Marine Minerals Program Science Exchange Meeting

December 2, 2015
New Orleans, LA

Meeting Objectives

- Receive update on BOEM Marine Minerals Program (MMP) applied studies
- Facilitate multidisciplinary discussion on previous, ongoing, and future research efforts
- Identify opportunities for continued collaboration and leveraging

BOEM
Bureau of Ocean Energy Management

Agenda

9:00-9:30	**Welcome & Introductions (Mike Miner and Jennifer Culbertson, BOEM)**
9:30-10:00	Ecological Function and Recovery of Biological Communities within Dredged Ridge-Swale Habitats in the South-Atlantic Bight
10:00-10:30	Use of Acoustic Telemetry to Examine Habitat Preferences and Migration Patterns of Red Drum, Finetooth Sharks and Blacknose Sharks
10:30-10:45	Break
10:45-11:15	Propagation Characteristics of High-Frequency Sounds Emitted During High-Resolution Geophysical Surveys
11:15-11:45	Characterization of Underwater Sound Produced by a Hopper Dredge during Dredging, Pump-out and Placement Operations
11:45-1:15	Lunch (on your own). See “Dining Options” handout.
1:15-1:45	Late Quaternary Stream and Estuarine Systems to Holocene Sea Level Rise on the OCS Louisiana and Mississippi: Preservation Potential of Prehistoric Cultural and Sand Resources
1:45-2:15	Sand Shoal Geomorphic Evolution with Application to Fish Habitat
2:15-2:45	Upgrade of WAVCIS
2:45-3:15	Break
3:15-3:45	Assessment of Mud-Capped Dredge Pit Evolution on the Outer Continental Shelf of northern Gulf of Mexico
3:45-4:15	Economic and Geomorphic Comparison of OCS Sand vs Nearshore Sand for Barrier Island Restoration Projects
4:15-4:30	Wrap Up and Adjourn

Ground Rules

- "Honor" the agenda
- Participate actively and respectfully
- Focus comments and speak concisely
- Speak in order; facilitator will mind the queue
- Speak clearly into the microphone for those joining by phone/webinar
- Limit side conversations or take them outside
- Cell phones off/silent

Introductions

Use of Acoustic Telemetry to Examine Habitat Preferences and Migration Patterns of Coastal Sharks and Red Drum

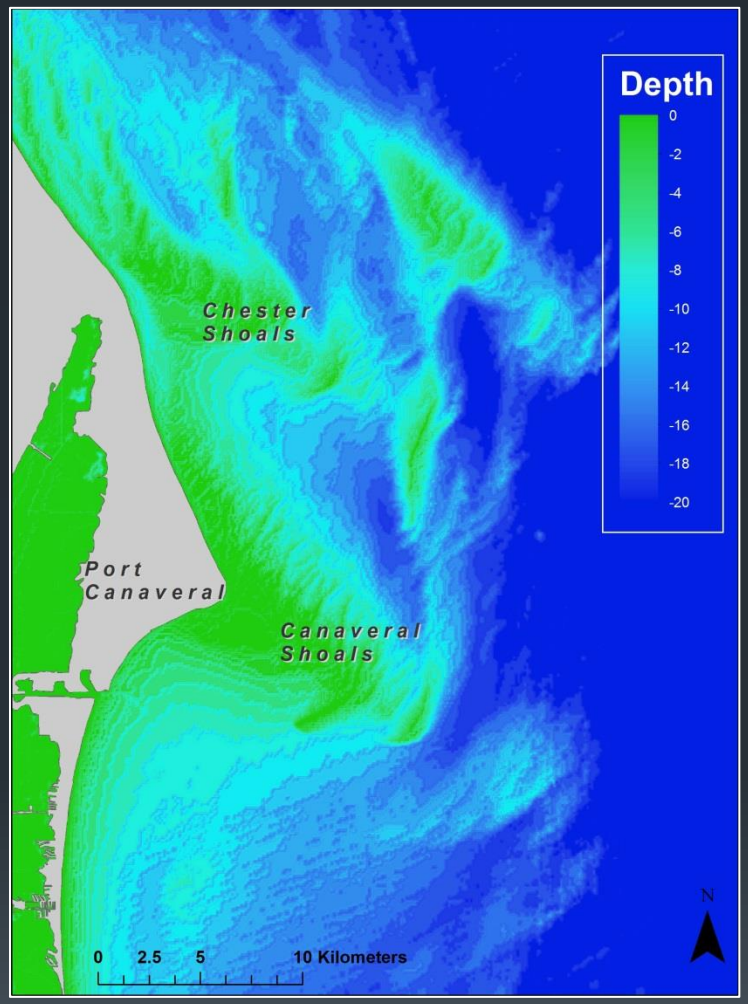
Joseph Iafrate, Stephanie Watwood
Naval Undersea Warfare Center, Newport

Eric Reyier, Douglas Scheidt
Kennedy Space Center Ecological Program

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Goal: Determine use of sand shoal habitats by coastal species

- Canaveral offshore shoal habitat:
  - EFH
  - Prominent ridge-swale features and shoal complexes
  - Past and present sand mining



- Data Gaps:
  - Migratory coastal fish species
  - Movements on local and regional scales
  - Characterization of habitat value and function

Finetooth and Blacknose Sharks

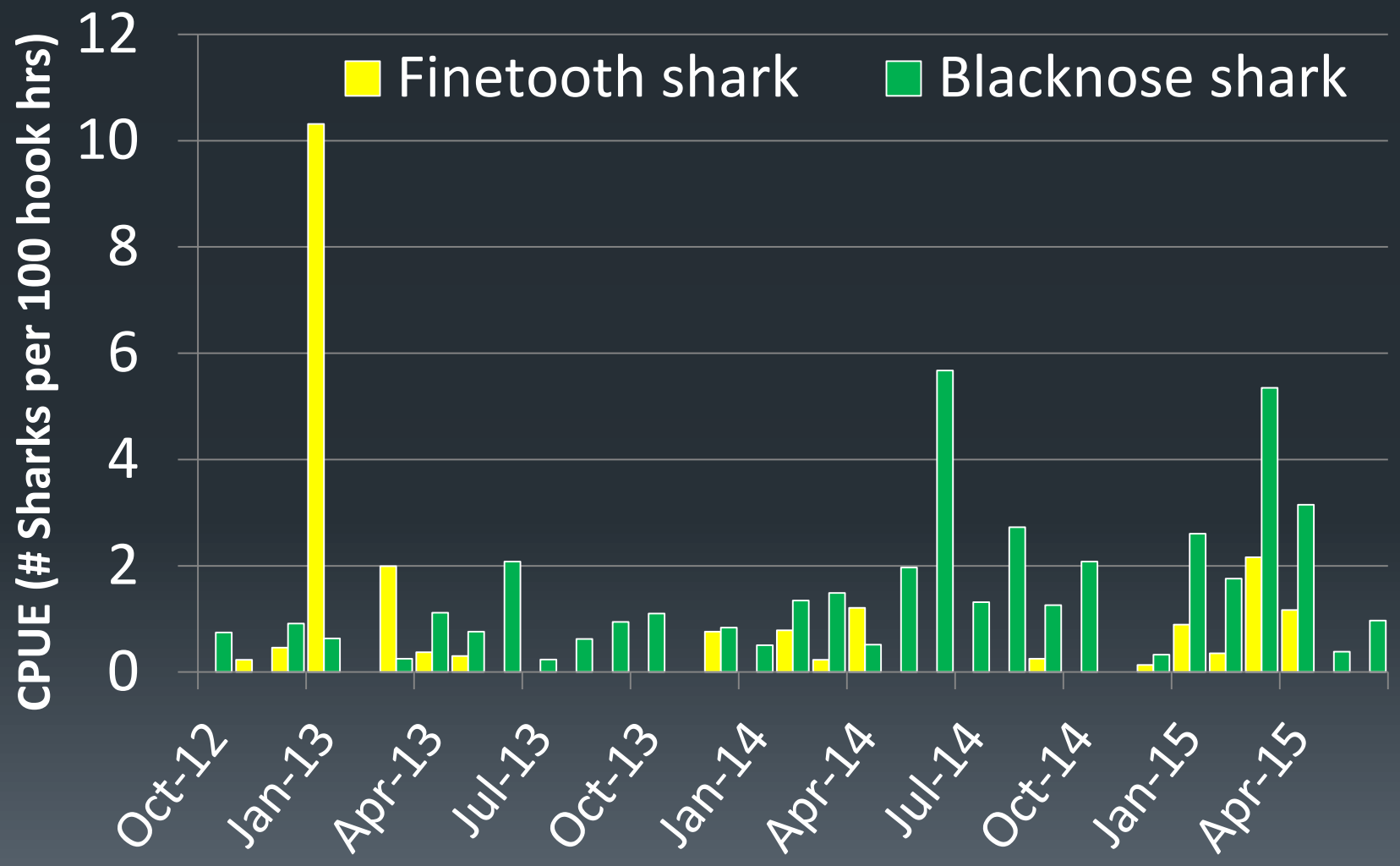
Atlantic Highly Migratory Species
Small Coastal Shark Complex

Finetooth:
- Seasonal Migratory Patterns

Blacknose:
- Higher Fidelity to Canaveral

Questions:
- Residency in Canaveral?
- Core activity space?
- Seasonal migratory movements?
- Function of shoal complex?

