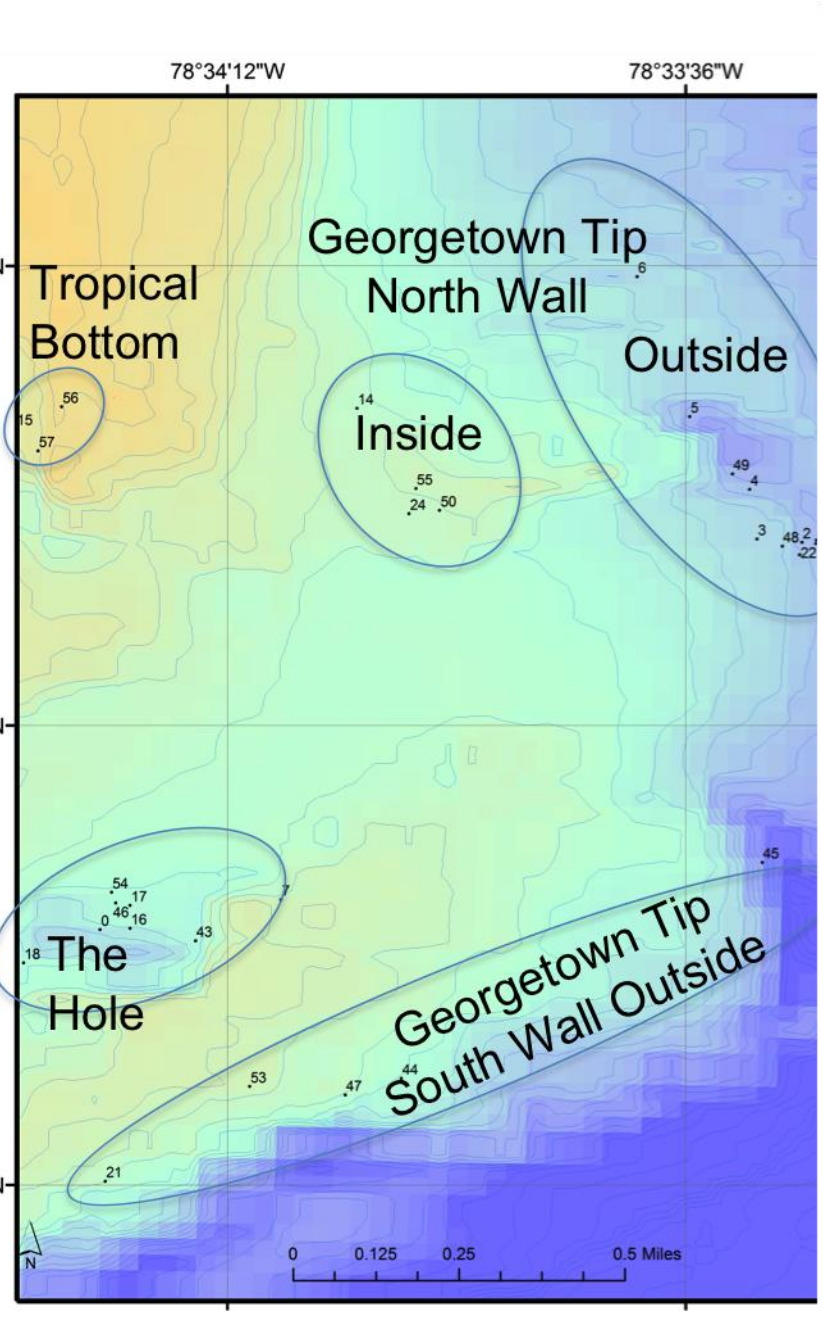
Figure 6. Point and spawning observations. A) Point observations of speckled hind (X) and warsaw grouper (+) relative to bathymetry and B) anecdotal spawning or aggregation observations of speckled hind (yellow star) and warsaw grouper (green crosses) relative to speckled hind geographic distribution model output and rejected (dashed lines) and proposed (solid lines) marine protected areas east of Murrell's Inlet, SC.

