Reef fish spawning aggregations: a rather brief love story

This presentation is brought to you today through the cooperation of the following institutions:

Reef Fish Spawning Aggregations (FSAs)

Why do fish form FSAs?

- Many reef fish species use spawning aggregations
  - Increases chances of finding mates
  - Increases genetic diversity in the population
  - Protect adults and eggs from predation
- Many species forming spawning aggregations (www.scrfa.org)
- Timing and size of the FSA vary greatly. Ex: wrasse vs. grouper

Reef Fish Spawning Aggregations (FSAs)

Why should we be concerned about the status of FSAs?

- There are species that use spawning aggregations as their only means of reproduction
  - These aggregations occur at predictable locations and times of the year.
  - This predictability increases the chances that these aggregations could be depleted due to over exploitation.

Reef Fish Spawning Aggregations (FSAs)

How do fish know where to form FSAs?

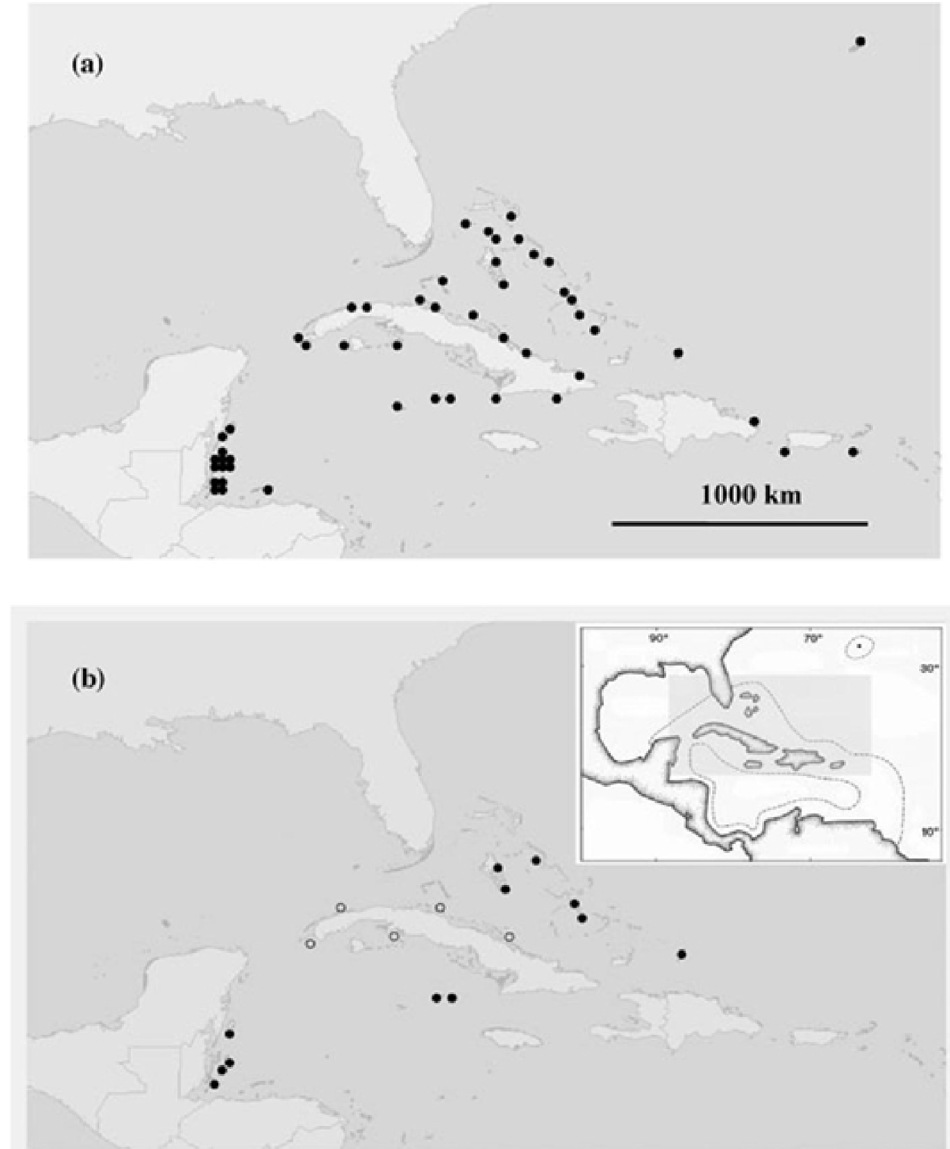
- One theory: young fish learn from older fish
  - The same individual fish return year after year, sometimes covering great distances.

Reef Fish Spawning Aggregations (FSAs)

What happens if an aggregation is fished out?

•If it is completely fished out, there is not much evidence that they can return.

- However, if there are some remnants of the population left, with time, it may recover.



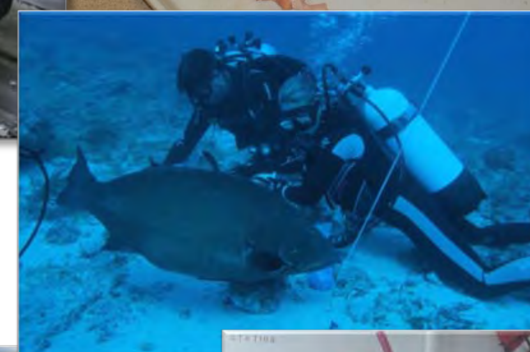
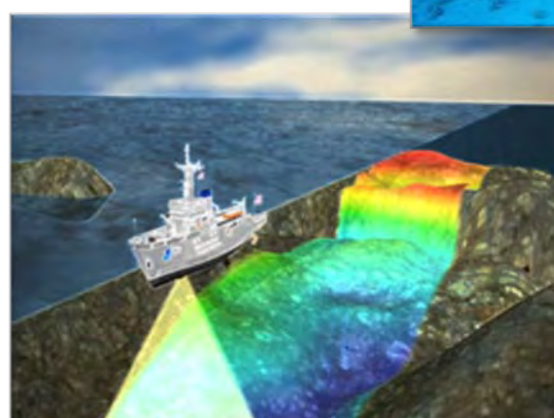
From: Sedovy de Mitcheson et al, 2008

Reef Fish Spawning Aggregations (FSAs)

How are FSAs studied?

- A variety of techniques:
  - Both fishery-dependent and fishery-independent
- Fishery-dependent:
  - Collect reproductive samples
  - Interview people fishing
- Fishery-independent:
  - Direct observation
  - Tag and release
  - Remote Operating Vehicles
  - Acoustics




Reef Fish Spawning Aggregations (FSAs)

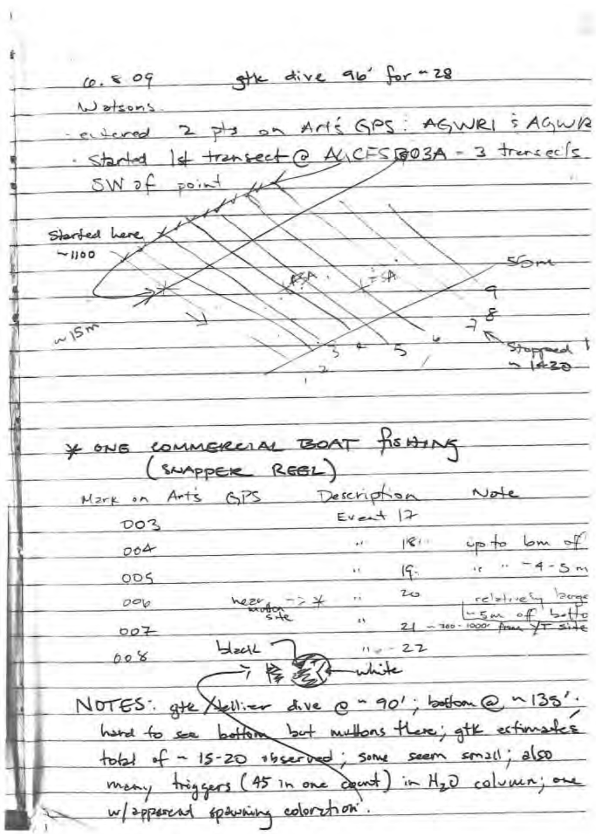
How we study the aggregations here in the Keys

Objectives:

1. Identify potential FSA sites
2. Assess reef fish utilization of the sites using sonar, diver surveys and telemetry (acoustic tagging)
3. Assess and compare geomorphological characteristics of the sites
   - Similar geomorphological characteristics across sites?
4. Communicate results to FKNMS and other management entities

Reef Fish Spawning Aggregations (FSAs)

What did we know about aggregations in the Keys?



6.8.09 gtk dive 96' for ~28
Watsons
- entered 2 pts on Art's GPS: AGWR1 & AGWR2
- Started 1st transect @ AGCFSB03A - 3 transects SW of point

* ONE COMMERCIAL BOAT FISHING (SNAPPER REEL)

Mark on Art's GPS		Description	Note
003		Event 17	
004		" 18	up to 6m off
005		" 19	" " ~4-5m
006	near mutton site -> *	" 20	relatively large
007		" 21	~5m off botto ~300-1000' from YT site
008	black	" ~ 22	

white

NOTES: gtk/Kellier dive @ ~90'; bottom @ ~135'. hard to see bottom but muttons there; gtk estimates total of ~15-20 observed; some seem small; also many triggers (45 in one count) in H_2O column; one w/ apparent spawning coloration.

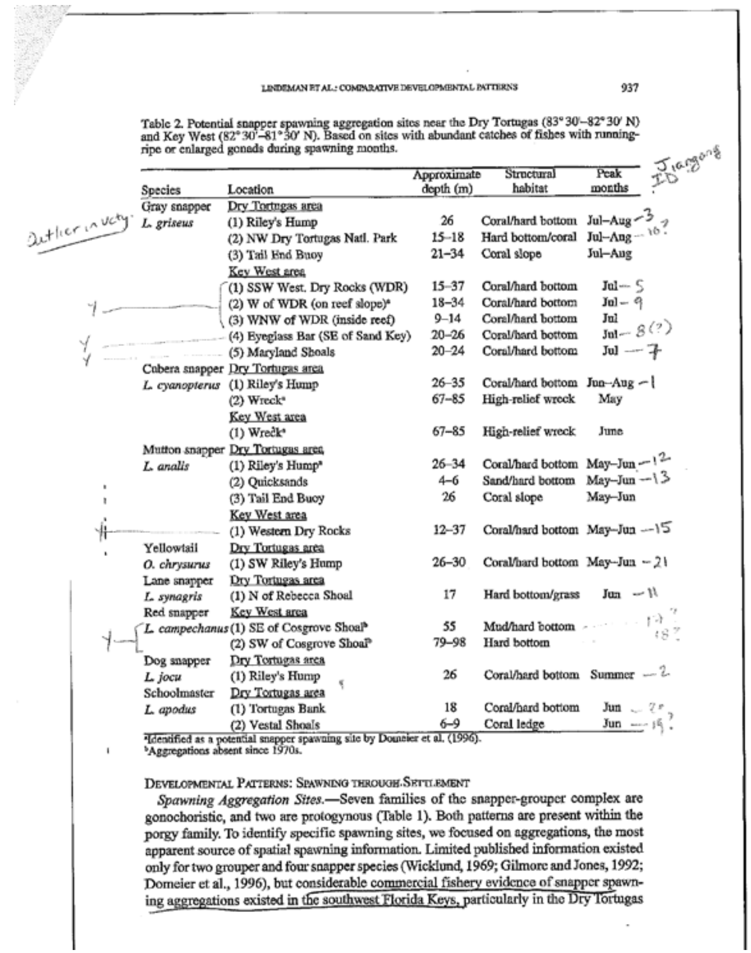


Table 2. Potential snapper spawning aggregation sites near the Dry Tortugas (83°30′–82°30′ N) and Key West (82°30′–81°30′ N). Based on sites with abundant catches of fishes with running-ripe or enlarged gonads during spawning months.

Species	Location	Approximate depth (m)	Structural habitat	Peak months	Jiangang ID
Gray snapper	Dry Tortugas area				
L. griseus	(1) Riley's Hump	26	Coral/hard bottom	Jul–Aug	3
	(2) NW Dry Tortugas Natl. Park	15–18	Hard bottom/coral	Jul–Aug	16?
	(3) Tail End Buoy	21–34	Coral slope	Jul–Aug	
	Key West area				
	(1) SSW West. Dry Rocks (WDR)	15–37	Coral/hard bottom	Jul	5
	(2) W of WDR (on reef slope)[a]	18–34	Coral/hard bottom	Jul	9
	(3) WNW of WDR (inside reef)	9–14	Coral/hard bottom	Jul	
	(4) Eyeglass Bar (SE of Sand Key)	20–26	Coral/hard bottom	Jul	8(?)
	(5) Maryland Shoals	20–24	Coral/hard bottom	Jul	7
Cubera snapper	Dry Tortugas area				
L. cyanopterus	(1) Riley's Hump	26–35	Coral/hard bottom	Jun–Aug	1
	(2) Wreck[a]	67–85	High-relief wreck	May	
	Key West area				
	(1) Wreck[a]	67–85	High-relief wreck	June	
Mutton snapper	Dry Tortugas area				
L. analis	(1) Riley's Hump[a]	26–34	Coral/hard bottom	May–Jun	12
	(2) Quicksands	4–6	Sand/hard bottom	May–Jun	13
	(3) Tail End Buoy	26	Coral slope	May–Jun	
	Key West area				
	(1) Western Dry Rocks	12–37	Coral/hard bottom	May–Jun	15
Yellowtail	Dry Tortugas area				
O. chrysurus	(1) SW Riley's Hump	26–30	Coral/hard bottom	May–Jun	21
Lane snapper	Dry Tortugas area				
L. synagris	(1) N of Rebecca Shoal	17	Hard bottom/grass	Jun	11
Red snapper	Key West area				
L. campechanus	(1) SE of Cosgrove Shoal[b]	55	Mud/hard bottom		17?
	(2) SW of Cosgrove Shoal[b]	79–98	Hard bottom		18?
Dog snapper	Dry Tortugas area				
L. jocu	(1) Riley's Hump	26	Coral/hard bottom	Summer	2
Schoolmaster	Dry Tortugas area				
L. apodus	(1) Tortugas Bank	18	Coral/hard bottom	Jun	20?
	(2) Vestal Shoals	6–9	Coral ledge	Jun	19?

[a]Identified as a potential snapper spawning site by Domeier et al. (1996).
[b]Aggregations absent since 1970s.

Outlier in vcty.