Sharks: Seasonal Longline Data CPUE



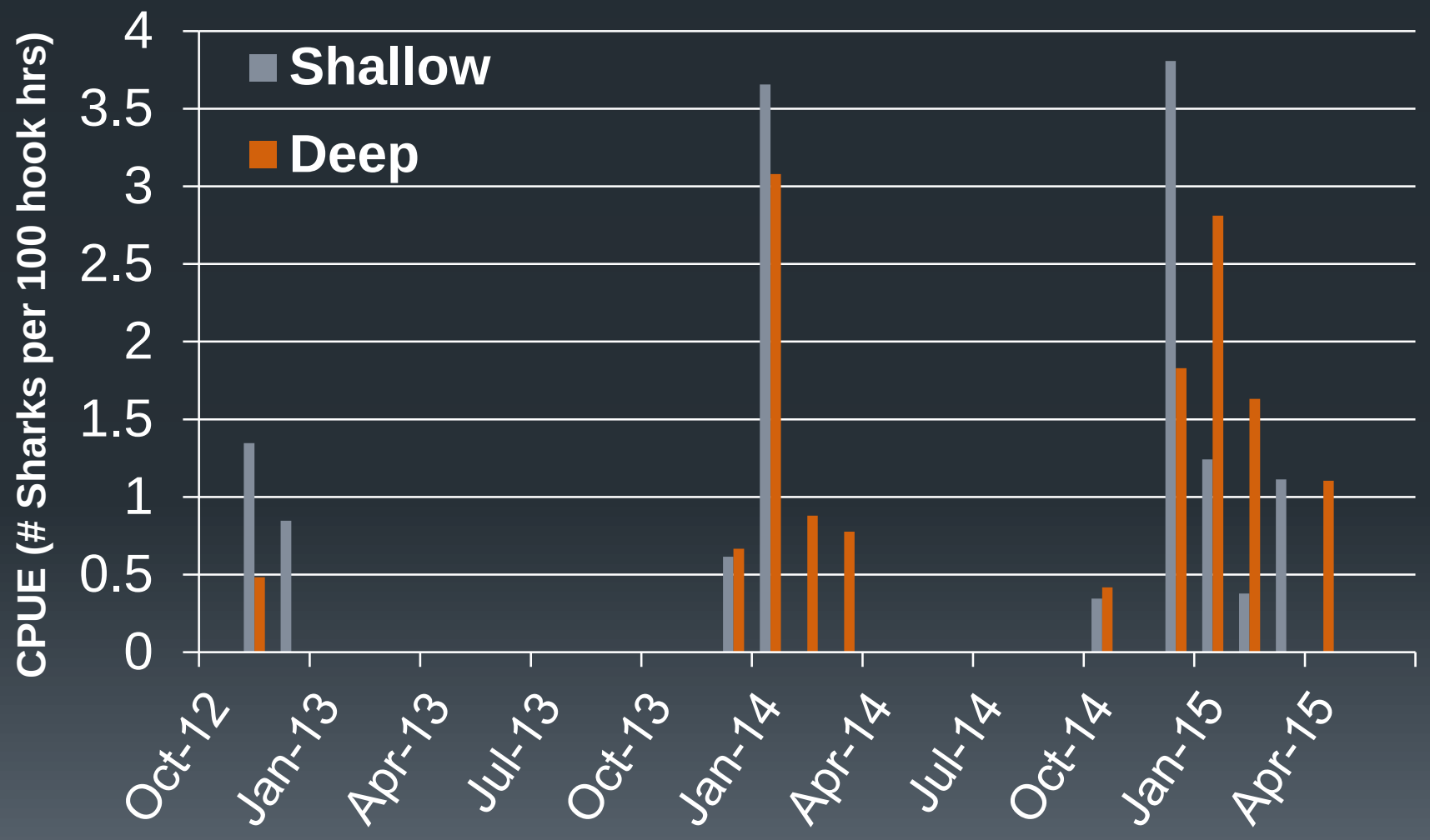
Red Drum

- High value species
- Little known about offshore movements
- Fidelity to Canaveral area
- Spawn in nearshore/estuarine habitats late summer/fall
- Resident IRL contingent (intermixing)

Questions:

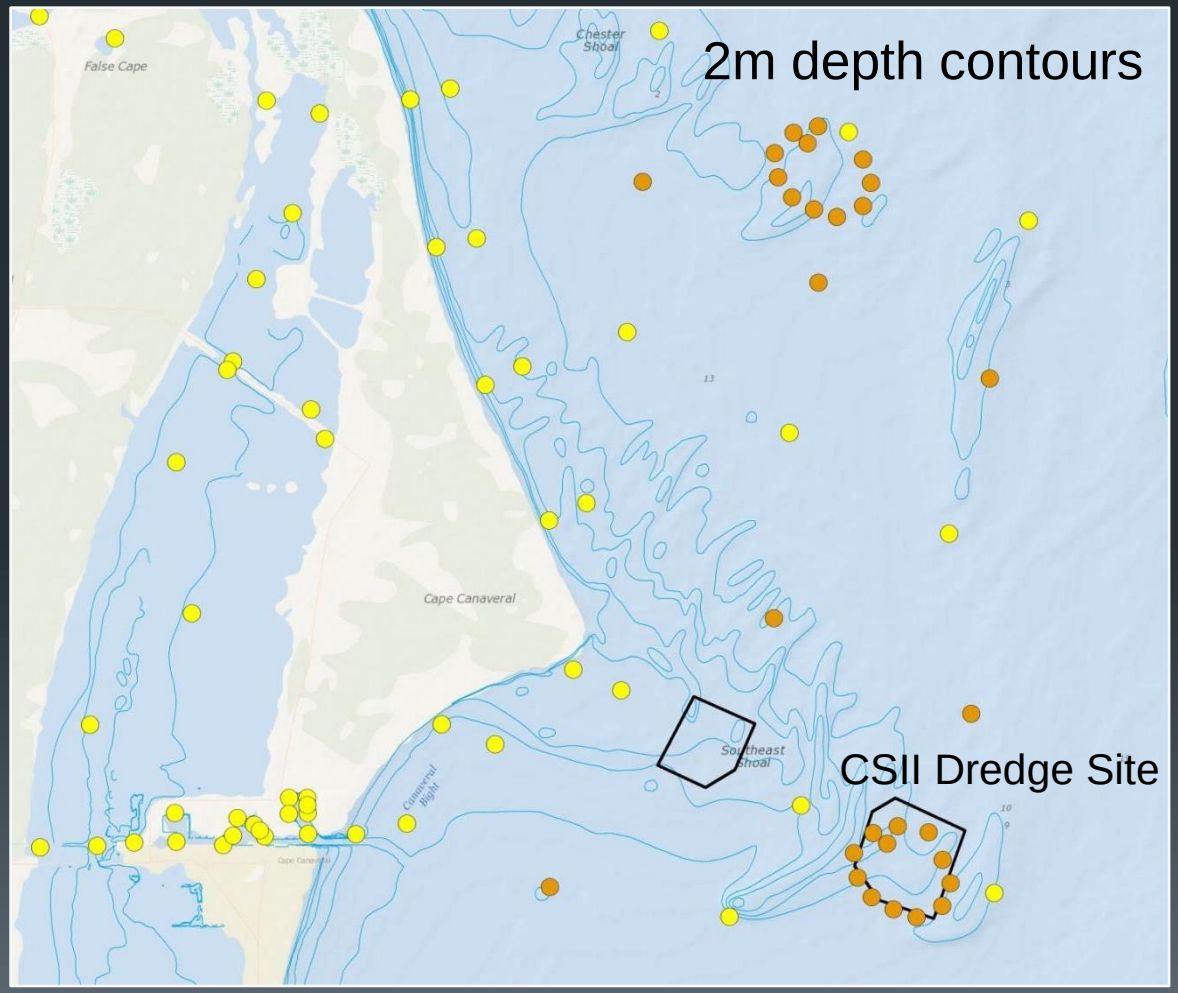
- Habitat preference for shoals?
- Use of adjacent habitats?
- Onshore/offshore movements?
- Seasonal distribution?

