Habitat-Stratified Population Estimates of Reef Fishes in the Gulf of Mexico

Steve Murawski, Luiz Barbieri, Sarah Grasty, Chad Lembke, Matt Hommeyer, Alex Ilich, John Gray, Jennifer Brizzolara, Alex Silverman, Gerardo Toro-Farmer, Heather Broadbent, Abigail Vivlamore

C-SCAMP

Continental Shelf Characterization, Assessment and Mapping Project

Gulf of Mexico Fishery Management Council
Scientific and Statistical Committee Meeting
27 March, 2018
Tampa, FL

Overview

- ✓ Merging Habitat Mapping and Fish Density Estimates
- ✓ Enabling Technologies
- ✓ Turning Bathymetry Into Habitat-Classified Maps
- ✓ Putting the fish into the equation
- ✓ Proposed Red Snapper work in the western & eastern GoM
- ✓ Discussion – Mapping Priorities for 2018-2019

Unknown, Unknowns of Bathymetry & Habitat

NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Bathymetric

NOAA > NESDIS > NCEI (formerly NGDC) > Maps > Bathymetry

Layers

Bathymetric Surveys

- [x] Multibeam Bathymetric Surveys
- [x] Single-Beam (Trackline) Bathymetric Surveys

NOS Hydrographic Surveys:

- [x] Surveys with BAGs (Bathymetric Attributed Grids)
- [ ] Surveys with Digital Sounding Data
- [ ] Surveys without Digital Sounding Data

Filter Surveys | Reset

- [ ] BAG Color Shaded Relief Imagery

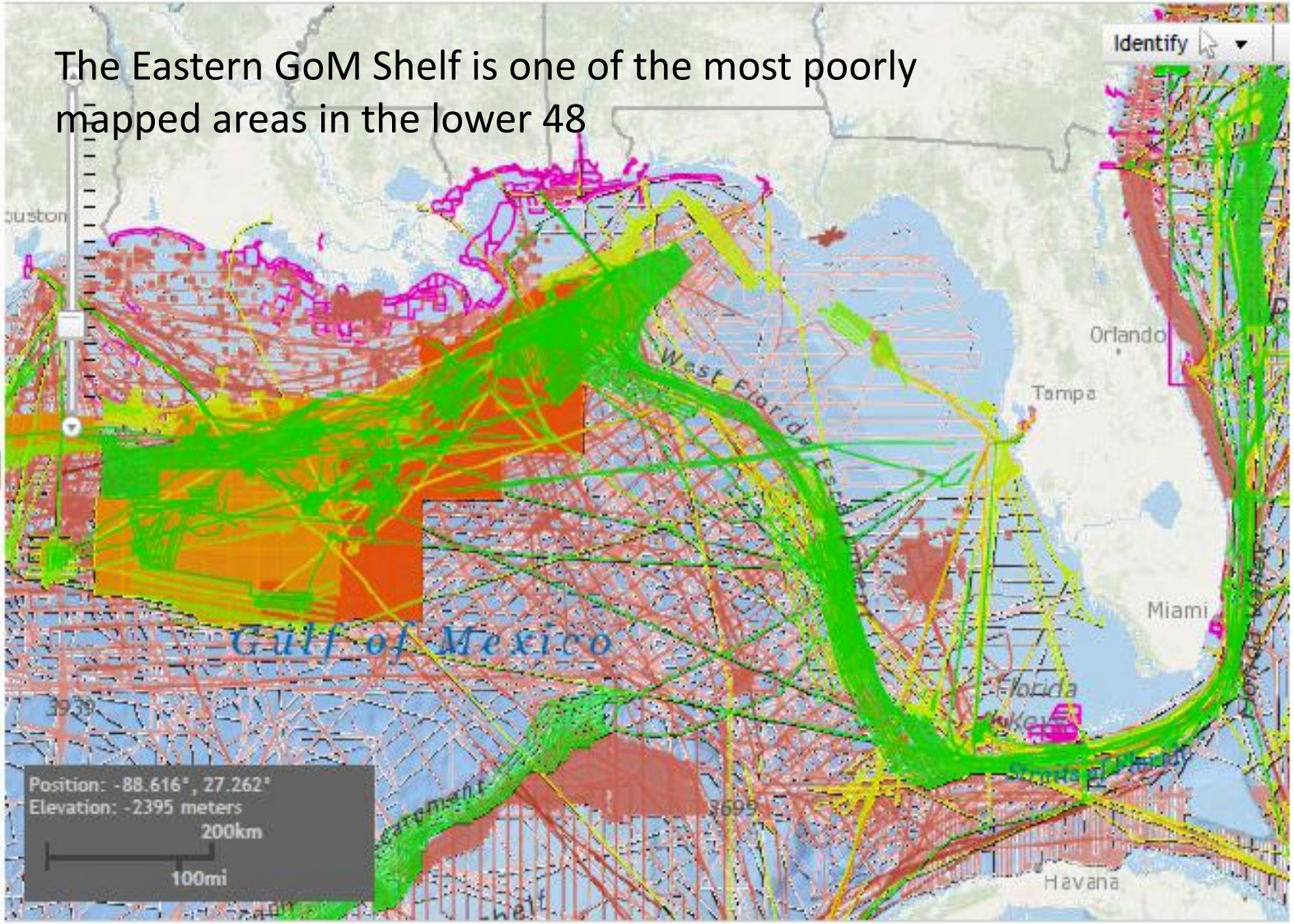
Digital Elevation Models (DEMs)

- [ ] DEM Footprints
- [ ] DEM Color Shaded Relief Imagery

Legend

More Information

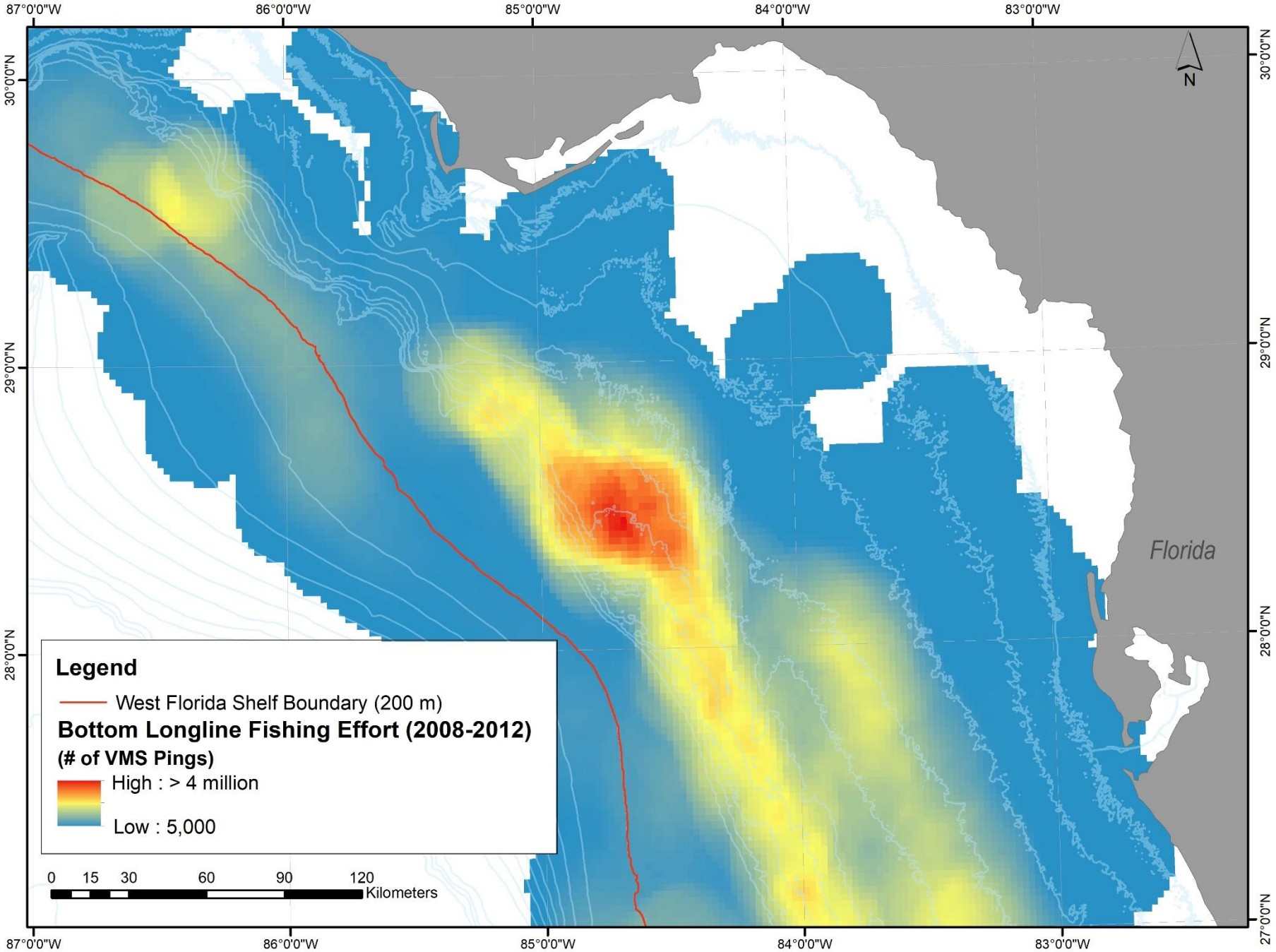
Help

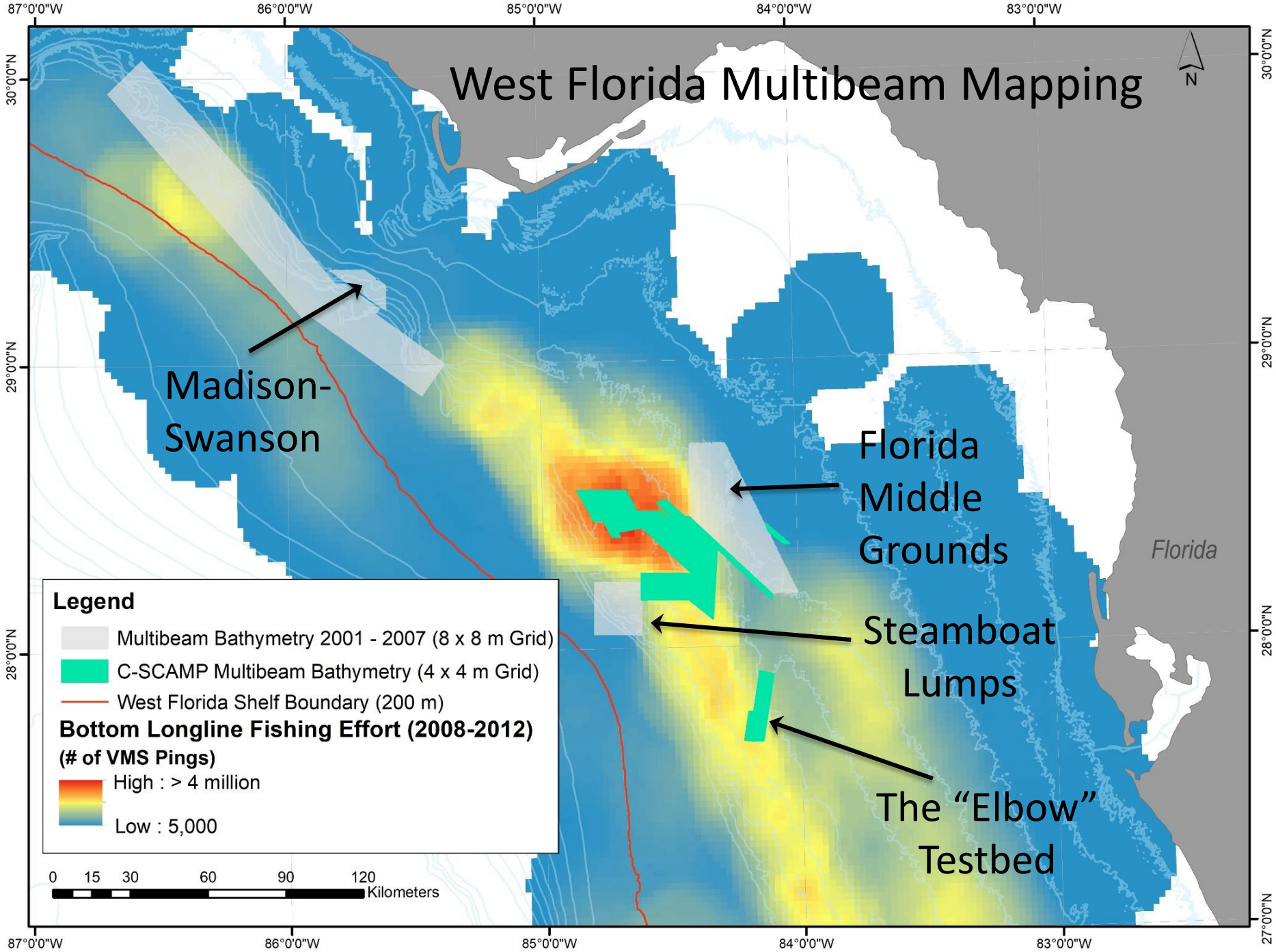


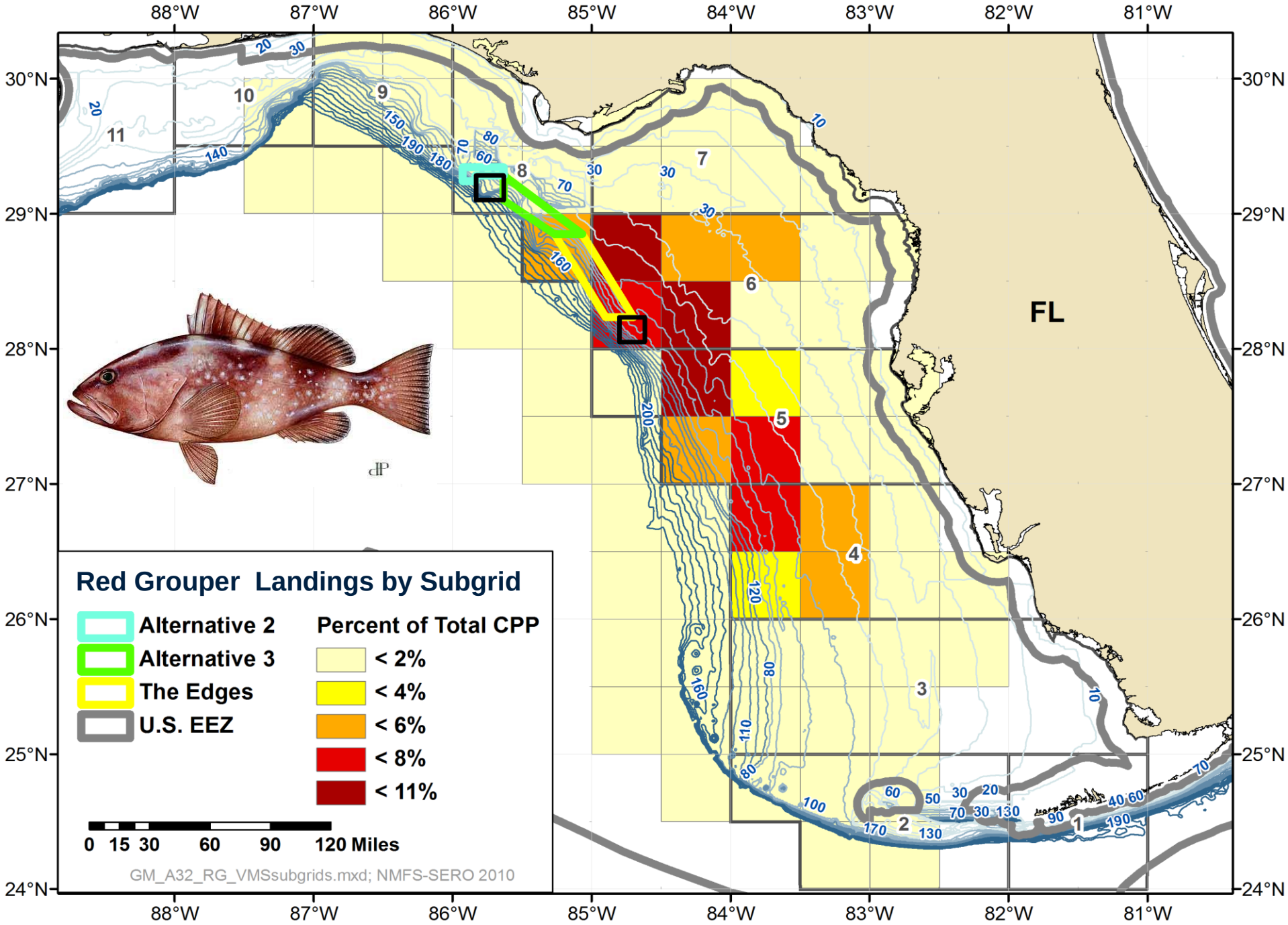
The Eastern GoM Shelf is one of the most poorly mapped areas in the lower 48

Where to Map?

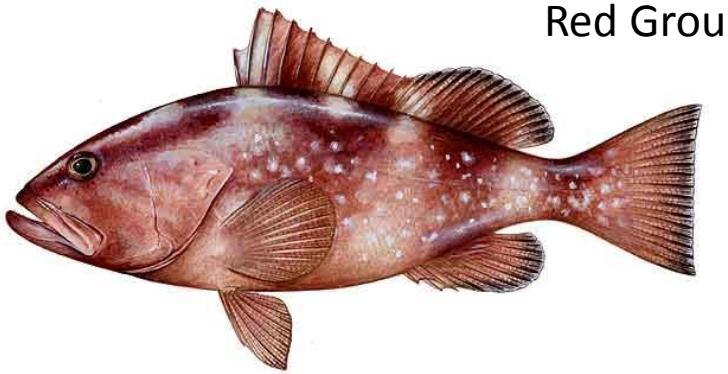
- Project goals related to reef fish & sea turtle populations potentially affected by *Deepwater Horizon*
- Habitats on the West Florida Shelf poorly mapped (only about 5% of region multibeamed prior to this project)
- Data are scattered among a variety of government & academic sources
- High resolution spatial data from fishers give us important clues regarding essential habitats
- Turtle tracking data likewise reveal “hot spots”


87°0'0"W
86°0'0"W
85°0'0"W
84°0'0"W
83°0'0"W
30°0'0"N
29°0'0"N
28°0'0"N
27°0'0"N
N
Florida
Legend
West Florida Shelf Boundary (200 m)
Bottom Longline Fishing Effort (2008-2012)
(# of VMS Pings)
High : > 4 million
Low : 5,000
0 15 30 60 90 120
Kilometers

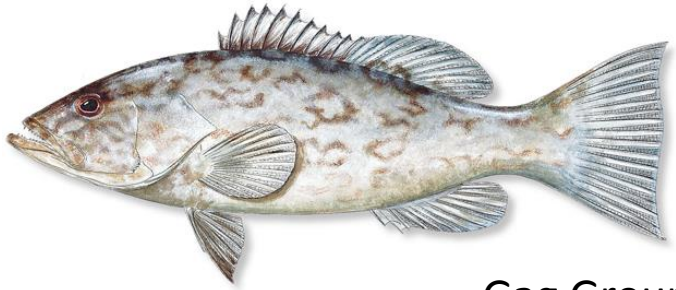

West Florida Multibeam Mapping
N
Madison-Swanson
Florida Middle Grounds
Steamboat Lumps
The "Elbow" Testbed
Florida
Legend
Multibeam Bathymetry 2001 - 2007 (8 x 8 m Grid)
C-SCAMP Multibeam Bathymetry (4 x 4 m Grid)
West Florida Shelf Boundary (200 m)
Bottom Longline Fishing Effort (2008-2012)
(# of VMS Pings)
High : > 4 million
Low : 5,000
0 15 30 60 90 120
Kilometers
87°0'0"W
86°0'0"W
85°0'0"W
84°0'0"W
83°0'0"W
30°0'0"N
29°0'0"N
28°0'0"N
27°0'0"N


Red Grouper Landings by Subgrid
Alternative 2
Alternative 3
The Edges
U.S. EEZ
Percent of Total CPP
< 2%
< 4%
< 6%
< 8%
< 11%
0 15 30 60 90 120 Miles
GM_A32_RG_VMSsubgrids.mxd; NMFS-SERO 2010
FL
88°W
87°W
86°W
85°W
84°W
83°W
82°W
81°W
30°N
29°N
28°N
27°N
26°N
25°N
24°N

Primary Inhabitants of West Florida Shelf Hard Bottom Reefs



Red Grouper



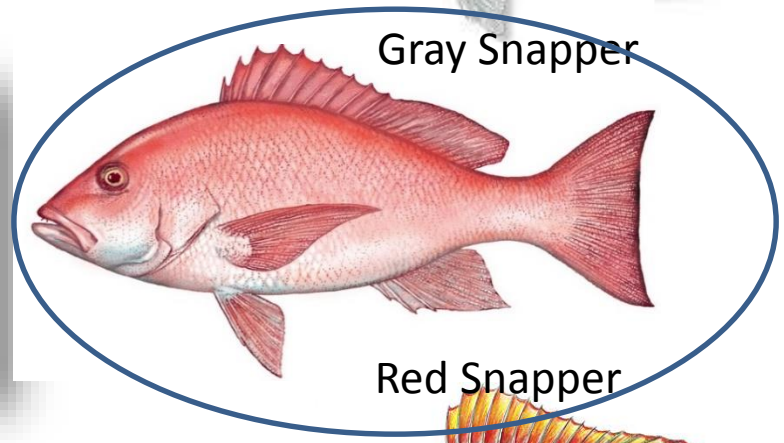
Gag Grouper

Red Porgy

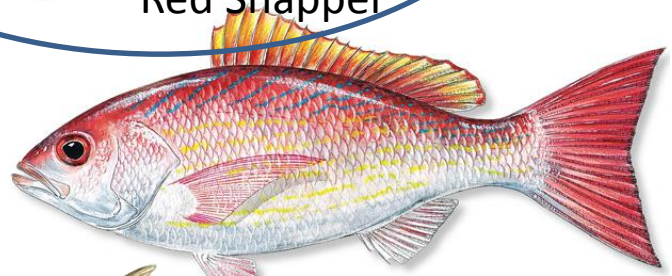
Loggerhead Turtle

Kemps Ridley Turtle

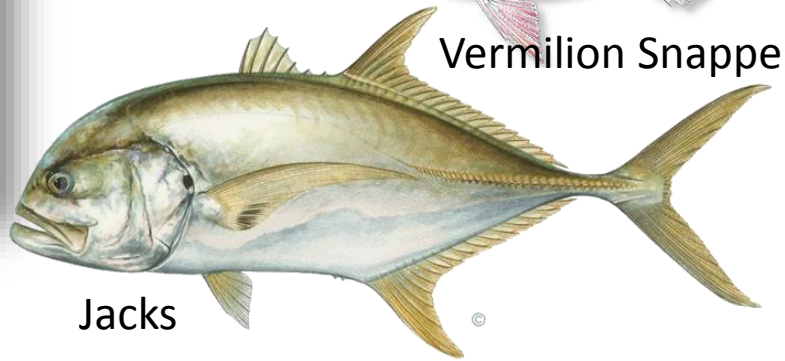
Gray Snapper



Red Snapper



Vermilion Snapper



Jacks

Drawings by Diane Peebles

Enabling Technologies
Ship Support
NFWF Mapping Project

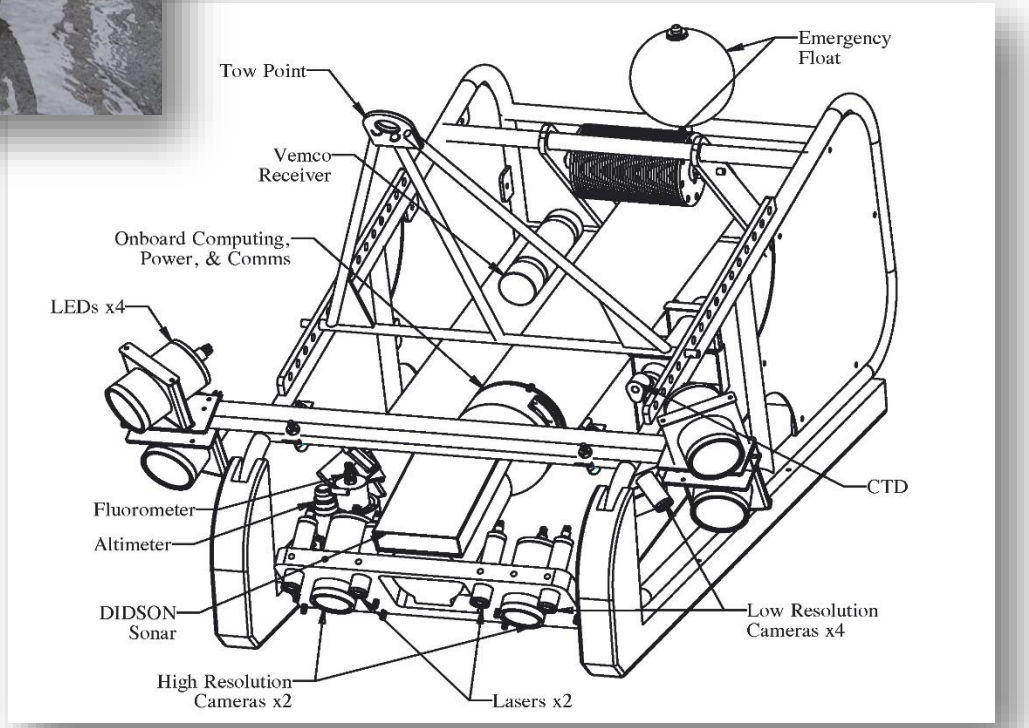
R/V *Weatherbird II*, Video assessment and EK-60 water column