DEVELOPMENTAL PATTERNS: SPAWNING THROUGH SETTLEMENT

Spawning Aggregation Sites.—Seven families of the snapper-grouper complex are gonochoristic, and two are protogynous (Table 1). Both patterns are present within the porgy family. To identify specific spawning sites, we focused on aggregations, the most apparent source of spatial spawning information. Limited published information existed only for two grouper and four snapper species (Wicklund, 1969; Gilmore and Jones, 1992; Domeier et al., 1996), but considerable commercial fishery evidence of snapper spawning aggregations existed in the southwest Florida Keys, particularly in the Dry Tortugas

From: Lindeman et al. 2000

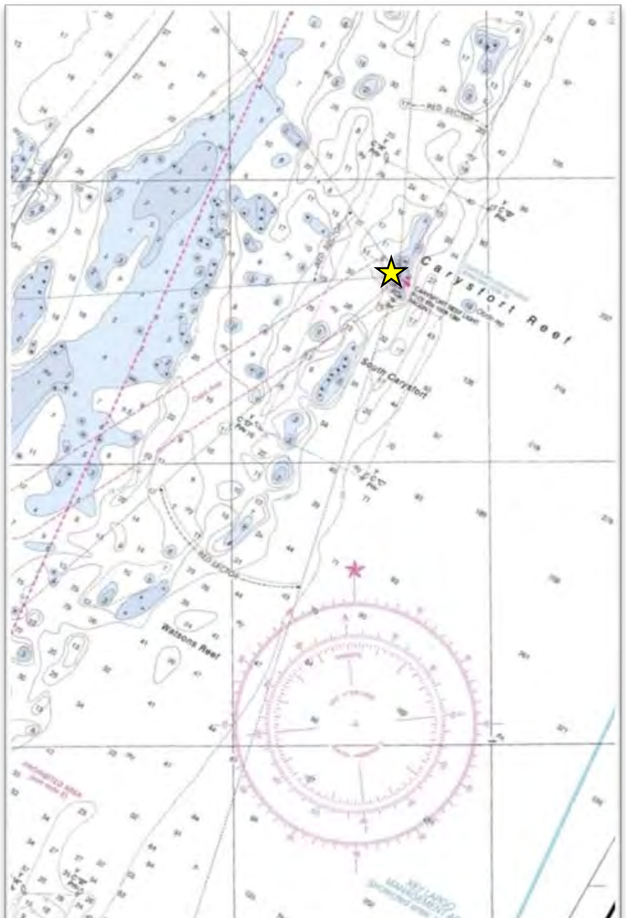
Reef Fish Spawning Aggregations (FSAs)

Species	D	J	F	M	A	M	J	J	A	S	O	N	Source
Black grouper													Domeier and Colin 1997, Eklund et al. 2000
Nassau grouper													Domeier and Colin 1997, Fine 1990, Claro et al 2009
Scamp													Domeier and Colin 1997
Gag grouper													Domeier and Colin 1997, Hood and Schlieder 1992
Red hind													Domeier and Colin 1997, Beets and Friedlander 1998, Poholek, pers. com.
Goliath grouper													Domeier and Colin 1997, Sadovy and Eklund 1999, NMFS 2006
Yellowtail snapper													Lindeman et al. 2000, Claro et al 2009
Dog snapper													Lindeman et al. 2000, RNA report
Mutton snapper													Domeier and Colin 1997, Lindeman et al. 2000, Claro et al 2009, FWC observations, RNA report
Gray snapper													Domeier and Colin 1997, Lindeman et al. 2000, Claro et al 2009
Schoolmaster													Lindeman et al. 2000
Lane snapper													Lindeman et al. 2000, Claro et al 2009, Poholek pers. com.
Cubera snapper													Domeier and Colin 1997, Lindeman et al. 2000, Heyman et al 2005, Claro et al 2009, FWC observations, RNA report
Permit													Ault et al 2006, RNA report

Best available bathymetry

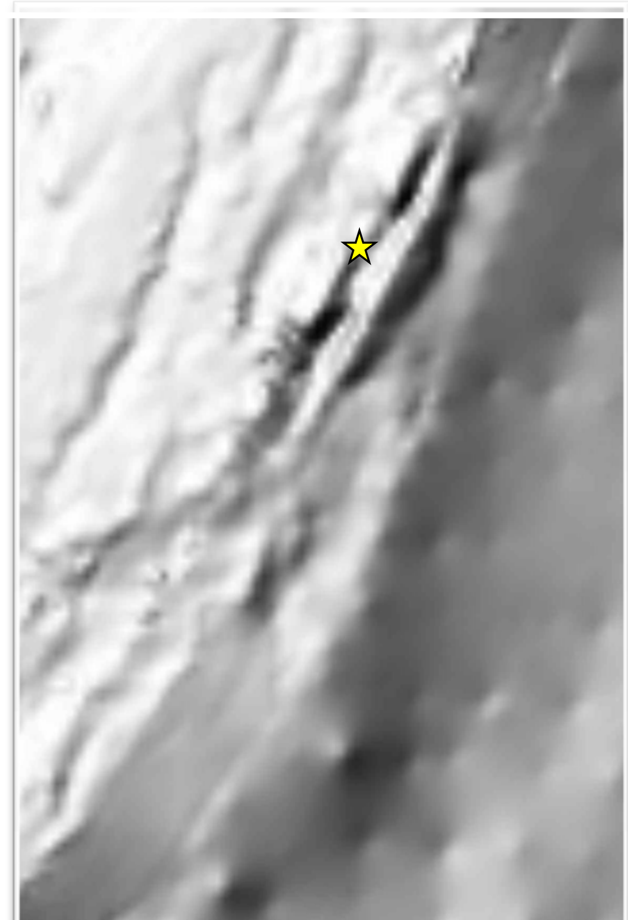
NOAA Chart 11463

- Contours only



NGDC (National Geophysical Data Center) gridded Bathymetry

- Digital, 90m resolution



☆ = Carysfort Lighthouse

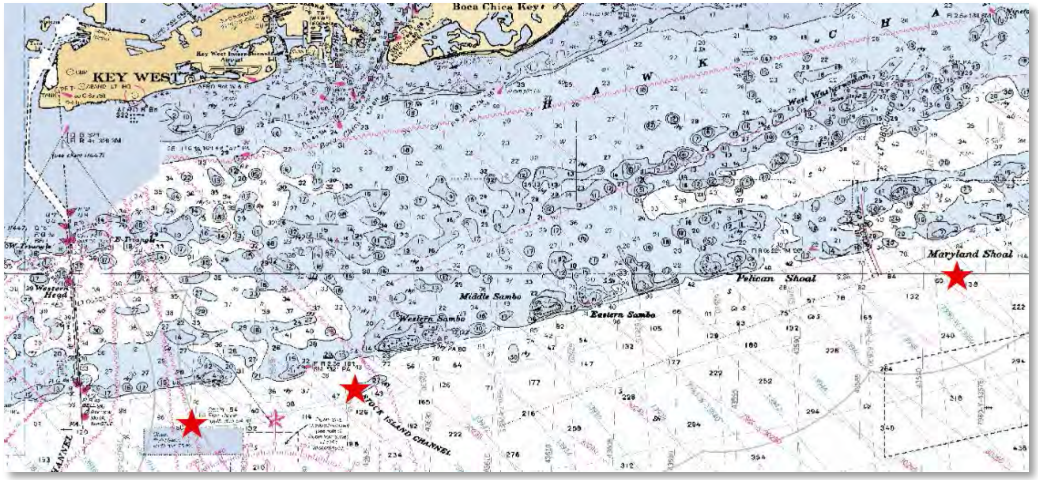
Reef Fish Spawning Aggregations (FSAs)

How did we know where to start?

- Site selection:
  - Gathered information from many sources: fishermen, divers, managers
    - Still an ongoing process

- Sites are mapped during the 'off' season using sonar to determine benthic structures

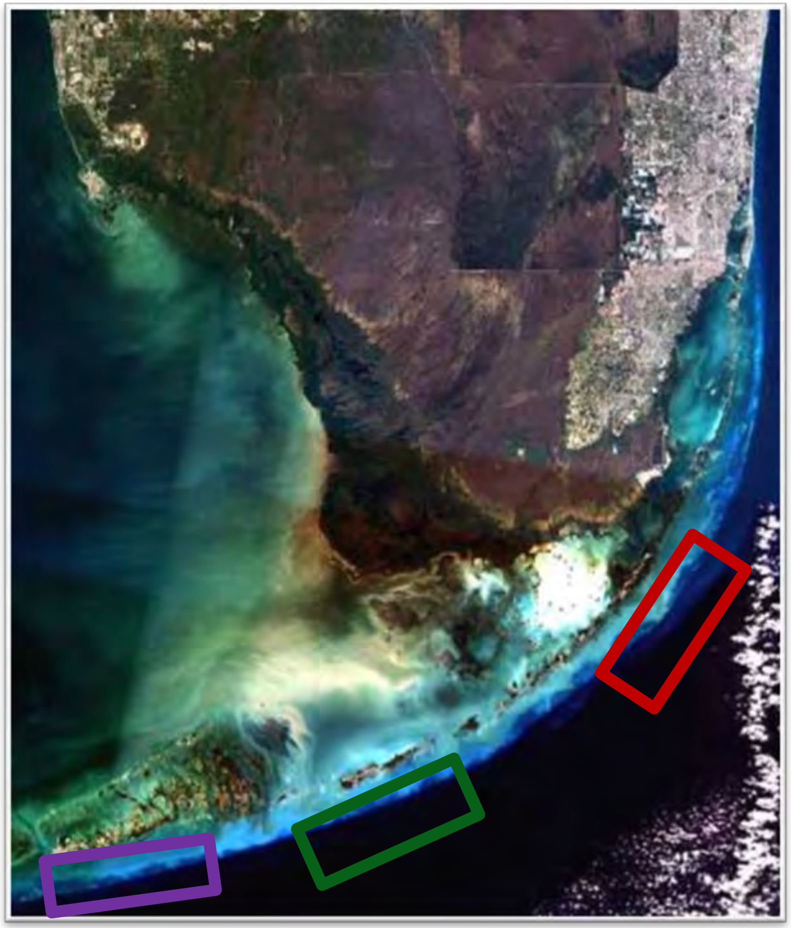
- Surveys were conducted during the predicted spawning moons of the targeted species



Reef Fish Spawning Aggregations (FSAs)

How do we currently study aggregations in the Keys?

- **Upper Keys**
  - Initiated in 2007
  - FSA sites previously "fished out"
- **Lower Keys**
  - Initiated in 2009
  - Status of FSA sites unknown
- **Middle Keys**
  - Initiated in 2011
  - Mapping currently in progress

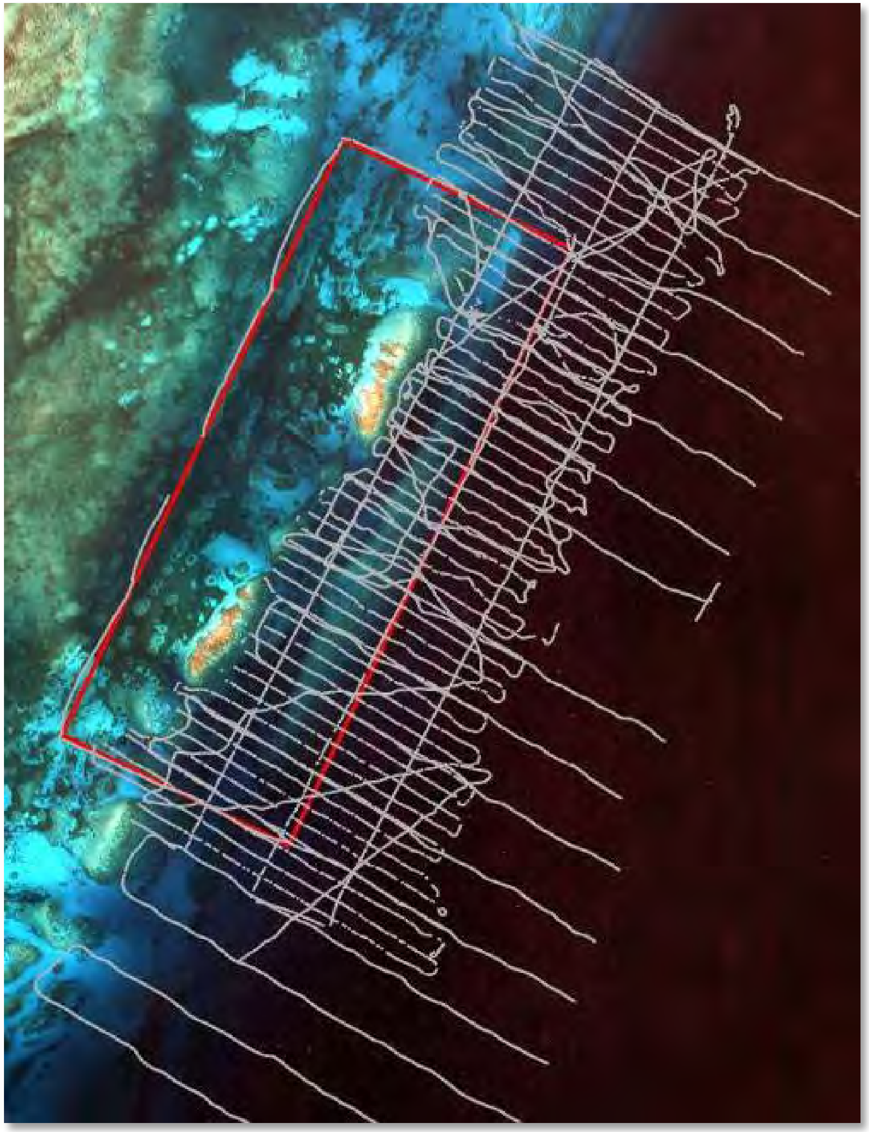


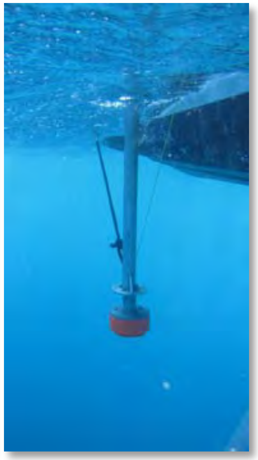
Reef Fish Spawning Aggregations (FSAs)

How did we map the FSAs?

- Using acoustic sonar
  - Project began using a single beam and split-beam system.
  - Currently, we use a multi-beam system.