Red Drum: Seasonal Longline Data CPUE, Shallow and Deep Sets



Methodology: Acoustic telemetry

2013: 57 Vemco VR2Ws in Canaveral waters



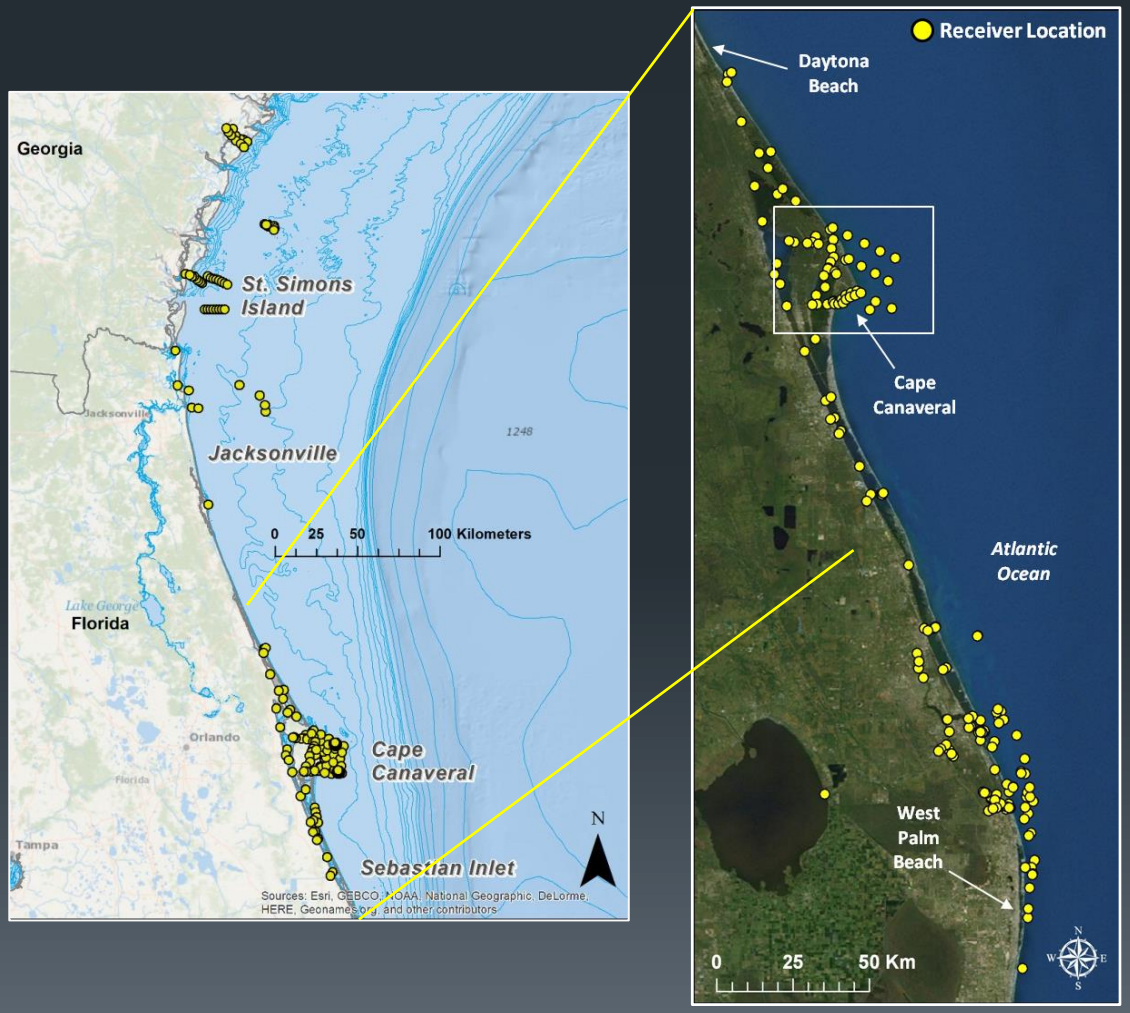
Methodology: Acoustic telemetry

- Vemco V16 tags
  - 90 sec burst interval
  - 5-9.7 yr battery life

- Forage Fish = V7

Florida Atlantic Coast Telemetry (FACT) and Atlantic Cooperative Telemetry (ACT) arrays:

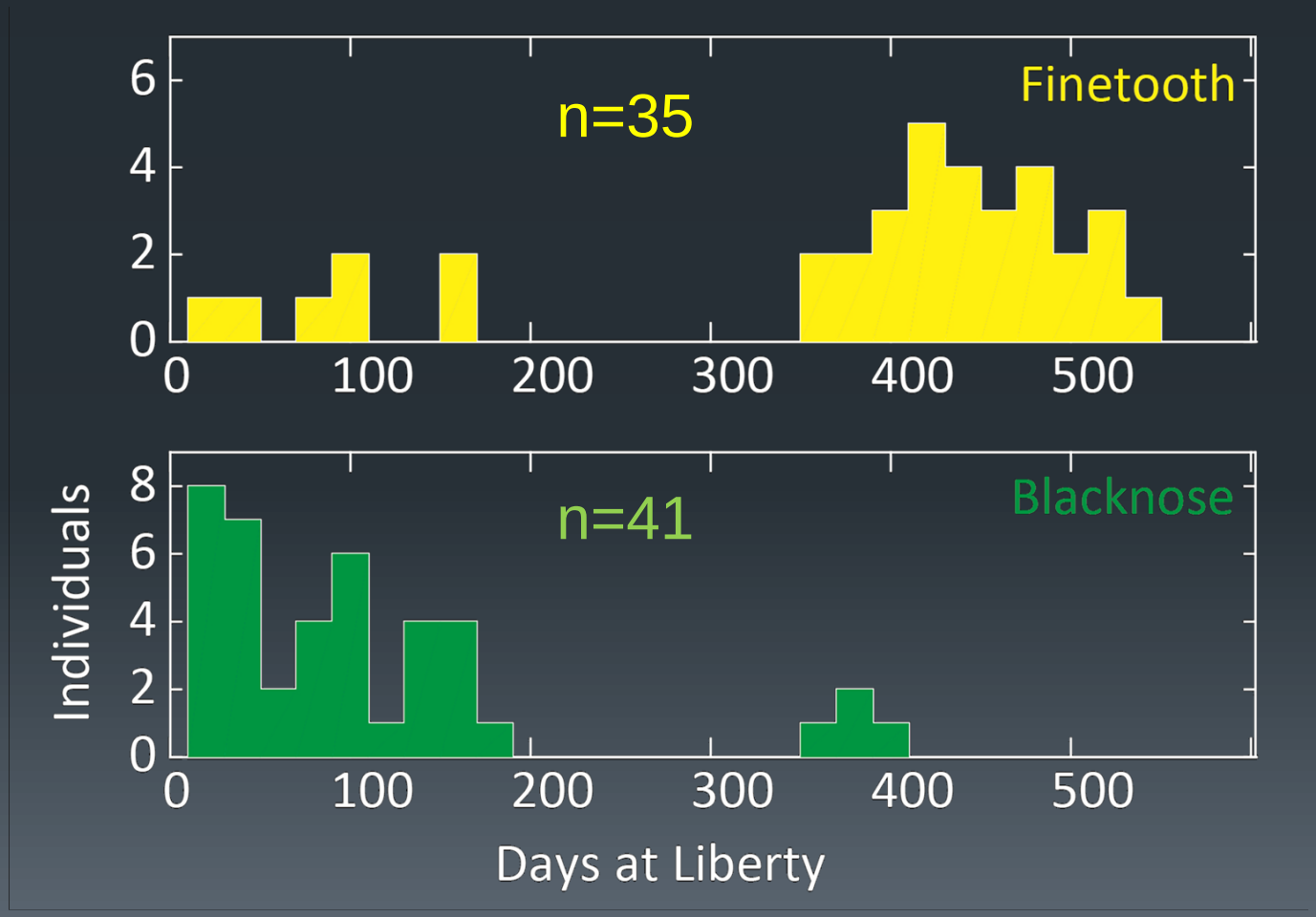
Tracking regional movements



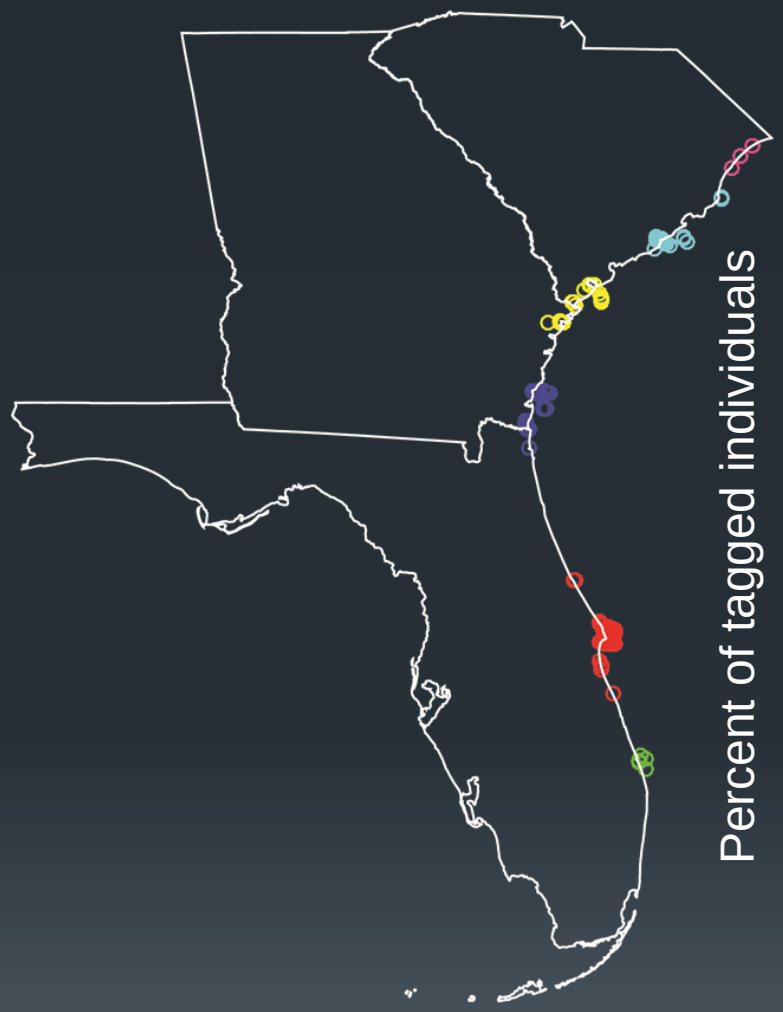
- Bimini Biological Field Station
- Cape Eleuthera Institute (Bahamas)
- Continental Shelf Associates
- East Coast Biologists
- Florida Atlantic University
- Florida Fish & Wildlife Conservation Commission
- Florida Institute of Technology
- Florida International University
- Florida Program for Shark Research
- Florida State Museum of Natural History
- Florida State University
- GA Department of Natural Resources
- Loxahatchee River District
- Pew Institute of Ocean Sciences
- Rosenstiel School of Marine and Atmospheric Science
- Savannah State University
- Shedd Aquarium
- SC Dept. of Natural Resources
- United States Geological Survey
- University of Central Florida
- University of Florida
- University of Georgia
- University of North Florida

