Assessing Reef Fish Habitat and Population Abundance on the West Florida Shelf

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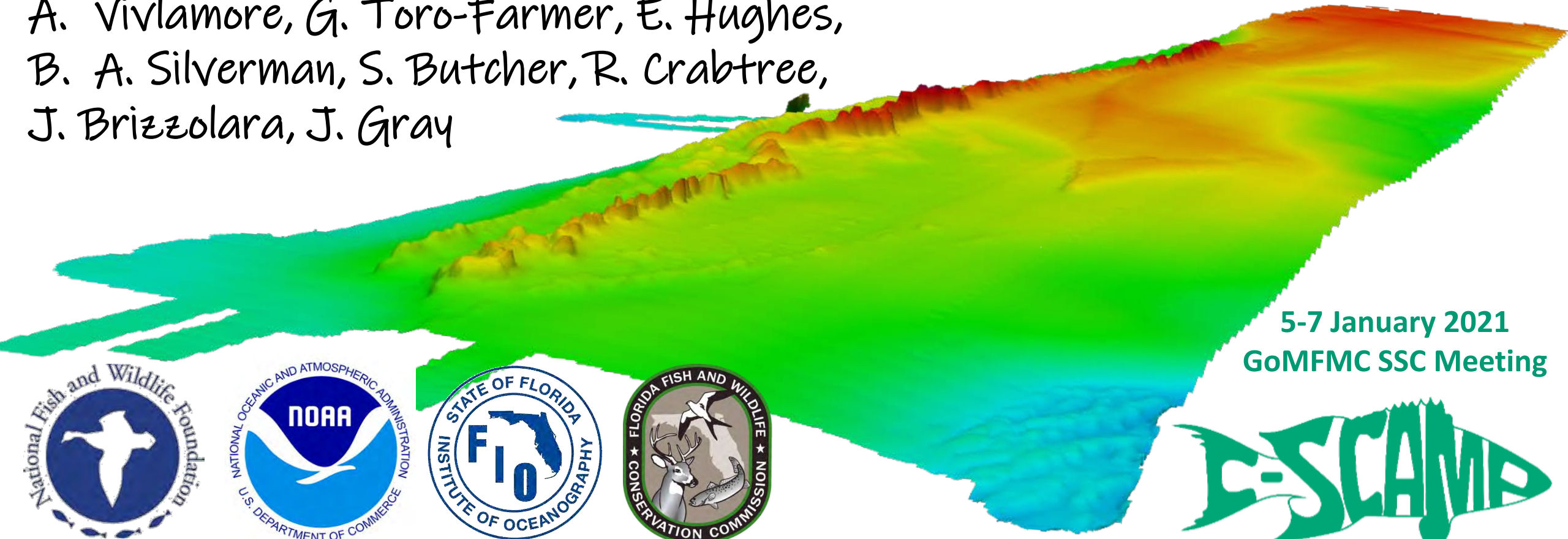
A. Vivlamore, G. Toro-Farmer, E. Hughes,
B. A. Silverman, S. Butcher, R. Crabtree,
J. Brizzolara, J. Gray



5-7 January 2021
GoMFMC SSC Meeting

Overview & Objectives....

- Describe a 5-year program of habitat mapping and direct fish abundance estimation on the West Florida Shelf (and elsewhere in the GoM)
- Outline potential management-related actions based on new habitat data
- Discuss and get feedback on mapping & habitat-related research priorities

Scope of the problem and long-term goal

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

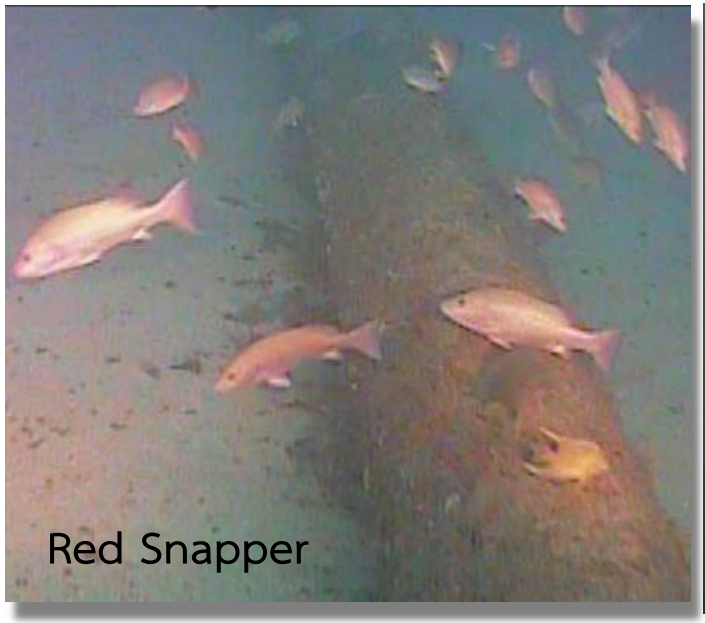
Long-Term Goal: Design a sampling system to estimate absolute abundance of reef fish populations and habitats

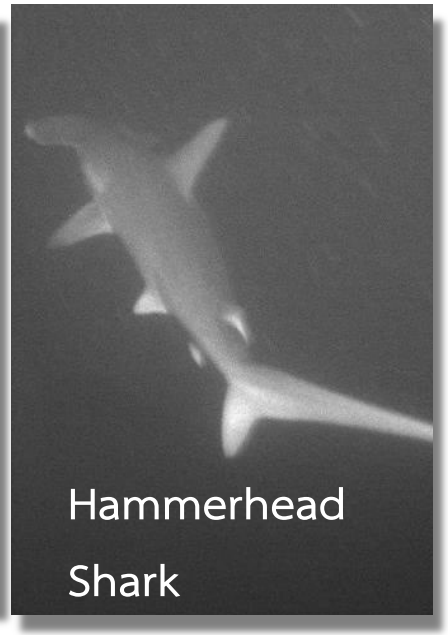
Primary Target Species

Red Snapper
Vermilion Snapper
Red Grouper
Gag Grouper
Sea turtles

Secondary Target Species

Other snappers
Other groupers
Various reef fishes


Red Snapper


Hammerhead Shark


Cobia

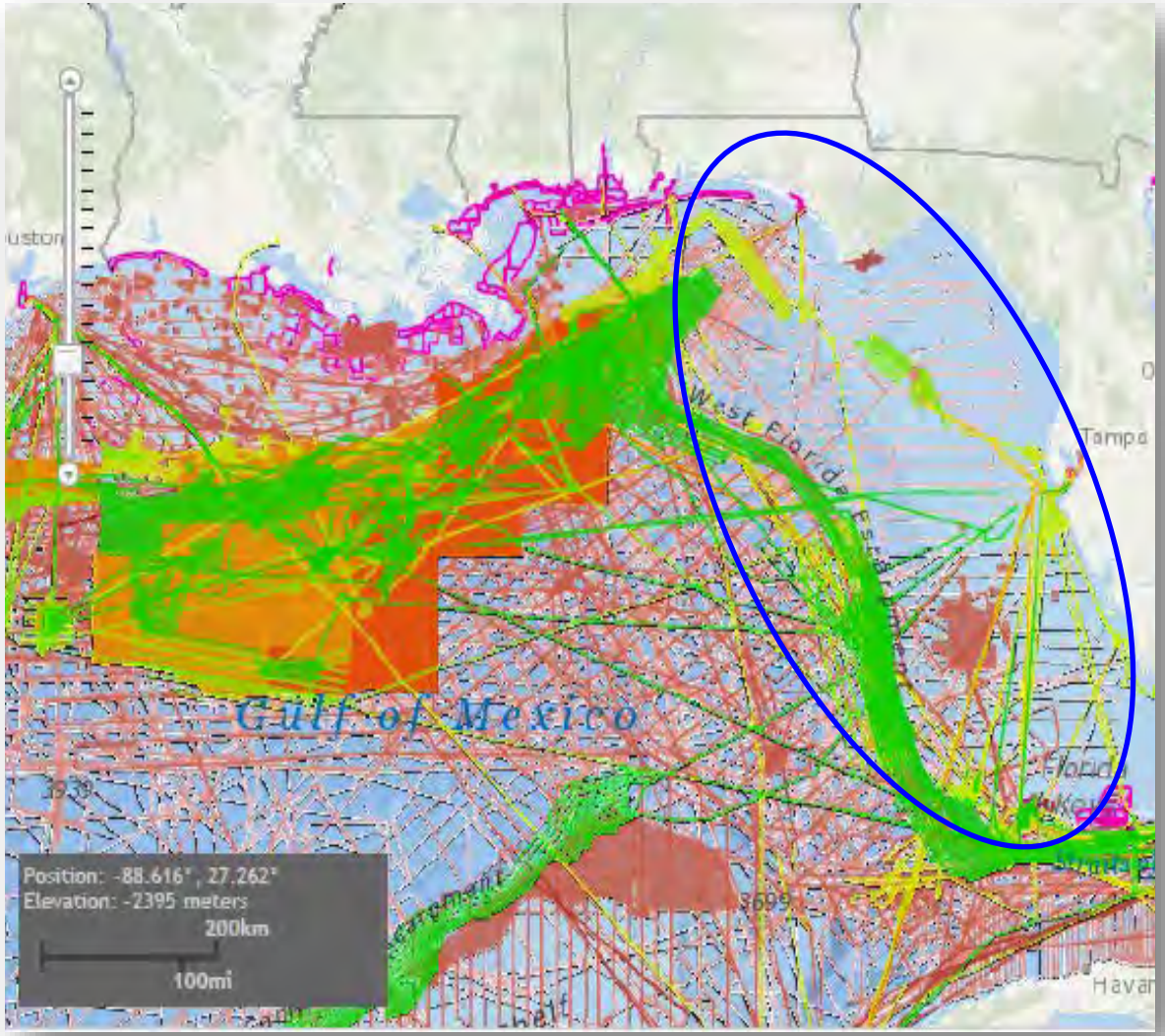

Kemp's Ridley Sea Turtle


Goliath Grouper

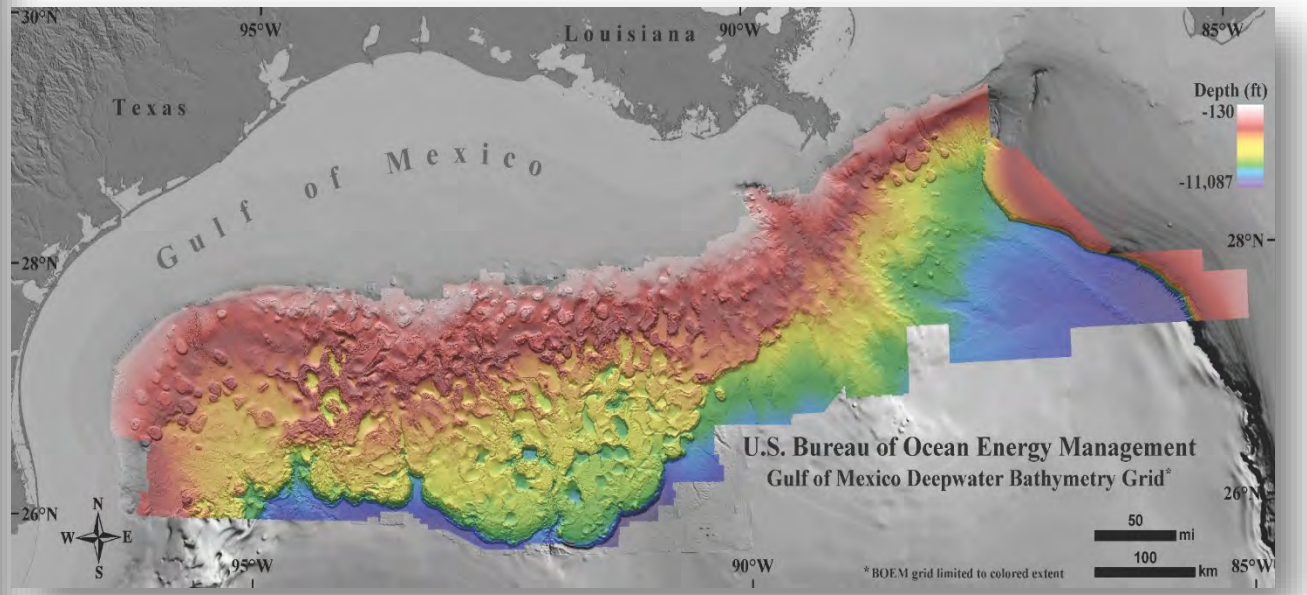
Objectives of the C-SCAMP Program (funded by NFWF)

- ✓ Provide about 2,400 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 GoMFMC and NMFS to consider additional HAPCs and MPAs
- ✓ Develop new technologies and methods
- ✓ Identify promising areas for additional habitat sampling

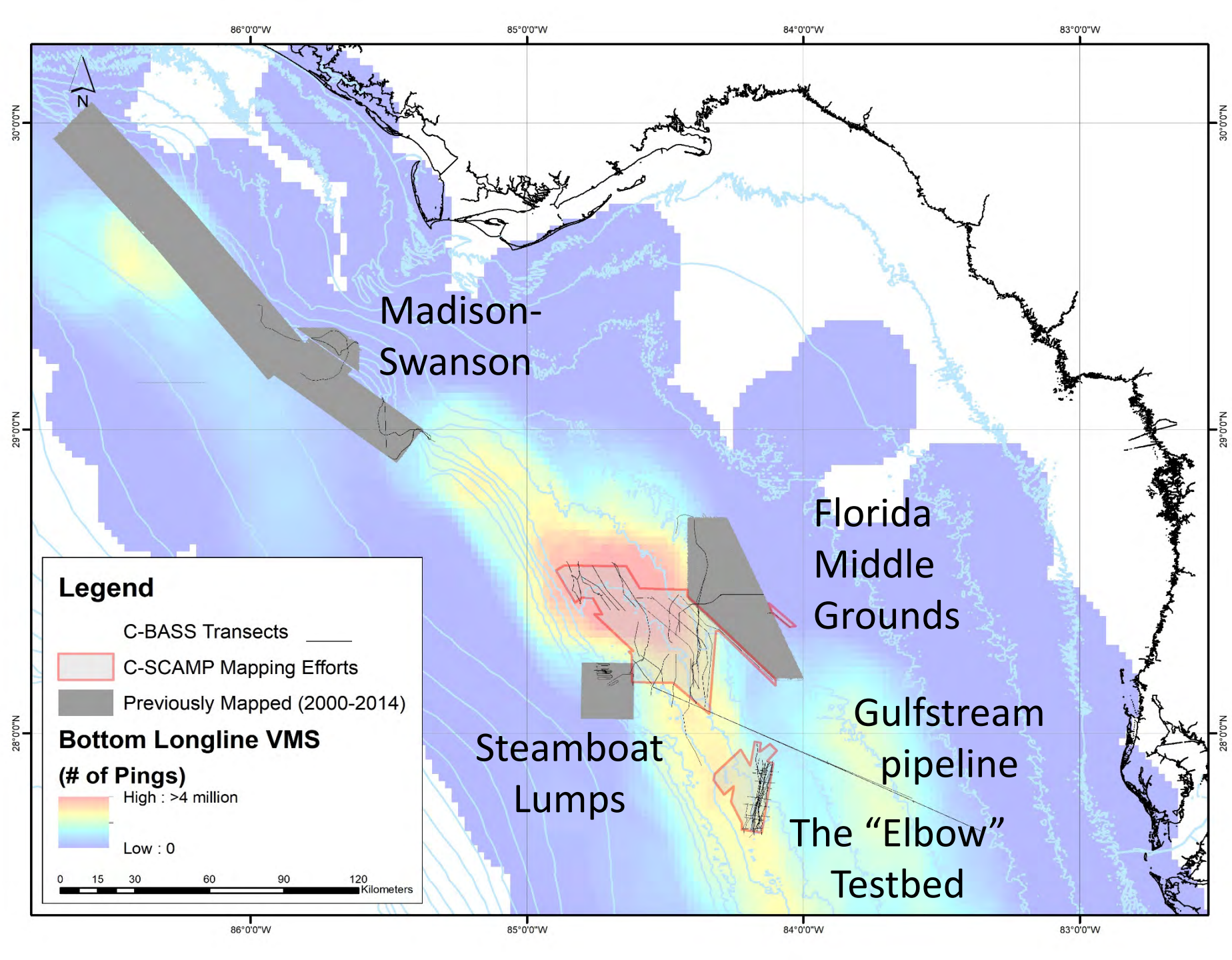
The Eastern GoM Shelf is one of the most poorly mapped areas in the lower 48



NCEI's Online Mapping Inventory

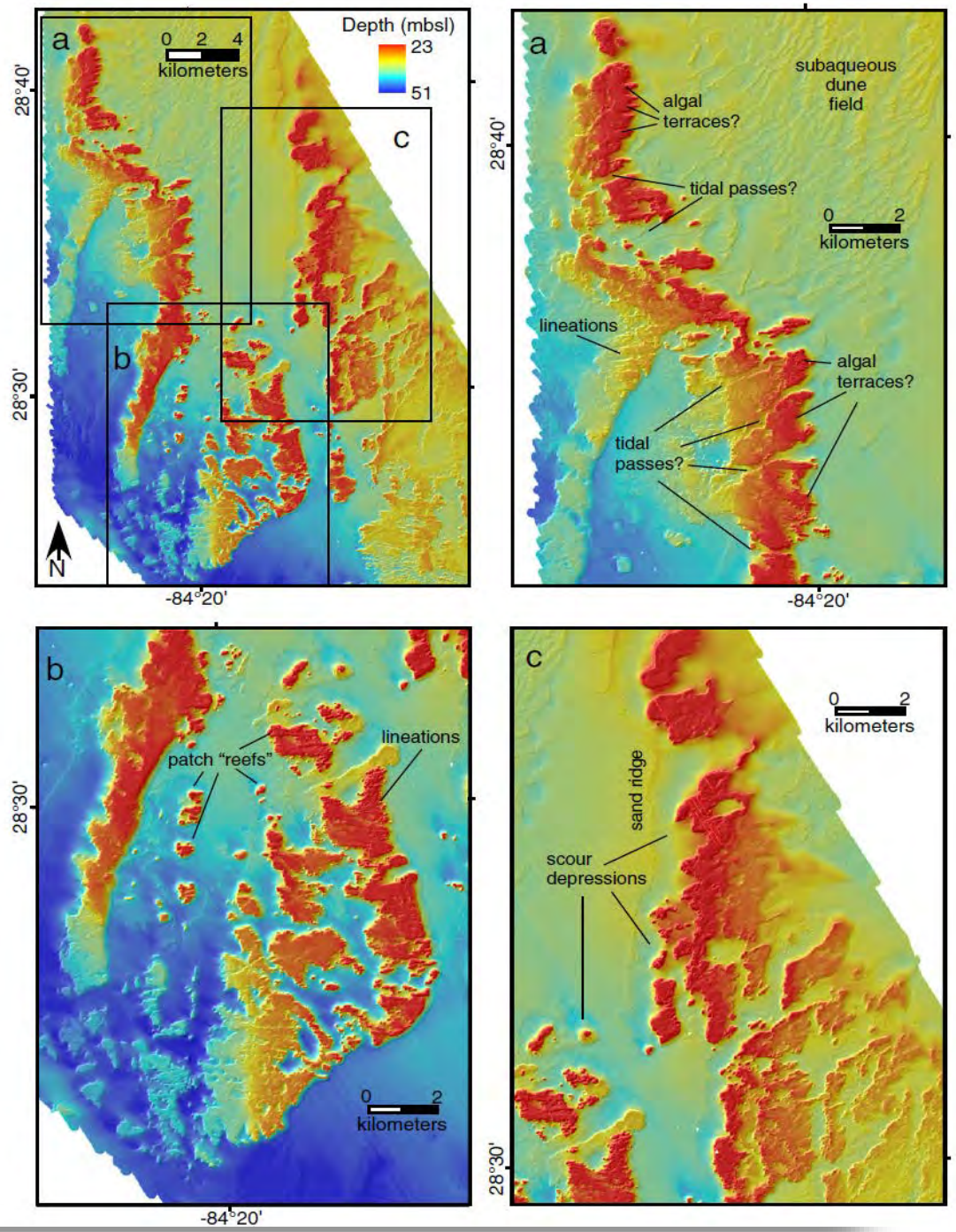


BOEM's Compilation from Industry Seismic Data



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



Contents lists available at ScienceDirect

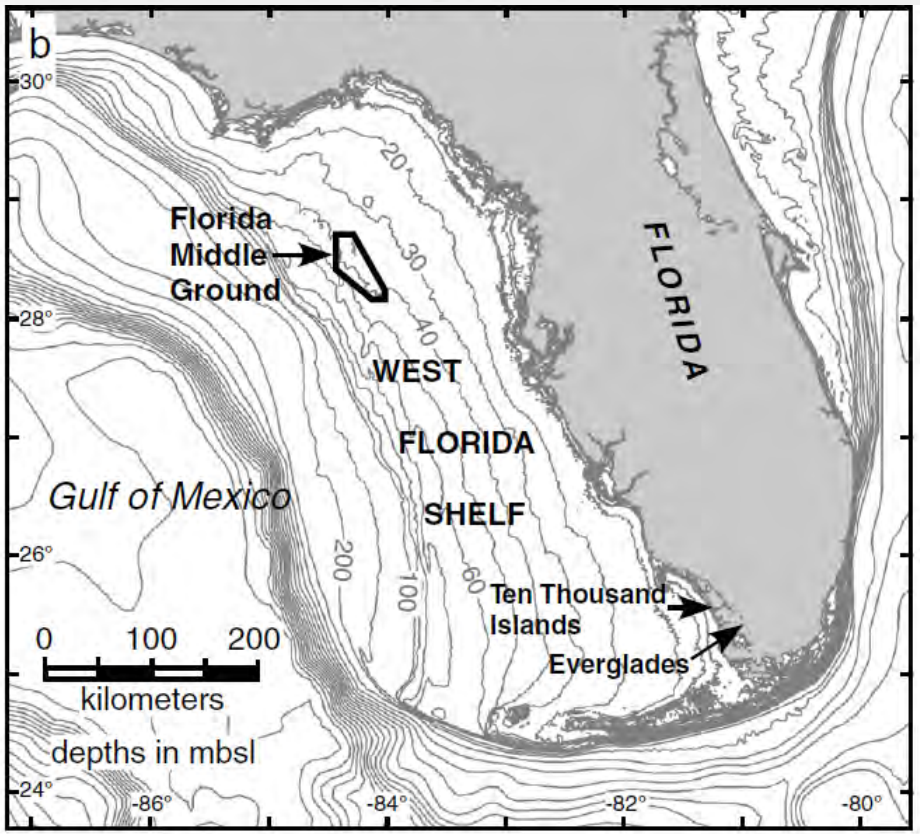
Marine Geology

journal homepage: www.elsevier.com/locate/margeo

New perspectives on the geology and origin of the Florida Middle Ground carbonate banks, West Florida Shelf, USA

