Shelf-edge Reserves: Reef fish Recovery and Production

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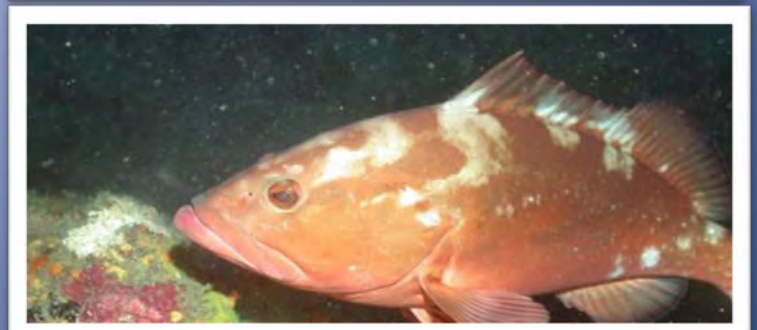
Groupers

- Long-lived
- Slow to mature
- Sequential hermaphrodites
- Complex social interactions
- Spawn in large groups
- High degree site fidelity
- Top-level predators
- * Small population size



*Characteristic of Warsaw grouper and Speckled hind?

Reef fish overfished and subject to overfishing in the SATL region as of 31 Dec 2011

Overfished

- *Red grouper
- *Red porgy
- Red snapper
- *Snowy grouper

- **Goliath grouper

Undergoing overfishing

- *Black sea bass
- *Gag
- *Red grouper
- Red snapper
- Vermilion snapper
- *Snowy grouper
- *Speckled hind
- *Warsaw grouper

- *Change sex female to male
- ** Protected

Warsaw grouper and Speckled Hind: What must be done?

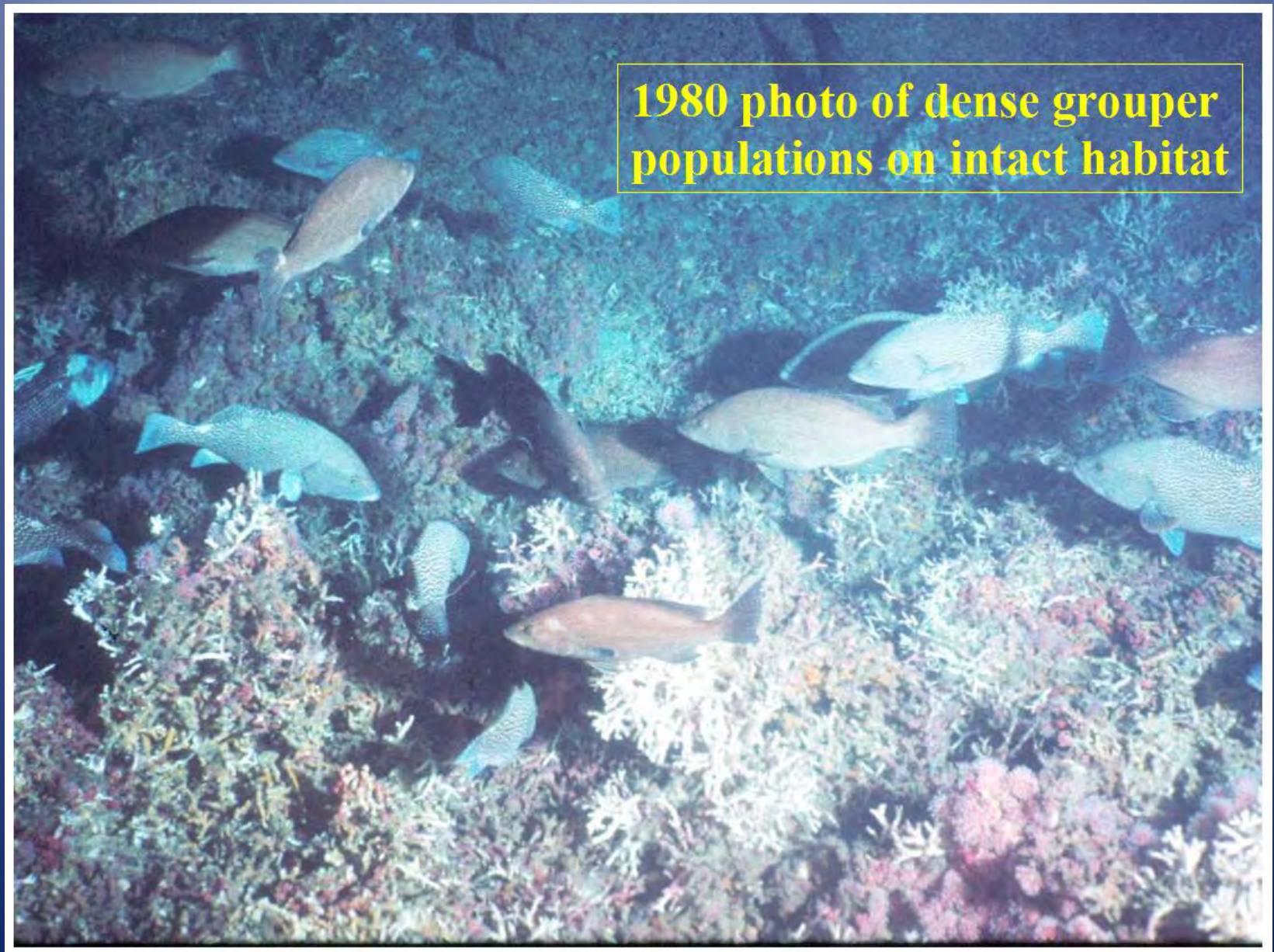
- NMFS (2003) determined that populations are overfished and undergoing overfishing in the SATL region by incidental catch.
- Captured = near 100% mortality through swimbladder rupture & hemorrhage.
- Catch locations on shelf edge (150 – 400 ft)
- Associated species in the catch not deep water species—makes sense because that's where the most intense fishing is.
- The problem with small populations (also males rare in warsaw population).

Warsaw grouper: Once abundant

One-half day catch on Madison Ridge in 1963 (Dr. Robert Bass)

Speckled hind: also called “Strawberry Grouper” or “Kitty Mitchell”, also once abundant in the US SATL.

Oculina Banks, “Jeff’s Reef” (photo by Grant Gilmore on JSL submersible)



NMFS reef fish stock assessment scientists at the Beaufort, NC Lab (Huntsman, Potts, Mays, and Vaughn 1999) wrote:

- "For the speckled hind *Epinephelus drummondhayi* in 1990 the numerical population was 10%, the population biomass was 5%, and the biomass of mature fish was 2% of that existing in 1973. The warsaw grouper *E. nigritus* is now so rare that too few individuals are measured to assess the population status." …

- "Of the several potential management schemes for groupers only the implementation of a system of marine reserves solves all the complex problems of managing these valuable fishes."

Shelf-edge reefs ("breaks") are important spawning areas for reef fish.

- Belize: Heyman et al. (2008), Kobara & Heyman (2010)
- Cuba: Claro & Lindeman (2003)
- US South Atlantic: Sedberry et al. (2006)
- Florida Keys: Gleason, Kellison, Reid (2011)
- West Florida Shelf: Coleman, Koenig & Collins (1996), Koenig et al. (2000), Coleman et al. (2010), Coleman, Koenig, Scanlon (2011)

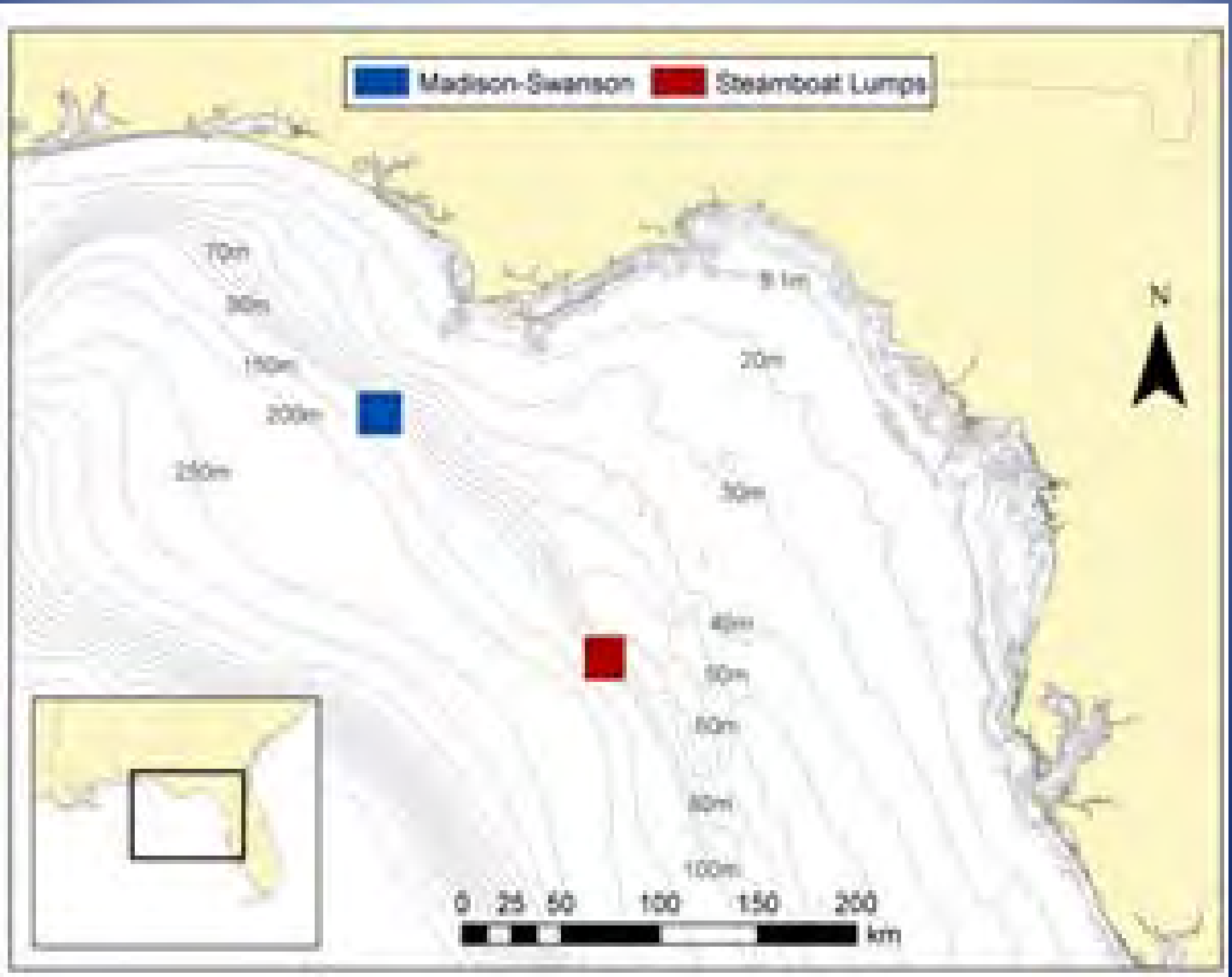
- Fishing spawning populations is like living on the principal of an investment rather than the interest—it is not sustainable.

Can shelf-edge reserves protect threatened reef fish species and fishery production?

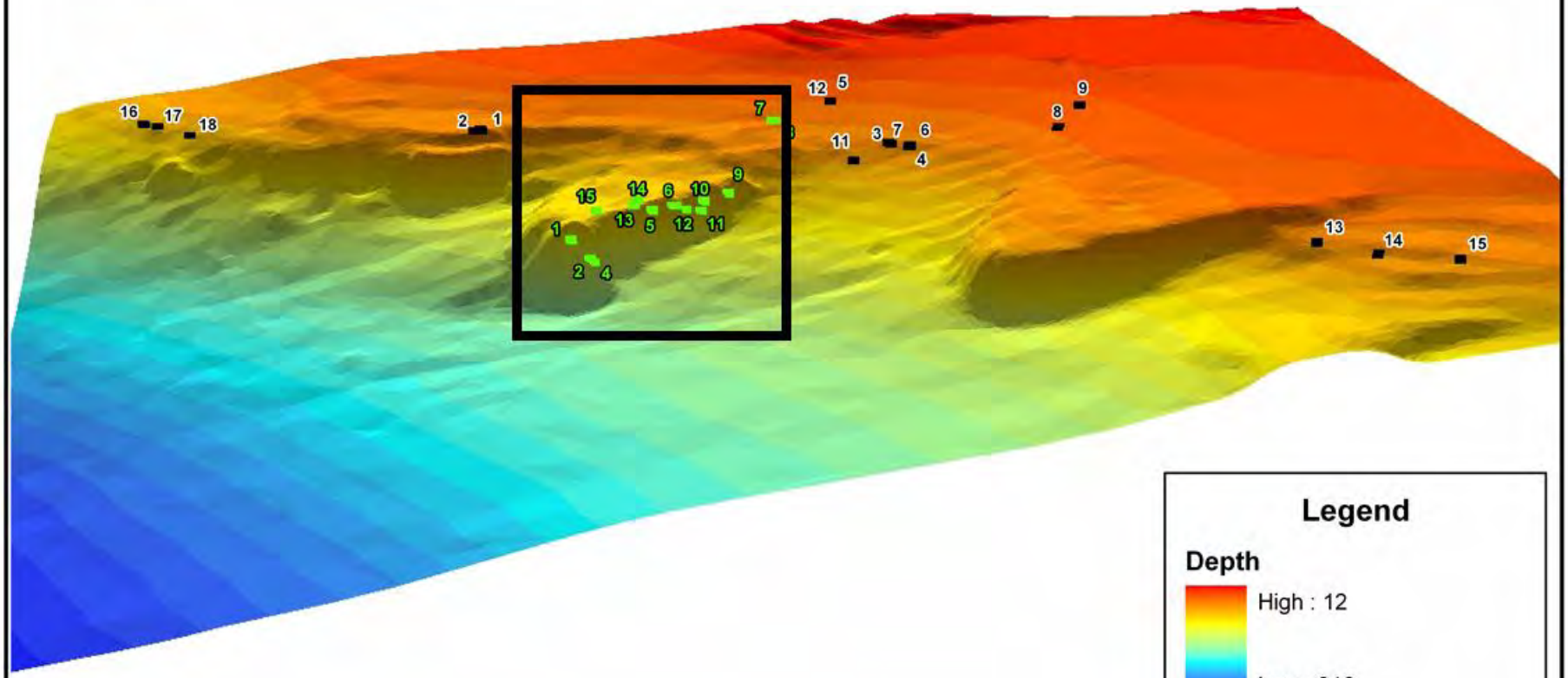
- Benefits for threatened species:
  - Protect juvenile and adult habitat
  - Provide opportunities for understanding their biology
- Benefits for shallow water species.
  - Protect sex ratios in gag
  - Protect age & size structure of spawners
  - Protect reproductive output
- Benefits to fishermen
  - Spillover
  - Protection of future recruitment
- Benefits to management
  - Monitor shifting baselines
  - Habitat protection
  - Controls for environmental impacts (e.g., oil spills)

My experience working in Madison Swanson Marine Reserve (MSMR)

- History—the problem with gag, fishermen opposition, then support.
- Protection of warsaw and speckled hind
- Movements
- Size and age structure
- Abundance
- Gag sex ratio
- Spillover
  - VMS data
  - Gag spawning migrations
  - Red snapper spawning
  - Anecdotal information


Madison-Swanson
Steamboat Lumps
70m
90m
150m
200m
250m
9.1m
20m
30m
40m
50m
60m
80m
100m
N
0 25 50 100 150 200
km