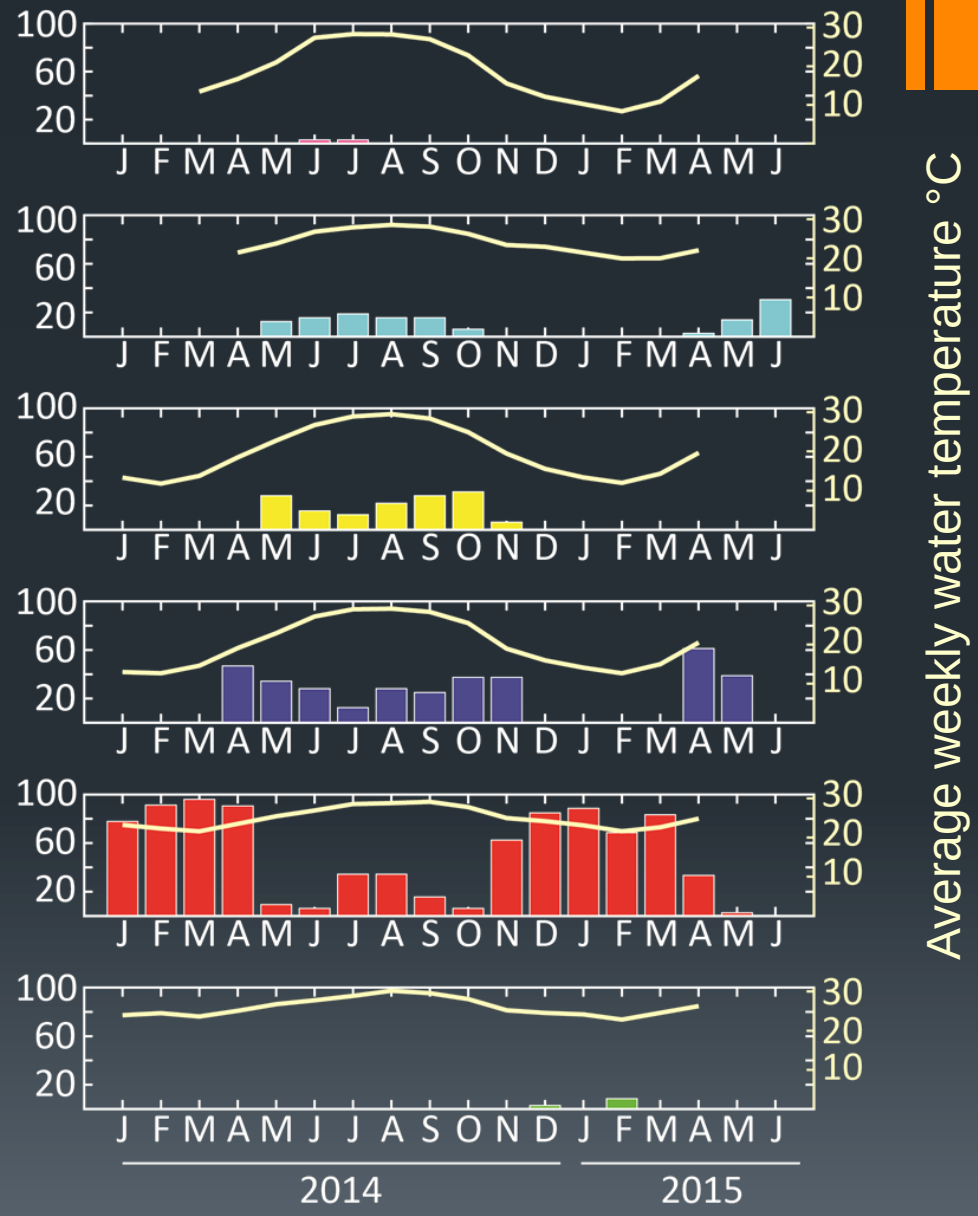
Tagging Summary: Sharks

Days at Liberty

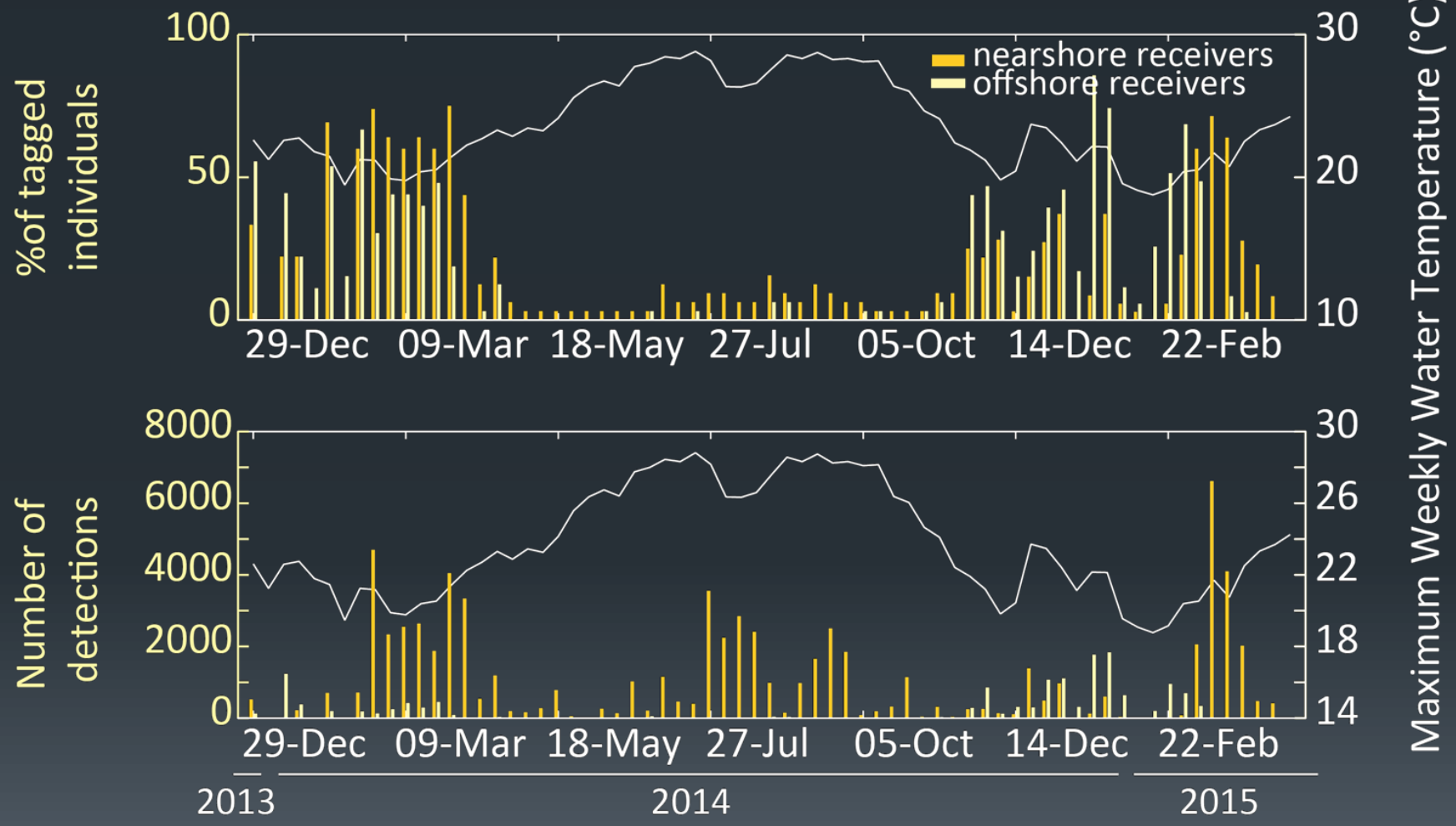


Finetooth shark





Finetooth Shark



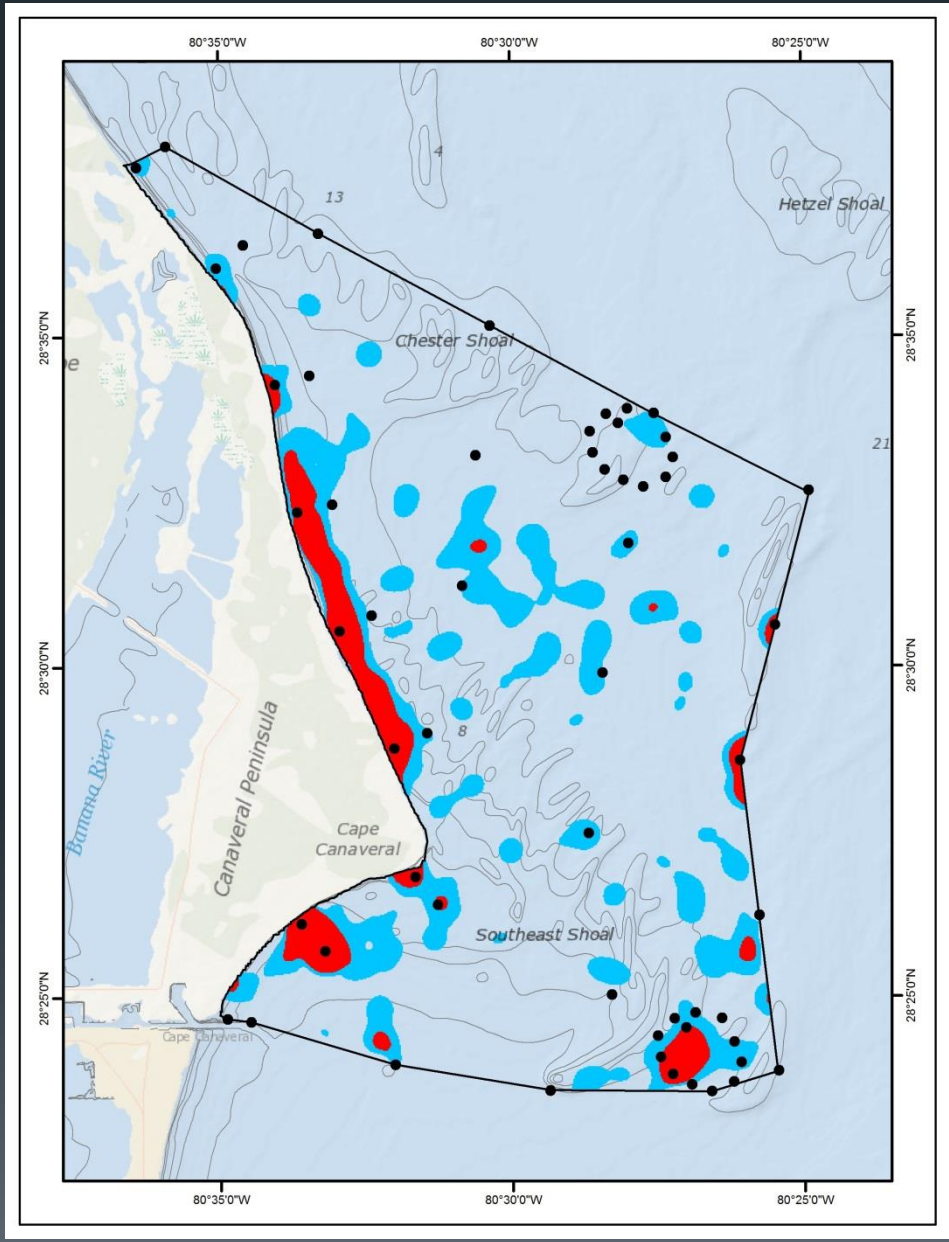
Nearshore: < 1.5 km from shore