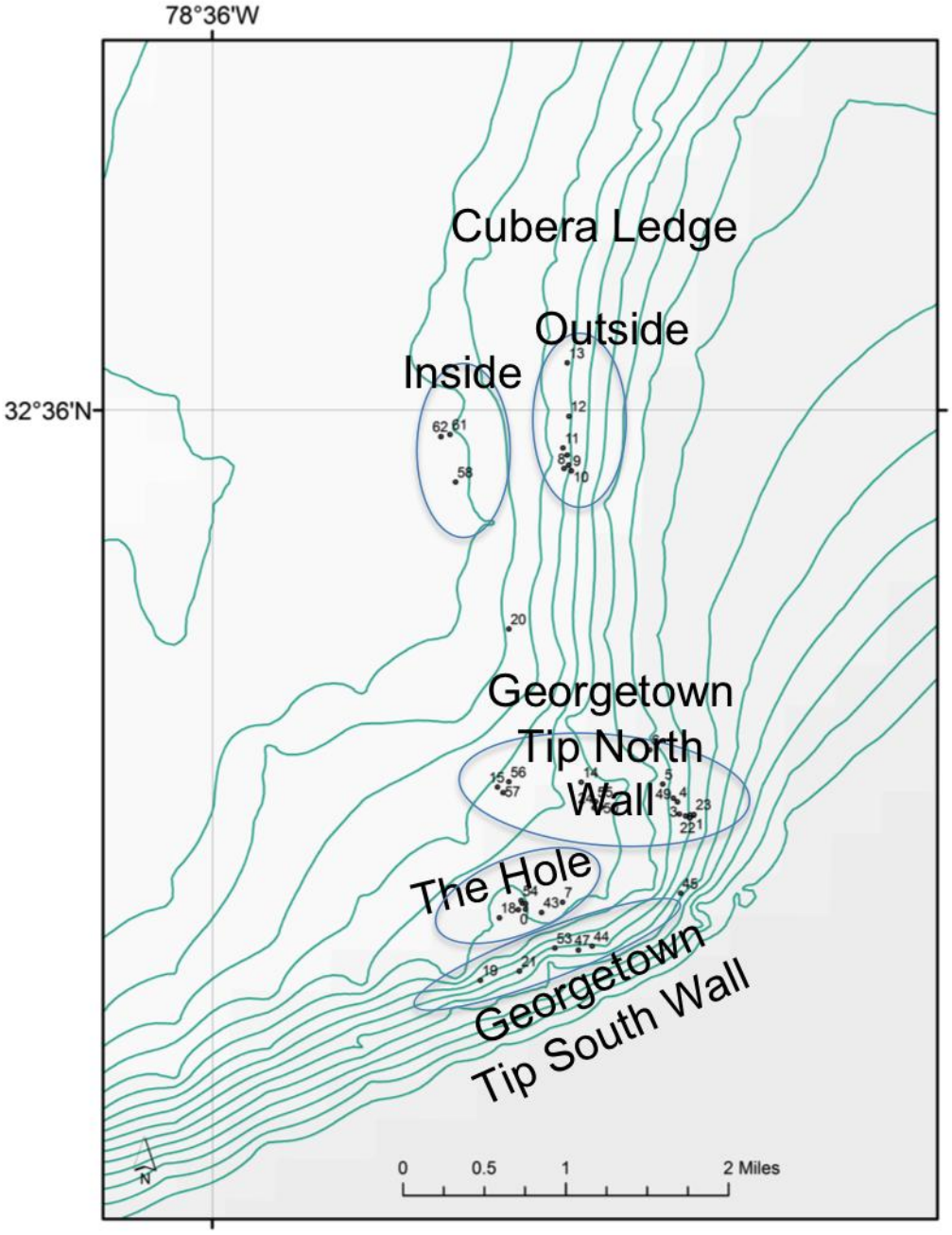
From: Farmer, N.A., Karnauskas, M., 2013. Spatial Distribution and Conservation of Speckled Hind and Warsaw Grouper in the Atlantic Ocean off the Southeastern U.S. PLoS ONE 8, e78682. doi:10.1371/journal.pone.0078682.s002



Multi-beam data from
Dr. Leslie Sauter,
College of Charleston


78°38'0"W
78°37'0"W
78°36'0"W
78°35'0"W
78°34'0"W
78°33'0"W
78°32'0"W
78°31'0"W
78°30'0"W
32°36
32°35
32°35
32°34
32°34
32°33
32°33
32°32
32°32
0 1 2 4 Kilometers


78°34'12"W
78°33'36"W
Tropical Bottom
Georgetown Tip North Wall
Outside
Inside
The Hole
Georgetown Tip South Wall Outside
0 0.125 0.25 0.5 Miles
N


78°36'W
32°36'N
Cubera Ledge
Outside
Inside
Georgetown Tip North Wall
The Hole
Georgetown Tip South Wall
0 0.5 1 2 Miles
N

Example “Evidence” Slides

- Do they provide evidence of imminent or recent spawning?
- Do they offer evidence of a spawning aggregation?
- What other information do you need?

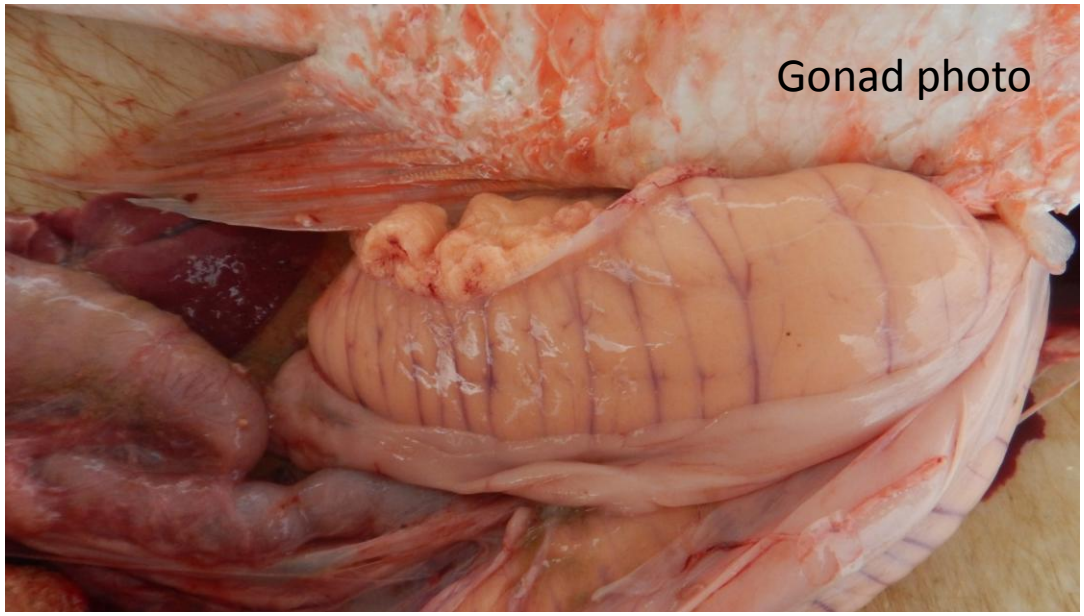


Plate 1: American Red Snapper

Georgetown Hole
32.xxx 78.xxx
(GPS 142)