- Transects were driven while acoustics 'pinged' the bottom
  - Mowing the lawn

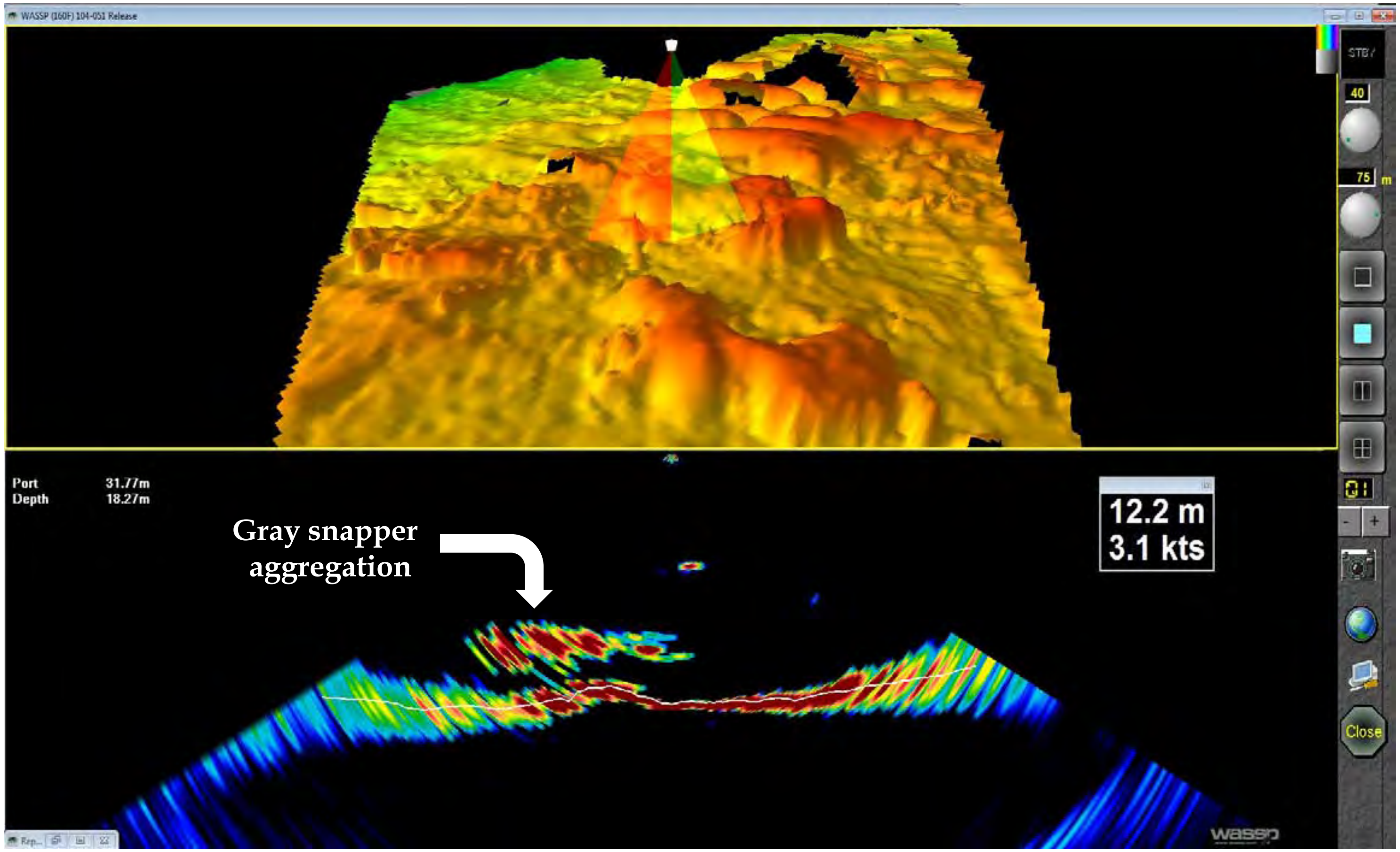




Reef Fish Spawning Aggregations (FSAs)

How did we conduct surveys?

- Using sonar equipment
  - Previously mapped areas were surveyed during predicted spawning times



Reef Fish Spawning Aggregations (FSAs)

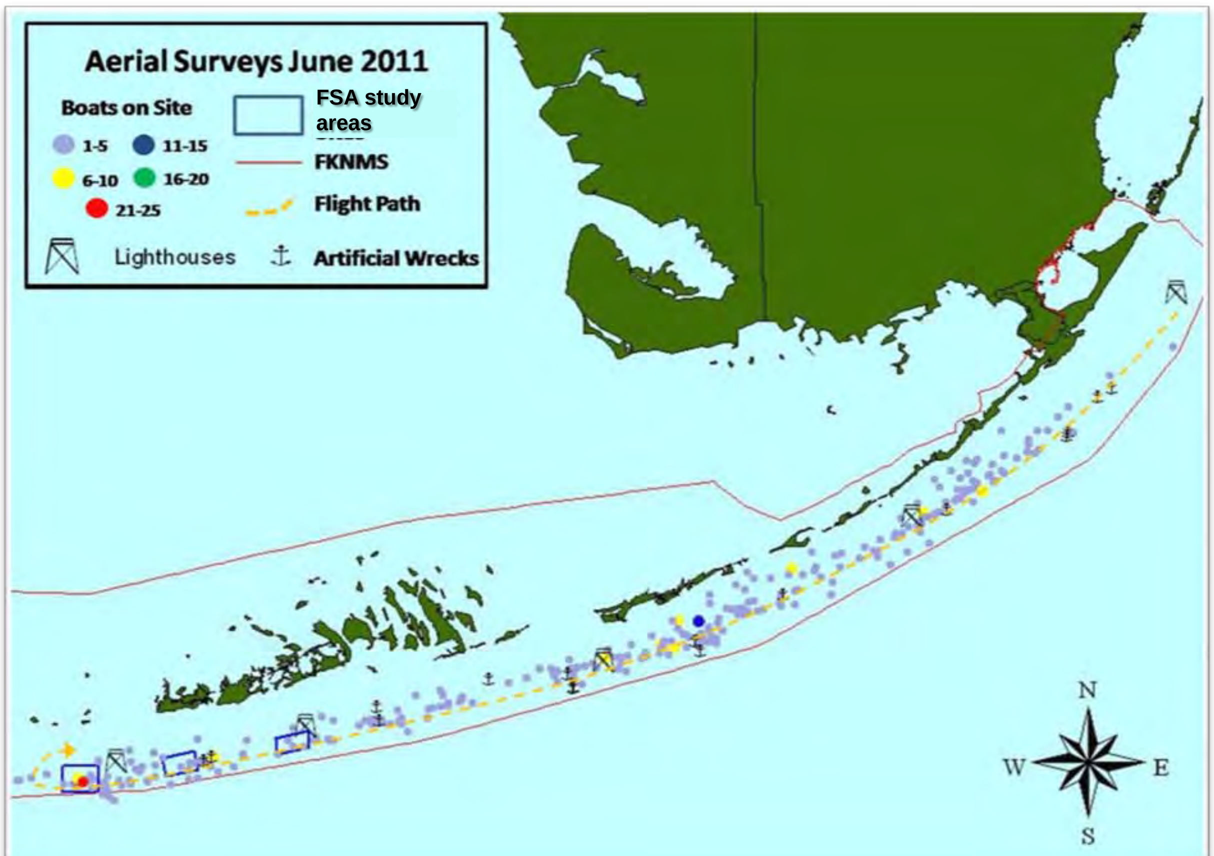
Diver surveys to groundtruth sonar observations

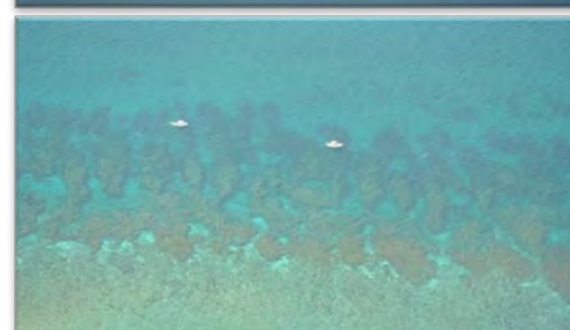
- Divers were deployed when a large fish mark was detected by the sonar equipment
- Sometimes it was a target species, sometimes not.

Reef Fish Spawning Aggregations (FSAs)

Aerial Surveys:

- Examine boating pressure on known sites
- Used to identify potential FSAs





Reef Fish Spawning Aggregations (FSAs)

What have we discovered about aggregations in the Keys?

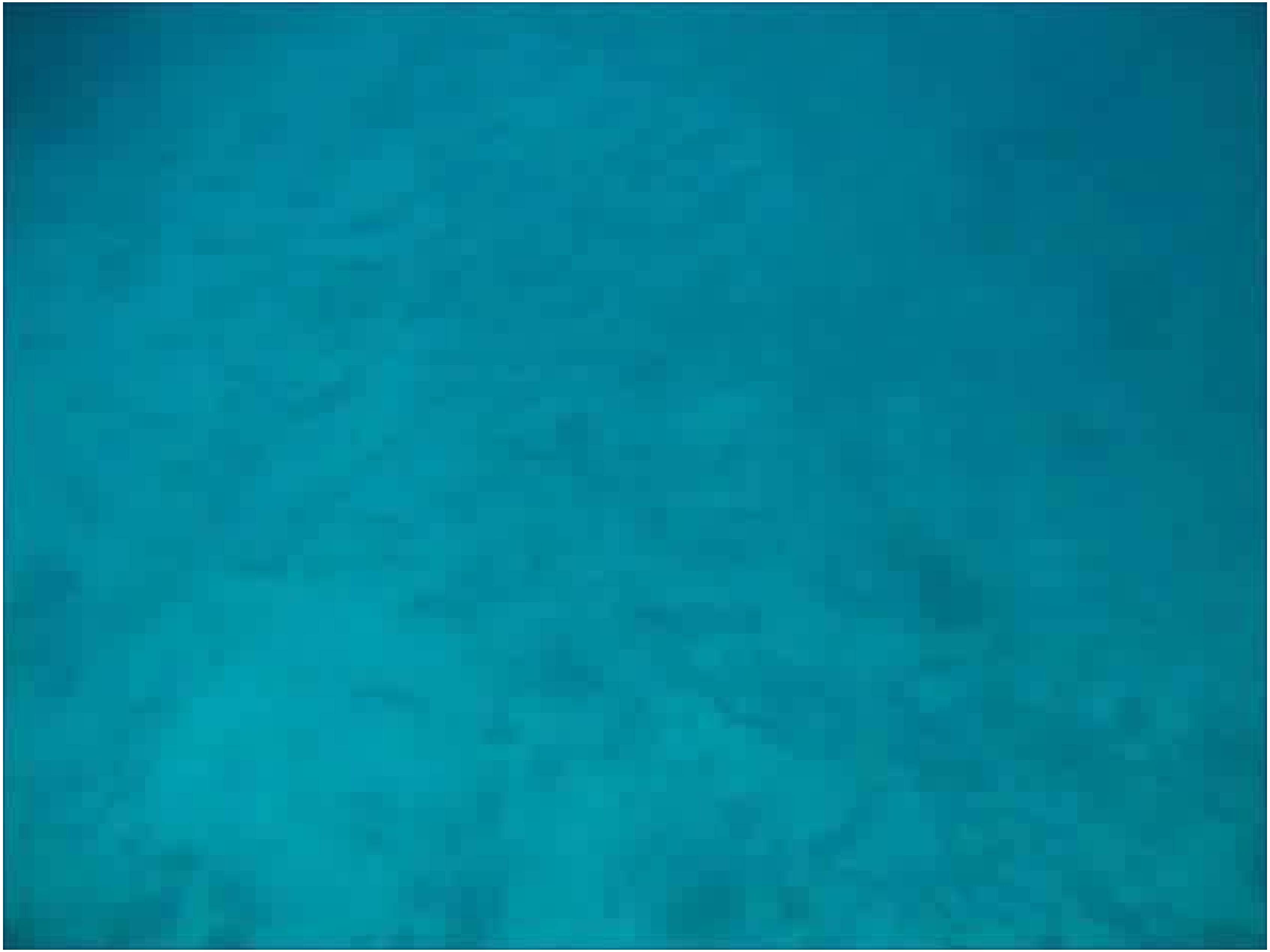
Keep in mind

- Keys aggregation research: began 5 years ago…
- Other areas of the Caribbean began in the 1990s and early 2000s

What has not been done:

- Other than the Tortugas South Ecological Reserve, have not successfully documented spawning at these aggregations
  - Spawning is implied: fisheries dependent data, timing of observations, condition of fishes observed
  - Aggregating fish will still attract higher levels of exploitation


Photo credit: C. Parsons

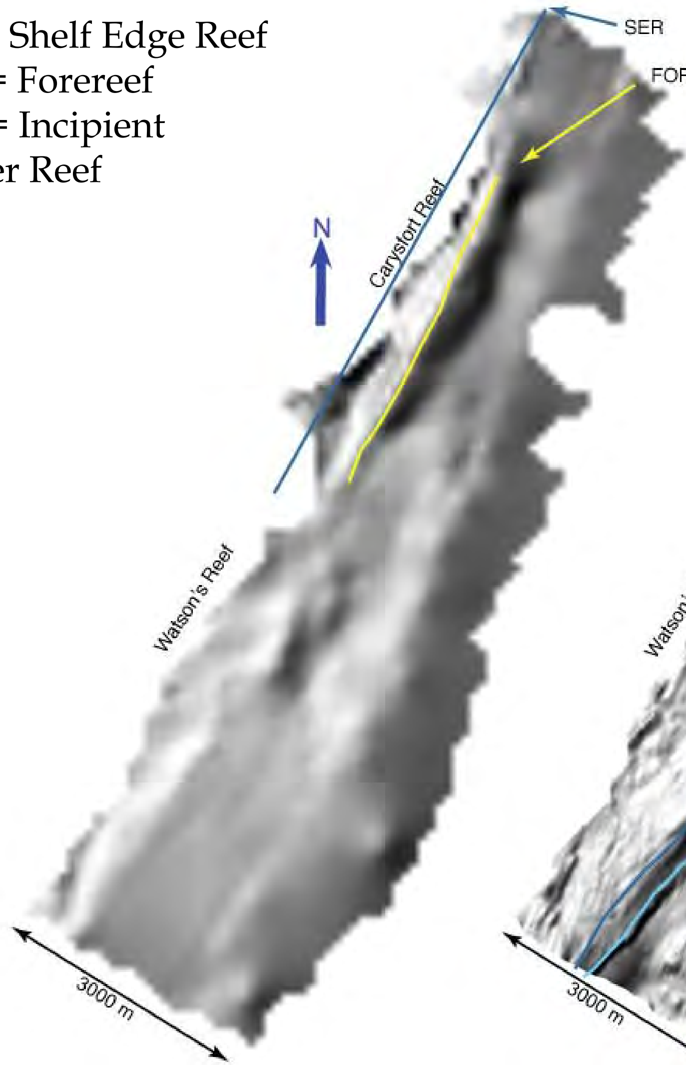


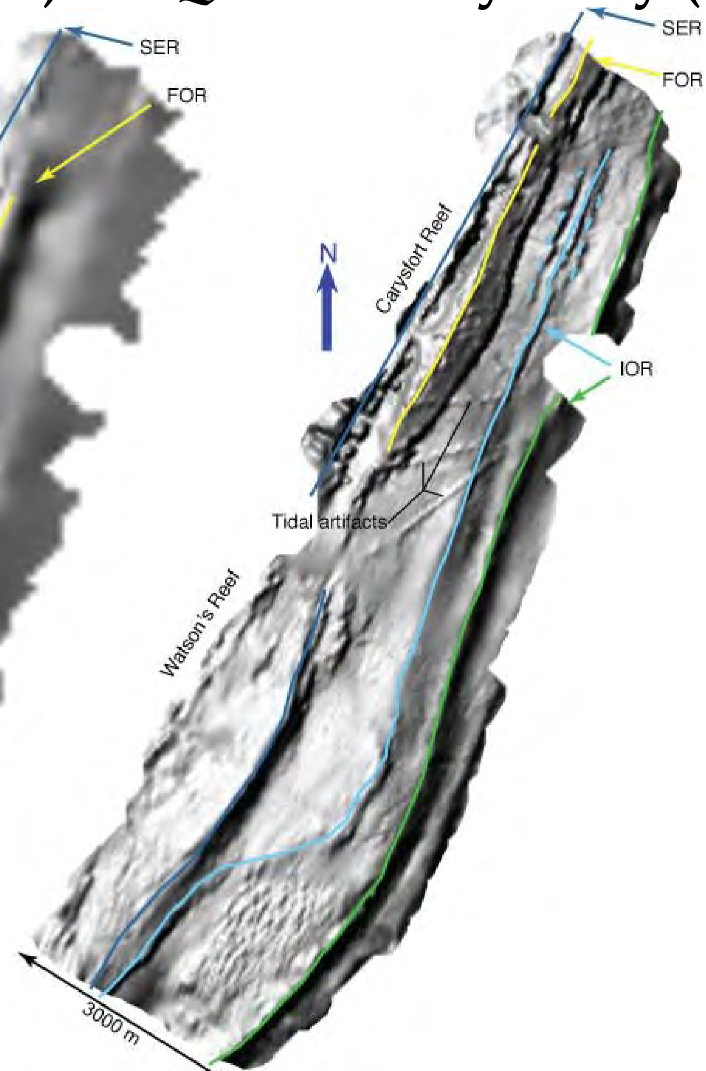
Reef Fish Spawning Aggregations (FSAs)

What have we found in the Keys?