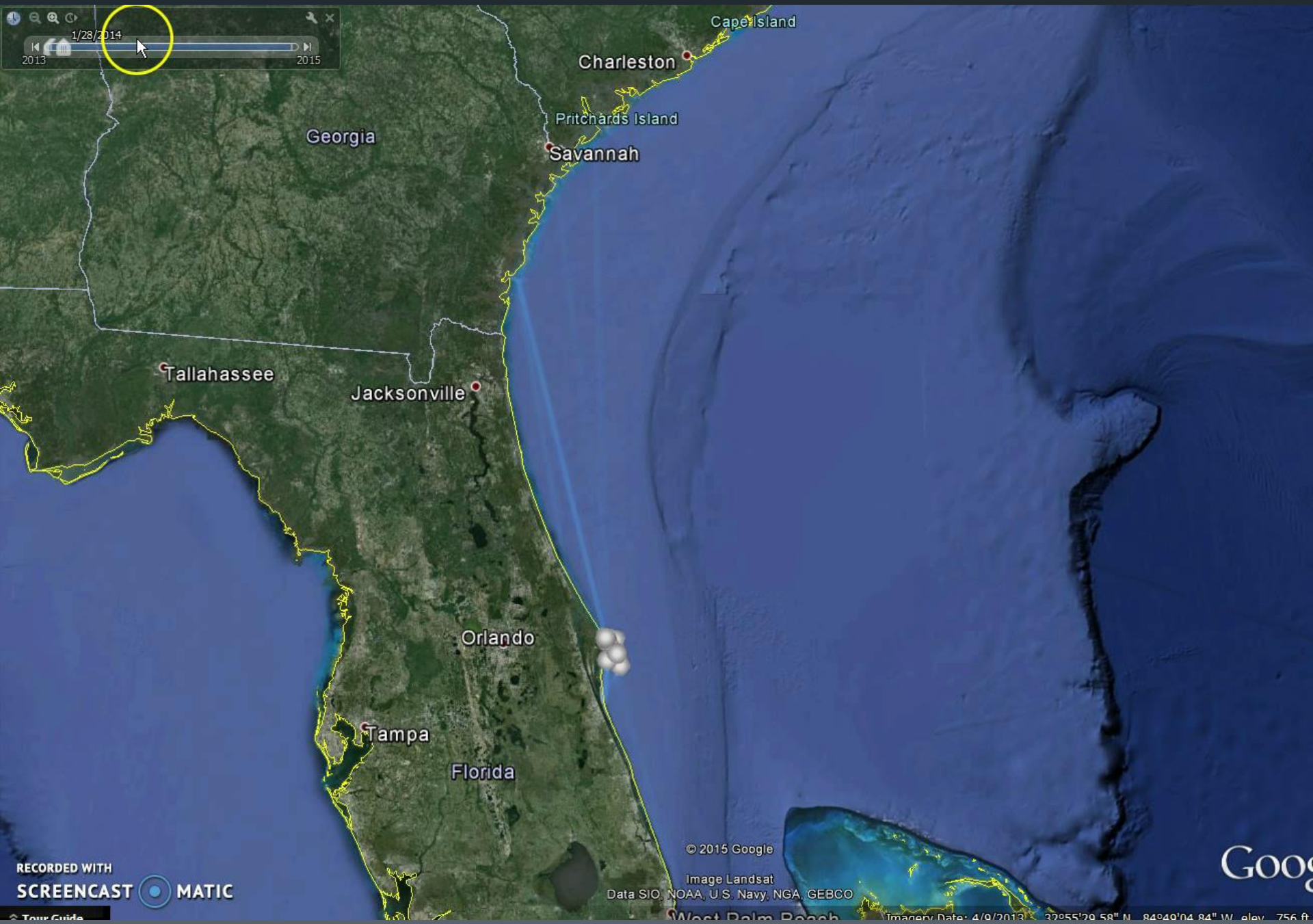
Offshore: 1.5-15 km from shore

Finetooth: 50% and 95% KDE

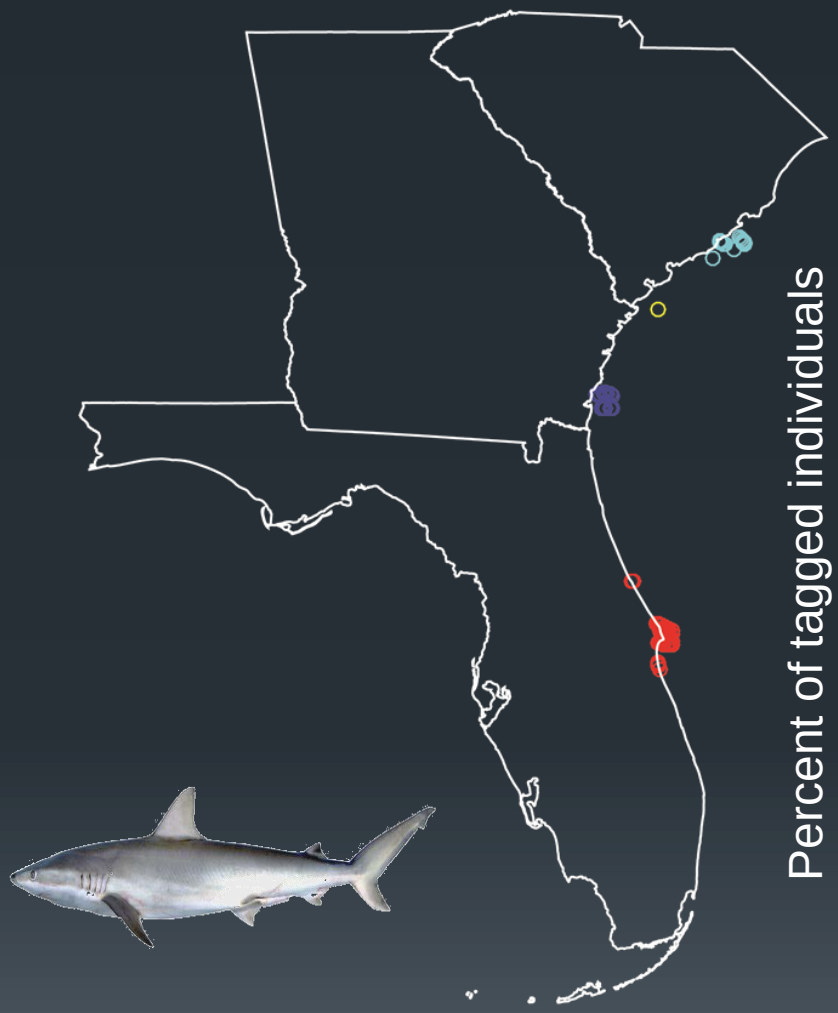
Created from Weekly Avg Positions

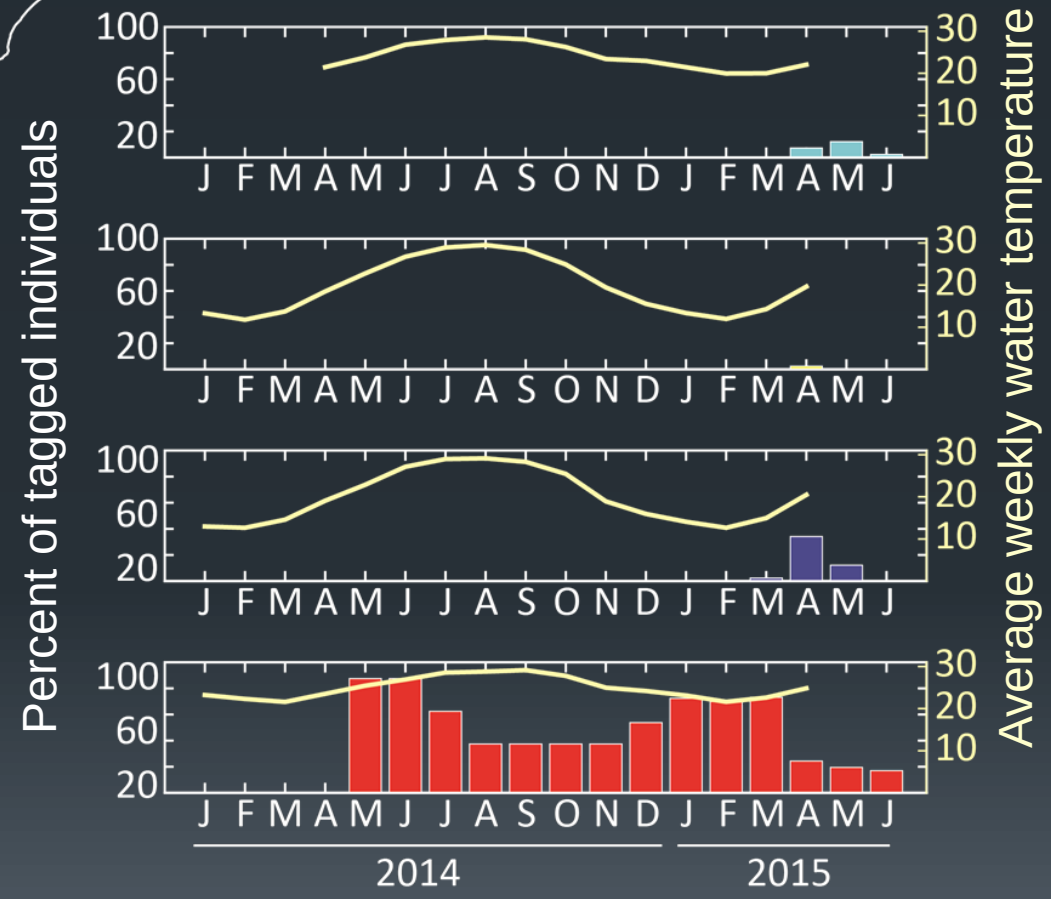
50% = Core Range