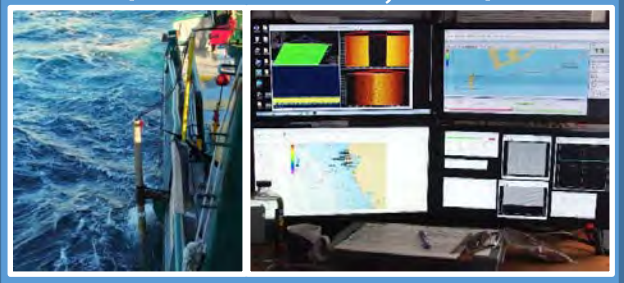
David Mallinson [a,*], Albert Hine [b], David Naar [b], Stanley Locker [b], Brian Donahue [b]

[a] Department of Geological Sciences, East Carolina University, Greenville, NC 27858, United States
[b] College of Marine Science, University of South Florida, St. Petersburg, FL 33701, United States

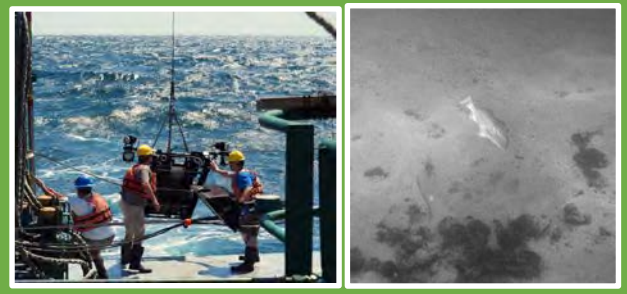


Project Recipe

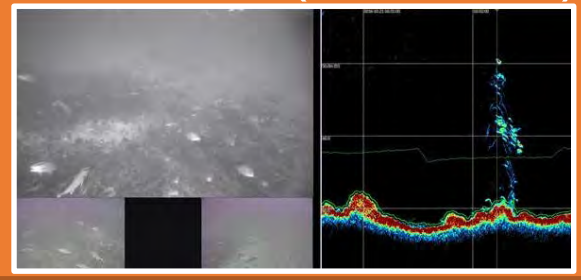
Multibeam Echosounder (SeaBat 7125, T50)



Towed Video (C-BASS)



Split-Beam Fisheries Echosounder (Simrad EK60)



First Order Analysis

- Bathymetry Analysis
- Backscatter Analysis
- CMECS-based Classification
- Environmental Sensor Data
- Fish and Turtle Analysis
- Biomass Analysis

Inter Relational Analysis

- Map Benthic Habitat Characteristics
- Fish-Habitat Relationships
- Combine Species and Biomass

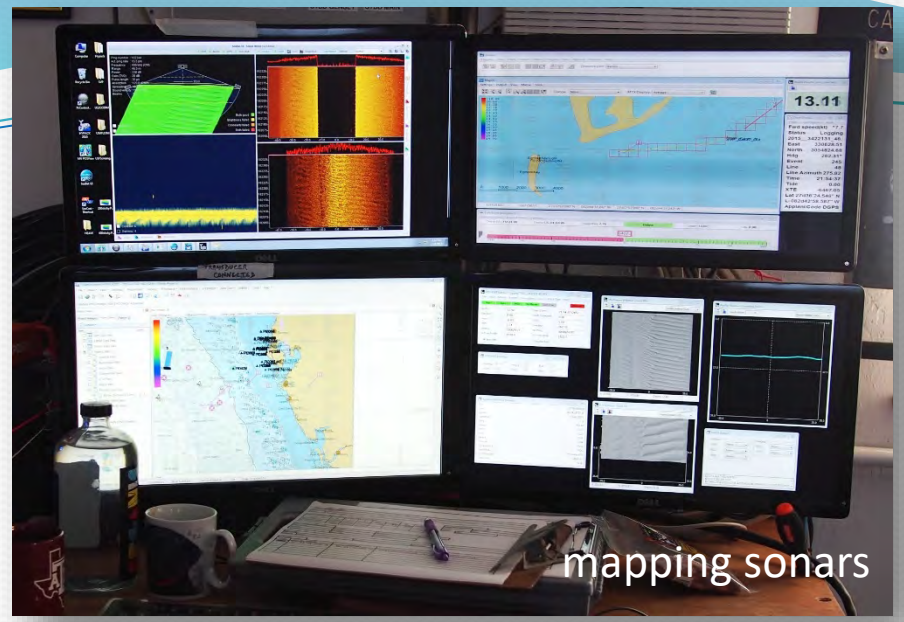
User Based Products

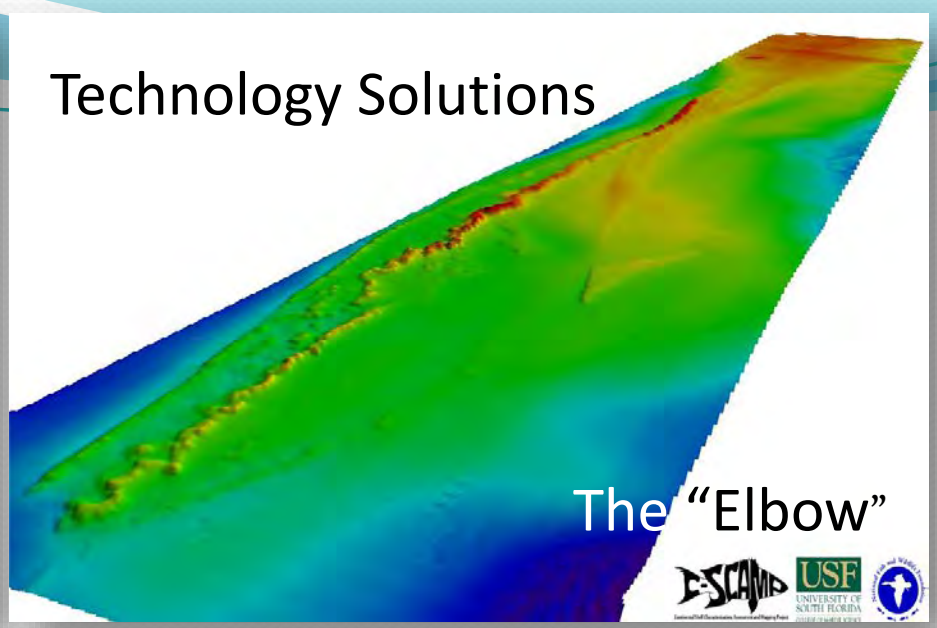
- Species Habitat Maps
- Stratified Population Estimates

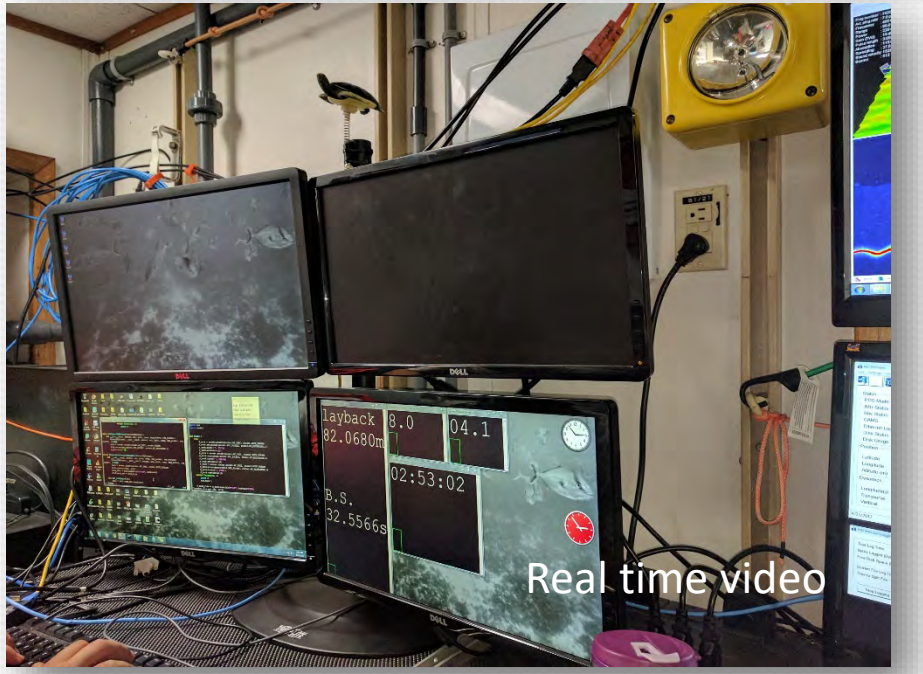
Enabling Technologies - Ship Support For Offshore Mapping

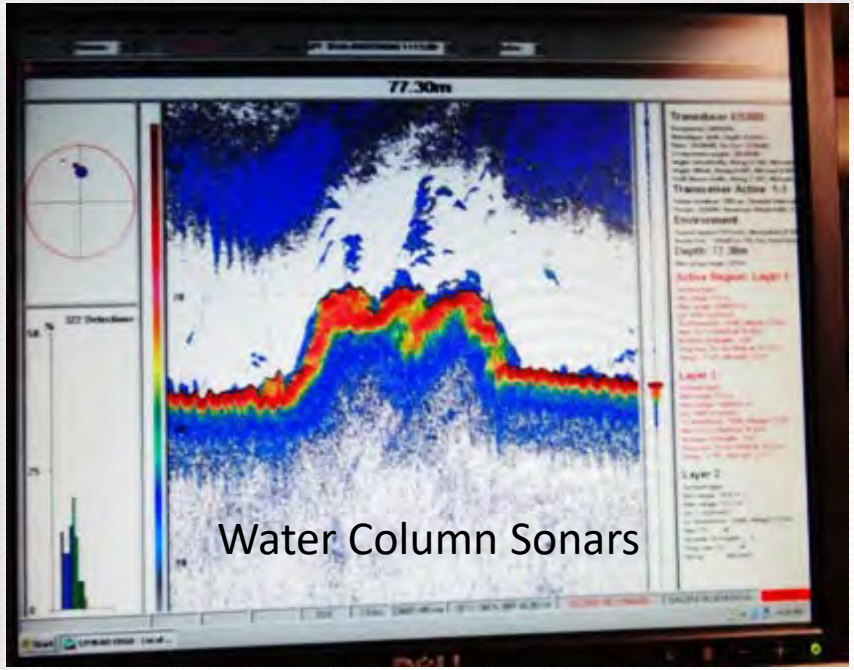
R/V *Weatherbird II*, 115 feet, Video assessment and EK-60/80 water column

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


mapping sonars


Technology Solutions
The “Elbow”

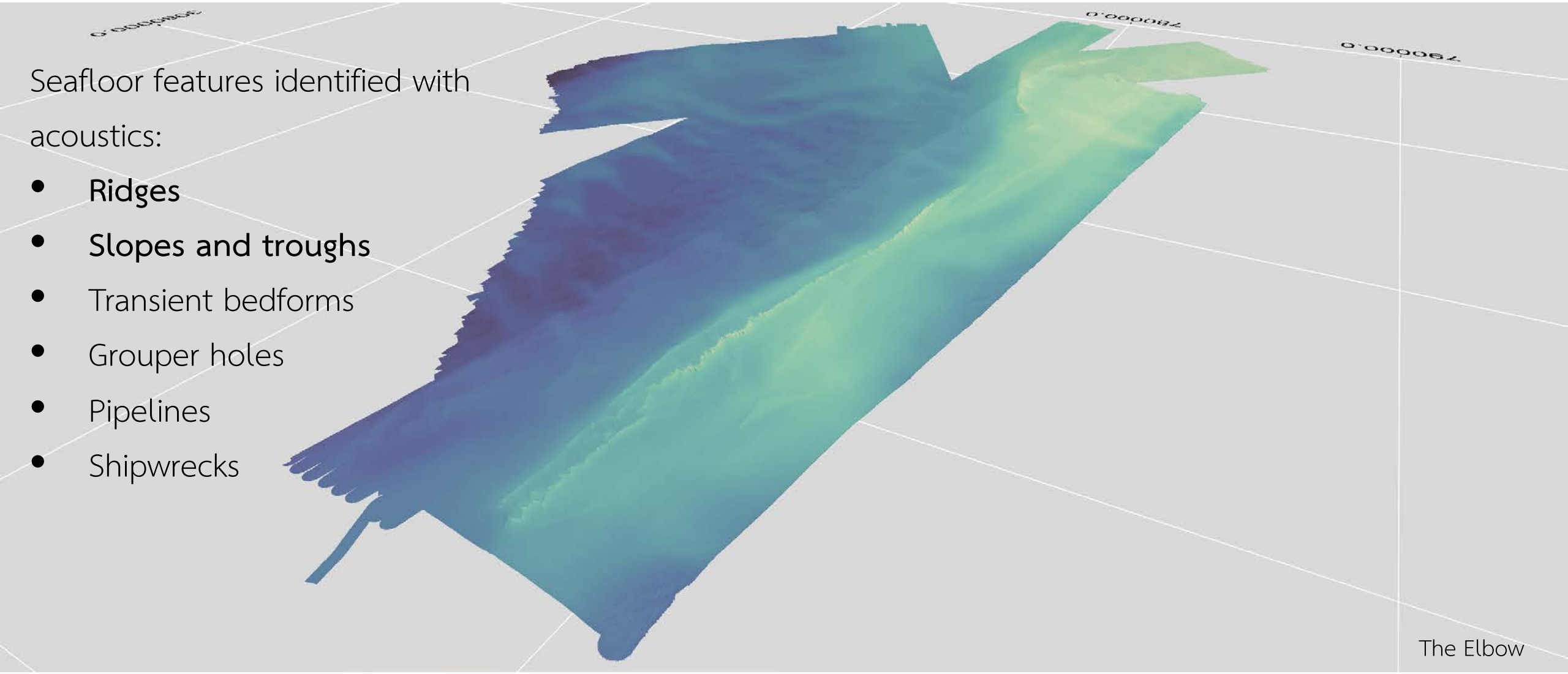

Real time video


Water Column Sonars

Multibeam Bathymetry & Backscatter

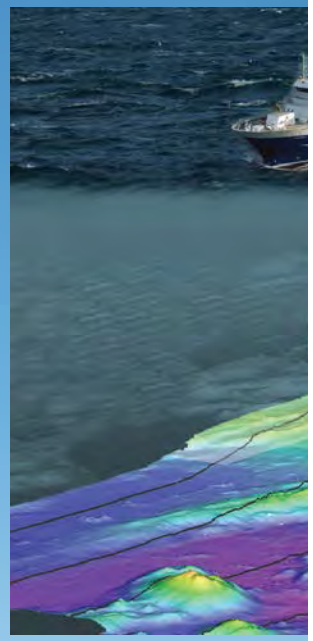
Seafloor features identified with acoustics:

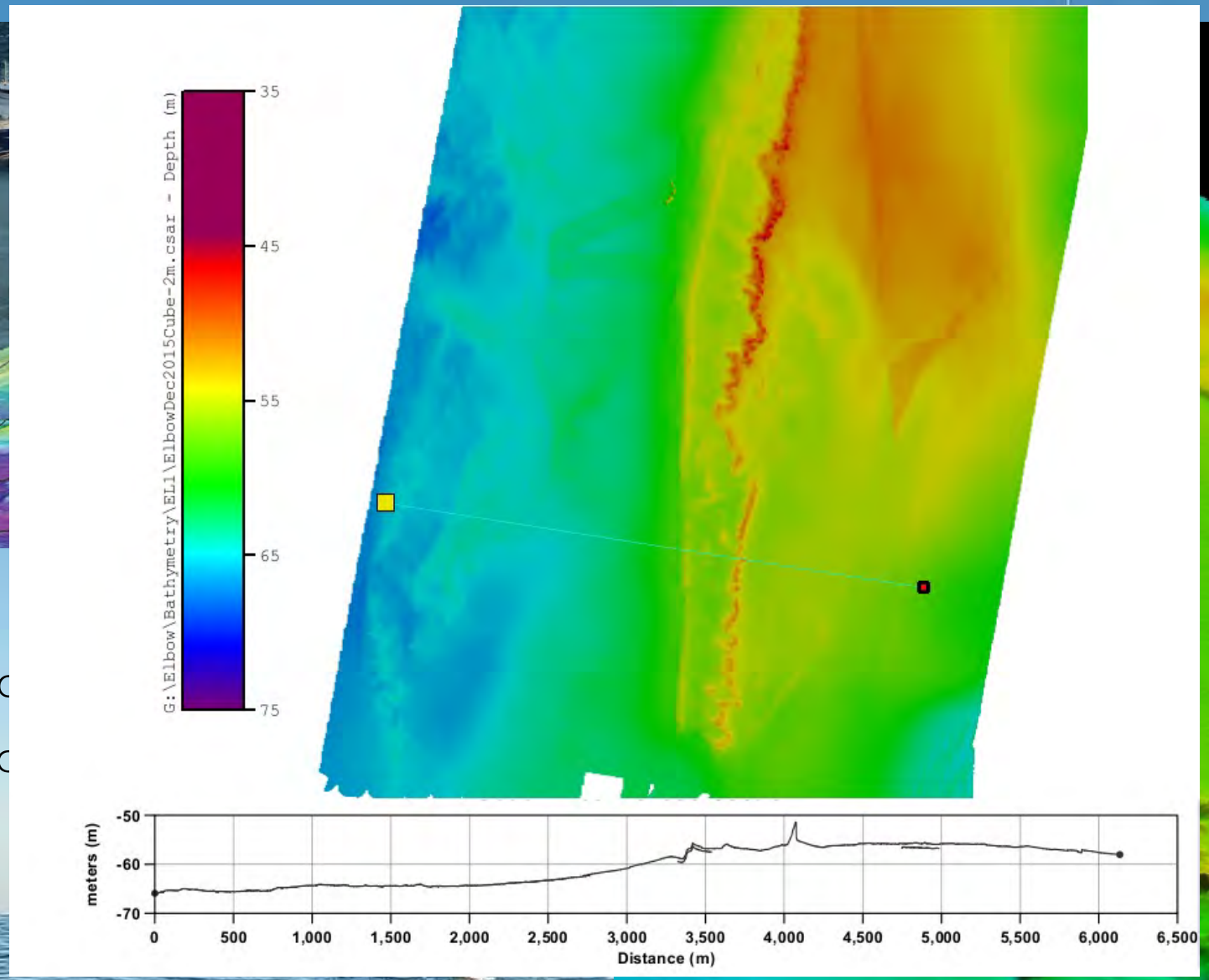
- **Ridges**
- **Slopes and troughs**
- Transient bedforms
- Grouper holes
- Pipelines
- Shipwrecks

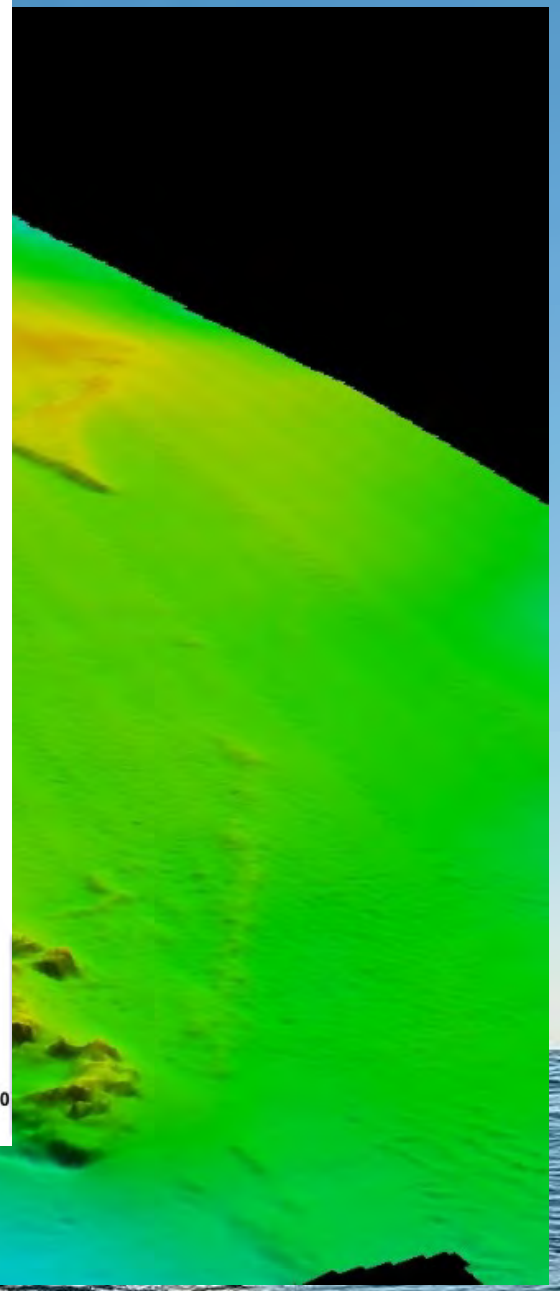


Project Scientist: Matthew Hommeyer (mhommeyer@usf.edu)

