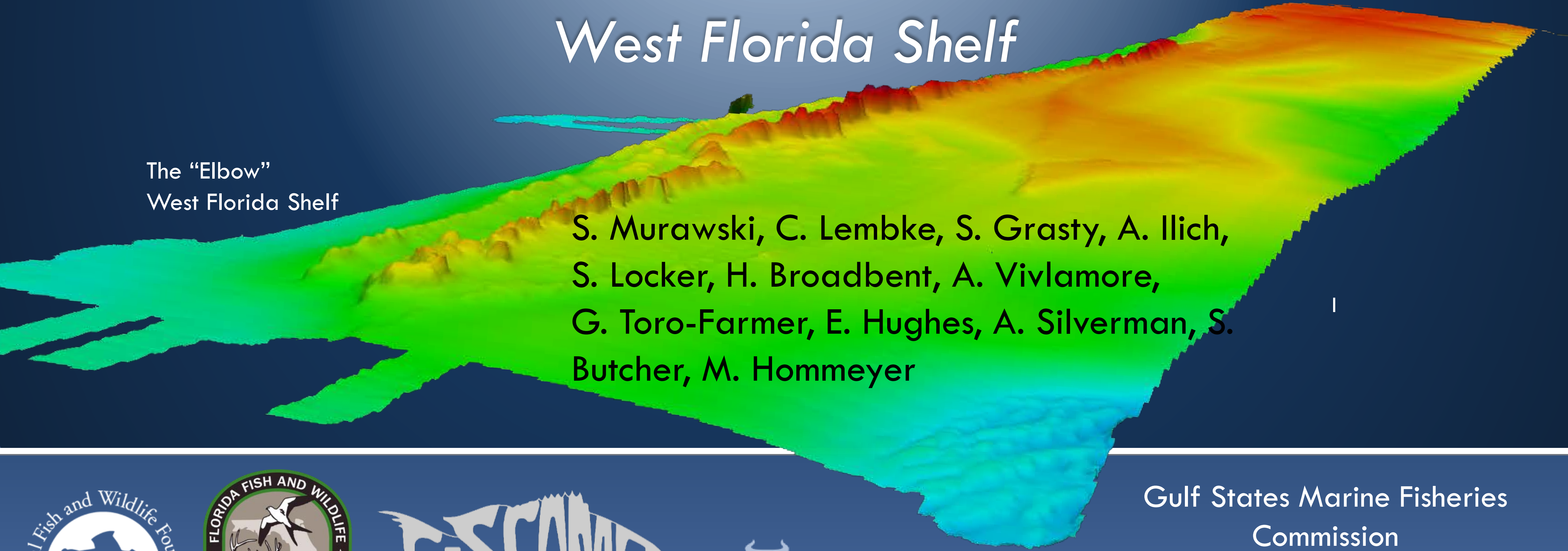
Advanced Technology Approaches to Quantifying Reef Fish and Sea Turtle Abundance and Habitat Types on the West Florida Shelf



S. Murawski, C. Lembke, S. Grasty, A. Ilich, S. Locker, H. Broadbent, A. Vivlamore, G. Toro-Farmer, E. Hughes, A. Silverman, S. Butcher, M. Hommeyer

National Fish and Wildlife Foundation

Florida Fish and Wildlife Conservation Commission

C-SCAMP
Continental Shelf Characterization, Assessment and Mapping Project

USF | College of Marine Science

Gulf States Marine Fisheries Commission
11 March, 2020
Gulf Shores, AL

Scope of the problem and long term goal

Reef fish species occur on the West Florida Shelf on carbonate reefs that cannot be easily quantified with traditional gears (nets, traps, hooks, trawls, fixed baited cameras, acoustics)

Long-Term Goal: Design a sampling system to estimate absolute biomass and length composition of reef fish populations

Primary Target Species

Red Snapper

Vermillion Snapper

Red Grouper

Gag Grouper

Sea turtles

Secondary Target Species

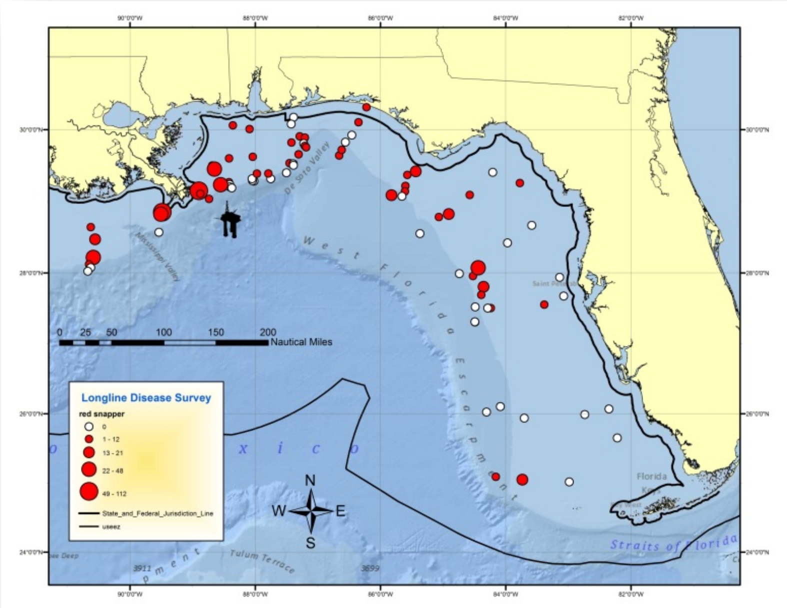
Other snappers

Other groupers

Various reef fishes

Red Snapper

Gag



Snowy Grouper

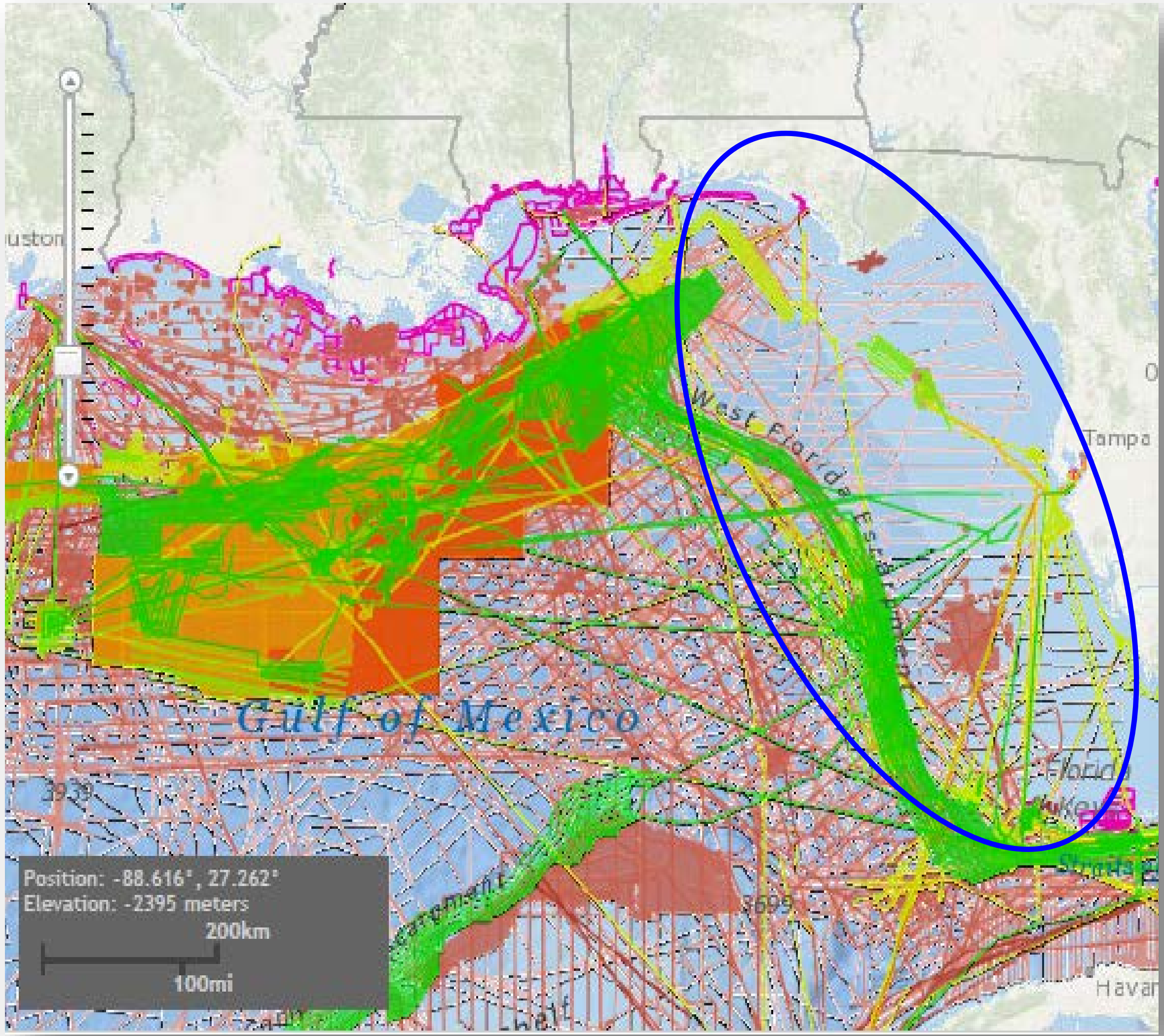
Using Towed Cameras to Count Fish - Challenges

- ✓ Attraction/Avoidance of fish to the camera system
- ✓ Visibility (detection probability)
- ✓ Calibration of view to estimate density (numbers/area)
- ✓ Habitat-stratified abundance (mapping w/fish counting)
- ✓ Water column + near bottom abundance (stacking)
- ✓ Autoprocessing of video imagery
- ✓ Concept of operations (scale up to population-level)

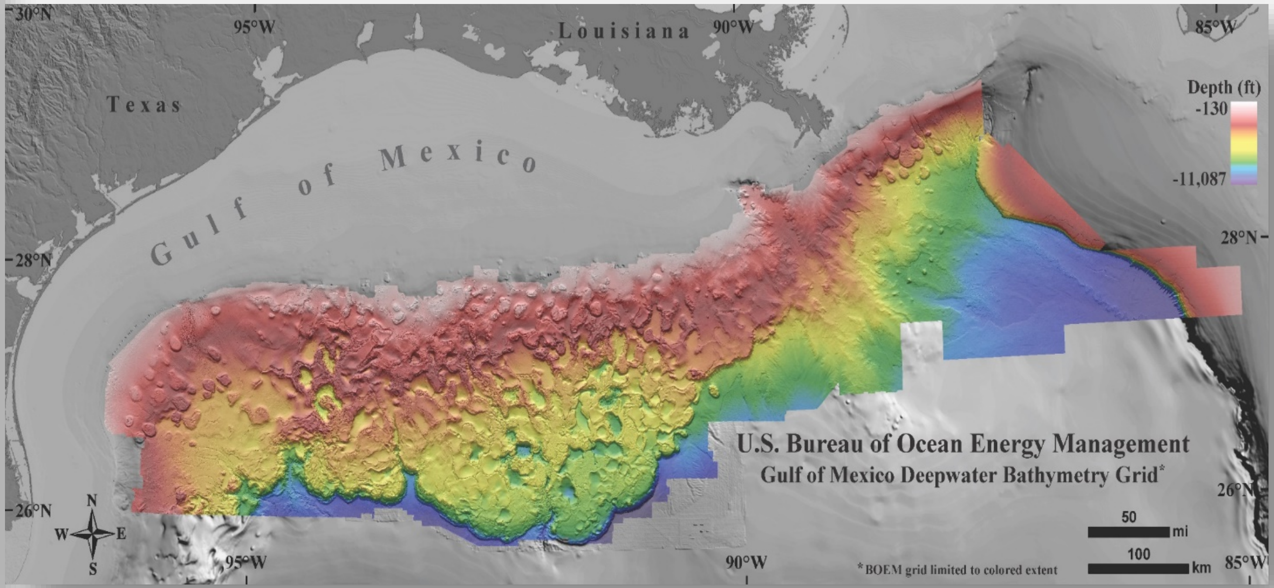
Objectives of Program (currently funded by NFWF)

- ✓ Provide about 2700 km^2 of new high resolution bathymetry and associated habitat characterization (using the USGS's CMECS classification system)
- ✓ Assess the relative density and absolute abundance of fishes and sea turtles in areas evaluated
- ✓ Develop methods to reprocess existing multibeam data into comparable habitat maps
- ✓ Provide information to the GMFMC and NMFS to consider additional HAPCs and MPAs
- ✓ Develop new technologies and methods
- ✓ Identify promising areas for additional sampling activity

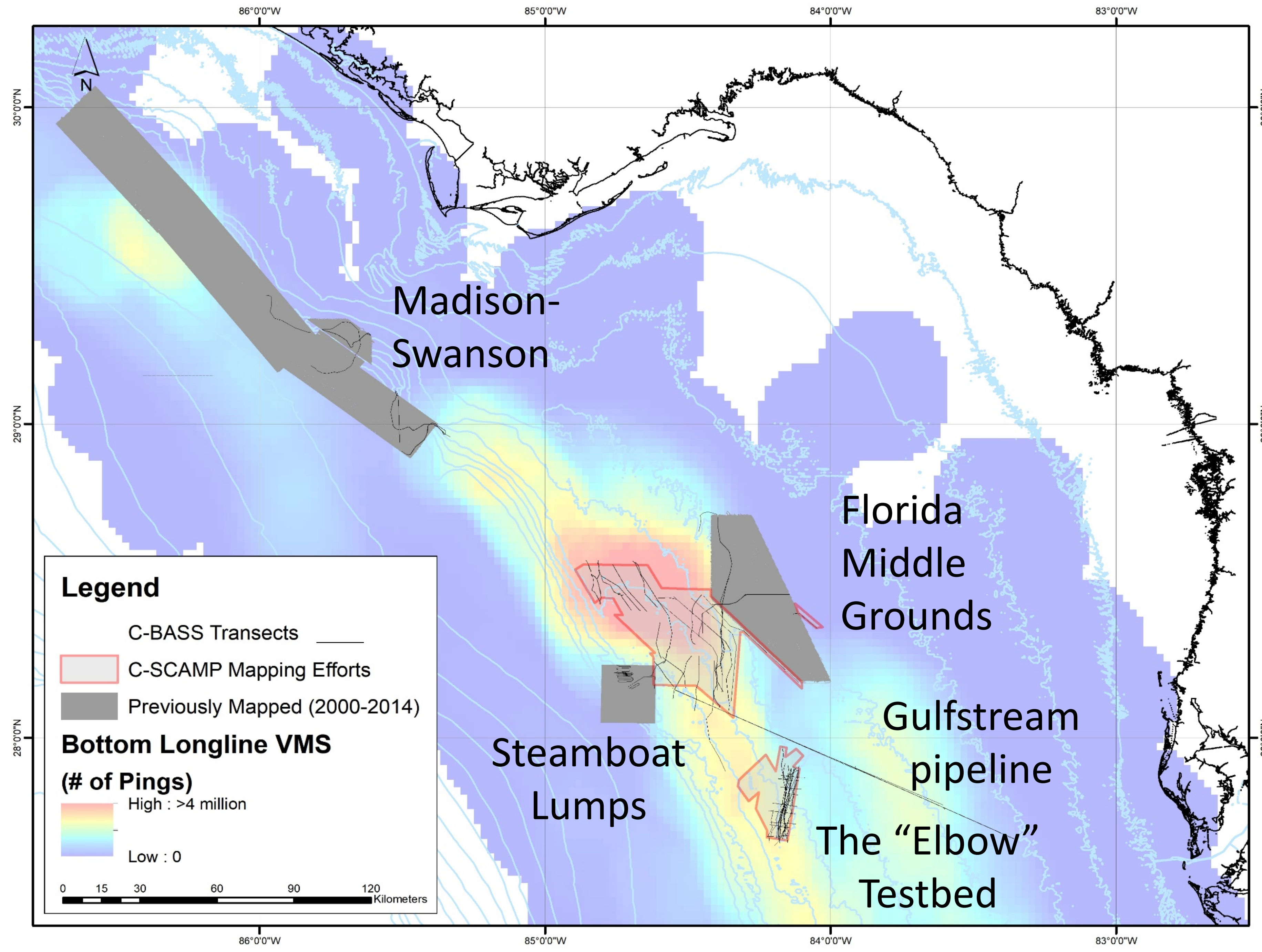
The Eastern GoM Shelf is one of the most poorly mapped areas in the lower 48