NGDC bathymetry (left) vs. QTCV bathymetry (right)

SER = Shelf Edge Reef
FOR = Forereef
IOR = Incipient Outlier Reef

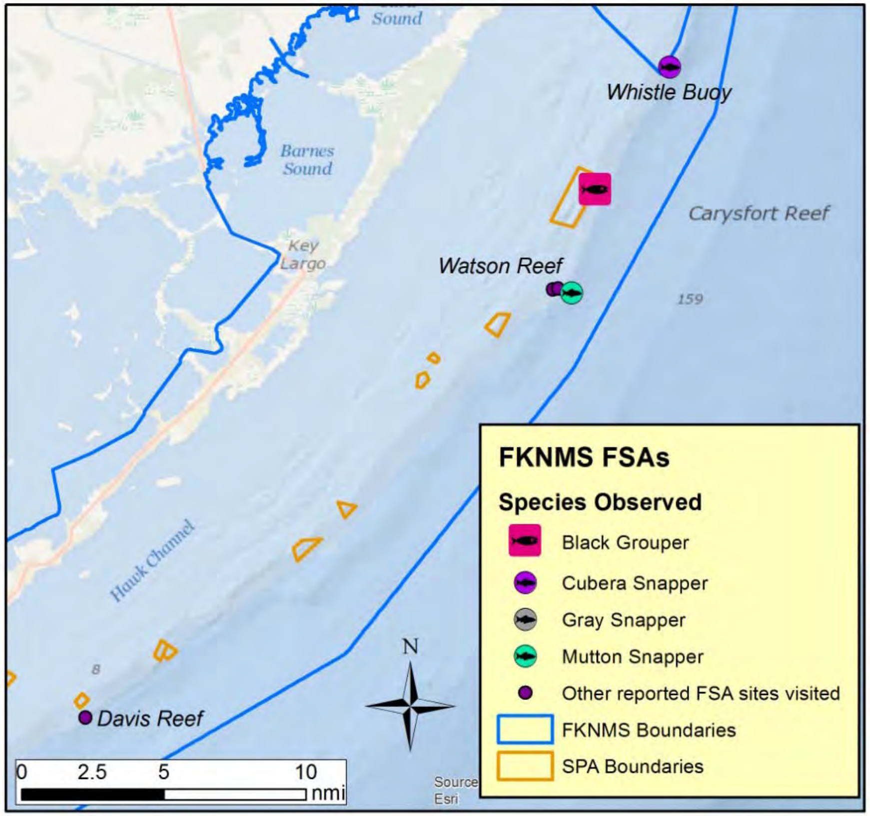




Reef Fish Spawning Aggregations (FSAs)

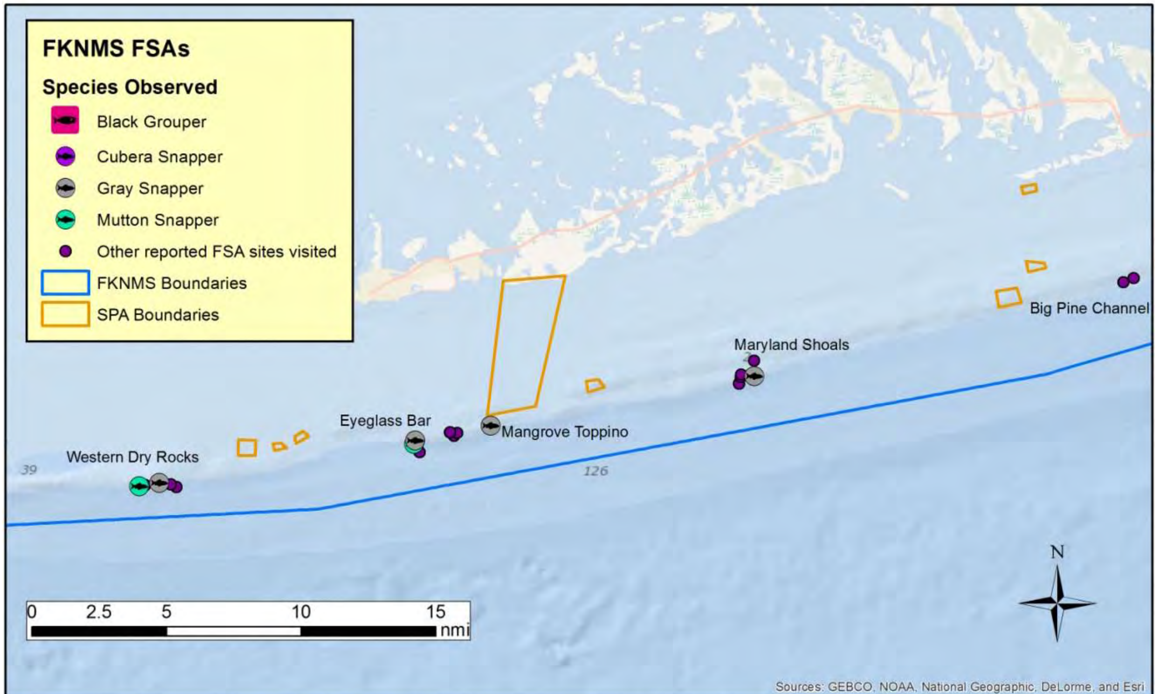
In the Upper Keys:

Site Name	Species Observed	Description
Whistle Buoy	Cubera Snapper	Several visual observations of 15-34 schooling cubera snapper (60-85 cm), June and July 2009
Carysfort	Black Grouper	Several observations of 6-11 large black grouper (50-85 cm), Feb & March 2010
Watson Reef*	Mutton Snapper	Visual observation of 35-45 mutton snapper (60-65 cm) swimming in water column



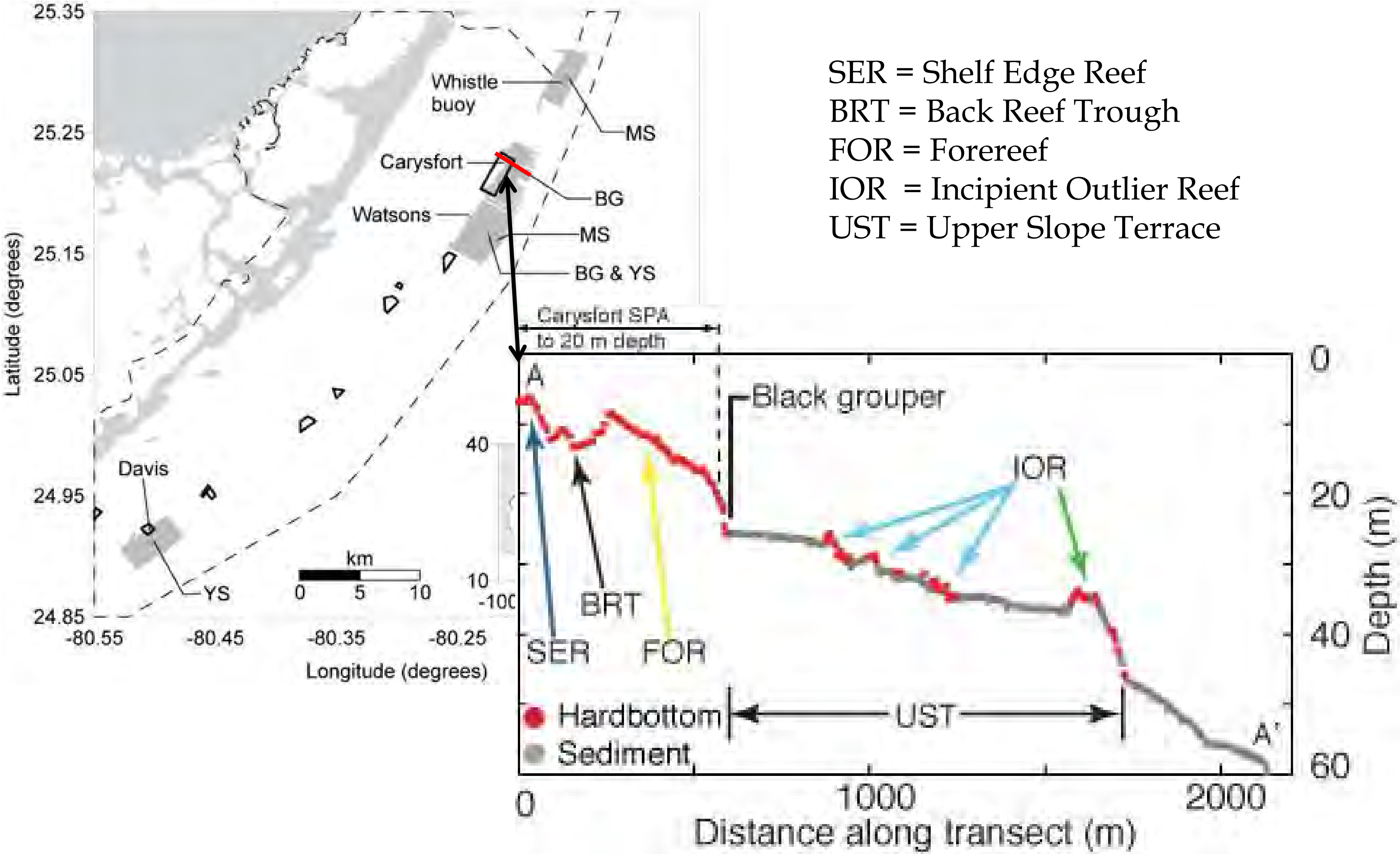
* Watson Reef was also reported as a location for black and yellowtail snapper, but direct observations for those species have yet to be confirmed.

Reef Fish Spawning Aggregations (FSAs)



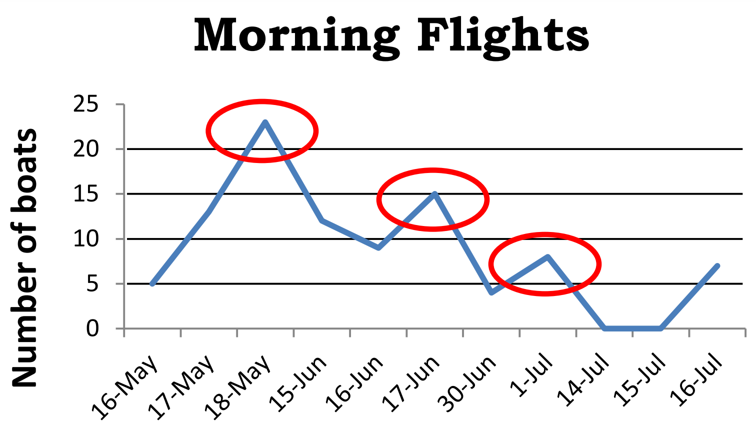
Site Name	Species Observed	Description
Western Dry Rocks	Mutton snapper, gray snapper, yellow goatfish, mahogany snapper, spadefish, striped grunts	**Dozens of mutton snapper observed by divers May 2011, observations of 38 fishing boats on site in May 2011; Hundreds to over 1000 gray snapper** observed over several months (June, July, and/or August) 2010 and 2012, with additional species
Mangrove Toppino	Gray snapper	**Over 1000 gray snapper swimming in tight school** over two successive days, August 2012
Eyeglass Bar	Gray snapper, mutton snapper	Hundreds of gray snapper observed over three consecutive months (June, July, August) 2010: Fishing boats observed catching mutton snapper in May 2012, no visual observation by divers
Maryland Shoal	Gray snapper, yellowtail snapper	Numerous schools of 12-25 fish, large (30-50 cm) fish, swimming in close formation. Observations of 10 fishing boats (1 commercial, 9 recreational) fishing on gray snapper in July 2010

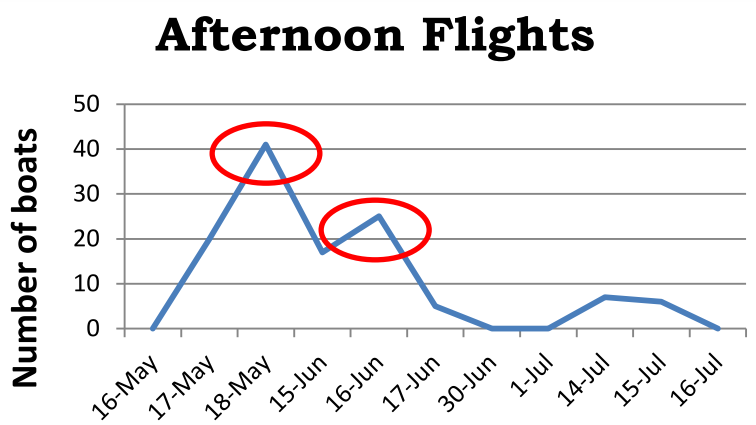
SPAs do not contain reef fish aggregation sites



SER = Shelf Edge Reef
BRT = Back Reef Trough
FOR = Forereef
IOR = Incipient Outlier Reef
UST = Upper Slope Terrace

Aerial Surveys - Boating Pressure

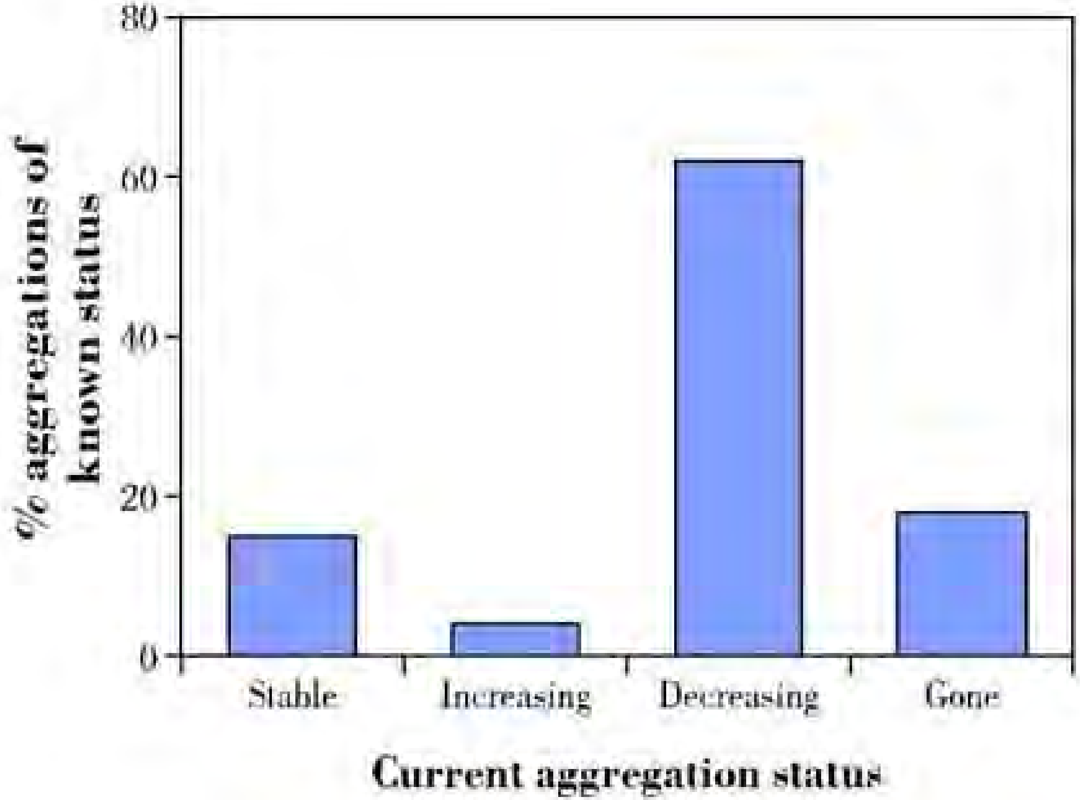




Reef Fish Spawning Aggregations (FSAs)

How have FSAs fared in other locations?