Greater Madison Swanson Fishing Reserve



Legend

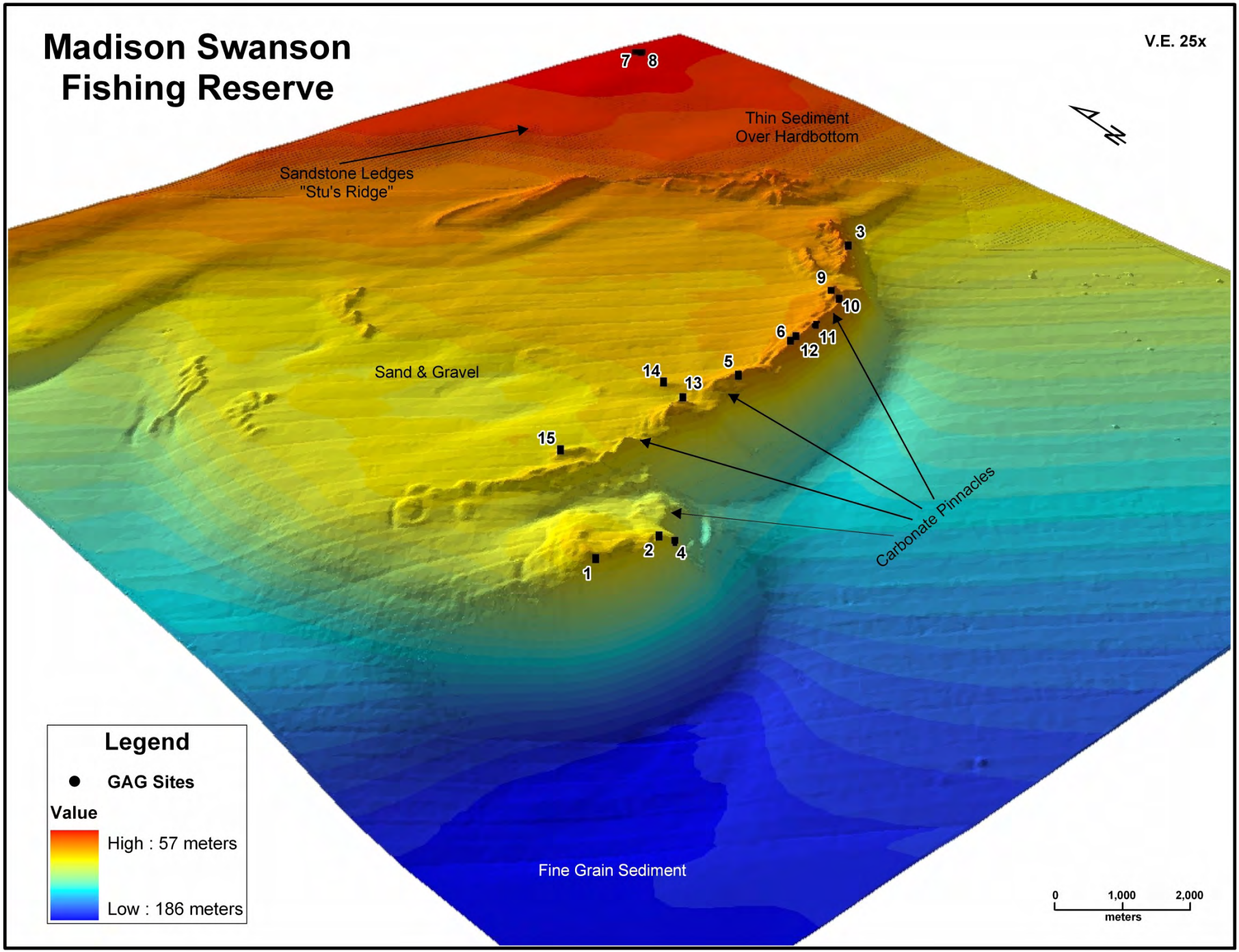
Depth

High : 12

Low : 316

GAG Sites

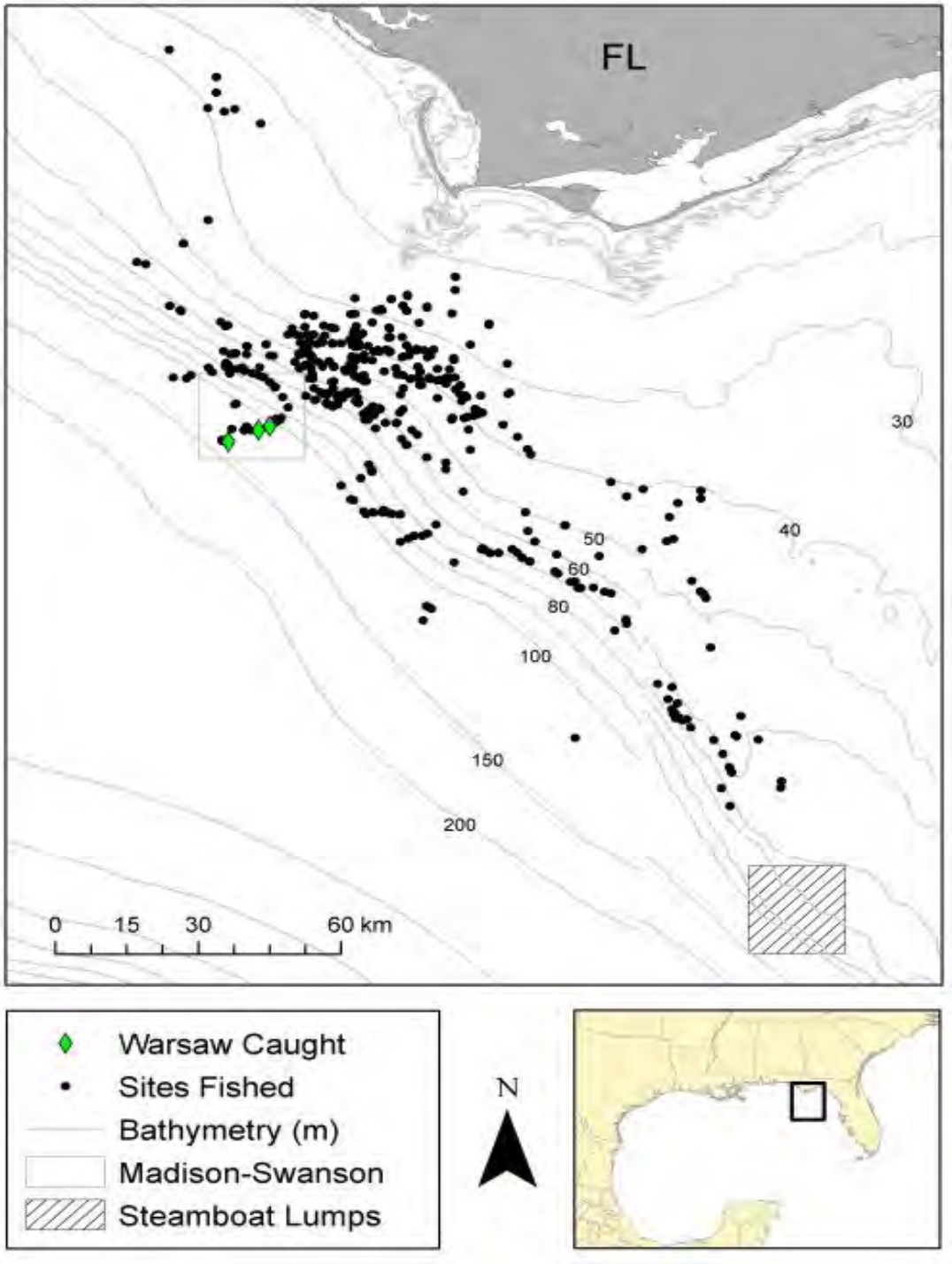
- Inside Madison Swanson
- Outside Madison Swanson


Madison Swanson
Fishing Reserve
V.E. 25x
Thin Sediment
Over Hardbottom
Sandstone Ledges
"Stu's Ridge"
Sand & Gravel
Carbonate Pinnacles
Fine Grain Sediment
7
8
3
9
10
6
11
12
5
14
13
15
2
4
1
Legend
GAG Sites
Value
High : 57 meters
Low : 186 meters
0
1,000
2,000
meters

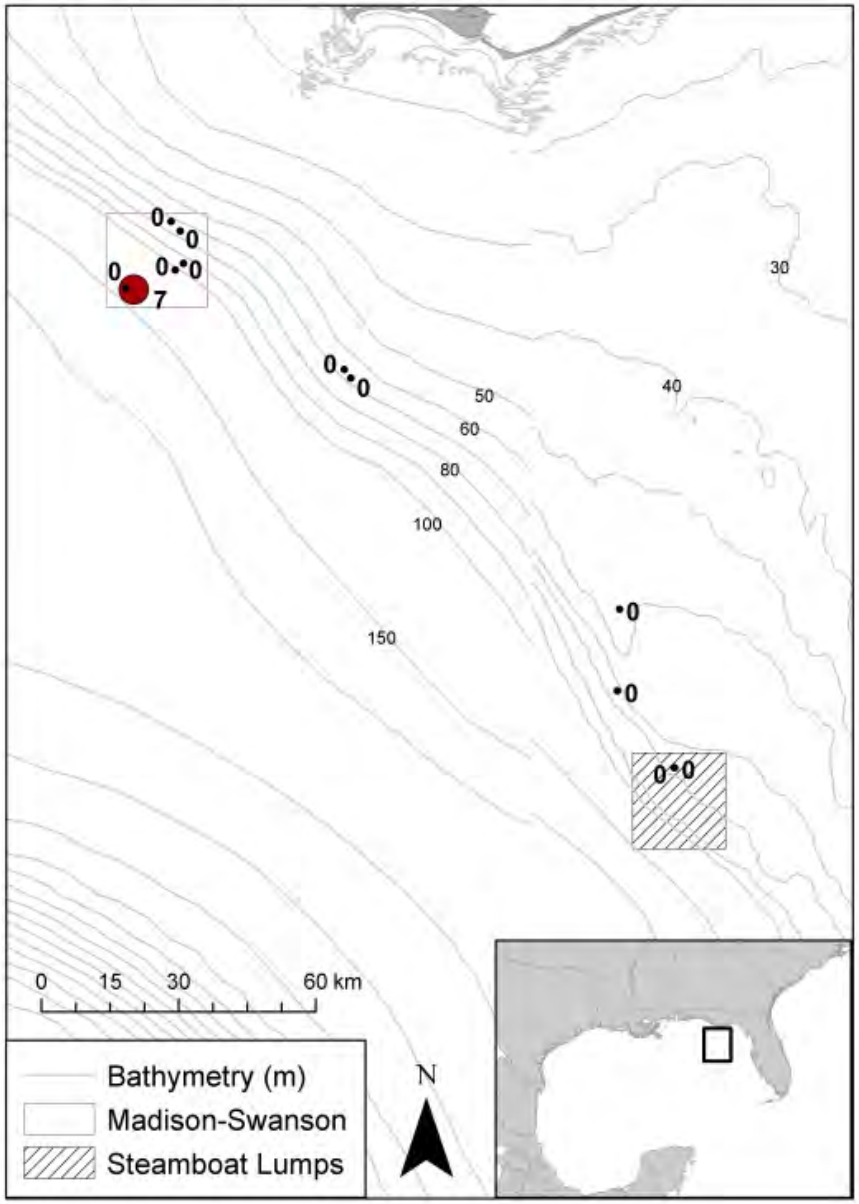
Protection of warsaw grouper and speckled hind in MSMR.

- Warsaw grouper were only caught and observed on Madison Ridge
- Speckled hind were only caught and observed in and around MSMR
- Snowy grouper were mostly associated with MSMR; also found in excavations in MSMR.

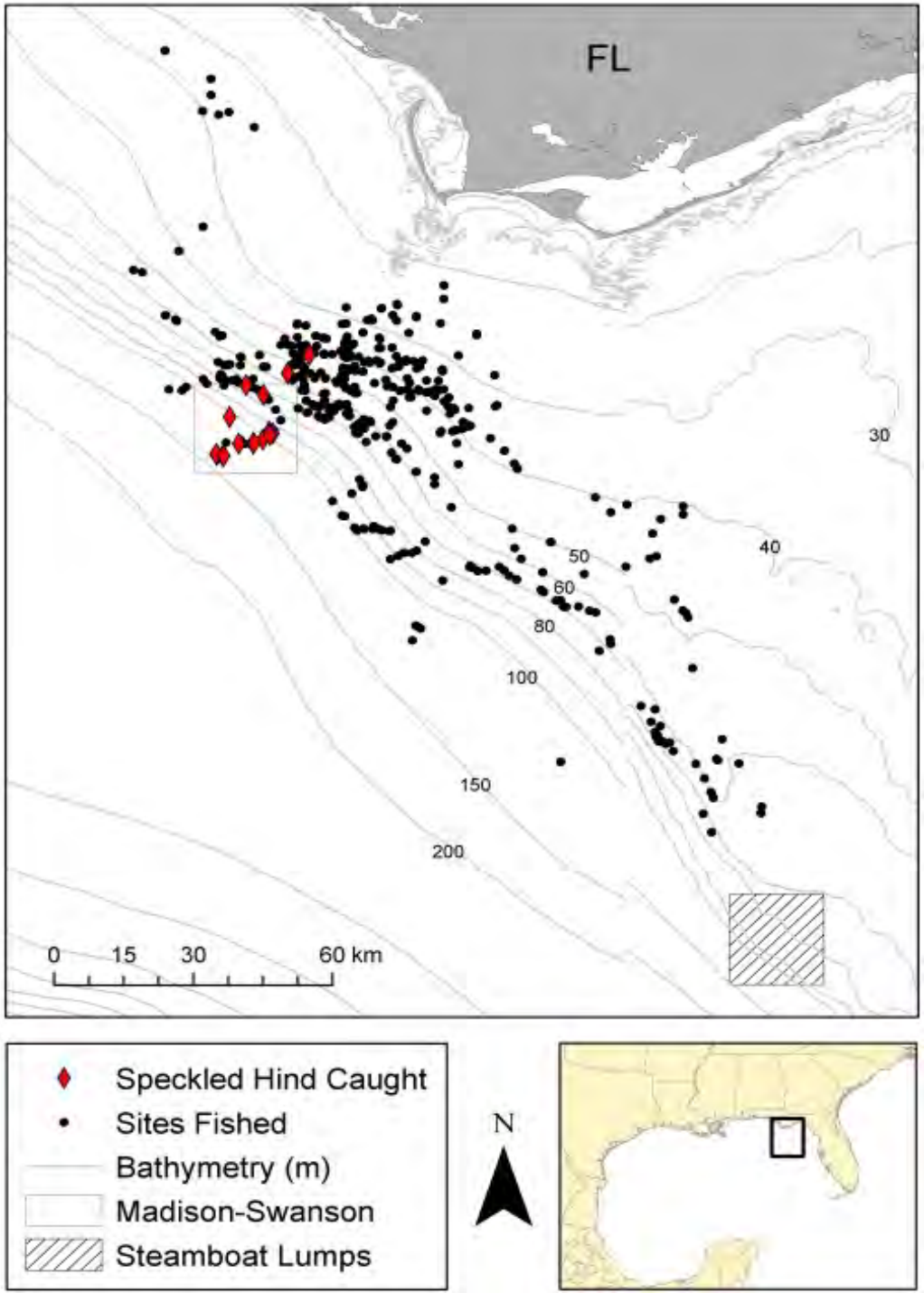
Warsaw grouper catch on shelf-edge reefs



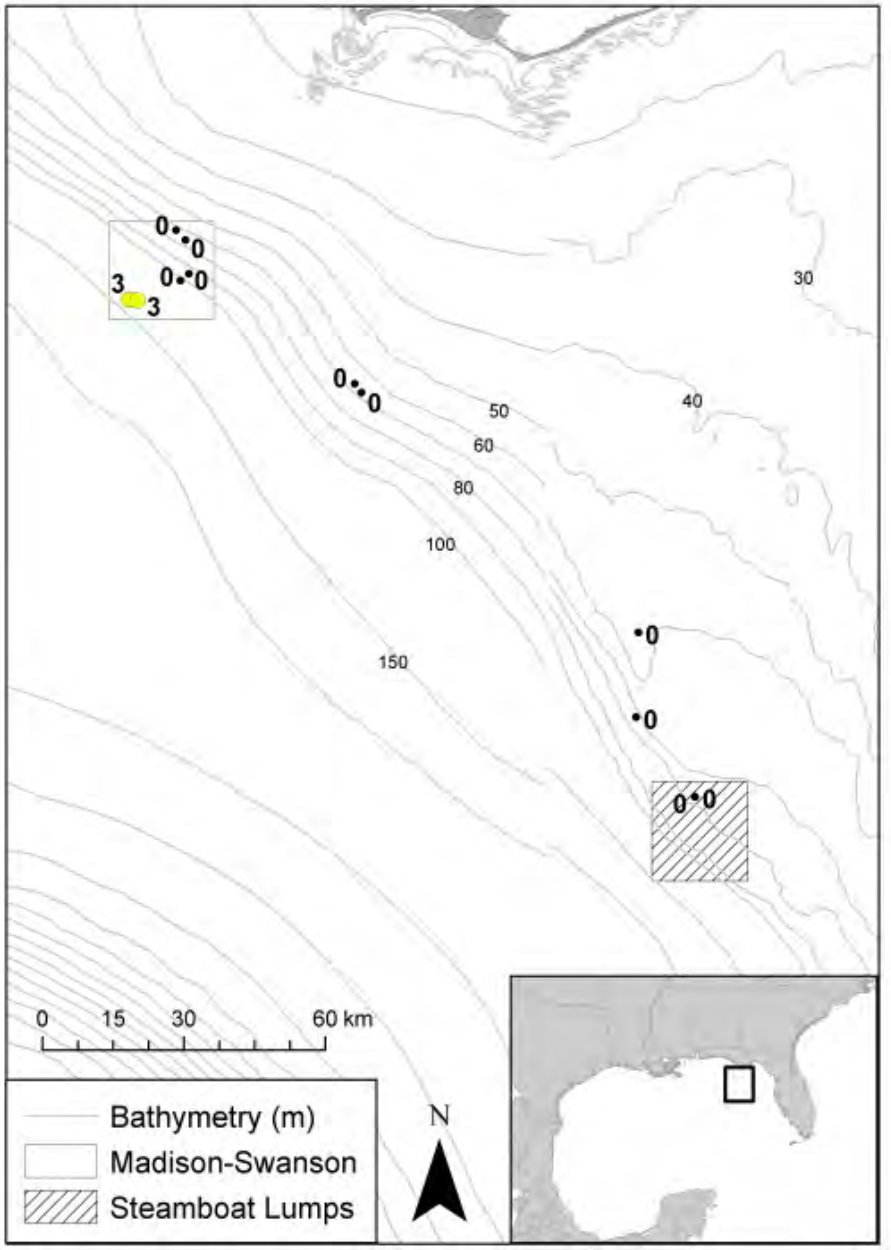
Warsaw grouper seen on sub dives on high-relief reefs