R/V *W.T. Hogarth*
78 feet, capable of multibeam and video missions

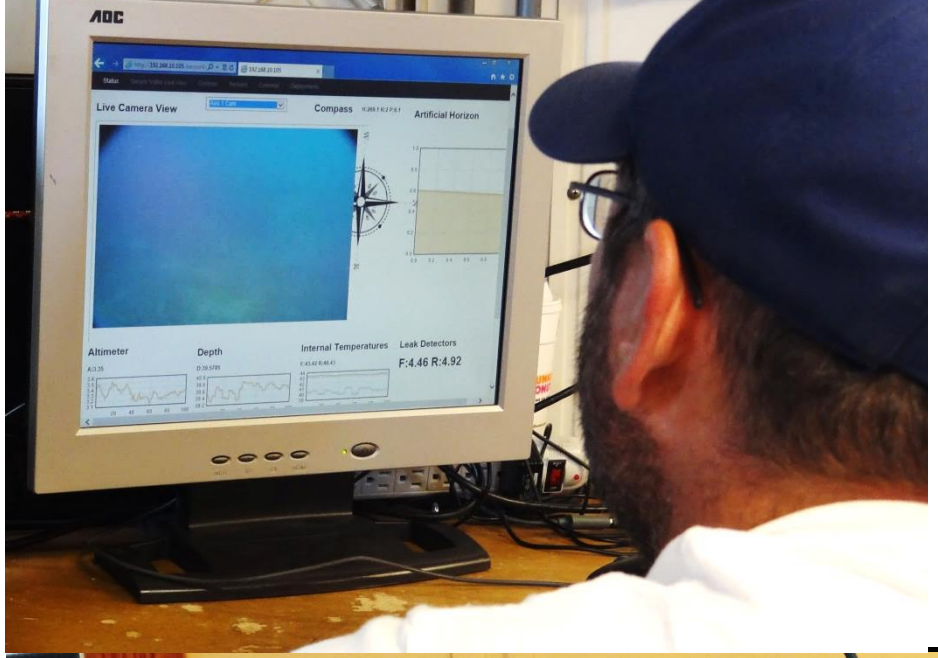
C-BASS: Camera-Based Assessment Survey System

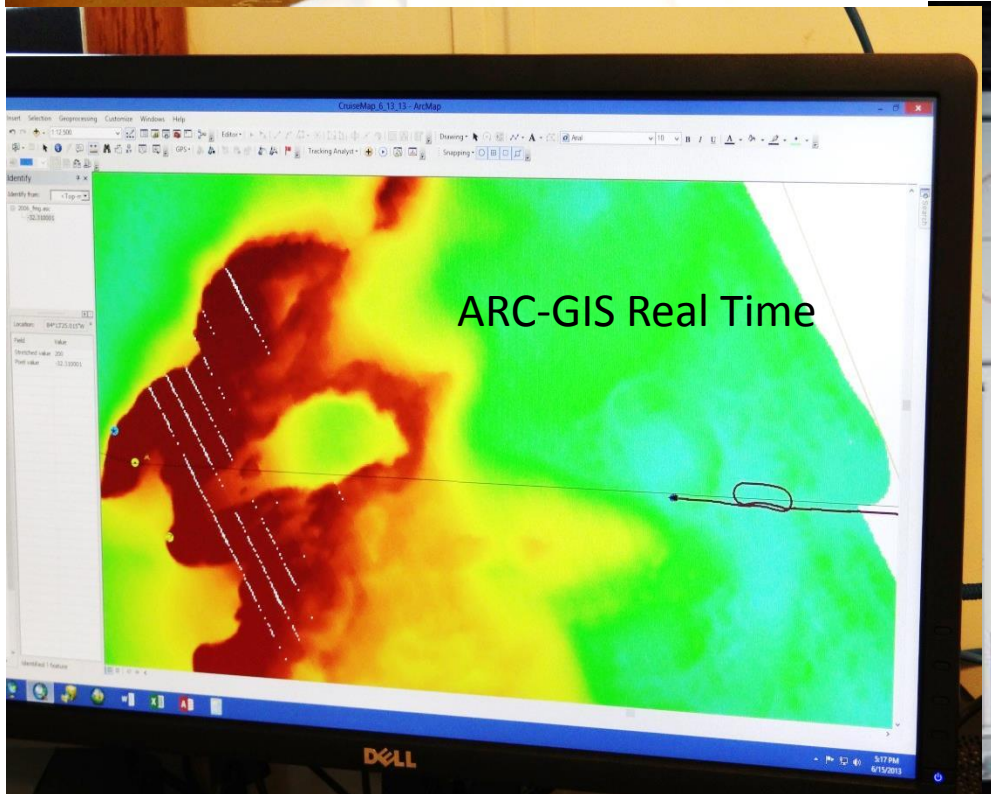
A Highly maneuverable towed video and environmental sensing array

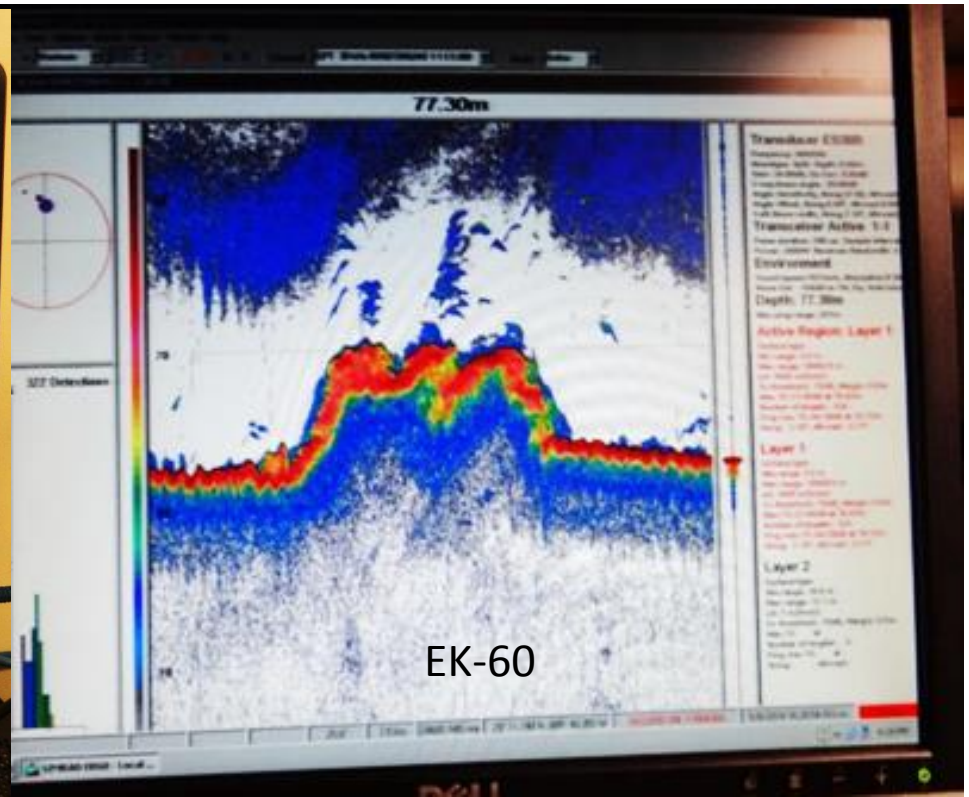
- Optimal tow speeds: 3-5 kn,
- Flown 2-4 meters above the bottom
- Capable of 20 hrs per day continuous operation

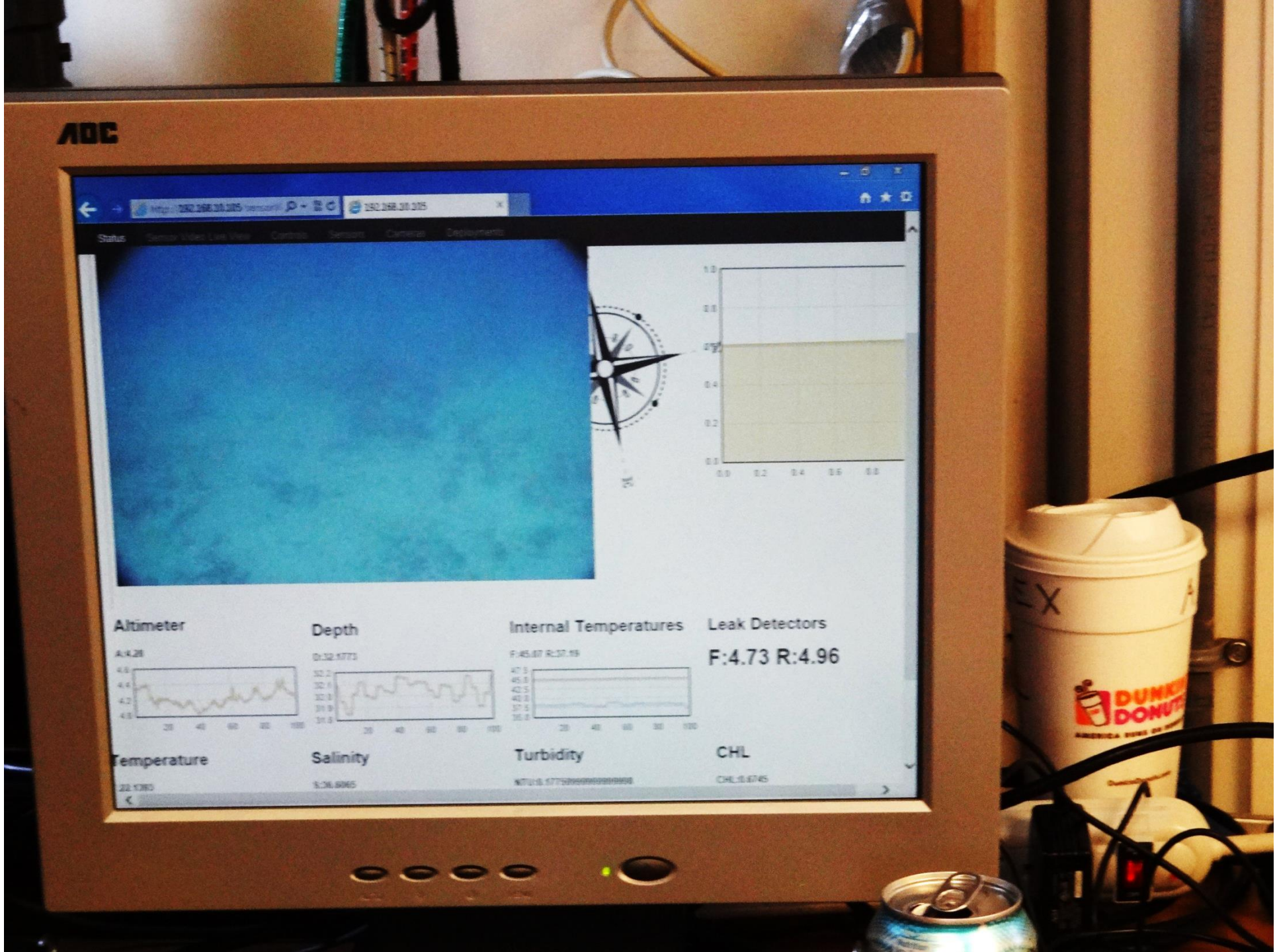


“Flying” C-BASS

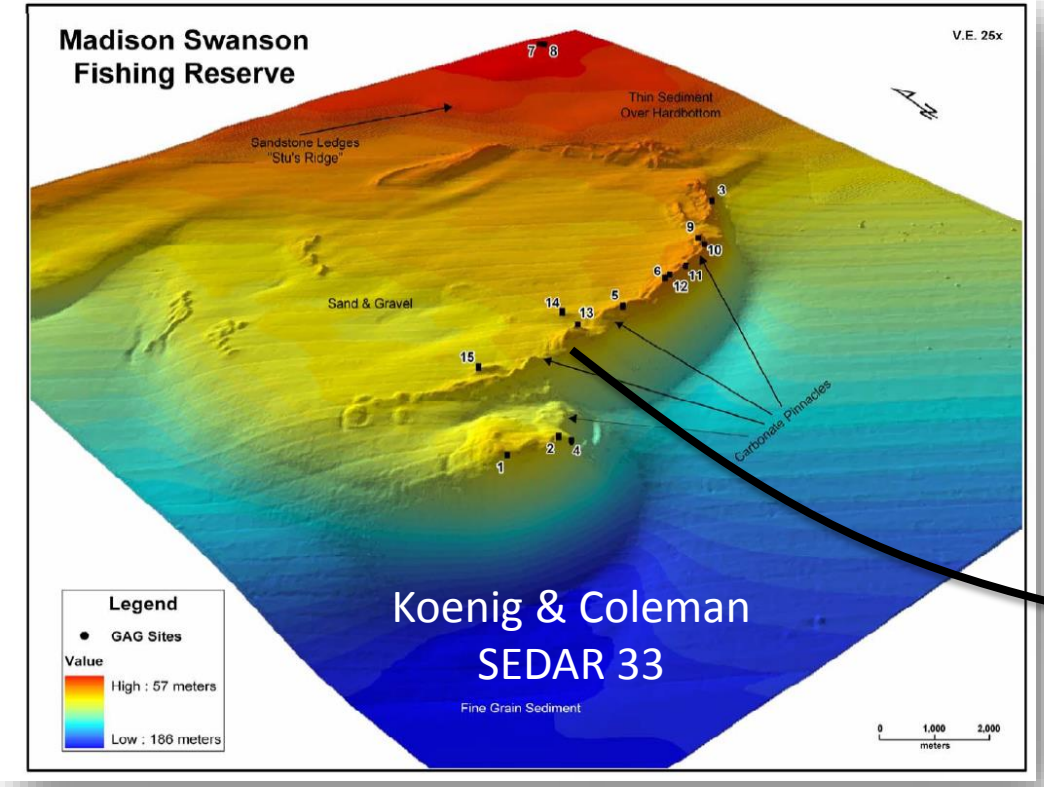






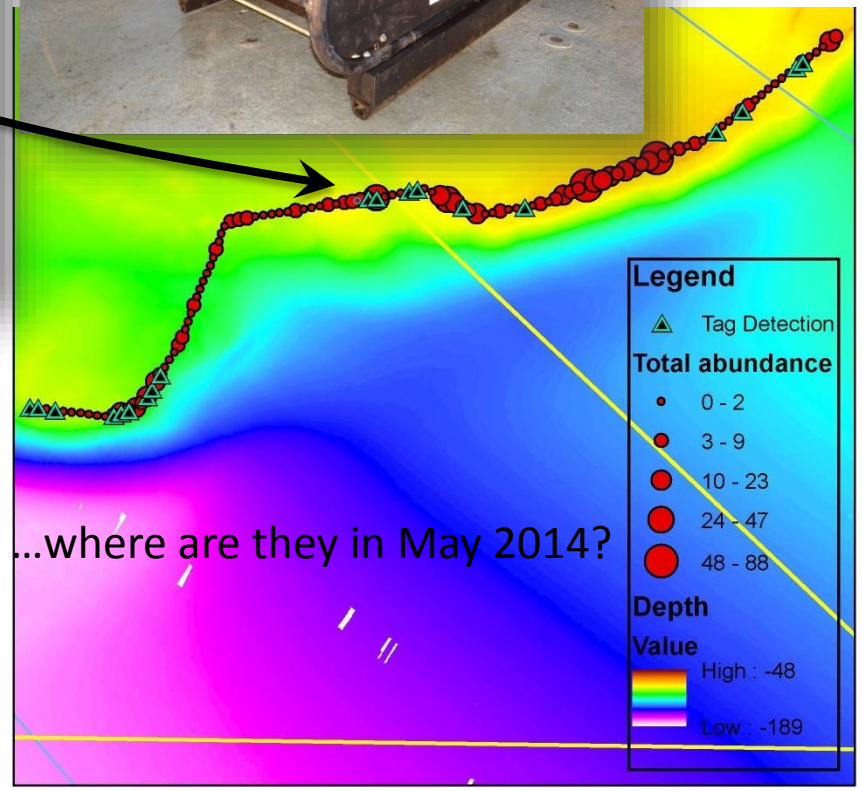

AOC
Status
Altimeter
Depth
Internal Temperatures
Leak Detectors
F:4.73 R:4.96
Temperature
Salinity
Turbidity
CHL

Combining Technologies

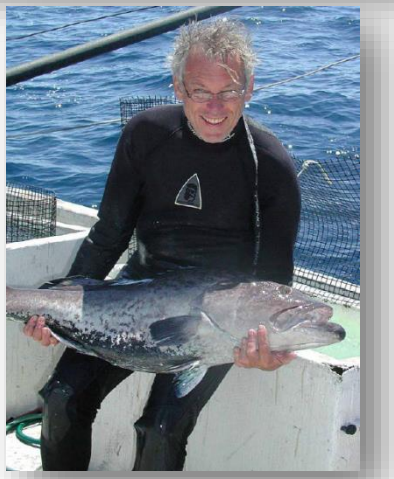


Koenig & Coleman
SEDAR 33

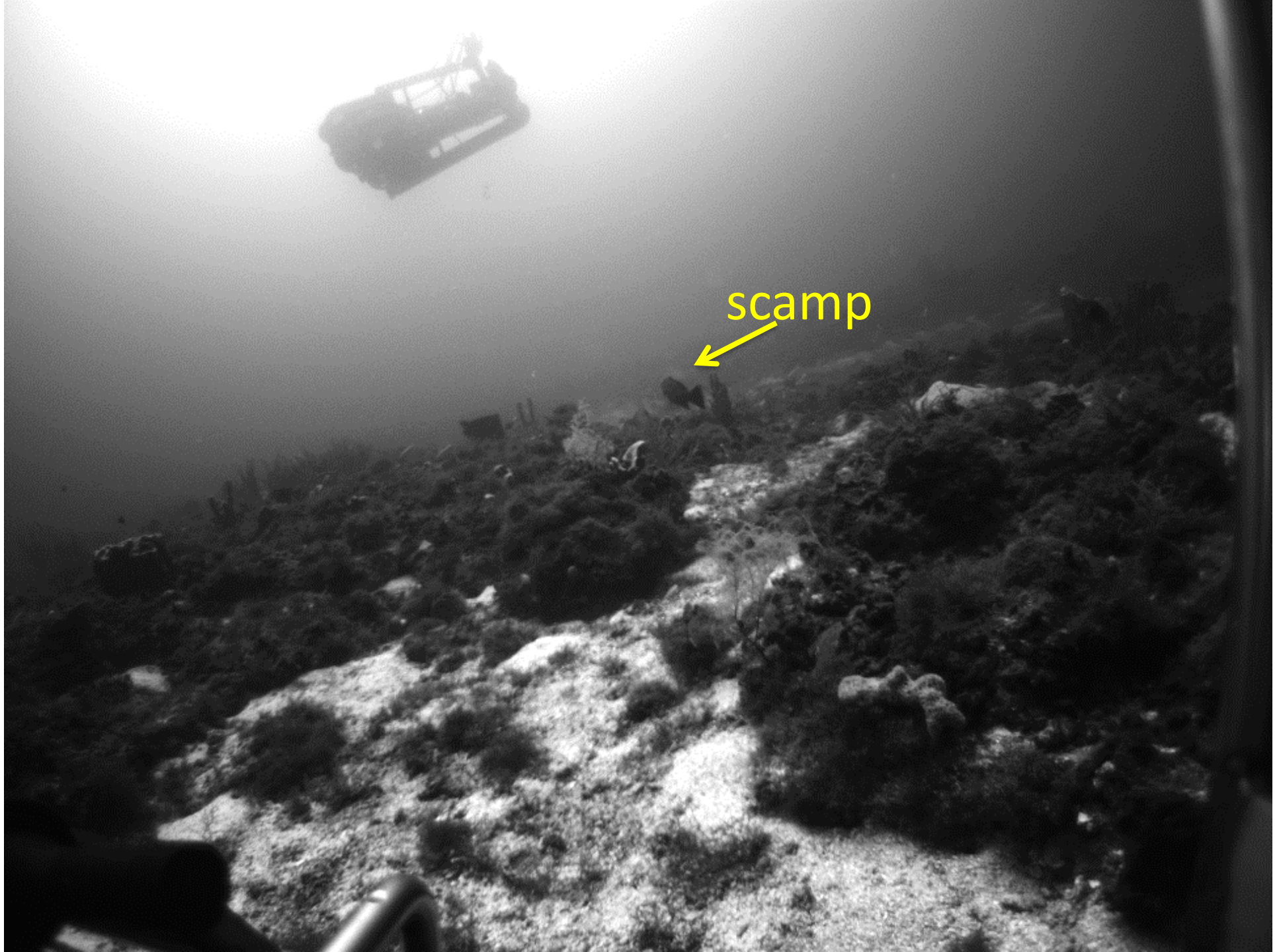
Acoustic Tagging of Gag Grouper & Red Snapper in 2008/9……



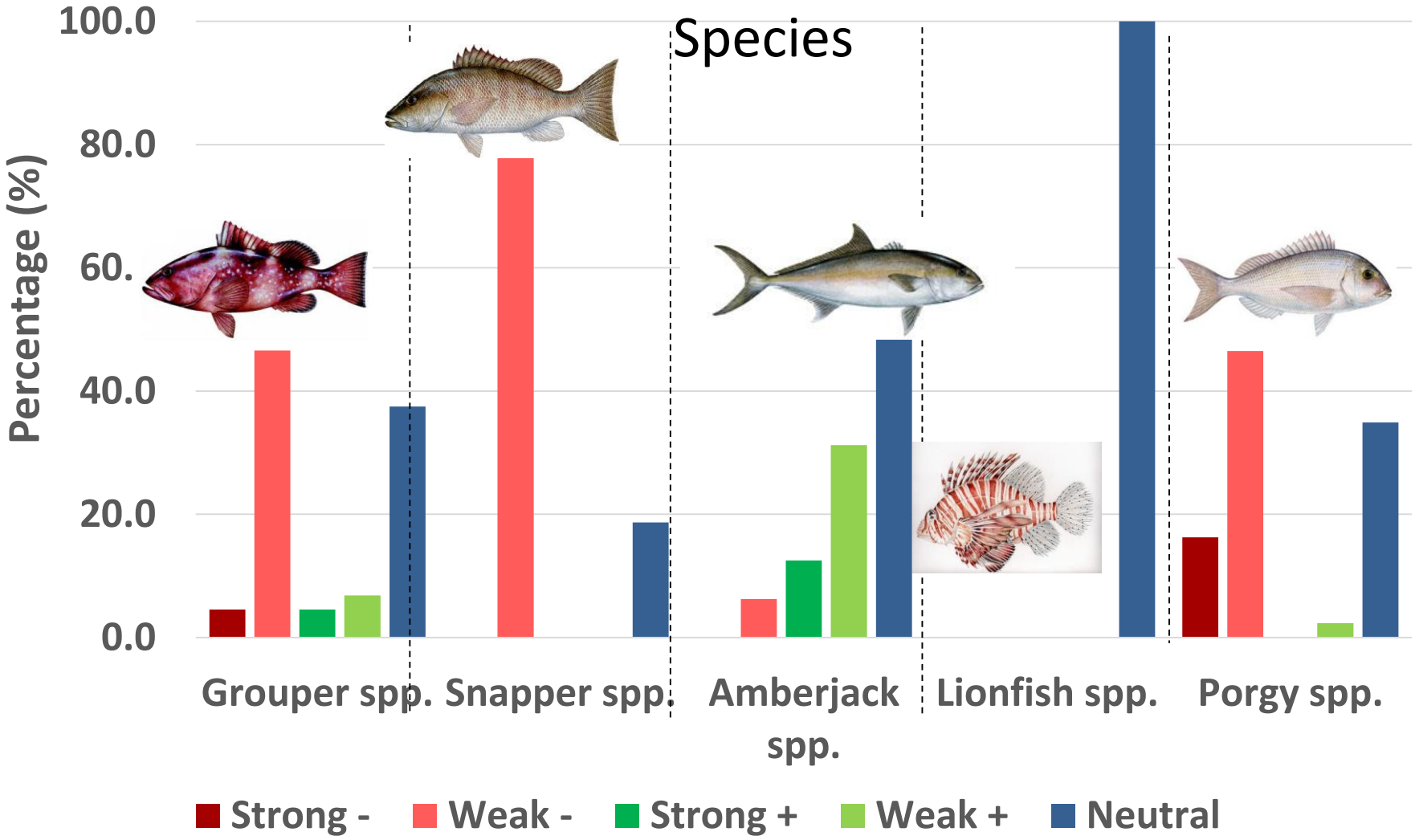
…where are they in May 2014?