Multibeam Bathymetry & Backscatter

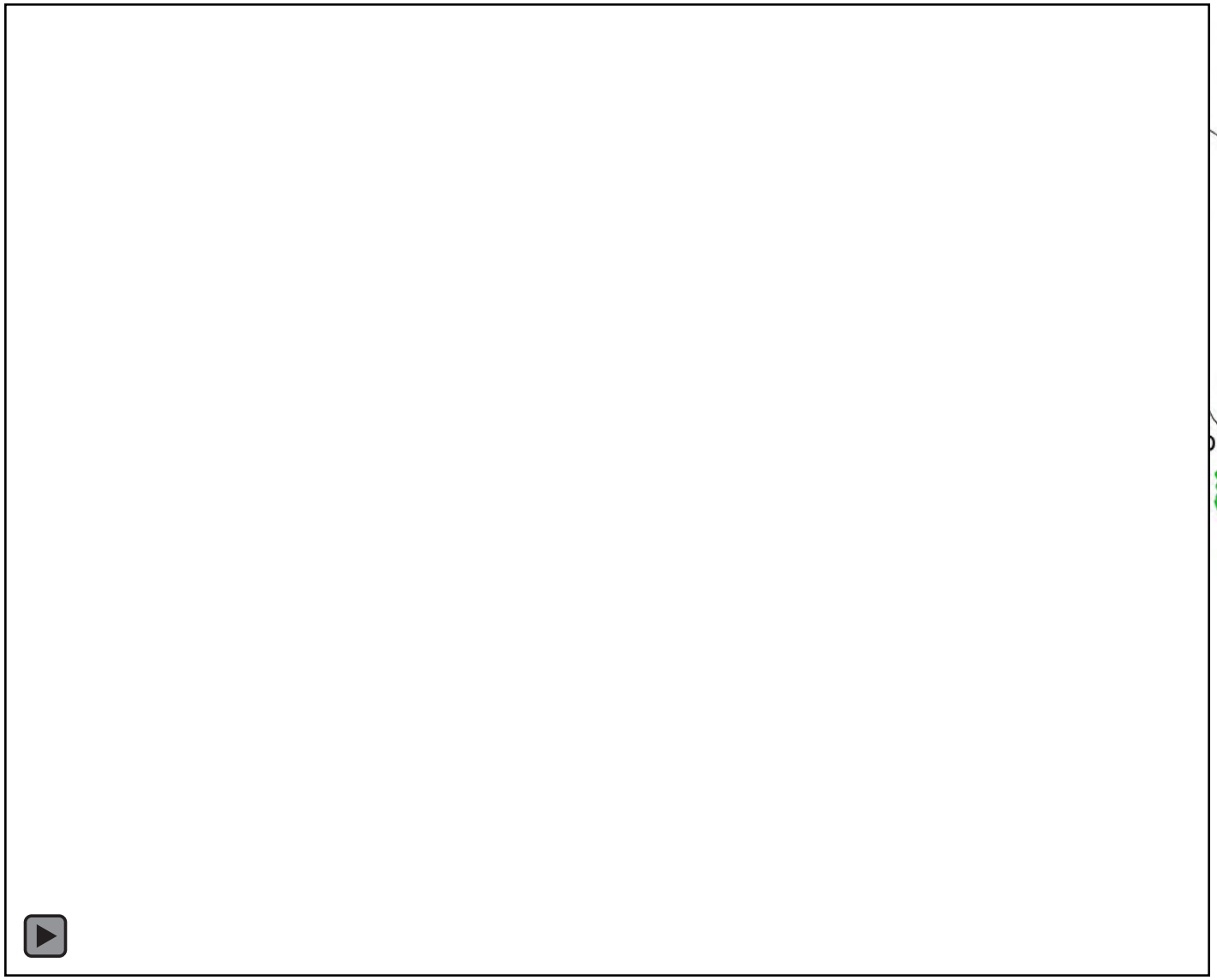


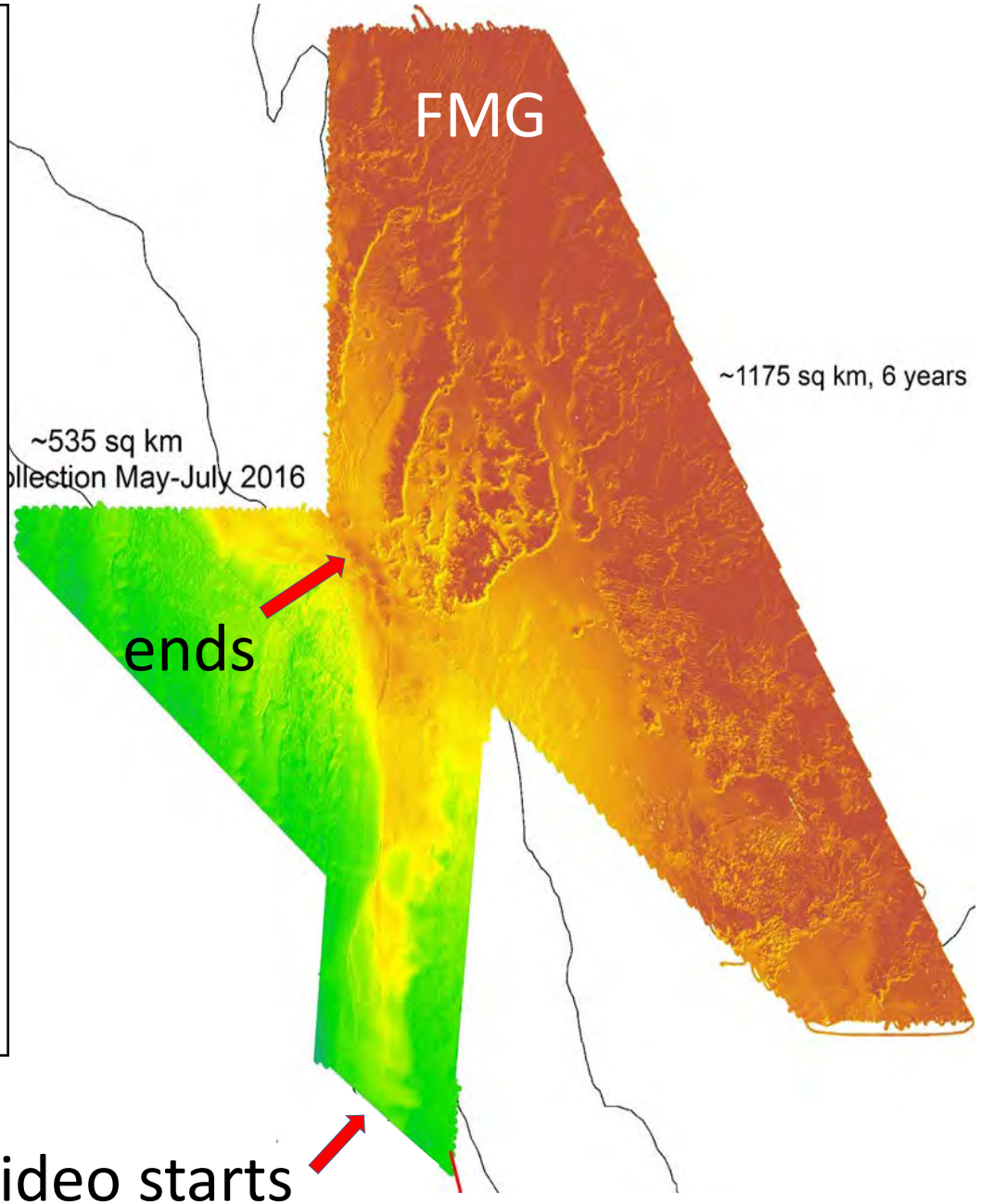




Raw multibeam

- Vessel motic
- Sound veloc
- Tide



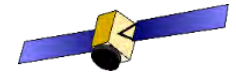


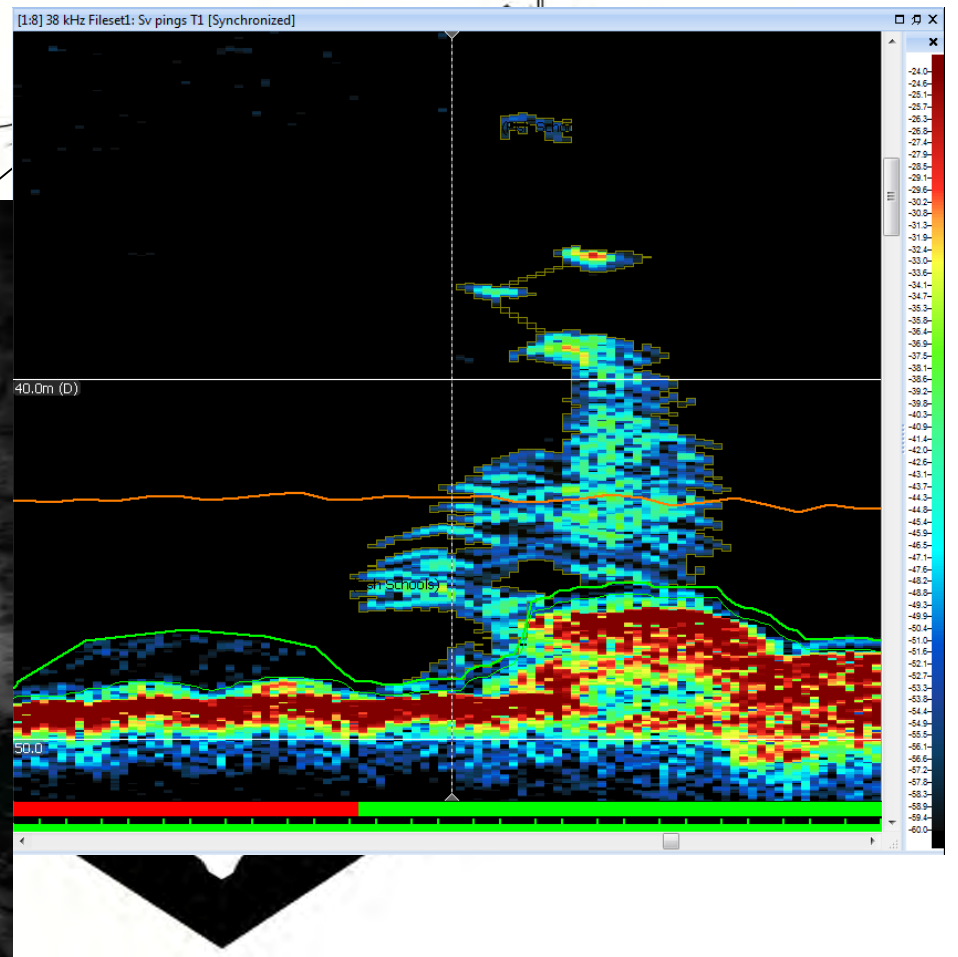
Southwest Florida Middle Grounds

Using Towed Cameras to Count Fish - Challenges

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

Leveraging Multiple Technologies for Mapping and Ground-Truthing



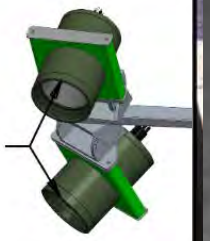


Tow Point

Vemco Receiver

Onboard Computing, Power, & Comms

Fluorometer



LEDs x4

Altimeter

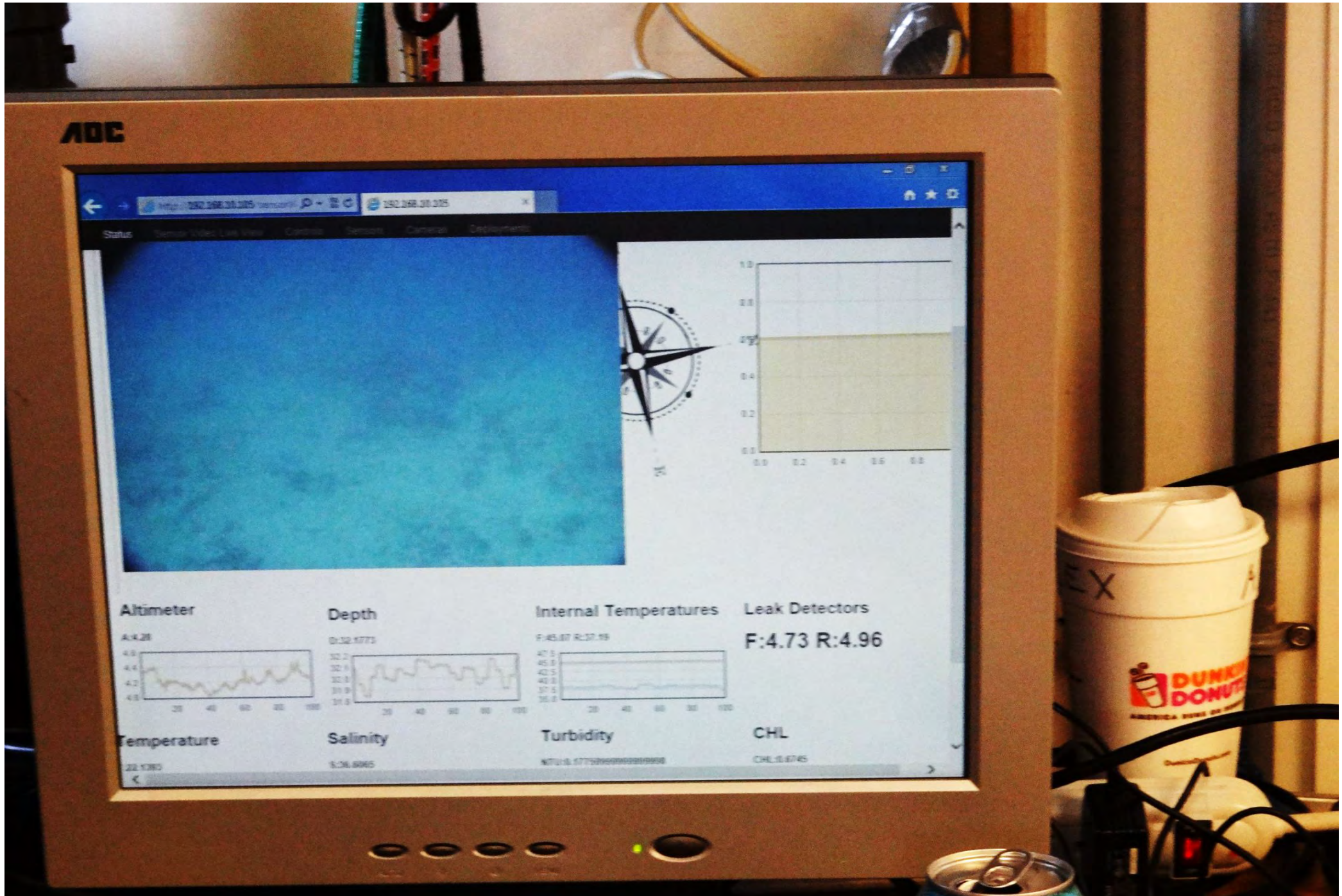
DIDSON Sonar

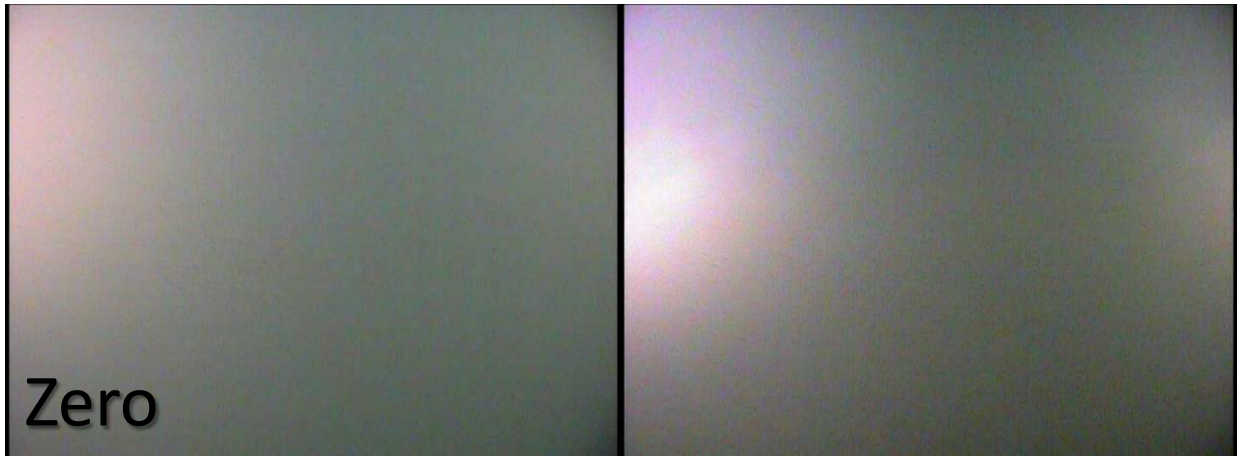
HD Ca

C-BASS

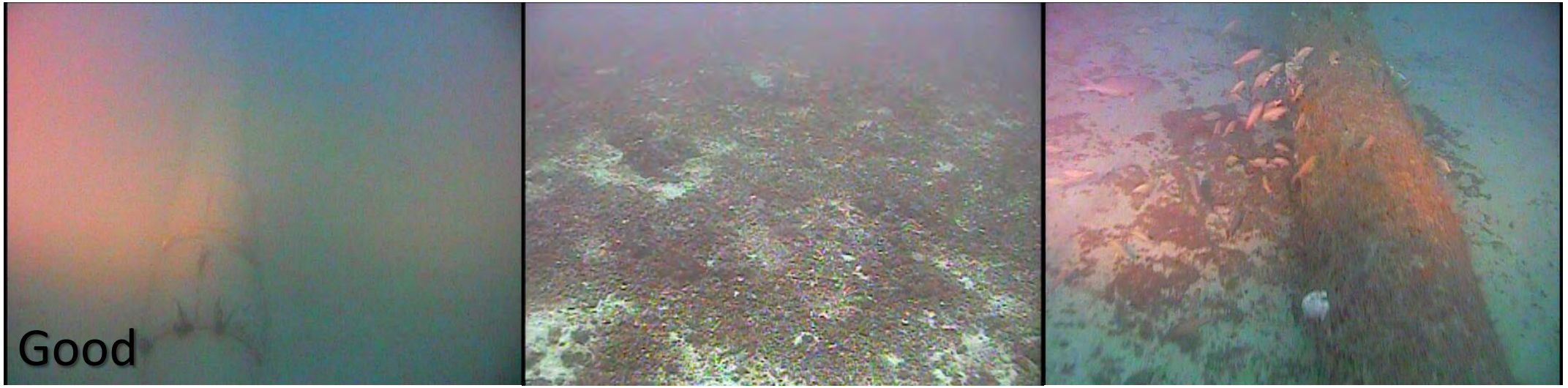
6 came

Sensors


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

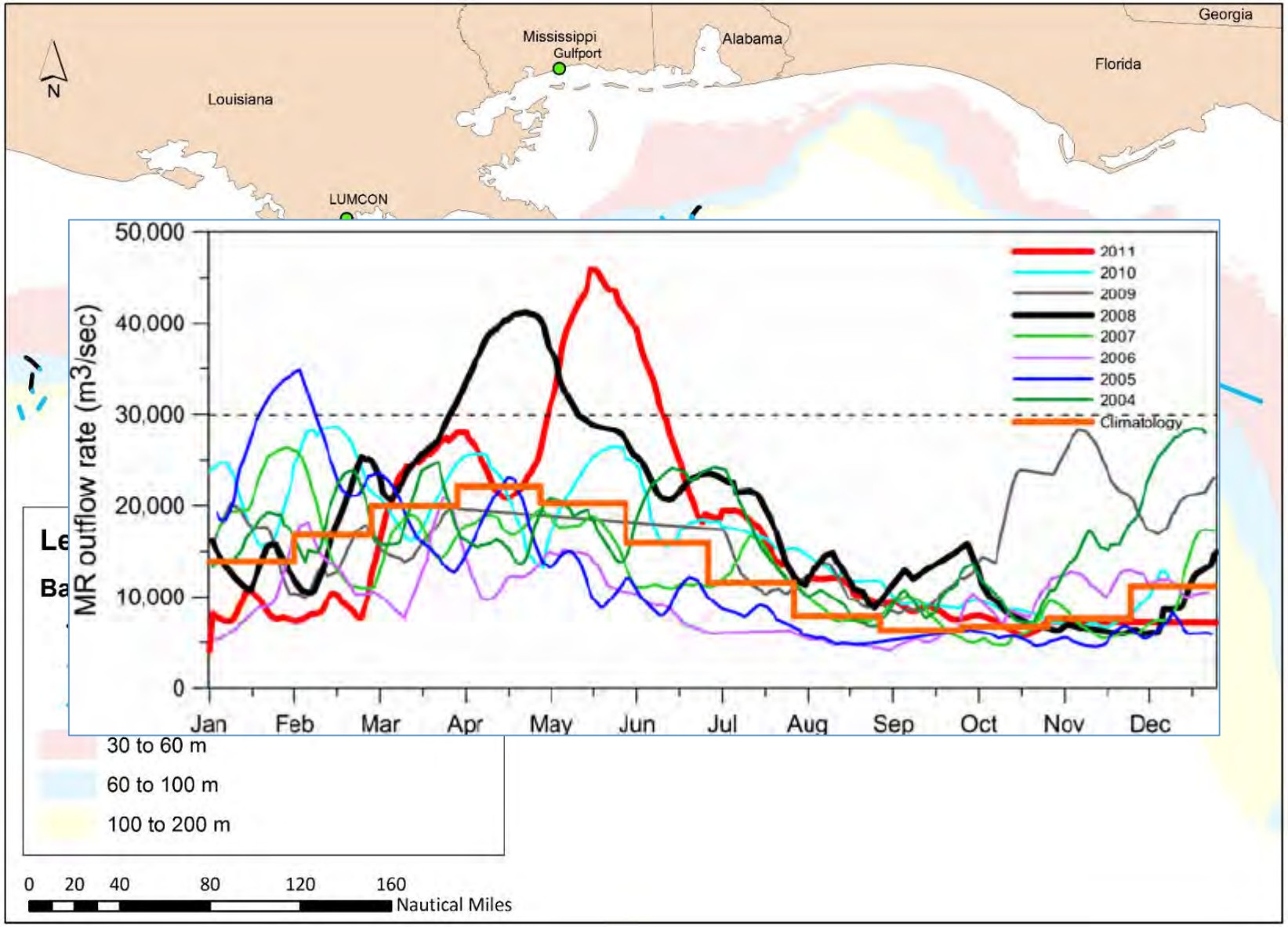


The Visibility Spectrum

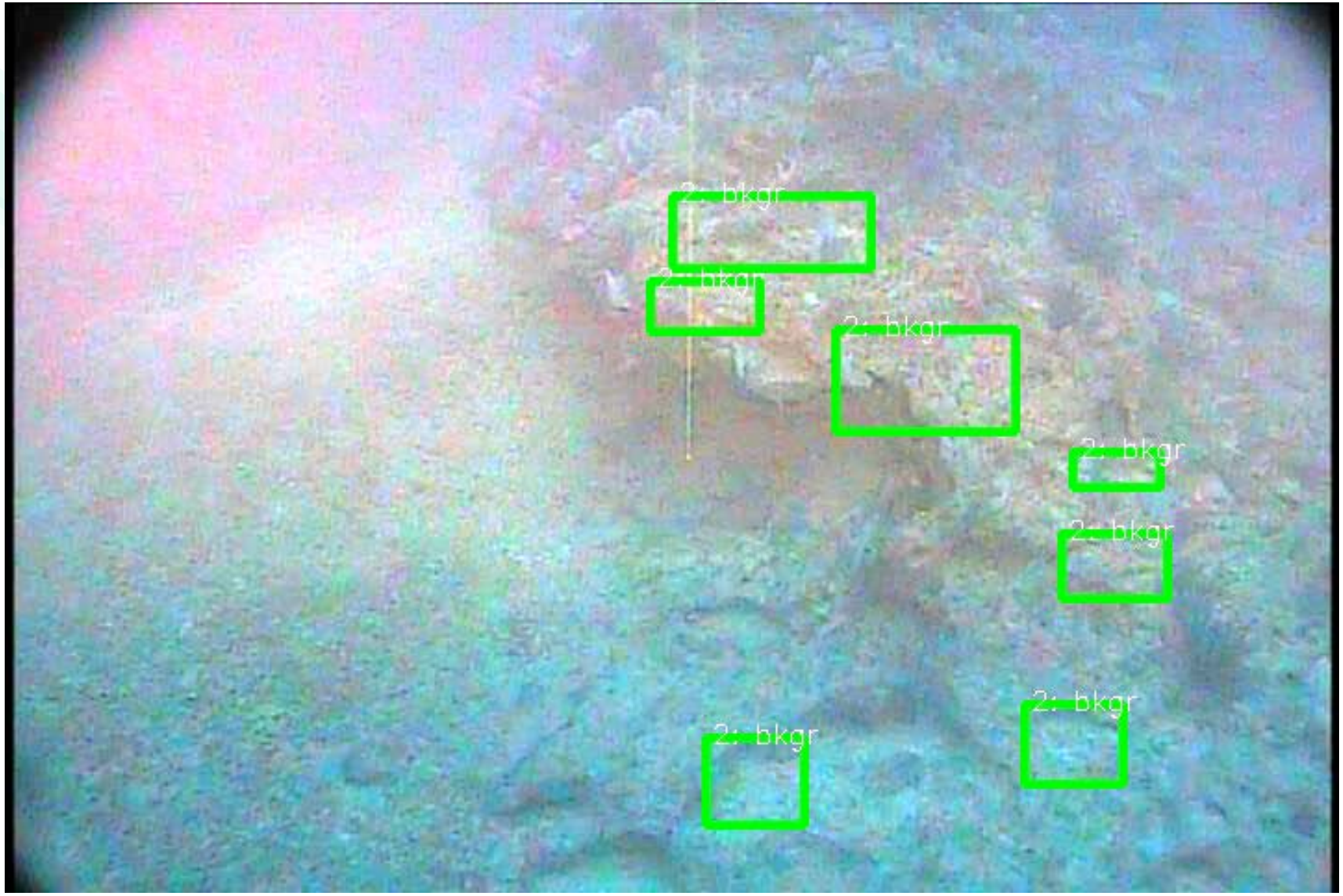


Preliminary Results – Visibility

- 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”