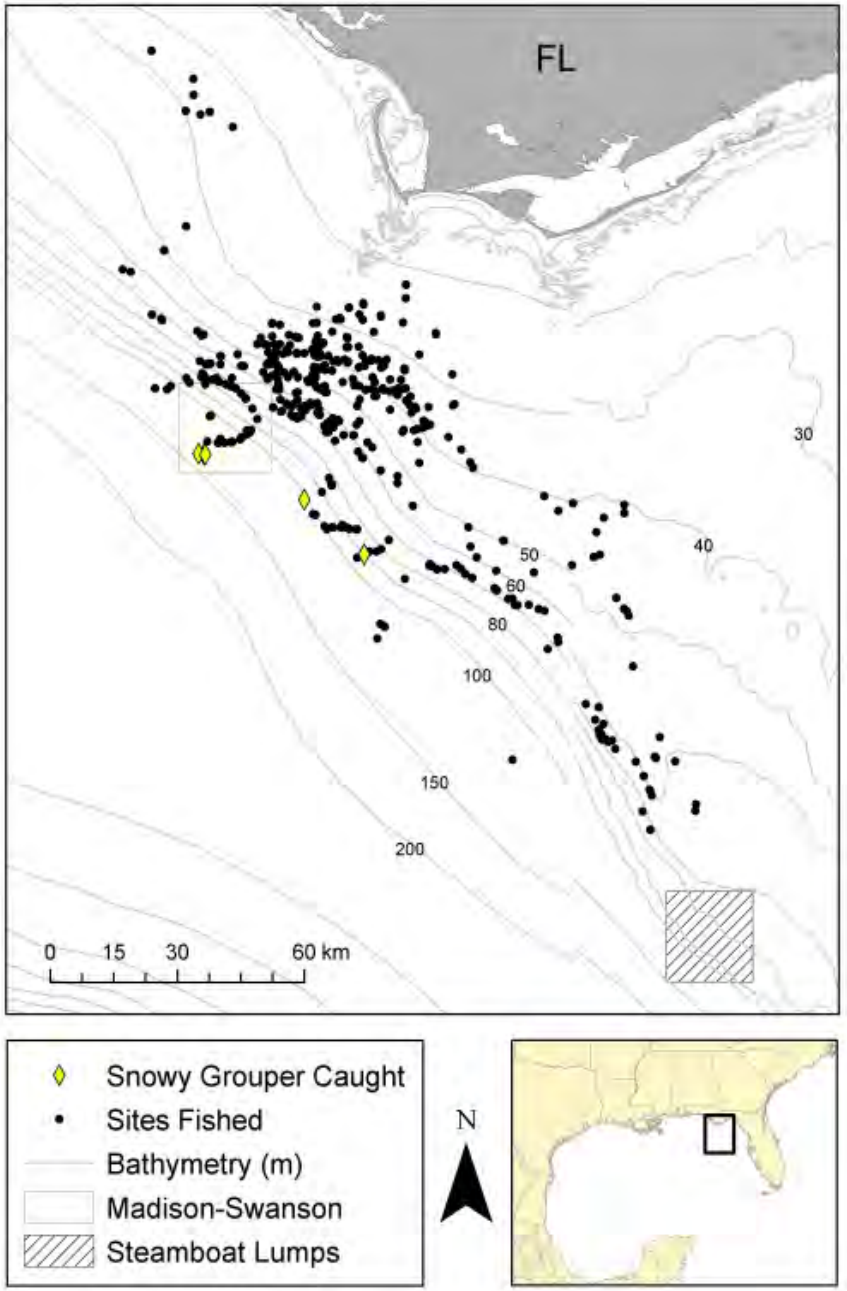
Speckled hind catch along shelf edge



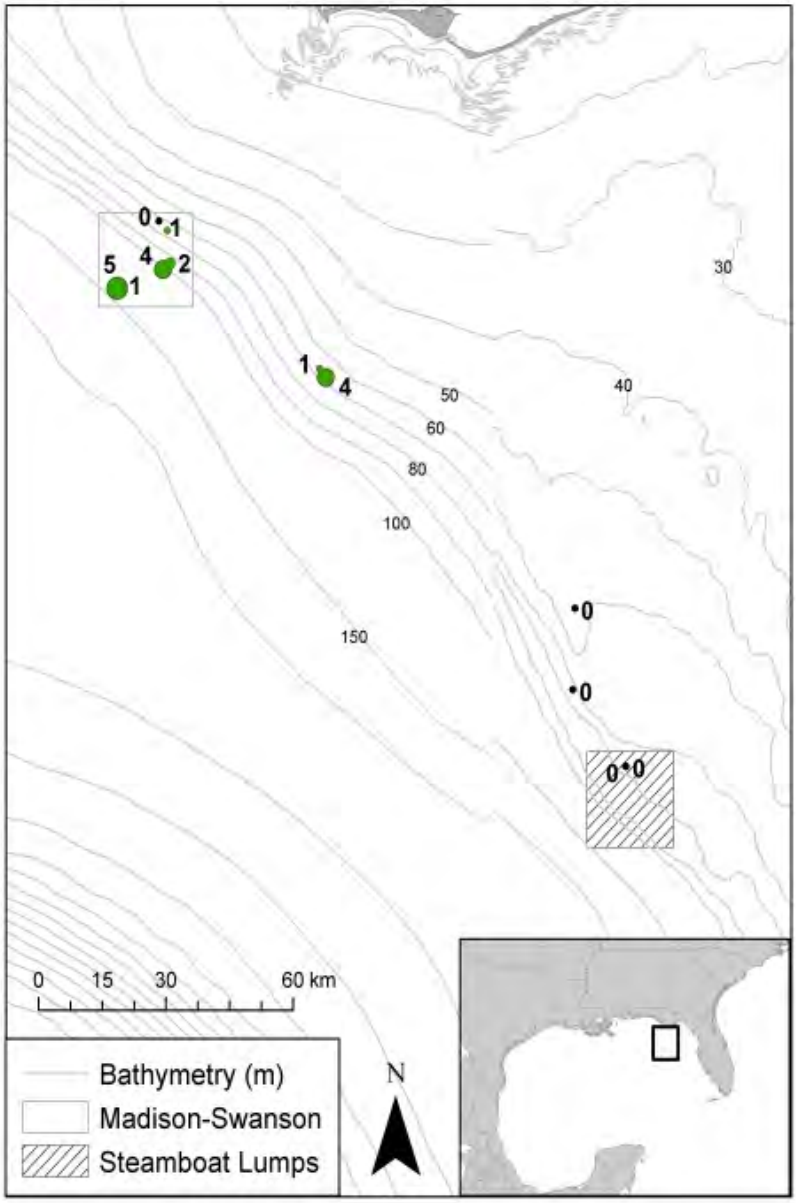
Speckled hind seen on sub dives on high-relief reefs



Snowy grouper catch along shelf edge.



Snowy grouper seen on sub dives on high-relief reefs



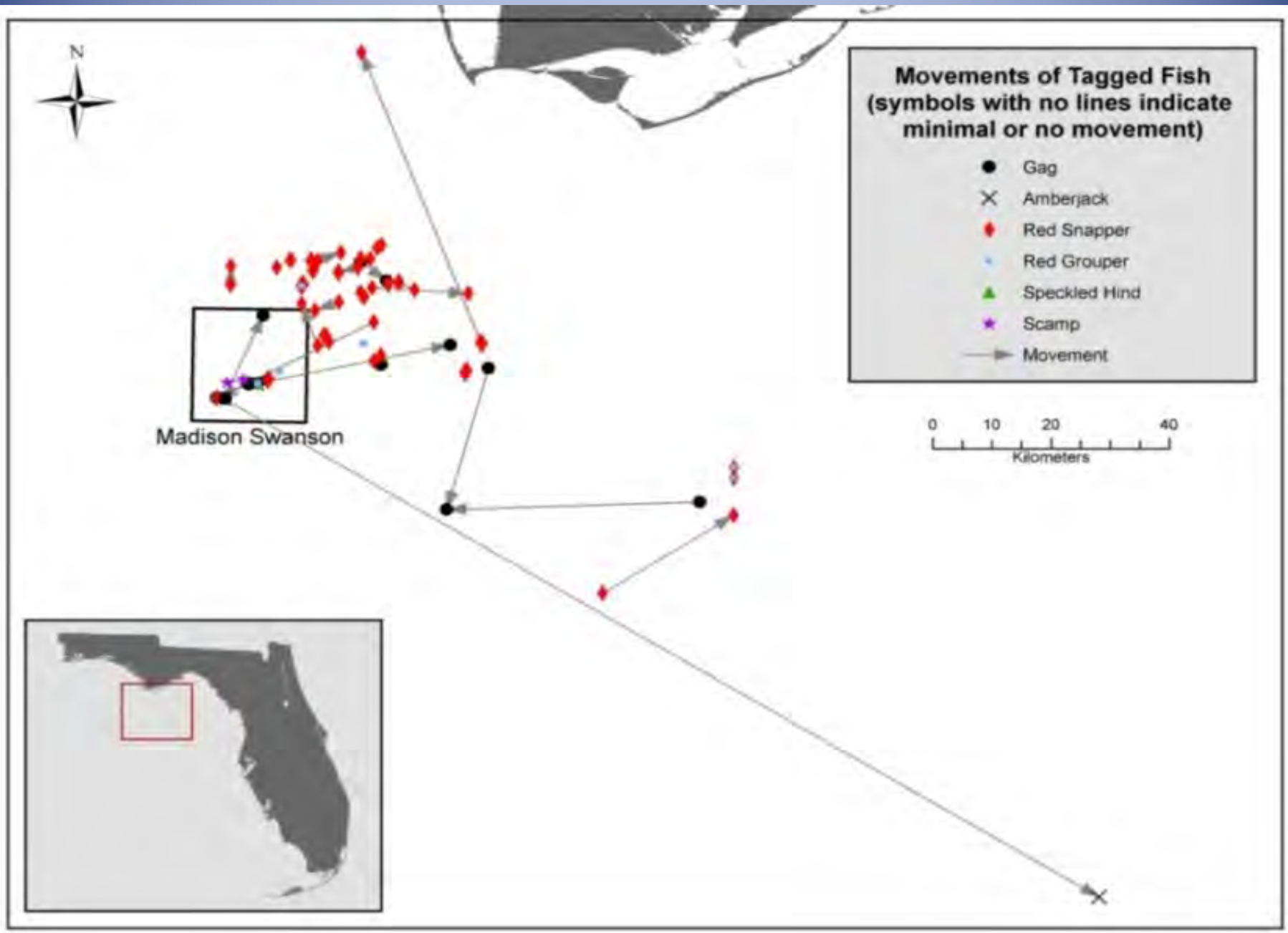
Demographic data from MSMR: inside vs outside

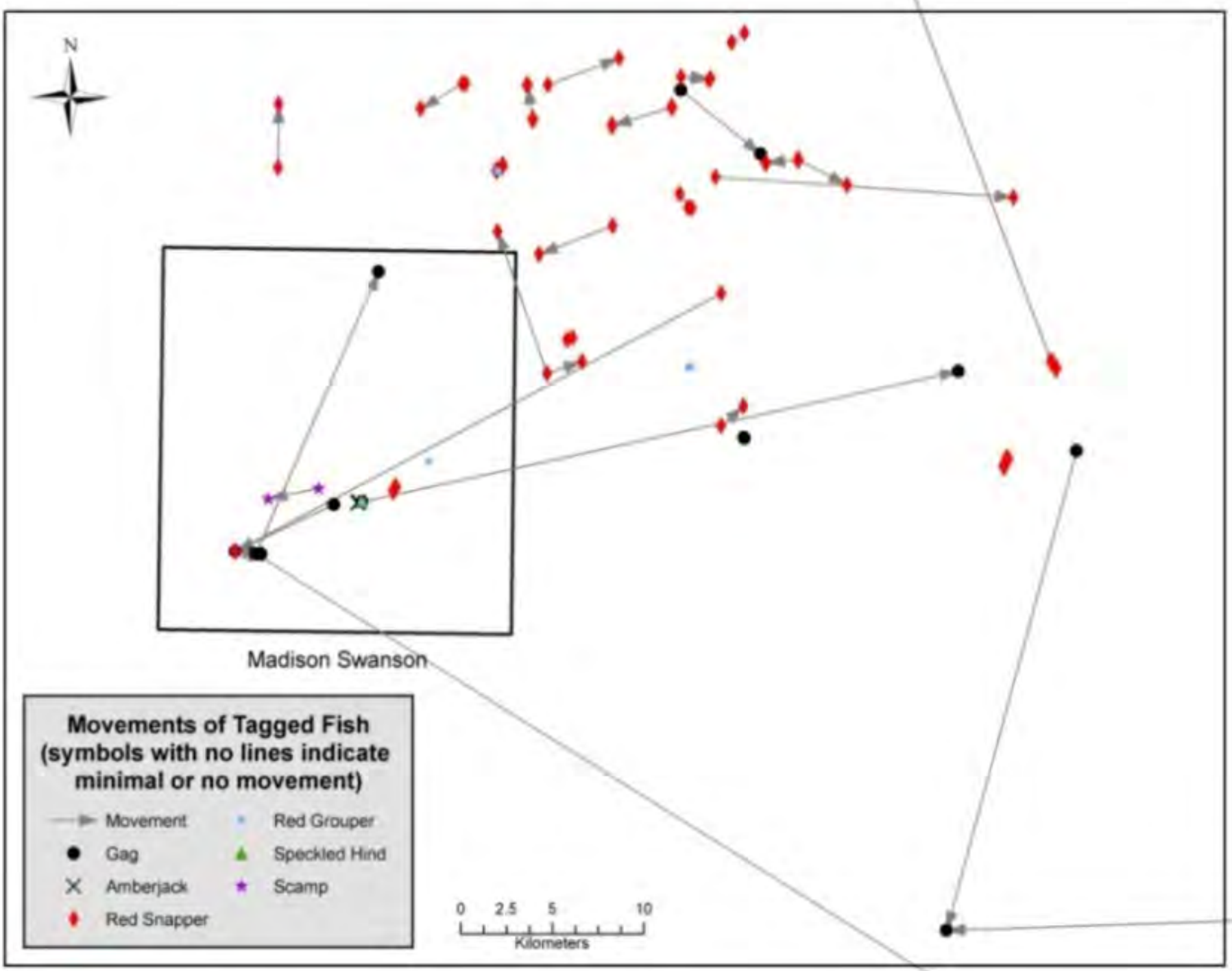
- Movements
- Size structure
- Age structure
- Abundance
- Gag sex ratio

- Note: Poaching was intense in 2004 and 2005 when hurricanes Ivan, Katrina, and Rita impacted the northern Gulf of Mexico because Coast Guard surveillance was near zero after Ivan hit in Sept 2004 (Mobile Coast Guard base commander, personal communication)

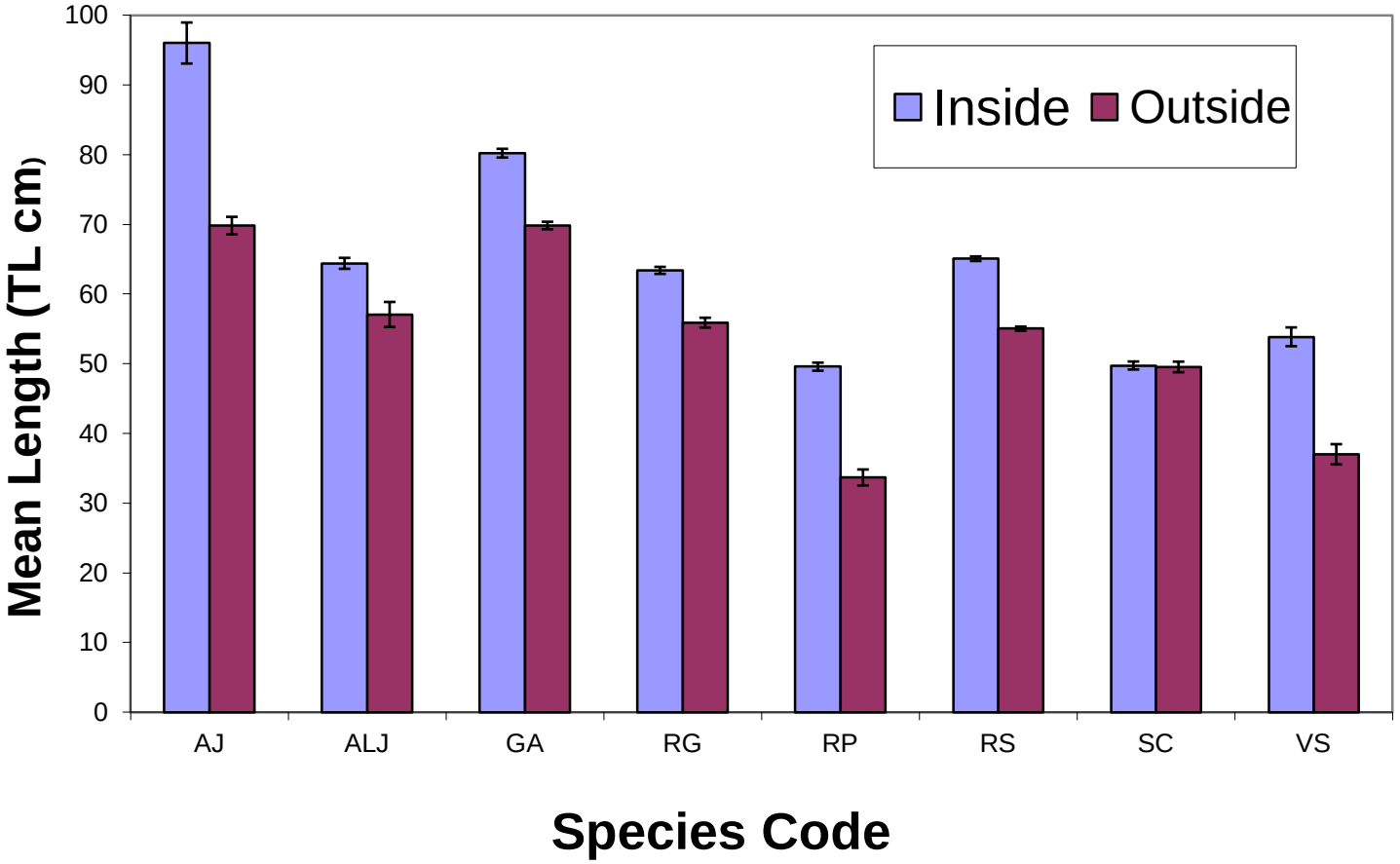
Venting method: vent at depth Swim Bldr. volume increase is less than 2.5 times

Capture depth (m)	Capture depth (ft)	Pressure at capture depth (atm)	Vent depth @ 2.0 x vol.	Vent depth @ 2.5 x vol.
0	0	1	--	--
10	33	2	--	--
20	66	3	--	--
30	98	4	33	--
40	131	5	48	33
50	164	6	66	46
60	197	7	82	59
70	230	8	98	72
80	262	9	115	85
90	295	10	131	98


N
Movements of Tagged Fish
(symbols with no lines indicate
minimal or no movement)
Gag
Amberjack
Red Snapper
Red Grouper
Speckled Hind
Scamp
Movement
0
10
20
40
Kilometers
Madison Swanson