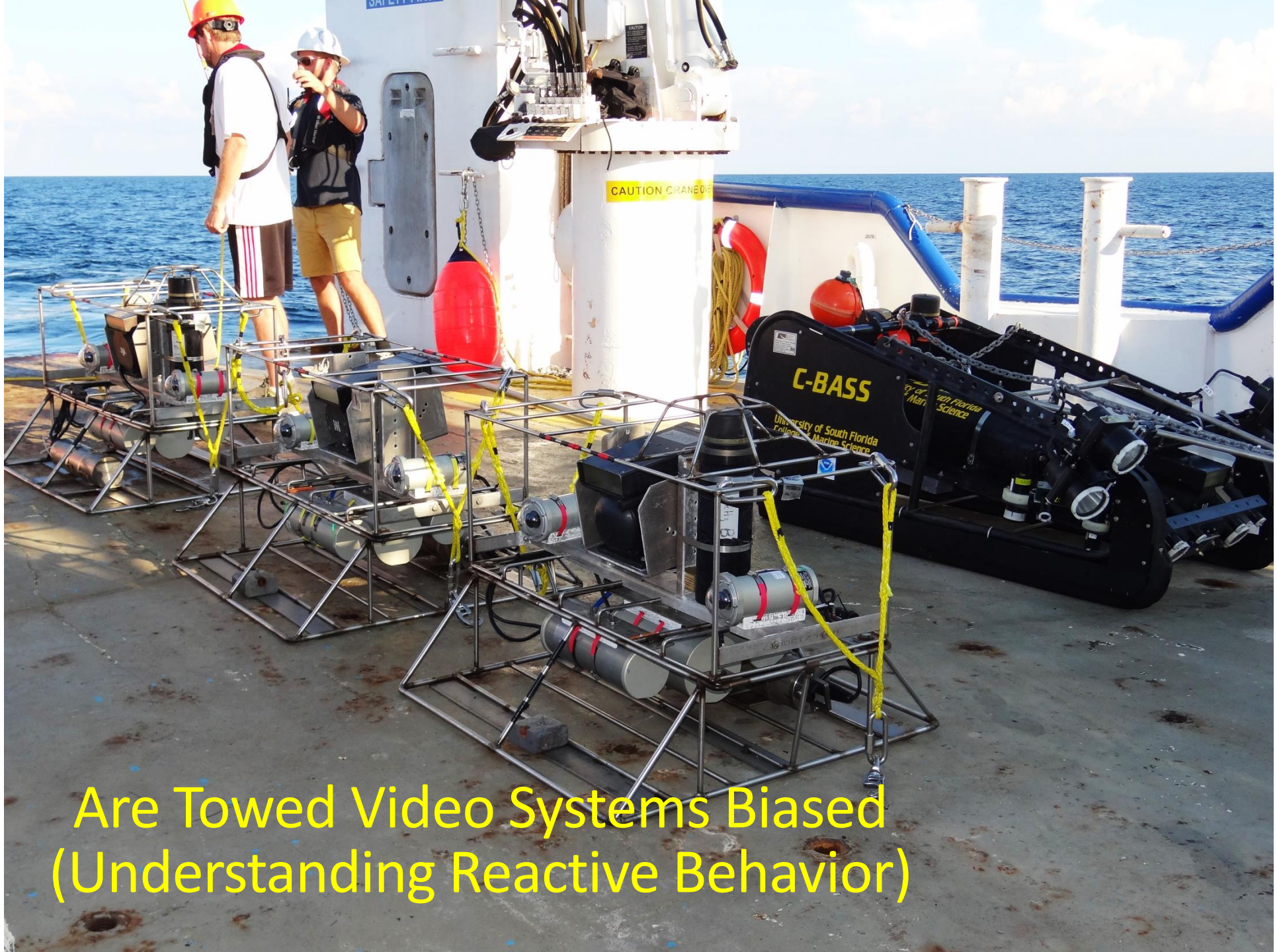
19 fish detected in May 2014 aboard C-BASS (towed camera sled) survey!


scamp

Variable Responsive Behavior between Target Species



S. Grasty, M.S. Thesis

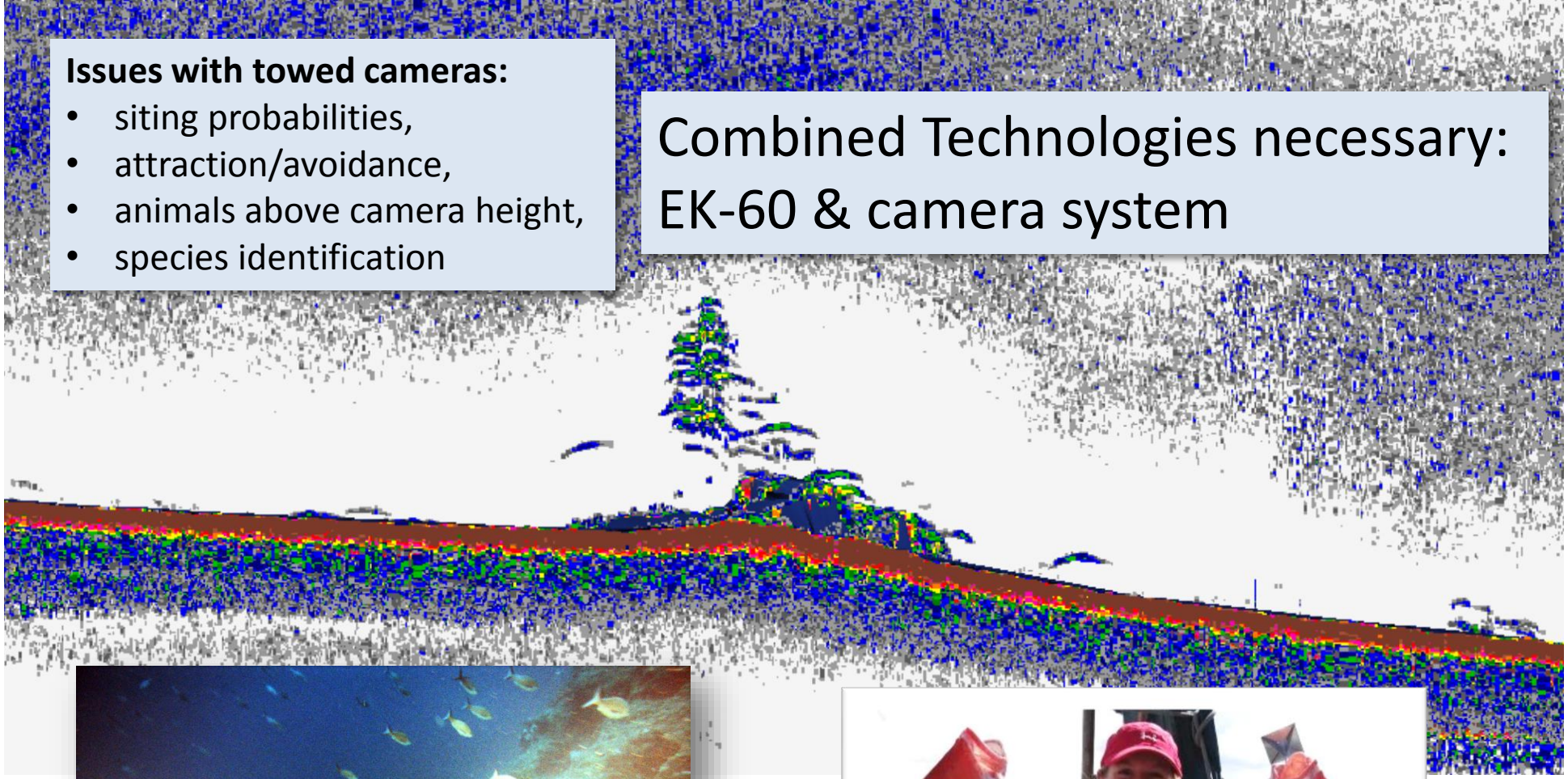


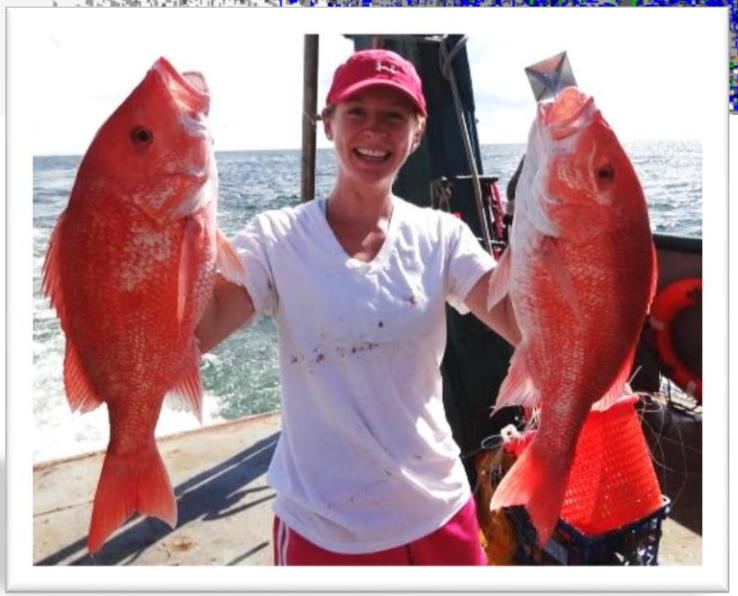
Are Towed Video Systems Biased (Understanding Reactive Behavior)

Issues with towed cameras:

- siting probabilities,
- attraction/avoidance,
- animals above camera height,
- species identification

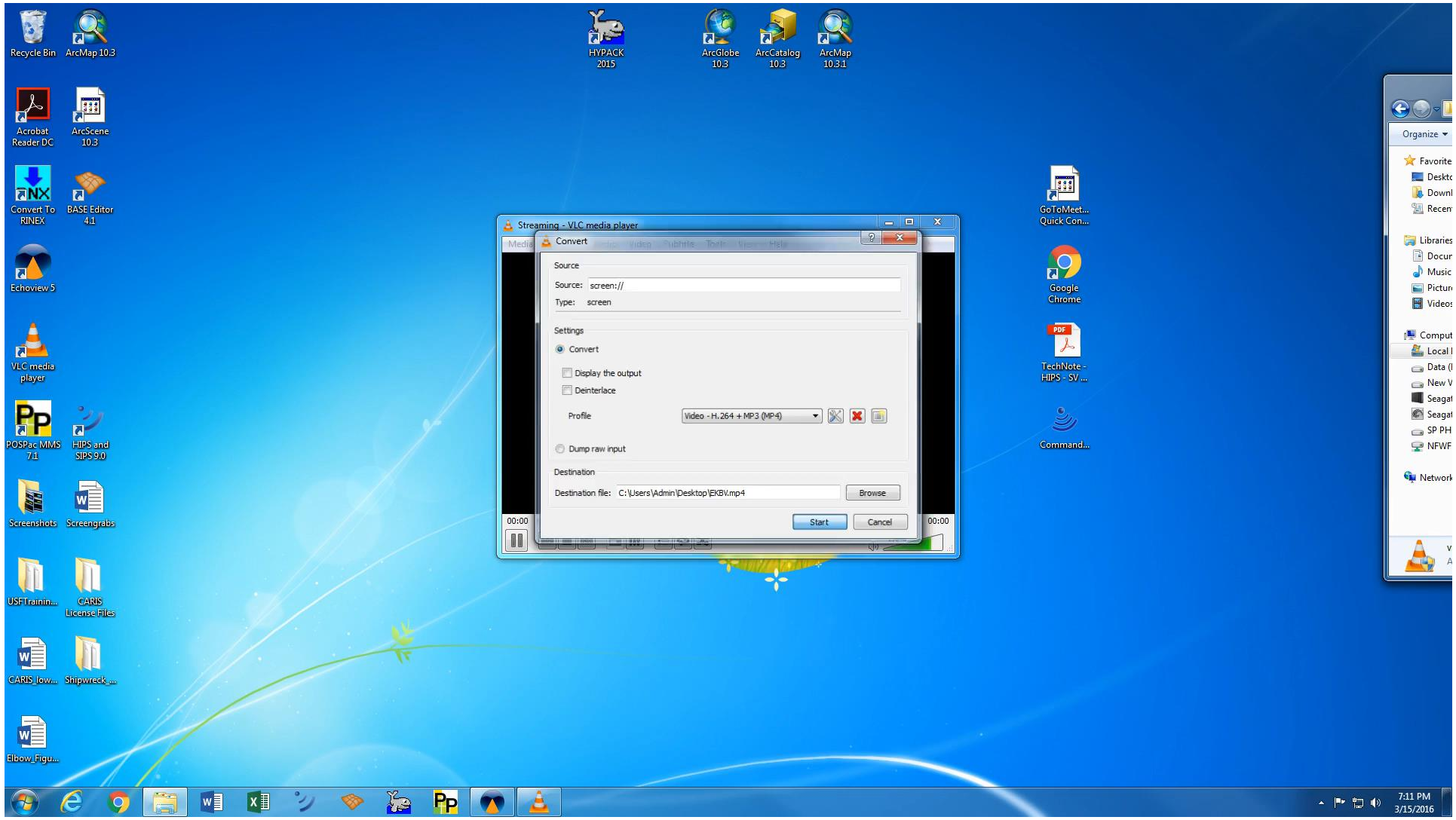
Combined Technologies necessary: EK-60 & camera system



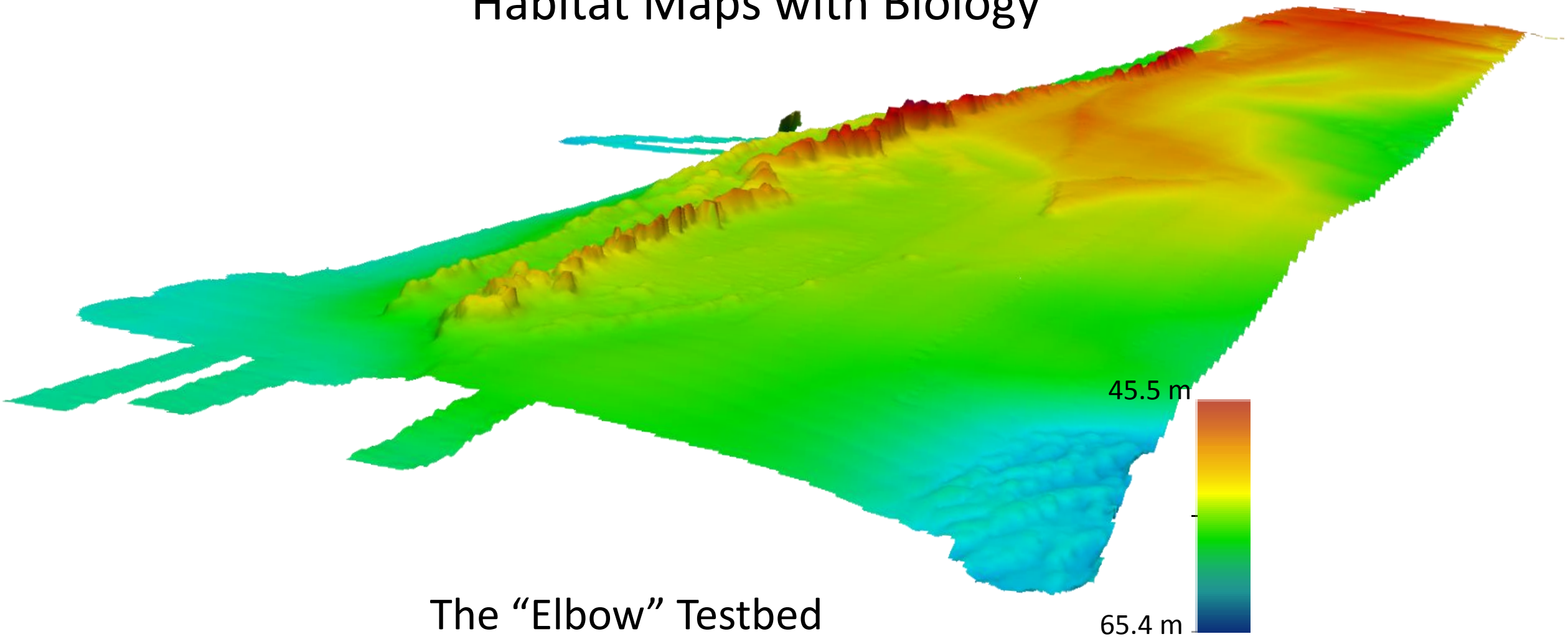


SIMRAD EK-60 Sonar

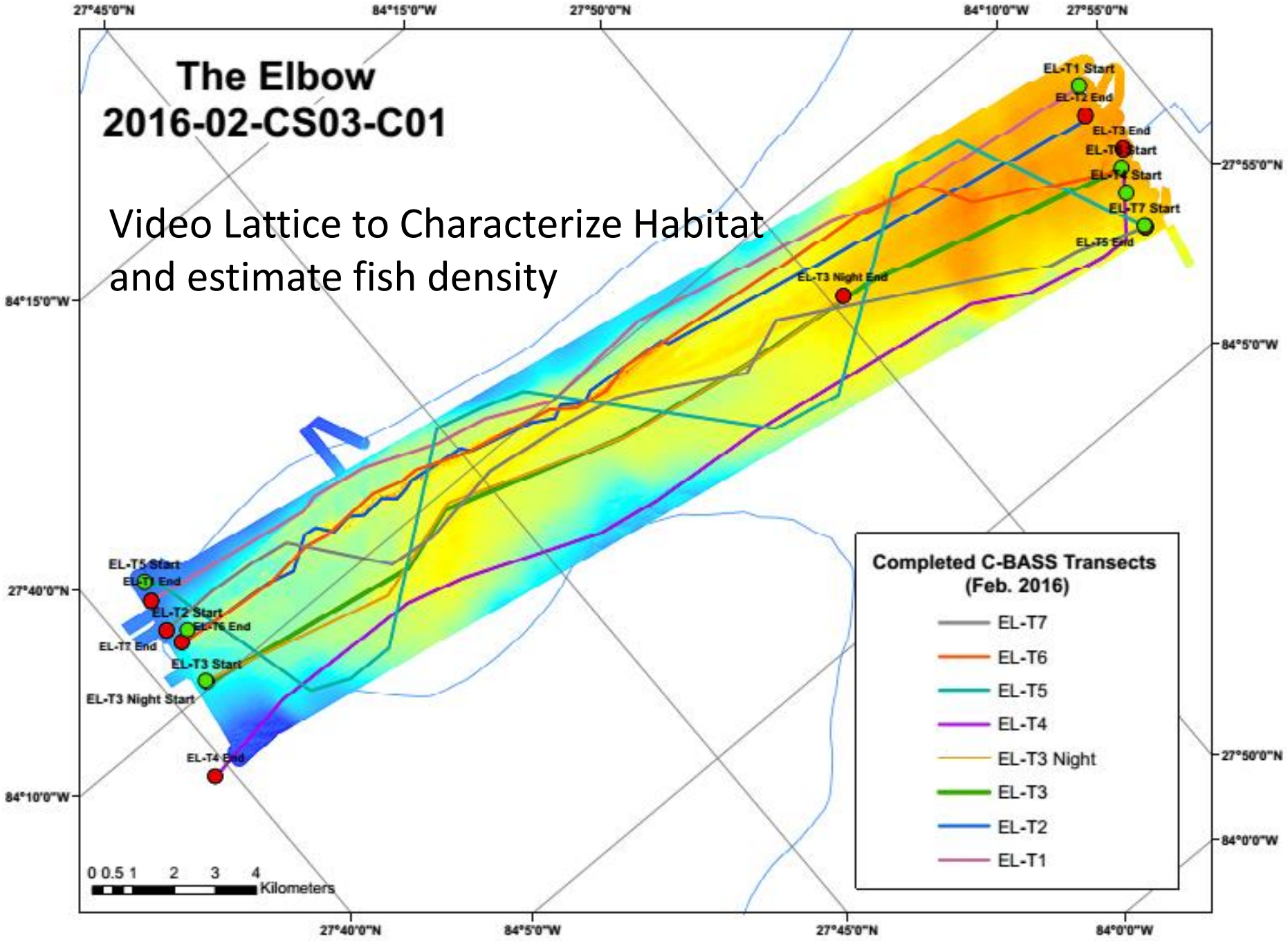
C-BASS Imagery
Gulfstream Gas Pipeline



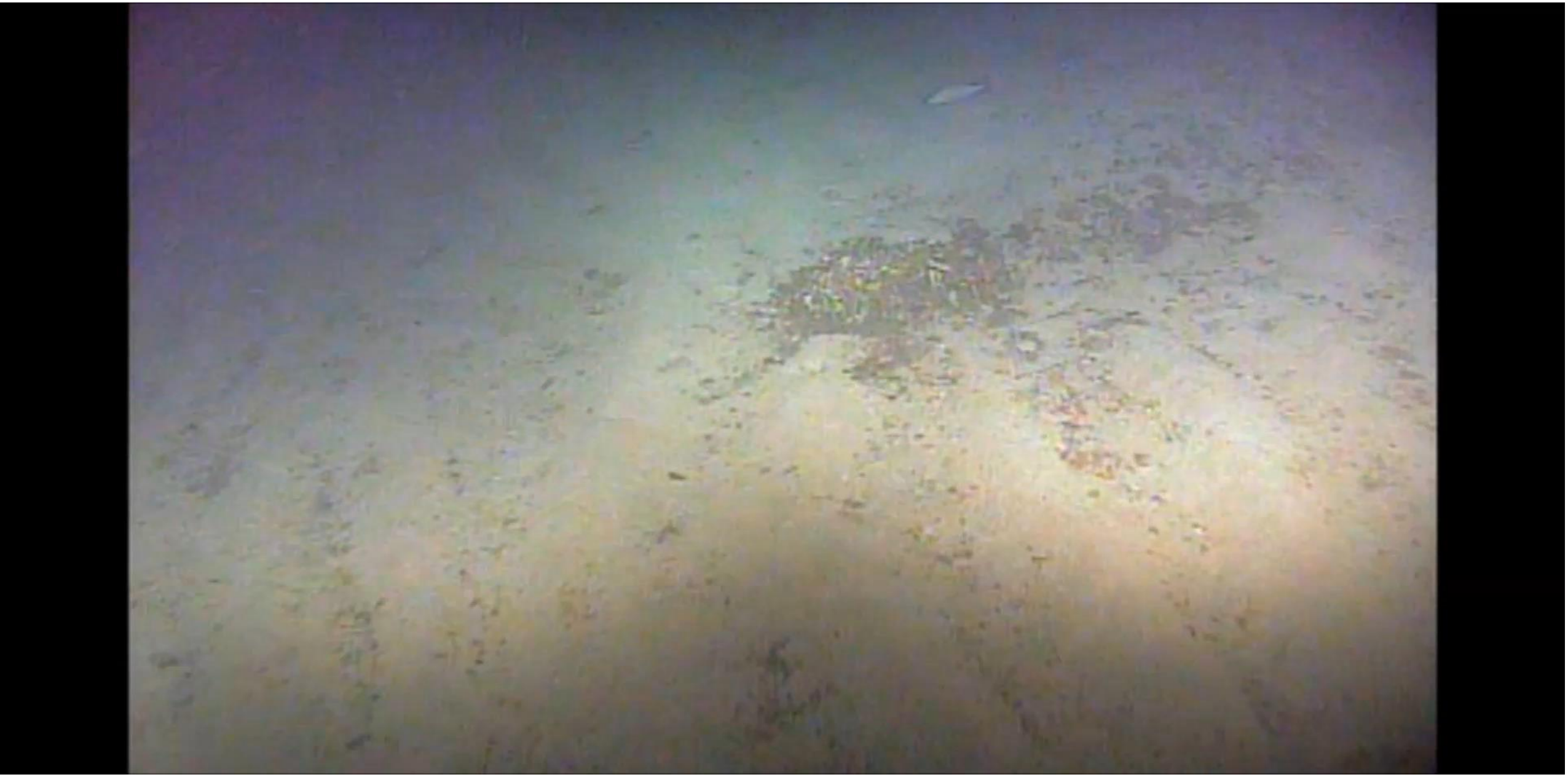
Converting High-Resolution Bathymetry to Habitat Maps with Biology