Fish Autorecognition – Near Ready for Primetime



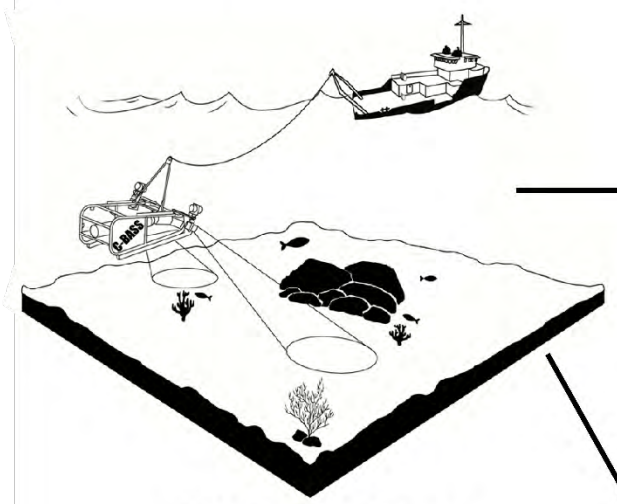
bkgr = Background

fish = Fish ☺

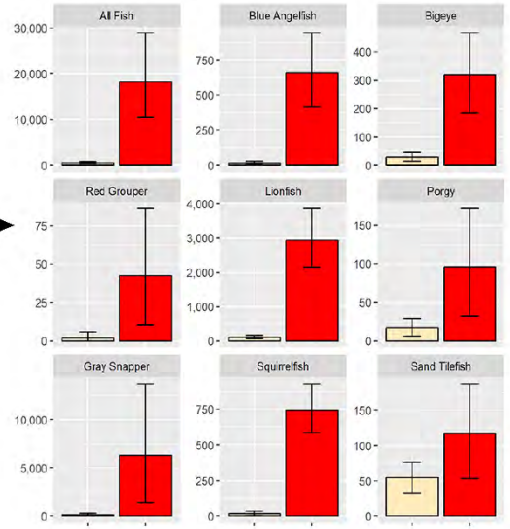
SRI International

Overall Procedure Converting Multibeam & Video into Habitat Maps

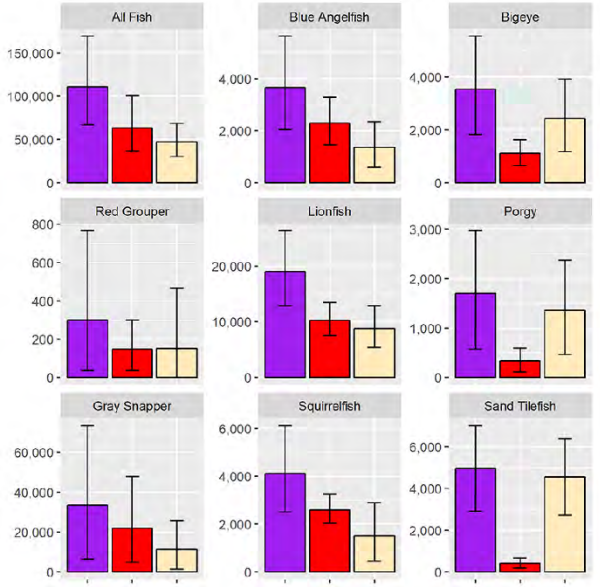
Towed Underwater Video



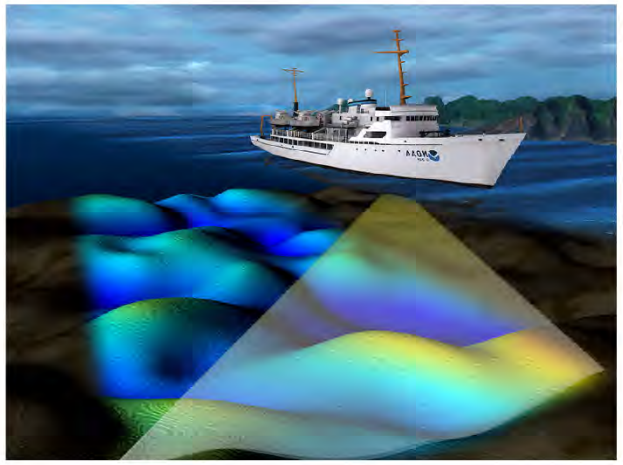
Habitat-Specific Fish Densities



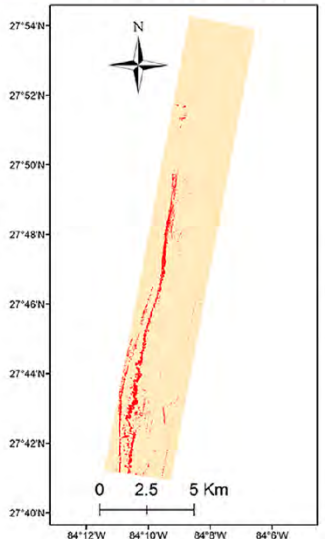
Total Abundance Estimates



Multibeam Sonar



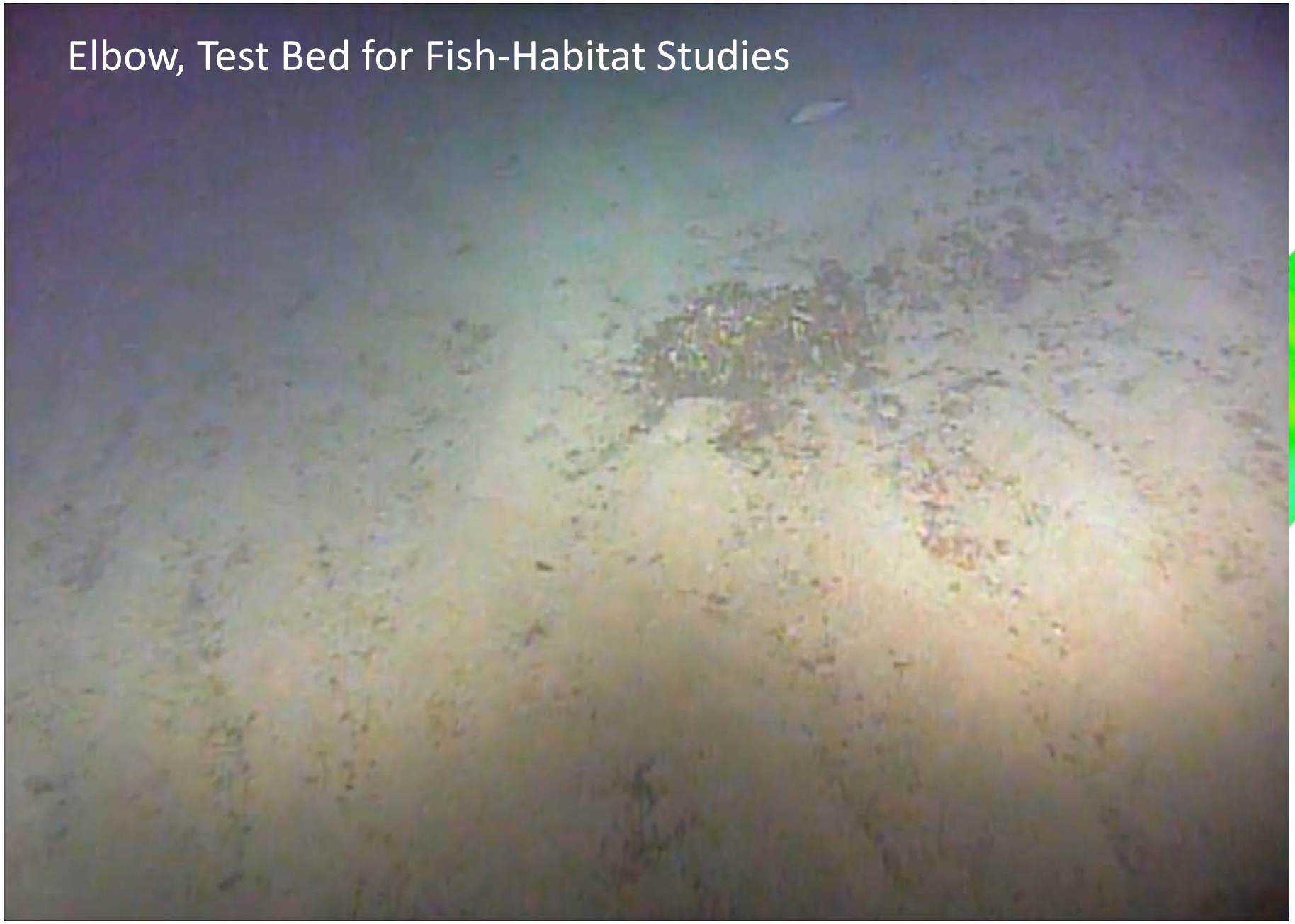
Habitat Map

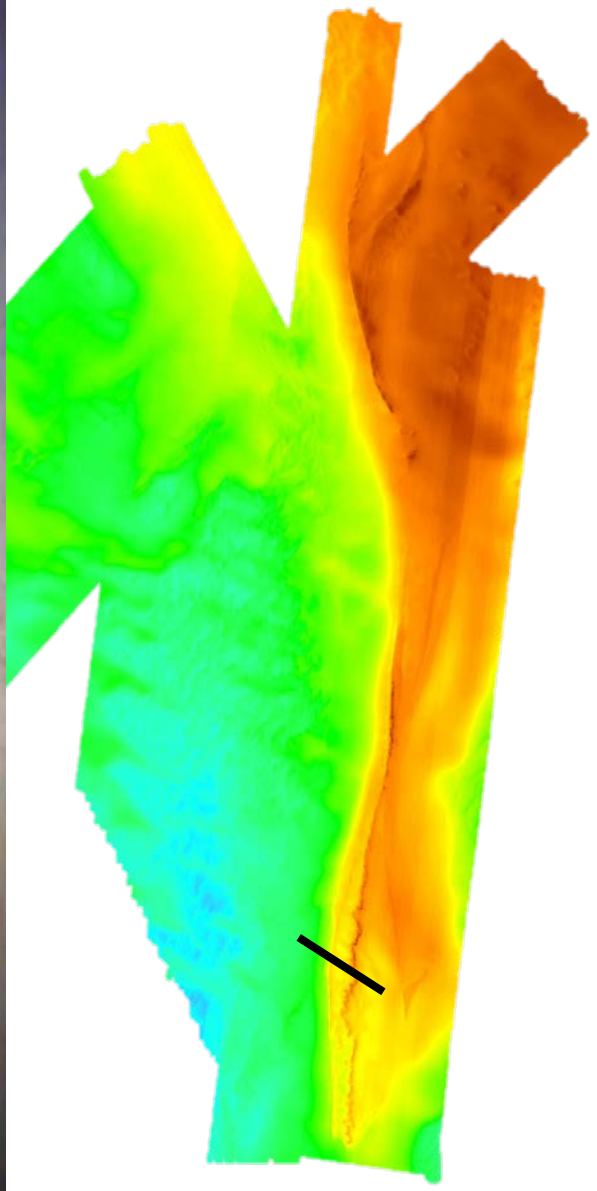


What is Habitat?

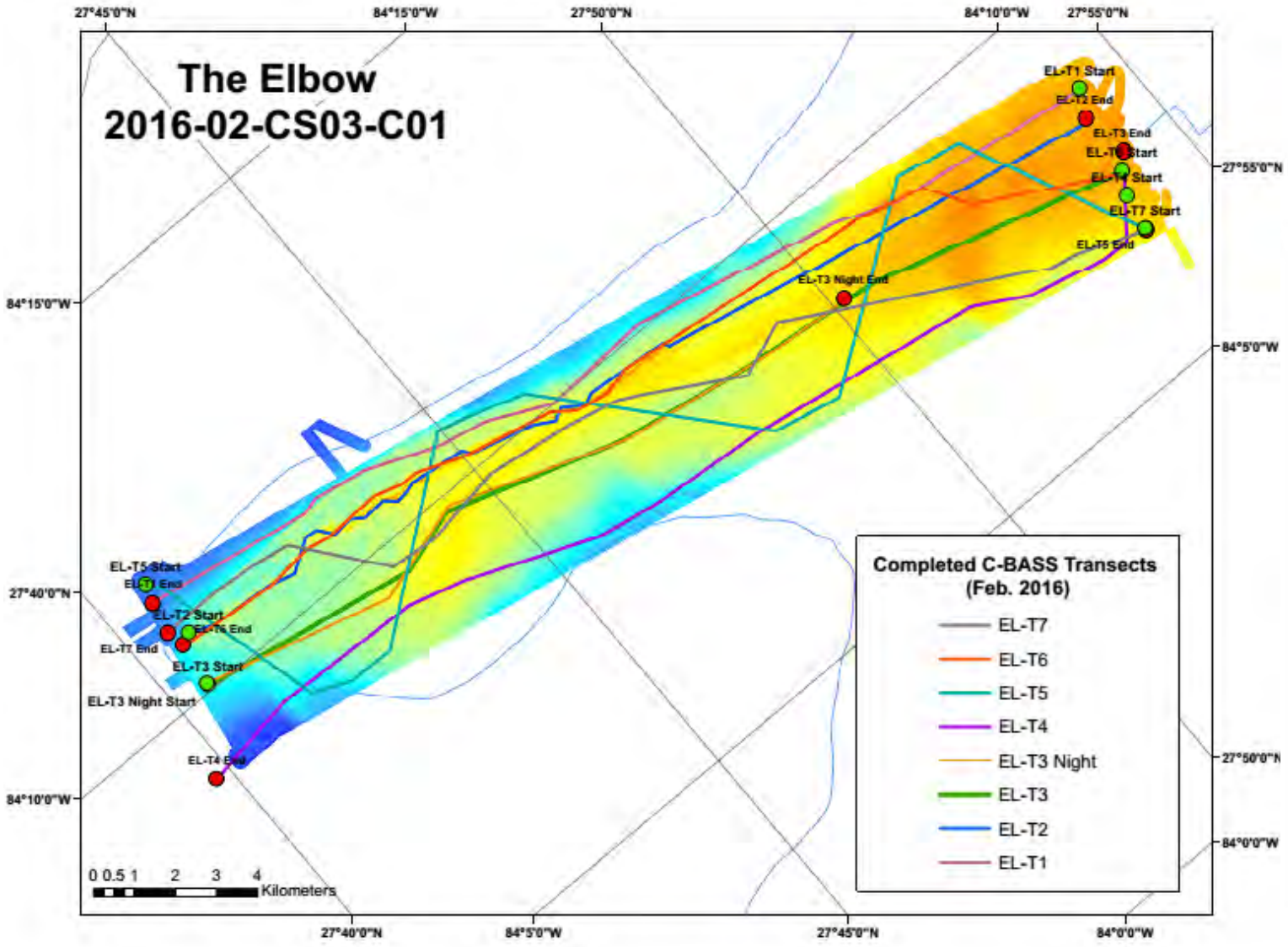
(Federal Geographic Data Committee, 2012)