Date caught: 17 July 2014
TL: 890 mm
Wt: 21.4 lbs

Female, late development
Otolith collected: yes
Gonad Histology collected: yes

Captain: Mark Marhefka
Vessel: M/V Amy Marie

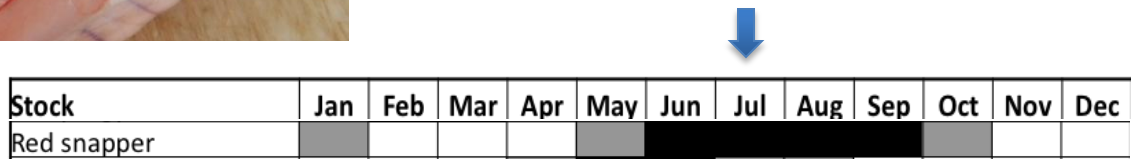


Plate 2: Yellowfin Grouper

Georgetown Hole
32.xxx N 78.xxx W
(GPS 136)

Date caught: 19 July 2014

TL: 796 mm
Wt: 16.9 lbs
Female, Late Development
Otolith and gonad collected by MARMAP for age and histological analysis

Captain: Mark Marhefka
Vessel: F/V Amy Marie

Plate 3: Scamp

Georgetown Hole Area
32.xxx N 78.xxx W
(GPS 57)

Date filmed: 23 April 2014
4:37 PM local time
Depth: 78 m

High density of scamp, rugosity

Captain: Mark Marhefka
Vessel: F/V Amy Marie

Still photo extracted from GoPro Hero 3+ video (file GoPro140.mp4)

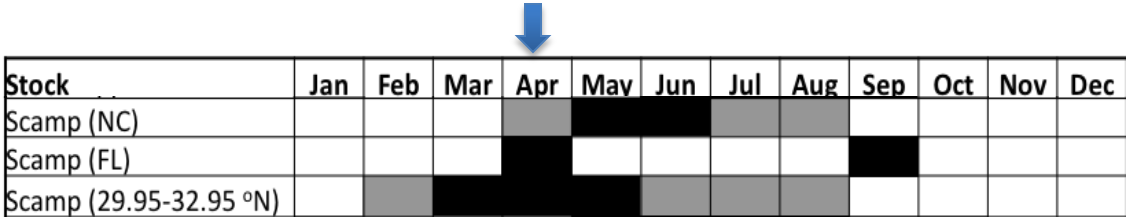


Plate 4: Scamp

Georgetown Hole Area
32.xxx N 78.xxx W
(GPS 58)

Date filmed: 23 April 2014
5:20 PM local time
Depth: 54 m

Courtship coloration and behavior

Captain: Mark Marhefka
Vessel: F/V Amy Marie

Still photo extracted from GoPro Hero 3+ video (file GoPro141.mp4)

Stock	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Scamp (NC)												
Scamp (FL)												
Scamp (29.95-32.95 °N)												