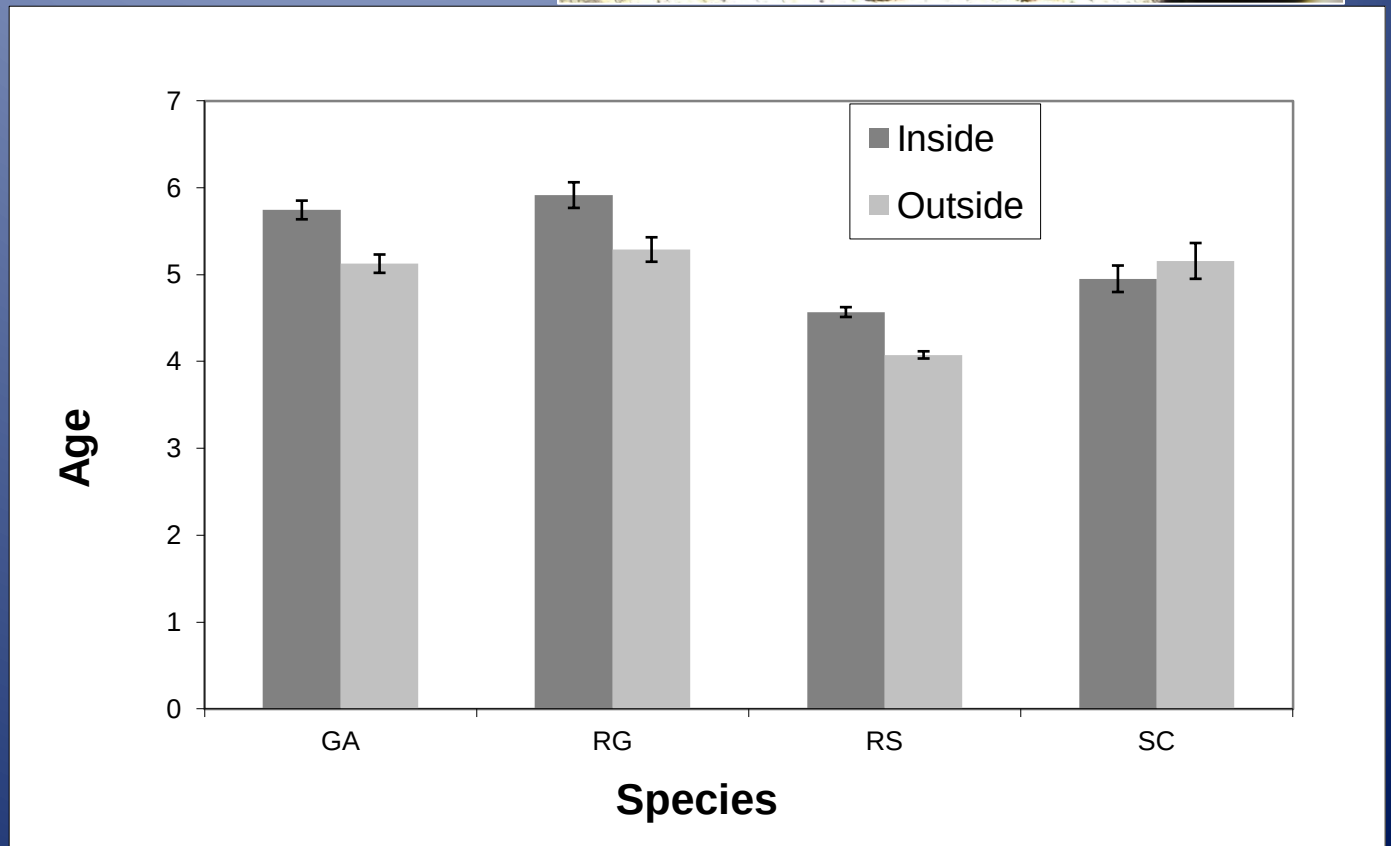

N
Madison Swanson
Movements of Tagged Fish
(symbols with no lines indicate
minimal or no movement)
Movement
Gag
Amberjack
Red Snapper
Red Grouper
Speckled Hind
Scamp
0 2.5 5 10
Kilometers

Size Structure

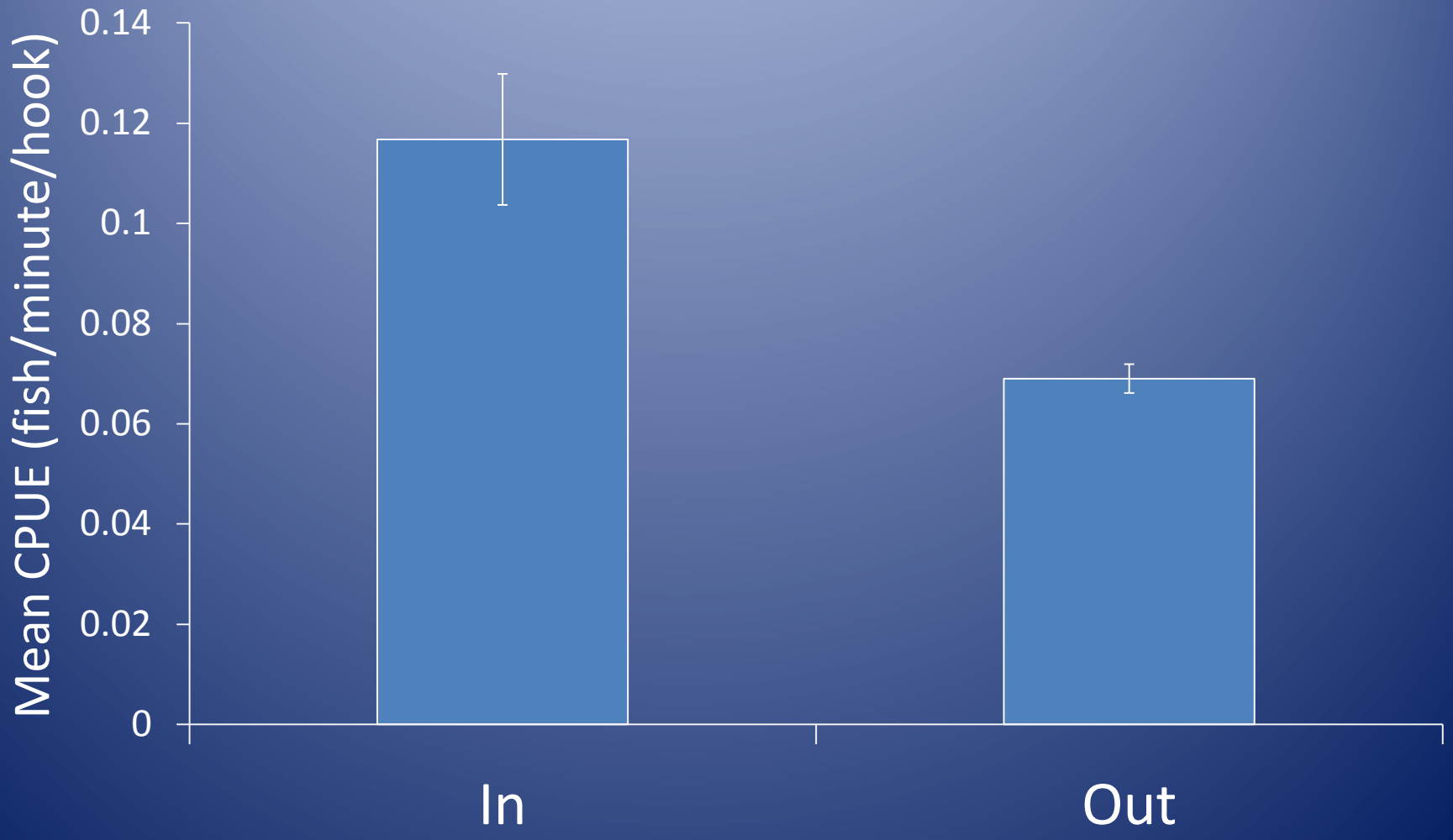


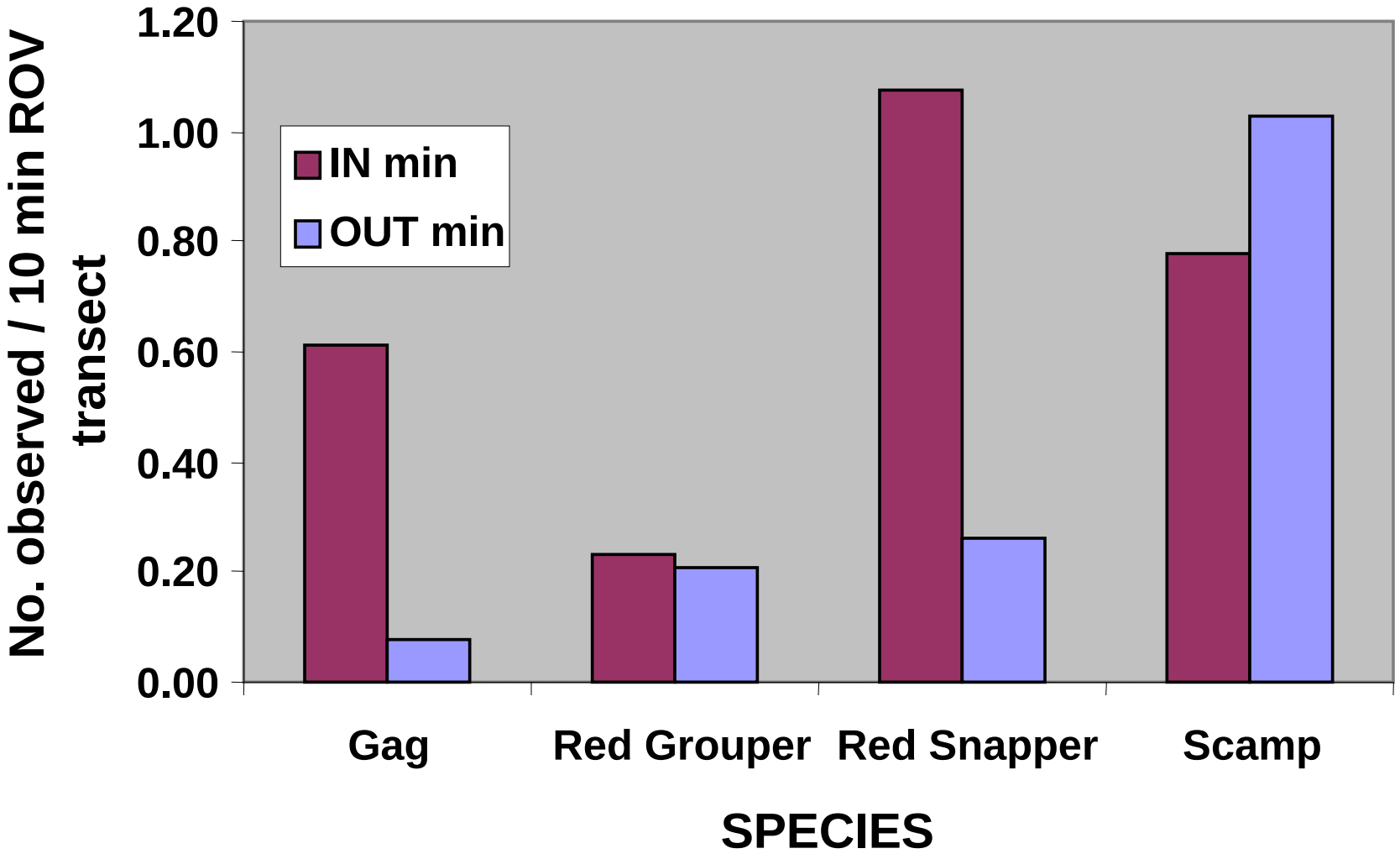
Age structure :

from dorsal fin rays (epoxy-embedded sections)



Abundance: H&L catch per Effort inside vs outside MSMR

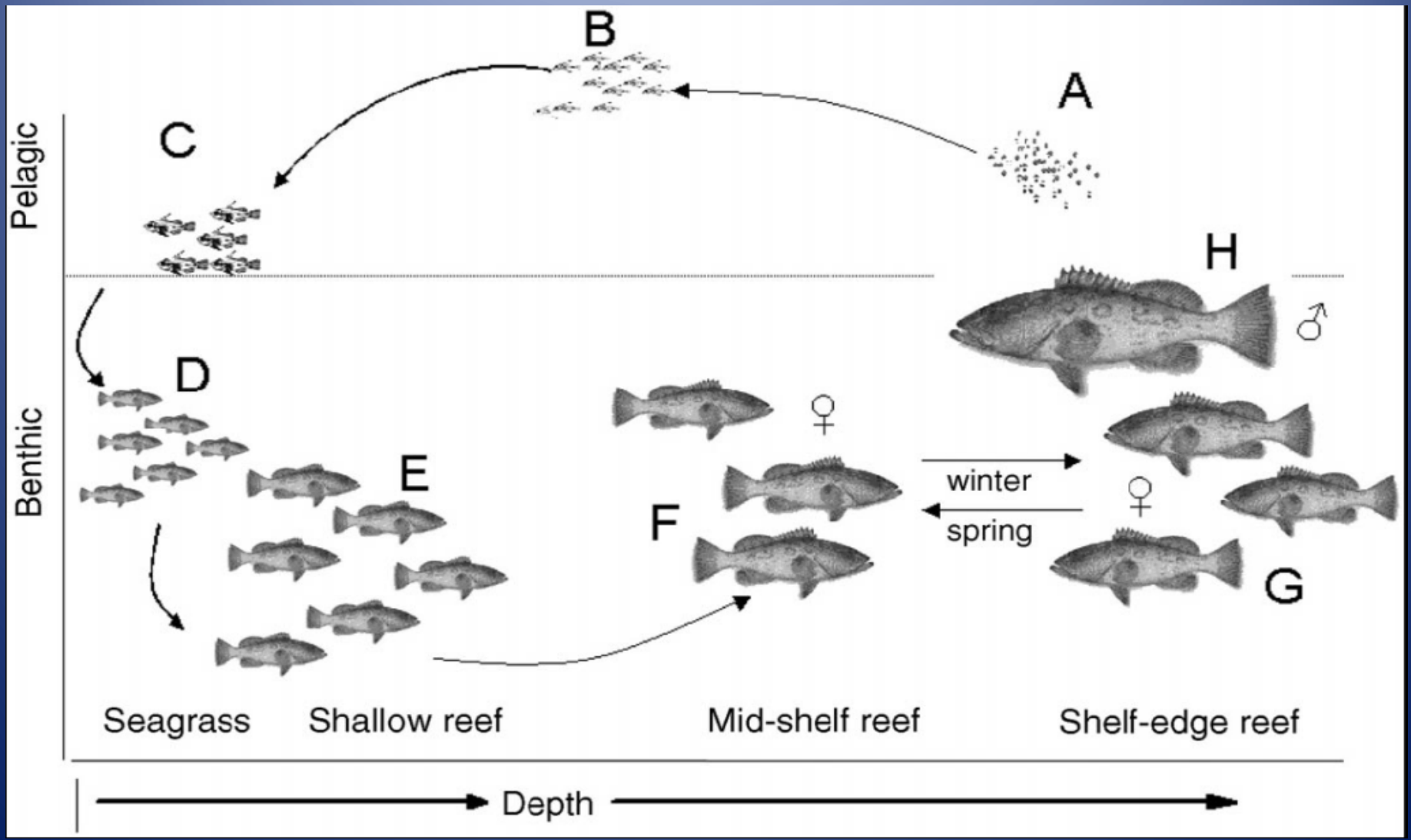



No. observed / 10 min ROV transect
1.20
1.00
0.80
0.60
0.40
0.20
0.00
IN min
OUT min
Gag
Red Grouper
Red Snapper
Scamp
SPECIES

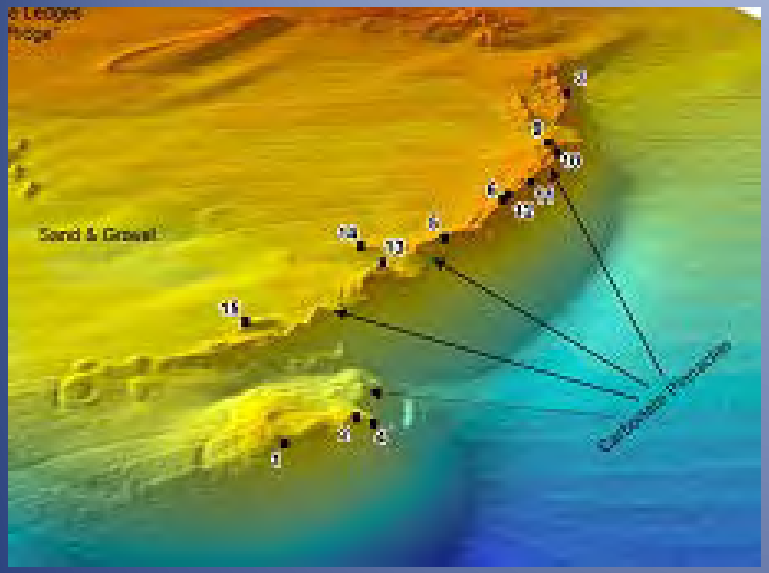
Gag sex ratio

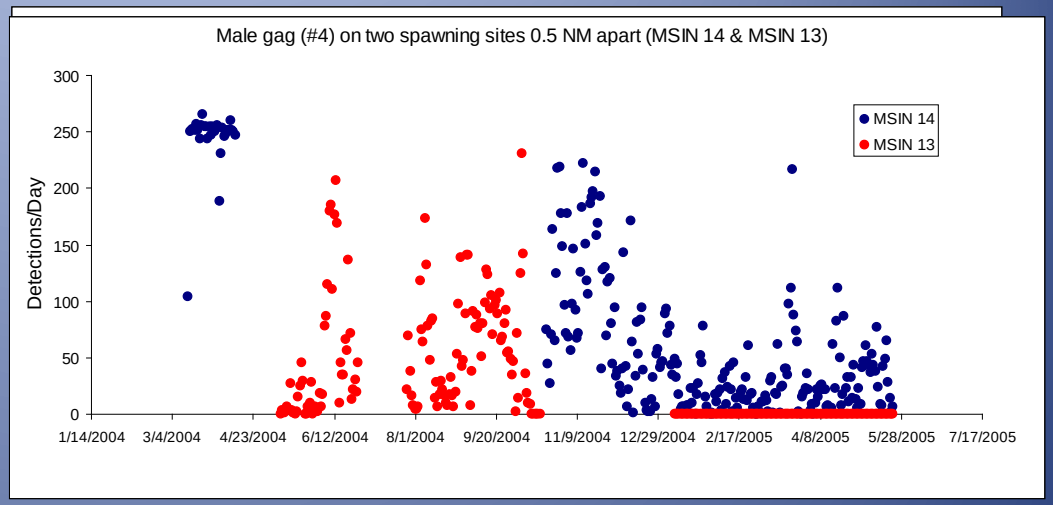
- Sex-changing fish typically have a female-biased sex ratio (groupers, typically 1:4 or 1:3, males to females [i.e., 20 to 25% males])
- Two Questions:
  - Gag sex ratio declined in the face of heavy fishing pressure to 1:20 to 1:99—Why?
  - Can shelf-edge reserves protect the natural sex ratio?