Elbow, Test Bed for Fish-Habitat Studies

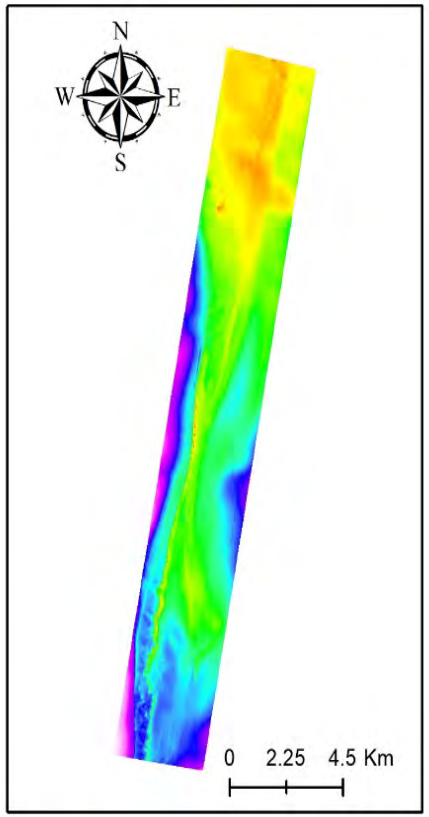


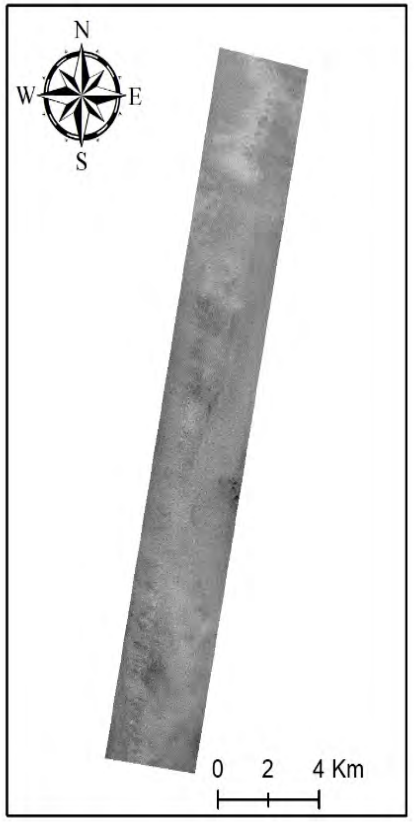


Classifying Landscape-Scale Habitats from Video subsamples



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

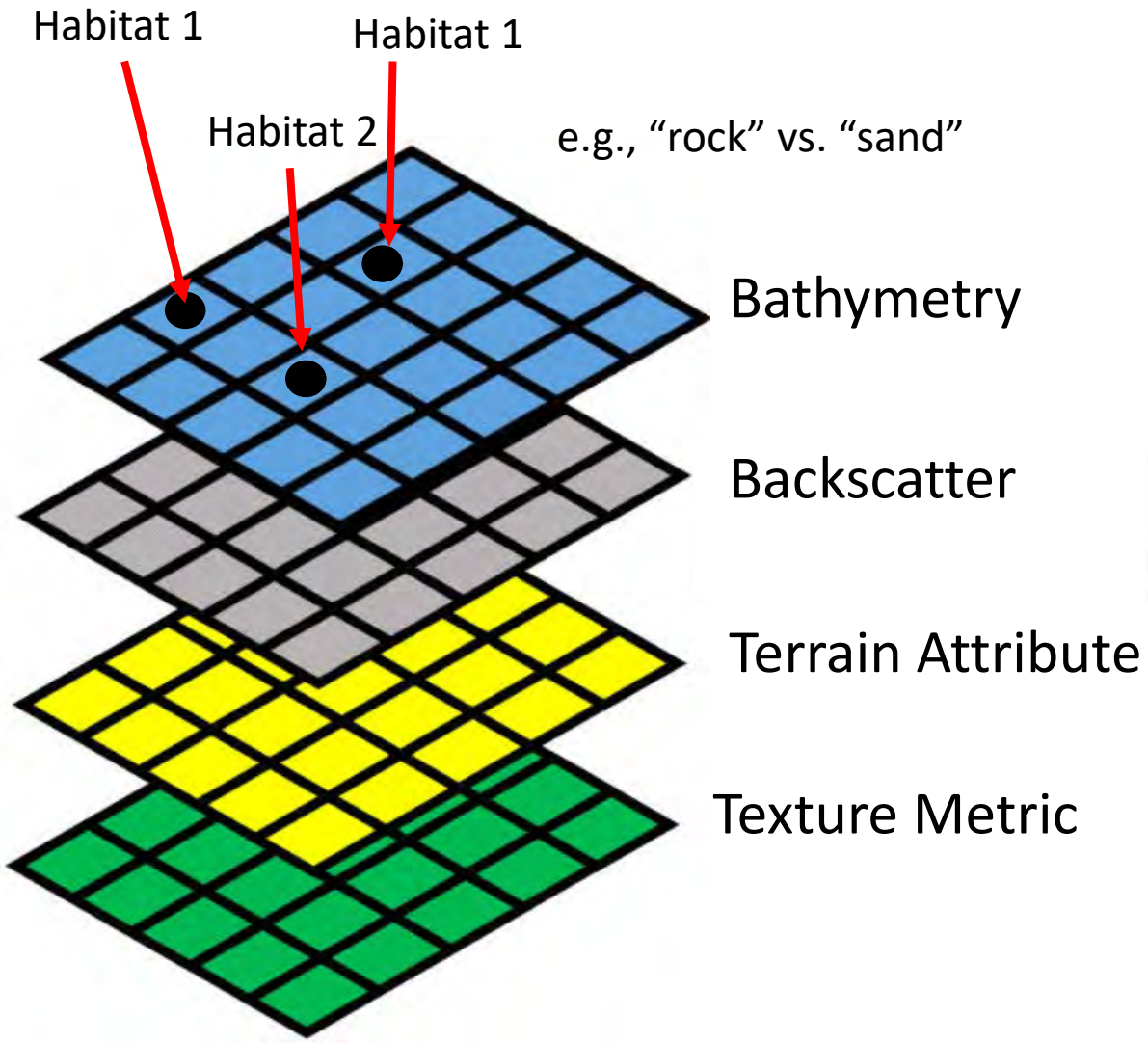
Backscatter Haralick Texture Metrics

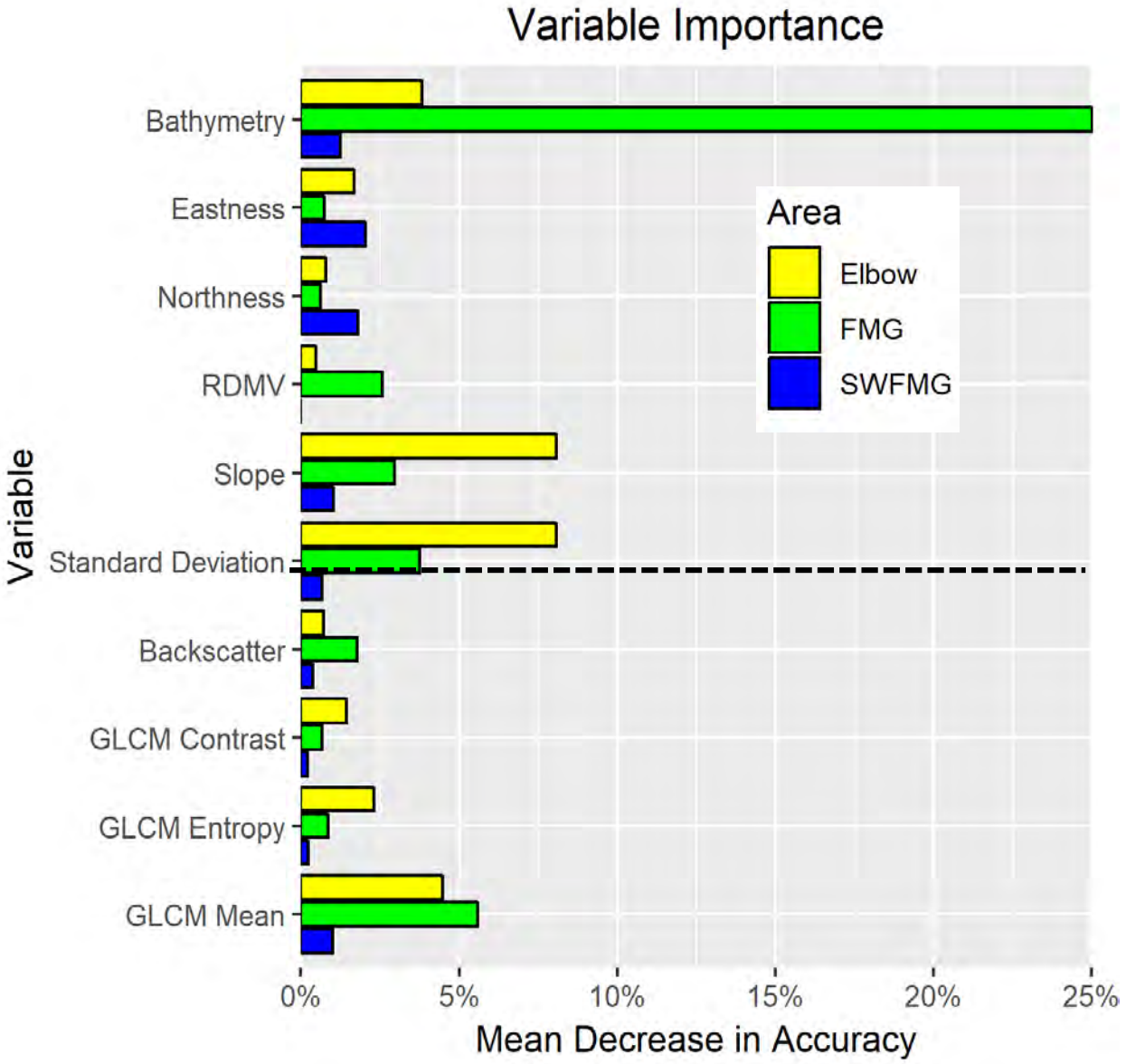
Feature	Description
GLCM (Gray Level Co-Occurrence Matrix) Mean	$\sum_{i,j=0}^{N-1} i(P_{i,j})$
GLCM Contrast	$\sum_{i,j=0}^{N-1} P_{i,j}(i-j)^2$
GLCM Entropy	$\sum_{i,j=0}^{N-1} P_{i,j}(-\ln(P_{i,j}))$

Alex Ilich's M.S. Thesis work

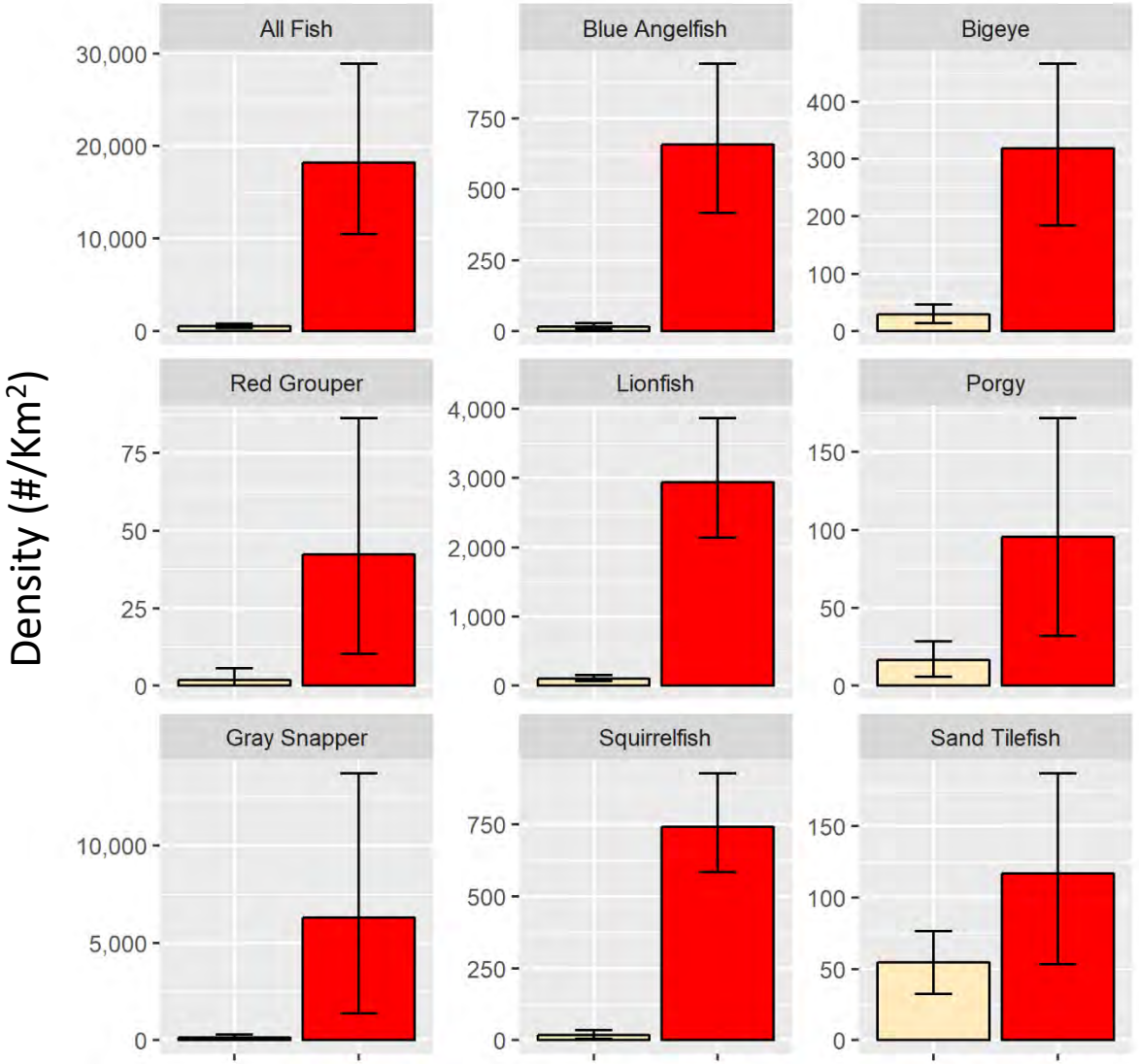
$P_{i,j}$ = probability that two features with gray scales i and j co-occur

Supervised Classification Regression Tree Model for Habitat Extrapolation





Habitat-Stratified Density Estimates of Fishes



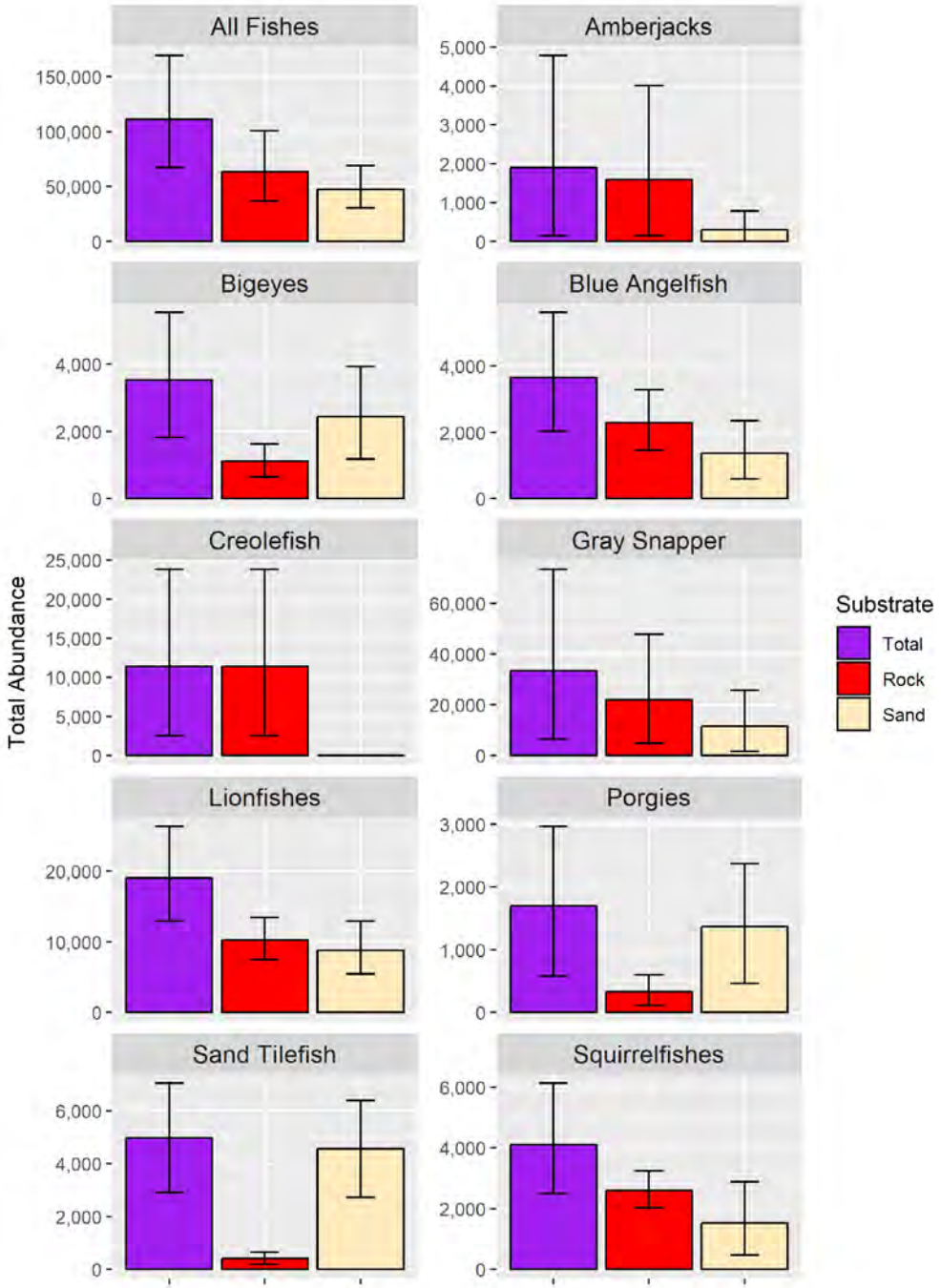
The Elbow

Substrate

- Sand
- Rock

	Area (Km²)
Rock	3.5
Sand	83.6

Alex Ilich's M.S. Thesis work



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

Extrapolating Densities to Total Abundance

Estimates of **total abundance** for **select fish taxa** within the portion of **The 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.

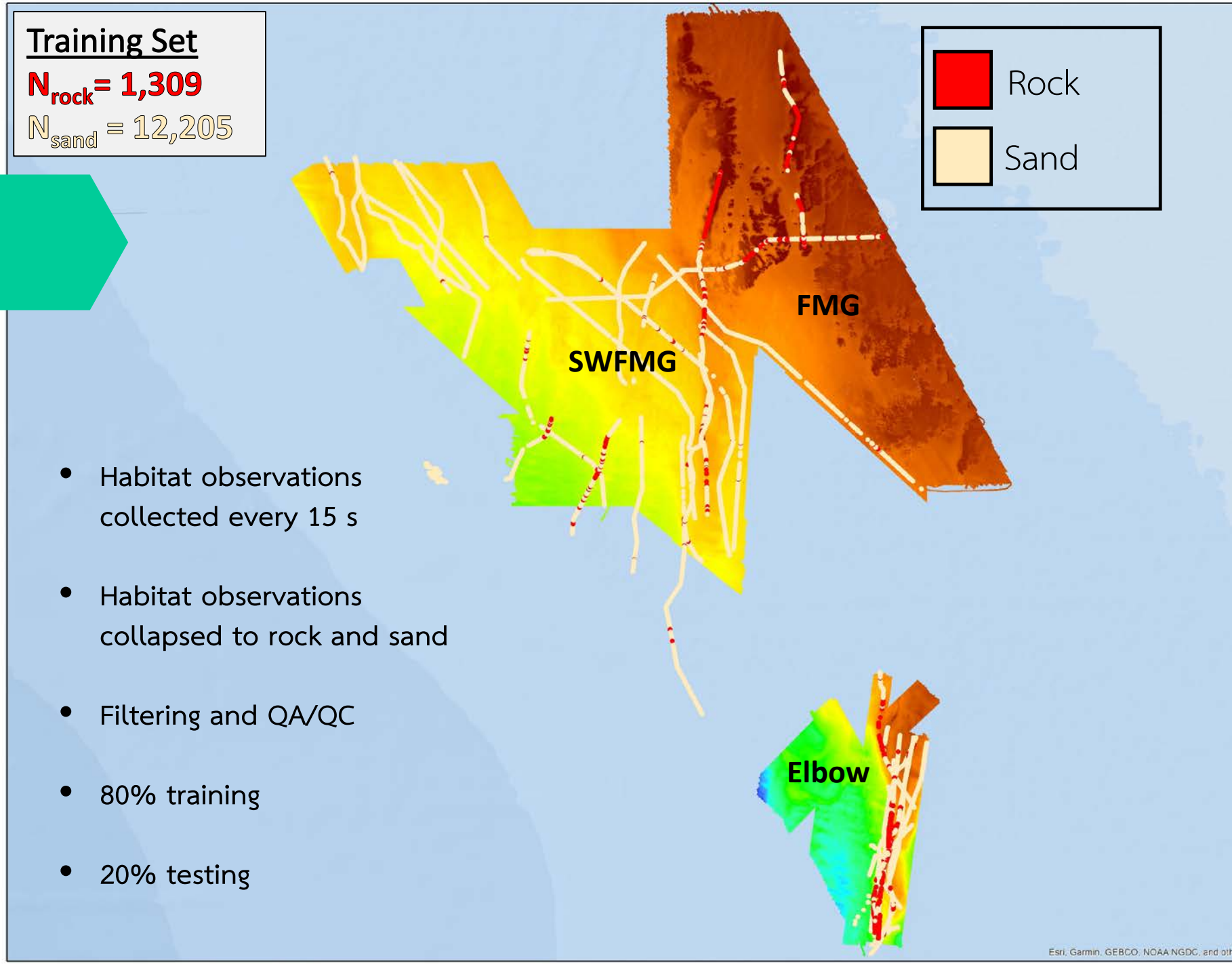
>50% of the fish are in 4% of the habitat (varies by species)

Groundtruth Habitat

Training Set

N_{rock} = 1,309

N_{sand} = 12,205



- Habitat observations collected every 15 s
- Habitat observations collapsed to rock and sand
- Filtering and QA/QC
- 80% training
- 20% testing

Model Validation: Accuracy Assessment

Elbow Confusion Matrix

Prediction \ Observation	Rock	Sand
	N_{rock} = 153, N_{sand} = 741	
Rock	114	21
Sand	39	720

Accuracy = 93%
Kappa = 0.75

FMG Confusion Matrix

Prediction \ Observation	Rock	Sand
	N_{rock} = 93, N_{sand} = 203	
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

Prediction \ Observation	Rock	Sand
	N_{rock} = 25, N_{sand} = 1,437	
Rock	9	7
Sand	16	1,430

Accuracy = 98%
Kappa = 0.43

Model Validation by Area Bathymetry Only

Overall Confusion Matrix

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

Accuracy = 96%
Kappa = 0.74

FMG Confusion Matrix

Prediction \ Observation	Rock	Sand
Rock	99	15
Sand	7	196

Accuracy= 93%
Kappa = 0.85

Elbow Confusion Matrix

Prediction \ Observation	Rock	Sand
Rock	122	14
Sand	51	817

Accuracy = 94%
Kappa = 0.75

SWFMG Confusion Matrix

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

Accuracy= 98%
Kappa = 0.25

Substrate Maps

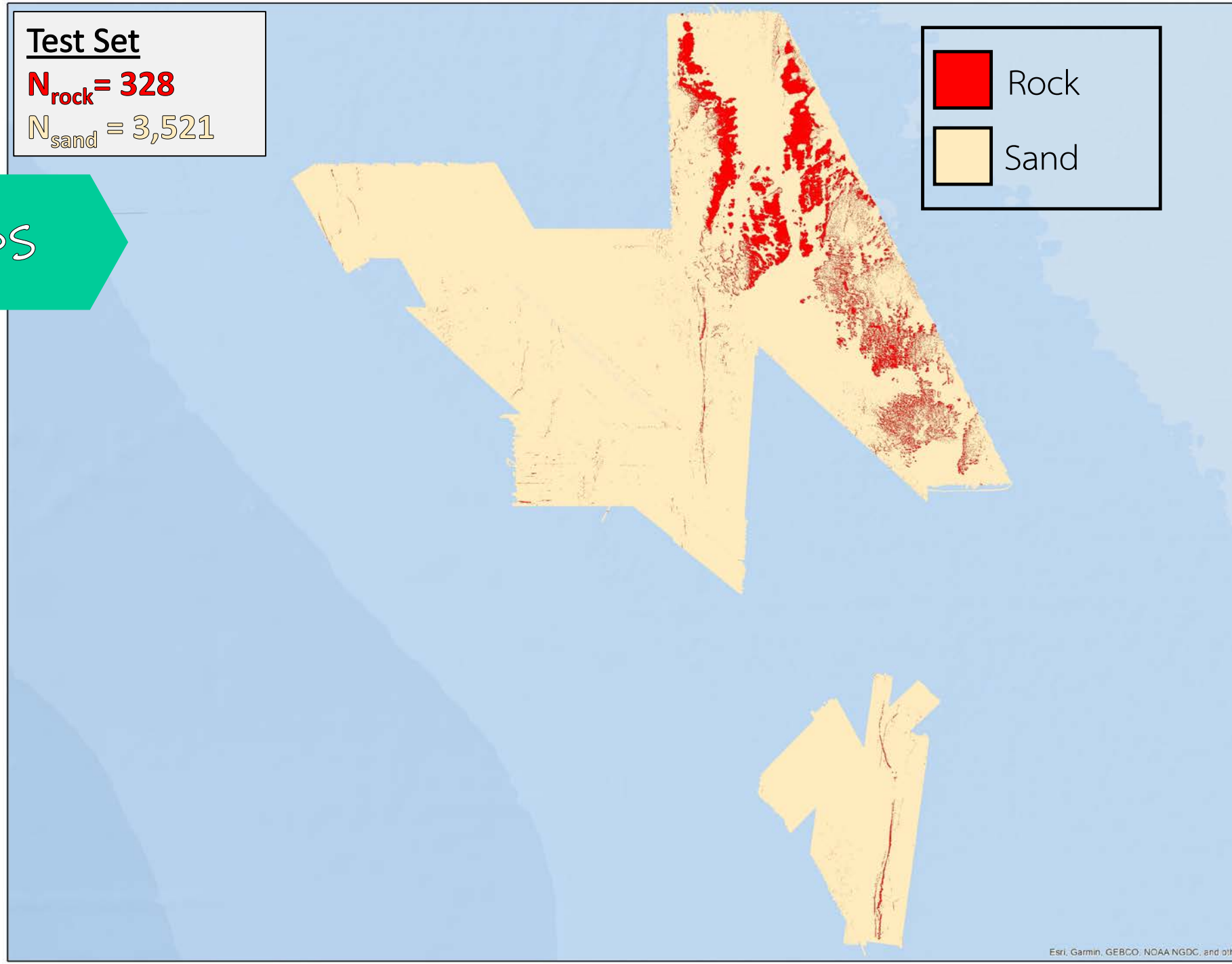
Accuracy = 96%

Kappa = 0.74

K > 0.6 indicates “substantial agreement”
(Landis and Koch, 1977)

Why use statistical classifiers?

- Manual delineation can be time consuming
- More objective
- Can be iteratively improved over time



Substrate Maps

Accuracy = 96%

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Why use statistical classifiers?