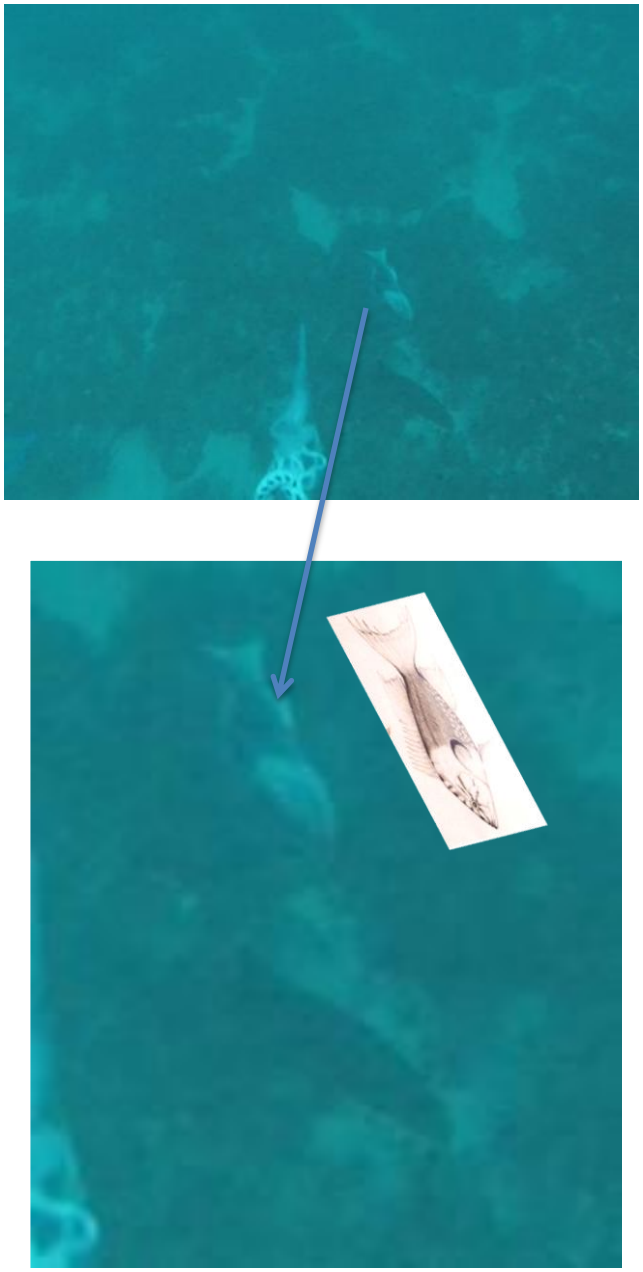


Plate 5: Scamp

Georgetown Hole Area
32.xxx N 78.xxx W
(GPS 62)

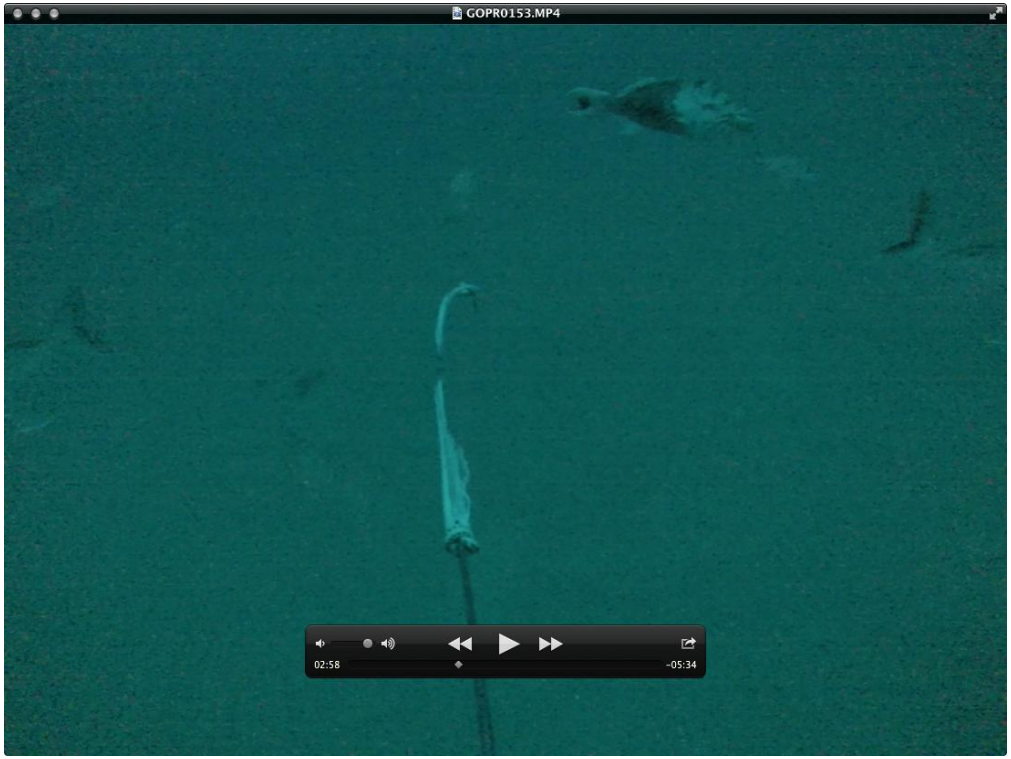
Date filmed: 23 April 2014
6:45 PM local time
Depth: 54 m

Courtship coloration and behavior

Captain: Mark Marhefka
Vessel: F/V Amy Marie

Still photo extracted from GoPro Hero 3+ video (file GoPro143.mp4)

Stock	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Scamp (NC)												
Scamp (FL)												
Scamp (29.95-32.95 °N)												