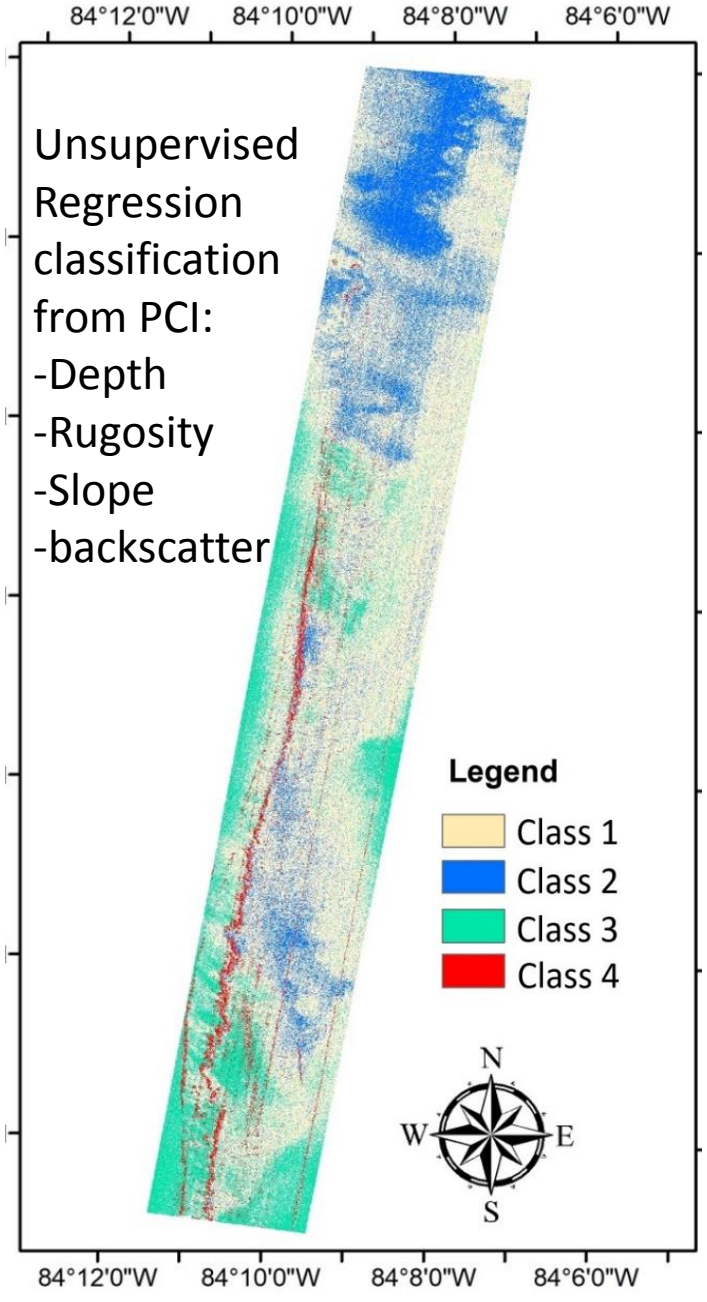
The “Elbow” Testbed

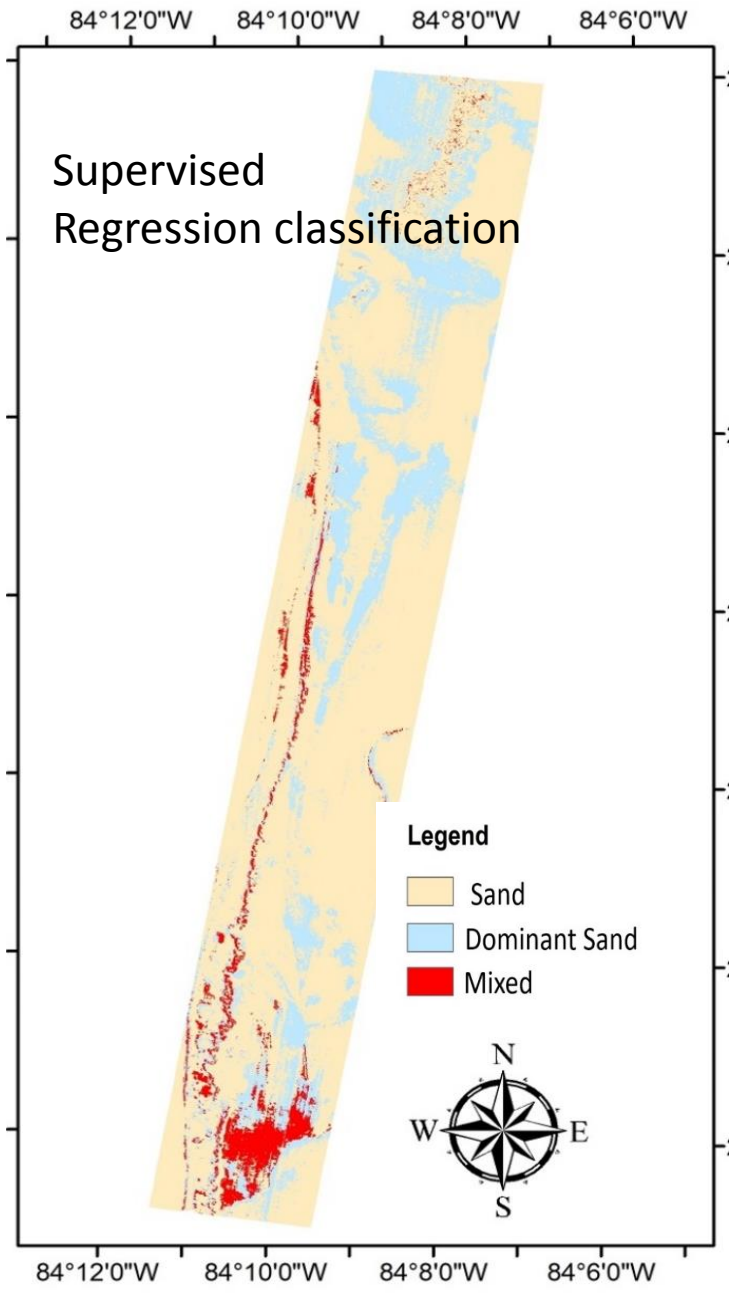

The Elbow
2016-02-CS03-C01
Video Lattice to Characterize Habitat
and estimate fish density
EL-T1 Start
EL-T2 End
EL-T3 End
EL-T7 Start
EL-T5 End
EL-T3 Night End
EL-T5 Start
EL-T2 Start
EL-T6 End
EL-T7 End
EL-T3 Start
EL-T3 Night Start
EL-T4 End
Completed C-BASS Transects
(Feb. 2016)
EL-T7
EL-T6
EL-T5
EL-T4
EL-T3 Night
EL-T3
EL-T2
EL-T1
0 0.5 1 2 3 4
Kilometers
27°45'0"N
84°15'0"W
27°50'0"N
84°10'0"W
27°55'0"N
84°5'0"W
27°40'0"N
84°0'0"W

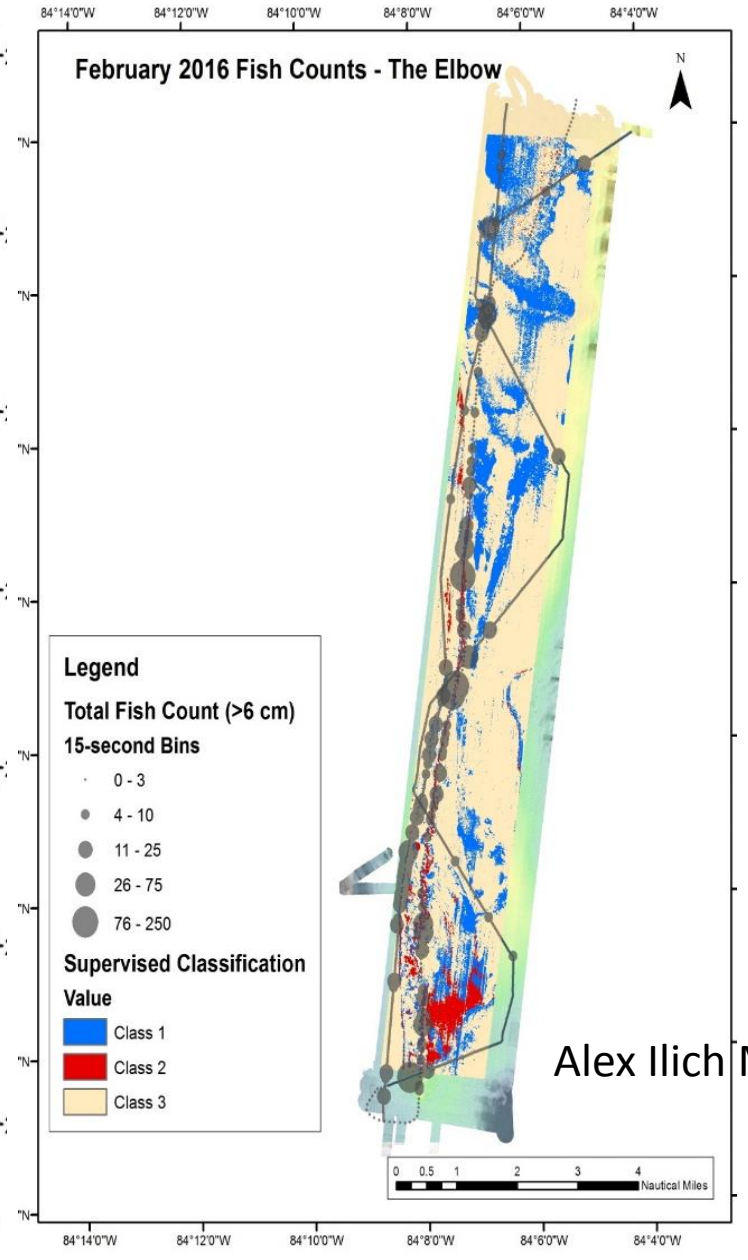
Elbow, Hard Bottom Ridge



Converting Bathymetry to Habitat Typing & Stratifying Biological Data







Alex Ilich M.S. thesis

Calculating Area Swept

Geometry of Viewing Platform:

Height above bottom (altimeter)

Angle of view of cameras

Visibility (probability of detect)

Monitored constantly (changes)

Habitat-Stratified Population Estimates

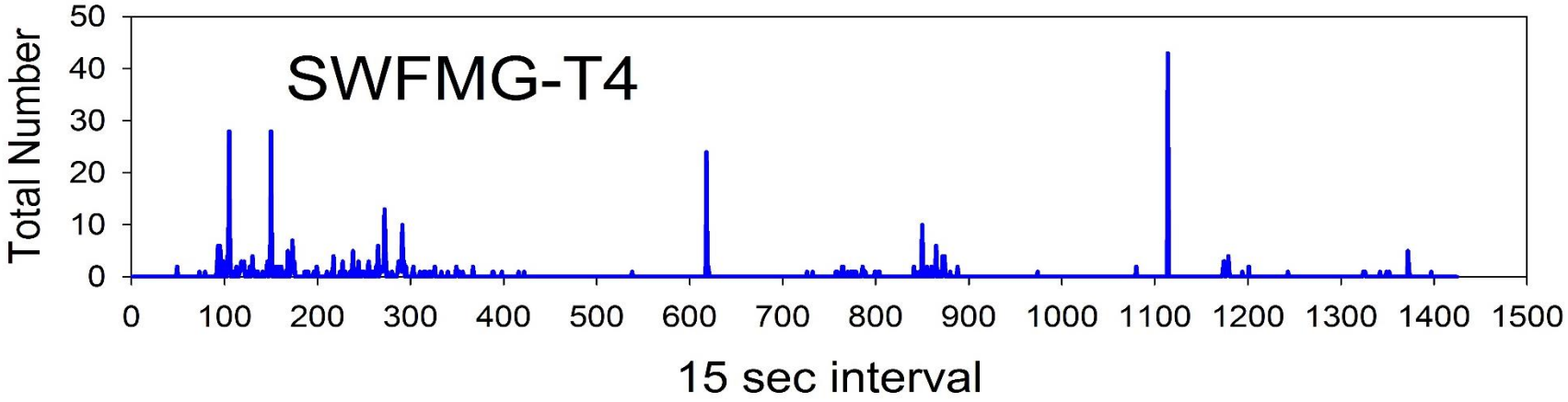
Sand
Sand w/Covered HB
Mixed Hard Bottom

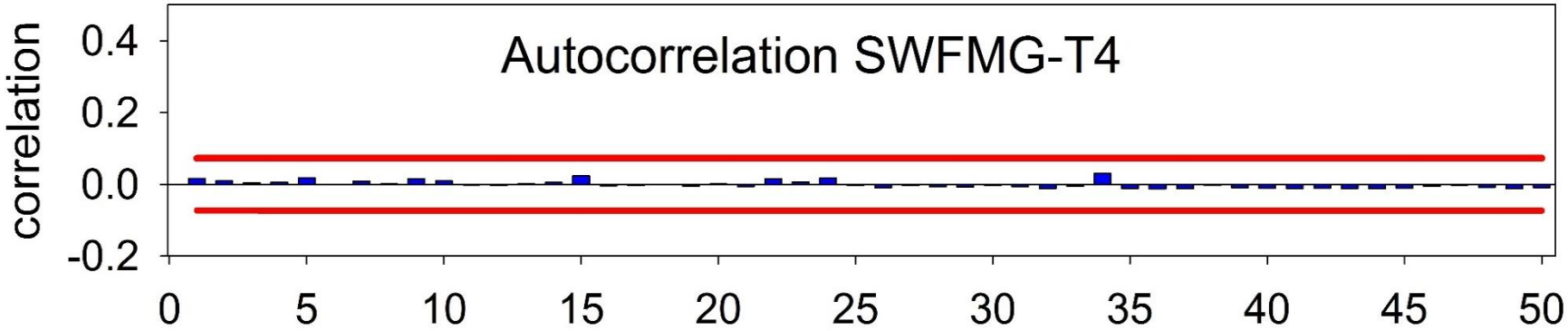
Habitat Type	% of Total	Density (#/M²), SD		Population Size Expanded
Sand	74%	Snappers	0.00016 (0.0037)	9,357
		Groupers	0.0000054 (0.00011)	316
		Jacks	0.000086 (0.0000045)	5,030
		Total > 6 cm	0.00058 (0.0041)	**33,920**
Sand w/Covered HB	22%	Snappers	0.000864 (0.011)	15,263
		Groupers	0.000150 (0.002)	2,650
		Jacks	0.000060 (0.001)	1,060
		Total > 6cm	0.006400 (0.093)	**113,059**
Mixed Hard Bottom	4%	Snappers	0.00110 (0.0037)	3,654
		Groupers	0.00034 (0.0051)	1,129
		Jacks	0.00200 (0.0240)	6,644
		Total > 6cm	0.00540 (0.0340)	**17,938**

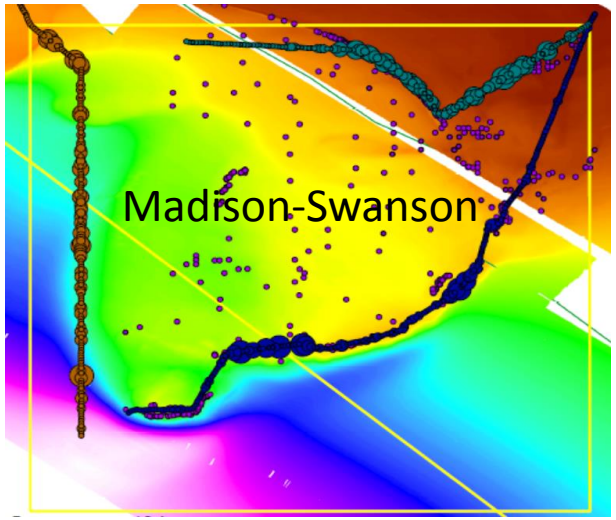
26% of the Habitat Accounts for 79% of the fish!

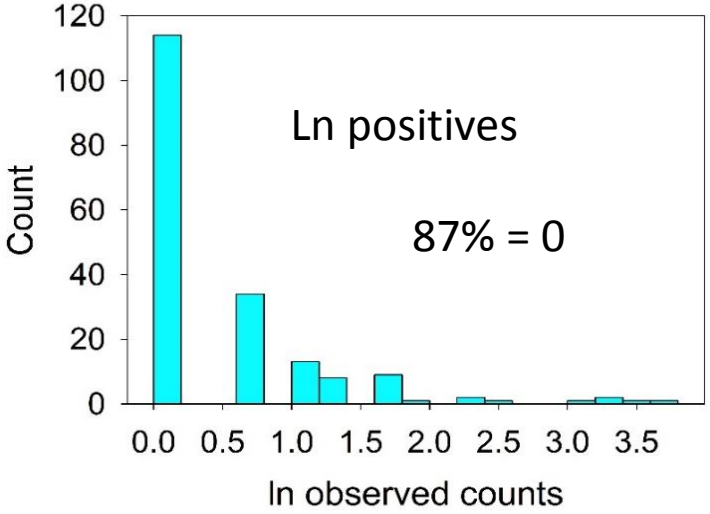
Operationalizing Standardized Surveys
High Through-Put Fish Counts & Habitat Classification (w/SRI International, Princeton)

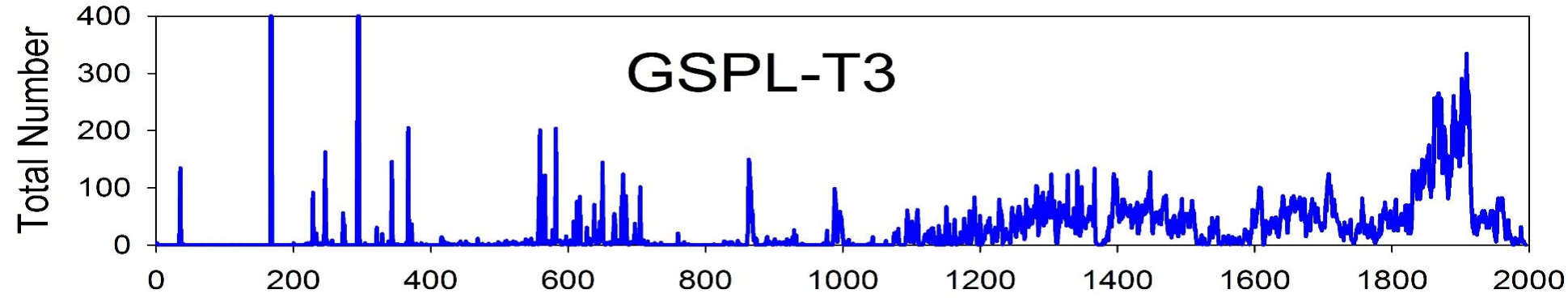
Dealing with Autocorrelation: Statistics of Transect Survey Data

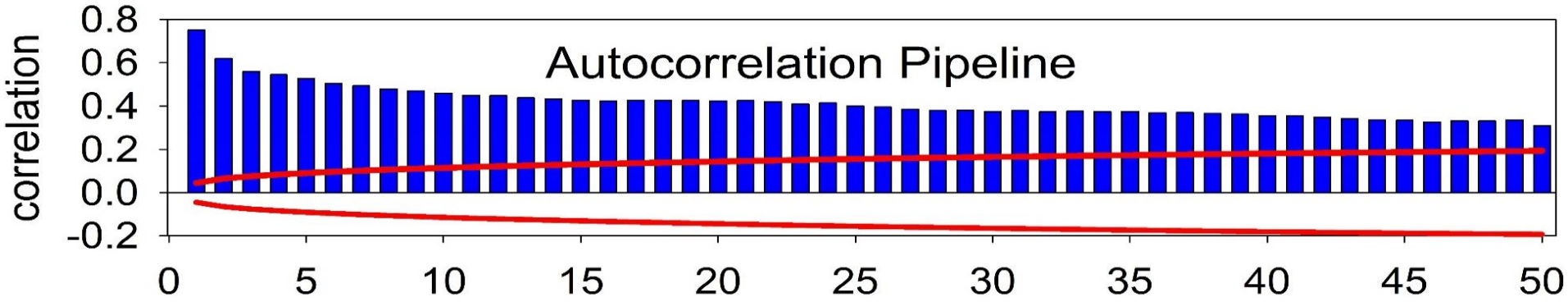


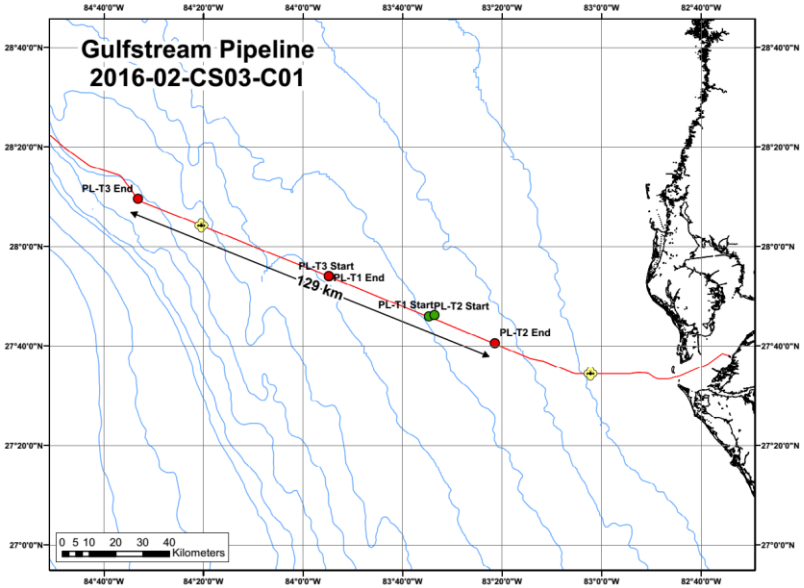


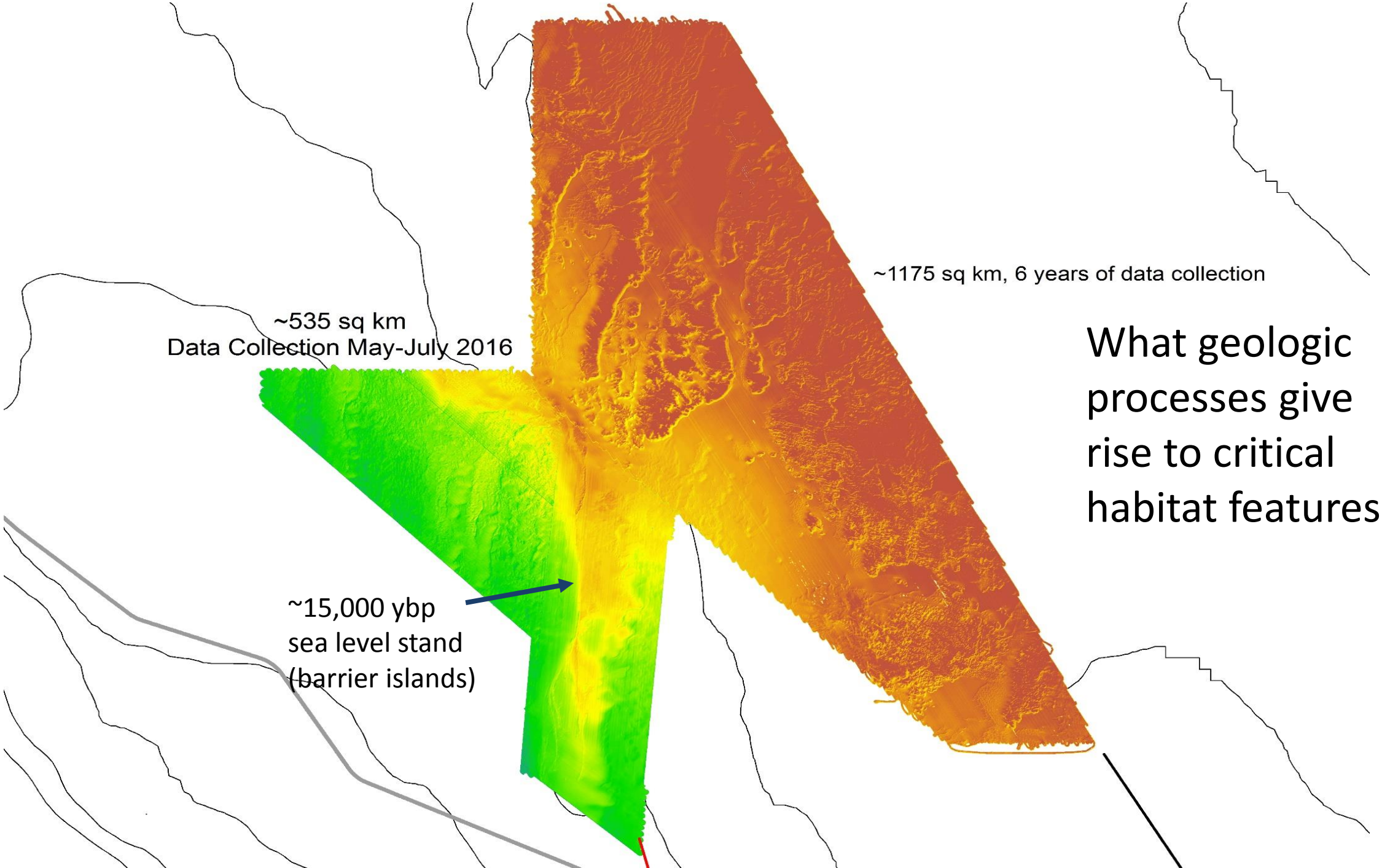





GSPL-T3
Total Number
400
300
200
100
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000