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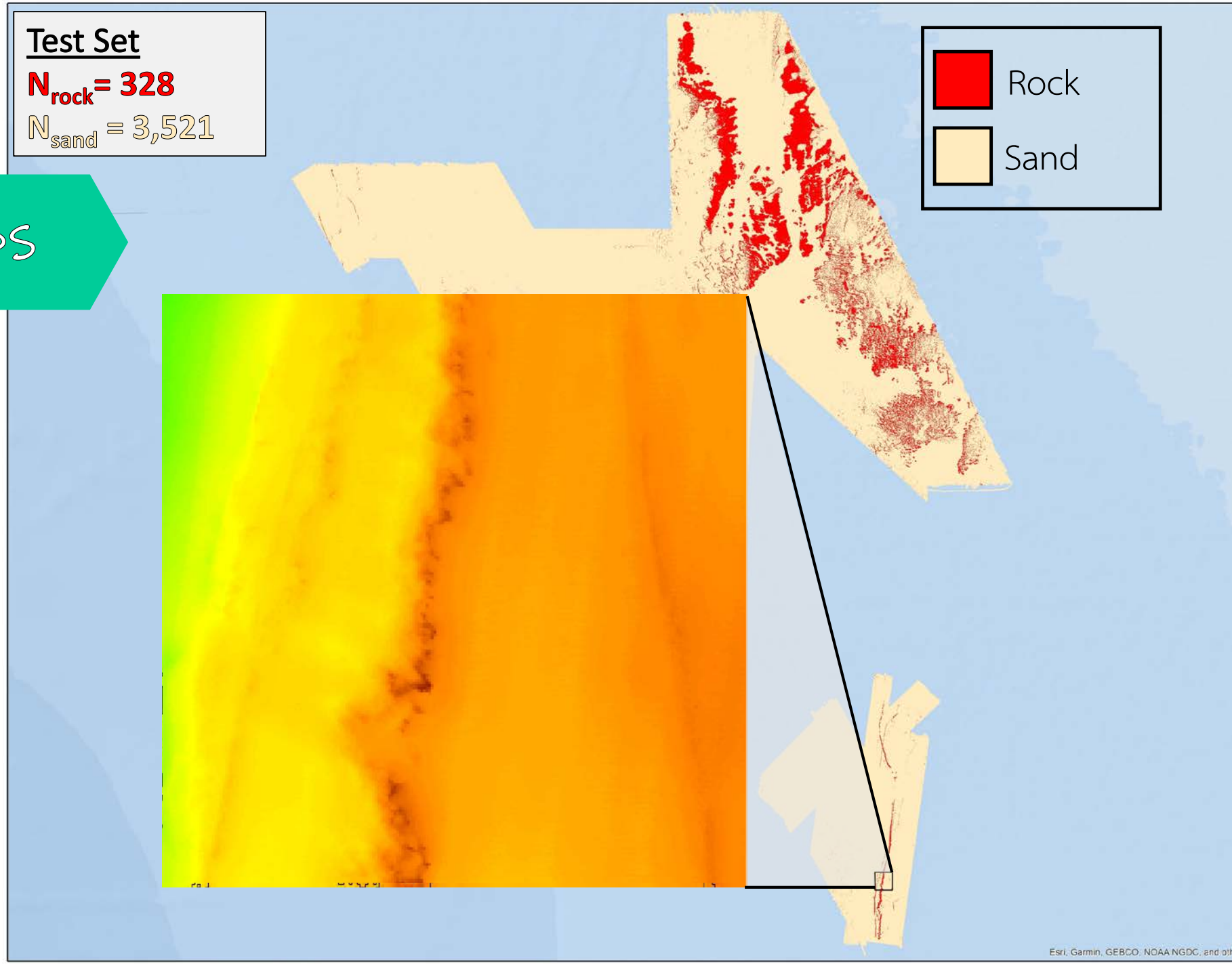
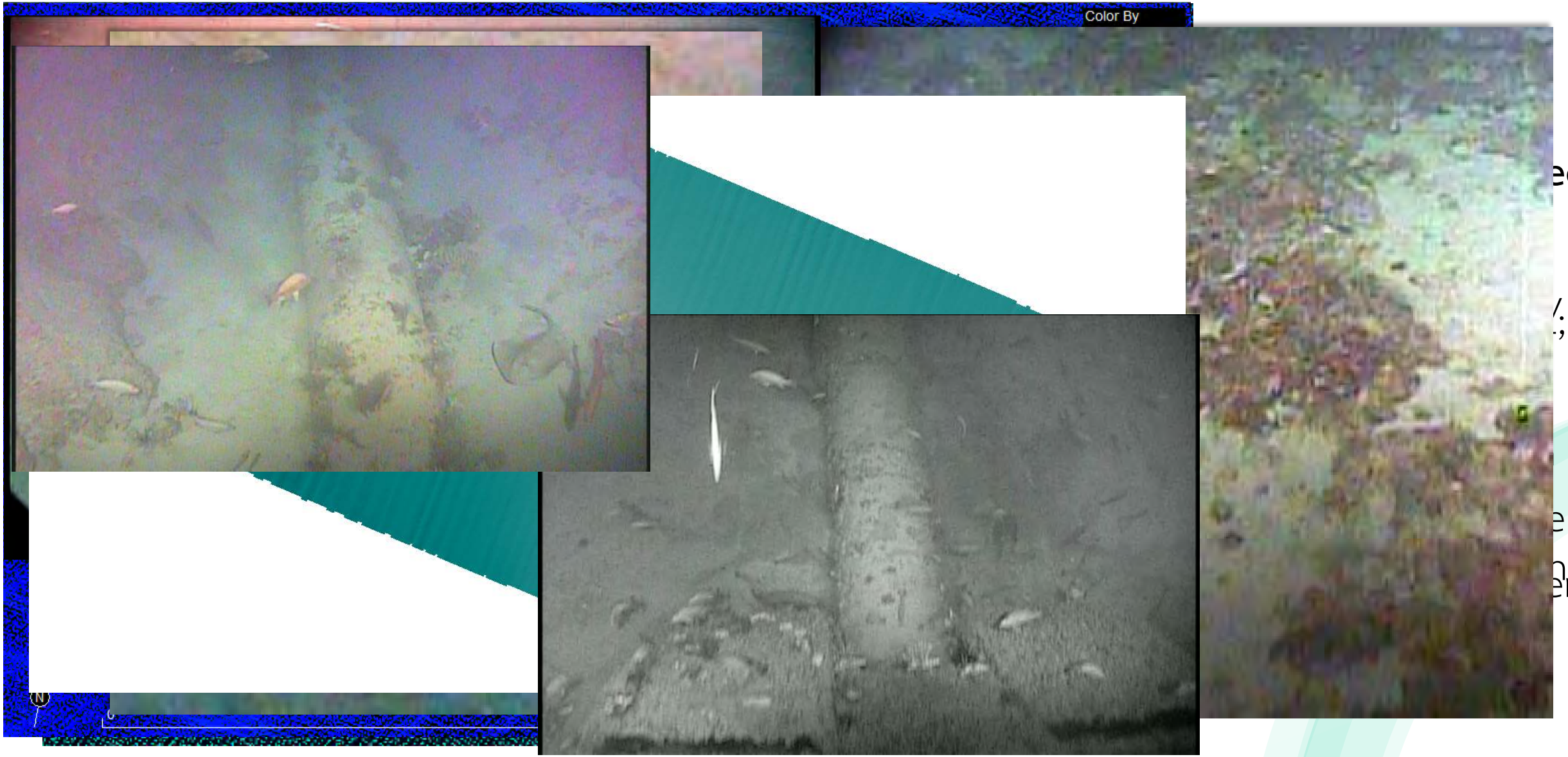


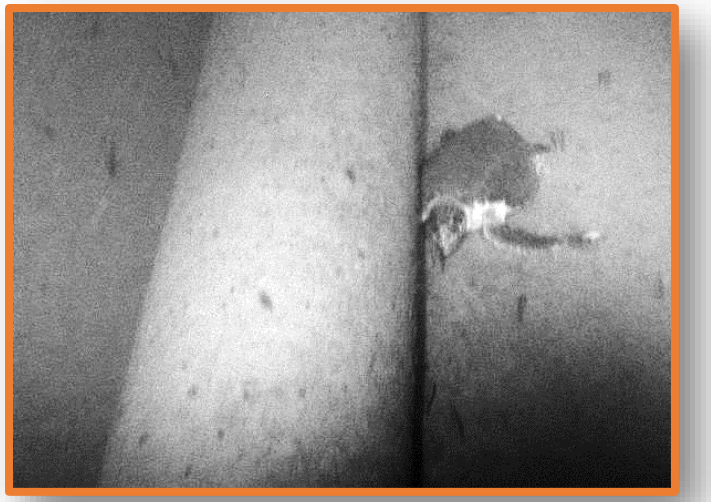
Cultural Resources via Multibeam Sonar ^(& sometimes C-BASS!)



Project Scientist: Matthew Hommeyer (mhommeyer@usf.edu)

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

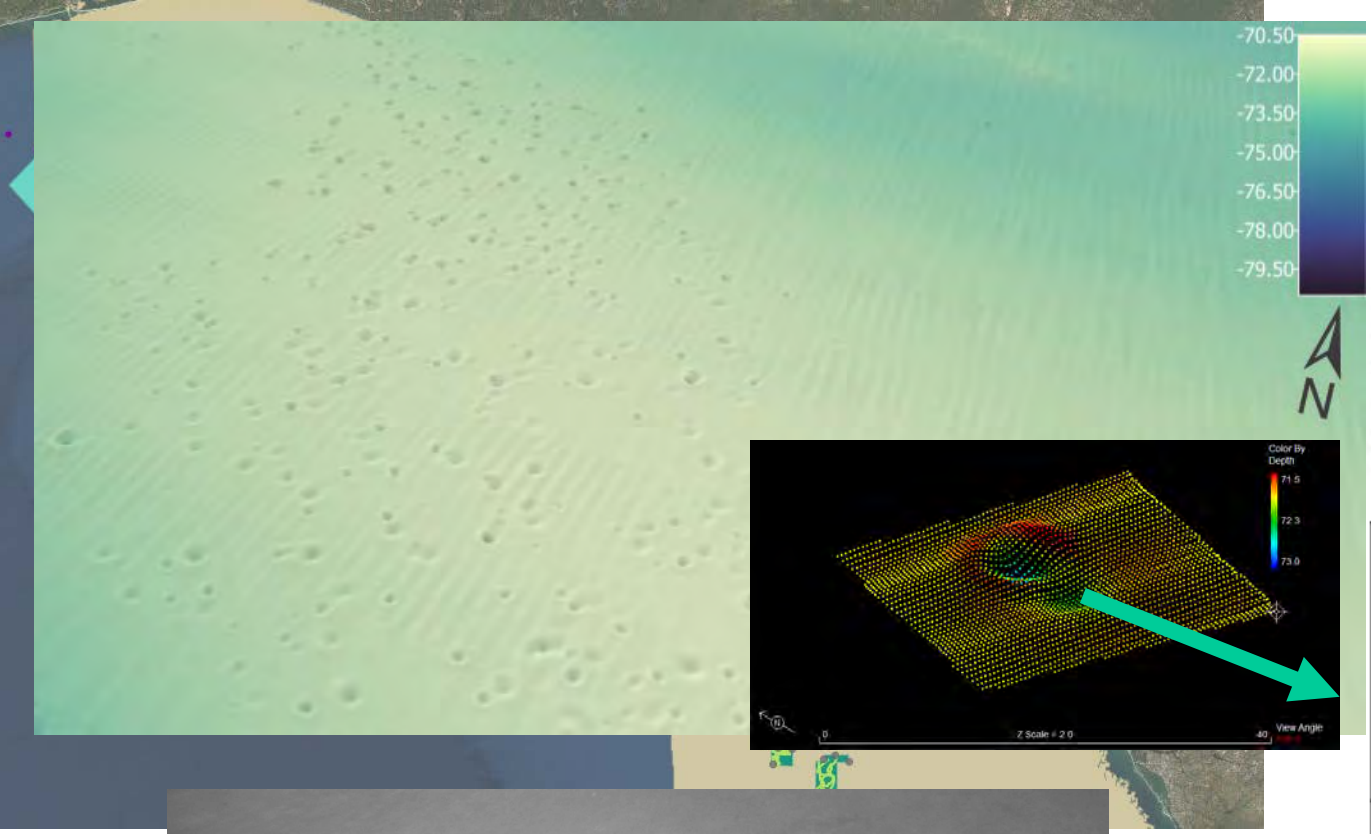


FMG = Florida Middle Grounds
MS = Madison-Swanson Area
SL = Steamboat Lumps
GSPL = Gulfstream Pipeline

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

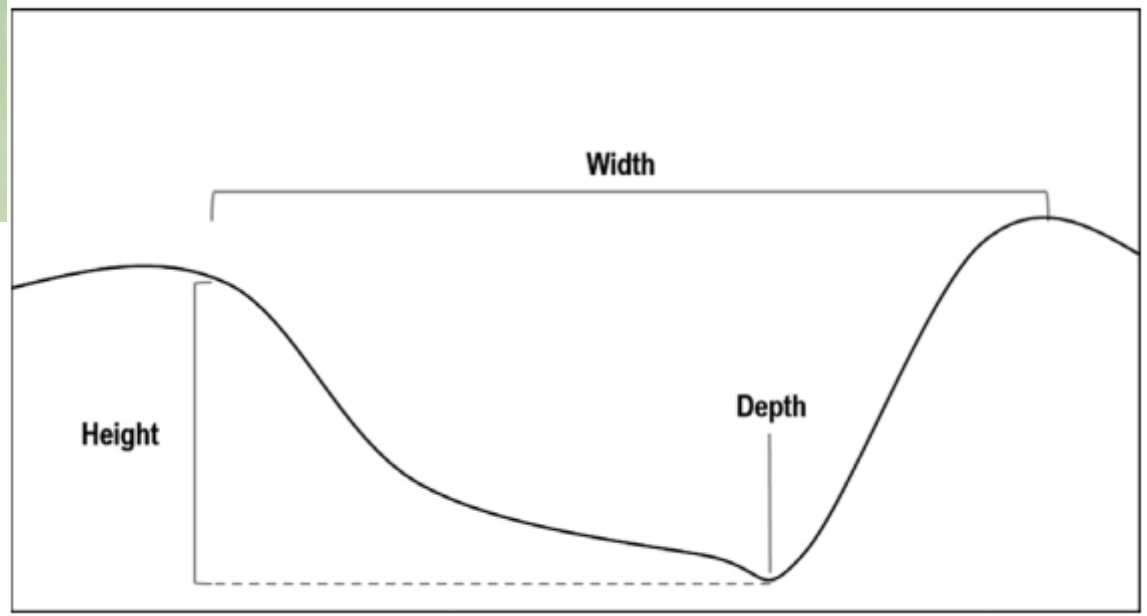
Broadbent et al. (2020). West Florida Shelf pipeline serves as sea turtle benthic habitat based on in situ towed camera observations. Aquatic Biology.

Exploring Fish "Neighborhoods" And Change Over Time



Spatial and temporal variability of red grouper holes within Steamboat Lumps Marine Reserve, Gulf of Mexico

Article (PDF Available) *in* Marine Ecology Progress Series 431:243-254 · June 2011 *with* 471 Reads
DOI: 10.3354/meps09167



Sarah E. Grasty, Carrie C. Wall, John Willis Gray, Jennifer Brizzolara, Steven Murawski

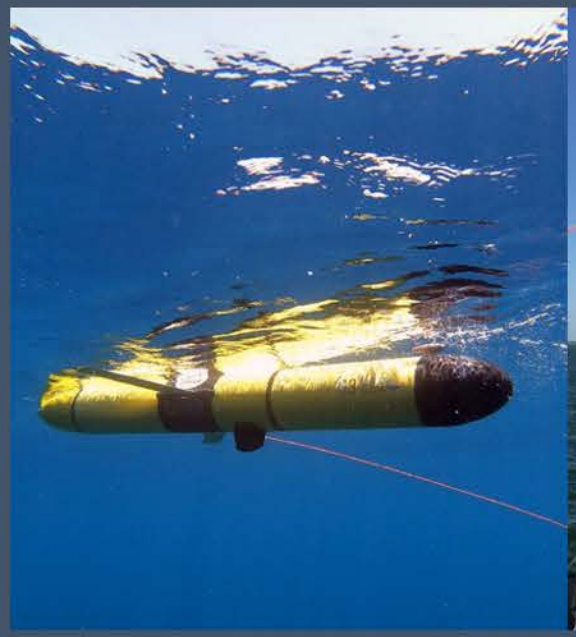
First published: 19 February 2019 | https://doi.org/10.1002/tafs.10154 | Citations: 1

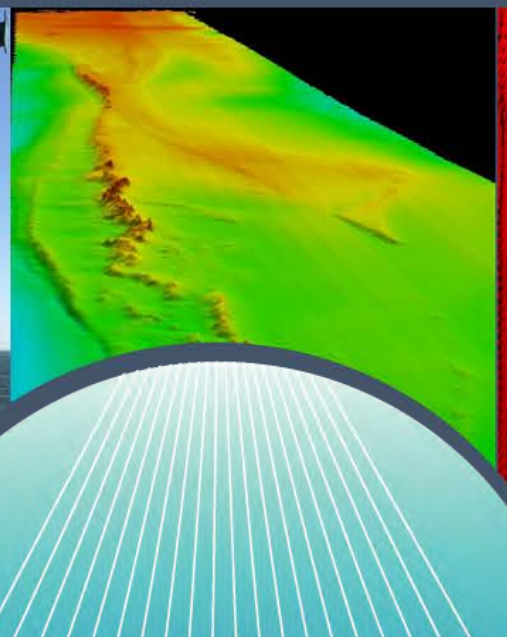
Overall, found that hole density increased and of the 95 holes observed with CBASS, approx. 84% had at least 1 Lionfish

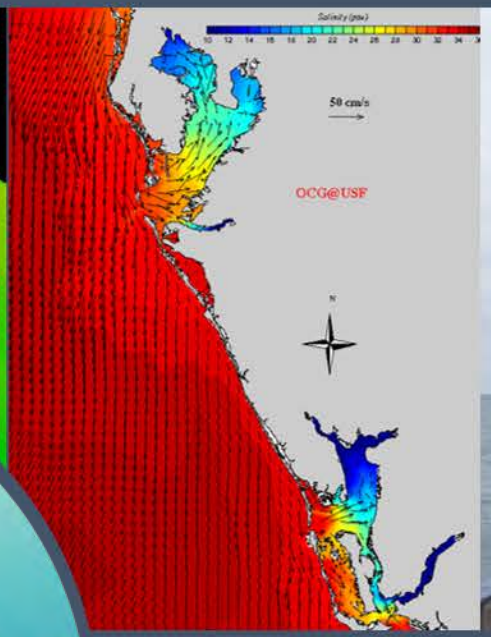
Project Scientist: Sarah Grasty (grastys@usf.edu)

Next Steps for the C-SCAMP Project

- ✓ Extend high-resolution mapping in the Eastern GoM to an additional ~15,000 km^2 of important offshore reef fish & sea turtle habitat – Assess GoMFMC's Amendment 9 HAPCs?
- ✓ 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 (why we are here….)
- ✓ Cross-calibration studies with NMFS & FWRI camera systems
- ✓ Help create an enduring "community of practice" and stable resource base to close the "map gap". New COMIT Center








COMIT

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

UNIVERSITY OF SOUTH FLORIDA
College of MARINE SCIENCE

Center for Ocean Mapping and Innovative Technologies

Established with a 5-year cooperative agreement between NOAA's National Ocean Service, Office of Coast Survey & USF-CMS

Some Strategic Opportunities with the new Center:

- Academic – Government partnership focused on development activities
- Goal to extend mapping capabilities/support among various NOAA line offices
- Addressing the Presidential Executive Order on Ocean Mapping of the EEZ
- Part of USA's contribution to Seabed 2030: https://seabed2030.org/
- Collaborations between NOAA, USF & UNH Joint Hydrography Institute
- Enhancing local capabilities & partnerships

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U.S. DEPARTMENT OF COMMERCE

https://www.marine.usf.edu/comit/

@COMITusf

WHAT THE CENTER WILL DO?

Theme A: Multibeam sonar integration into unmanned systems,

Theme B: Enhancing geodetic observations,

Theme C: Applied hydrography for coastal and disaster response, and

Theme D: Forecasting and remote sensing technologies.

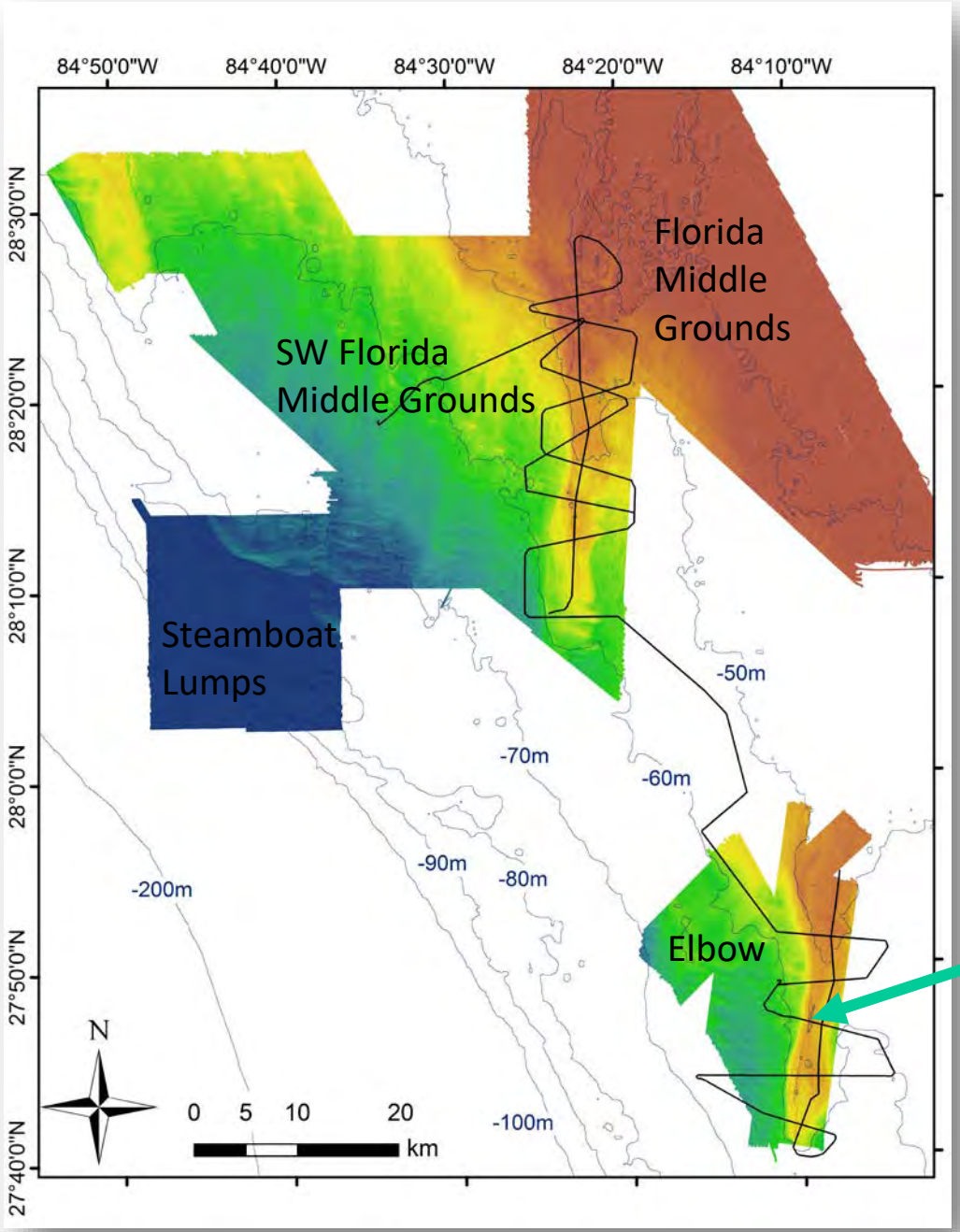
Theme E: Education program:

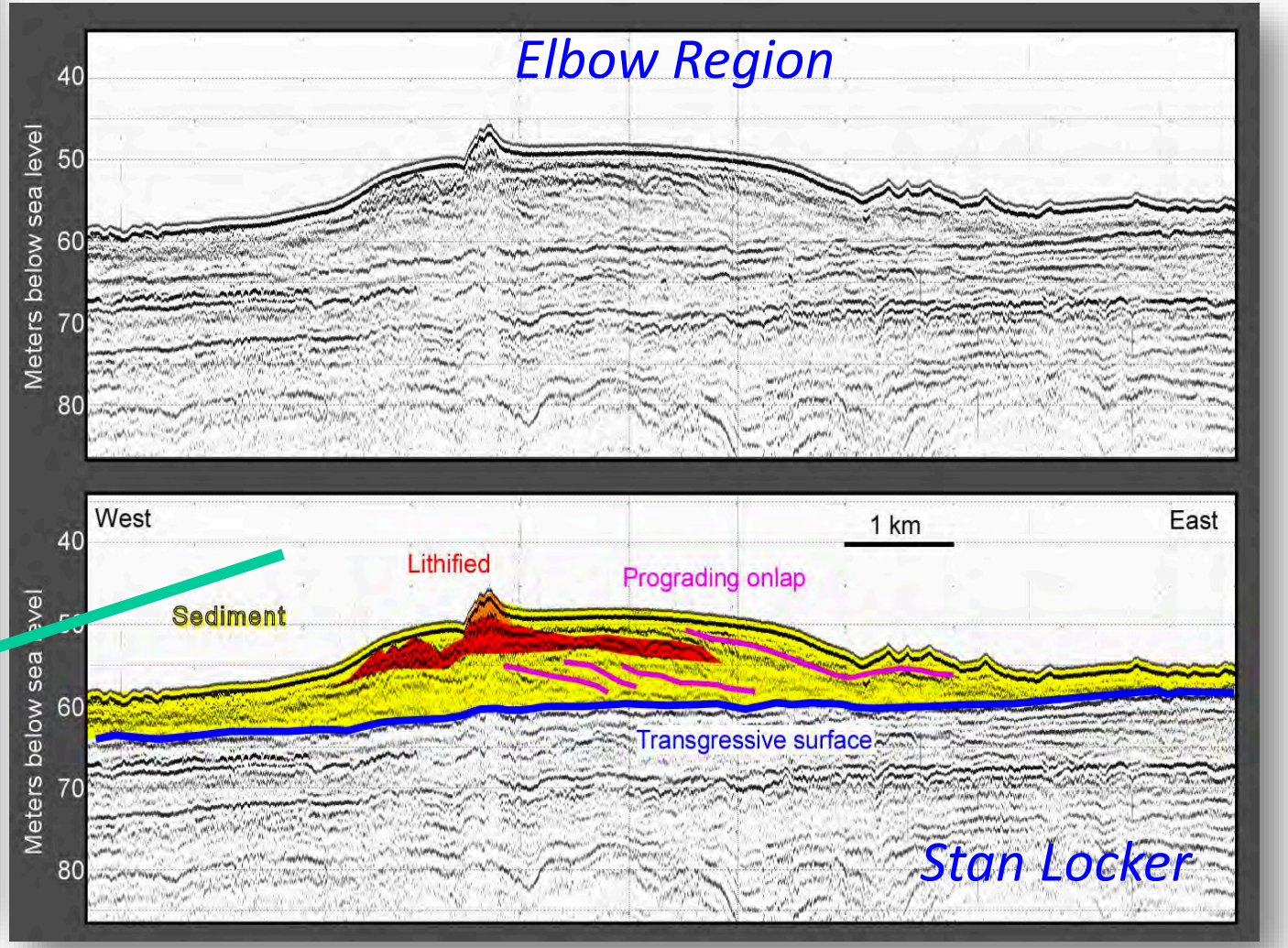
(1) augmenting existing semester-level training in hydrographic services,

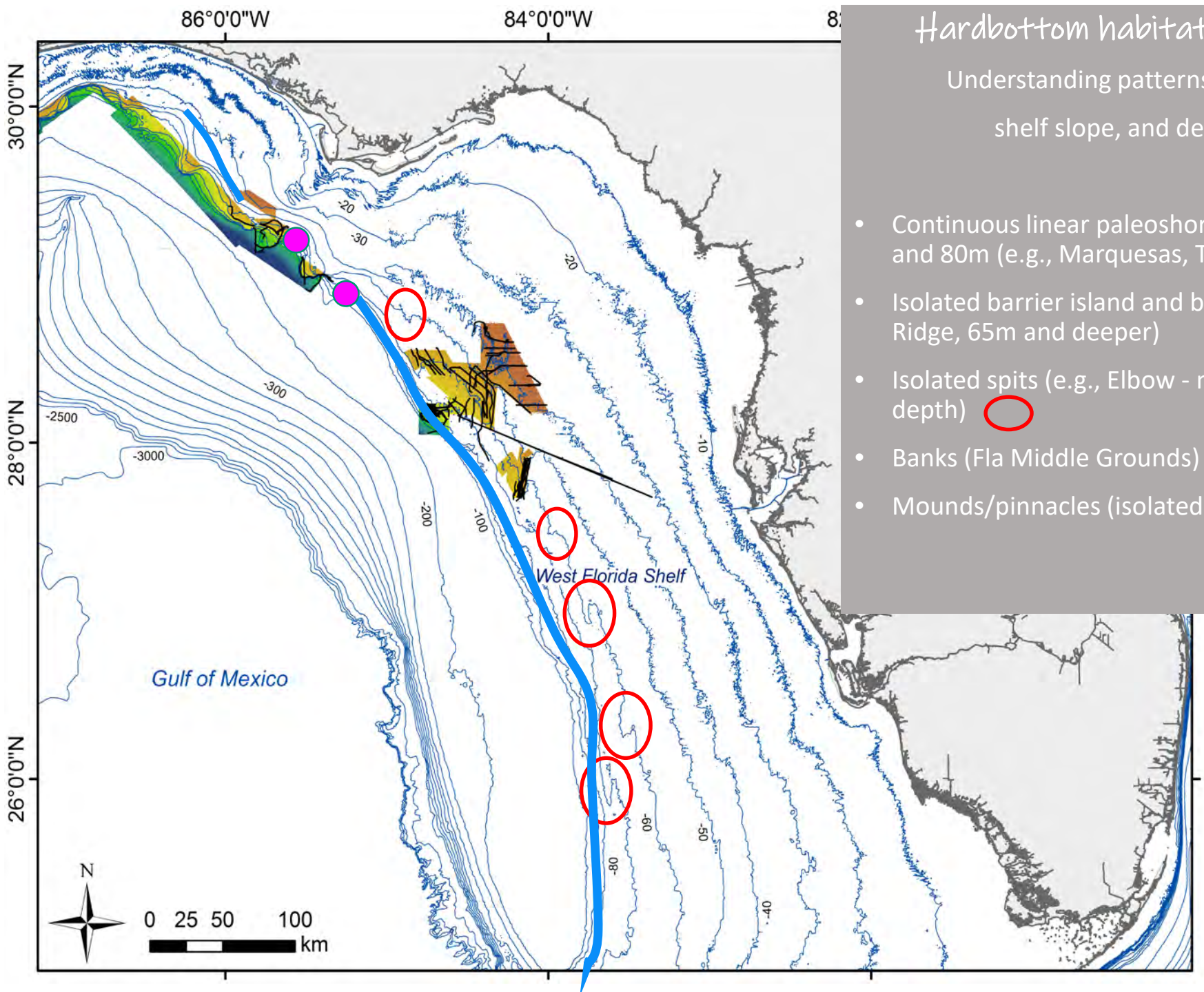
(2) development of short-courses for in-service professionals and students, and

(3) outreach to diverse regional communities regarding ocean mapping services and trialing the concept of crowd-sourcing the collection of bathymetric data.

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







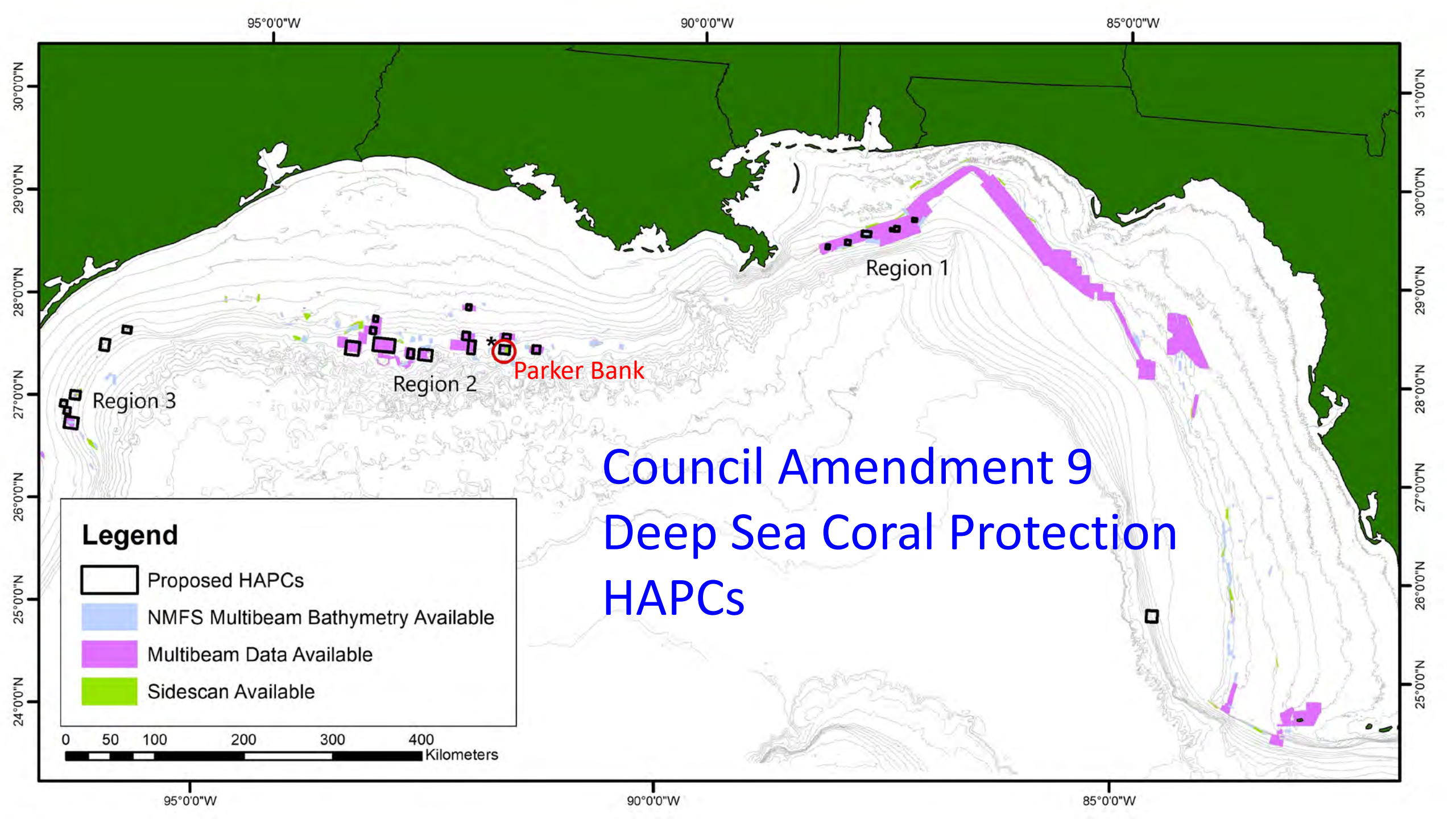
Hardbottom habitat - A regional perspective

Understanding patterns related to sea-level history,

shelf slope, and depositional environment.

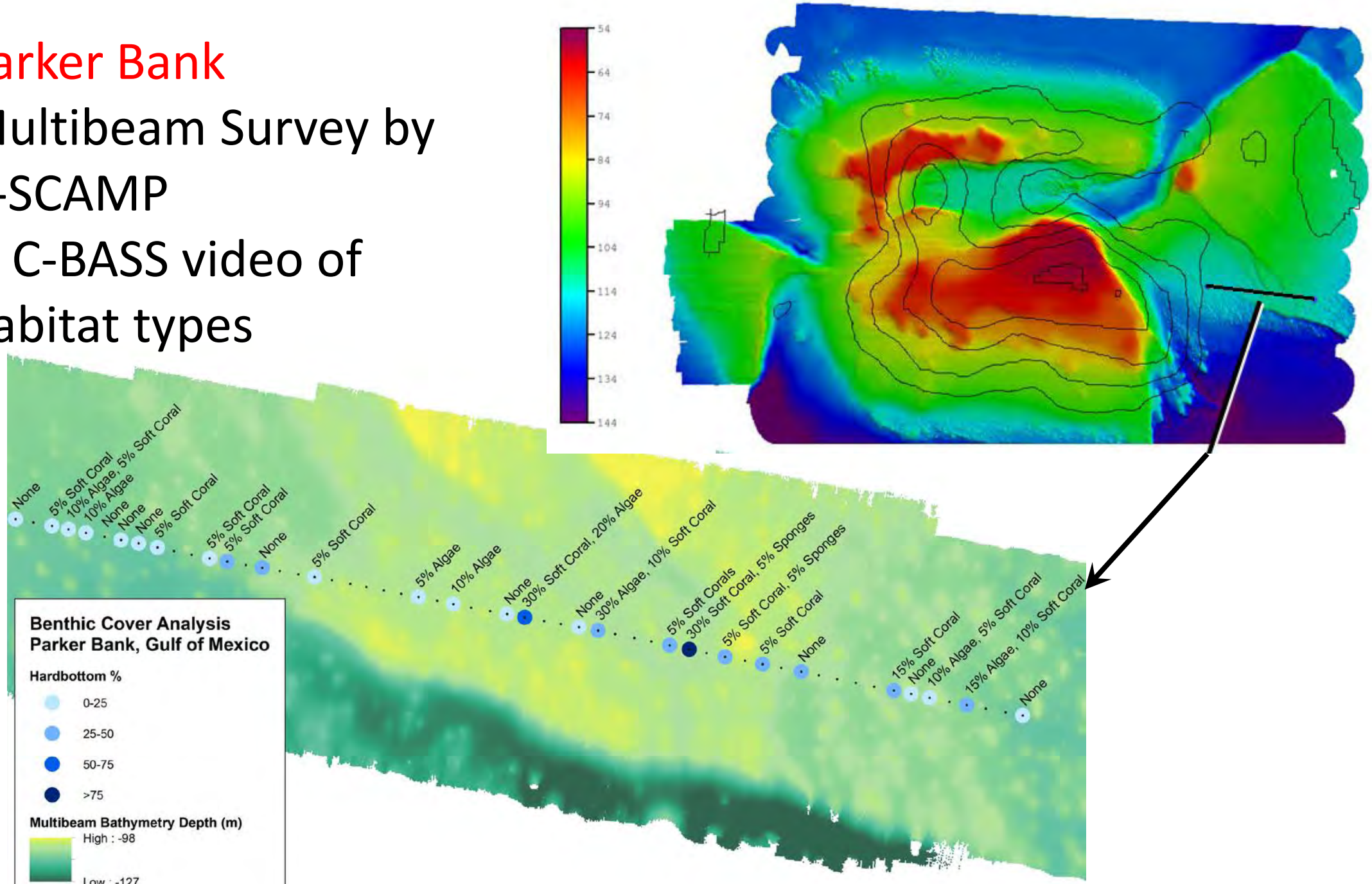
- Continuous linear paleoshoreline ridges –water depths of 70m and 80m (e.g., Marquesas, Twin Ridges)
- Isolated barrier island and broad ridge systems (e.g., Pulley Ridge, 65m and deeper)
- Isolated spits (e.g., Elbow - many features in 50-60 m water depth)
- Banks (Fla Middle Grounds)
- Mounds/pinnacles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

Interpreting maps for additional habitats of interest....


95°0'0"W
90°0'0"W
85°0'0"W
30°0'0"N
29°0'0"N
28°0'0"N
27°0'0"N
26°0'0"N
25°0'0"N
24°0'0"N
31°0'0"N
Region 1
Region 2
Region 3
Parker Bank
Council Amendment 9
Deep Sea Coral Protection
HAPCs
Legend
Proposed HAPCs
NMFS Multibeam Bathymetry Available
Multibeam Data Available
Sidescan Available
0 50 100 200 300 400
Kilometers

Parker Bank

Multibeam Survey by C-SCAMP
& C-BASS video of habitat types



Improving Reef Fish Sampling with FWRI-FIM

S-BRUV

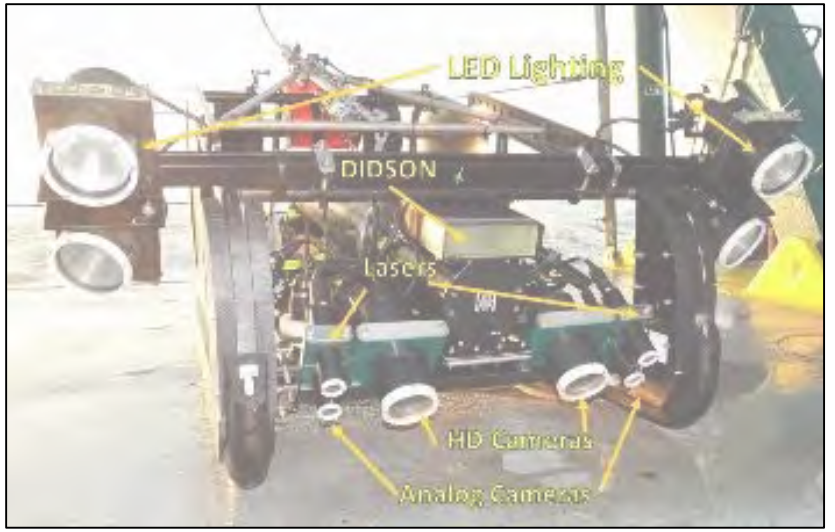
- Baited
- MaxN Metric
- No Lights
- Stationary
- Sidescan for habitat

Both

- Measurement
- Camera model

C-BASS

- Unbaited
- Density Metric
- Lighted
- Mobile
- MBES/Video for habitat



C-BASS

S-BRUV

Collaborators: Dr. Ted Switzer & Sean Keenan (FWRI)

Thoughts for Discussion

- Mapped areas as candidates for additional HAPCs or other spatial management areas
- The Gulfstream pipeline as an important sea turtle habitat?
- Use of direct estimates of population size in stock assessments
- Additional research on visual methods supporting stock assessment and fish-habitat research:
    - Serial autorecognition in line transect video studies,
    - Estimation of the siting probability function
    - Spatial ecology & fractal geometry of fish-habitat relationships
    - Multispecies associations
- Priority areas for additional mapping and fish density estimates

Questions?