NCEI's Online Mapping Inventory



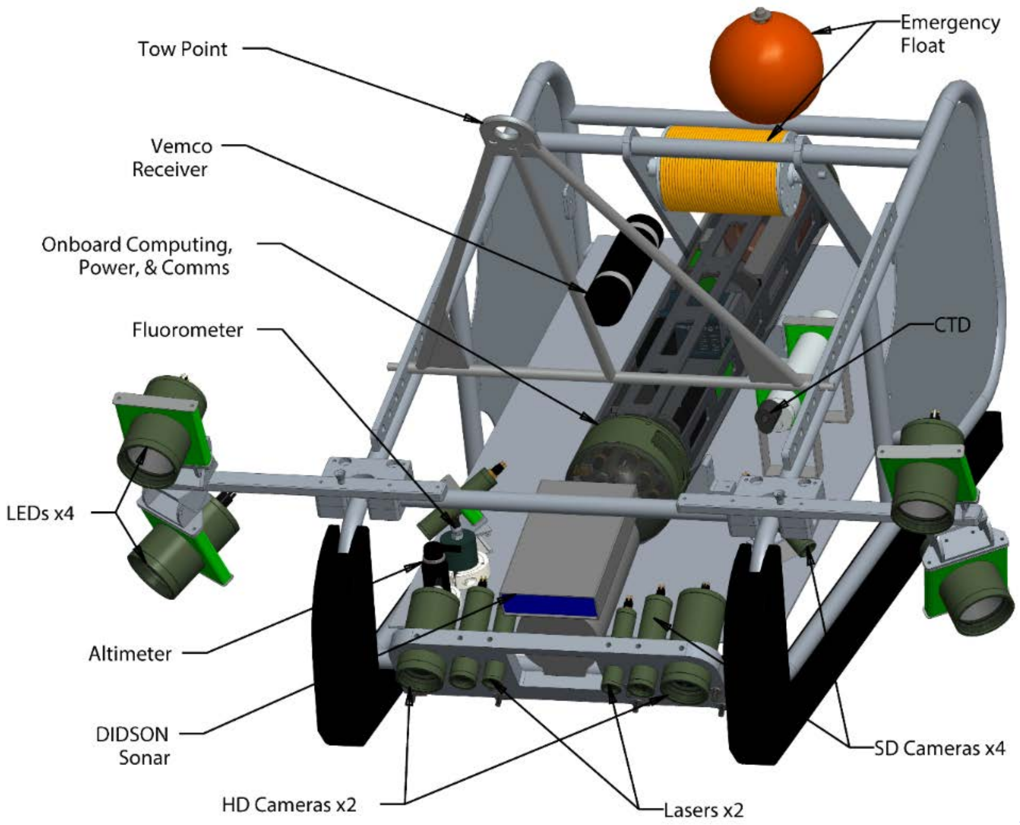
BOEM's Compilation from Industry Seismic Data



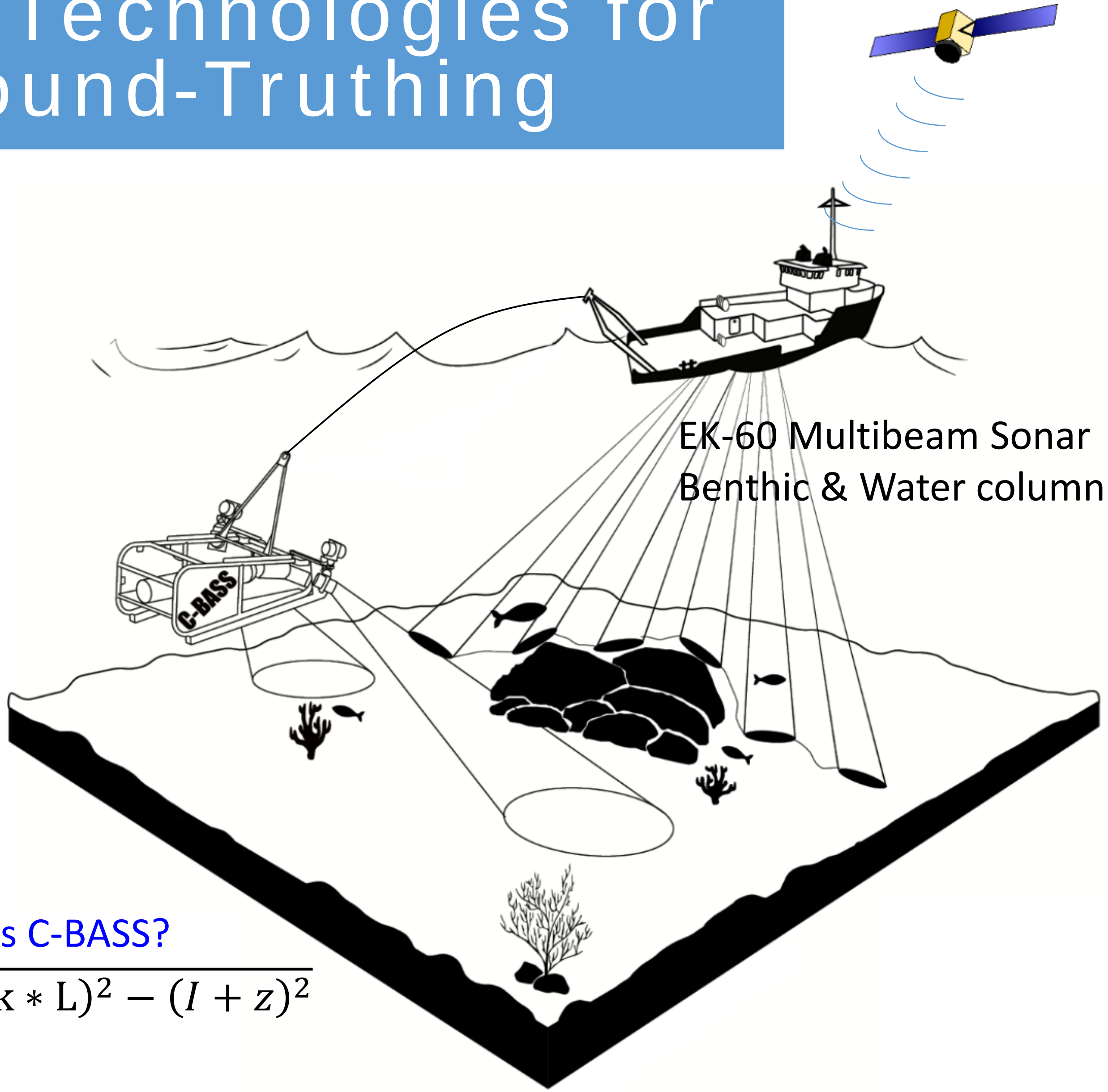
Where to Map?

- VMS Data from Reef Fish fishery, filtered for fishing activity indicates high-value habitats
- Extend from previously mapped areas to understand processes giving rise to hard bottom habitats

Leveraging Multiple Technologies for Mapping and Ground-Truthing



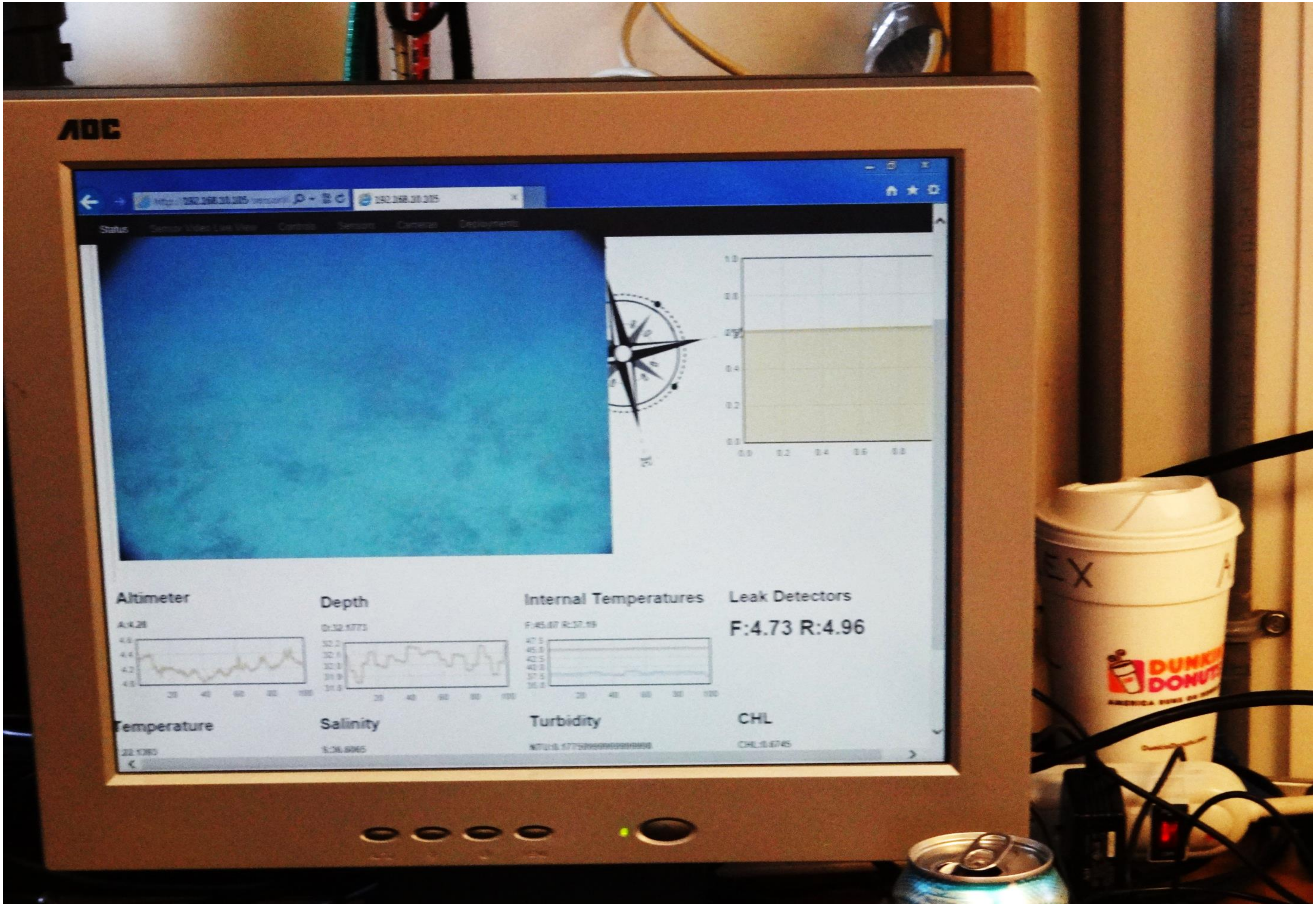
C-BASS Towed Video Array
6 cameras, Didson Sonar, Array of Environmental Sensors



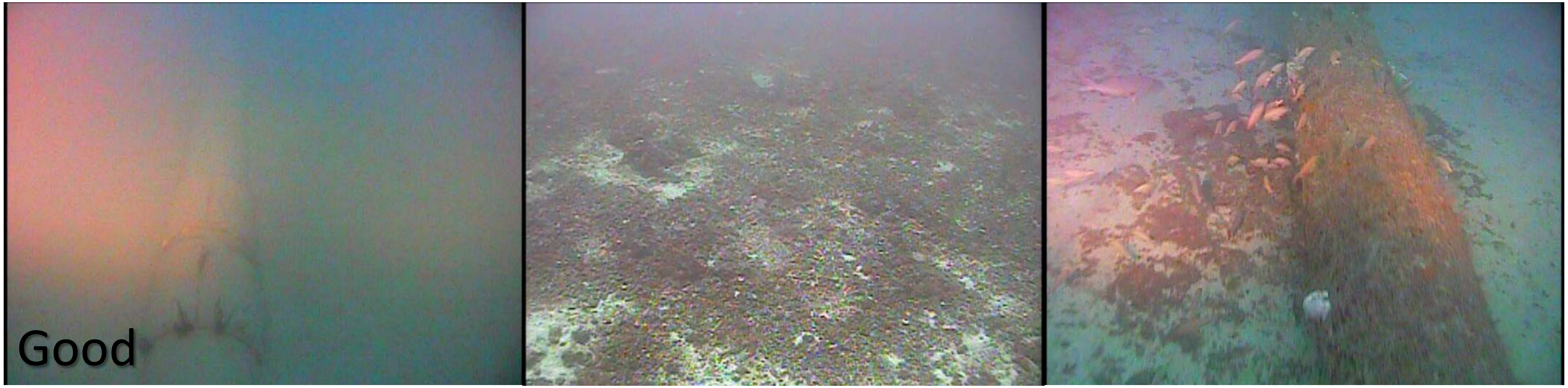
Where is C-BASS?