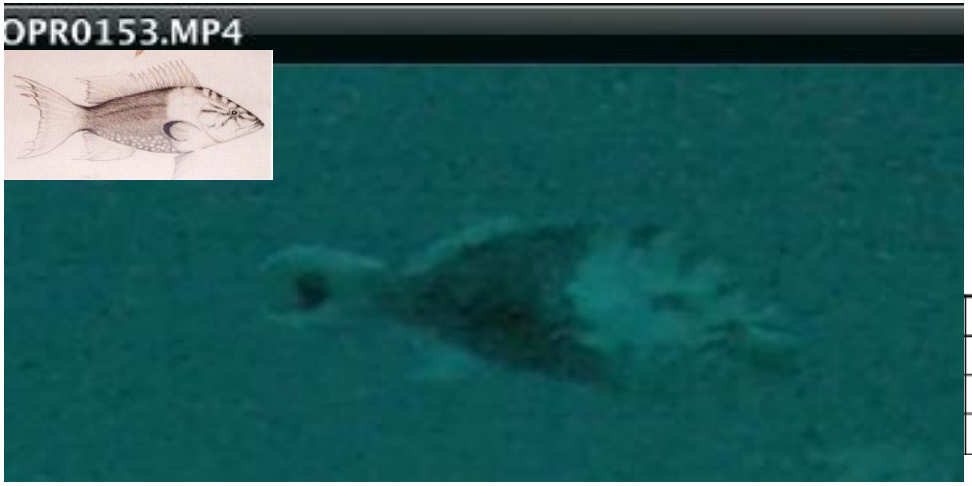


Plate 6: Scamp

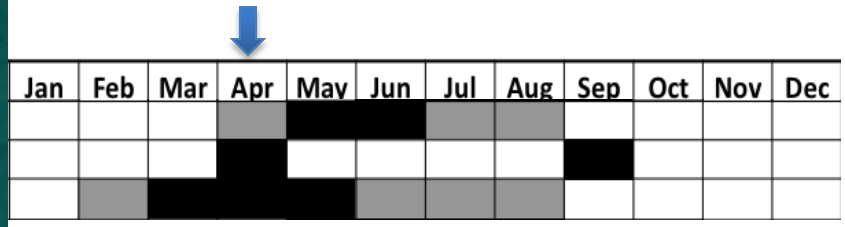
Georgetown Hole – next Elbow North
32.xxx N 78.xxx W
(GPS 78)

Date filmed: 24 April 2014
5:57 PM local time
Depth: 124 m

Courtship coloration and behavior

Captain: Mark Marhefka
Vessel: F/V Amy Marie

Still photo extracted from GoPro Hero 3+ video (file GoPro 153.mp4)



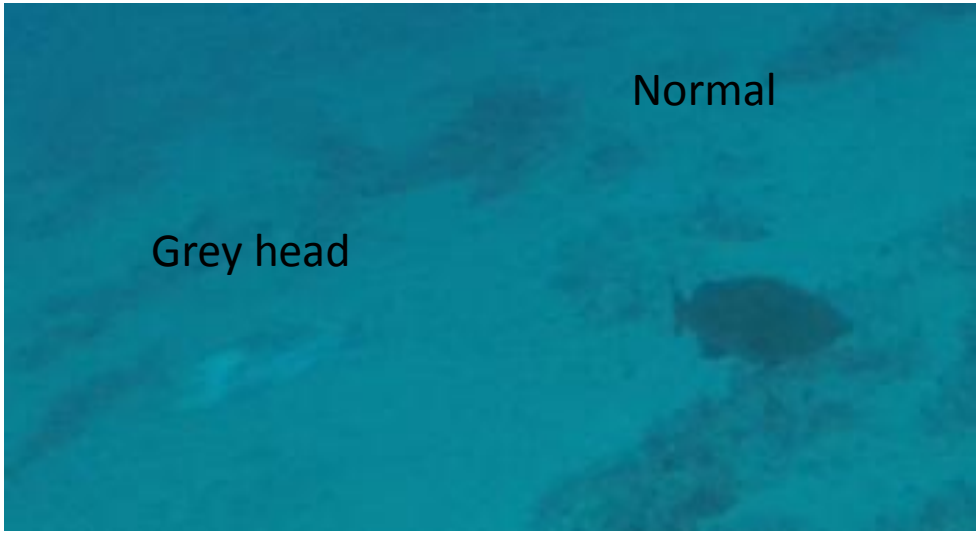


Plate 7: Scamp

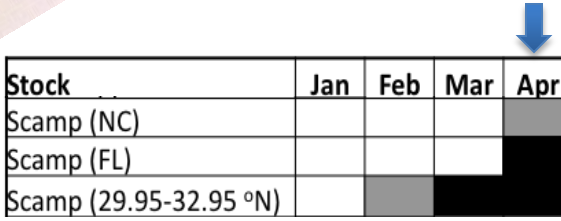
Georgetown Hole Area
32.xxx N 78.xxx W
(GPS 84)

Date filmed: 25 April 2014
7:48 am local time
Depth: 86 m

Courtship coloration and behavior

Captain: Mark Marhefka
Vessel: F/V Amy Marie

Still photos extracted from GoPro Hero 3+ video (file GoPro169.mp4)



Stock	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Scamp (NC)												
Scamp (FL)												
Scamp (29.95-32.95 °N)												

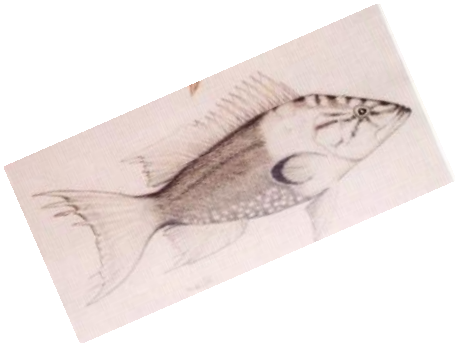


Plate 8: Scamp

Georgetown Hole
32.xxx N 78.xxx W
(GPS 88)