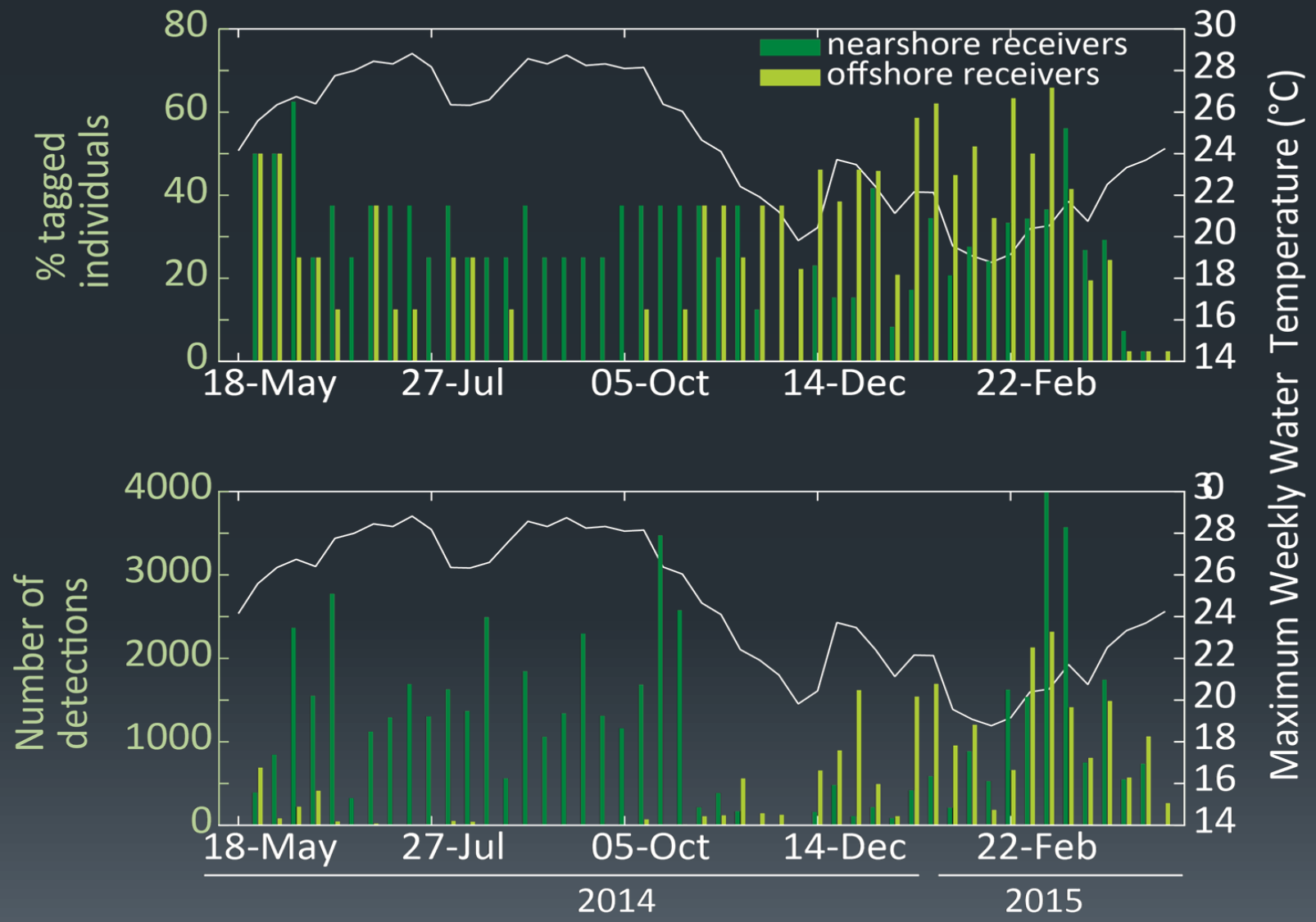

1/28/2014
2013
2015
Cape Island
Charleston
Pritchards Island
Savannah
Georgia
Tallahassee
Jacksonville
Orlando
Tampa
Florida
© 2015 Google
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
RECORDED WITH
SCREENCAST MATIC