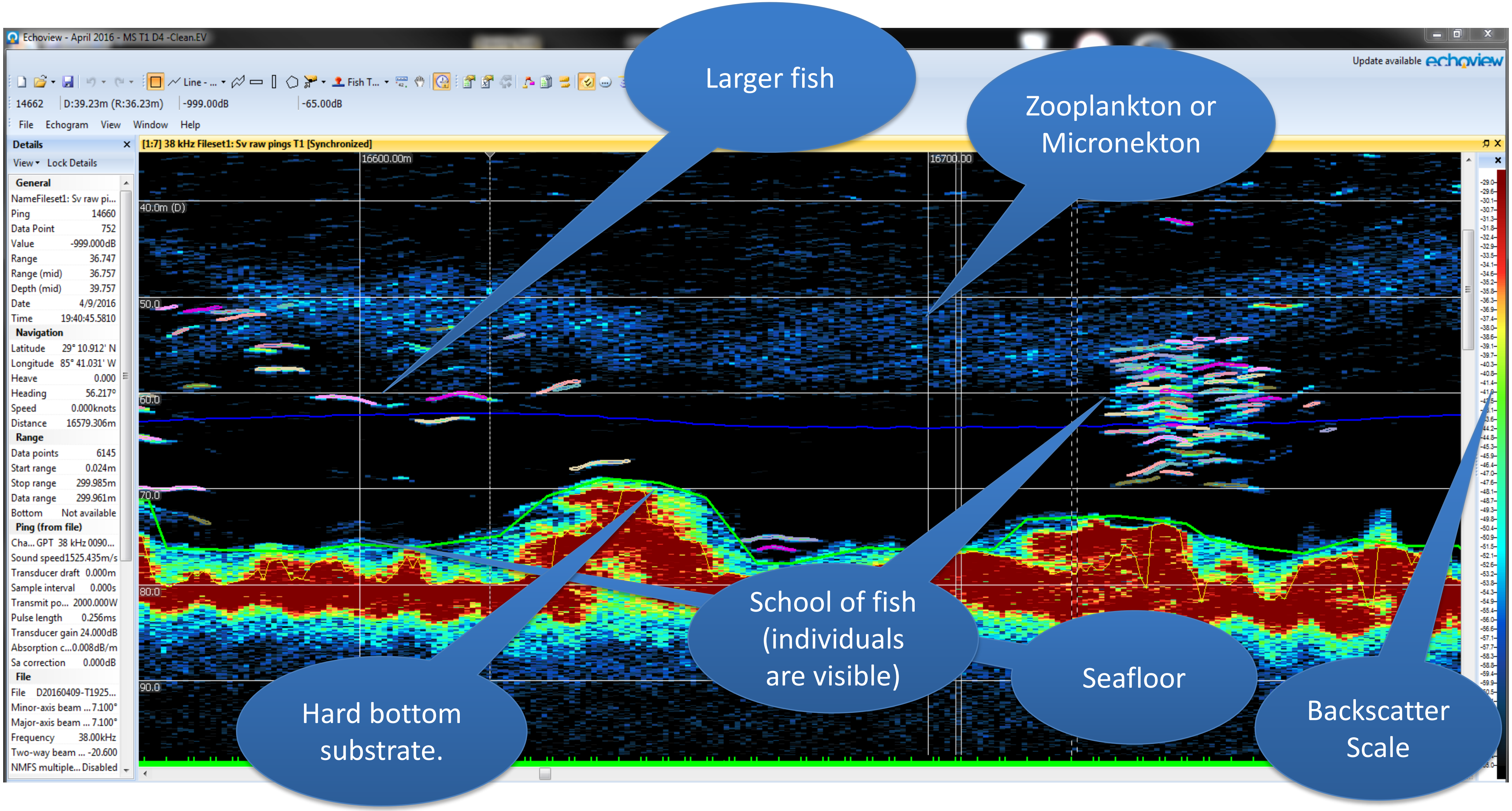
$$Layback = \sqrt{(\mathrm{k} * \mathrm{L})^2 - (I + z)^2}$$

L= Cable Out (m)
k= Catenary Factor
I= C-BASS Depth (m)
z= A-Frame Offset (m)

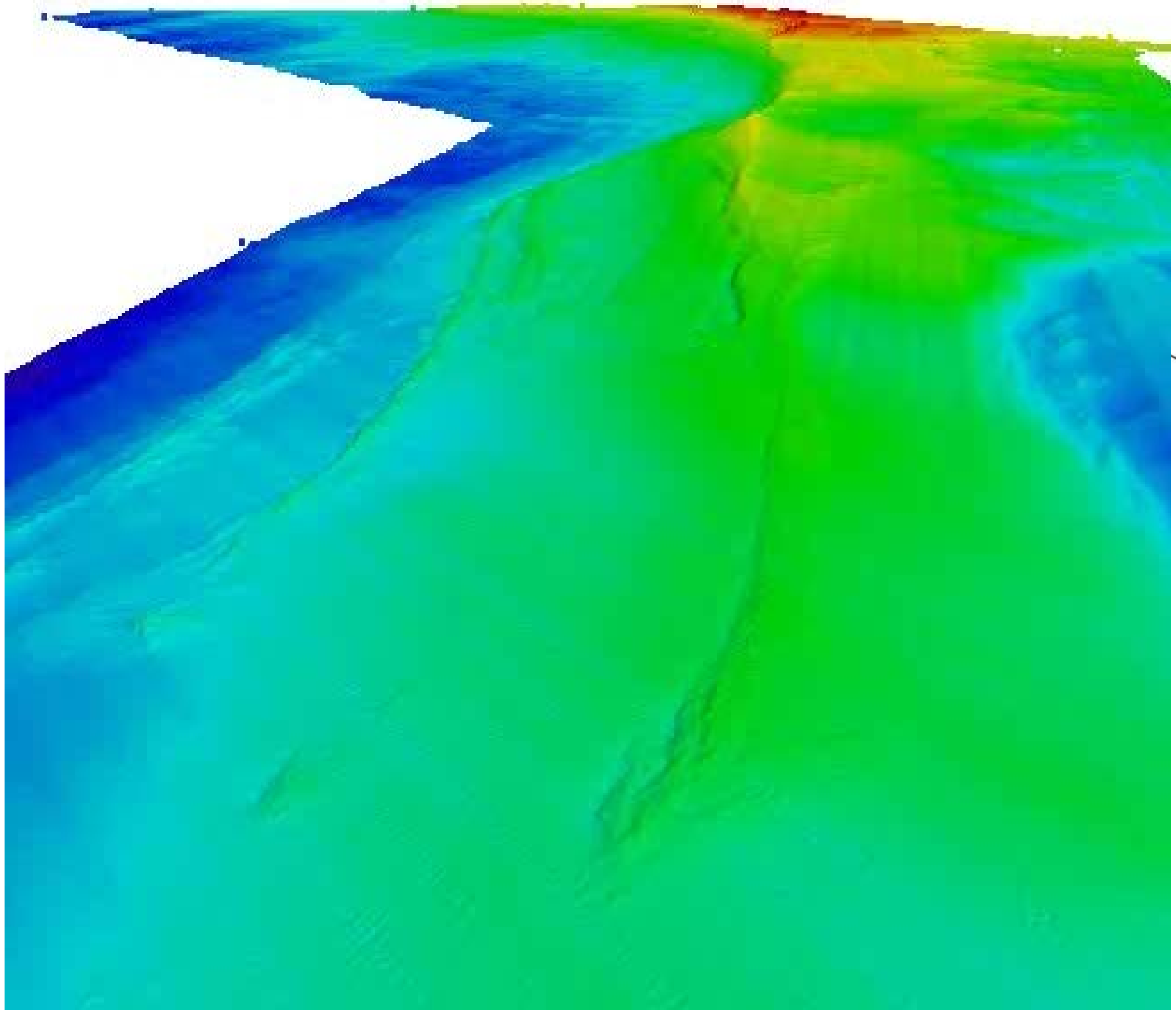

AOC
Status
Altimeter
Depth
Internal Temperatures
Leak Detectors
F:4.73 R:4.96
Salinity
Turbidity
CHL

The Visibility Spectrum

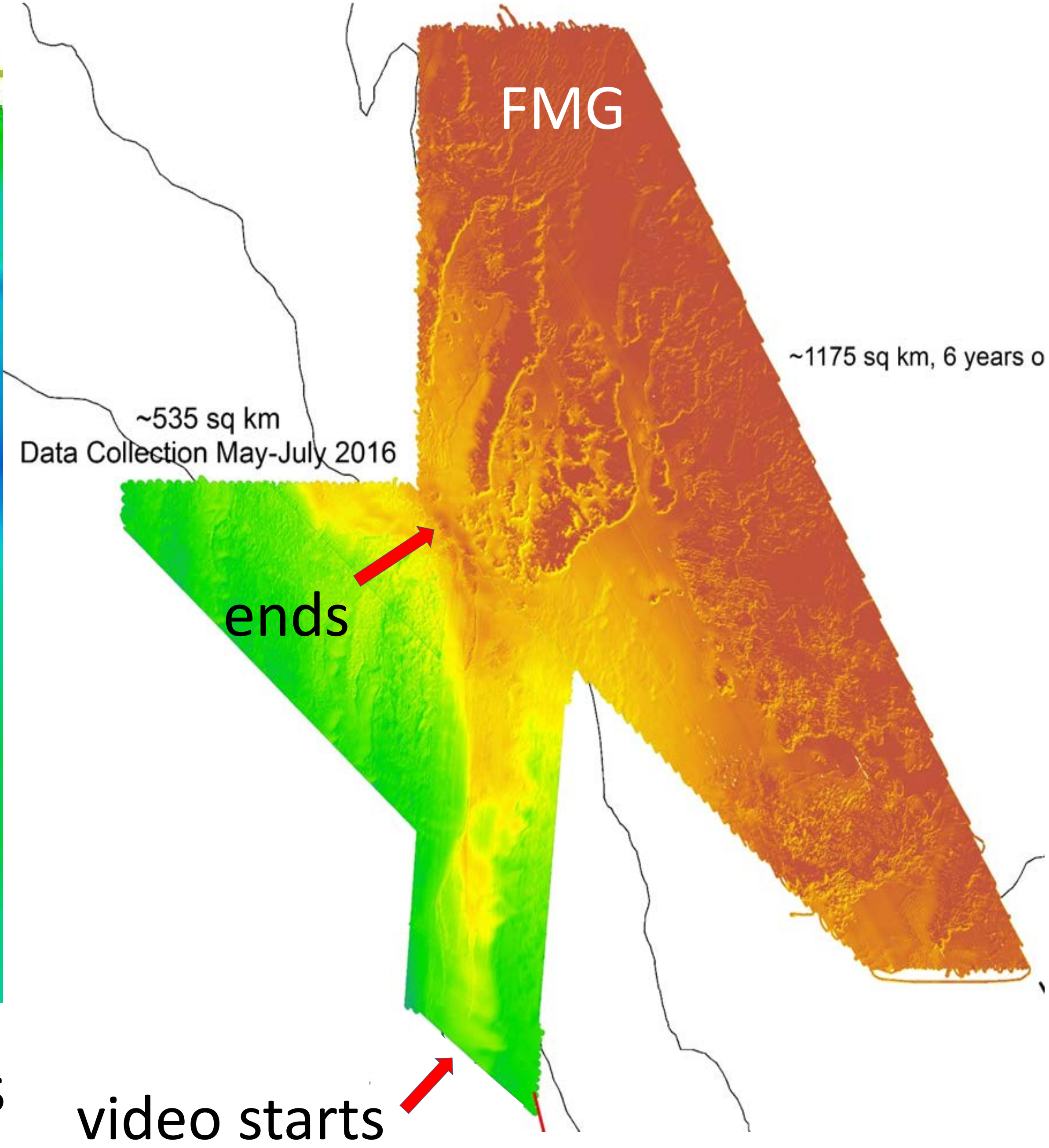




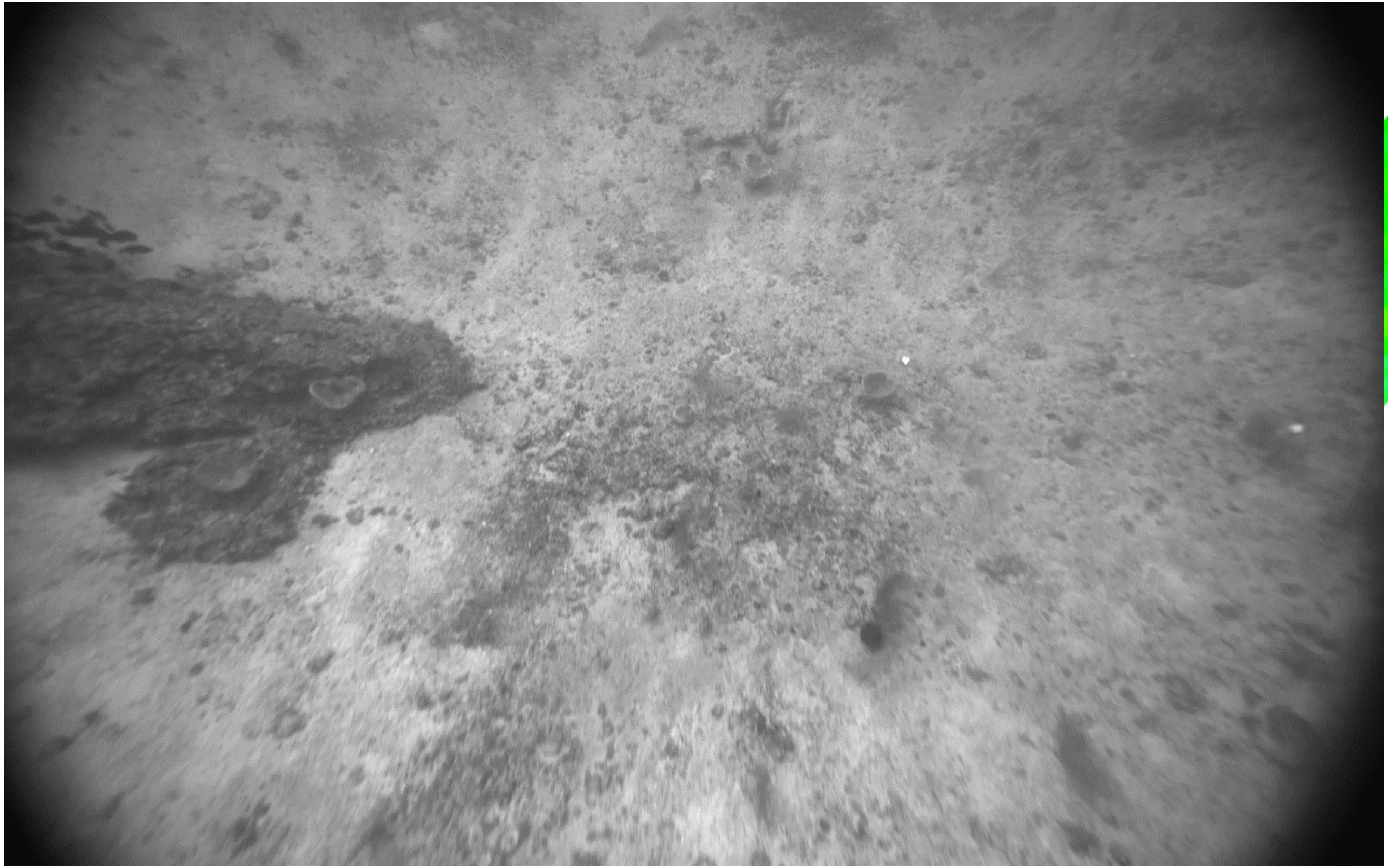
Larger fish
Zooplankton or Micronekton
School of fish (individuals are visible)
Seafloor
Hard bottom substrate.
Backscatter Scale
Echoview - April 2016 - MS T1 D4 -Clean.EV
Update available echoview
14662
D:39.23m (R:36.23m)
-999.00dB
-65.00dB
File Echogram View Window Help
Details
View Lock Details
[1:7] 38 kHz Fileset1: Sv raw pings T1 [Synchronized]
16600.00m
16700.00
40.0m (D)
50.0
60.0
70.0
80.0
90.0
General
NameFileset1: Sv raw pi...
Ping 14660
Data Point 752
Value -999.000dB
Range 36.747
Range (mid) 36.757
Depth (mid) 39.757
Date 4/9/2016
Time 19:40:45.5810
Navigation
Latitude 29° 10.912' N
Longitude 85° 41.031' W
Heave 0.000
Heading 56.217°
Speed 0.000knots
Distance 16579.306m
Range
Data points 6145
Start range 0.024m
Stop range 299.985m
Data range 299.961m
Bottom Not available
Ping (from file)
Cha... GPT 38 kHz 0090...
Sound speed1525.435m/s
Transducer draft 0.000m
Sample interval 0.000s
Transmit po... 2000.000W
Pulse length 0.256ms
Transducer gain 24.000dB
Absorption c...0.008dB/m
Sa correction 0.000dB
File
File D20160409-T1925...
Minor-axis beam ...7.100°
Major-axis beam ...7.100°
Frequency 38.00kHz
Two-way beam ... -20.600
NMFS multiple... Disabled