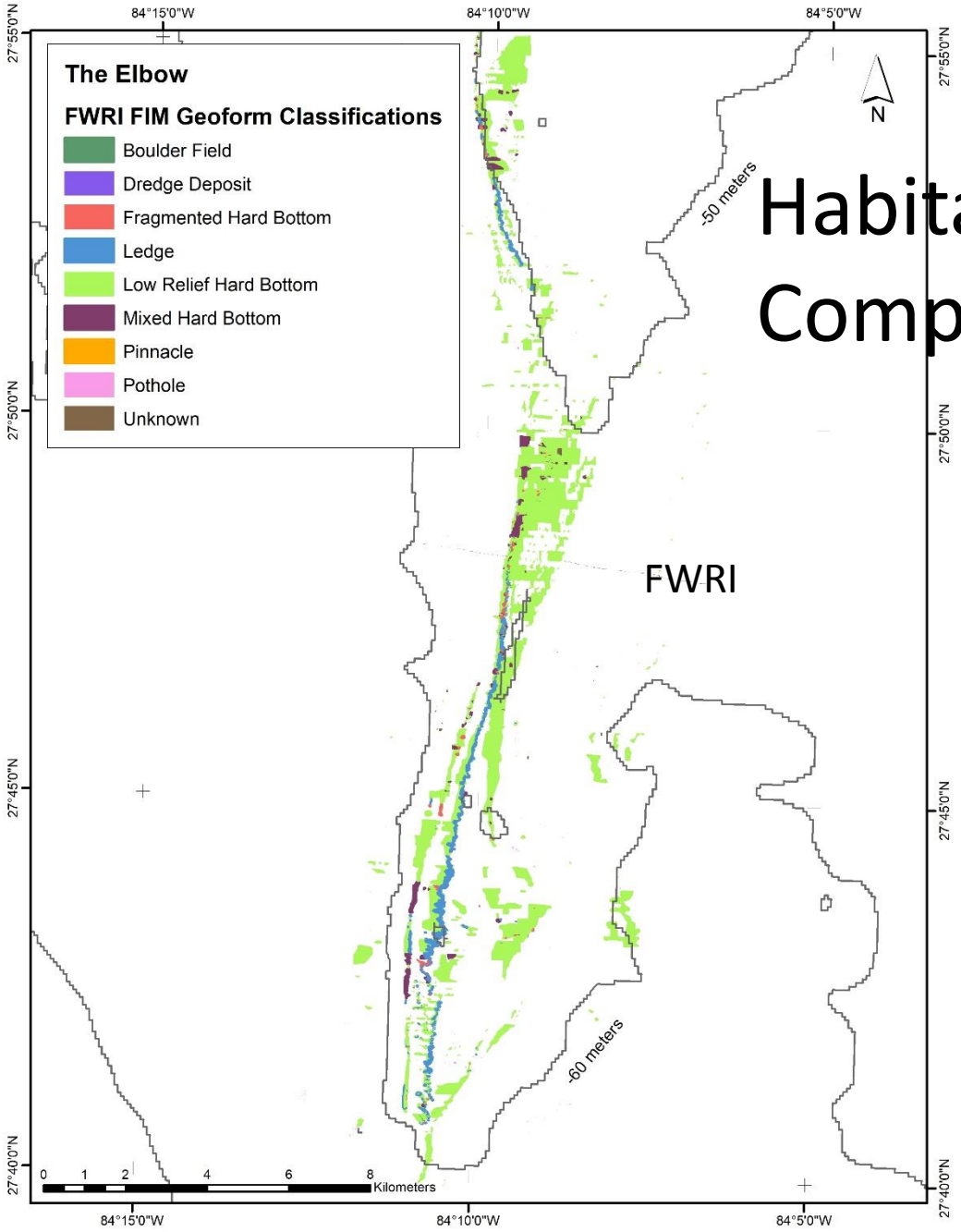

Autocorrelation Pipeline
correlation
0.8
0.6
0.4
0.2
0.0
-0.2
0
5
10
15
20
25
30
35
40
45
50


Gulfstream Pipeline
2016-02-CS03-C01
PL-T3 End
PL-T3 Start
PL-T1 End
129 km
PL-T1 Start
PL-T2 Start
PL-T2 End
0 5 10 20 30 40
Kilometers

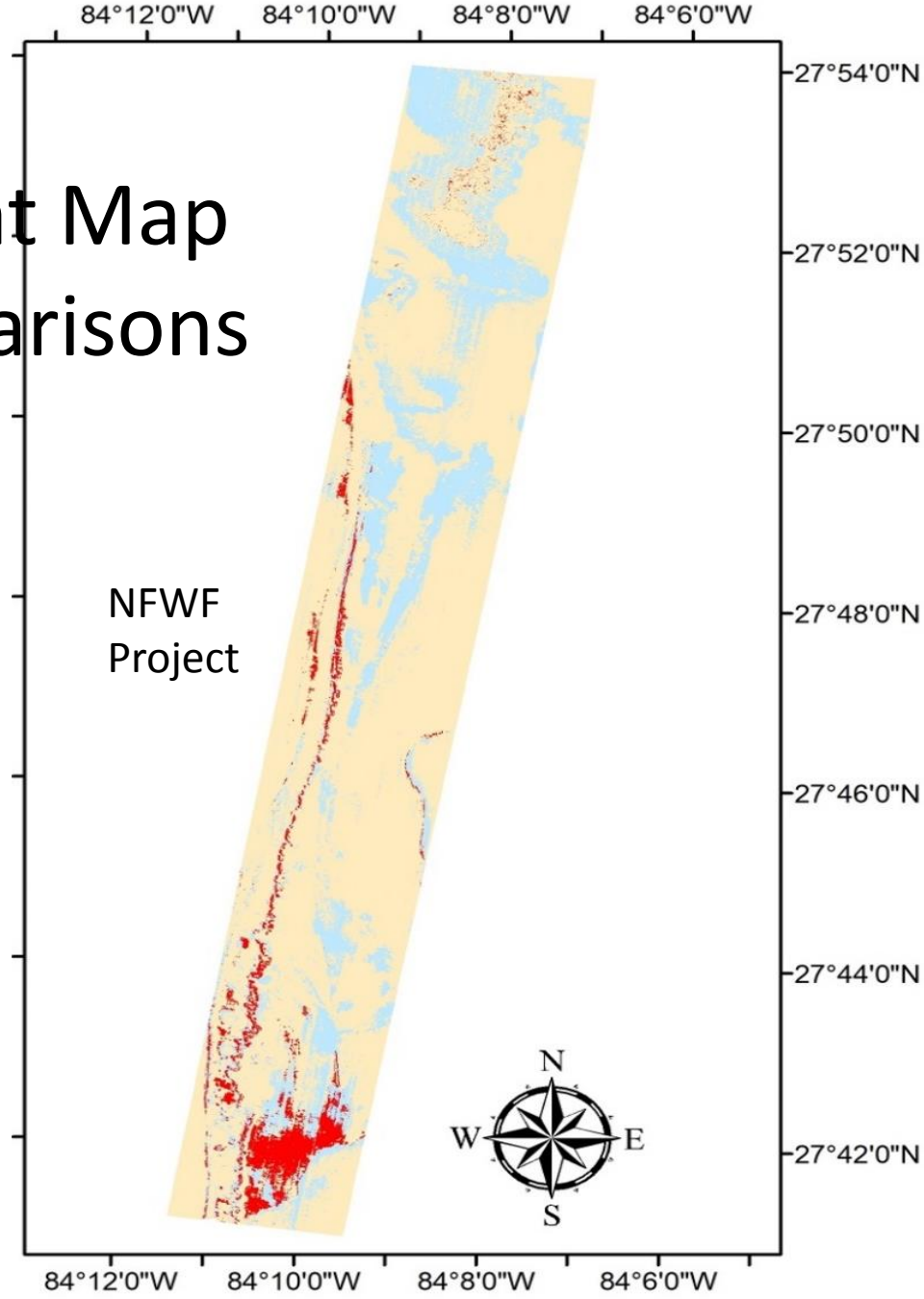


What geologic processes give rise to critical habitat features?

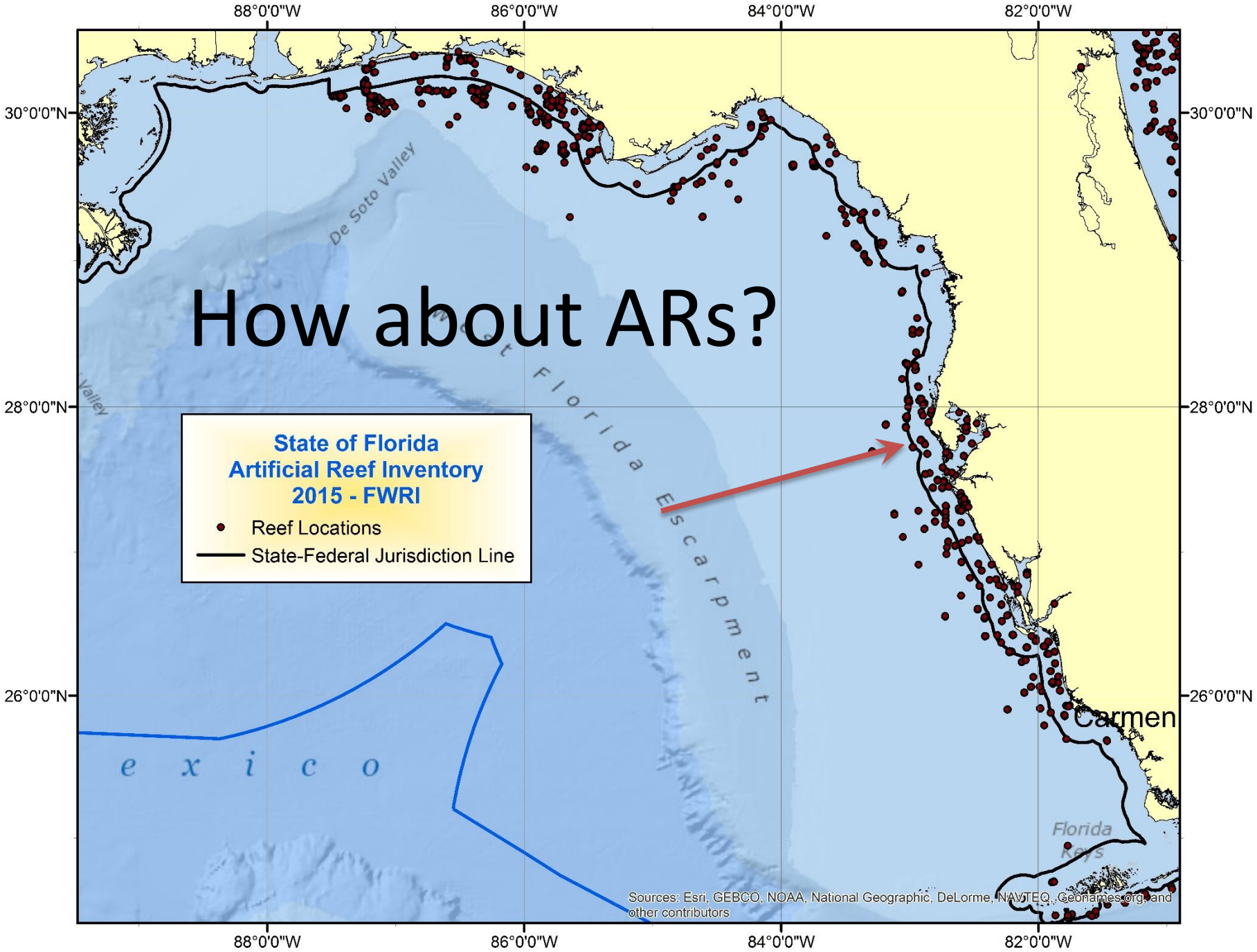
Habitat Map Comparisons



FWRI



NFWF Project


How about ARs?
State of Florida
Artificial Reef Inventory
2015 - FWRI
Reef Locations
State-Federal Jurisdiction Line
88°0'0"W
86°0'0"W
84°0'0"W
82°0'0"W
30°0'0"N
28°0'0"N
26°0'0"N
De Soto Valley
Florida Escarpment
e x i c o
Carmen
Florida Keys
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and other contributors

St. Pete Beach Artificial Reef
5 miles off Pass-a-Grille, FL

The Great Red Snapper Count: C-BASS Scheduled Shiptime (2018)

- April 23-May 2nd (Eastern and some Central GoM)
  - RV Weatherbird II
  - 2 days devoted to CSCAMP operations in the Elbow, all others for RS Pipeline work
- July 5-20 (Central GoM; MS & AL)
  - RV Weatherbird II
- Note: the 2019 field season will focus on the Far Western GoM

Surveying Active/Non-Removed Pipelines in GoM

- Approx. total survey-able pipeline = 13, 292 km
- Depth stratify pipeline?
  - Not nearly as much pipeline in the 100-200 meters depth
  - Murawski et al. CIMAGE cruises found RS concentrated around 75-125 meters based on bottom longline data
- C-BASS Tows
  - Can travel at 3 - 4.5 knots
  - Will use EK60 (and potentially RESON Seabat 7125 MBES) for small surveys of the pipelines overnight to verify location and status (i.e. not buried, removed, etc.)

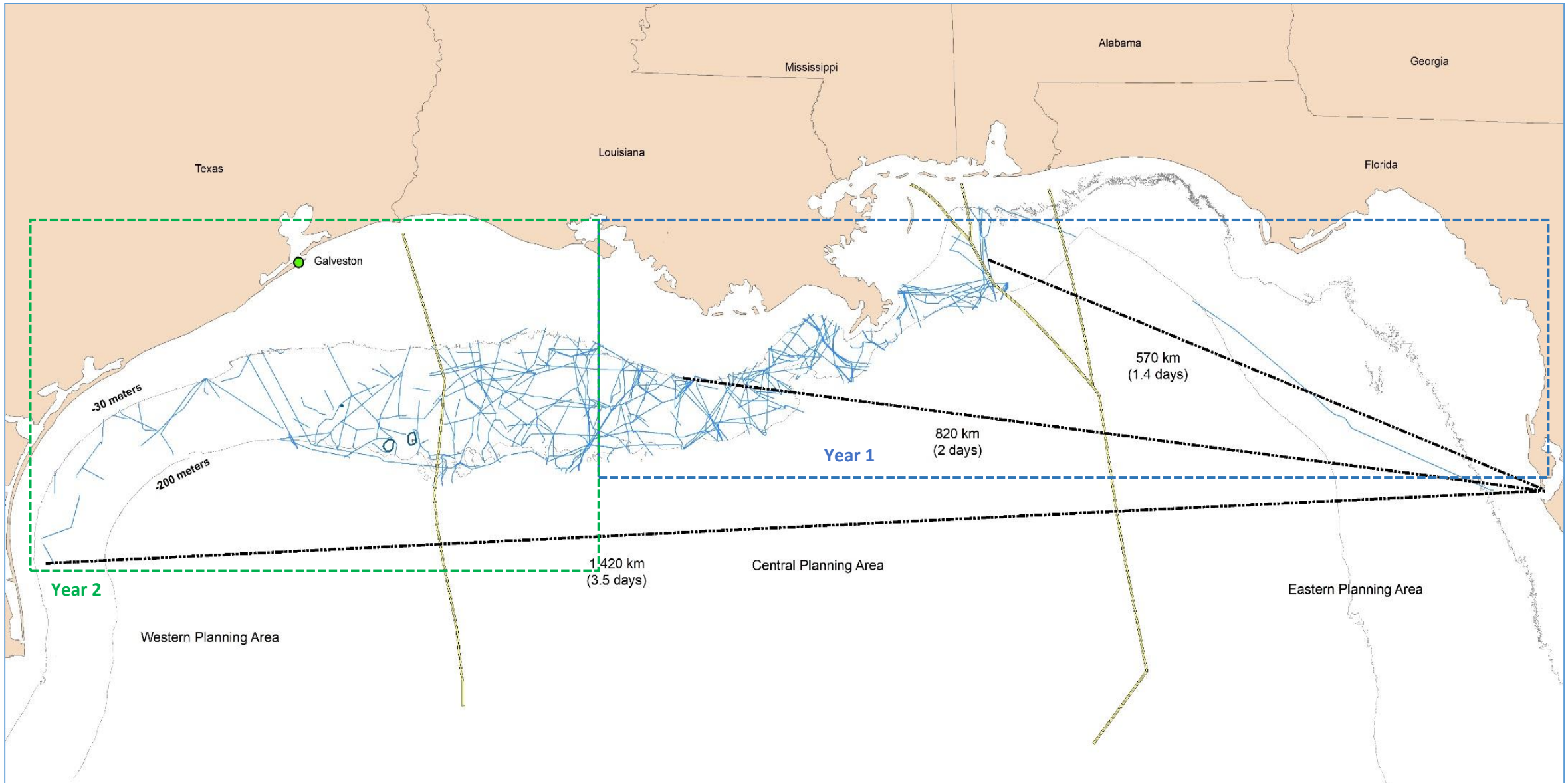
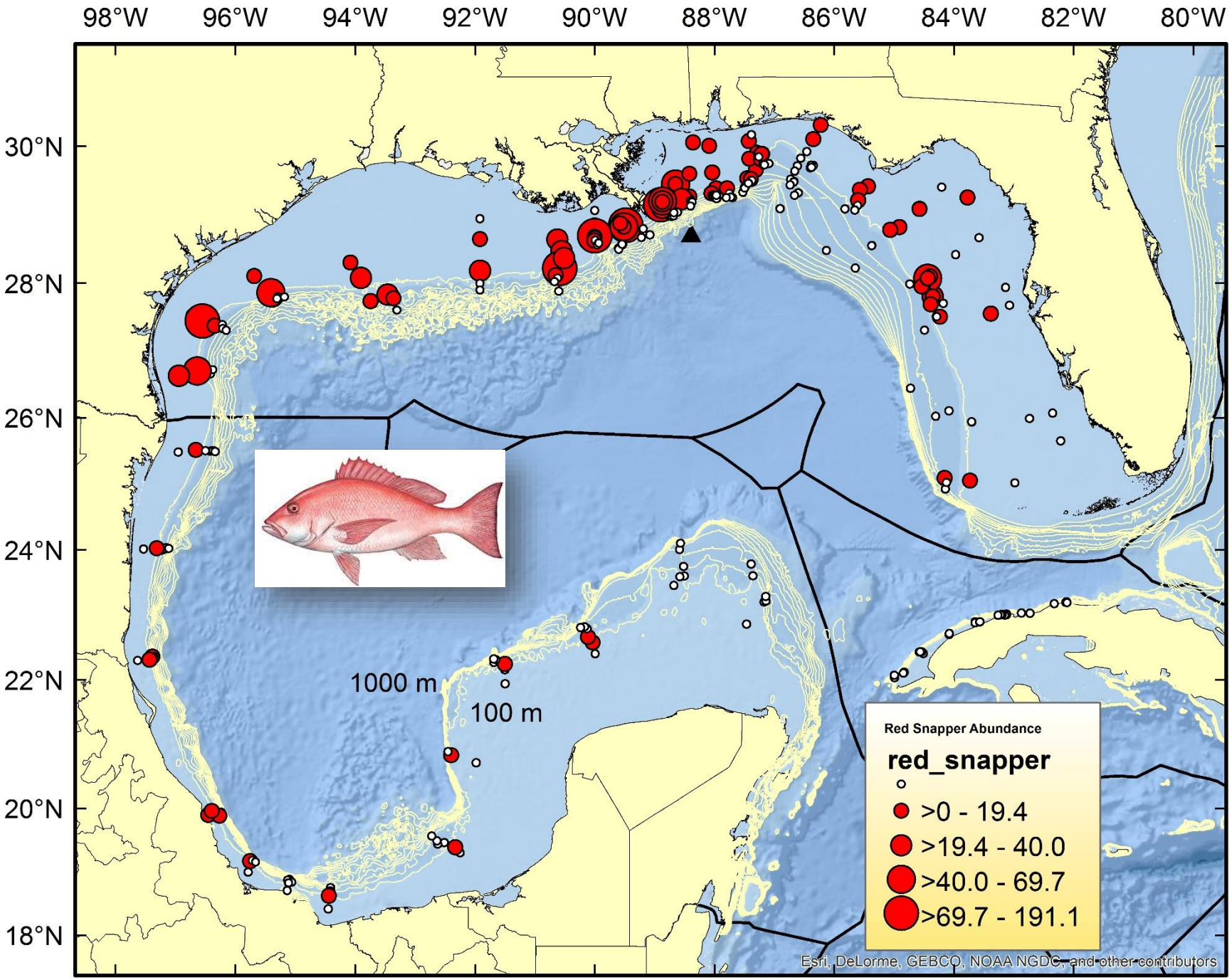


Figure 1. Larger view of potential pipelines to be surveyed (blue lines) and the approximate transit times from Tampa Bay to different regions in the central and western Gulf of Mexico. Dotted boxes indicate where the focus will be in year 1 (2018; blue, central/eastern Gulf) and in year 2 (2019; green, western Gulf)


98°W
96°W
94°W
92°W
90°W
88°W
86°W
84°W
82°W
80°W
30°N
28°N
26°N
24°N
22°N
20°N
18°N
1000 m
100 m
Red Snapper Abundance
red_snapper
>0 - 19.4
>19.4 - 40.0
>40.0 - 69.7
>69.7 - 191.1
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

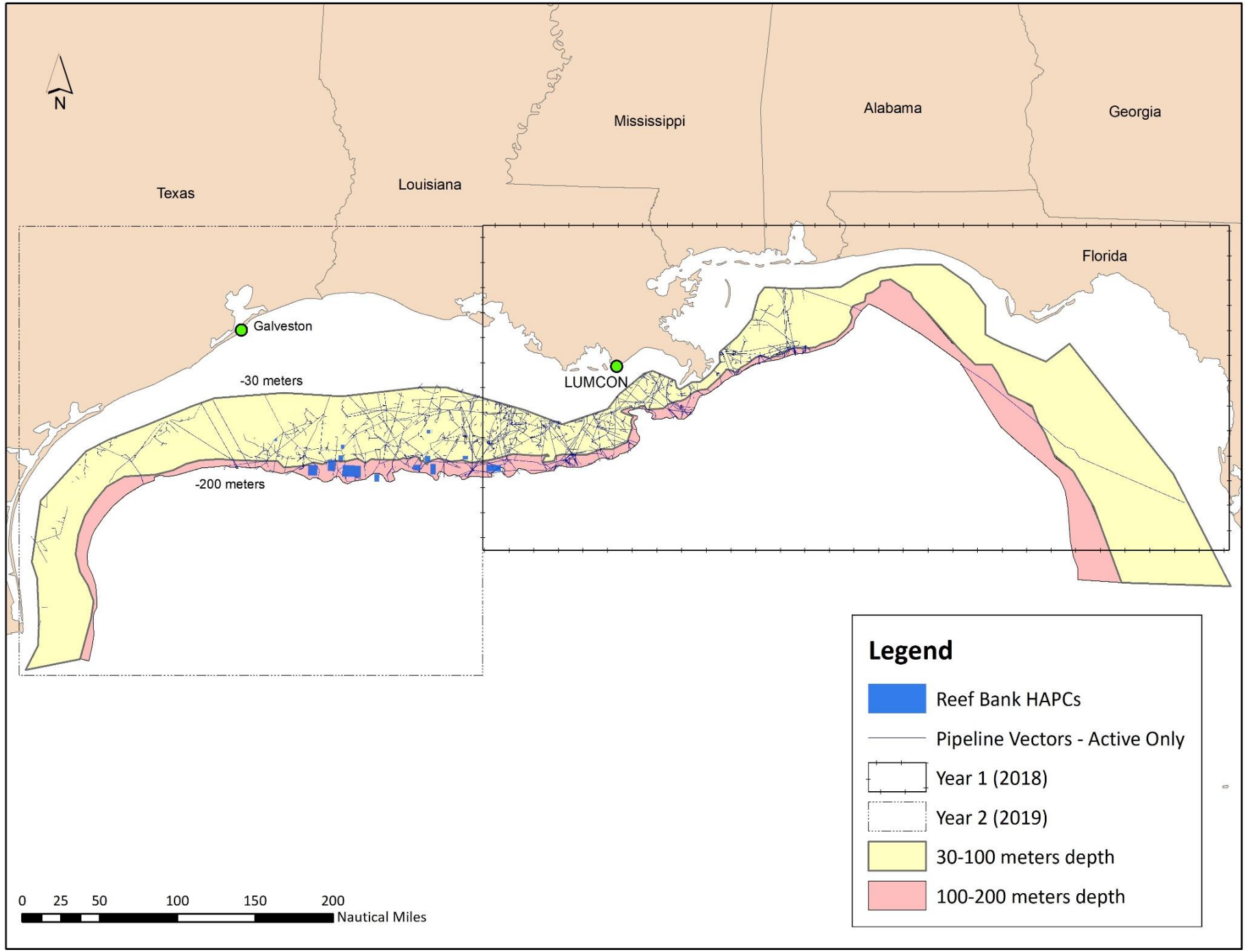
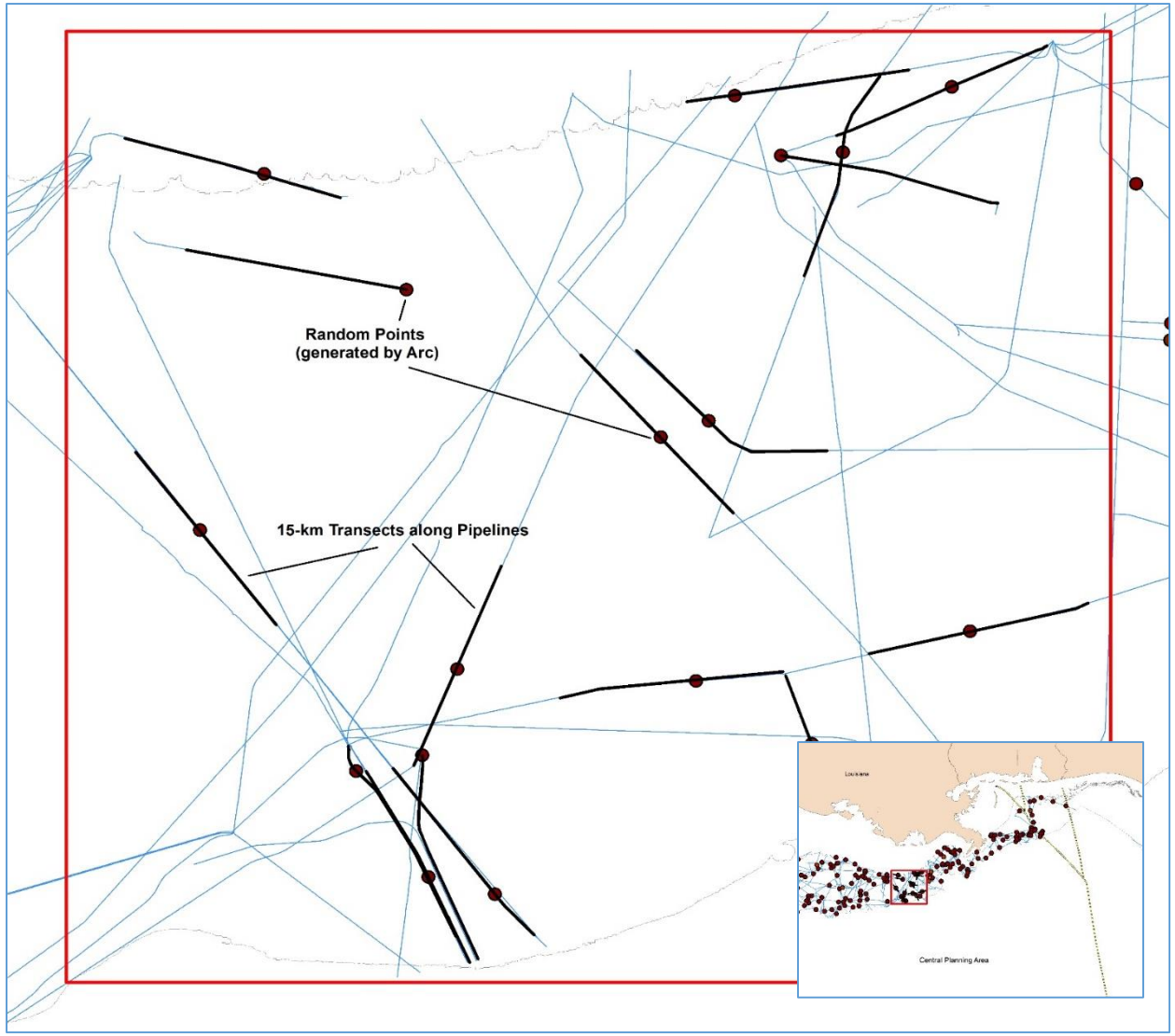