Reef Fish Spawning Aggregations (FSAs)



Of the 140 aggregation sites for which there is information on their current and past status, the great majority are in decline. Increases are typically associated with some form of protection.

From: The Society for the Conservation of Reef Fish Aggregations

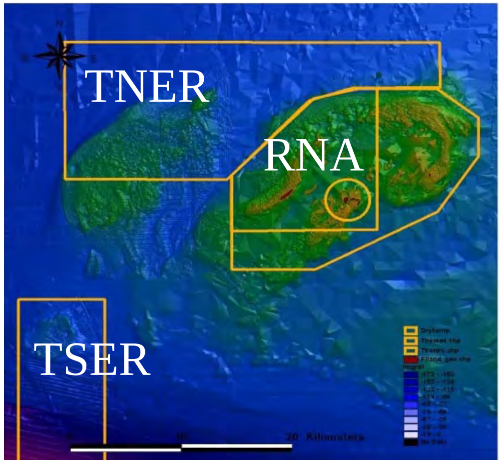
Reef Fish Spawning Aggregations (FSAs)

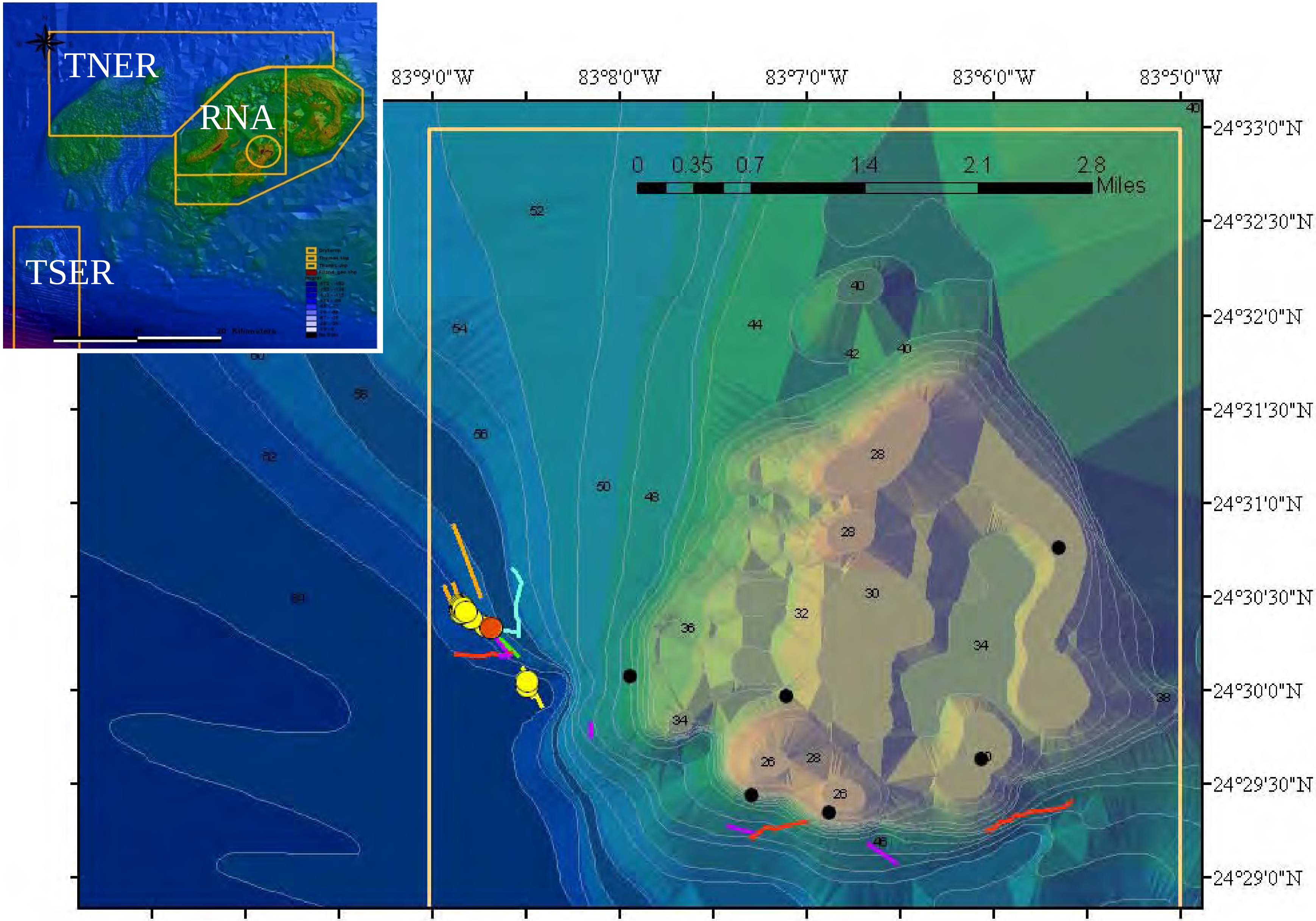
Observations of Mutton snapper (*Lutjanus analis*) on Riley's Hump		
Date and Station	Numbers observed	Moon phase
28 May–1 June 1999	1 fish in 3 of the 11 dives	Full moon May 30*
31 July–3 Aug 2000	1 fish in 5 of the 6 dives	New moon July 30*
17 July 2001 Station 2	10	3 days before new moon*
27 May 2002 Station 2	75 -100	1 day after full moon*
15 June 2003 Station 2	75 -100	1 day after full moon*
15 June 2003 Station 12	200 +	1 day after full moon*
4 July 2004 Station 12	300	2 days after full moon*
3 July 2007 Station 12	100 +	3 days after full moon**
12 June 2009 (1415-1715 hrs)	~4000	5 days after full moon***

•From: Burton ML, Brennan KJ, Muñoz RC, Parker RO Jr (2005) 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. Fish Bull 103:404–410.

** Mike Burton's Trip report

*** FWC current study

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FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

Reef Fish Spawning Aggregations (FSAs)

What about FSA work in other parts of the Caribbean?

Case studies:

How they study aggregations in Belize and U.S. Virgin Islands

Timing and occurrence of multi-species reef fish spawning aggregations

Dr. William D. Heyman
LGL Ecological Research Associates, Inc.

Hypothesis: multi-species reef fish spawning aggregations occur predictably at:

- shelf edges (20-60 m water depth)
- adjacent to deep water (>200 m)
- reef promontories (convex shelf-edge bend, or "submerged capes")
- ledges, humps or high-relief structure

BULLETIN OF MARINE SCIENCE, 83(3): 531–551, 2008

CORAL REEF PAPER

CHARACTERIZATION OF TRANSIENT MULTI-SPECIES REEF FISH SPAWNING AGGREGATIONS AT GLADDEN SPIT, BELIZE

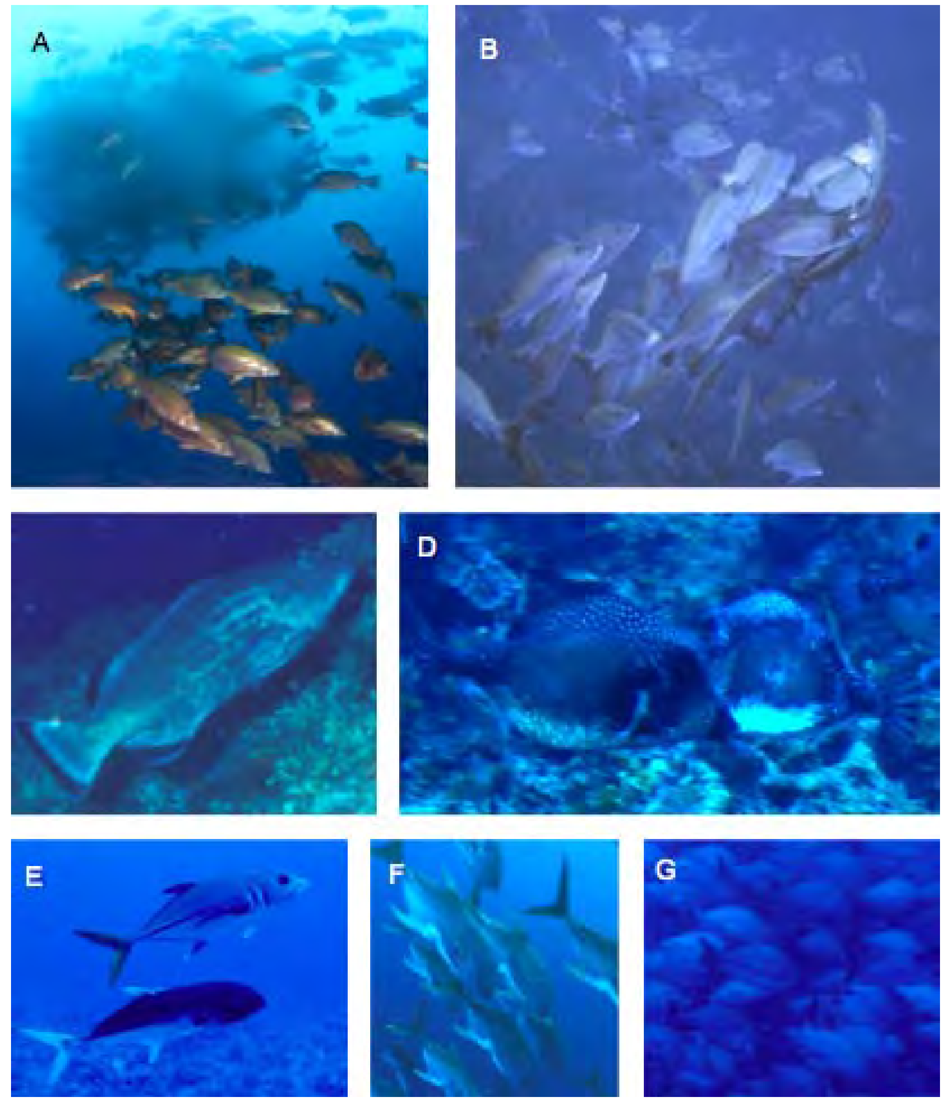
William D. Heyman and Björn Kjerfve

At least 17 species spawning at Gladden Spit

Table 2. Direct and indirect evidence of possible transient spawning aggregations at Gladden Spit. Spawning was observed (S) for 17 species, constituting direct evidence.

Family	Species name	Seasonal peak spawning period	Lunar abundance peak	Evidence for spawning aggregations						
Lutjanidae	*Lutjanus analis*	Mar–Jun	–2 to 7 dafm	S	R	3			C	F
	Lutjanus cyanopterus	Apr–Sep	–2 to 12 dafm	S	R	3	G	Δ	C	F
	Lutjanus jocu	Apr–Jun	–2 to 7 dafm	S	R	3			C	F
	Ocyurus chrysurus	Feb–Mar	No data	S	R	3				F
Serranidae	*Epinephelus striatus*	Dec–Feb	2–10 dafm	S	R	3	G	Δ	C	F
	Mycteroperca bonaci	Jan–Mar	5–14 dafm	S	R	3	G	Δ	C	F
	Mycteroperca tigris	Dec–Jan	2–10 dafm				G	Δ	C	F
	Mycteroperca venenosa	Jan–Apr	6–14 dafm	S	R	3	G	Δ	C	F
Carangidae	*Seriola dumerili*	Apr–Jun	No data		R	3			C	F
	Carangoides ruber	Apr–May	0–7 dafm	S		3		Δ	C	
	Caranx hippos	Apr–Jun	0–7 dafm	S		3		Δ	C	
	Caranx latus	Apr–Jun	0–7 dafm	S		3		Δ	C	
	Carangoides bartholomaei	Jun–Jul	0–7 dafm	S		3		Δ	C	
	Trachinotus falcatus	Jun	0–7 dafm	S		3		Δ		F
	Decapterus macarellus	Jun	No data	S		3			C	
Scombridae	*Scomberomorus cavalla*	Apr–May	No data		R					
Ephippidae	*Chaetodipterus faber*	Feb–Jul	0–7 dafm					Δ	C	
Labridae	*Lachnolaimus maximus*	Apr–May	0–7 dafm	S	R	3		Δ	C	
Haemulidae	*Haemulon album*	Apr–Jul	No data		R	3		Δ	C	
Balistidae	*Canthidermis sufflamen*	Apr–Jun	0–7 dafm			3		Δ	C	
	Xanthichthys ringens	Mar–Aug	0–7 dafm	S		3		Δ	C	
Sparidae	*Calamus bajonado*	Dec–Jan	0–7 dafm		R	3				
Ostraciidae	*Lactophrys trigonus*	Feb–Mar	0–7 dafm	S		3		Δ	C	
	Lactophrys triqueter	Jan–May	0–7 dafm	S		3		Δ	C	

dafm: days after full moon; negative numbers are days before full moon
S: spawning observed
R: ripe gonads found in high proportion ($\geq 70\%$) of fishery-landed individuals
3: at least 3× increase in abundance over non-aggregating time
G: gravid individuals observed underwater
Δ: color changes associated with spawning observed underwater
C: courtship behaviors observed underwater
F: reported by fishermen