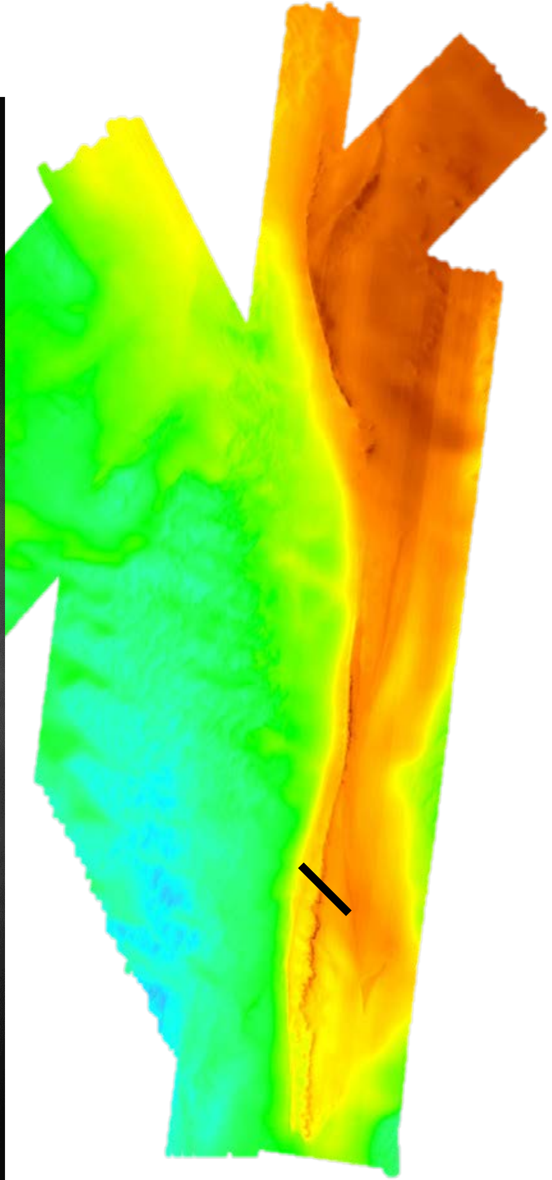


Southwest Florida Middle Grounds



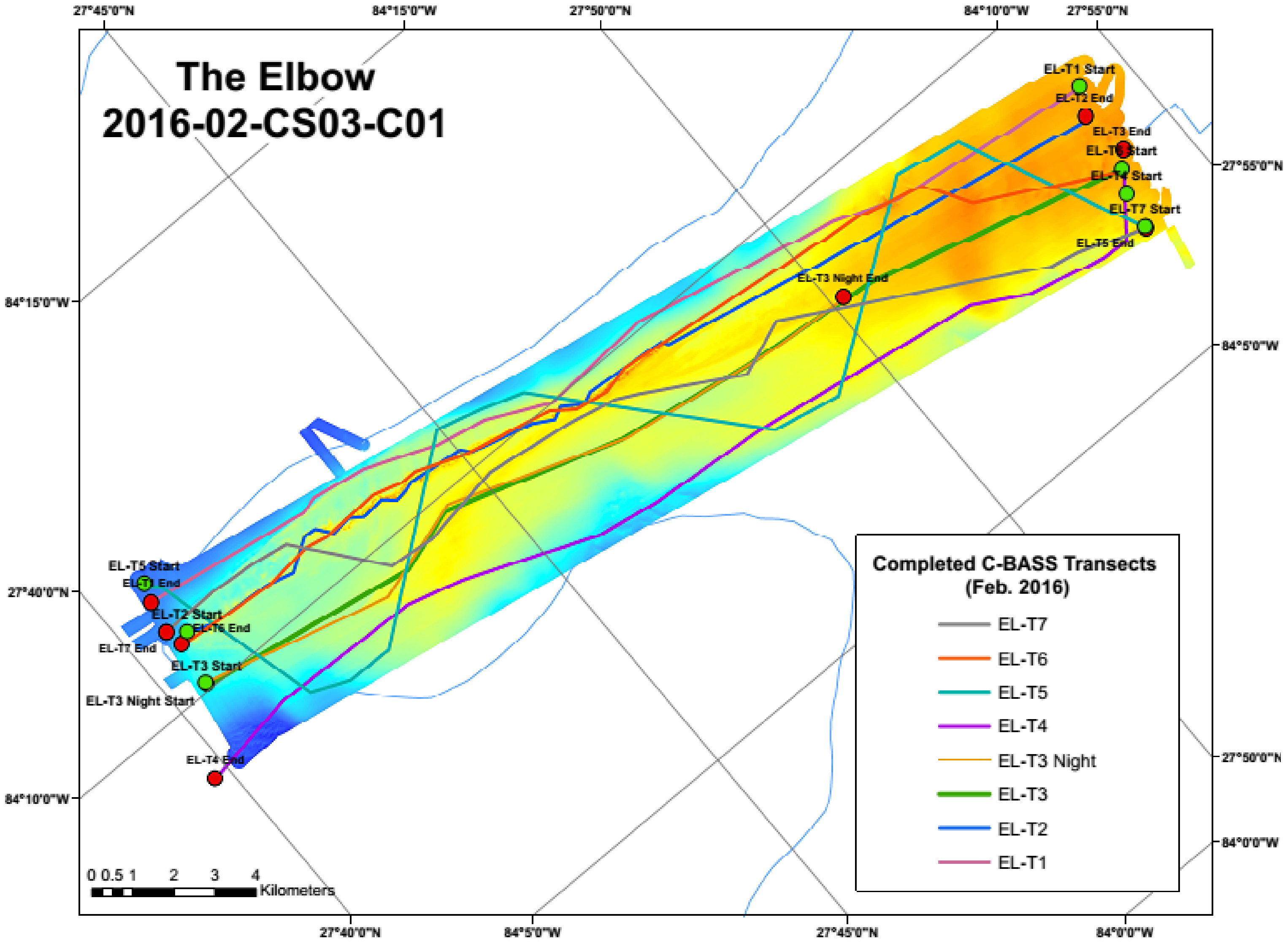
The Elbow, Hard Bottom Ridge



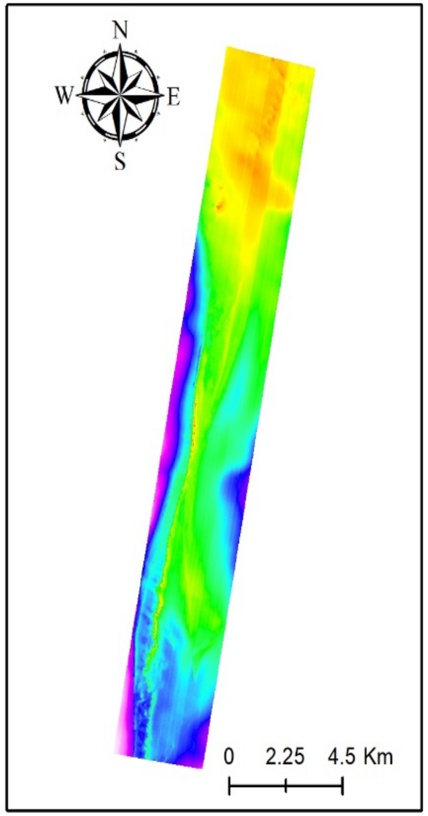


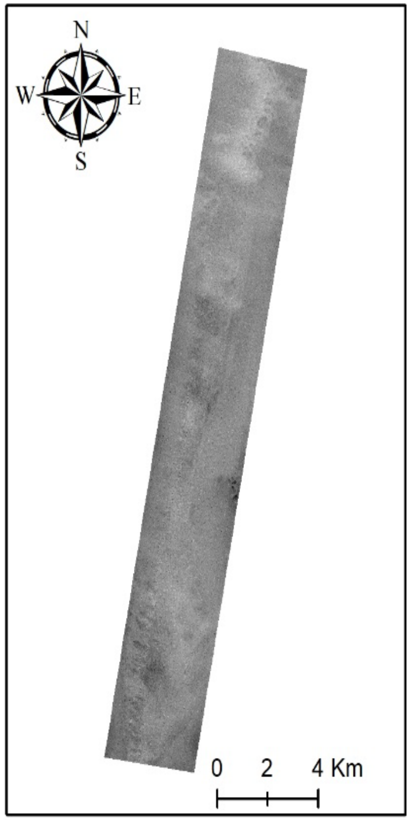

The Gulfstream Gas Pipeline
Tampa to Mobile, Al
3’ diameter

Classifying Landscape-Scale Habitats from video subsamples



Multibeam Derived Information:
-Bathymetry (depth, slope etc.)
-Backscatter (bottom hardness)





Derivative Metrics

Bathymetry Terrain Attributes

1. Curvature and Relative Position
- Relative deviation from mean value
  - (Depth - Local Mean)/ Local Range

2. Rugosity
- Standard Deviation

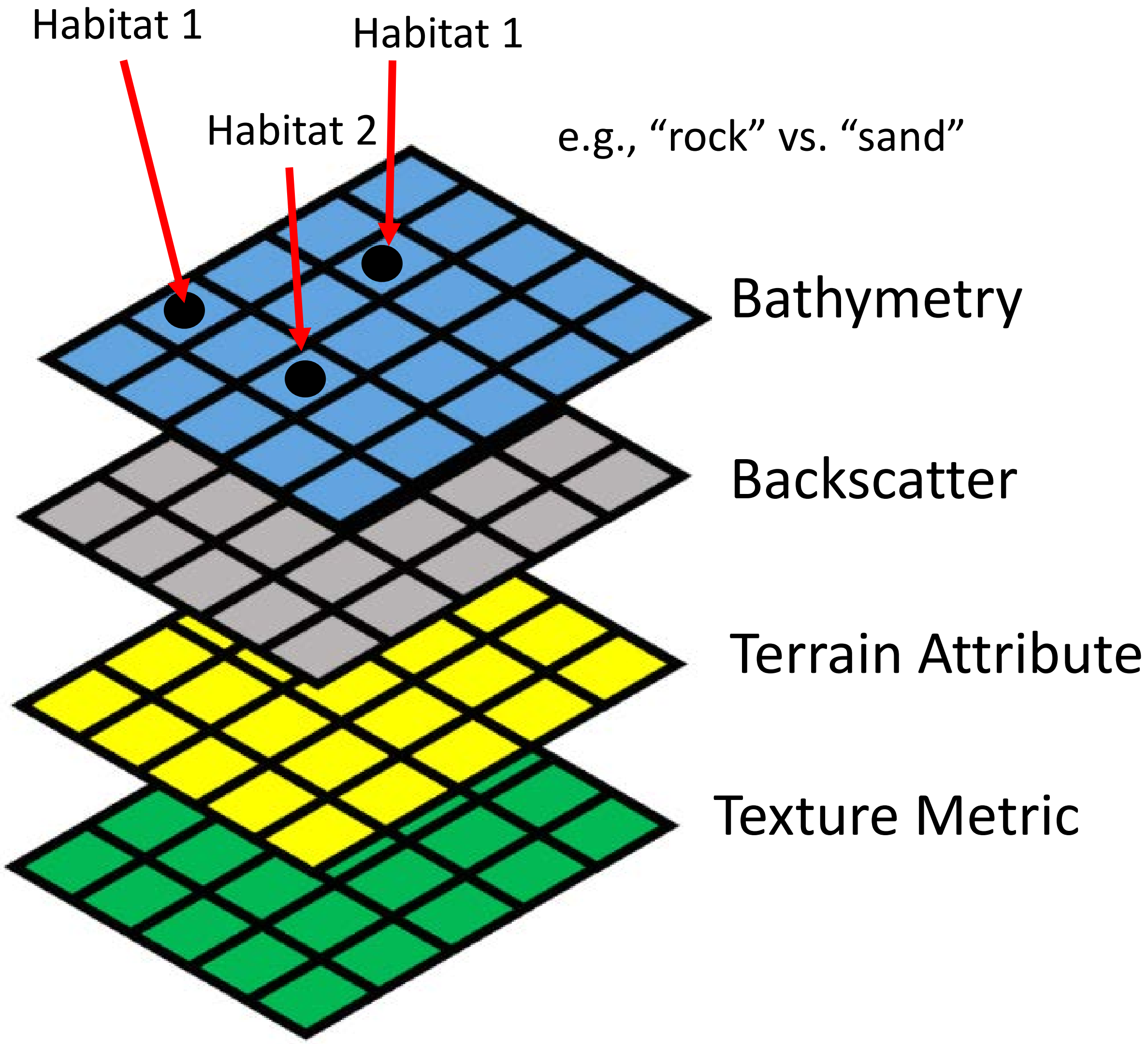
3. Orientation
- Eastness
  - Sin(aspect)
- Northness
  - Cos(aspect)