Gag life Cycle: males remain offshore and sex change occurs during aggregation.



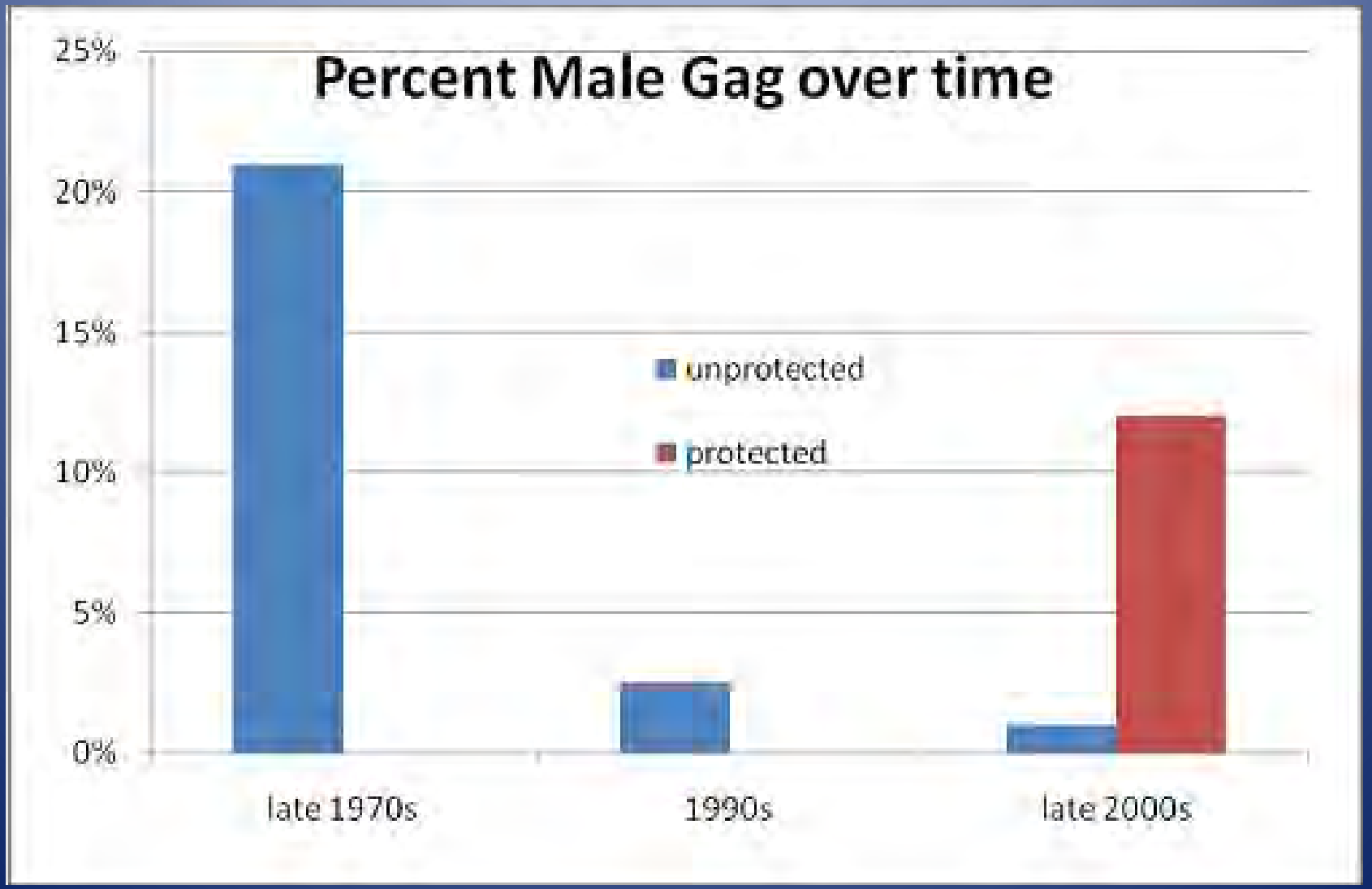
Male Gag On Site Year Round





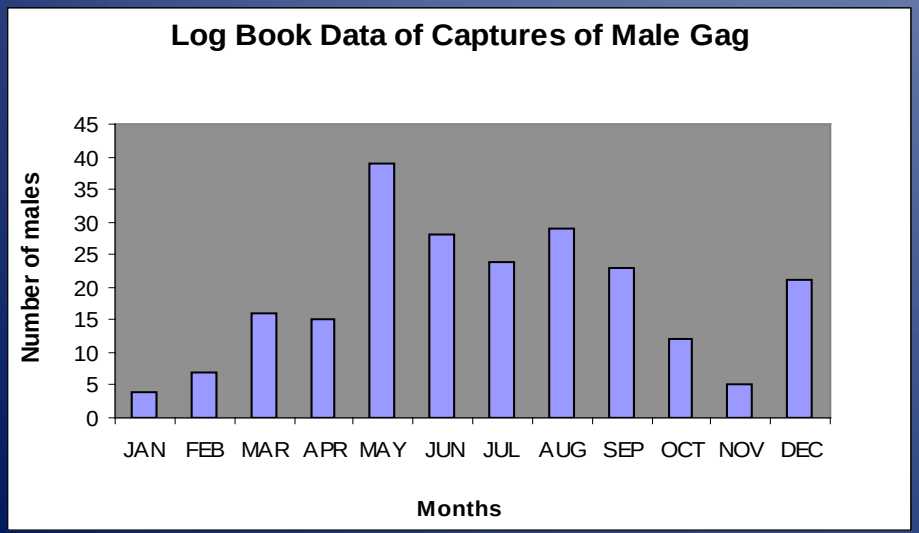
Tag date	Tag local	Months monitor.	% day tag site	% day alt site	Dist. moved (NM)
4/16/2003	MSIN15	26	97.5	0	0.0
4/17/2003	MSIN14	26	97.1	45.1 (MSIN13)	0.5
4//4/2003	MSIN3	26	97.1	0	0.0
5/10/2004	MSIN 12	11	75.3	84.5 (MSIN10)	1.0

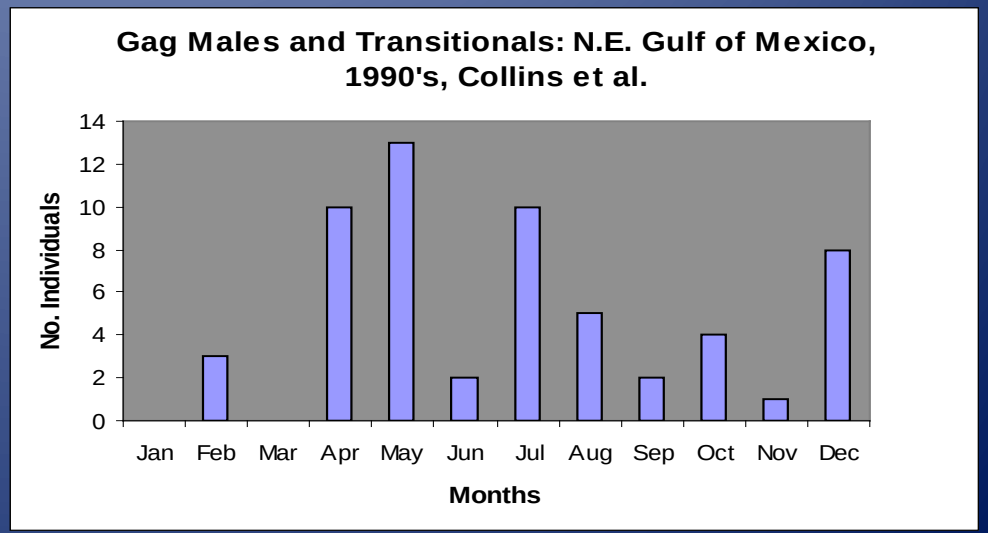
Percent male gag



Loss of male gag: mechanism

- Males remain on spawning sites year round.
- Sex change occurs during the spawning season.
- Transitionals appear after the spawning season.
- Fishermen target gag spawning sites year round.
- The catch of males increases after spawning.
- Closed areas, not seasons, will protect sex ratio





Spillover: MSMR

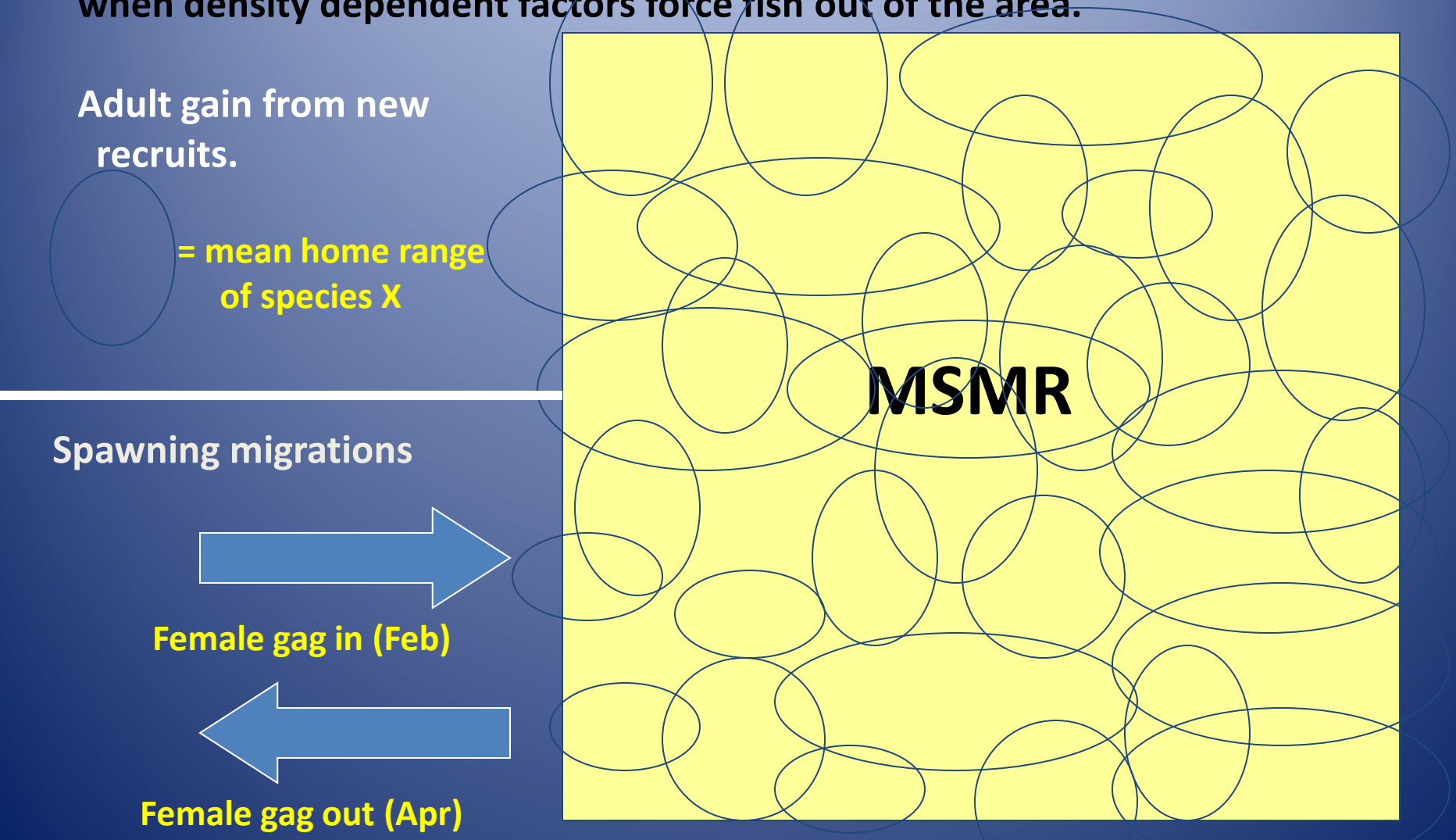
- Problem: no 'Before' data for comparison, so I relied on evidence from multiple sources.
- Evidence from:
  - Anecdotal from long-time fishermen
  - VMS data for 2008
  - NOAA flyovers in 2005
  - Commercial catches relative to distance from MSMR

MSMR: Spillover Concept

Adult loss to fishing when home range overlaps MPA border and when density dependent factors force fish out of the area.

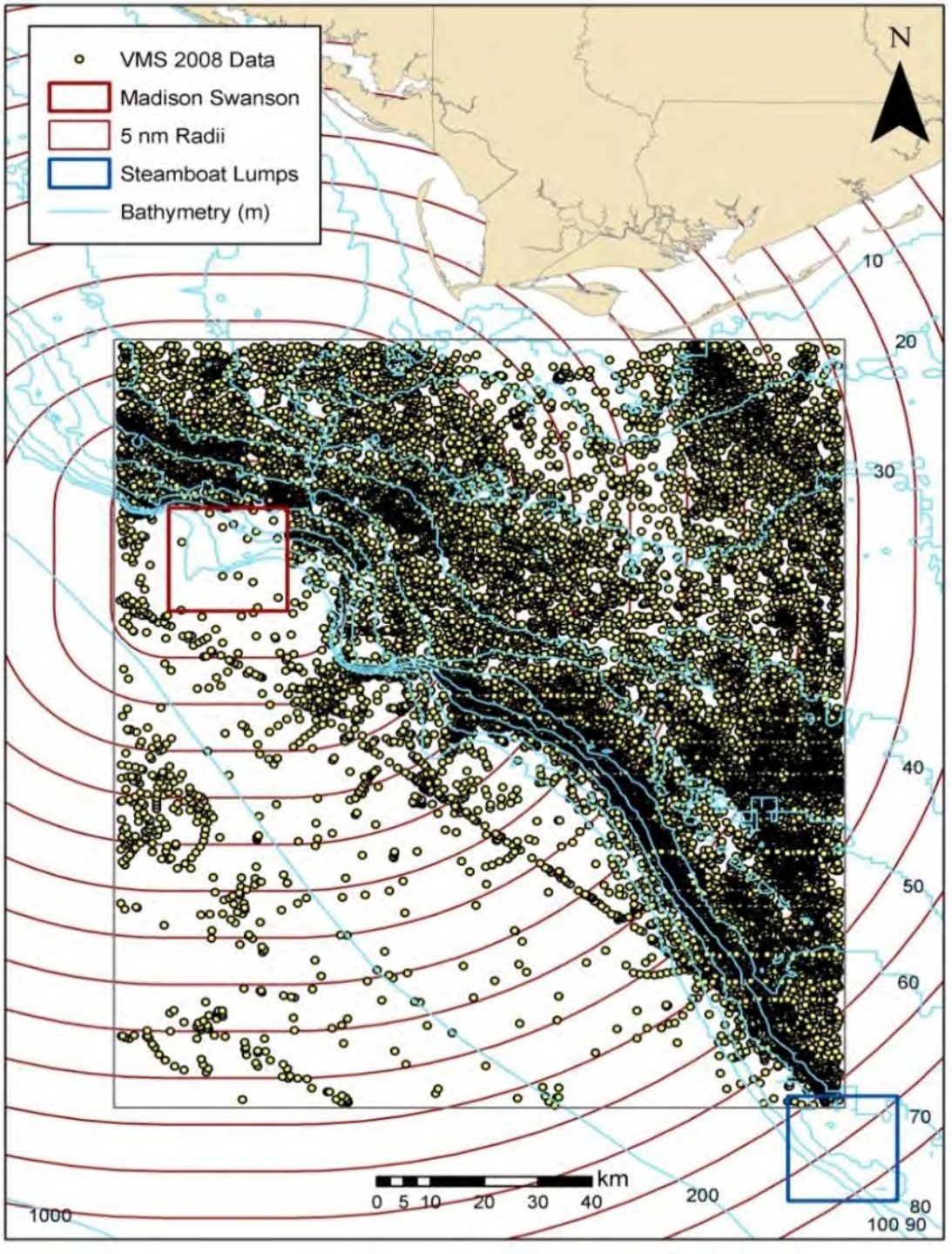
Adult gain from new recruits.