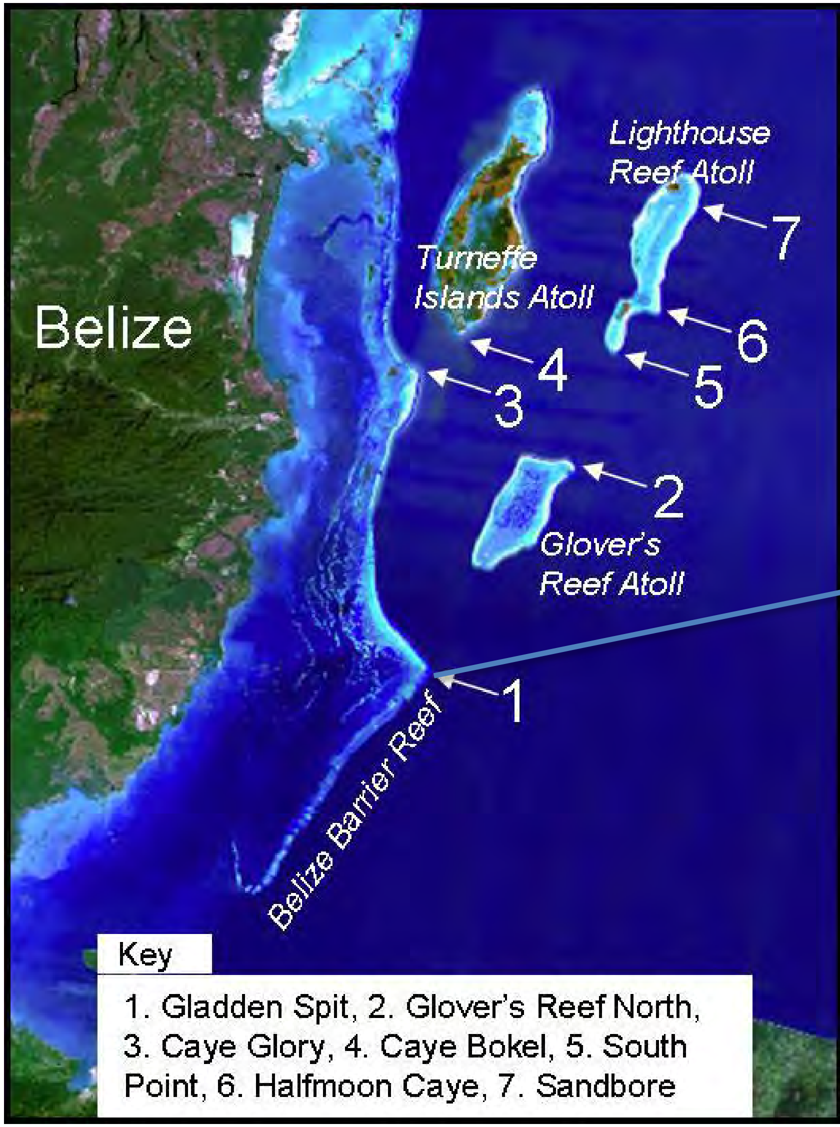


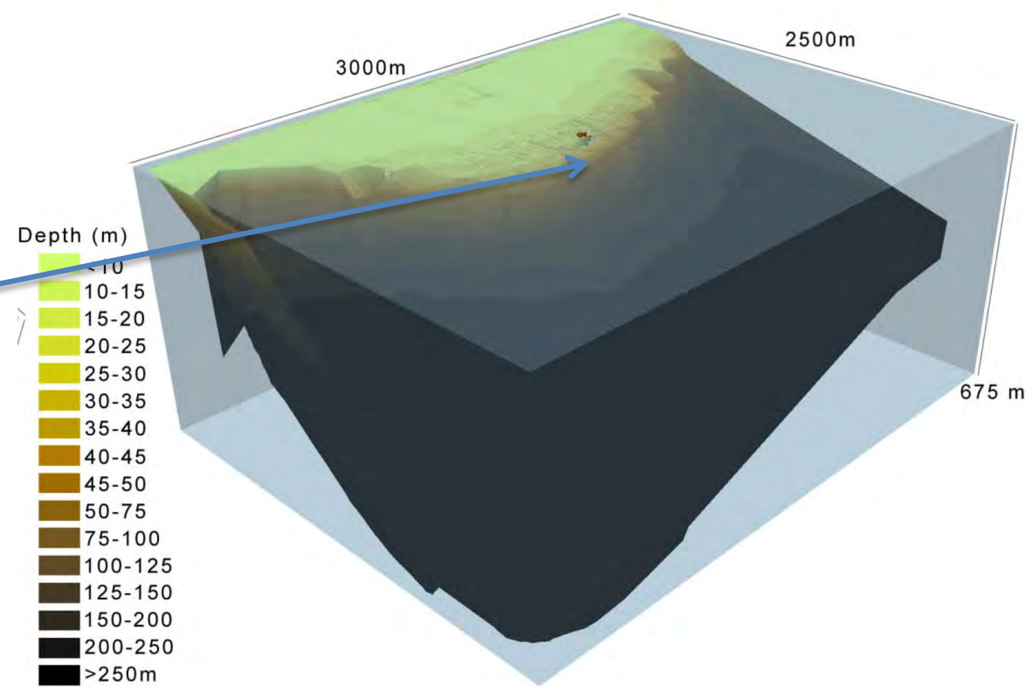
BULLETIN OF MARINE SCIENCE, 83(3): 531–551, 2008 CORAL REEF PAPER

CHARACTERIZATION OF TRANSIENT MULTI-SPECIES REEF FISH SPAWNING AGGREGATIONS AT GLADDEN SPIT, BELIZE

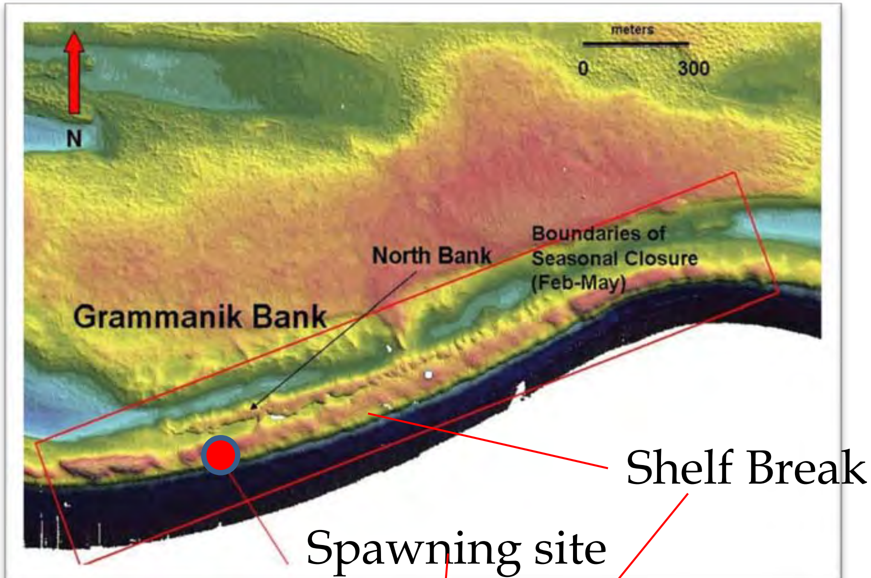
William D. Heyman and Björn Kjerfve

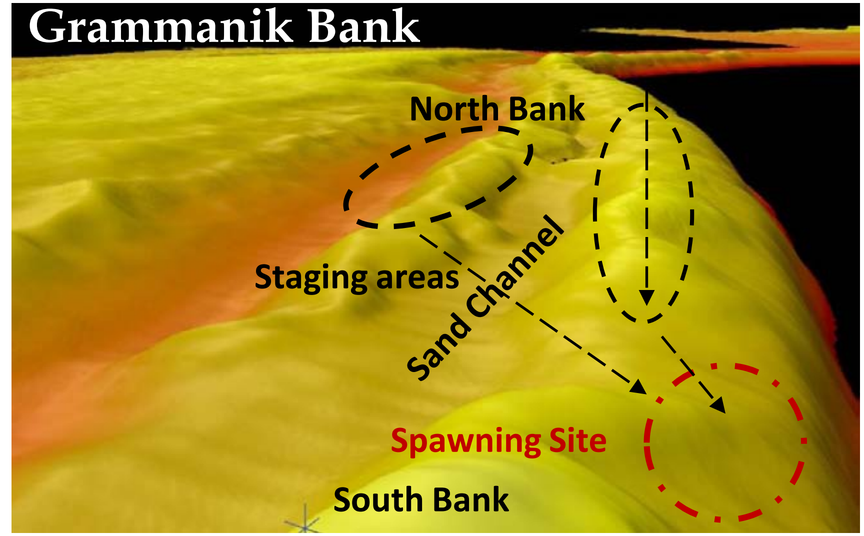
Gladden Spit example



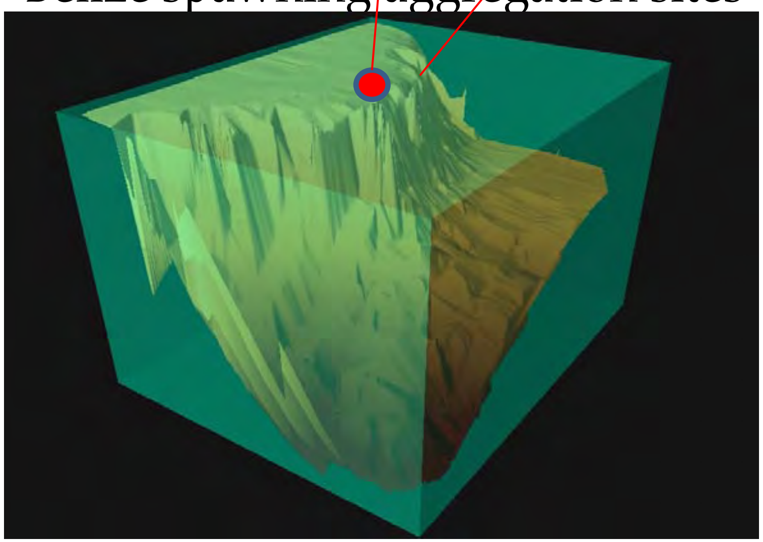


USVI Nassau Grouper FSA site. From Kadison et al 2010 GCFI presentation



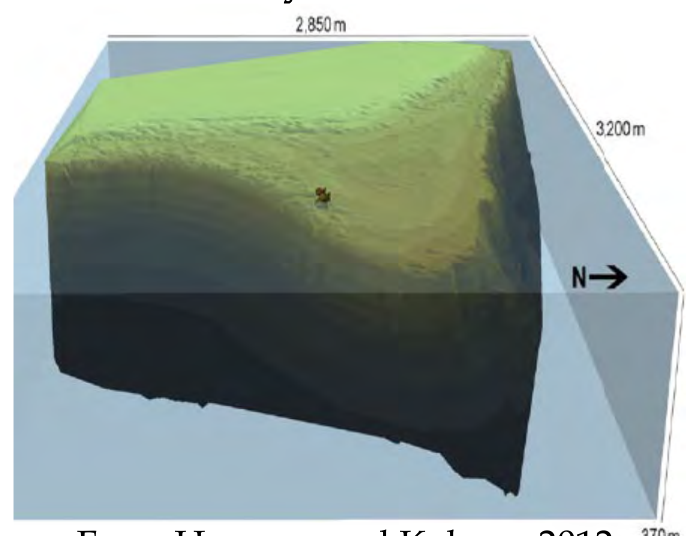


Belize spawning aggregation sites



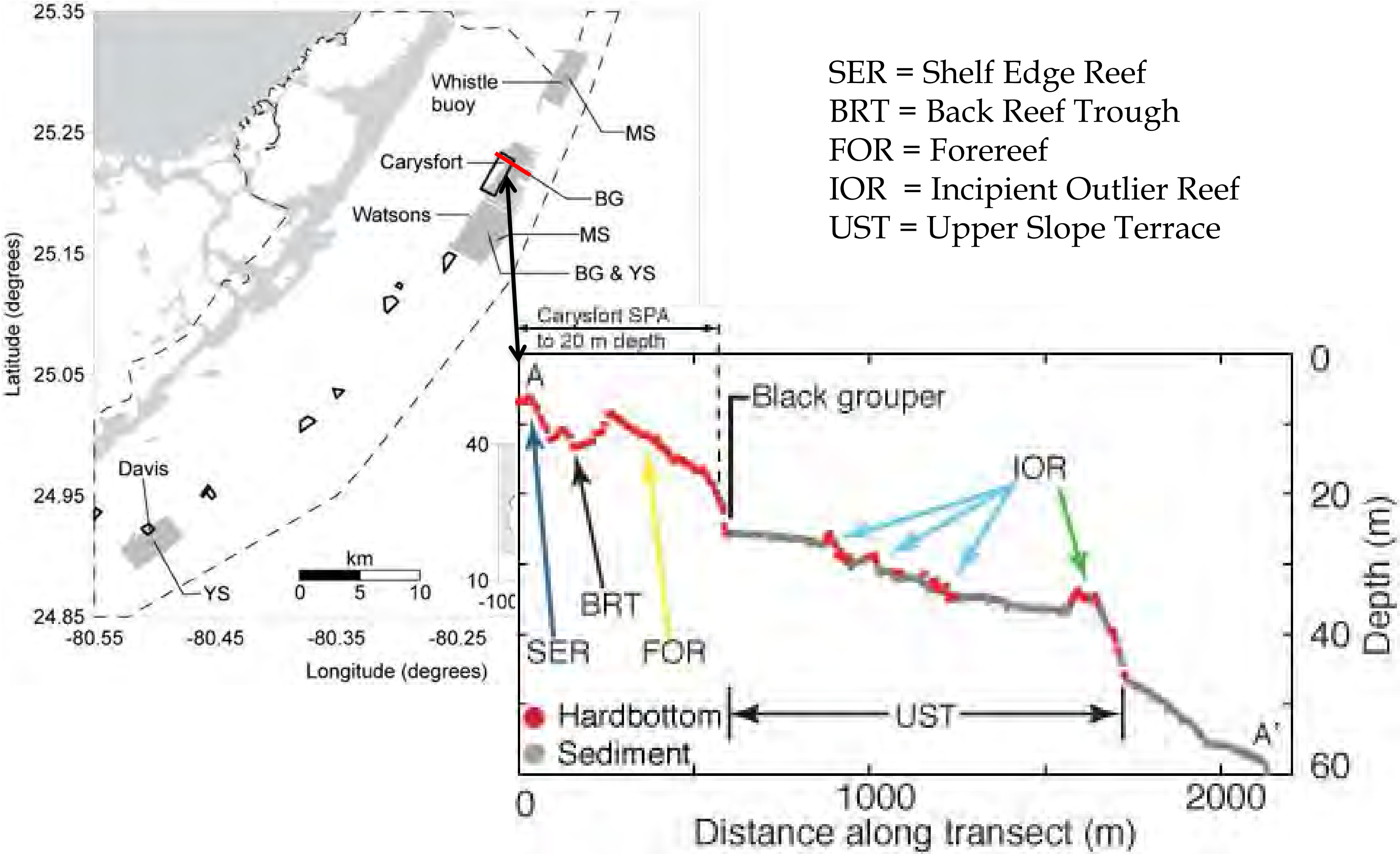
From Kovara and Heyman 2008 GCFI presentation