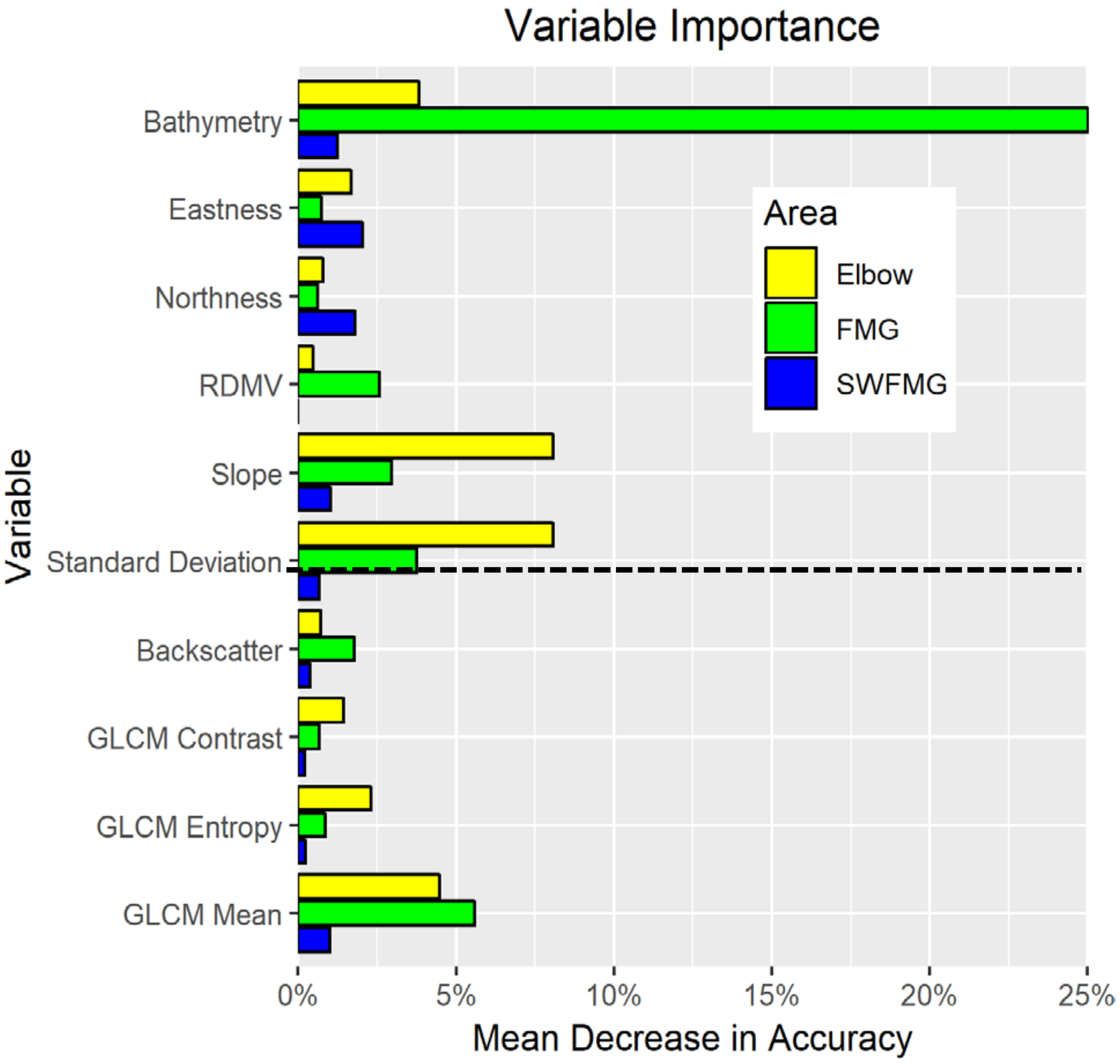
4. Slope
- Horn’s Method

Backscatter Haralick Texture Metrics

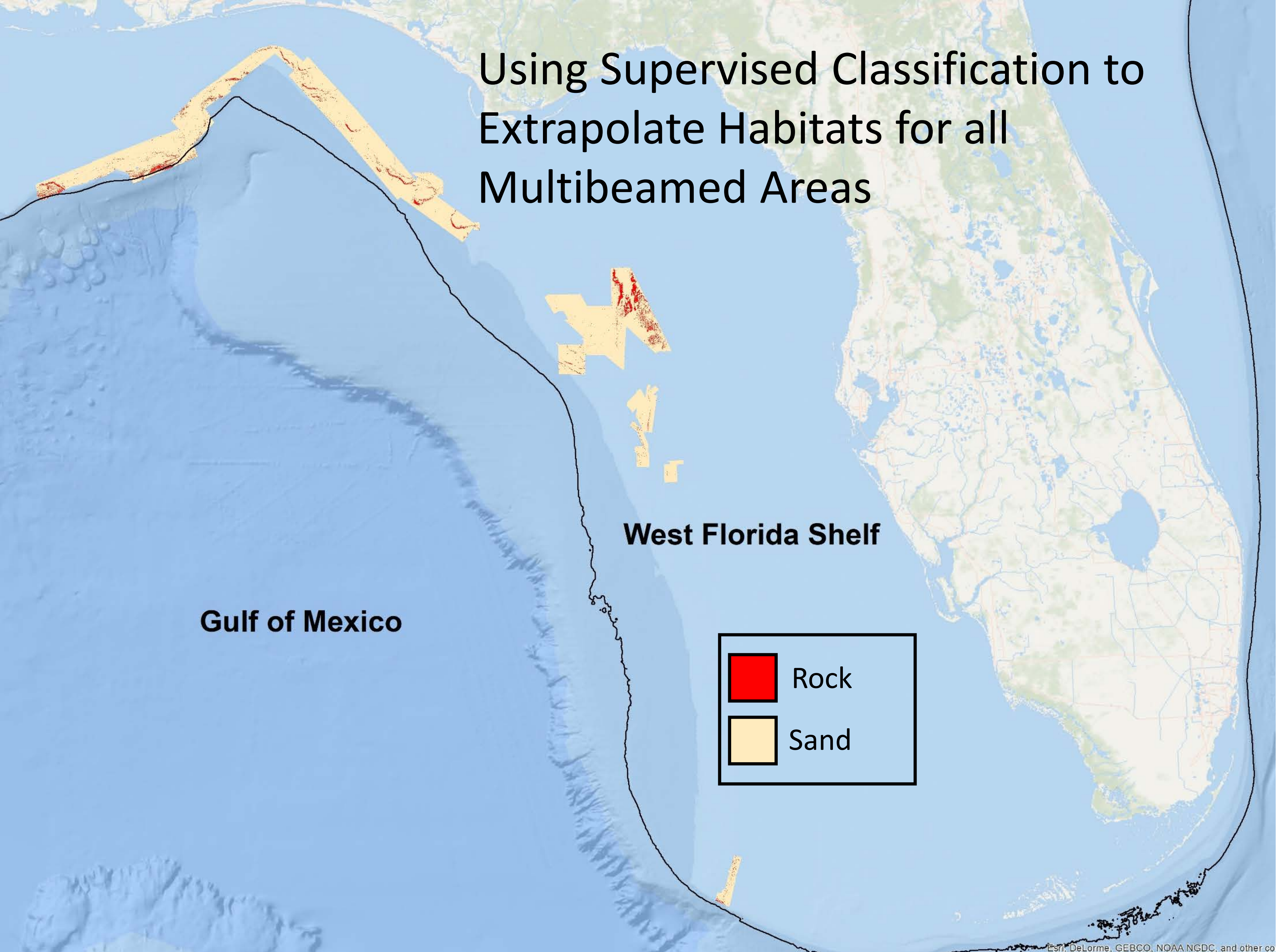
Feature	Description
GLCM (Gray Level Co-Occurrence Matrix) Mean	$\sum_{i,j=0}^{N-1} i(P_{i,j})$
GLCM Contrast	$\sum_{i,j=0}^{N-1} P_{i,j}(i-j)^2$
GLCM Entropy	$\sum_{i,j=0}^{N-1} P_{i,j}(-\ln(P_{i,j}))$

Supervised Classification Regression Tree Model for Habitat Extrapolation





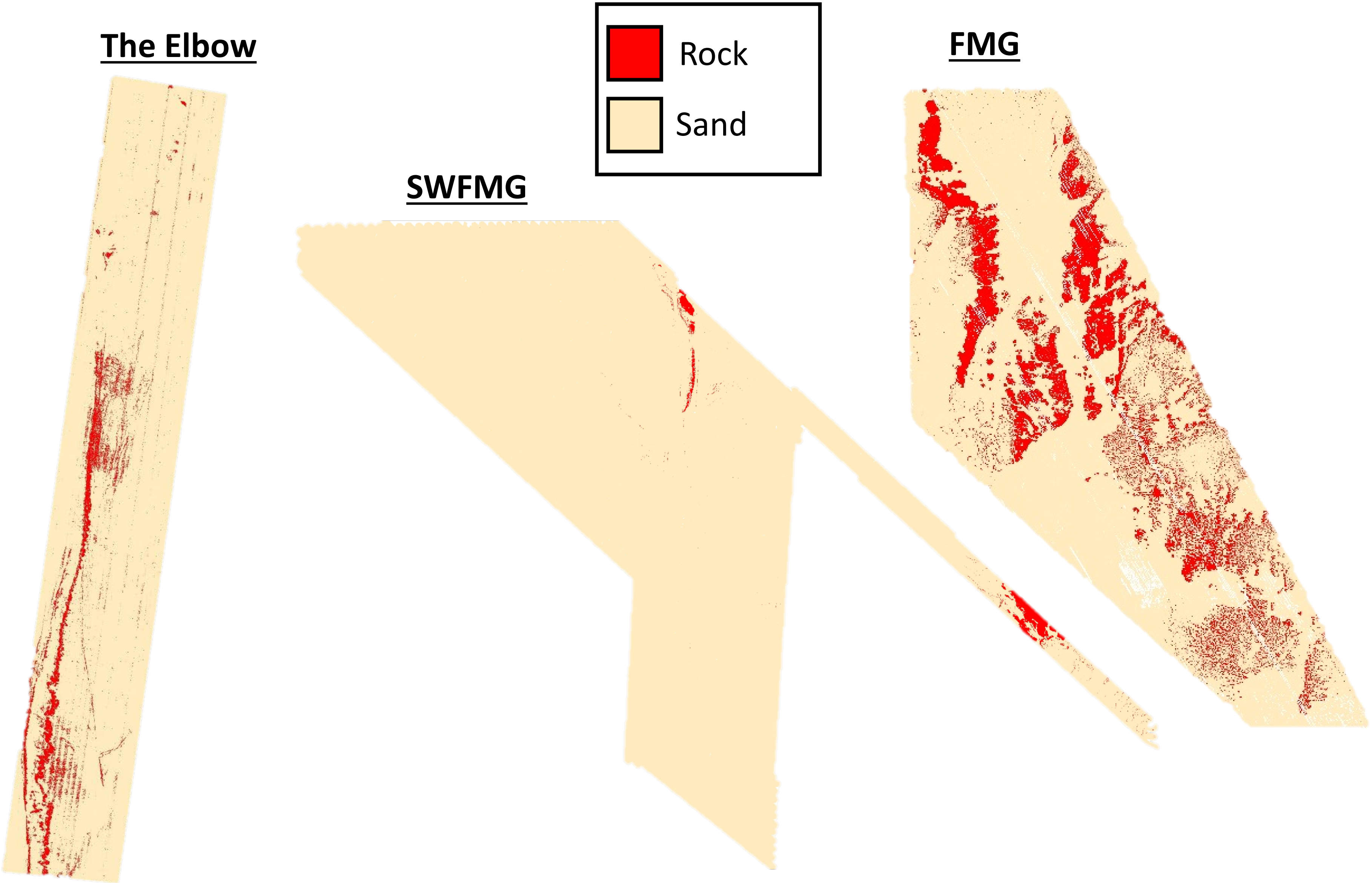
Using Supervised Classification to Extrapolate Habitats for all Multibeamed Areas



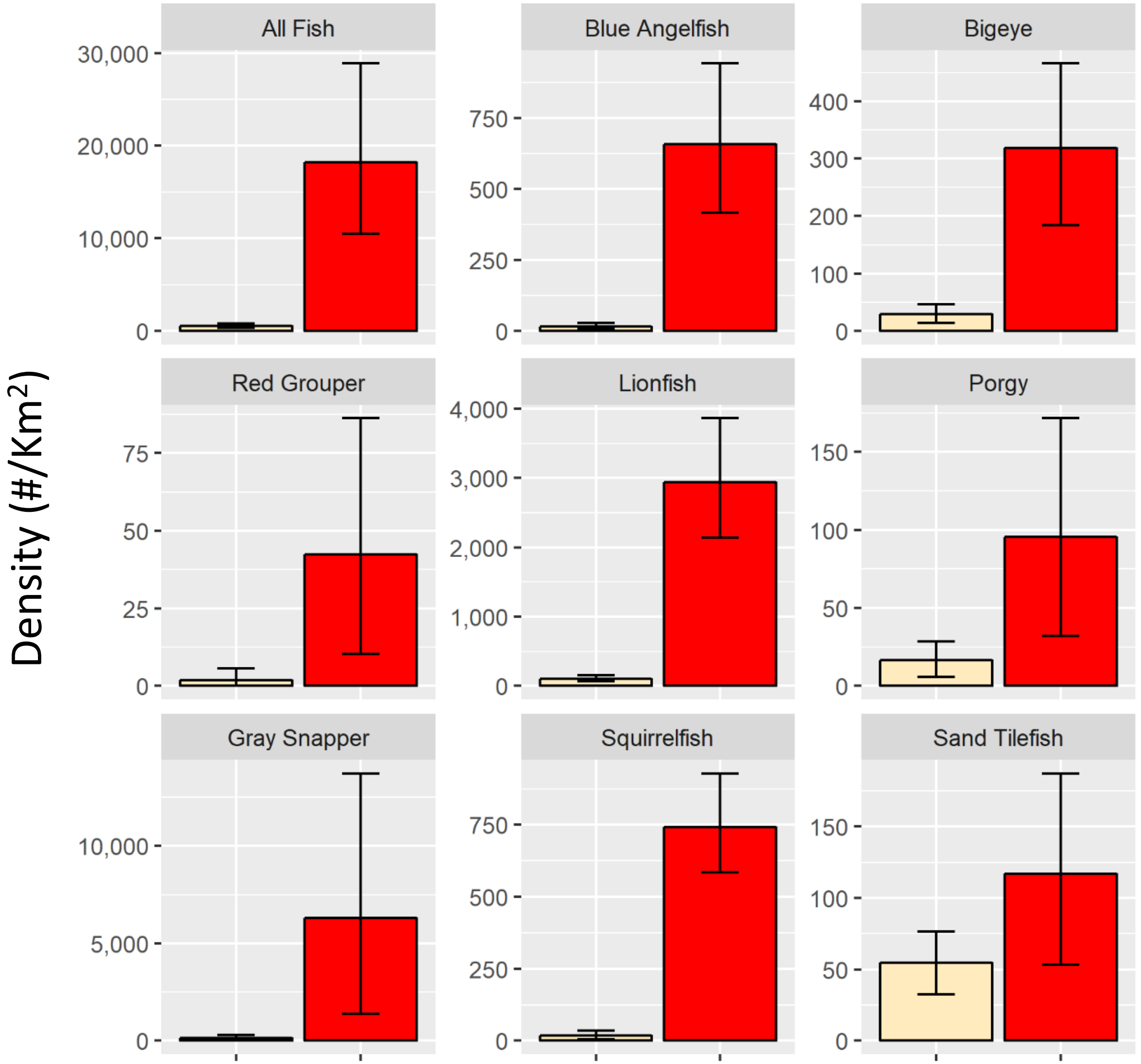
Bottom Classifications
Hard (red) vs.
Soft (tan) Bottom

Supervised Classification using MB Bathymetry and Towed Camera Ground-Truthing Data

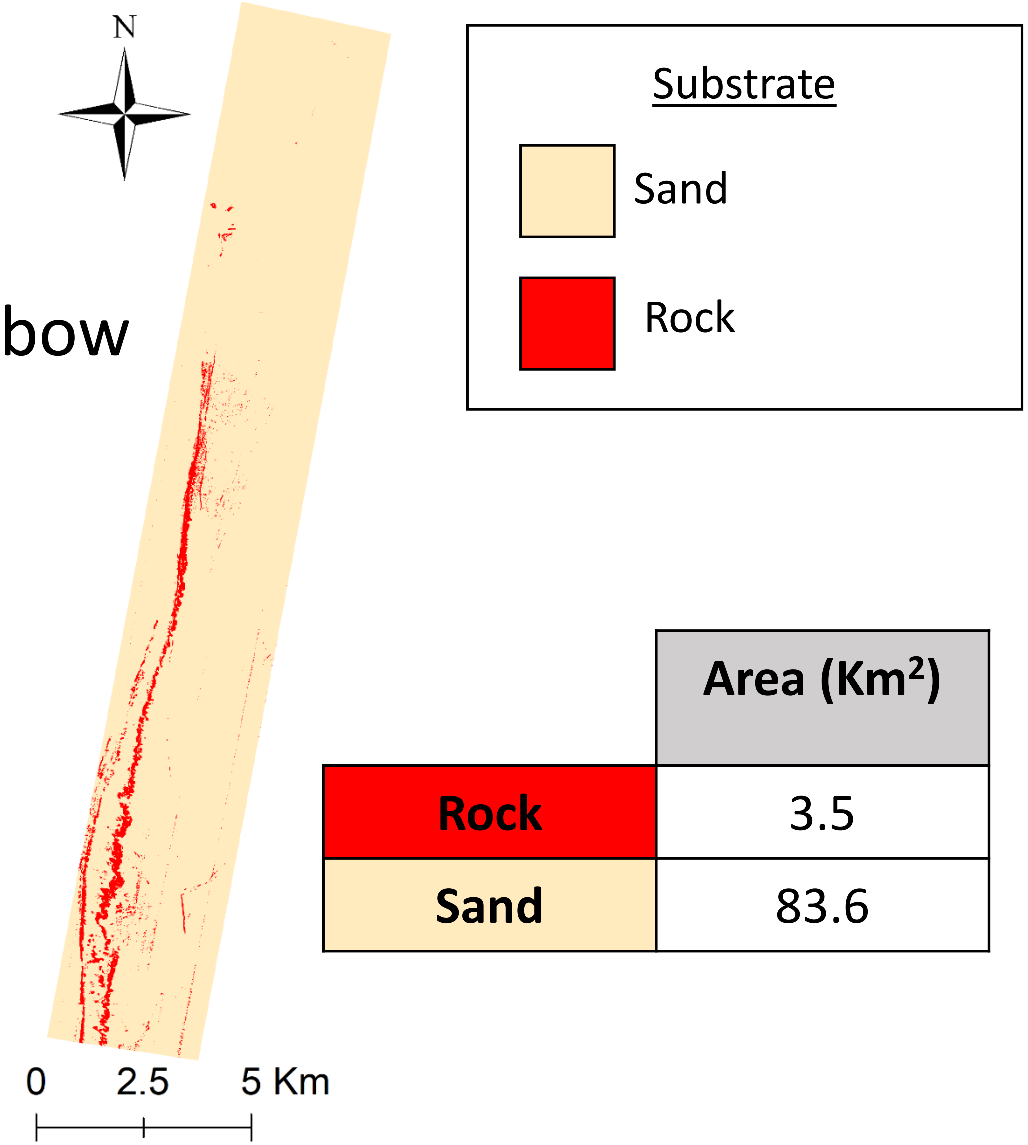
Classification Models:
Bathymetry & Backscatter applied to all of our mapped areas