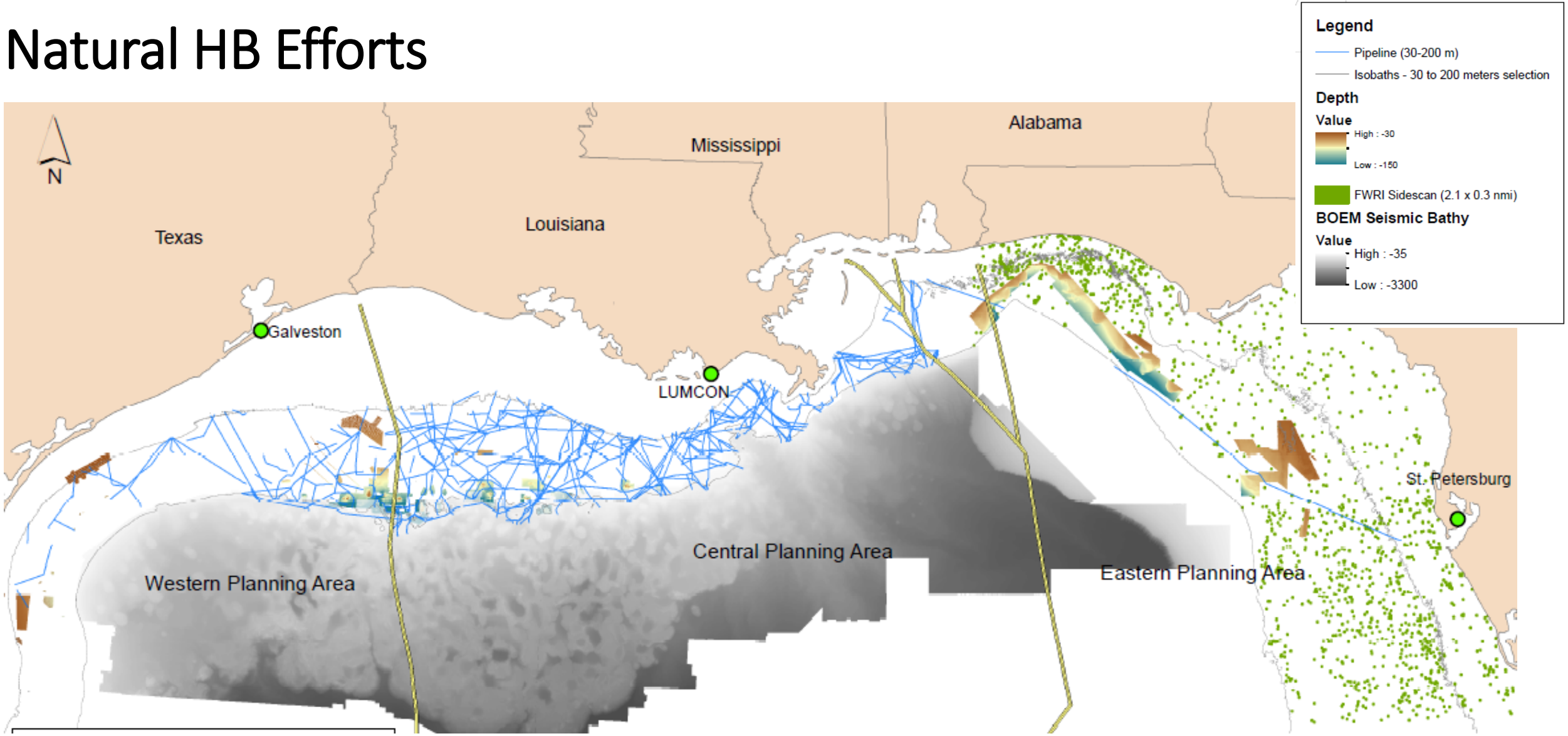
Figure 2. Focus regions for Year 1 (hatched line) and Year 2 (dotted line) along with delineating polygons for the 30-100 meter and 100-200 meter regions.

Towed Video Survey Method

- Randomly generate transect midpoints along the pipelines
  - Extend half the length of the transects in each direction along the pipeline
- 2 – 4 hour tows (the longer the better, more efficient); covers 15-30 km of pipeline
  - How to balance survey design with efficiency (i.e. how to make sure we don't waste too much time moving between pipelines but still use a random site selection)

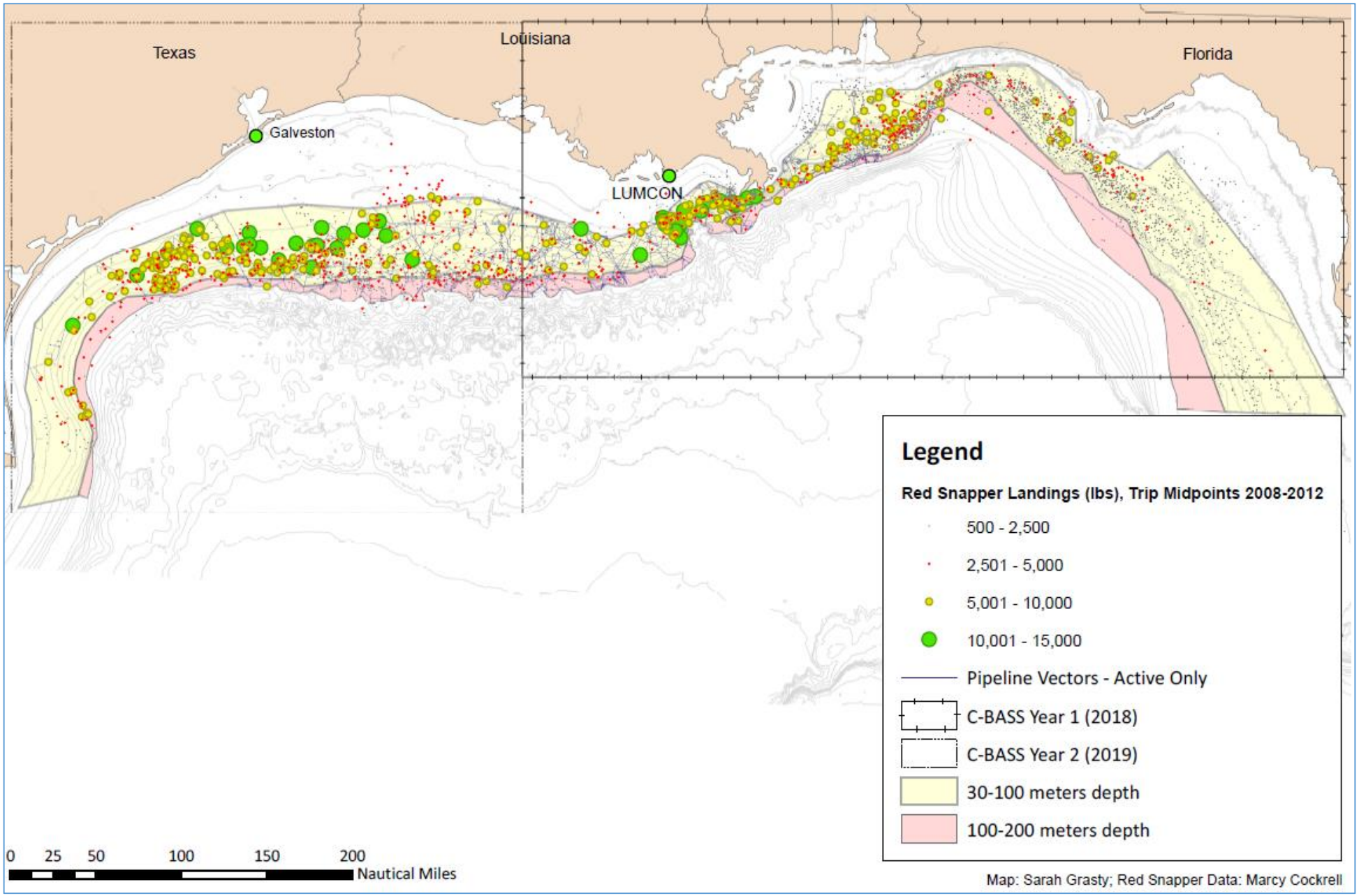


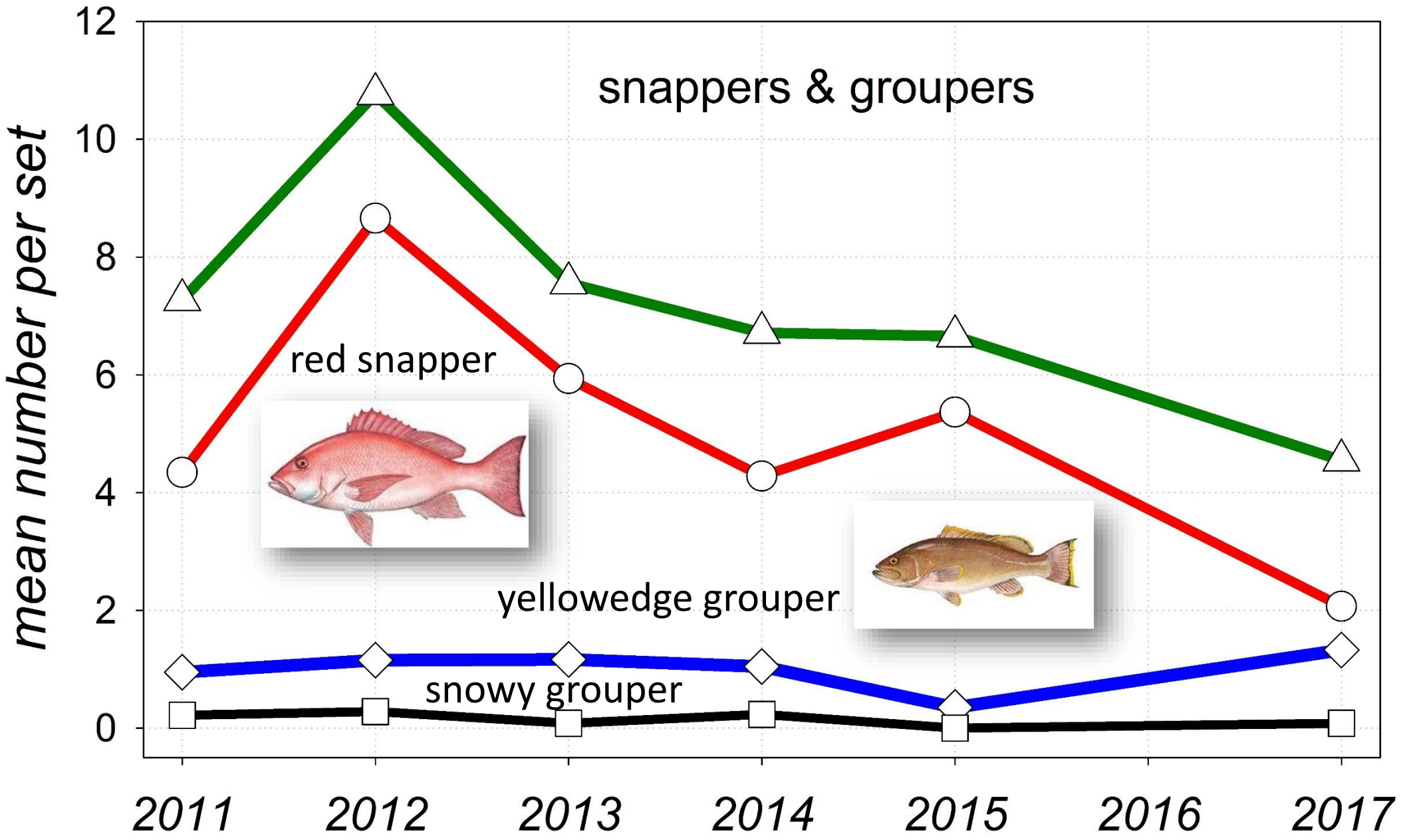
Natural HB Efforts

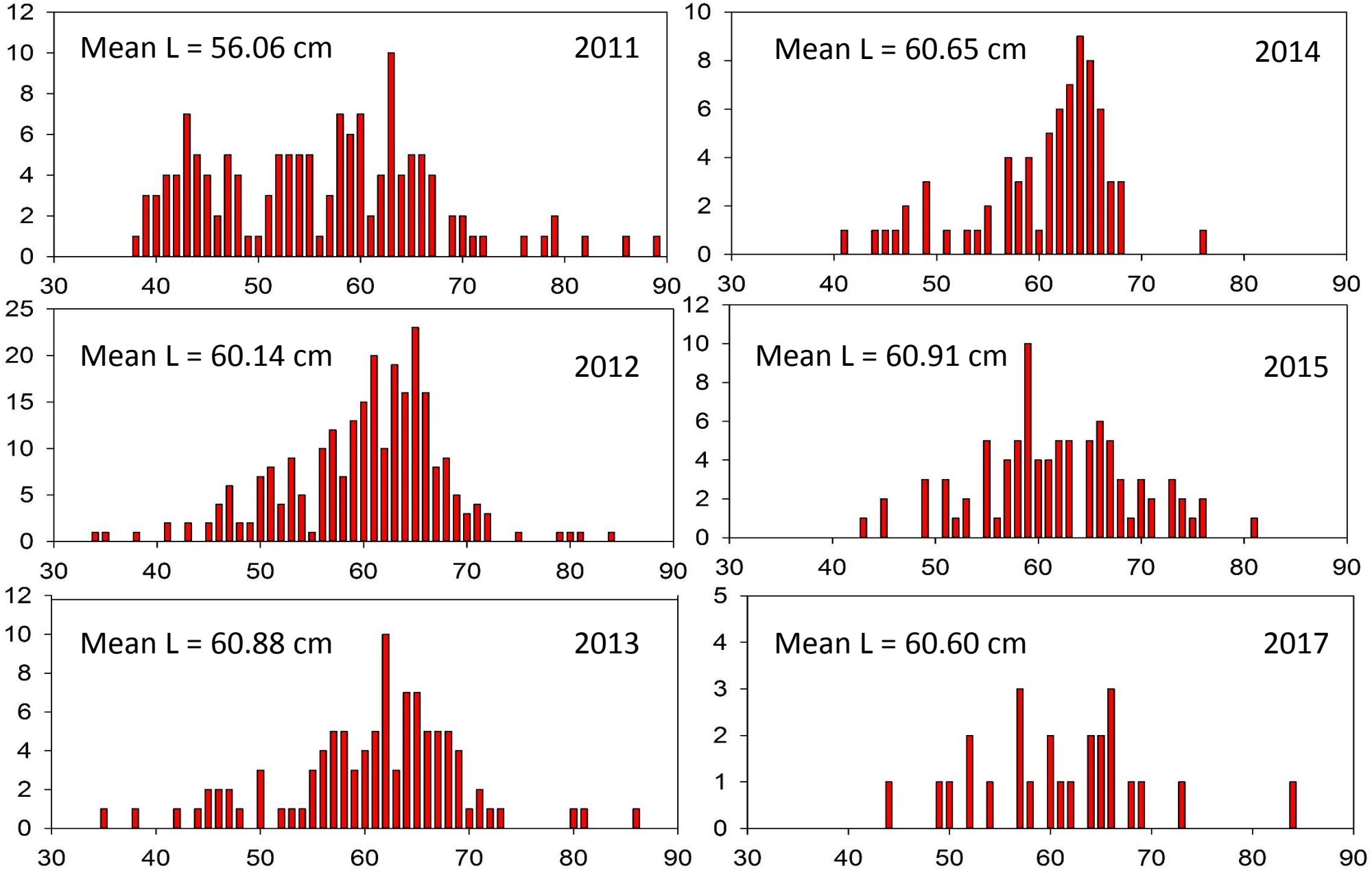


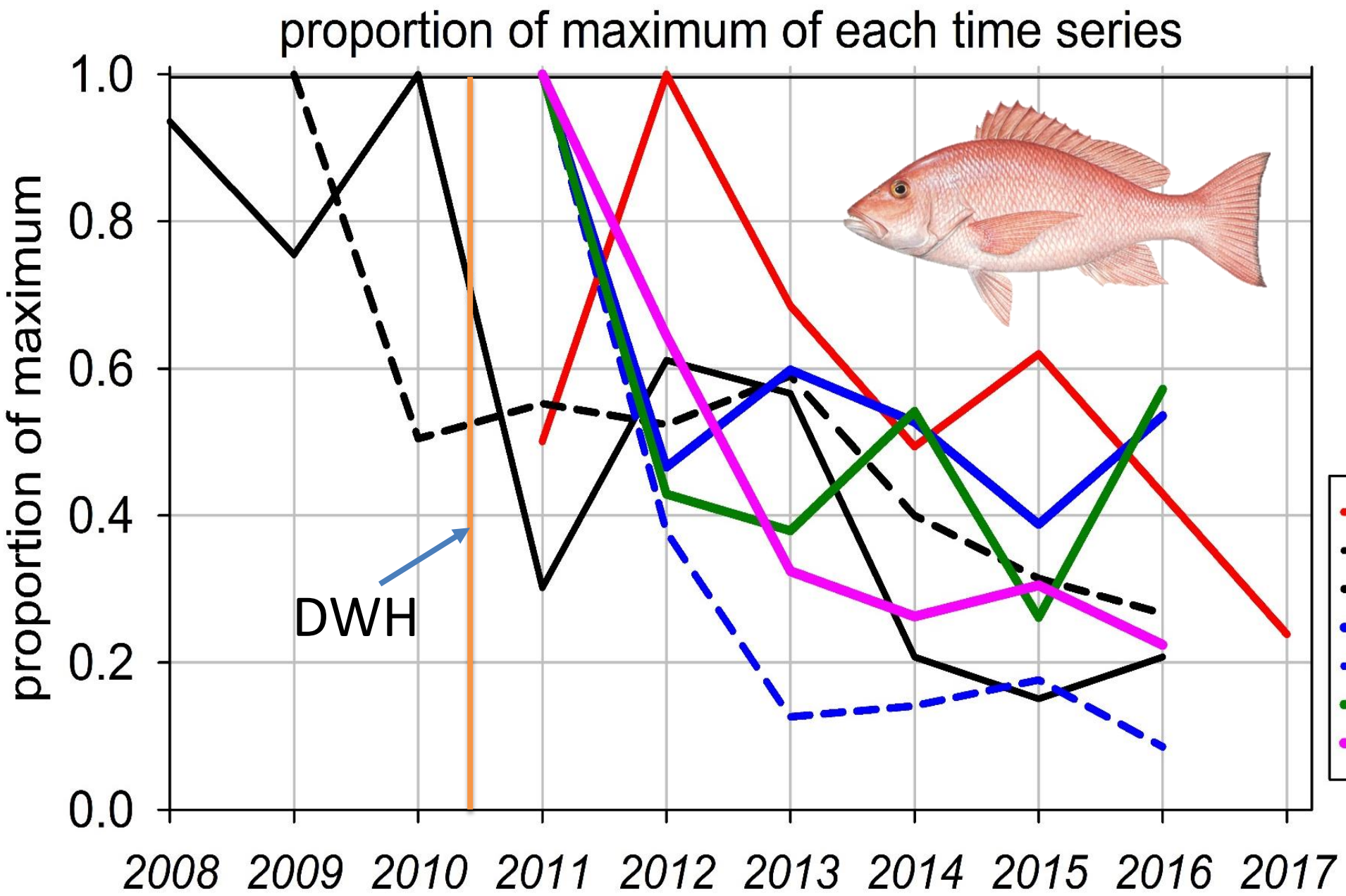
Follow usual CBASS protocol and target/focus effort high relief areas? Or do a more uniform/random transect survey?