Grand Cayman SPAG site

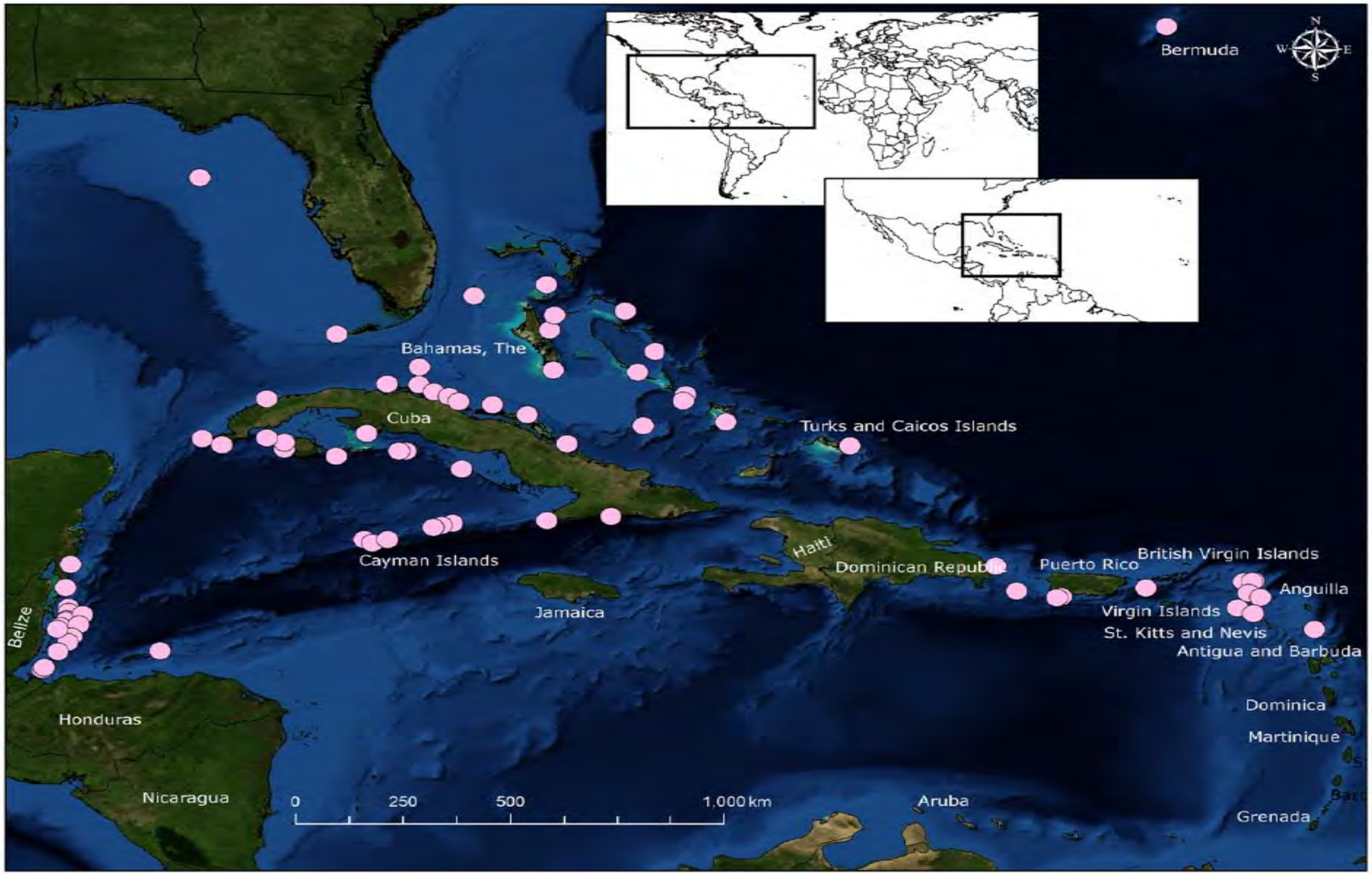


From Heyman and Kobara 2012

FSA near outlier reefs



SER = Shelf Edge Reef
BRT = Back Reef Trough
FOR = Forereef
IOR = Incipient Outlier Reef
UST = Upper Slope Terrace

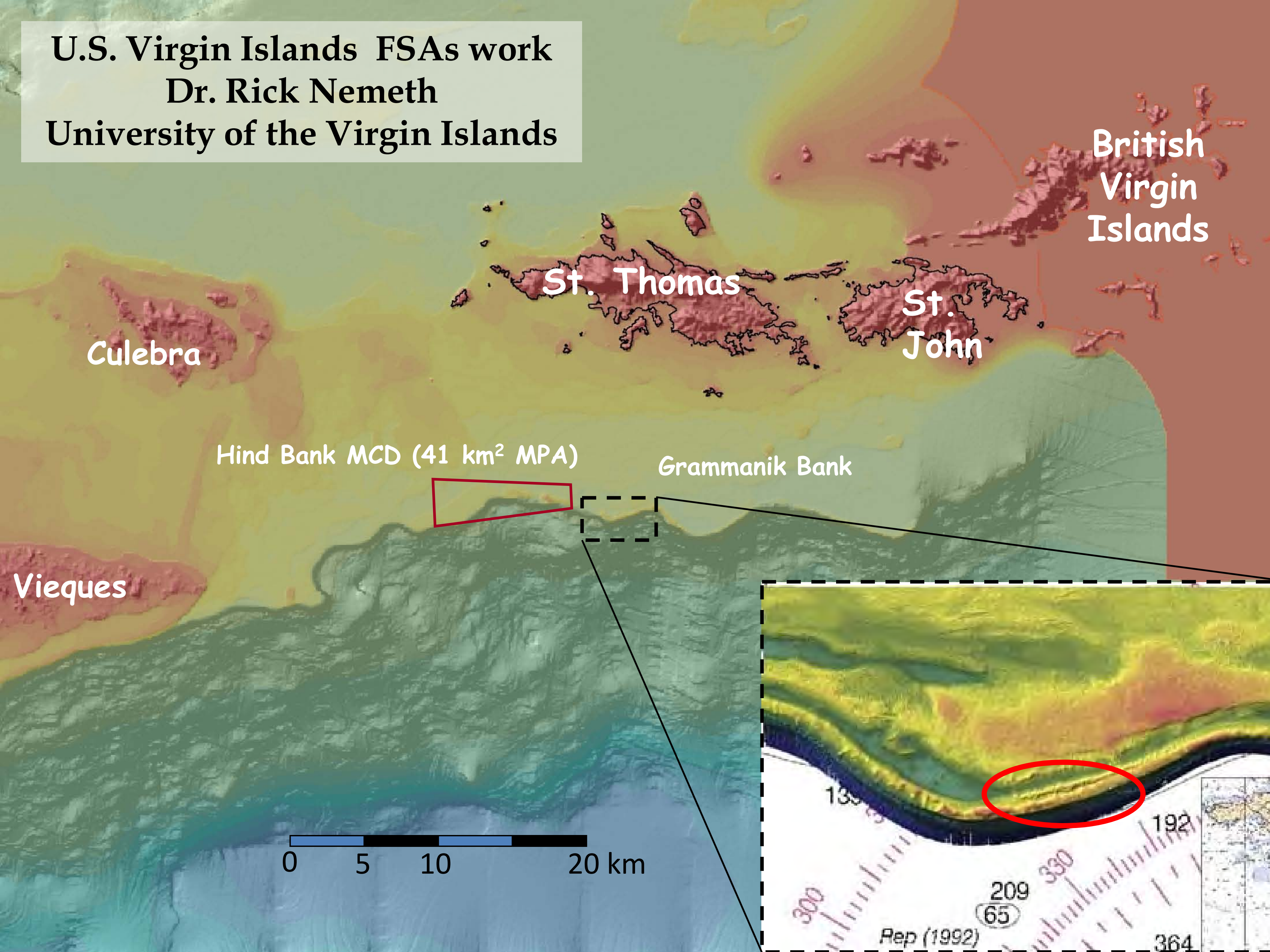


Most of the 36 documented and verified FSA sites in the Caribbean were found near shelf edges (29 sites or 81%) and dropoffs (23 sites or 64%).
From: Heyman and Kobara 2012.

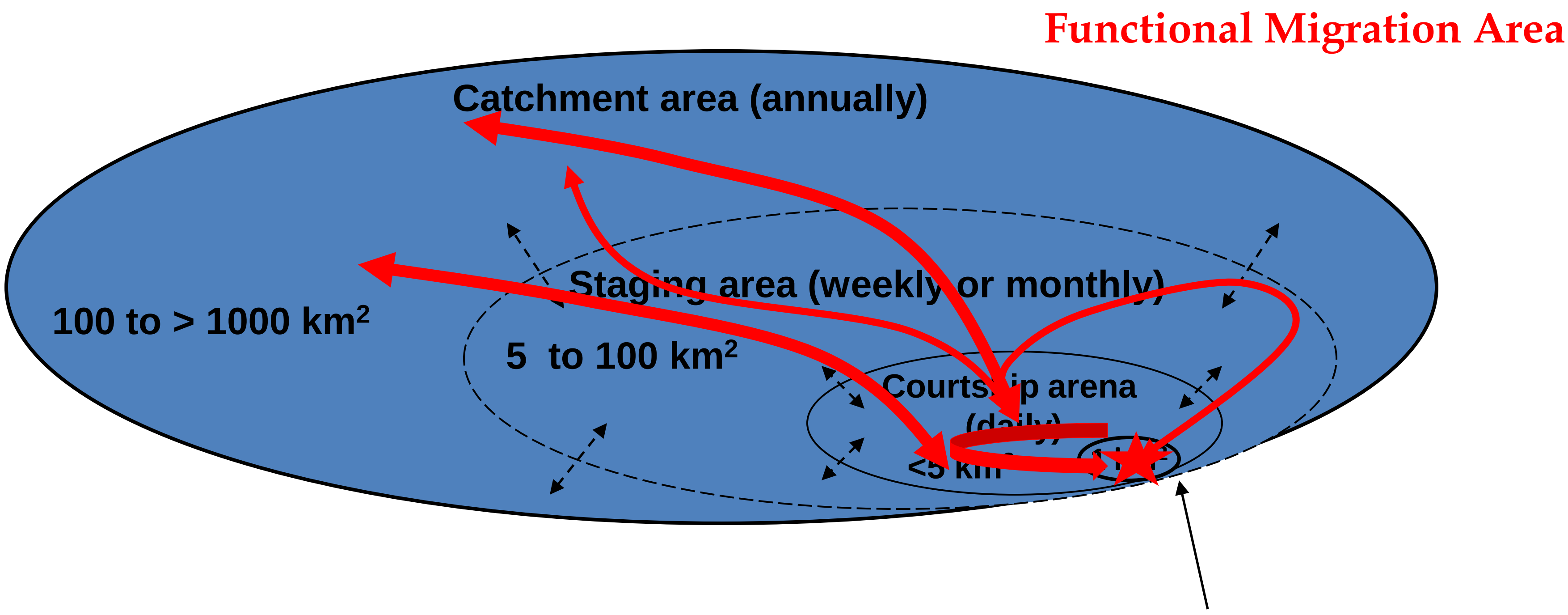
Reef Fish Spawning Aggregations (FSAs)

- U.S. Virgin Islands – using the geomorphology and acoustic tagging to examine grouper aggregations

U.S. Virgin Islands FSAs work
Dr. Rick Nemeth
University of the Virgin Islands



Defining spatial and temporal scales of movement of spawning aggregations

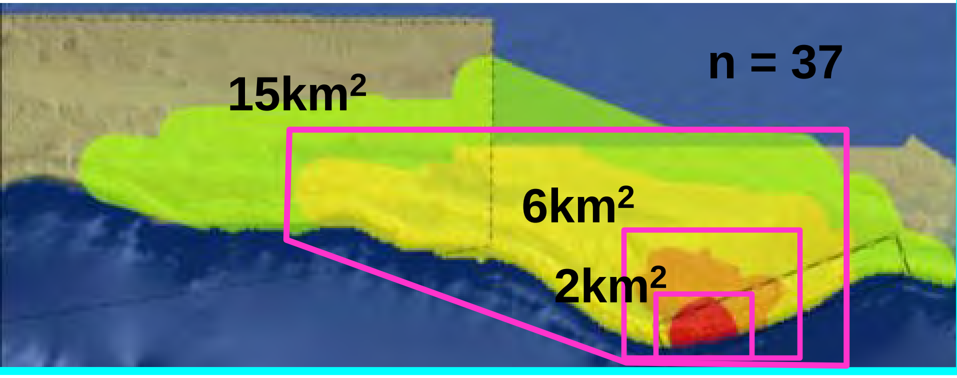


<u>Staging area</u>
- feeding
- cleaning stations
- guiding first-time spawners

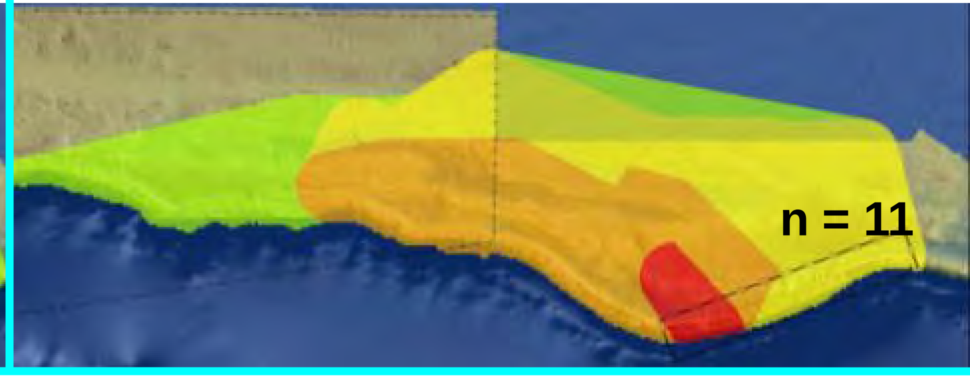
<u>Courtship arena</u>
- spawning coloration
- courtship behaviors
- aggression