Habitat-Stratified Density Estimates of Fishes

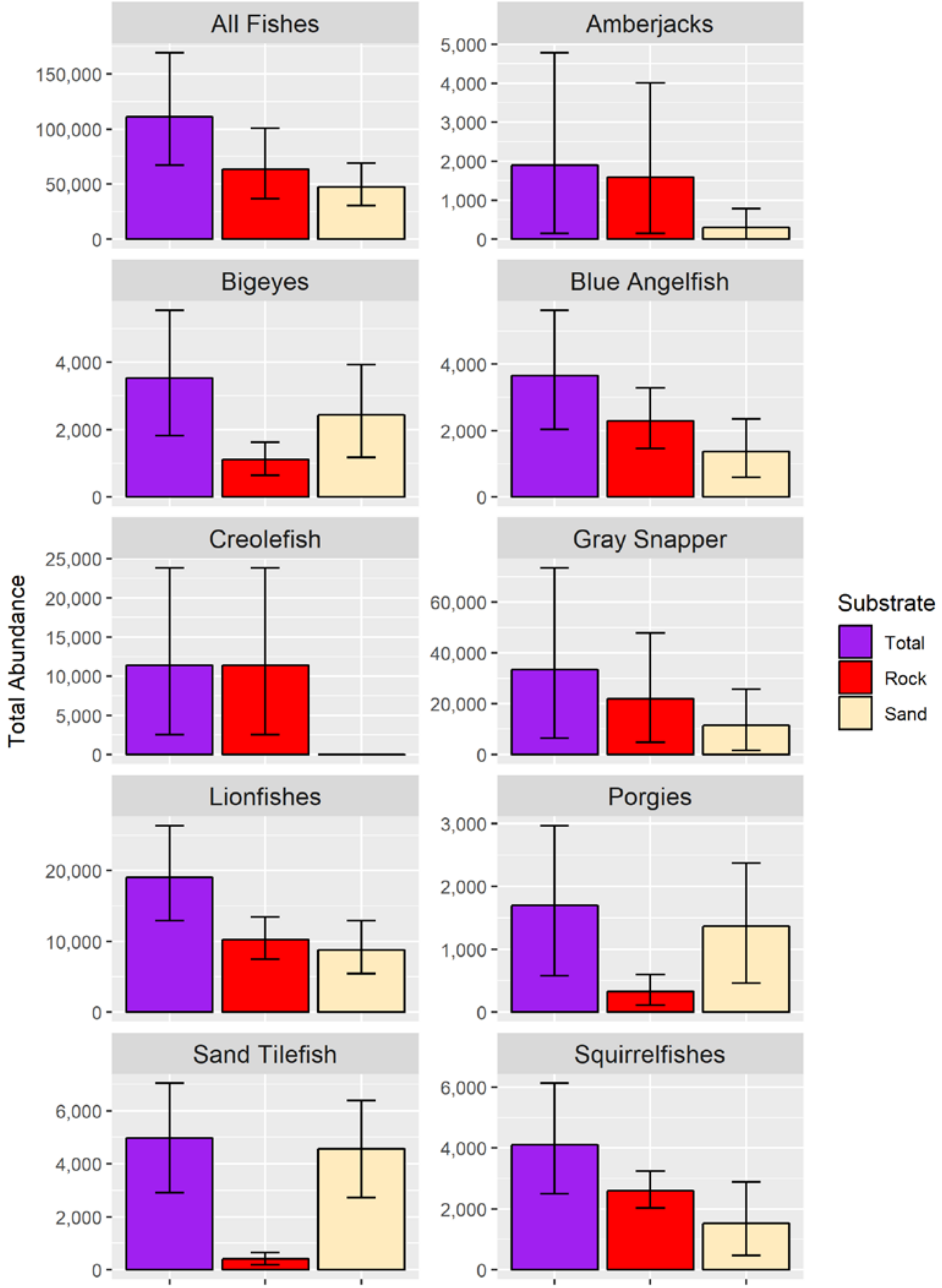


The Elbow



	Area (Km²)
Rock	3.5
Sand	83.6

Extrapolating Densities to Total Abundance



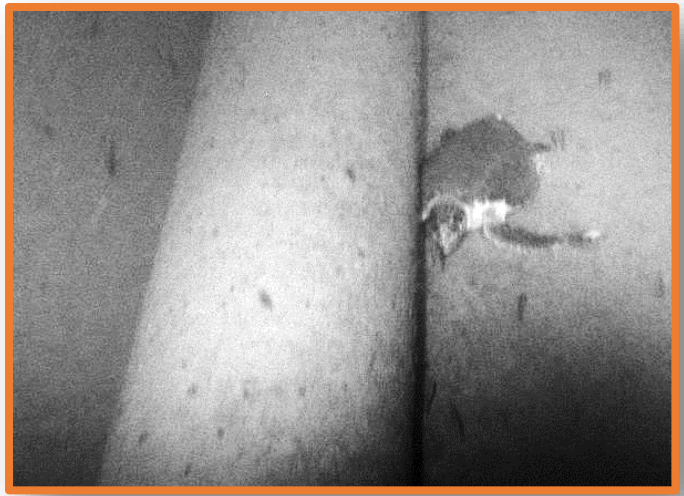
Estimates of **total abundance** for **select fish taxa** within the portion of **Elbow** on the West Florida Shelf that was mapped using multibeam. **Extrapolations are based on the area of sand vs rock substrate determined in the substrate map created using the supervised methodology.** Error bars represent the 95% bootstrap confidence intervals.

>50% of the fish are in 4% of the habitat (varies by species)

Ilich et al. (submitted, Dec. 2019), *Remote Sensing in Ecology*

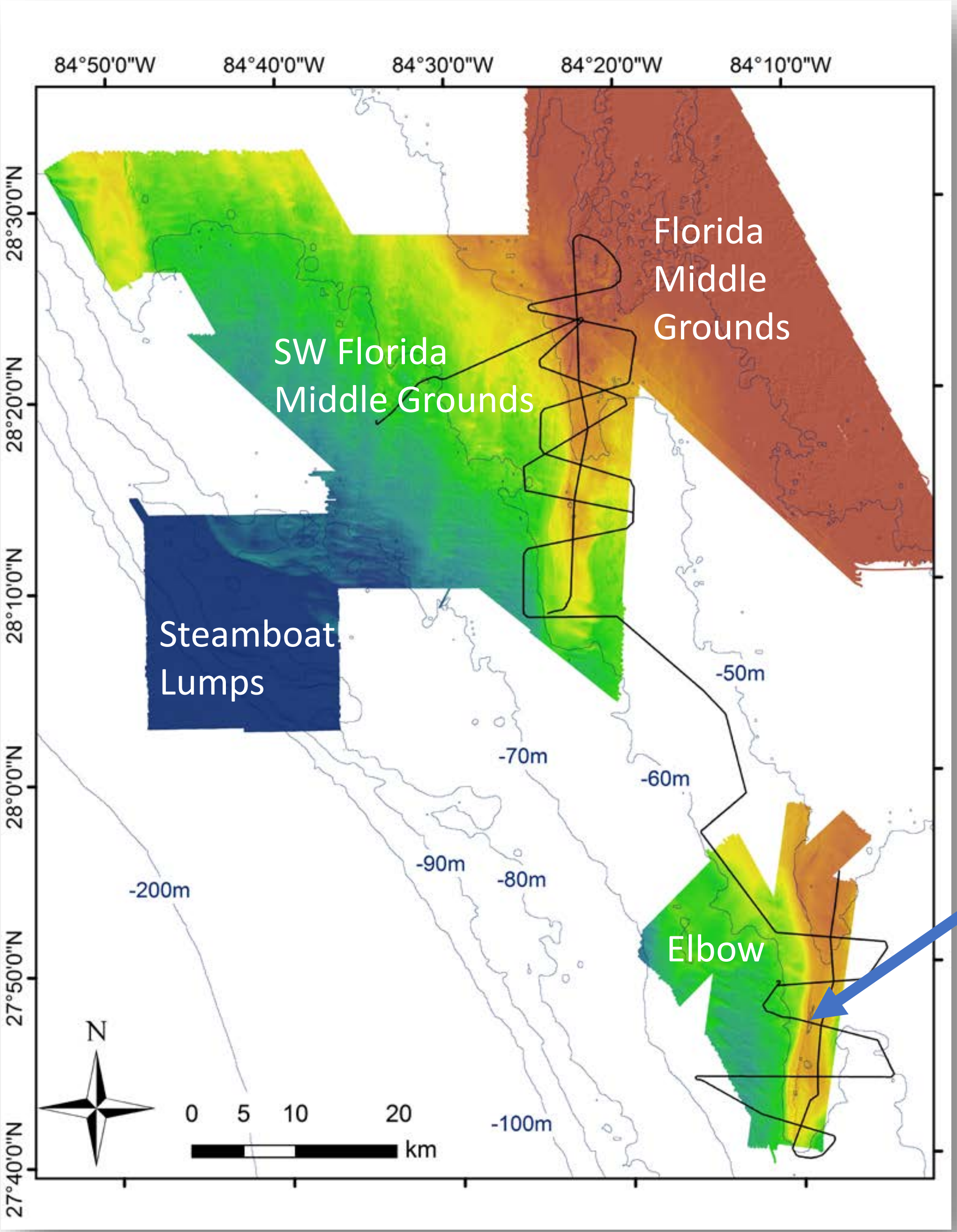
Sea Turtles Observed via C-BASS on the WFS (2014-2018)

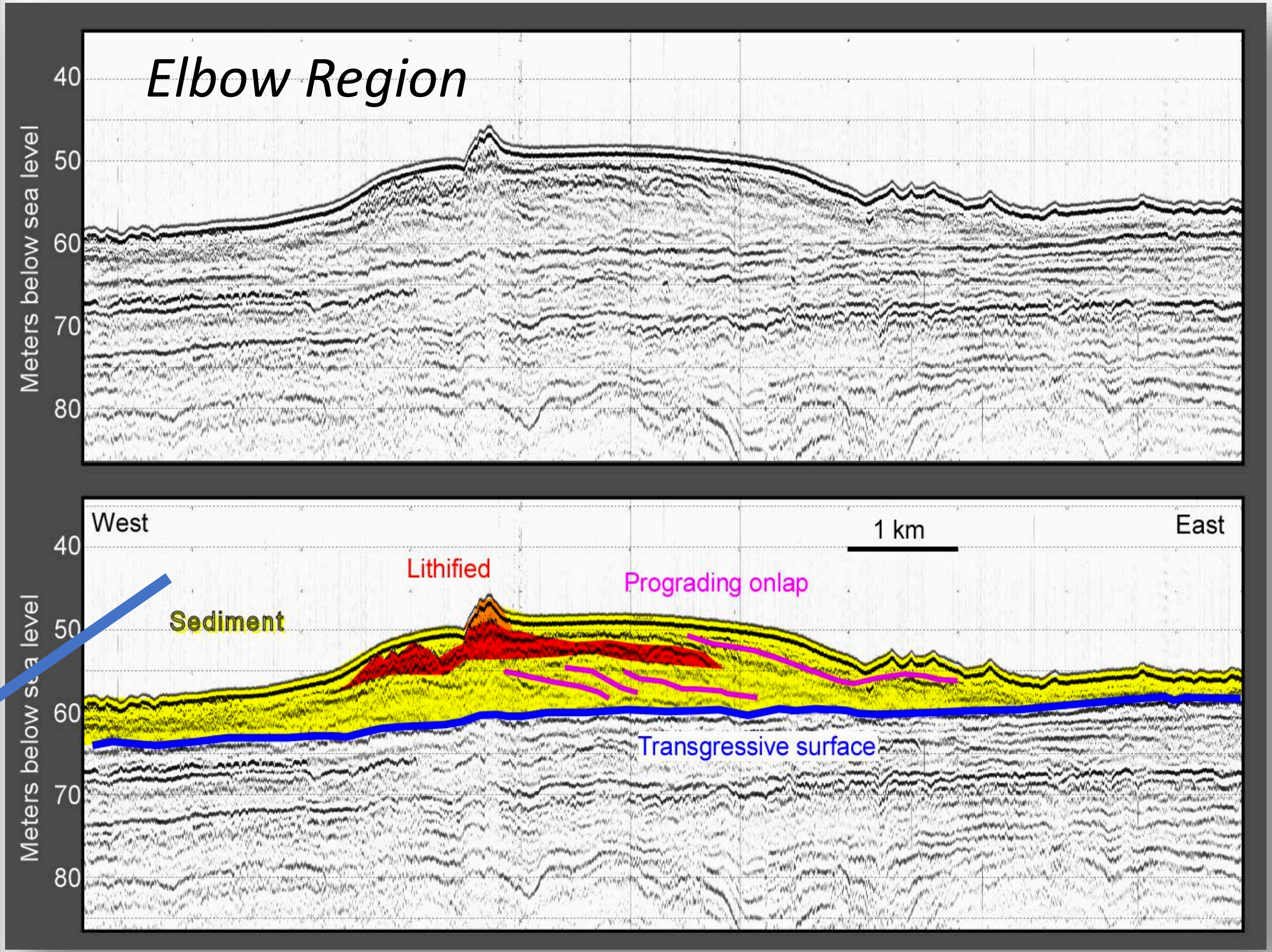
Cruise No.	Date (mm/yyyy)	Area surveyed	No. of transects	Distance (km)	No. of turtles
1	05/2014	FMG	6	140	1
		MS	2	41	0
		SL	2	64	0
2	02/2016	GSPL	3	125	40
		EL	7	208	1
		SL	2	91	0
3	04/2016	MS	4	158	0
4	10/2016	GSPL	1	68	10
		FMG	6	299	2
		EL	2	52	0
5	04/2017	GSPL	2	78	13
		FMG	6	195	1
		EL	9	172	0
		SL	1	27	0
6	10/2017	GSPL	2	44	1
		FMG	16	303	1
		EL	2	16	0
7	04/2018	GSPL	1	58	1
		EL	12	221	1
8	07/2018	GSPL	1	67	5
9	09/2018	FMG	6	215	2
		EL	4	108	0
Total			97	2750	79