Target Areas Using VMS Dataset (2008-2012)

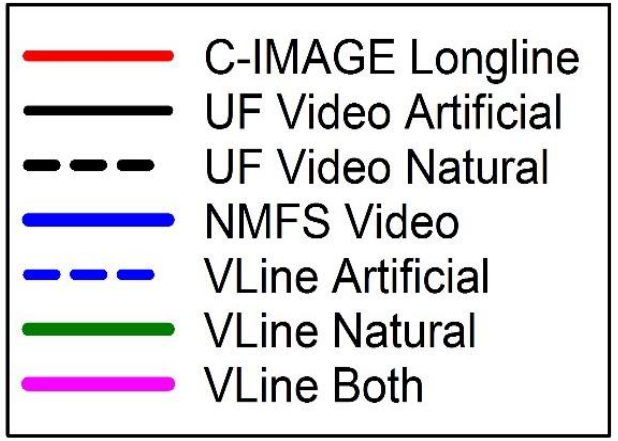



snappers & groupers
red snapper
yellowedge grouper
snowy grouper
mean number per set
12
10
8
6
4
2
0
2011
2012
2013
2014
2015
2016
2017


Mean L = 56.06 cm
2011
Mean L = 60.65 cm
2014
Mean L = 60.14 cm
2012
Mean L = 60.91 cm
2015
Mean L = 60.88 cm
2013
Mean L = 60.60 cm
2017



NB: Significant reductions in red snapper numbers after DWH *<u>in all time series</u>*



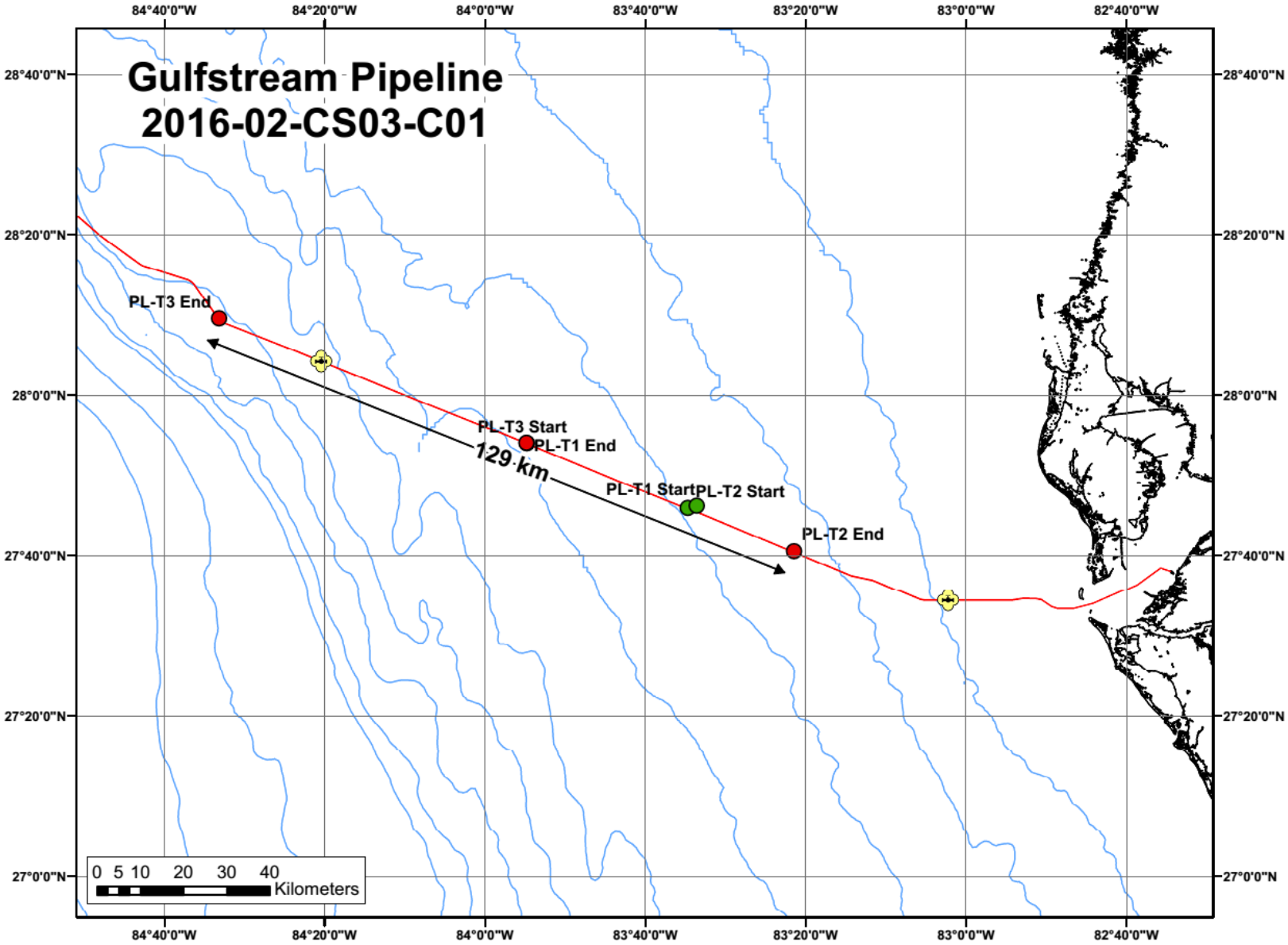
Mapping Priorities for 2018-2019

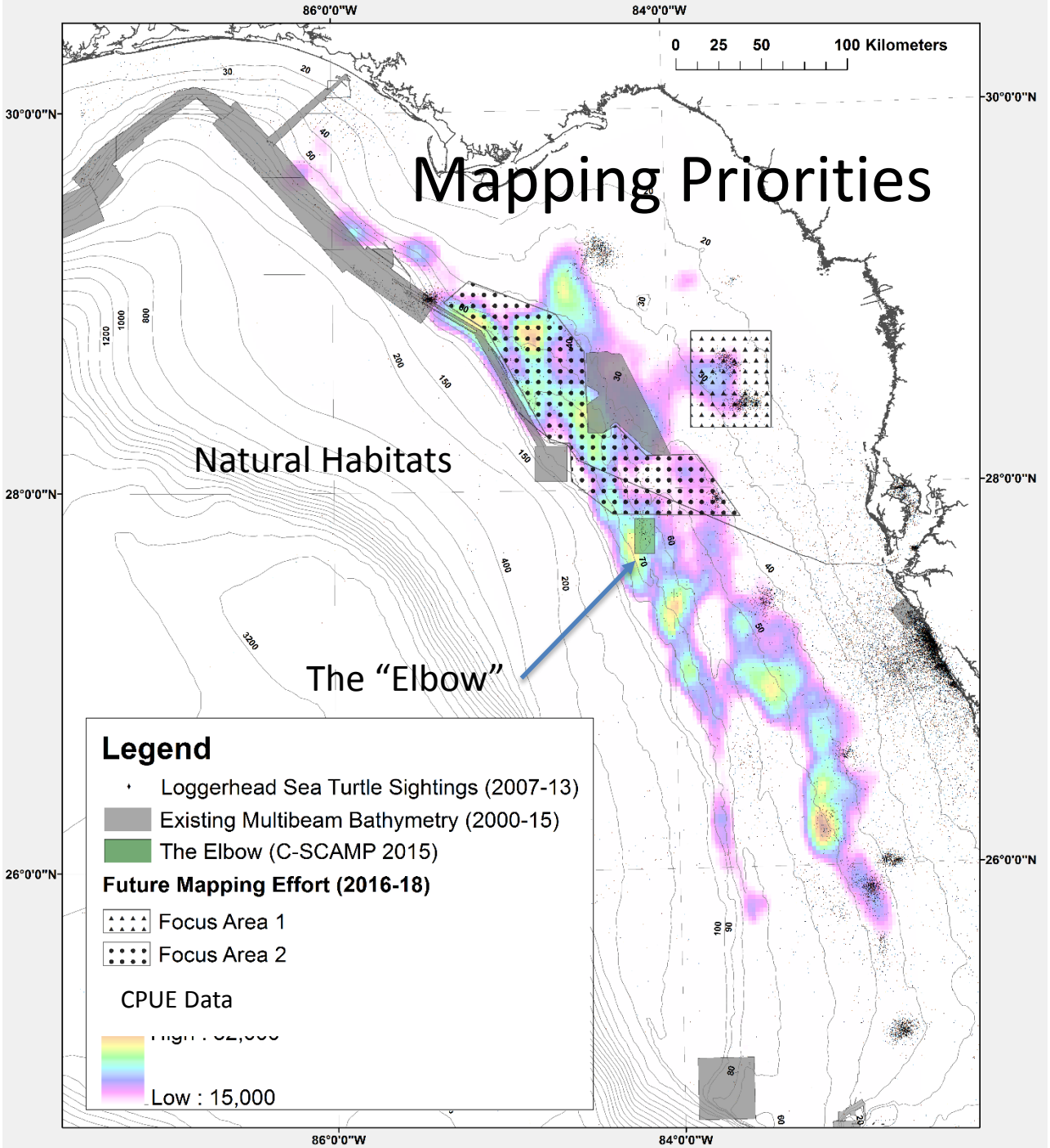
Our Team

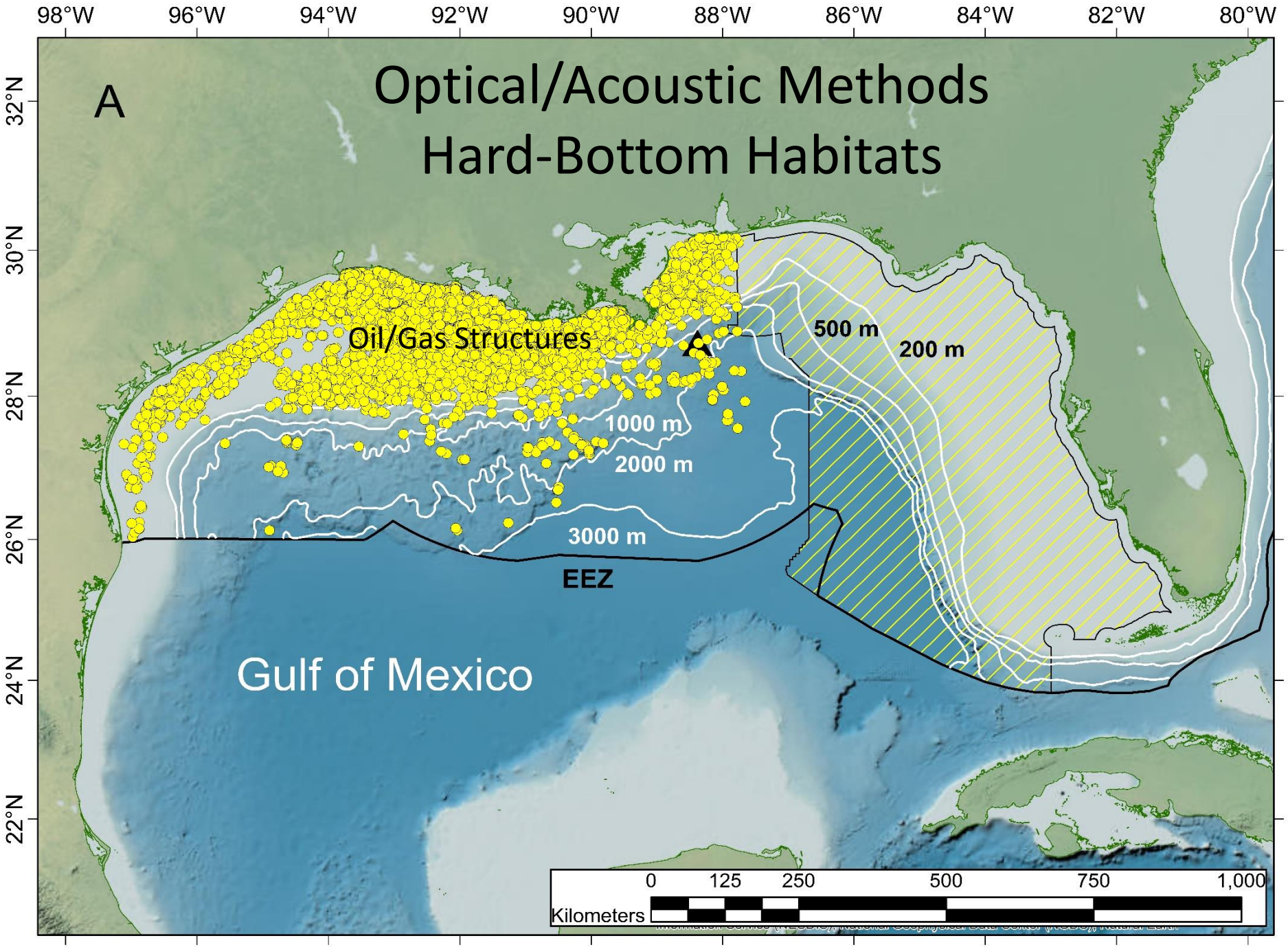
C-SCAMP
Continental Shelf Characterization, Assessment and Mapping Project

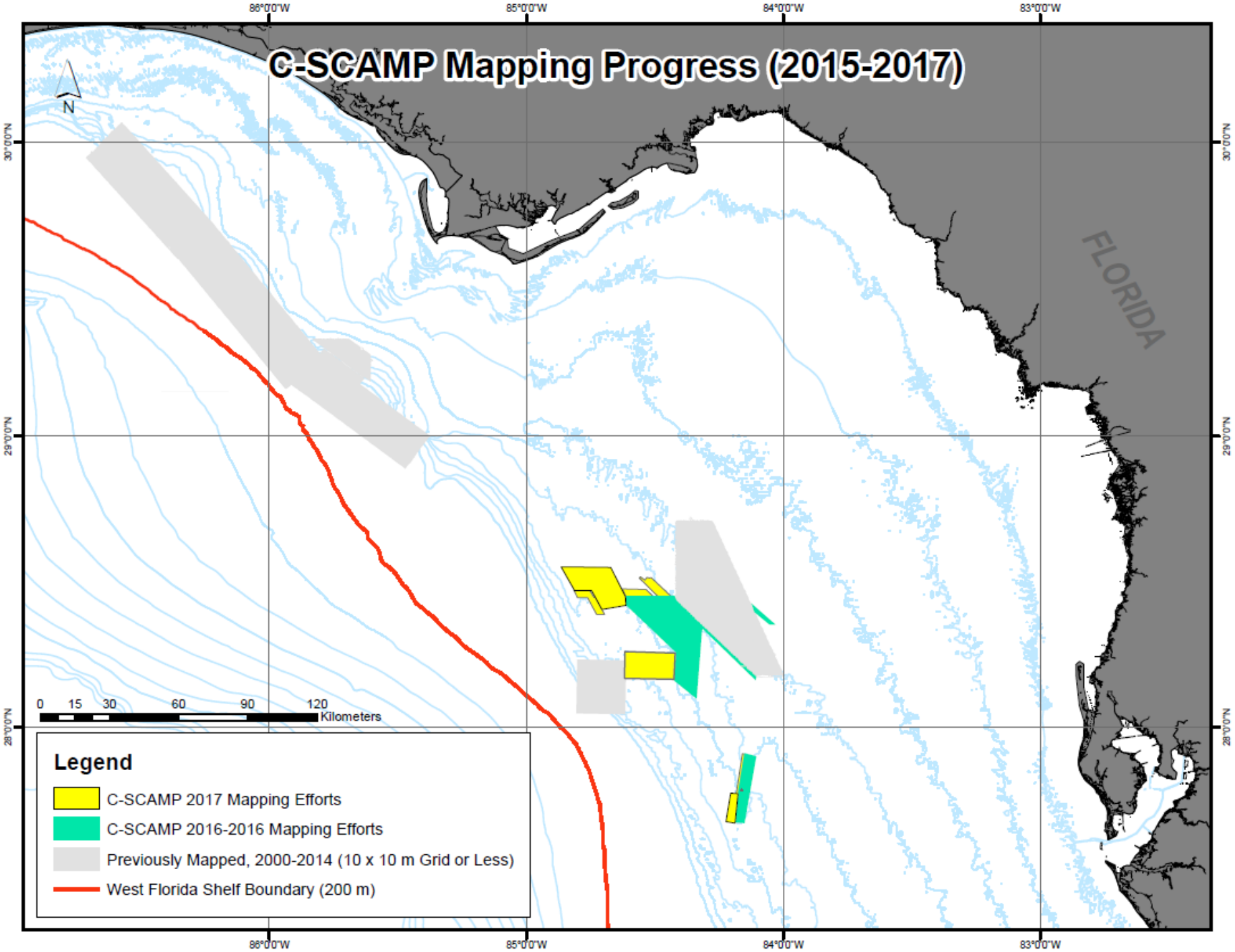
Backup Slides

Gulfstream Pipeline

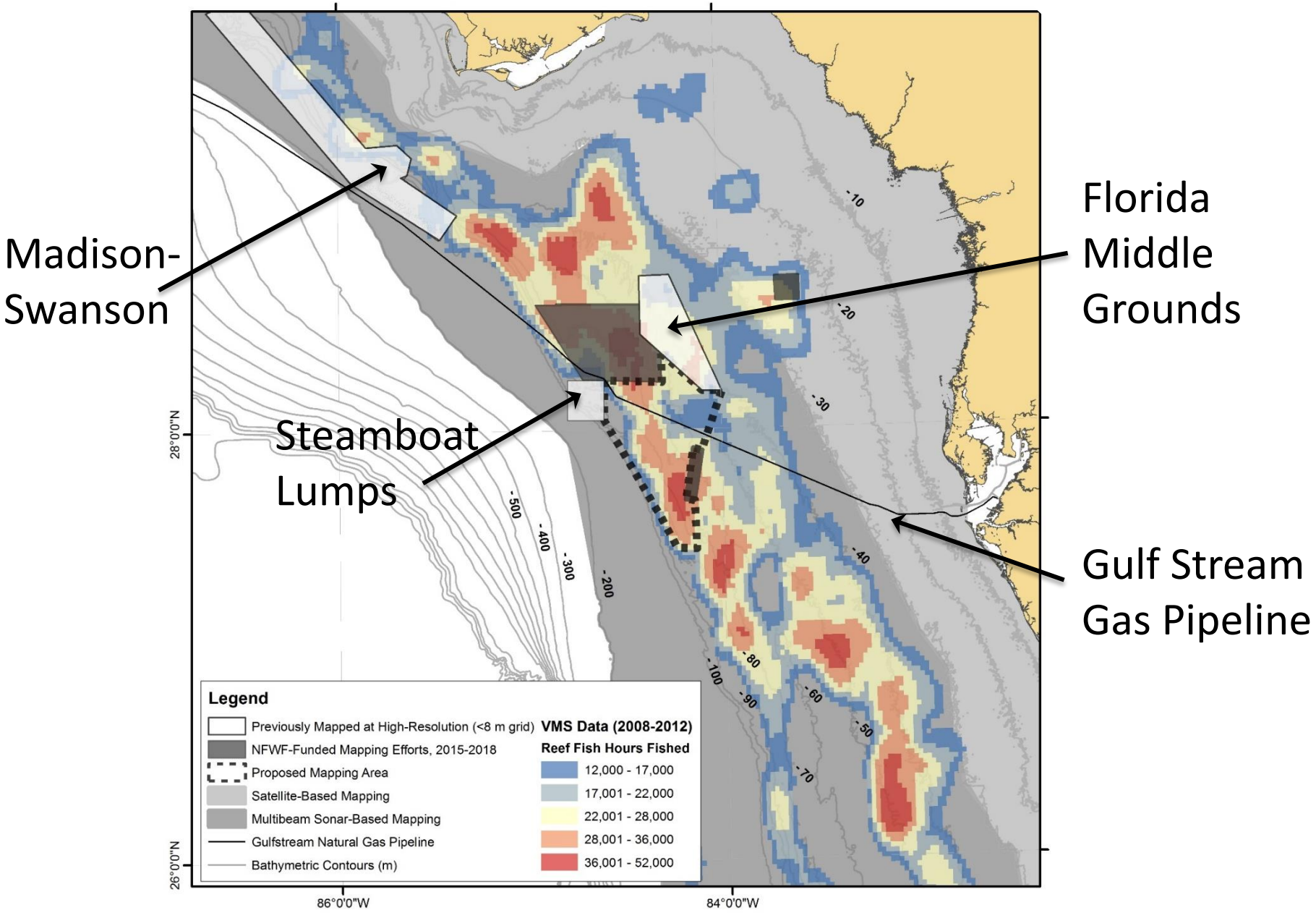



Mapping Priorities
Natural Habitats
The "Elbow"
0 25 50 100 Kilometers
86°0'0"W
84°0'0"W
30°0'0"N
28°0'0"N
26°0'0"N
Legend
Loggerhead Sea Turtle Sightings (2007-13)
Existing Multibeam Bathymetry (2000-15)
The Elbow (C-SCAMP 2015)
Future Mapping Effort (2016-18)
Focus Area 1
Focus Area 2
CPUE Data
Low : 15,000

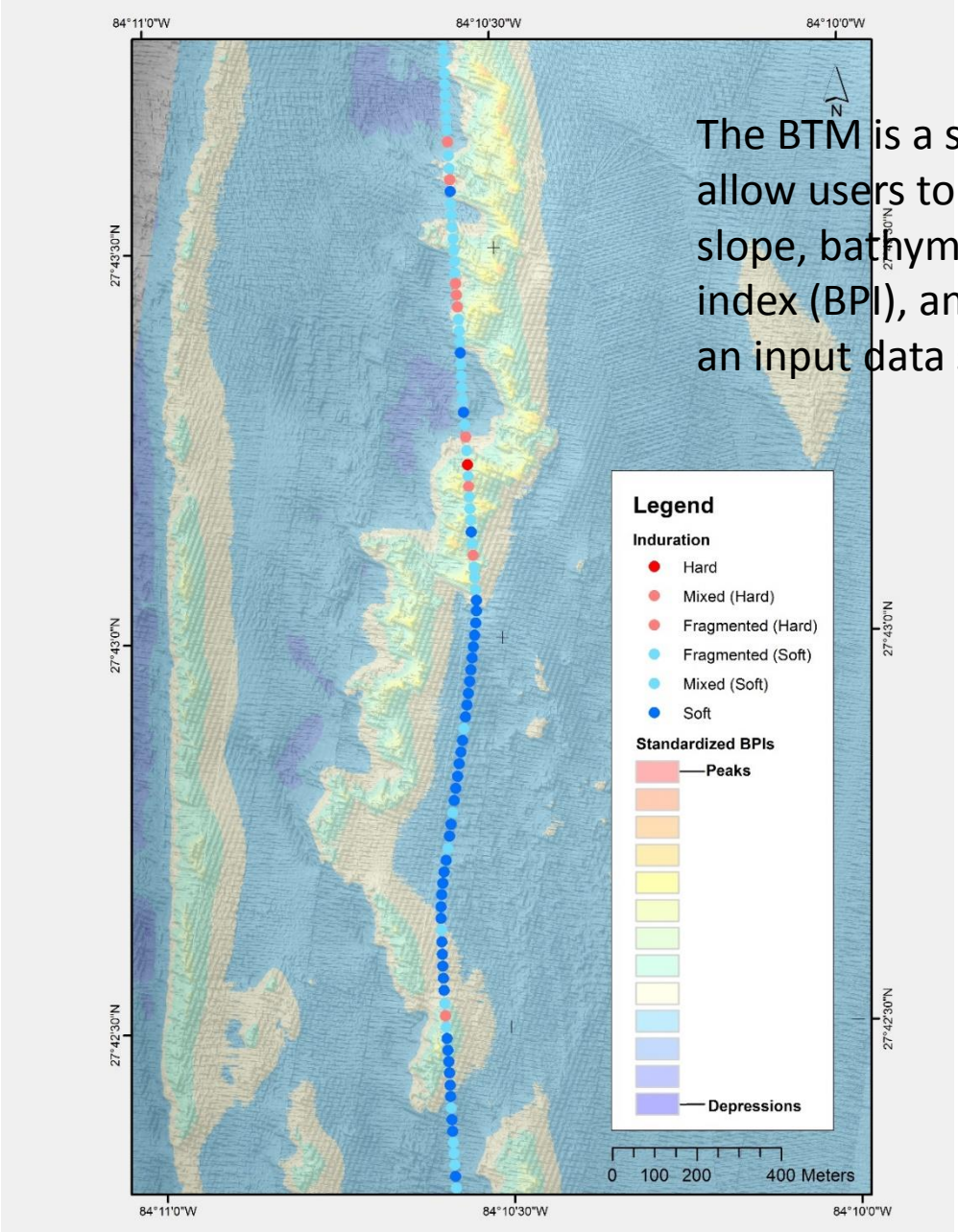

A
Optical/Acoustic Methods
Hard-Bottom Habitats
Oil/Gas Structures
500 m
200 m
1000 m
2000 m
3000 m
EEZ
Gulf of Mexico
98°W
96°W
94°W
92°W
90°W
88°W
86°W
84°W
82°W
80°W
32°N
30°N
28°N
26°N
24°N
22°N
0
125
250
500
750
1,000
Kilometers


C-SCAMP Mapping Progress (2015-2017)
N
FLORIDA
86°0'0"W
85°0'0"W
84°0'0"W
83°0'0"W
30°0'0"N
29°0'0"N
28°0'0"N
0 15 30 60 90 120
Kilometers
Legend
C-SCAMP 2017 Mapping Efforts
C-SCAMP 2016-2016 Mapping Efforts
Previously Mapped, 2000-2014 (10 x 10 m Grid or Less)
West Florida Shelf Boundary (200 m)

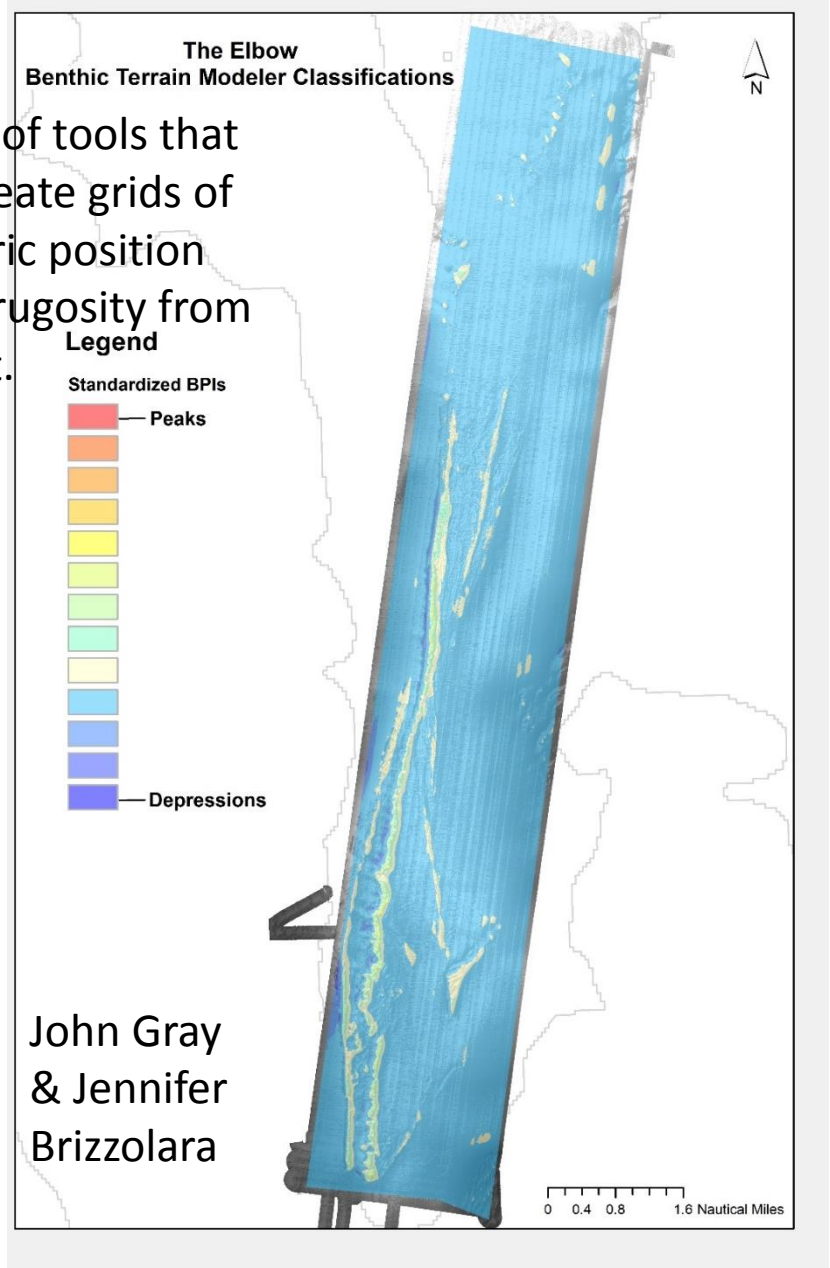
Identifying Habitat Areas of Particular Concern (HAPCs)