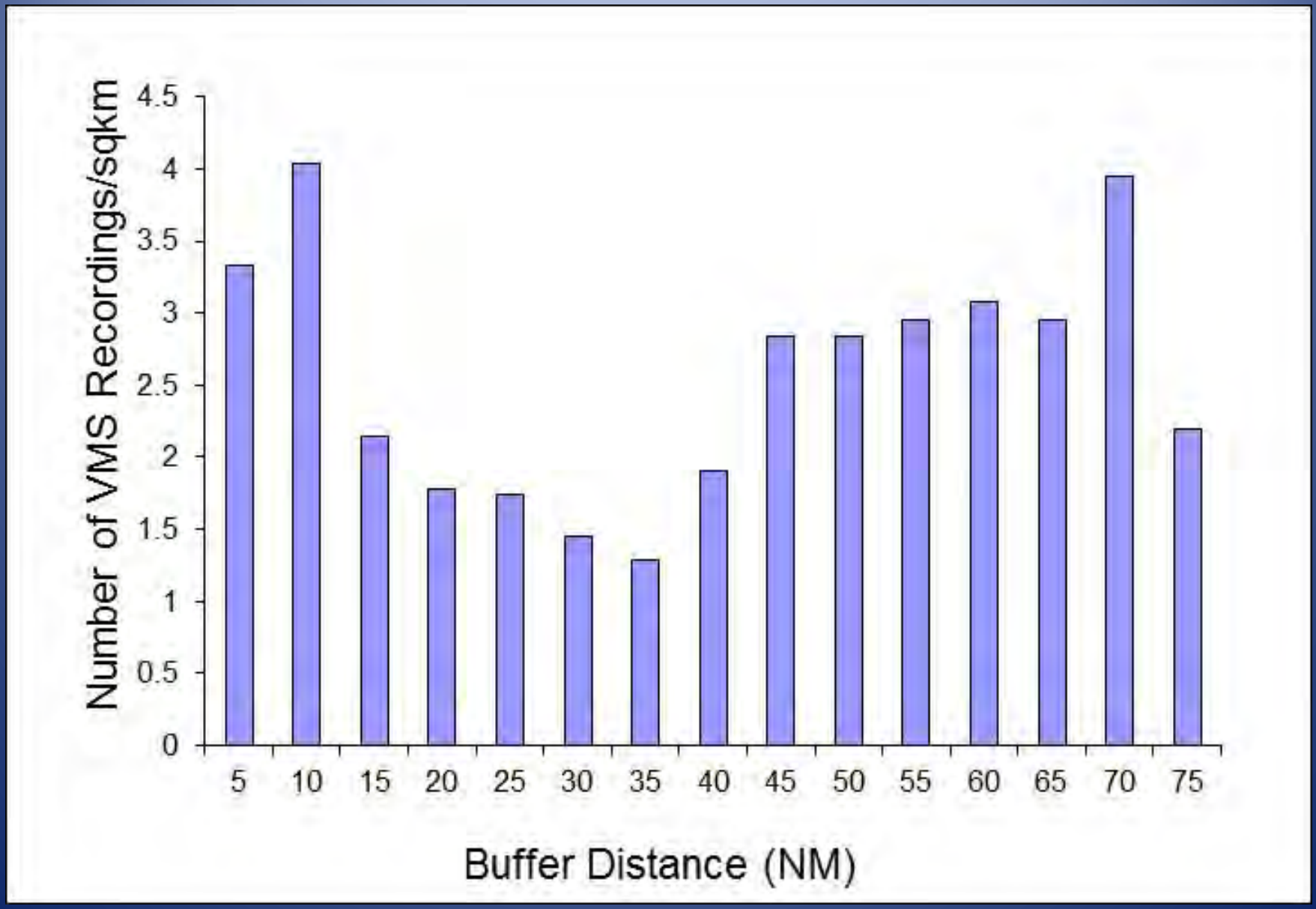
= mean home range of species X



Reserves should be large relative to fish home ranges

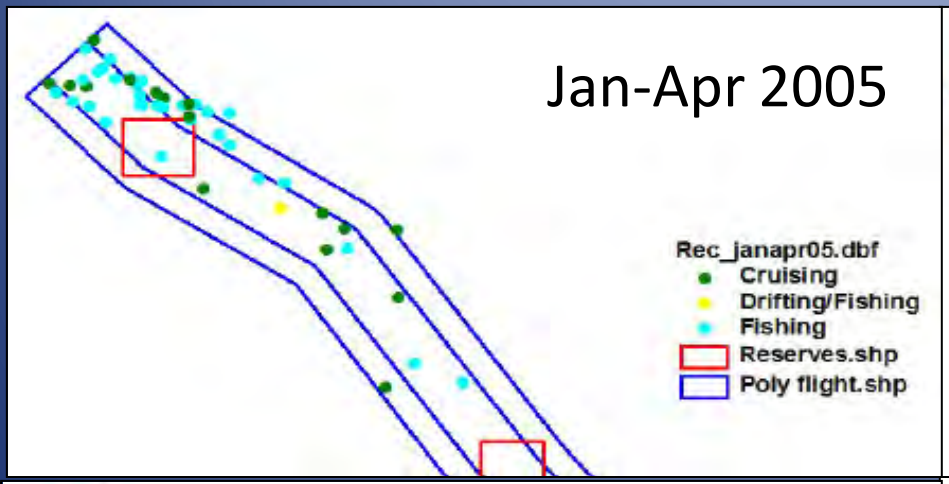
VMS data (2008): Each point represents an hourly position of a commercial reef-fishing vessel.

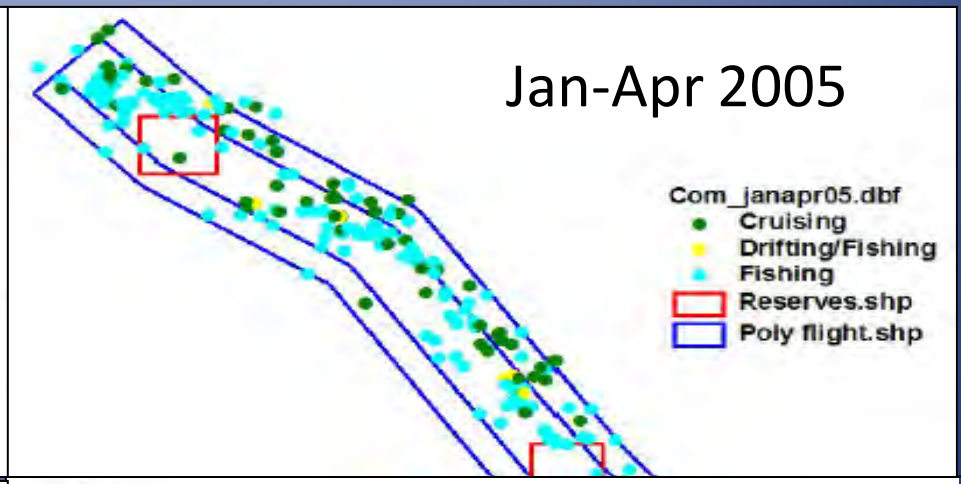


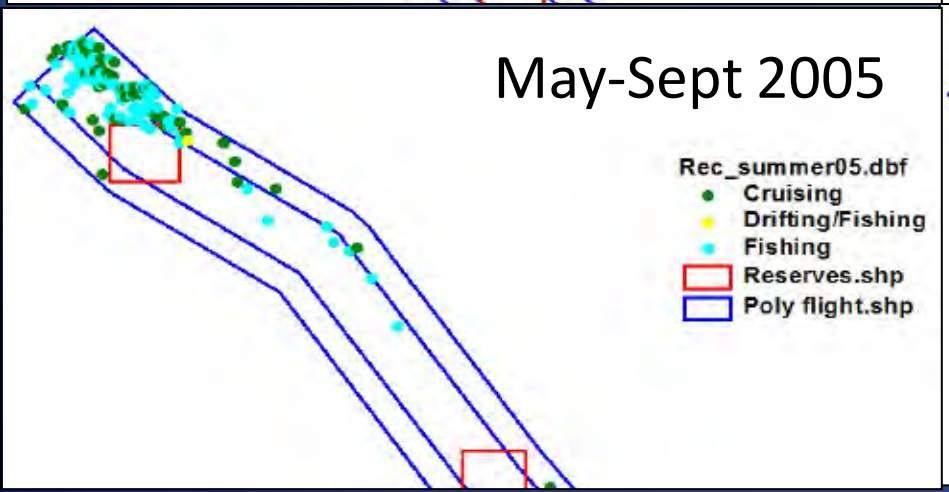

Number of VMS Recordings/sqkm
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
Buffer Distance (NM)

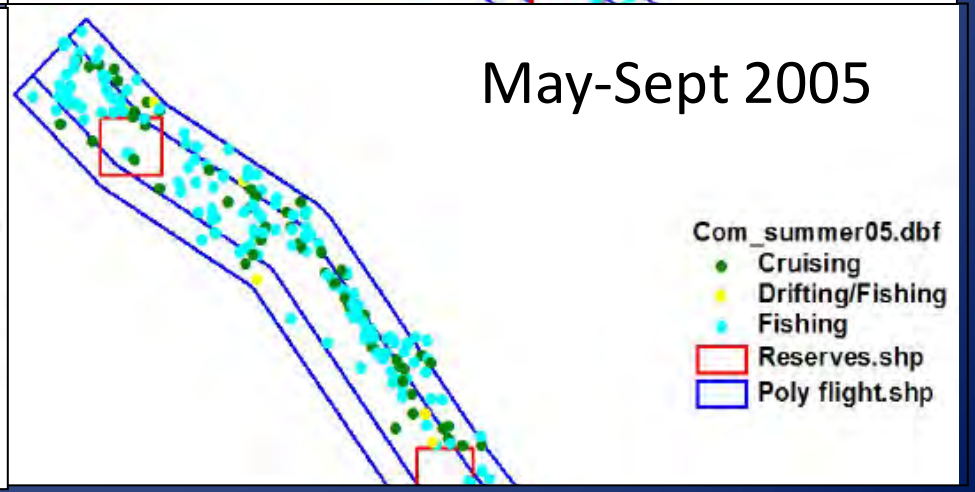
NOAA Flyovers (49 total) for winter and summer 2005

- Recreational
- Commercial

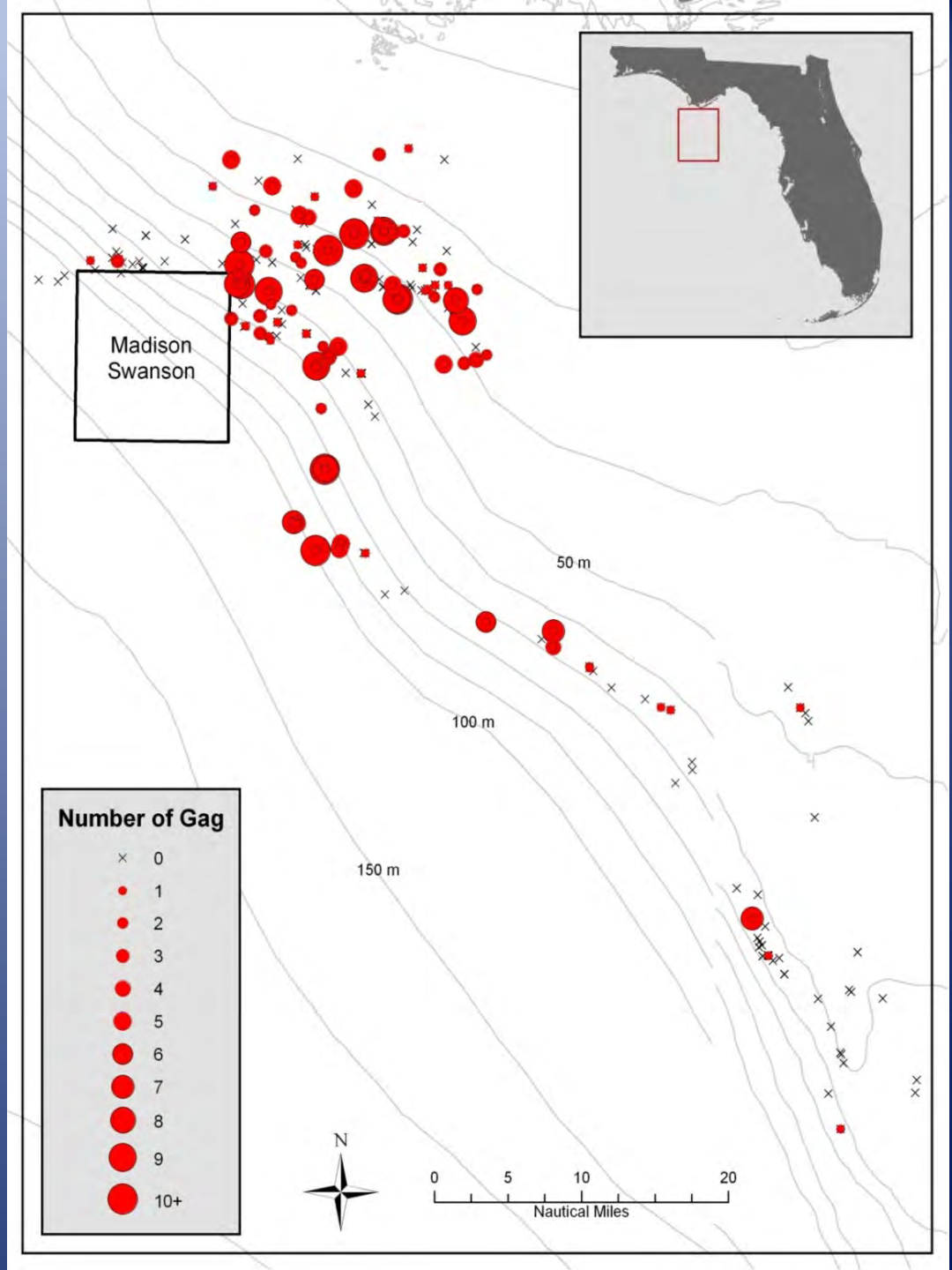




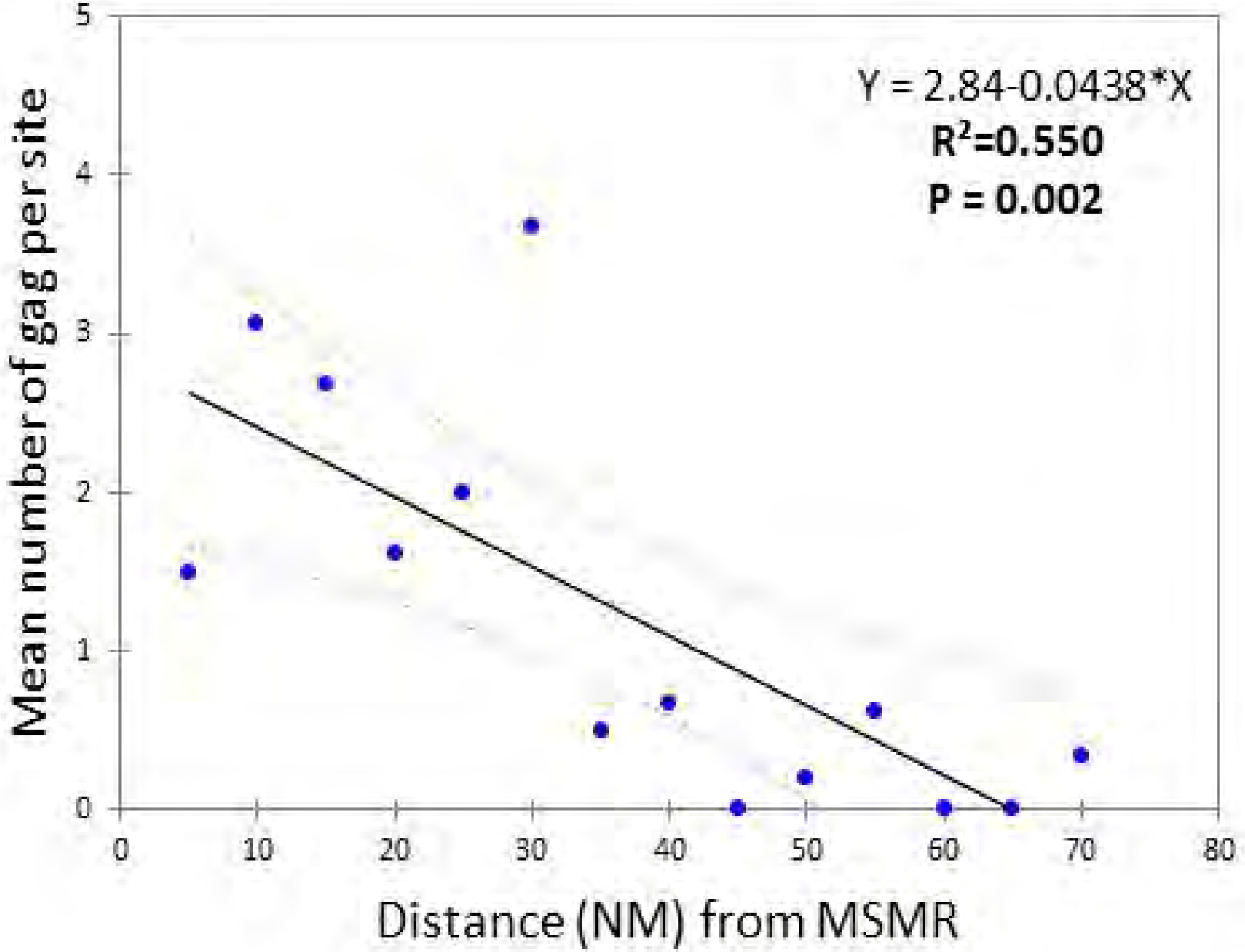




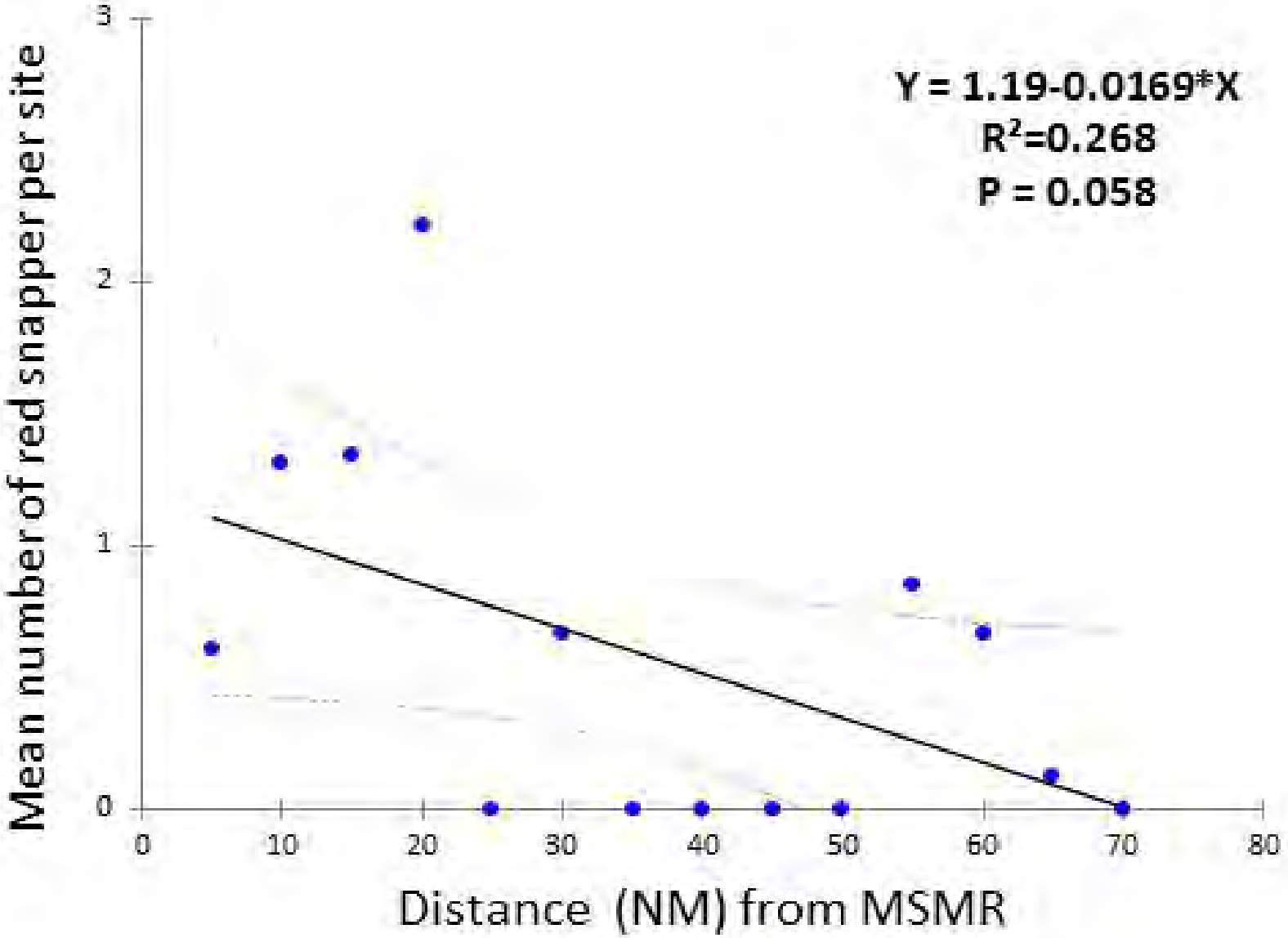
Catch of gag (commercial) on shelf edge relative to MSMR