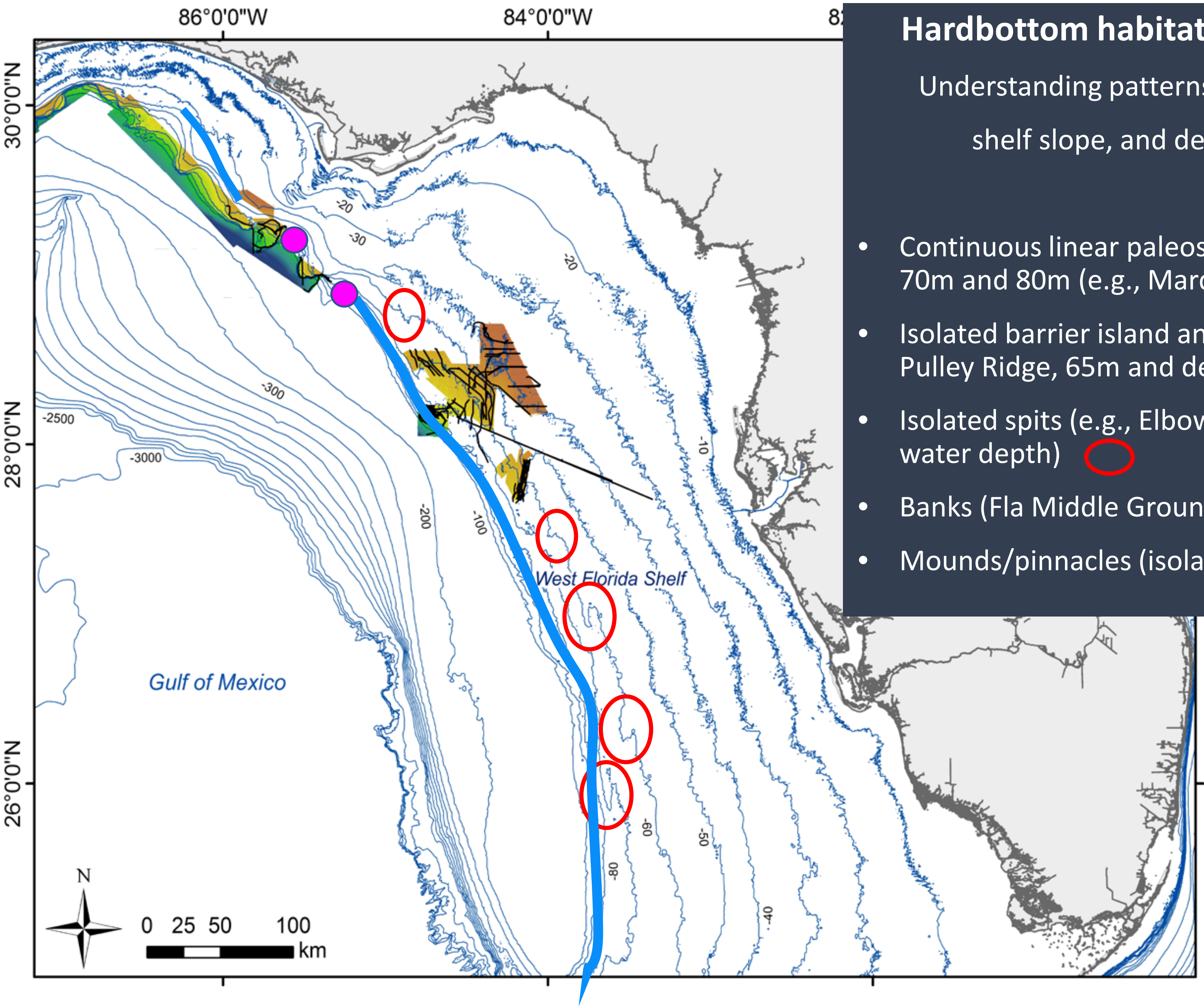
N.B.: Turtles 37 times more dense on the pipeline than natural habitats!

Understanding the Geological Setting of Hard Bottom Habitat: Bubble gun seismic survey





Predicting trends for additional habitat of interest

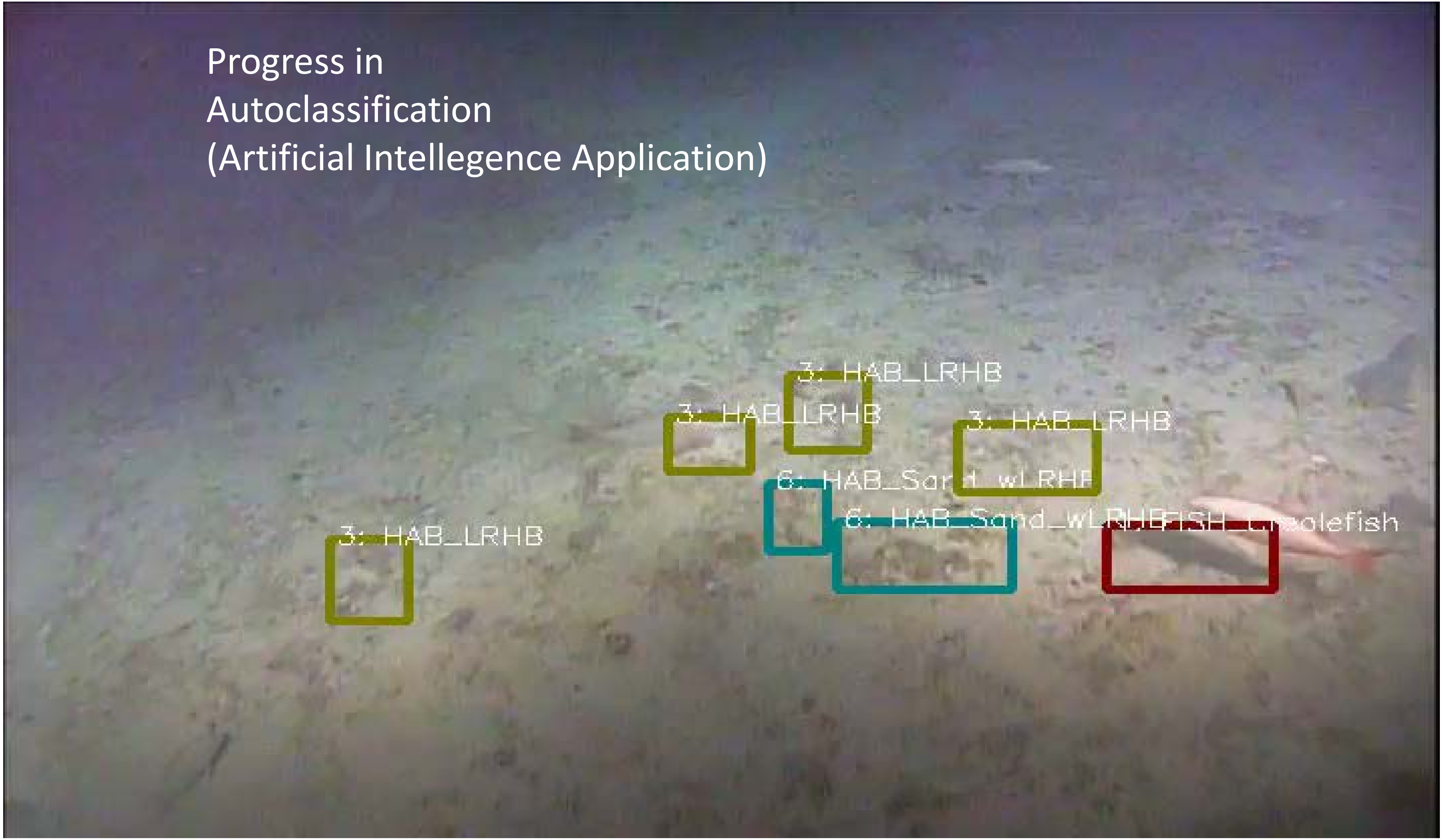


Hardbottom habitat - A regional perspective

Understanding patterns related to sea-level history, shelf slope, and depositional environment.

- Continuous linear paleoshoreline ridges –water depths of 70m and 80m (e.g., Marquesas, Twin Ridges)
- Isolated barrier island and broad ridge systems (e.g., Pulley Ridge, 65m and deeper)
- Isolated spits (e.g., Elbow - many features in 50-60 m water depth)
- Banks (Fla Middle Grounds)
- Mounds/pinnacles (isolated or large areas)

Progress in Autoclassification (Artificial Intellegence Application)



Some Proposed Next Steps for the Project

- ✓ Extend high-resolution mapping in the Eastern GoM to an additional ~15,000 km^2 of important offshore reef fish & sea turtle habitat
- ✓ Classify the habitat types & biota in areas surveyed
- ✓ Archive data collected for efficient discovery (NCEI, FWRI, USF)
- ✓ Further engage regulatory agencies in prioritizing and protecting valuable habitats
- ✓ Cross-calibration studies with NMFS & FWRI camera systems
- ✓ Help create an enduring "community of practice" and stable resource base

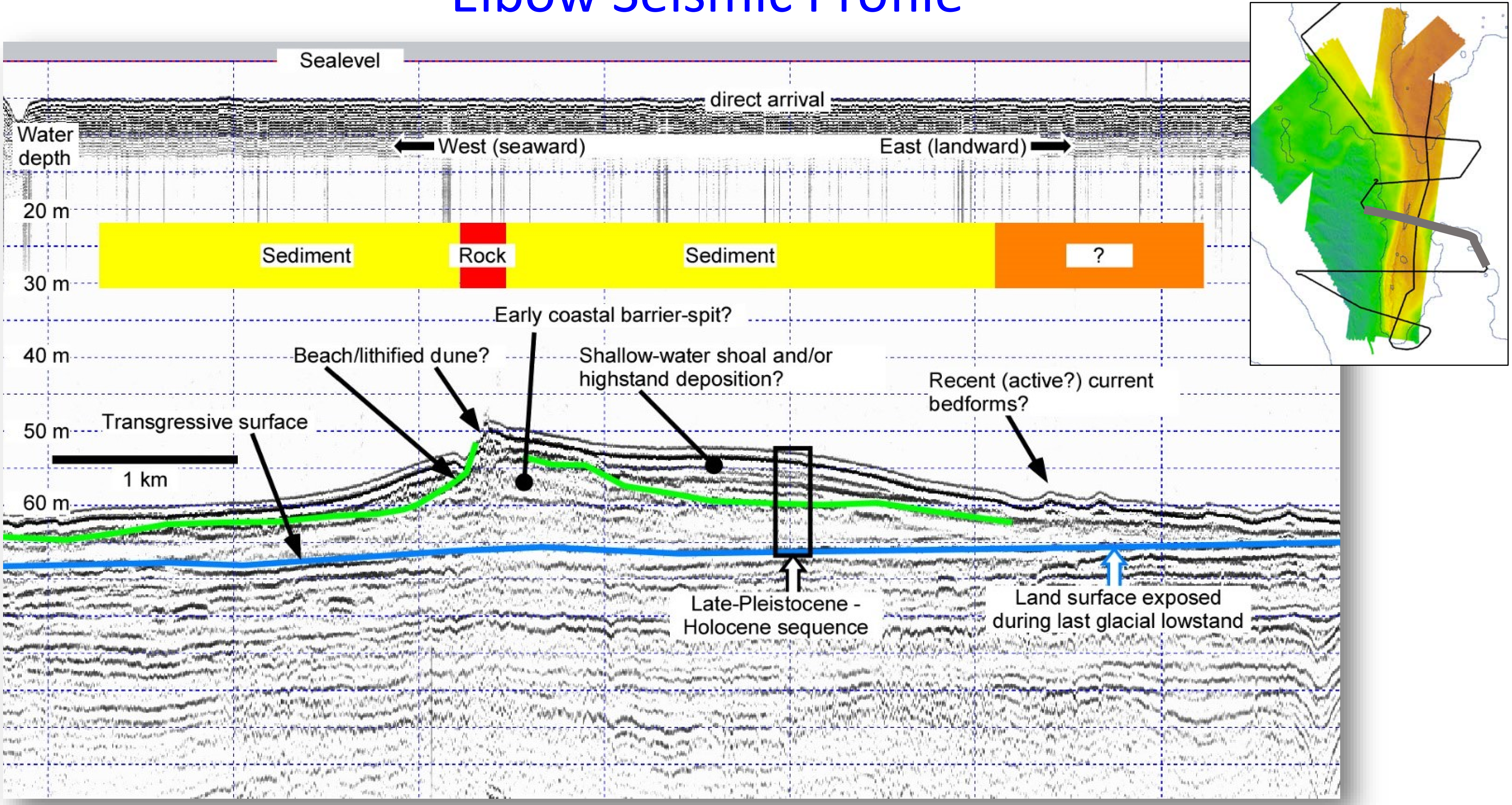
Thanks to Our Partners & the Project Steering Committee!

For a list of publications from this project, please visit:

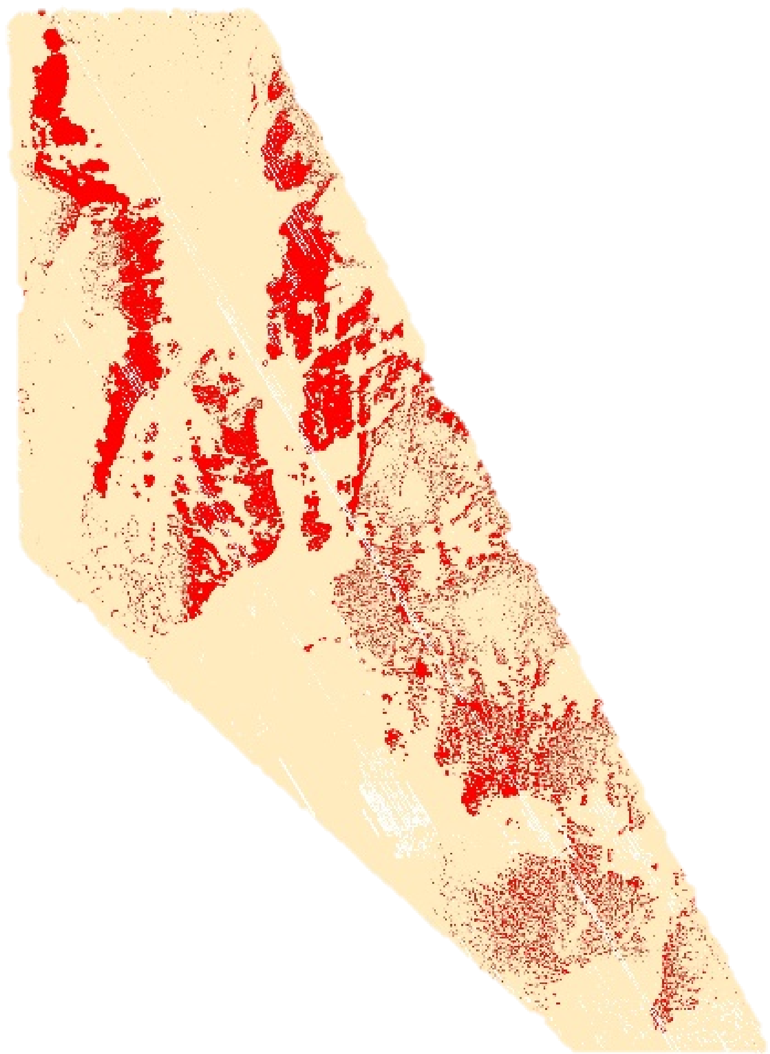
http://www.marine.usf.edu/scamp/publications