<u>Spawning site</u> (hourly)
- gamete release

Nassau grouper



Yellowfin grouper

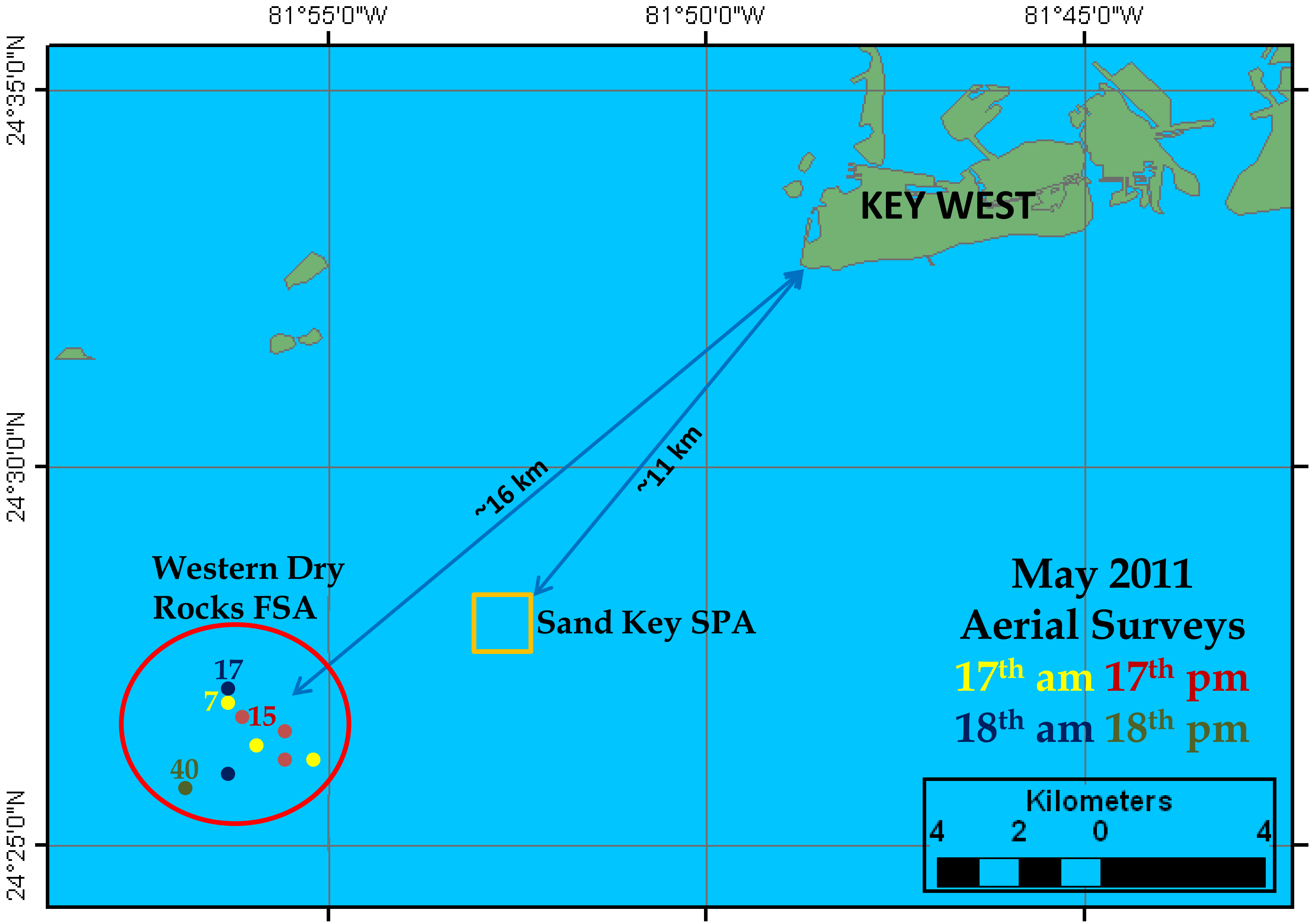


Staging area
- feeding
- cleaning stations
- guiding first-time spawners

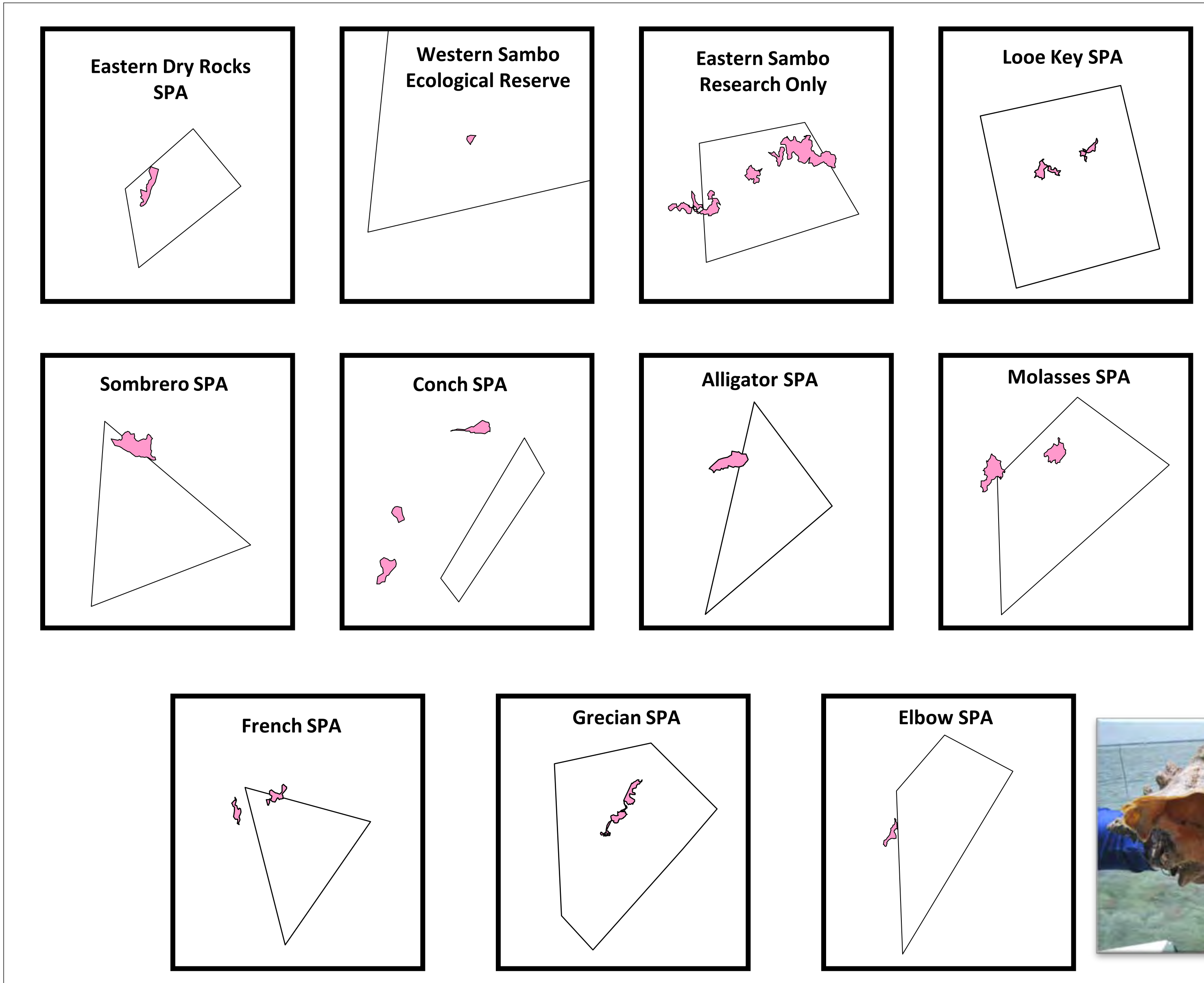
Courtship arena
- spawning coloration
- courtship behaviors
- aggression

Spawning site (hourly)
- gamete release

Tiger grouper


81°55'0"W
81°50'0"W
81°45'0"W
24°35'0"N
24°30'0"N
24°25'0"N
KEY WEST
~16 km
~11 km
Western Dry
Rocks FSA
Sand Key SPA
17
7
15
40
May 2011
Aerial Surveys
17th am 17th pm
18th am 18th pm
Kilometers
4 2 0 4

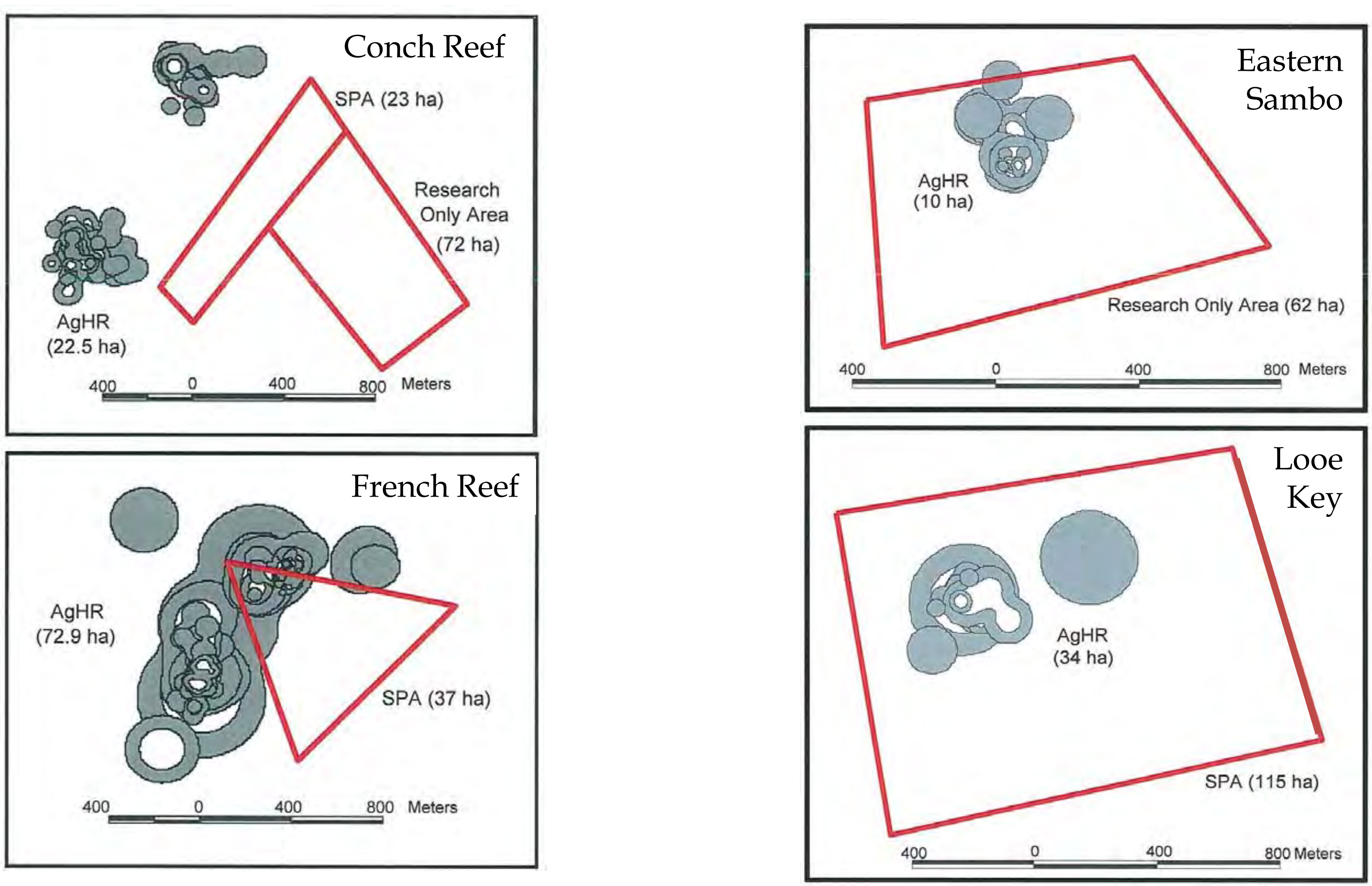
Other Spawning Aggregations - Conch



From: Glazer and Delgado report

Reef Fish Spawning Aggregations (FSAs)

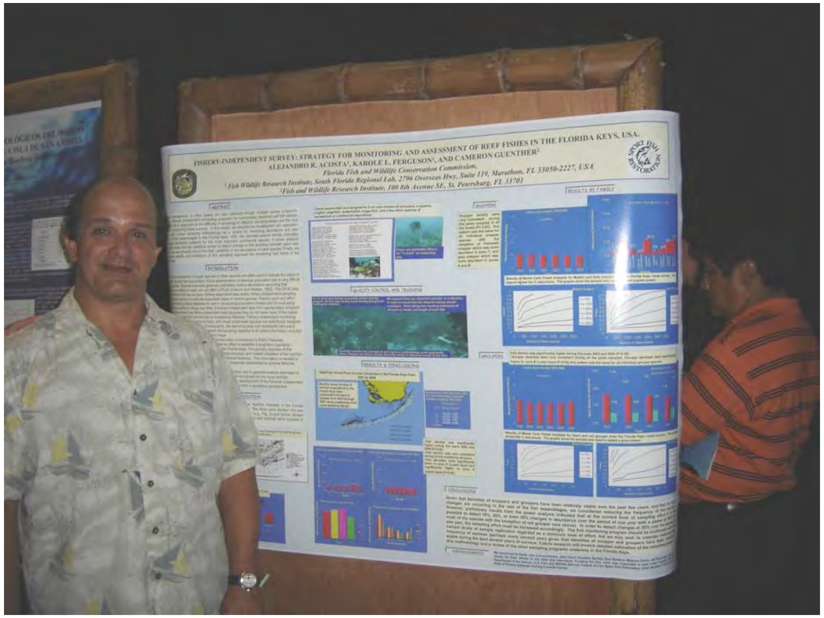
Home ranges of conch: adapted from Delgado and Glazer 2007



Reef Fish Spawning Aggregations (FSAs)

Communicating the importance of FSAs

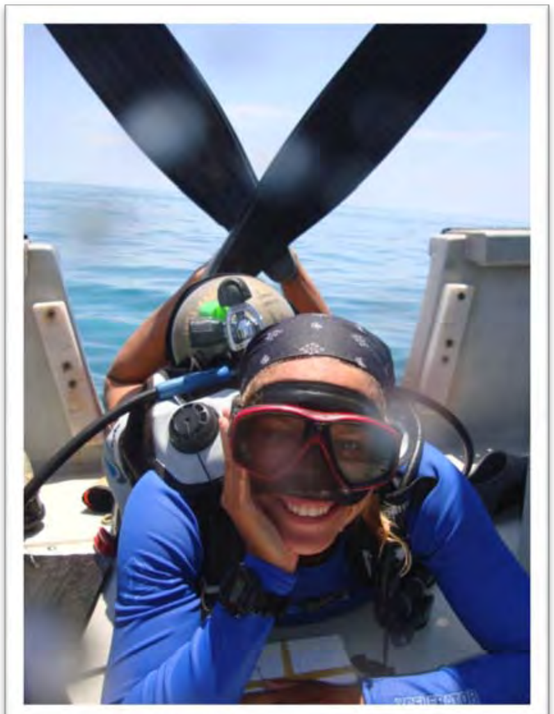
- Providing information to the community
  - Outreach and education
- Providing information to managers
  - Presentations to SAC, Sanctuary staff and FWC



Thank you montage slide…

- Project co-PIs:
  - Todd Kellison (NOAA)
  - Chris Taylor (NOAA)
  - Art Gleason (University of Miami)
- And a *huge* tip of the hat to Mike Feeley, Rick Nemeth, Will Heyman, the numerous FWC, NOAA personnel, and the community members who have provided both field support and their vast knowledge.

Any Questions?



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