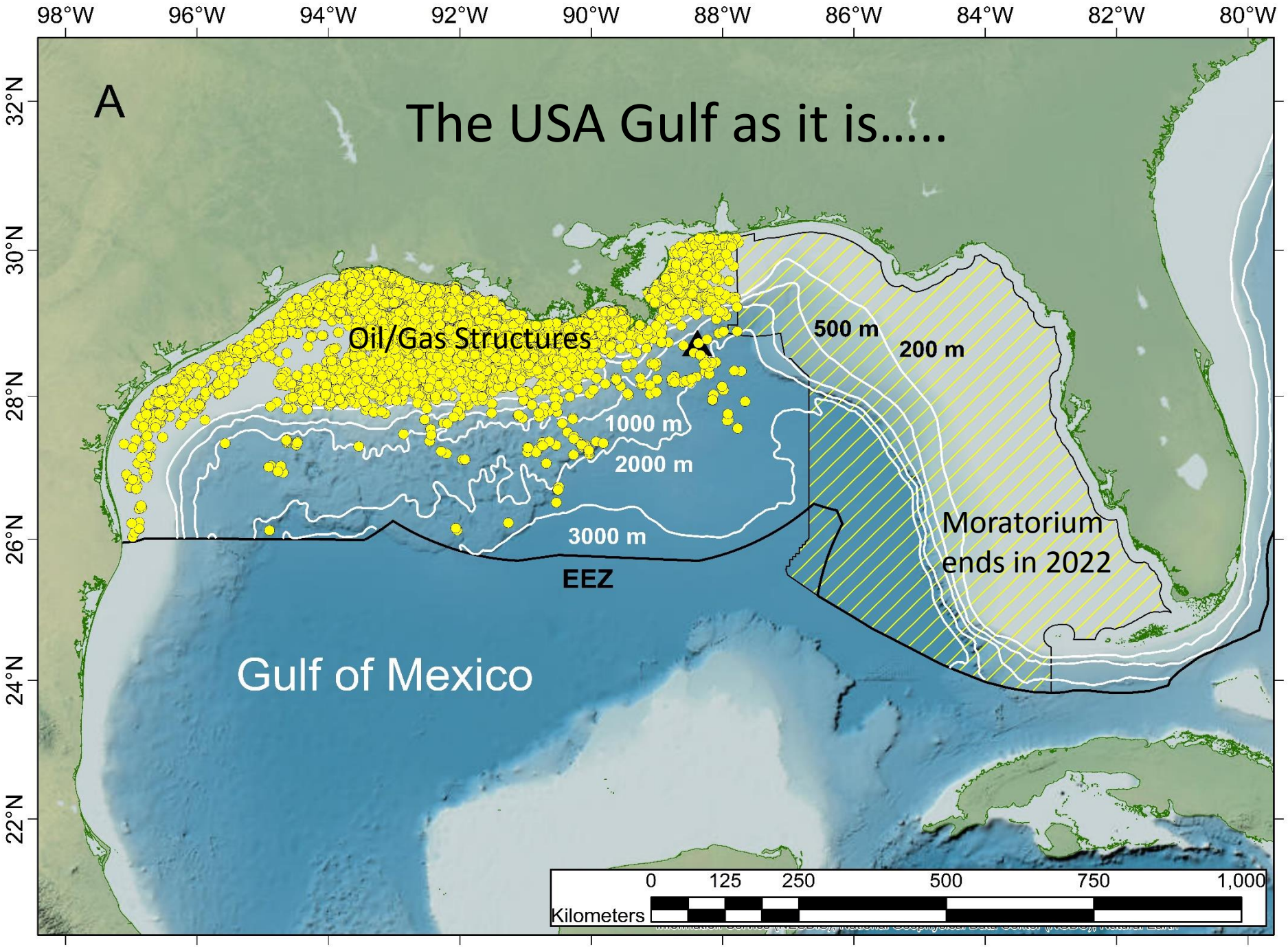
Auto Classification of Habitat Using Software Options – ARC-GIS

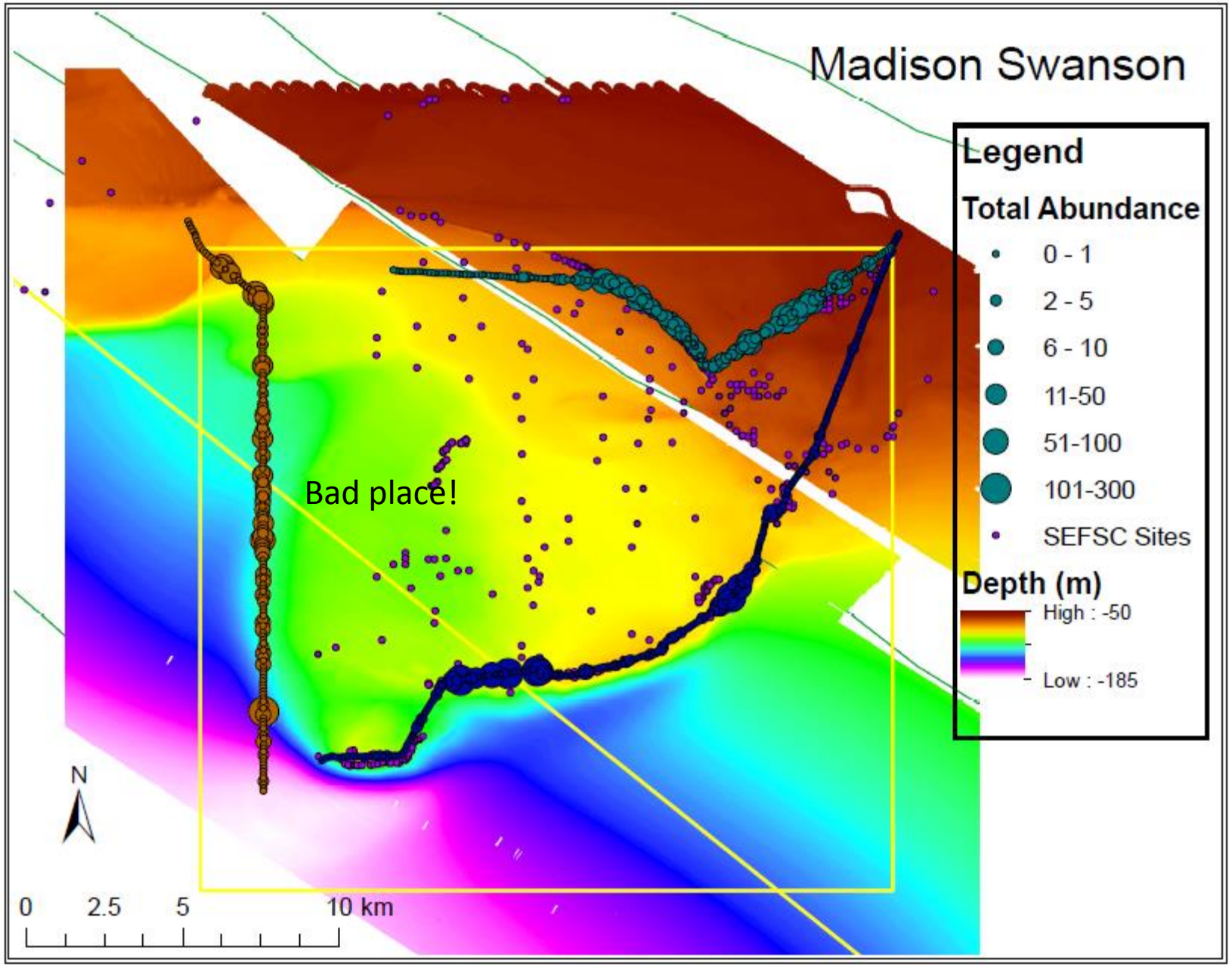


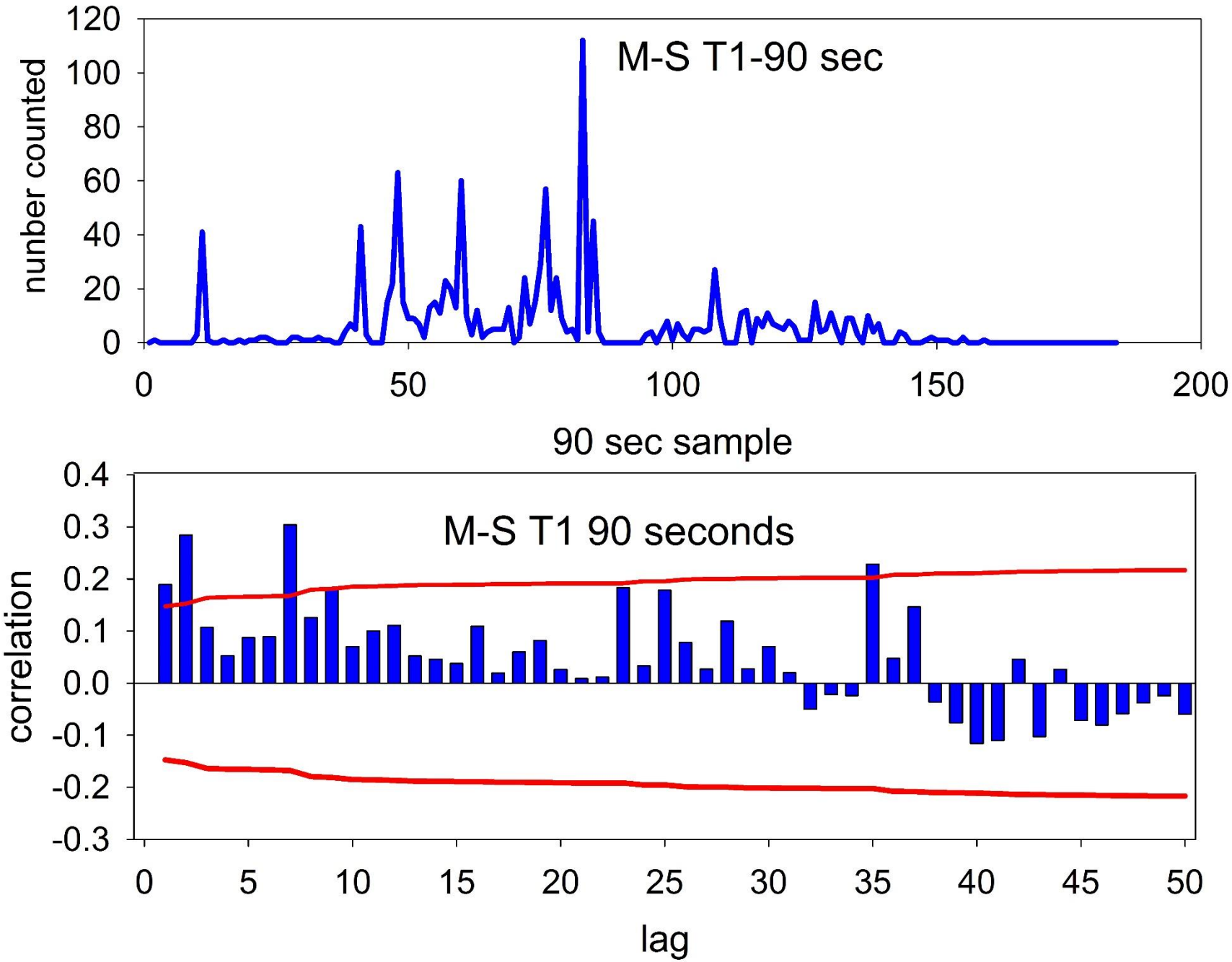
The BTM is a set of tools that allow users to create grids of slope, bathymetric position index (BPI), and rugosity from an input data set.

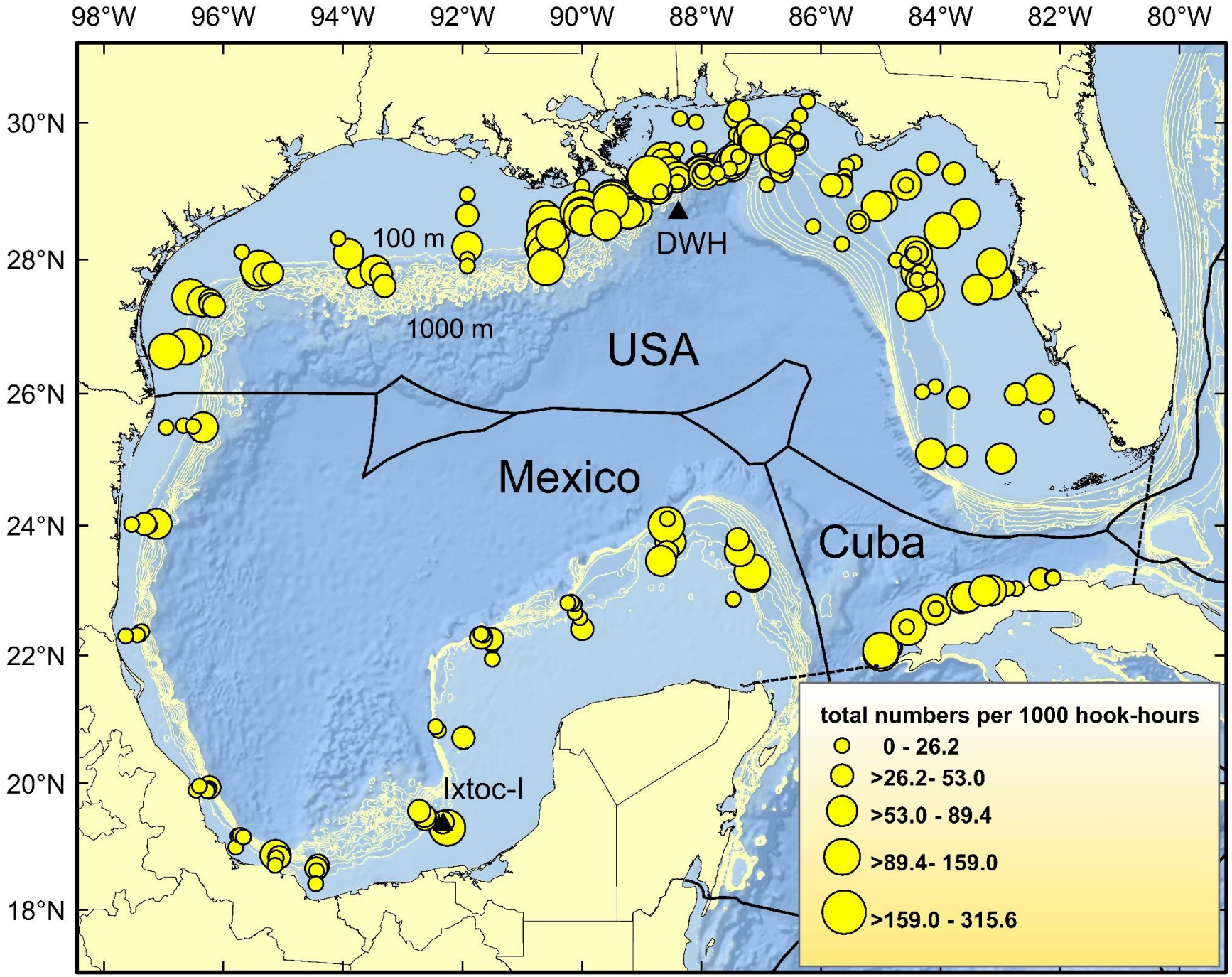


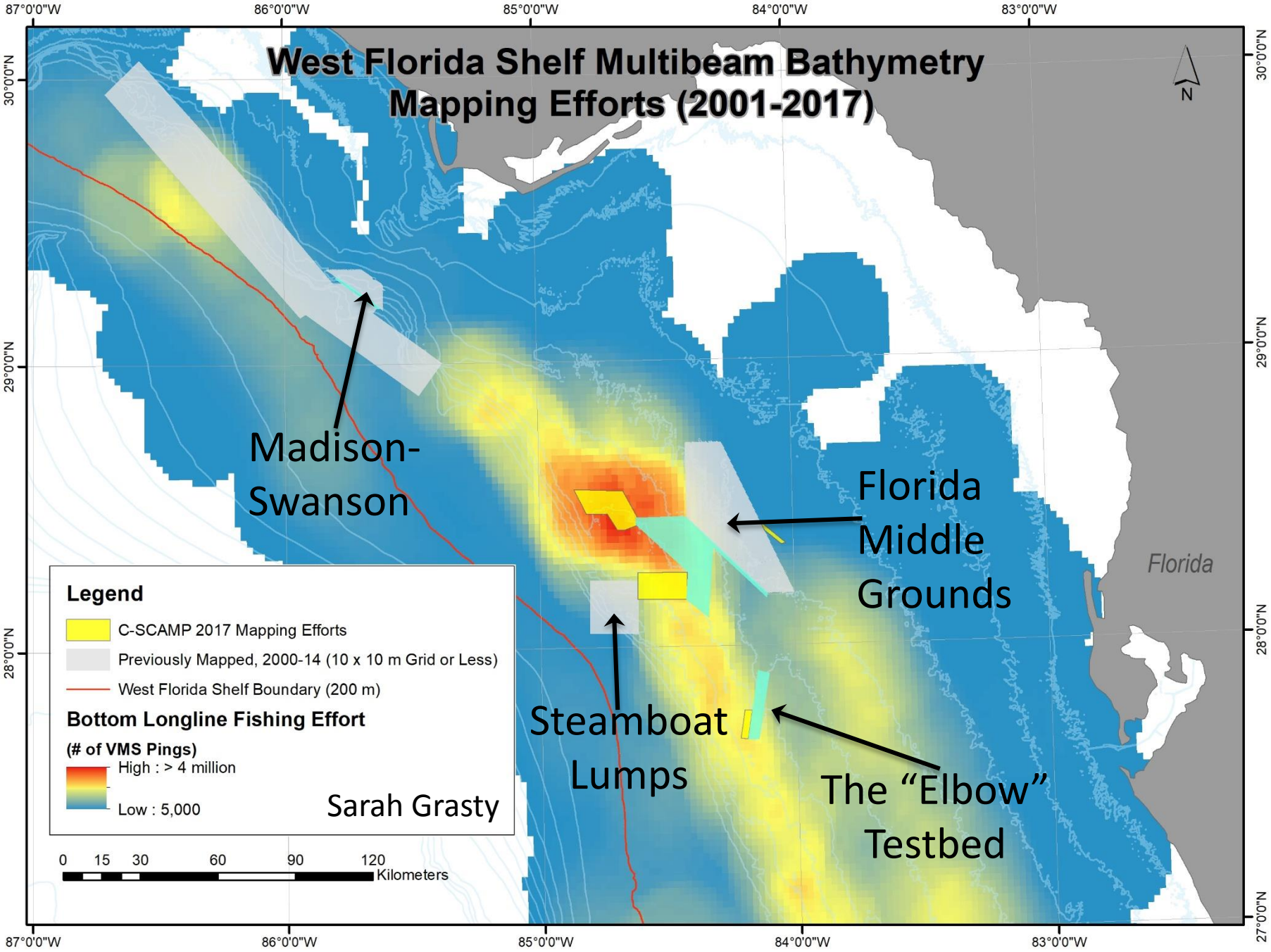
John Gray & Jennifer Brizzolara


A
The USA Gulf as it is…..
Oil/Gas Structures
500 m
200 m
1000 m
2000 m
3000 m
EEZ
Moratorium
ends in 2022
Gulf of Mexico
98°W
96°W
94°W
92°W
90°W
88°W
86°W
84°W
82°W
80°W
32°N
30°N
28°N
26°N
24°N
22°N
0
125
250
500
750
1,000
Kilometers


Madison Swanson
Legend
Total Abundance
0 - 1
2 - 5
6 - 10
11-50
51-100
101-300
SEFSC Sites
Depth (m)
High : -50
Low : -185
Bad place!
N
0
2.5
5
10 km


M-S T1-90 sec
nunber counted
120
100
80
60
40
20
0
0
50
100
150
200
90 sec sample
M-S T1 90 seconds
correlation
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
0
5
10
15
20
25
30
35
40
45
50
lag


98°W
96°W
94°W
92°W
90°W
88°W
86°W
84°W
82°W
80°W
30°N
28°N
26°N
24°N
22°N
20°N
18°N
100 m
1000 m
DWH
USA
Mexico
Cuba
Ixtoc-I
total numbers per 1000 hook-hours
0 - 26.2
>26.2- 53.0
>53.0 - 89.4
>89.4- 159.0
>159.0 - 315.6


West Florida Shelf Multibeam Bathymetry
Mapping Efforts (2001-2017)
87°0'0"W
86°0'0"W
85°0'0"W
84°0'0"W
83°0'0"W
30°0'0"N
29°0'0"N
28°0'0"N
27°0'0"N
N
Madison-
Swanson
Florida
Middle
Grounds
Steamboat
Lumps
The "Elbow"
Testbed
Florida
Legend
C-SCAMP 2017 Mapping Efforts
Previously Mapped, 2000-14 (10 x 10 m Grid or Less)
West Florida Shelf Boundary (200 m)
Bottom Longline Fishing Effort
(# of VMS Pings)
High : > 4 million
Low : 5,000
Sarah Grasty
0 15 30 60 90 120
Kilometers

- **DIDSON SONAR** – tested in August 2014 cruise
- "See" **up to 12 meters in front of C-BASS** (Boswell et al. 2008)
- Cannot ID species, anticipate being able to **estimate proportions of fish reacting**

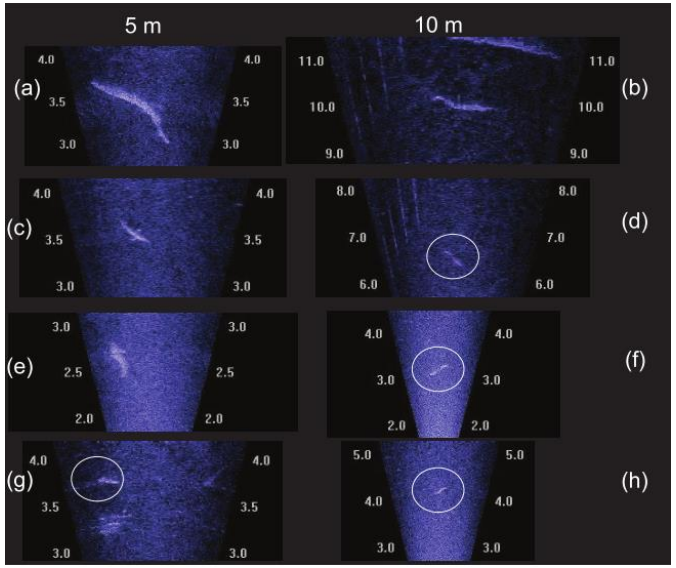
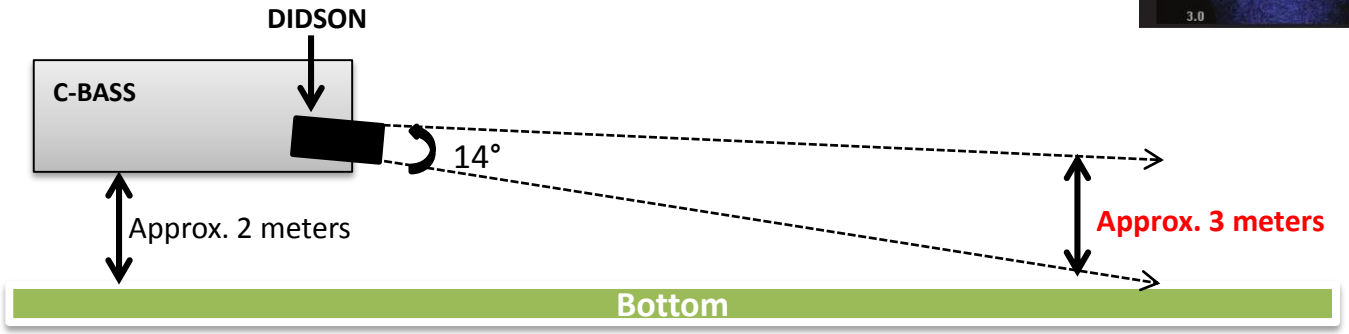



Image: Hightower et al. 2012