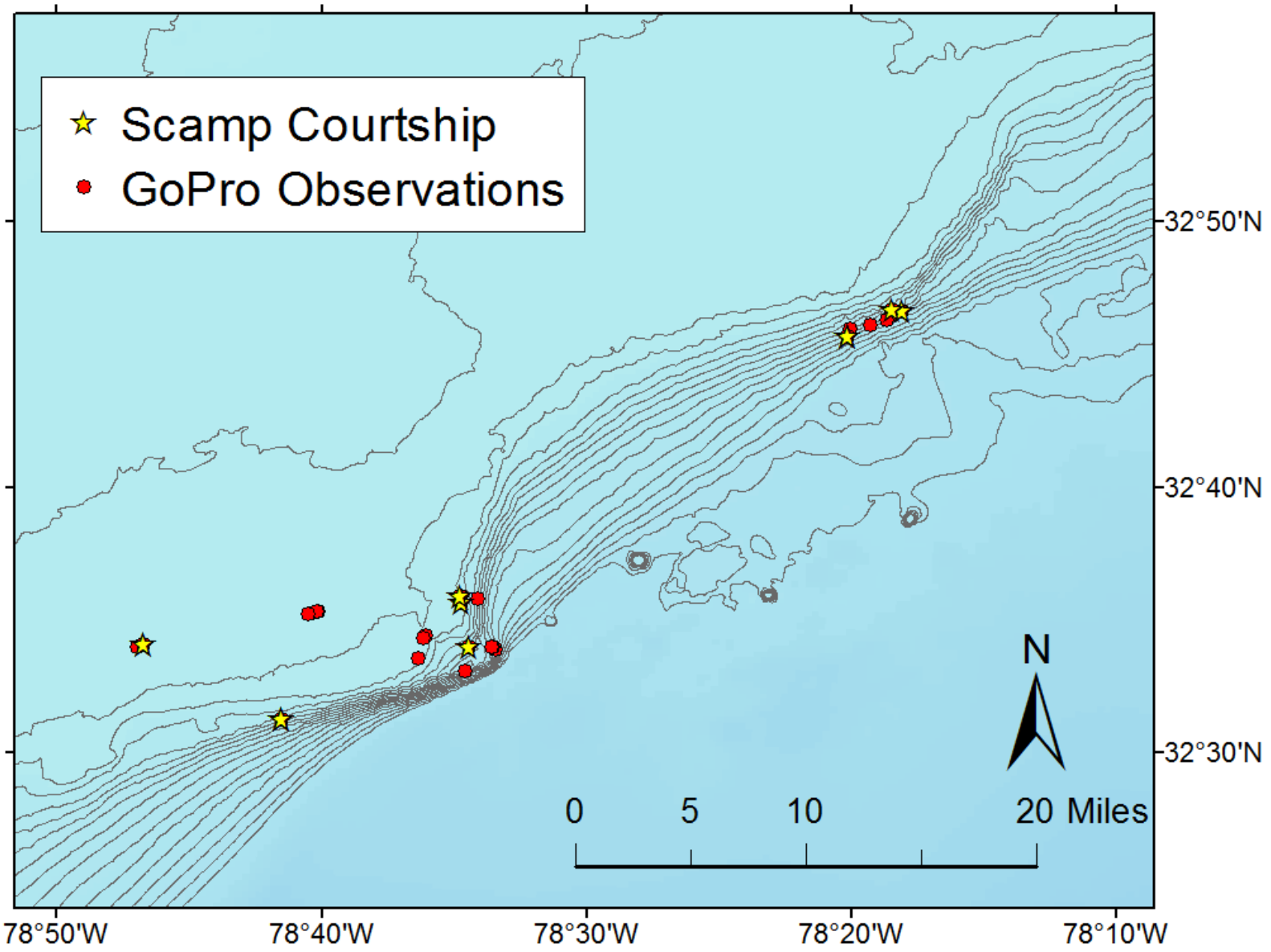
Date filmed: 25 April 2014
10:40 AM local time
Depth: 42 m