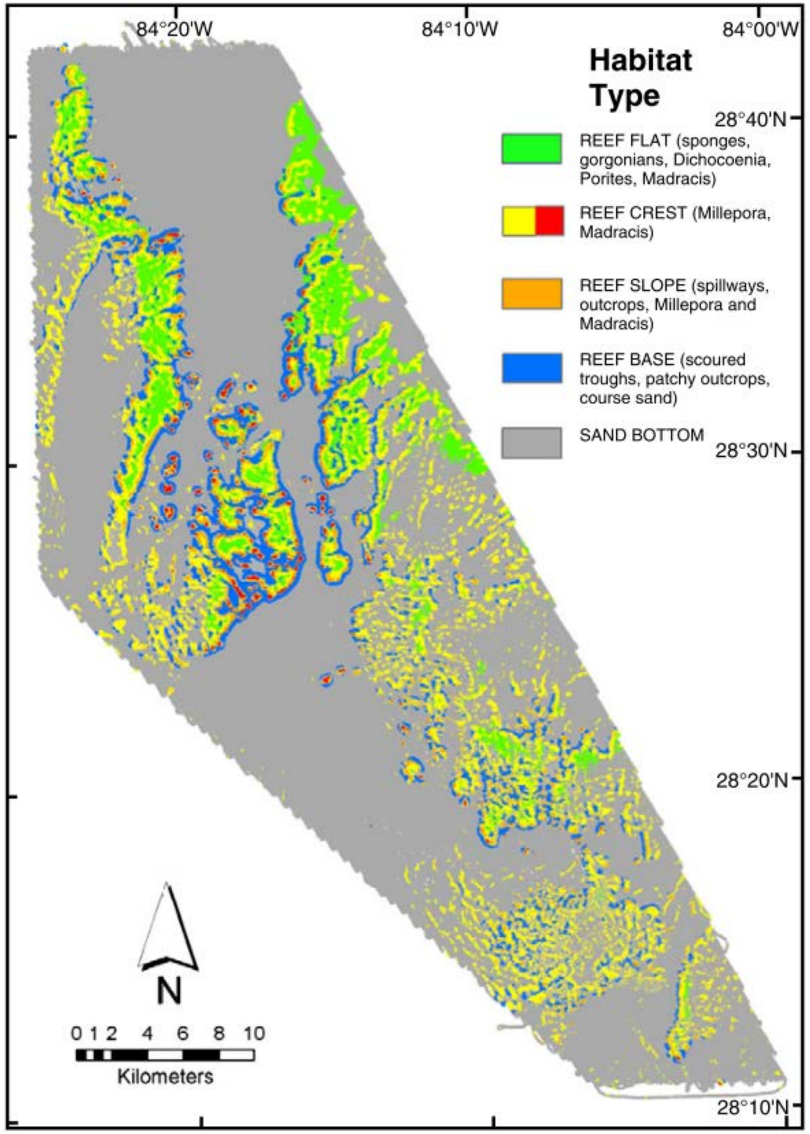
Backup Slides

Elbow Seismic Profile



FMG Comparison





Mallinson et al 2014

Model Validation by Area Bathymetry Only

Overall Confusion Matrix

Prediction	Observation: Rock	Observation: Sand
Rock	232	52
Sand	96	3,469

Accuracy = 96%
Kappa = 0.74

FMG Confusion Matrix

Prediction	Observation: Rock	Observation: Sand
Rock	99	15
Sand	7	196

Accuracy= 93%
Kappa = 0.85

Elbow Confusion Matrix

Prediction	Observation: Rock	Observation: Sand
Rock	122	14
Sand	51	817

Accuracy = 94%
Kappa = 0.75

SWFMG Confusion Matrix

Prediction	Observation: Rock	Observation: Sand
Rock	11	23
Sand	38	2,456

Accuracy= 98%
Kappa = 0.25

Supervised Classification: Model Validation

Confusion Matrix

Prediction \ Observation	Rock	Sand
Rock	20	11
Sand	8	573

Accuracy Metrics

Overall Accuracy- Percentage of observations correctly classified

User's Accuracy- Looking at an area on a map of a given class, how likely is it to be correct?

Producer's Accuracy- Given an observation of a certain class, how likely is it that my map makes the correct prediction

Kappa- Overall accuracy adjusted for what could occur by chance

0 = No better than random chance

1 = Perfect agreement

K > 0.6 indicates "substantial agreement"

(Landis and Koch, 1977)

Model Validation: Accuracy Assessment

Elbow Confusion Matrix

N_{rock}= 153
N_{sand} = 741

Prediction \ Observation	Rock	Sand
Rock	114	21
Sand	39	720

Accuracy = 93%
Kappa = 0.75

FMG Confusion Matrix

N_{rock} = 93
N_{sand} = 203

Prediction \ Observation	Rock	Sand
Rock	87	7
Sand	6	196

Accuracy = 96%
Kappa = 0.90

K > 0.6 indicates "substantial agreement"
K > 0.4 indicates "moderate agreement"
(Landis and Koch, 1977)

SWFMG Confusion Matrix

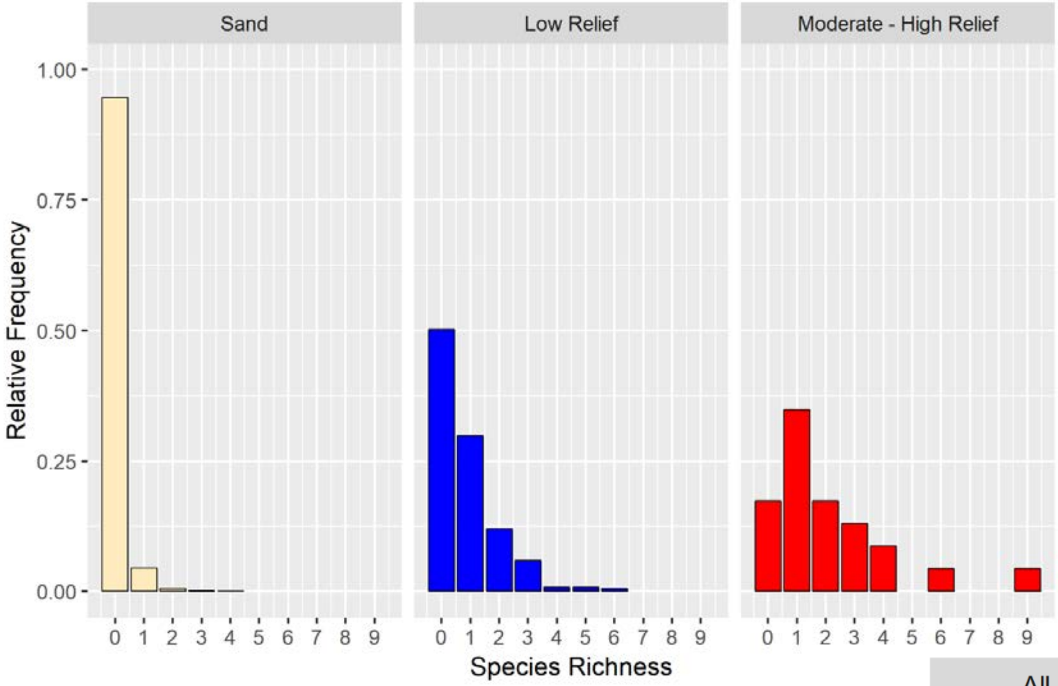
N_{rock} = 25
N_{sand} = 1,437

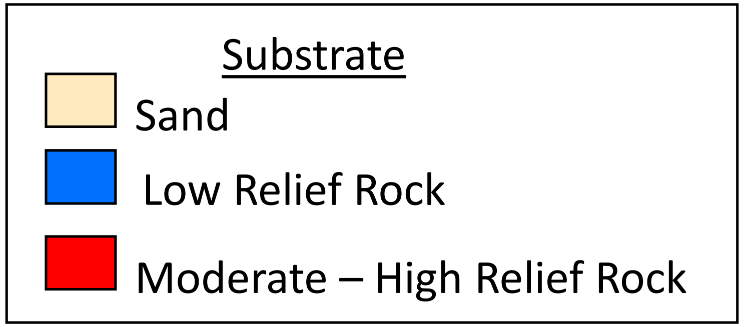
Prediction \ Observation	Rock	Sand
Rock	9	7
Sand	16	1,430

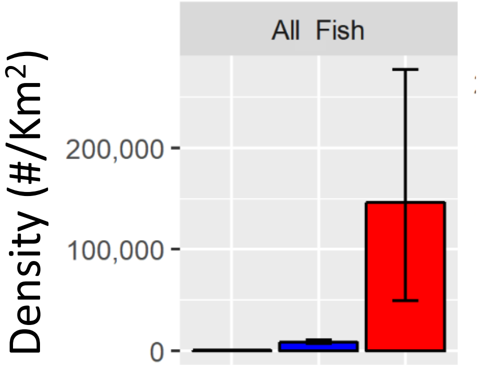
Accuracy = 98%
Kappa = 0.43

Fish Density and Species Richness

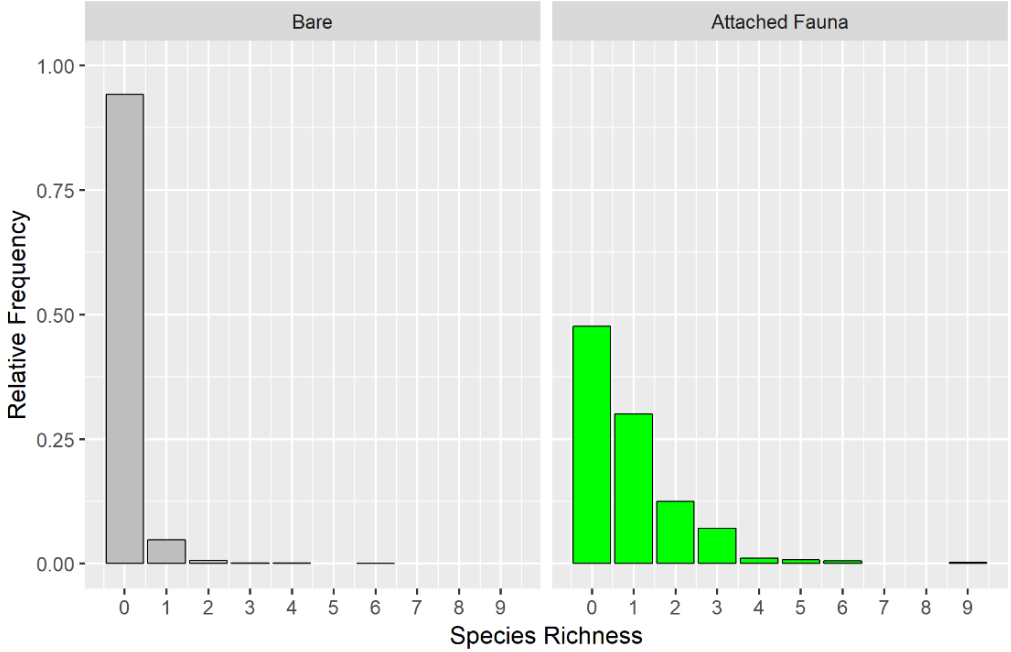
Substrate

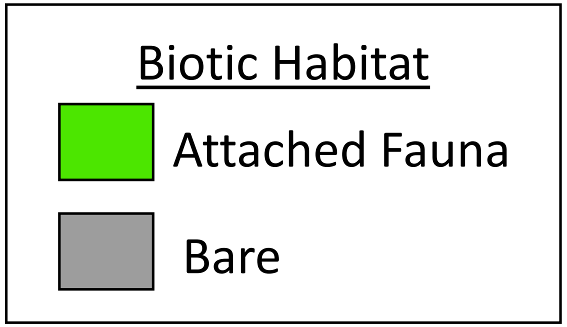


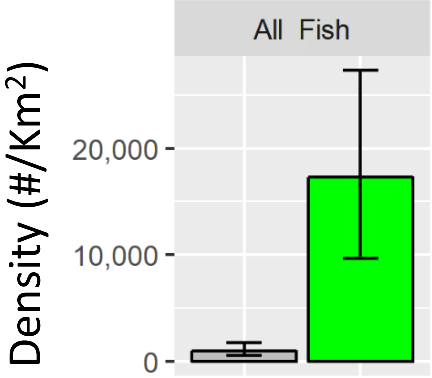




Biotic

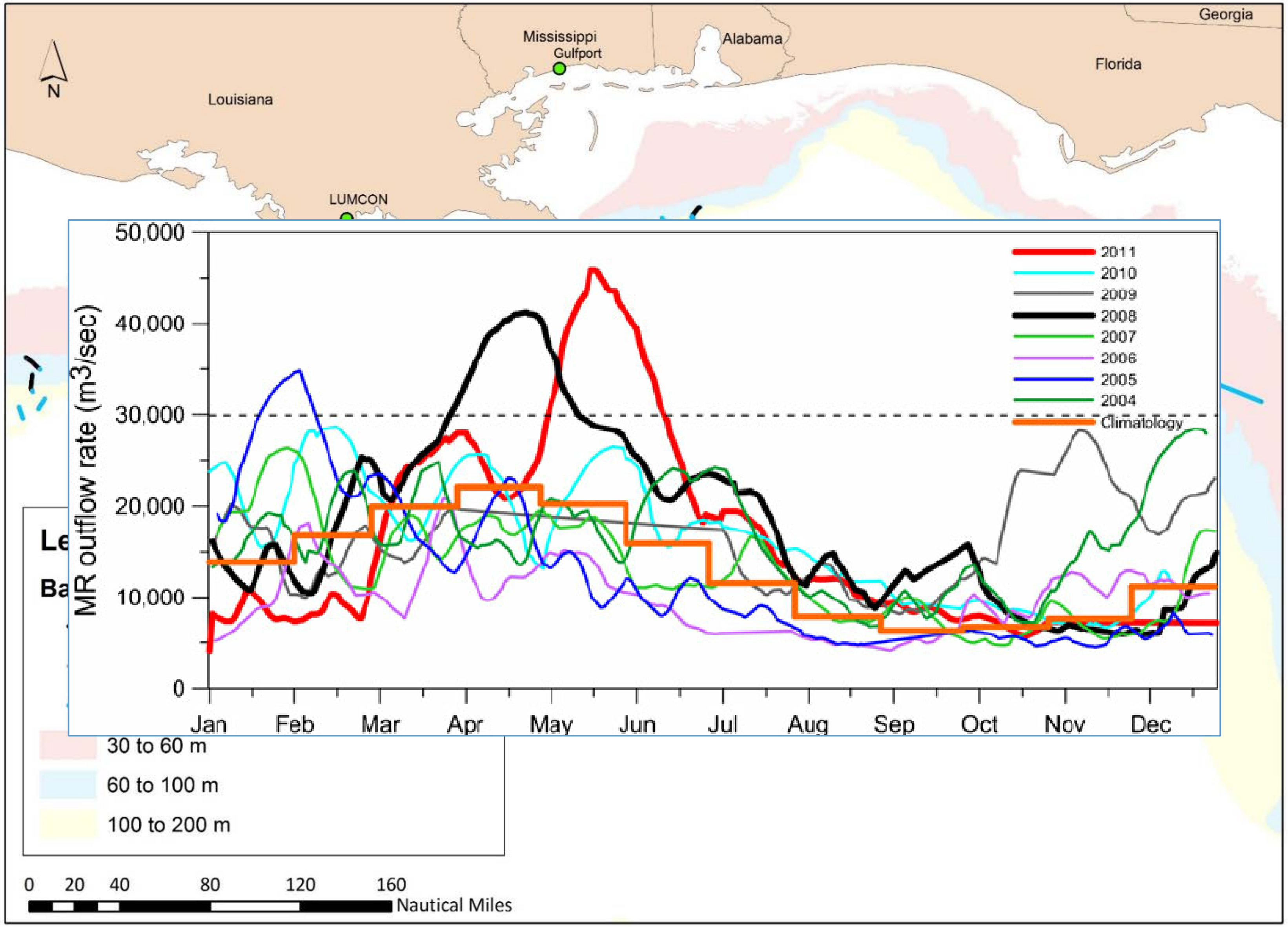






Preliminary Results – Visibility

- Experienced zero visibility frequently around LA and MS in depths < 160 meters
- Hardbottom generally had good visibility
- Changing survey window to March to avoid peak outflow
    - Androulidakis and Kourafalou (2013): "On the processes that influence the transport and fate of Mississippi waters under flooding outflow conditions"



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