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

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

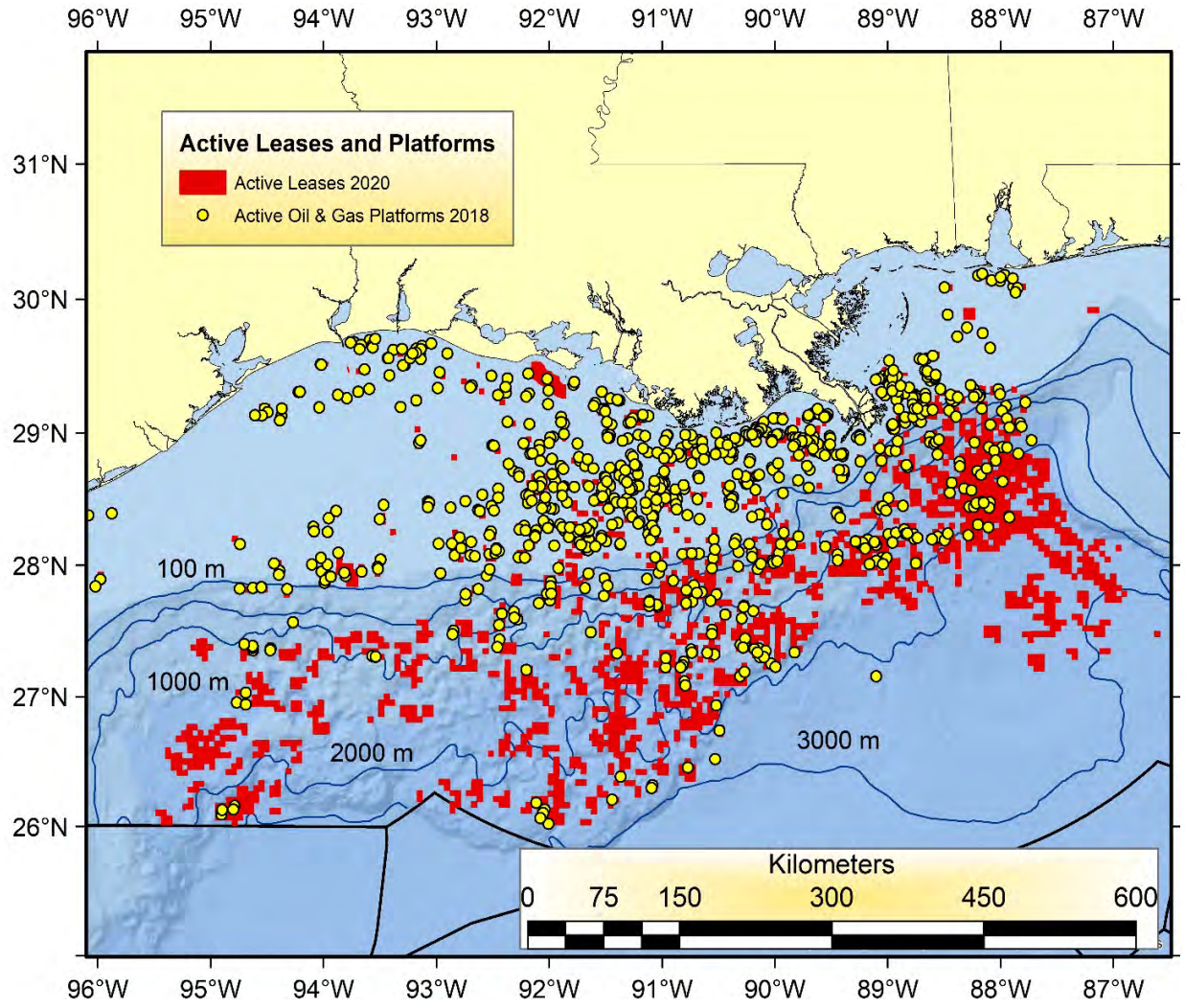
1 = Perfect agreement

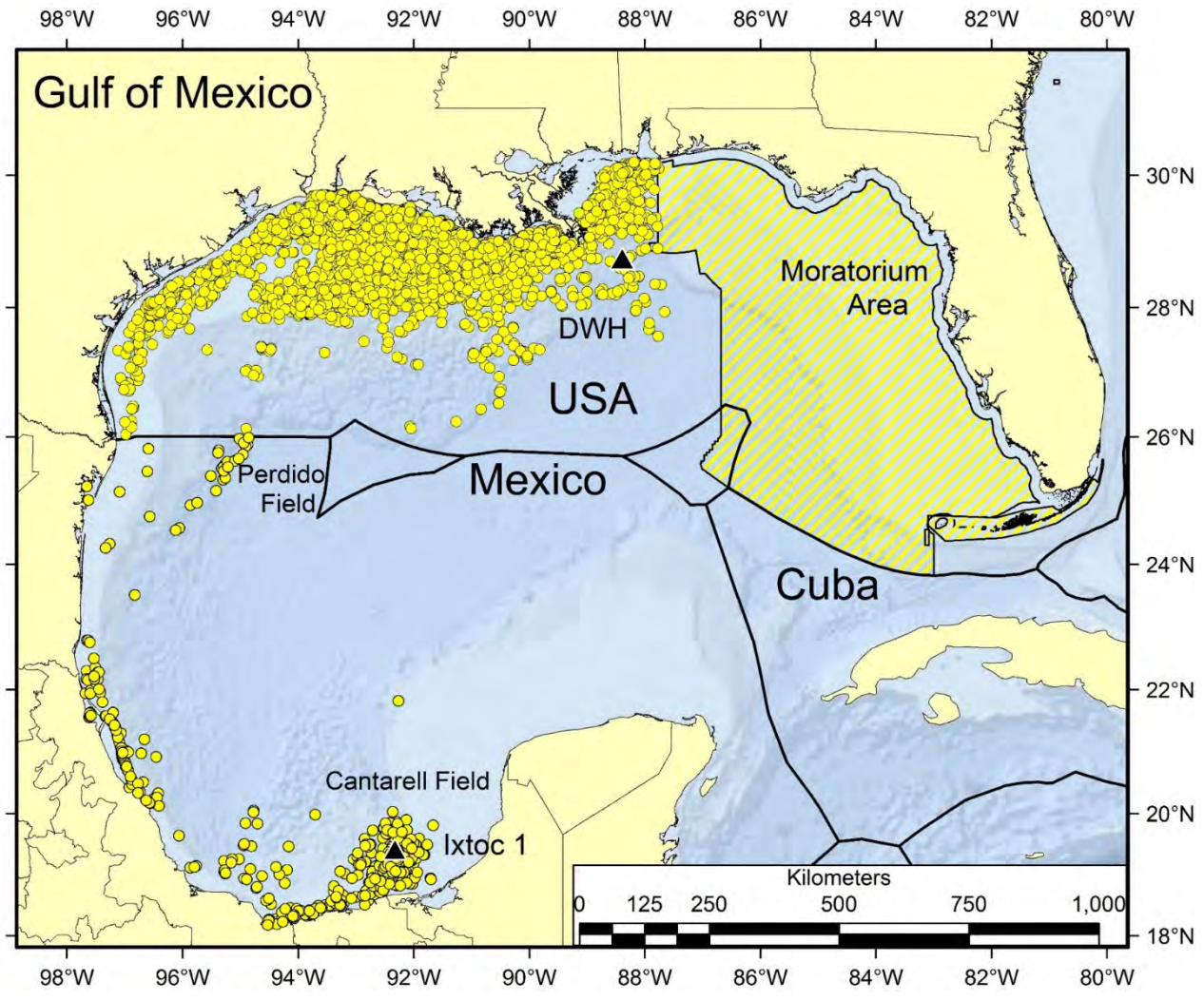
K > 0.6 indicates "substantial agreement"

(Landis and Koch, 1977)

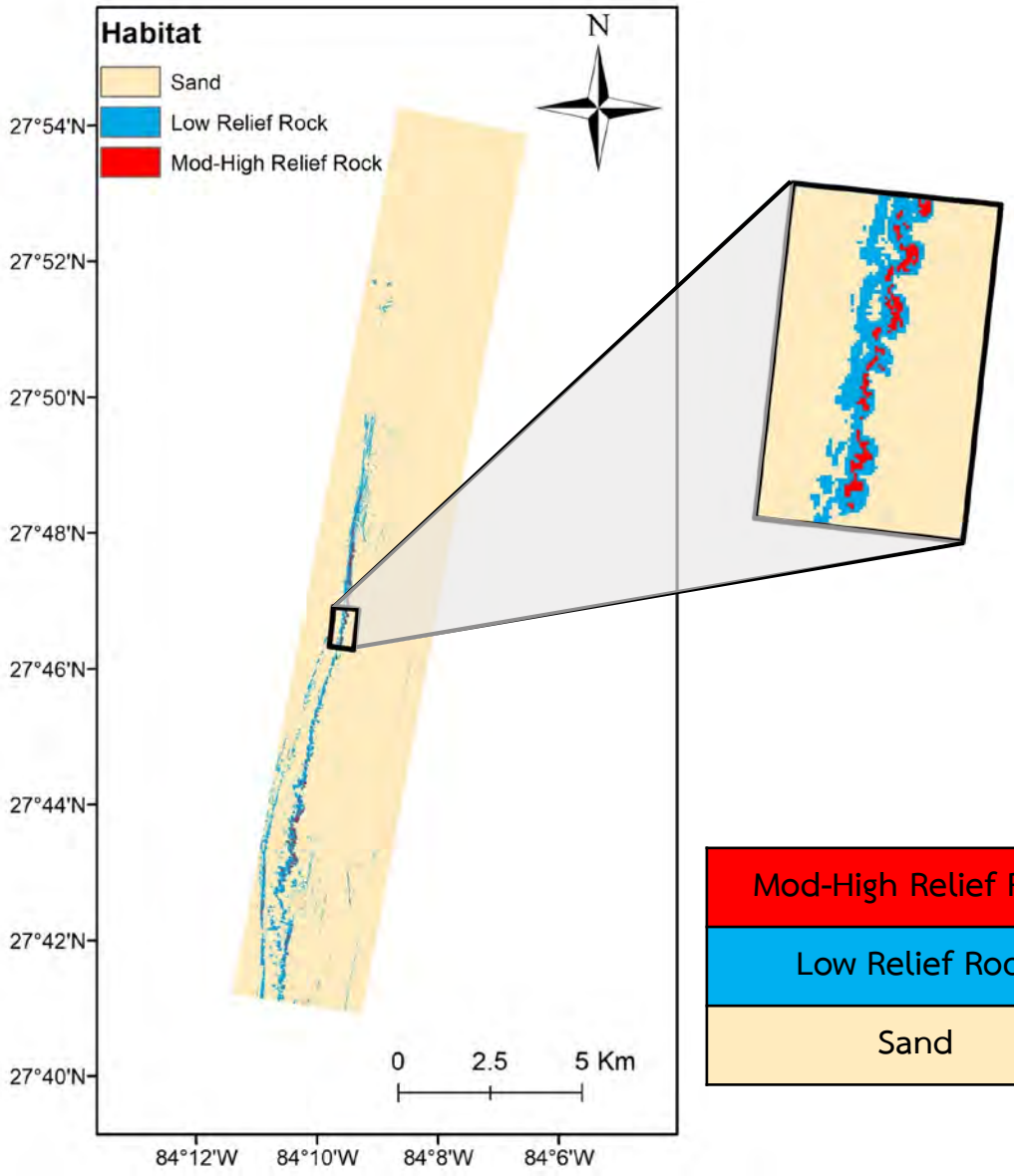
Active Wells & Current leases (2020)

Moratorium (until 2022)



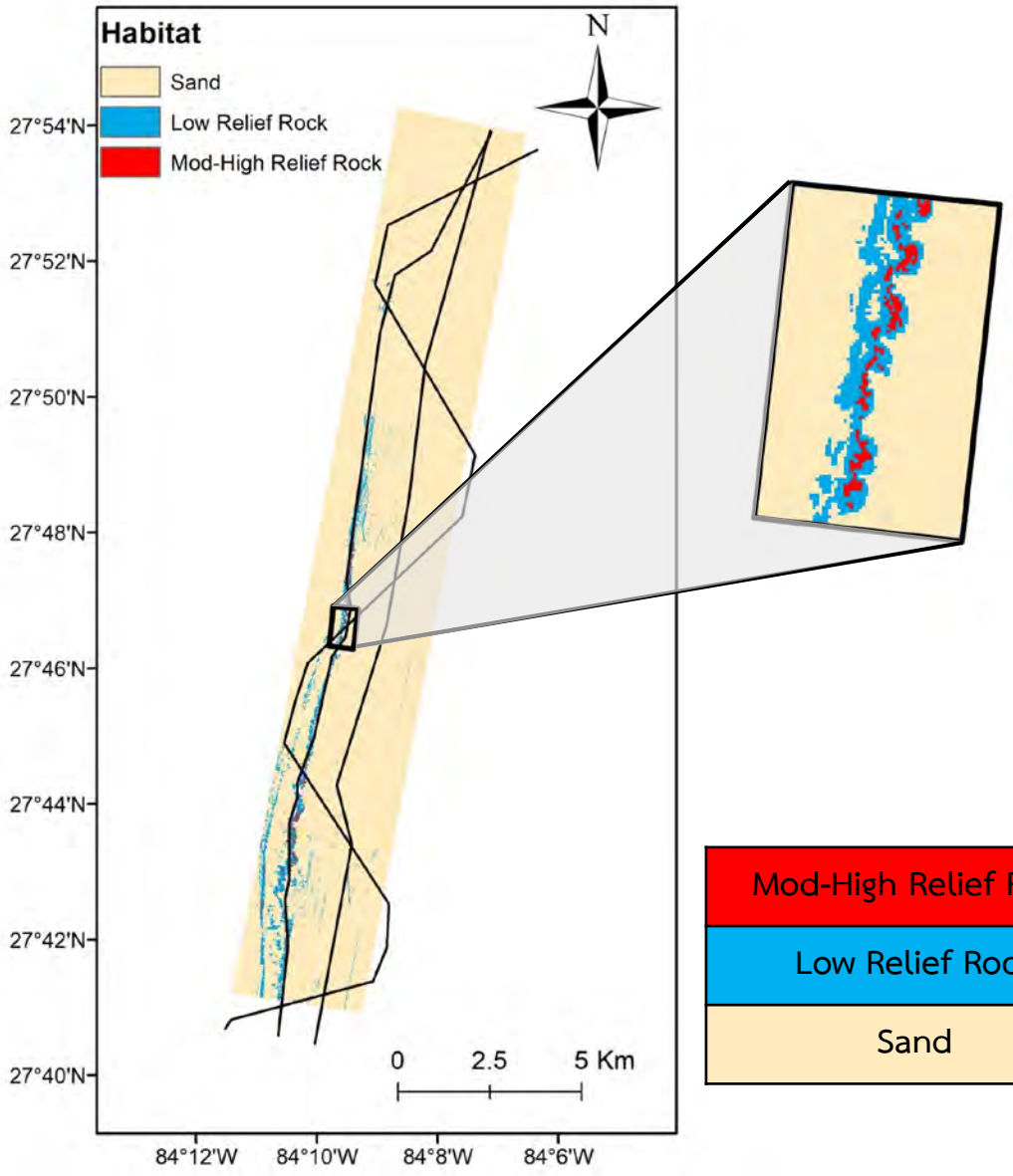


Fish Abundance Estimates



	Area (Km^2)
Mod-High Relief Rock	0.3
Low Relief Rock	3.2
Sand	83.6

Fish Abundance Estimates



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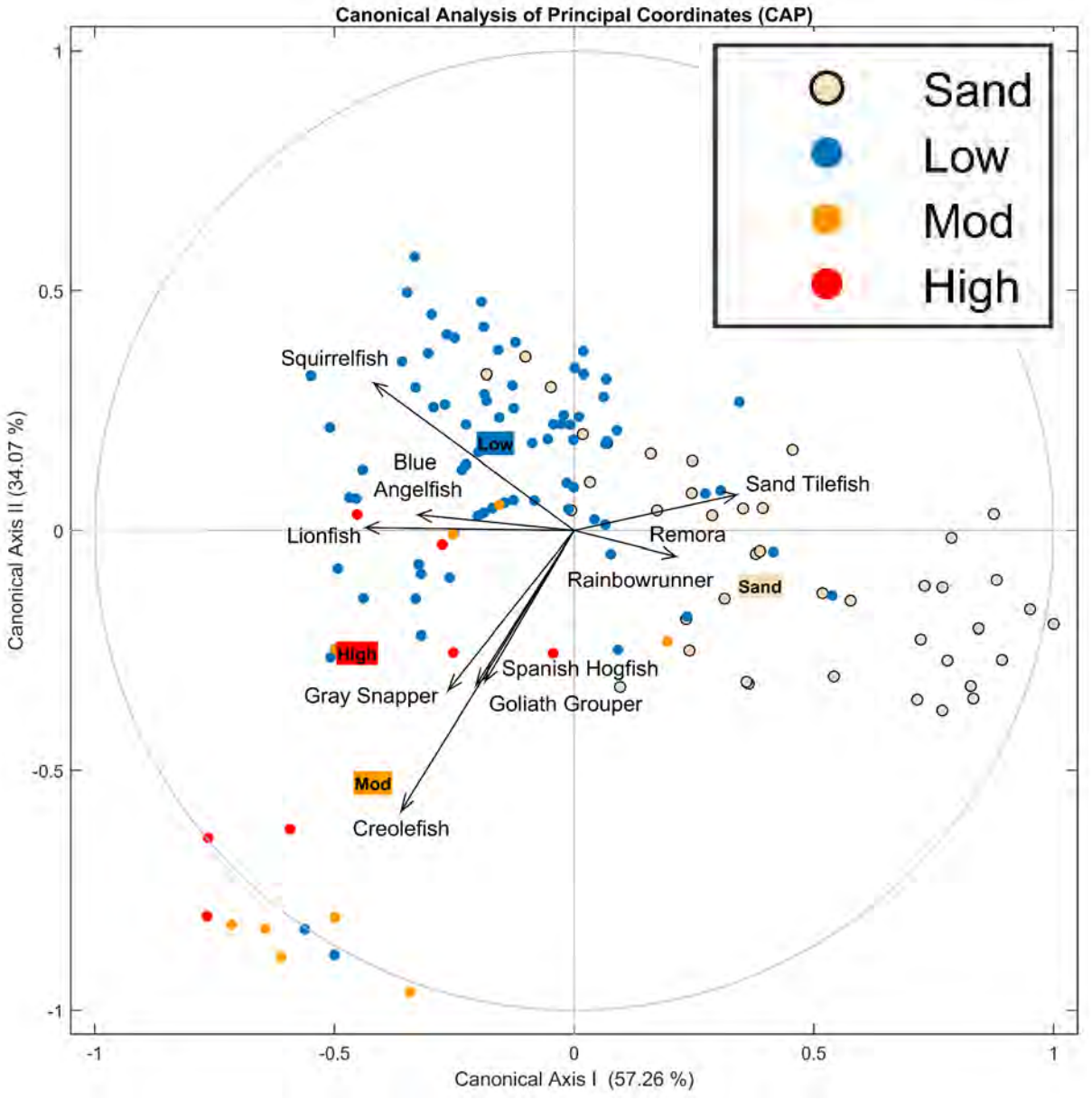

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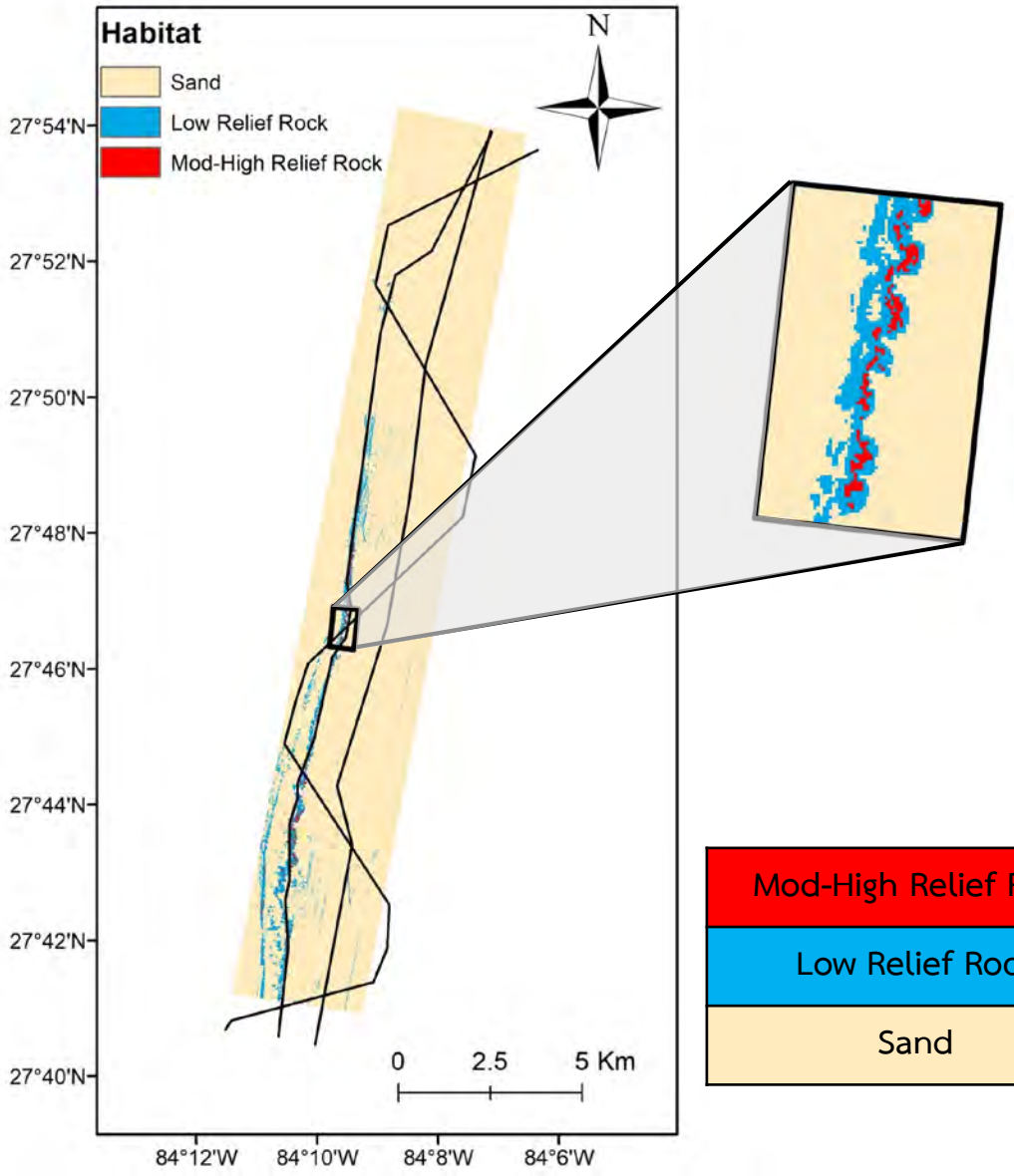

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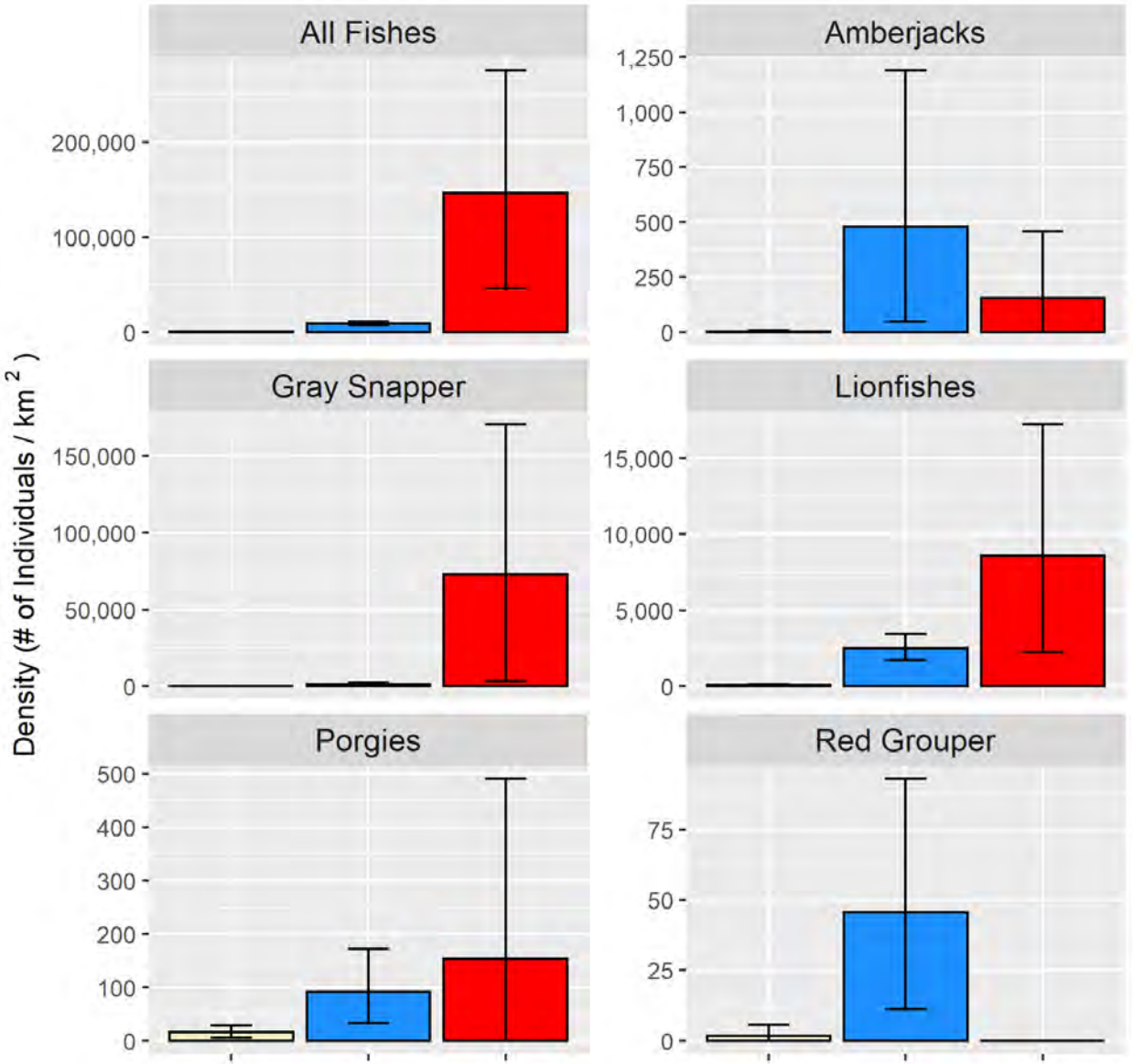

Fish Abundance Estimates