Courtship coloration and behavior

Captain: Mark Marhefka
Vessel: F/V Amy Marie

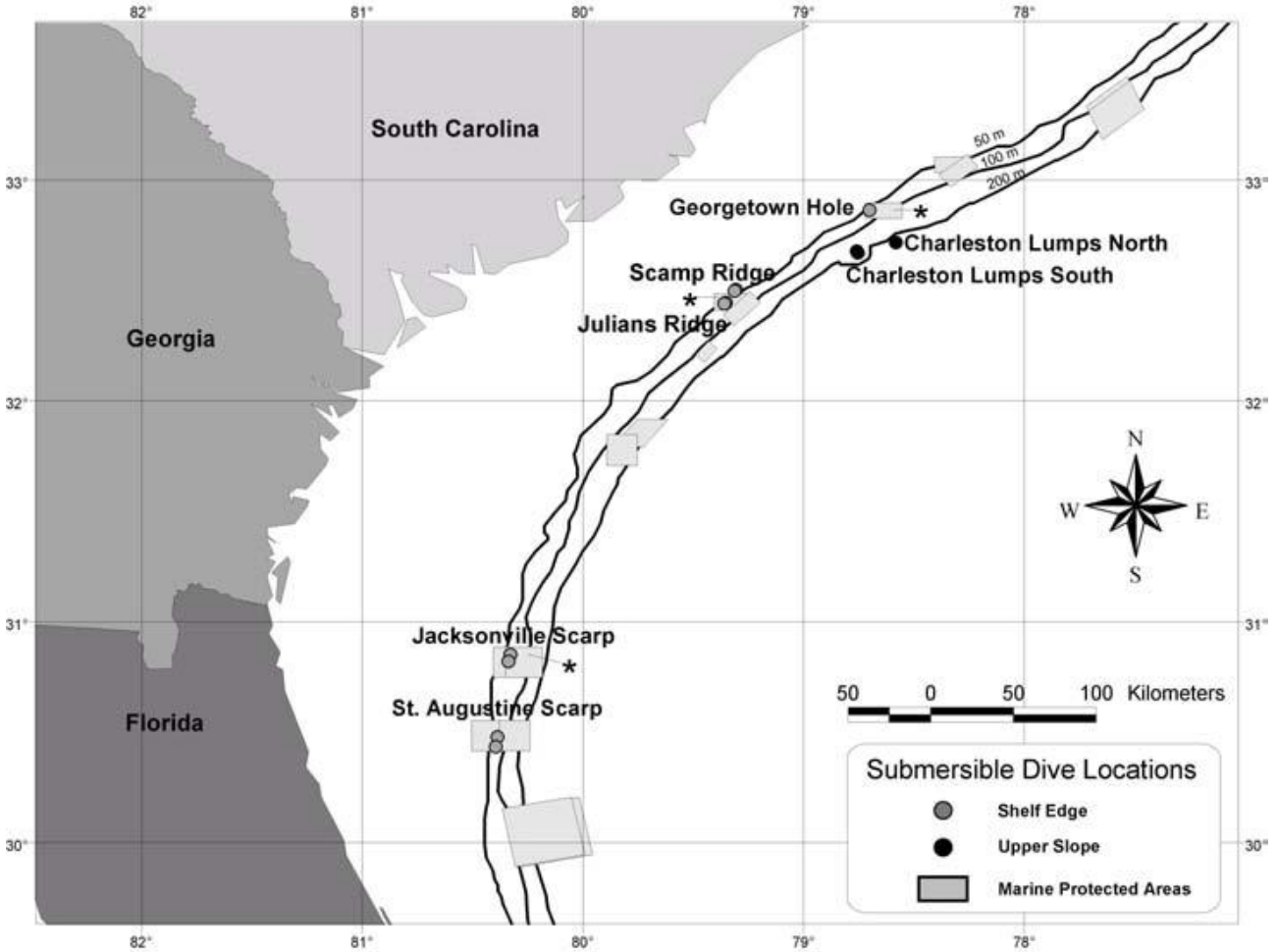
Still photo extracted from GoPro
Hero 3+ video (file GoPro 173.mp4)

Stock	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Scamp (NC)												
Scamp (FL)												
Scamp (29.95-32.95 °N)												