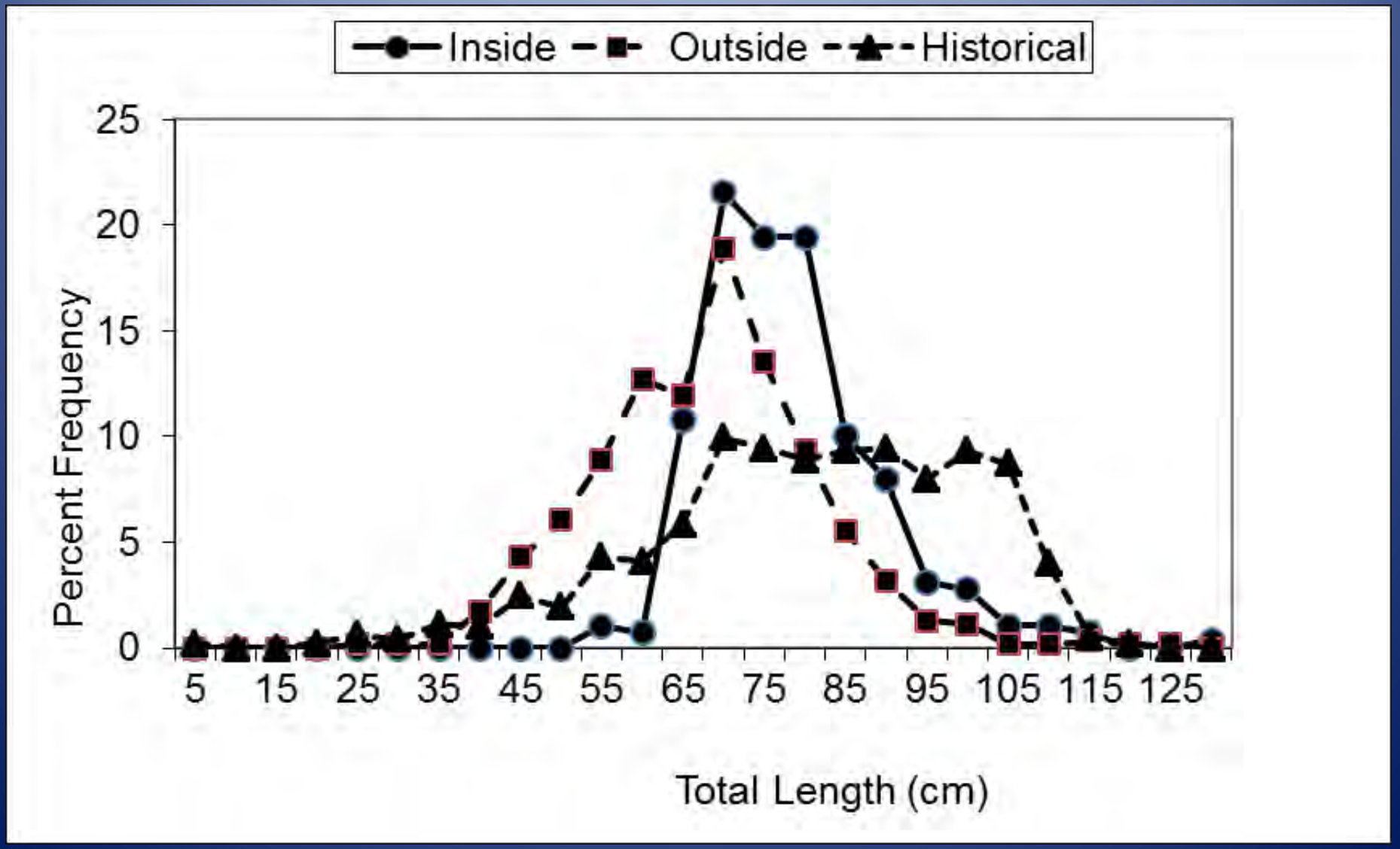
Commercial Catch



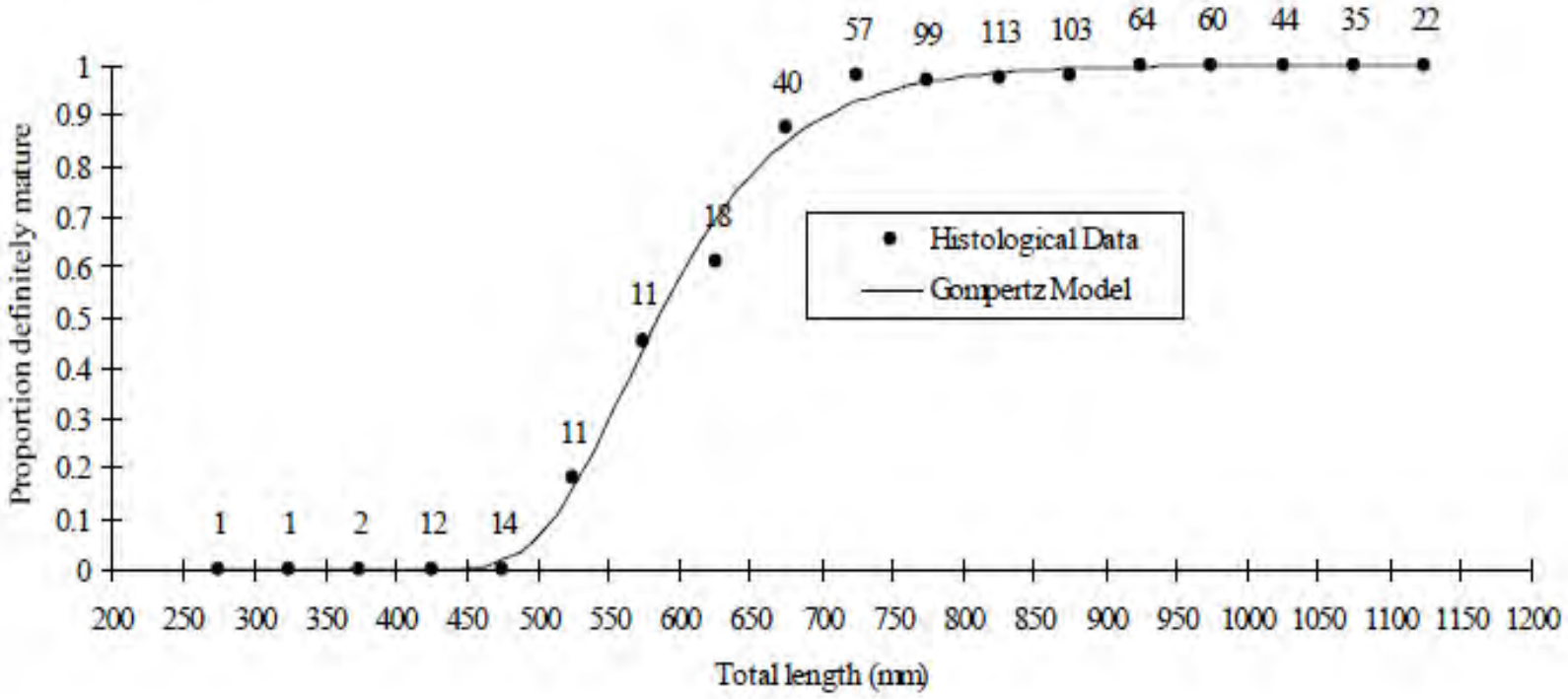
Commercial Catch



Gag: size—inside vs outside MSMR



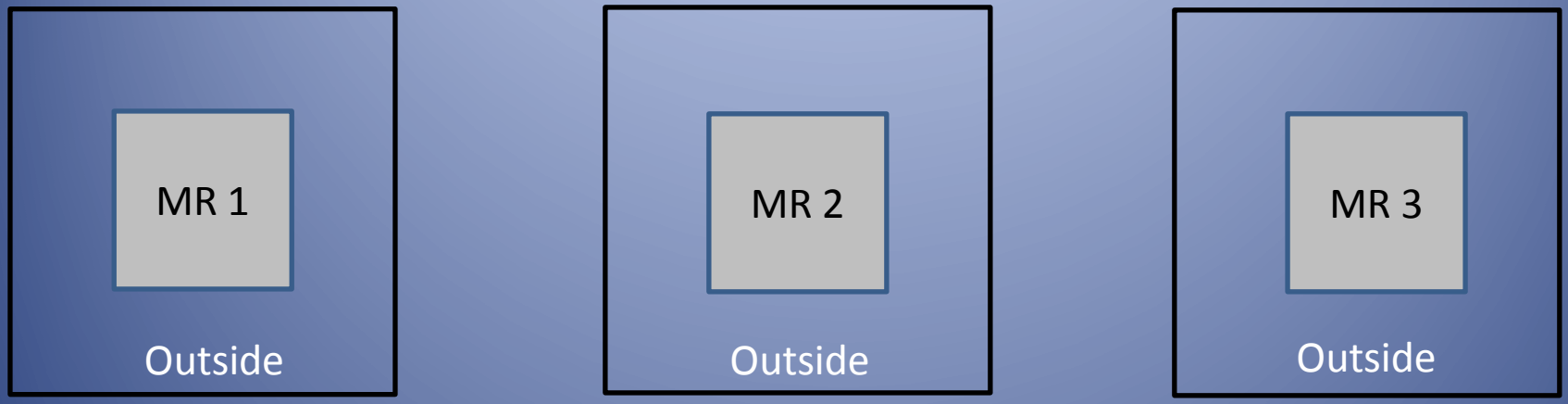
Gag maturity schedule (Fitzhugh et al. 2006)



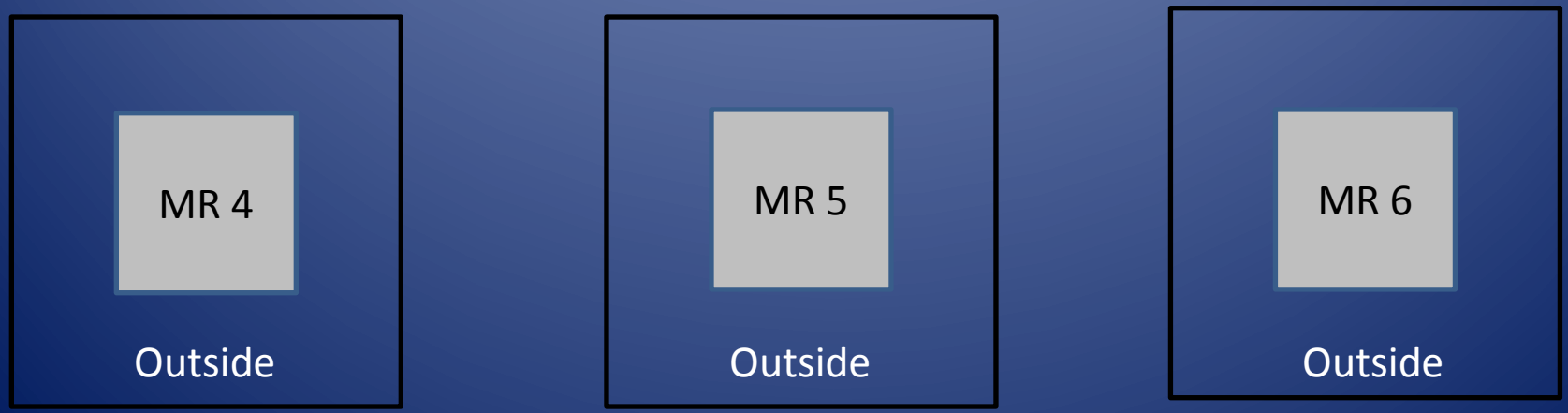
Opportunities for Experimentation

- Problems with most marine reserves, including MSMR, is that there are no statistically valid studies to determine that they are working.
- BACI experiments (Before-After-Control-Impact) with multiple controls are necessary to assign probabilities to observed changes.
- Reserve function must be verified to demonstrate that they are working (problem with the +240 ft closure).

BACI Experiment: shelf-edge reserves



- Select 6 potential reserves
- Monitor fish abundance in all 6 inside and out.
- Randomly select 3 to close to all fishing.
- Continue monitoring all 6 (3 serve as controls = remain open).



Surveillance and enforcement of marine reserves: Critical to optimal protection of threatened species and to fishery production.

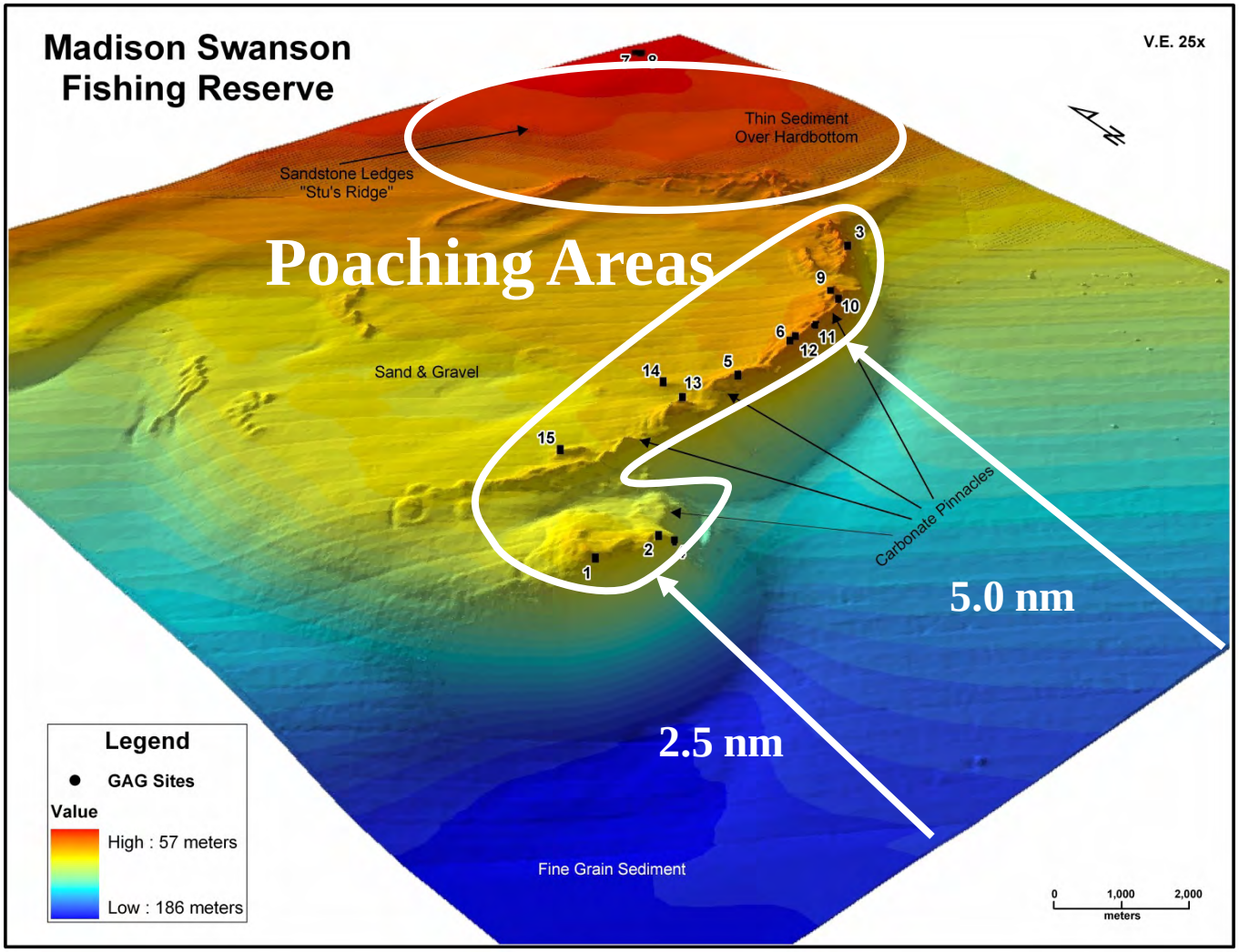
Various surveillance-enforcement measures

- **Satellite tracking (VMS), in place for commercial reef fishing vessels in Gulf since 2007.**
- **Aerial surveillance—hard to make a case.**
- **Satellite phones on cooperating fishing vessels so communication is private.**
- **Enforcement personnel on fishing vessels for day and especially night surveillance.**
- **Boat traffic monitoring acoustically (DSG acoustic monitor).**

Poachers avoid detection by:

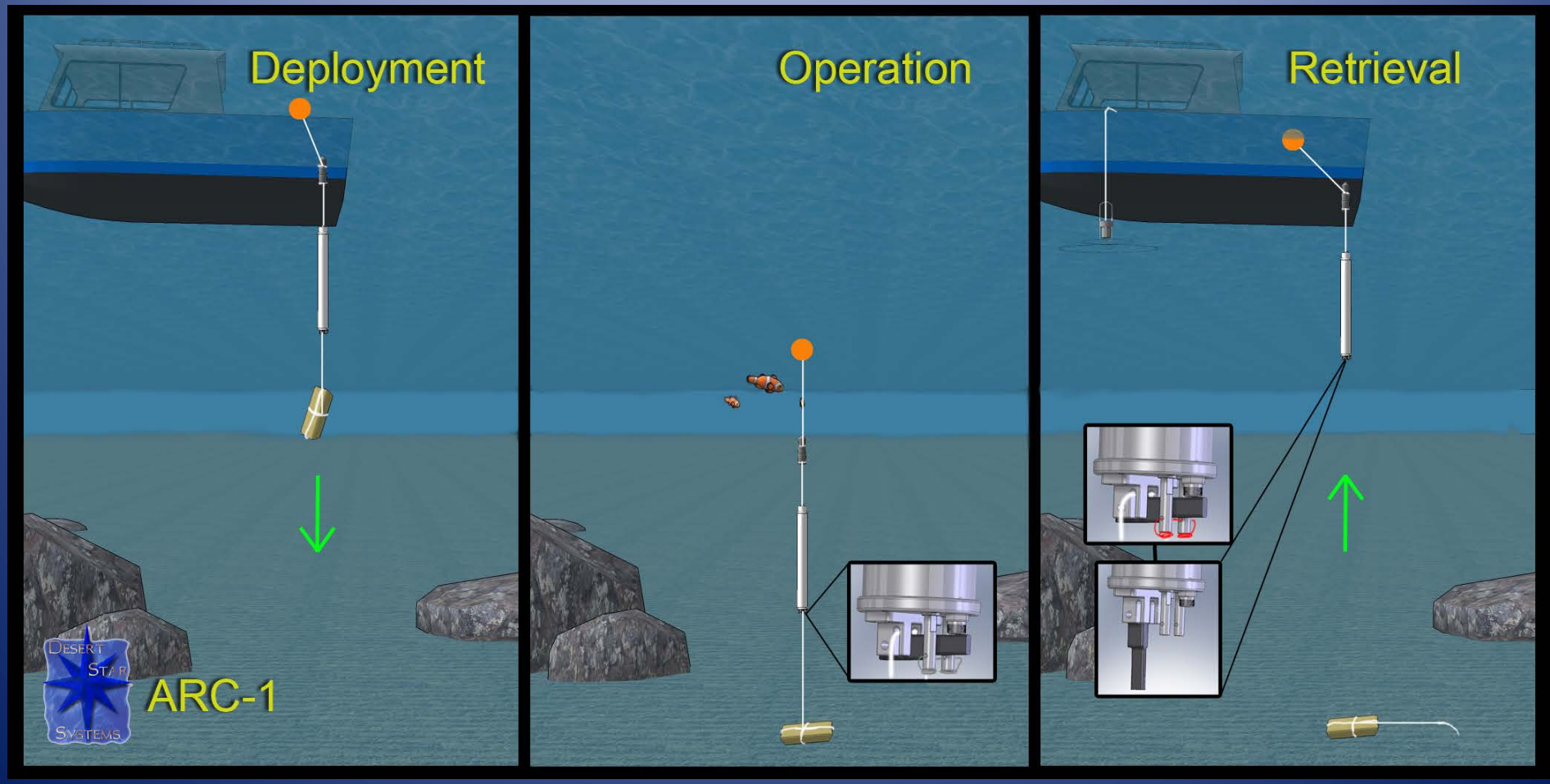
- **Survey sites during day, then fish at night.**
  - **Commercial vessels may turn off VMS**
  - **Recreational vessel poaching (no VMS required)**
  - **Unlicensed commercial vessel poaching with transfer of catch outside to licensed vessel.**
- **Quick runs, in and out (recreational mostly).**
- **Poachers monitor radar for large fast vessels (cutter).**
- **Poachers communicate with other vessels on the lookout for cutter (should approach reserves from offshore).**

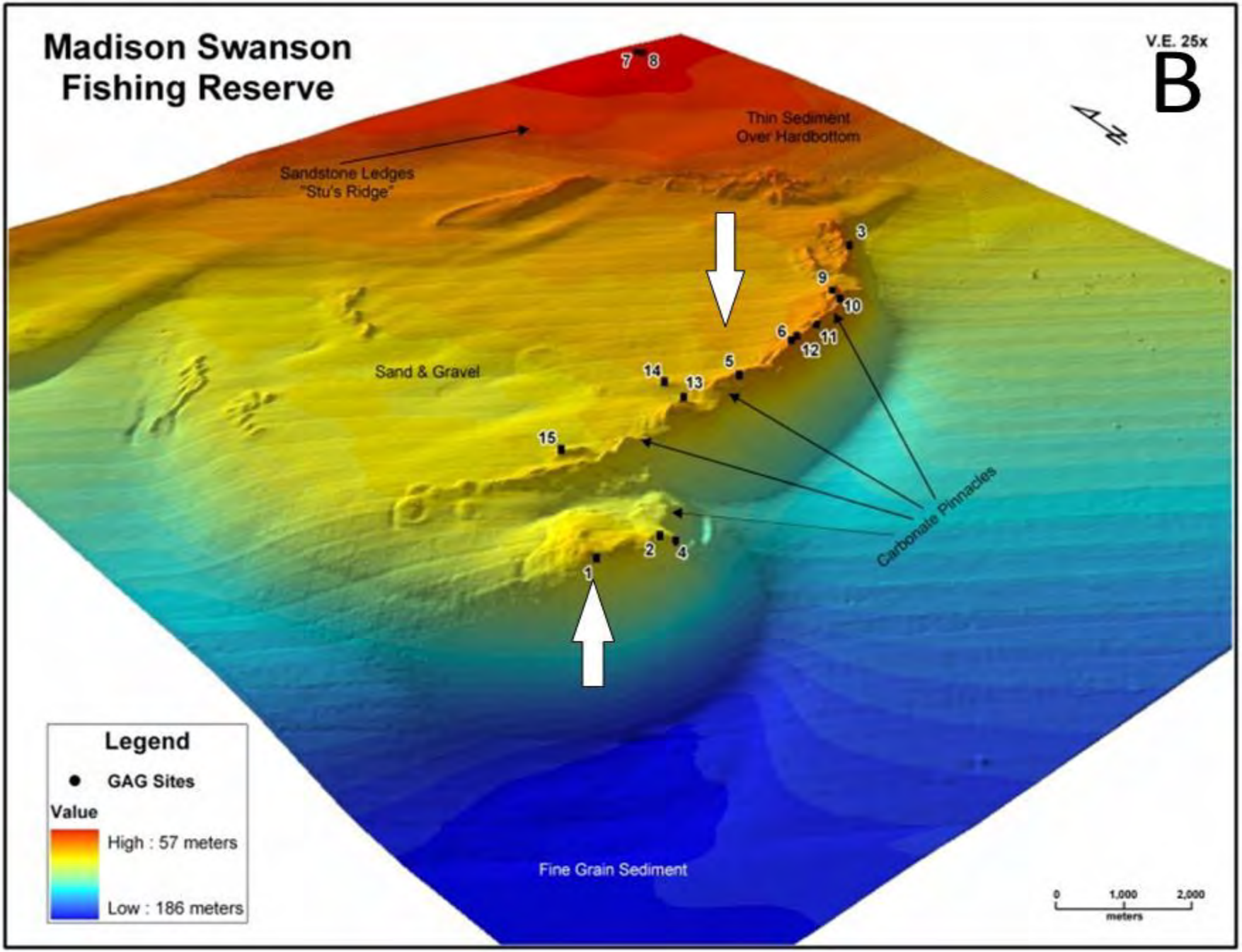
Most frequently poached areas



DSG acoustic recorder: records boat traffic (http://www.loggerheadinstruments.com/index.html

Deployment and retrieval of DSG receiver using acoustic release



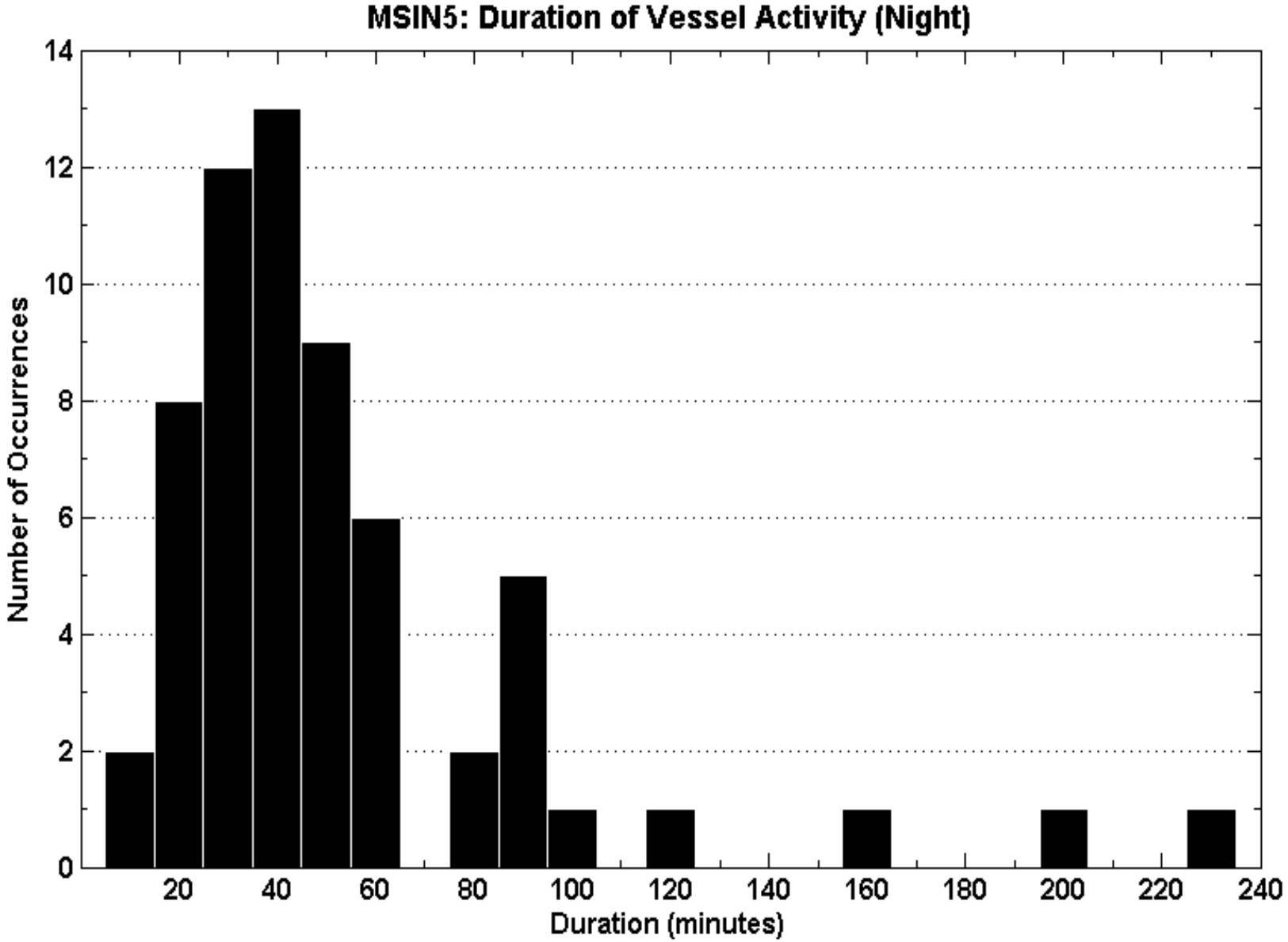

Madison Swanson
Fishing Reserve
V.E. 25x
B
N
Thin Sediment
Over Hardbottom
Sandstone Ledges
"Stu's Ridge"
Sand & Gravel
Carbonate Pinnacles
Fine Grain Sediment
7
8
3
9
10
6
11
12
5
14
13
15
2
4
1
Legend
GAG Sites
Value
High : 57 meters
Low : 186 meters
0
1,000
2,000
meters

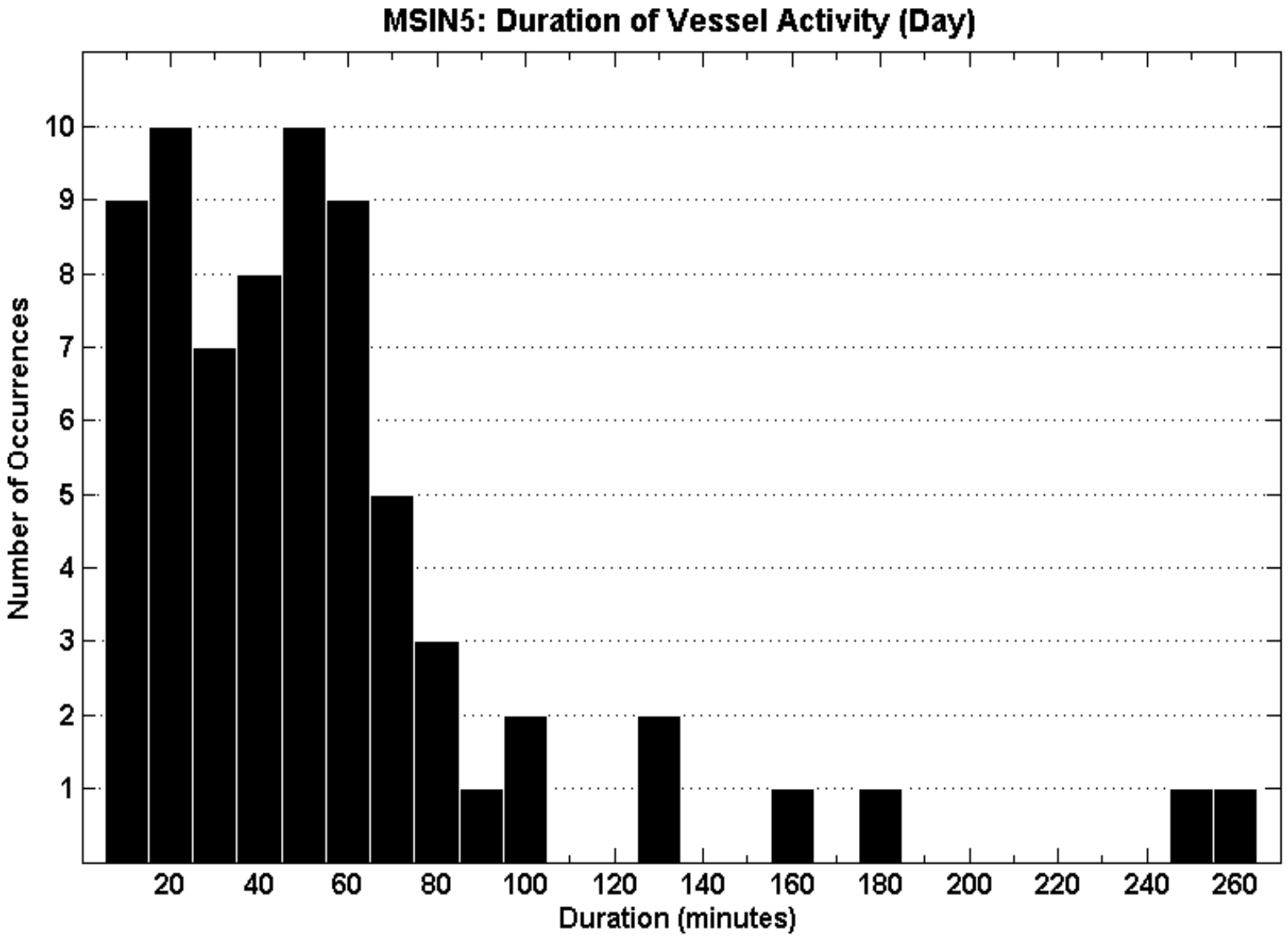
Within ½ nm of site #5: Aug-Nov 2008

Date	Time (EST)
8/14/2008	0:50 to 4:10
8/18/2008	2:50 to 4:35
8/19/2008	1:15 to 5:10
8/21/2008	5:20 to 5:55
8/24/2008	3:25 to 4:55
8/27/2008	21:00 to 22:25
8/28/2008	22:35 to 23:30
8/31/2008	3:45 to 4:05
9/7/2008	1:30 to 2:20
9/9/2008	2:25 to 2:55
9/9/2008	4:45 to 6:00
9/9/2008	23:20 to 0:15
9/11/2008	21:50 to 22:50
9/14/2008	3:35 to 4:15
9/16/2008	2:15 to 2:45
9/18/2008	23:15 to 0:00
9/22/2008	23:55 to 2:40
9/26/2008	1:30 to 3:05
10/26/2008	3:45 to 4:10
10/27/2008	4:40 to 5:10
10/28/2008	23:35 to 6:10
11/1/2008	19:15 to 20:00
11/10/2008	4:35 to 5:15
11/14/2008	5:35 to 7:05

Within ½ nm of site #5: Mar-May, 2009

3/18/2009	18:20 to 22:30
3/22/2009	22:10 to 2:20
3/26/2009	21:20 to 21:50
3/30/2009	0:50 to 1:50
4/8/2009	23:10 to 23:30
4/10/2009	3:20 to 3:40
4/11/2009	22:00 to 22:20
4/13/2009	3:40 to 4:20
4/18/2009	2:40 to 2:50
4/21/2009	2:10 to 3:40
4/26/2009	23:50 to 0:00
4/27/2009	0:00 to 0:40
4/29/2009	0:00 to 0:50
4/30/2009	1:00 to 1:40
5/5/2009	1:30 to 2:10
5/10/2009	4:40 to 5:20


MSIN5: Duration of Vessel Activity (Night)
Number of Occurrences
0
2
4
6
8
10
12
14
20
40
60
80
100
120
140
160
180
200
220
240
Duration (minutes)


MSIN5: Duration of Vessel Activity (Day)
Number of Occurrences
1
2
3
4
5
6
7
8
9
10
20
40
60
80
100
120
140
160
180
200
220
240
260
Duration (minutes)

Surveillance and enforcement of marine reserves are critical to optimal protection of threatened species and to fishery production.