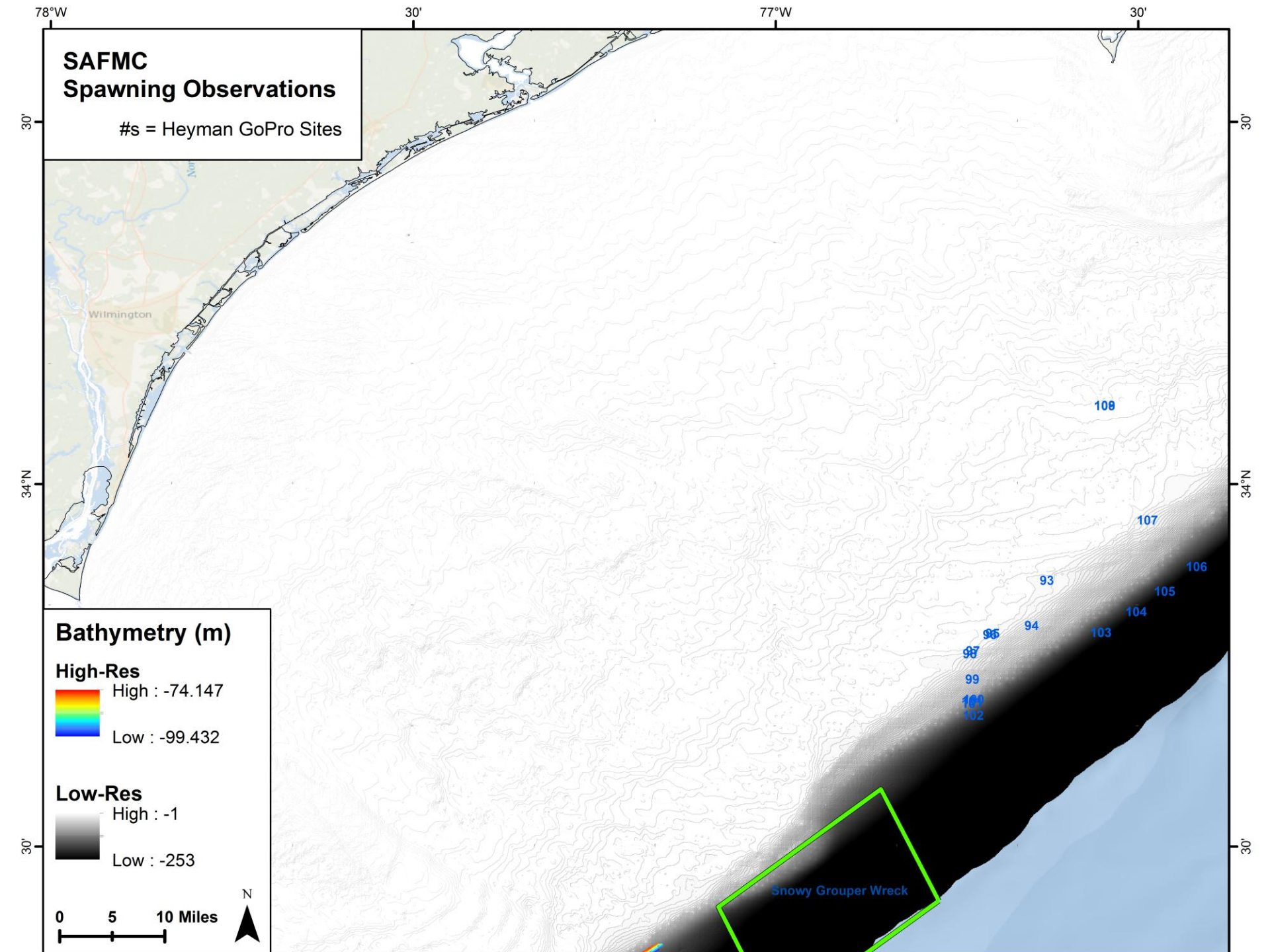

Scamp Courtship
GoPro Observations
32°50'N
32°40'N
32°30'N
N
0
5
10
20 Miles
78°50'W
78°40'W
78°30'W
78°20'W
78°10'W

Schobernd, C.M., Sedberry, G.R., 2009.

Scamp "gray-head" observed in late July and early August, between 1000 and 1923 EDT at all sites except Georgetown Hole



Evidence from North Carolina


SAFMC
Spawning Observations
#s = Heyman GoPro Sites
78°W
30'
77°W
30'
34°N
Wilmington
108
107
106
105
104
103
93
94
99
102
Snowy Grouper Wreck
Bathymetry (m)
High-Res
High : -74.147
Low : -99.432
Low-Res
High : -1
Low : -253
0
5
10 Miles
N

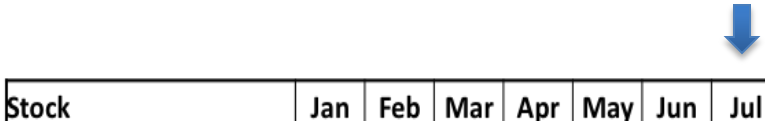
Almaco jack

NC Shelf Edge
33.69682 N 76.72901 W
(GPS 101)

Date caught: 12 July 2014
11:29 AM local time
80 m Depth

Male, Ripe and running

Captain: Jack Cox
Vessel: F/V Elizabeth



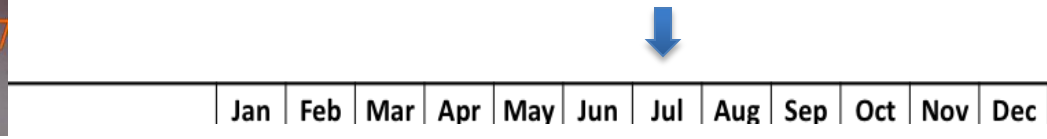
Mutton Snapper

NC Shelf Edge
33.xxx N 76.xxx W
(GPS 95)

Date caught: 12 July 2014
6:20 AM local time
46 m Depth

Female, Late Development

Captain: Jack Cox
Vessel: F/V Elizabeth



Mutton spawn in July in Florida

Plate 8: Gag

NC Shelf
33.7653 N 76.7322 W
(GPS 98)

Date filmed: 12 July 2014
Local time: 8:53 am

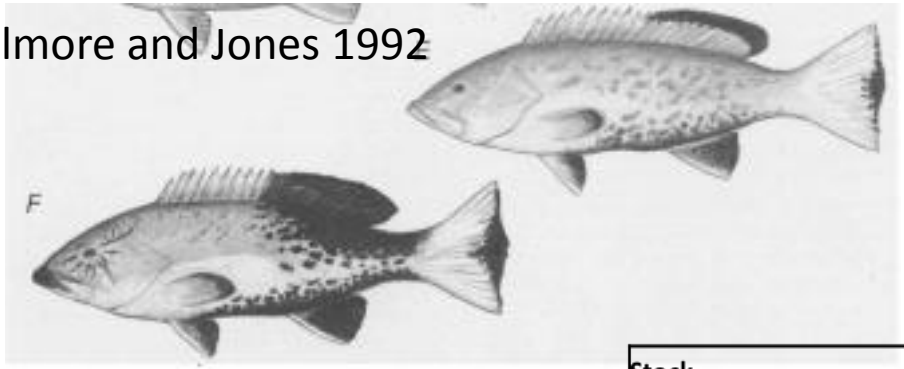
Courtship coloration?

48 m water depth

Captain: Jack Cox
Vessel: F/V Elizabeth

Still photo extracted from GoPro Hero 3+ video (file GoPro178.mp4)

Gilmore and Jones 1992



Stock	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gag												

If we had more funding

- Standardized monitoring protocol
- Training for more observers
- More on-the-water observations in more places and more times
- MARMAP needs support for additional sample processing – especially histology
- Database development
- More analyses

Future Additional Techniques and Actions

- Passive hydro-acoustic monitoring – sounds of spawning
- Mapping biomass with dual-beam hydro-acoustics
- Greater participation from more fishermen at more sites and more times
- Observation reports – procedure for verification of these reports