Blacknose shark





Blacknose shark

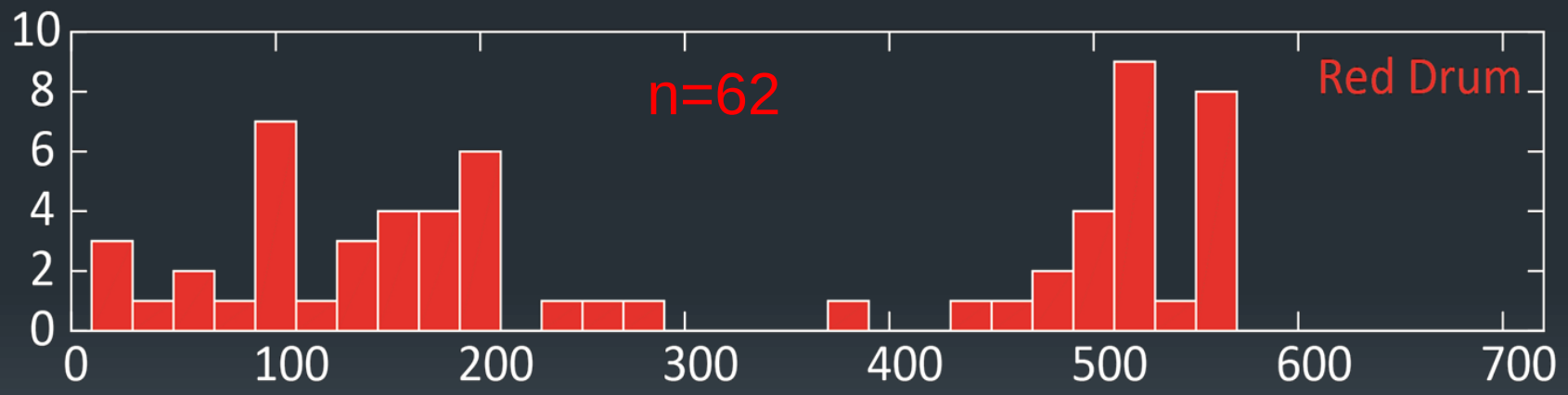


Nearshore: < 1.5 km from shore

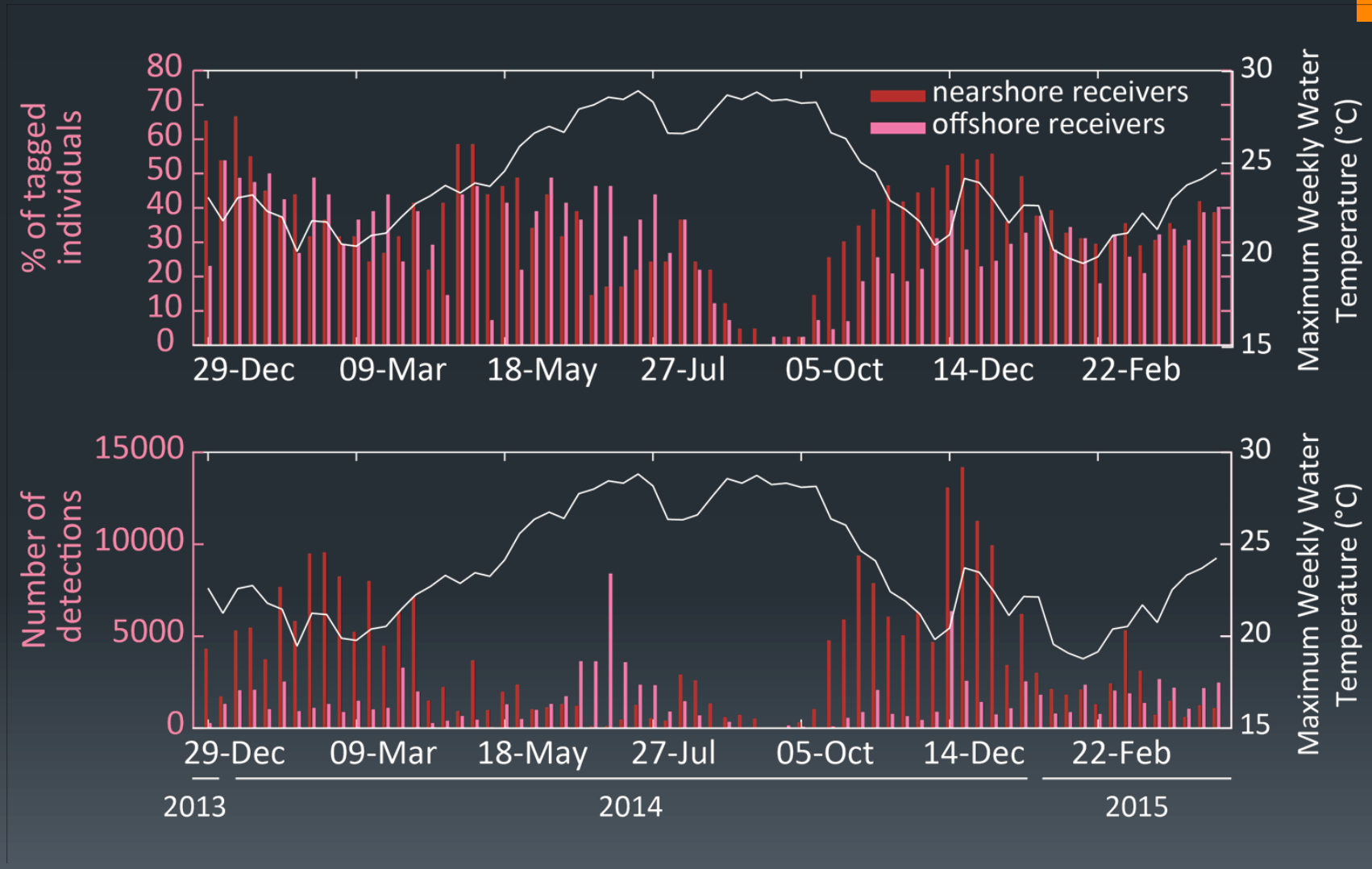
Offshore: 1.5-15 km from shore

Tagging Summary: Red Drum

Days at Liberty
Start Date: December 2013



Red Drum



Nearshore: < 1.5 km from shore

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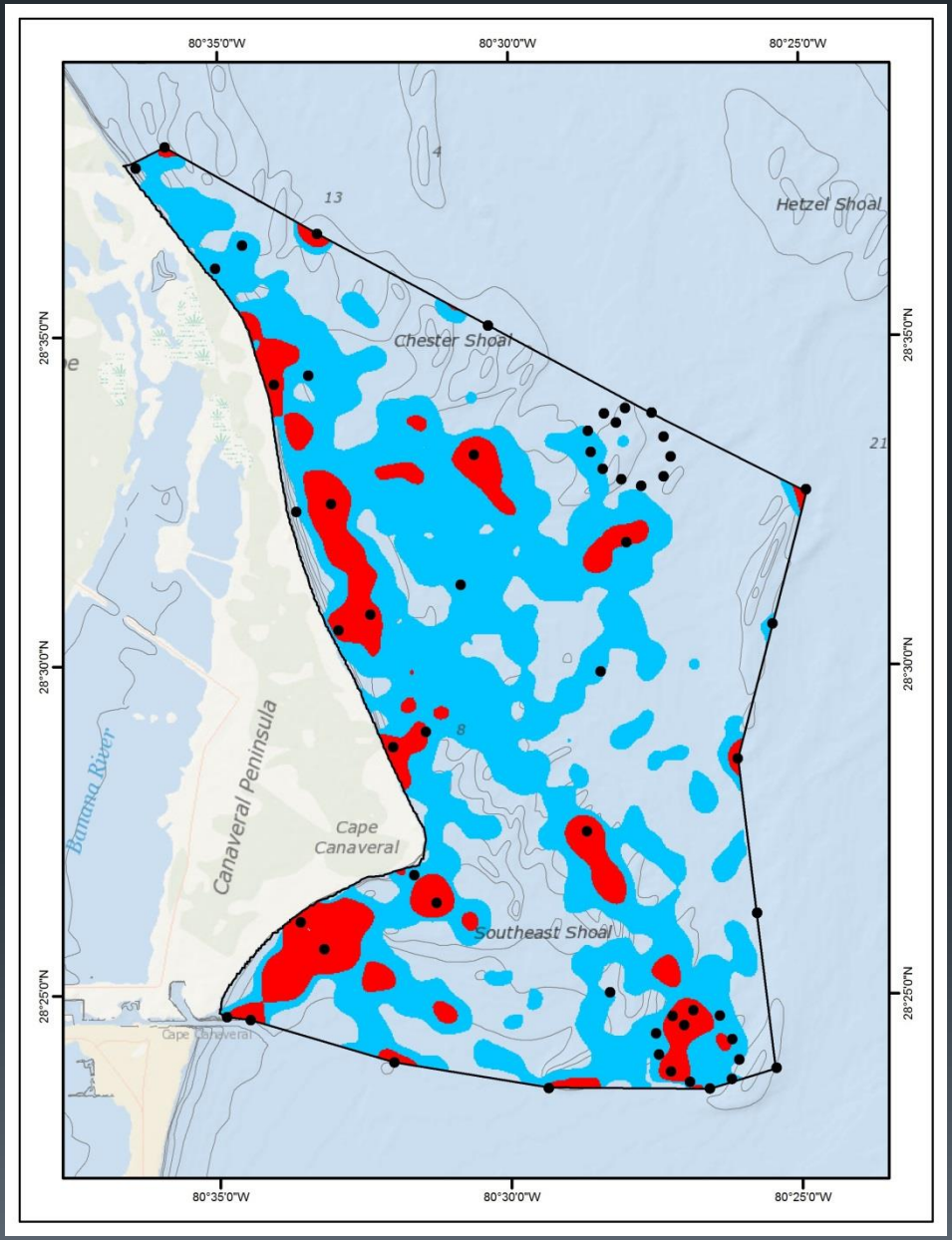
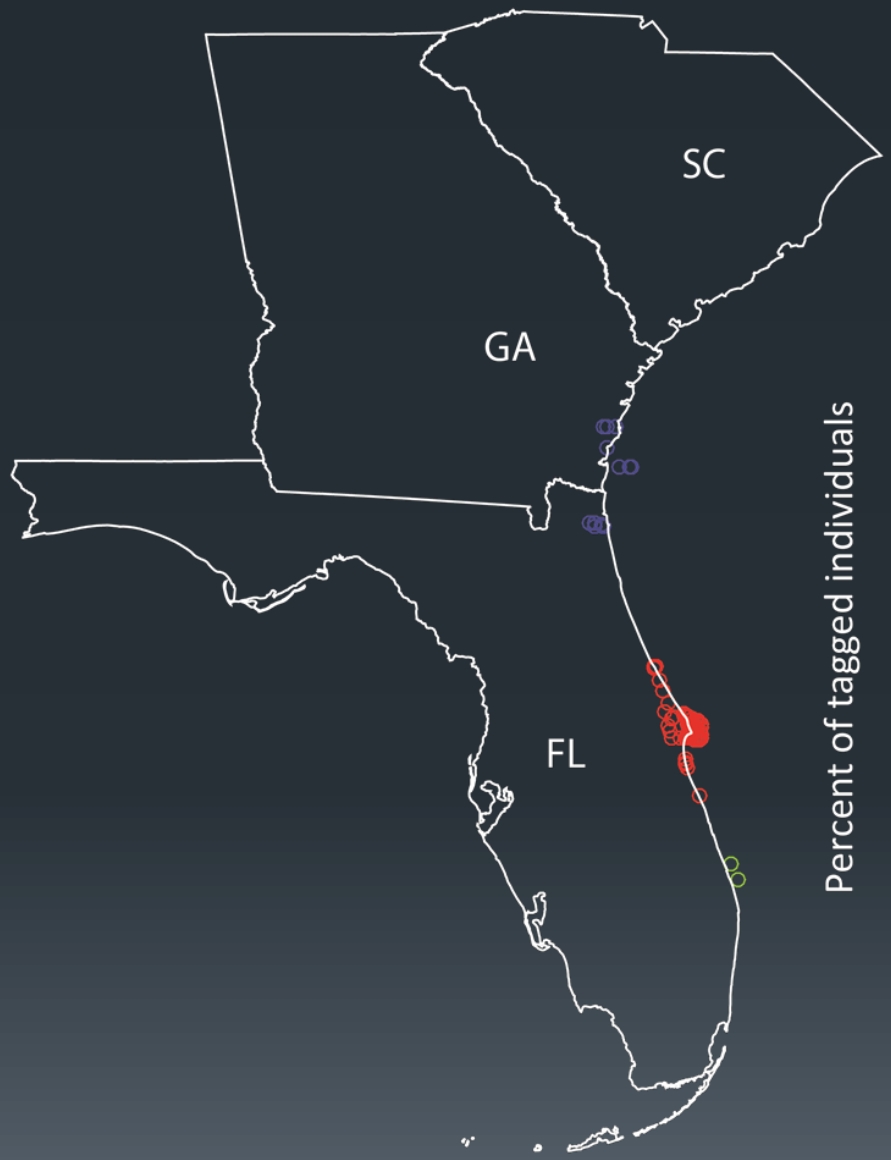
Red Drum: 50% and 95% KDE

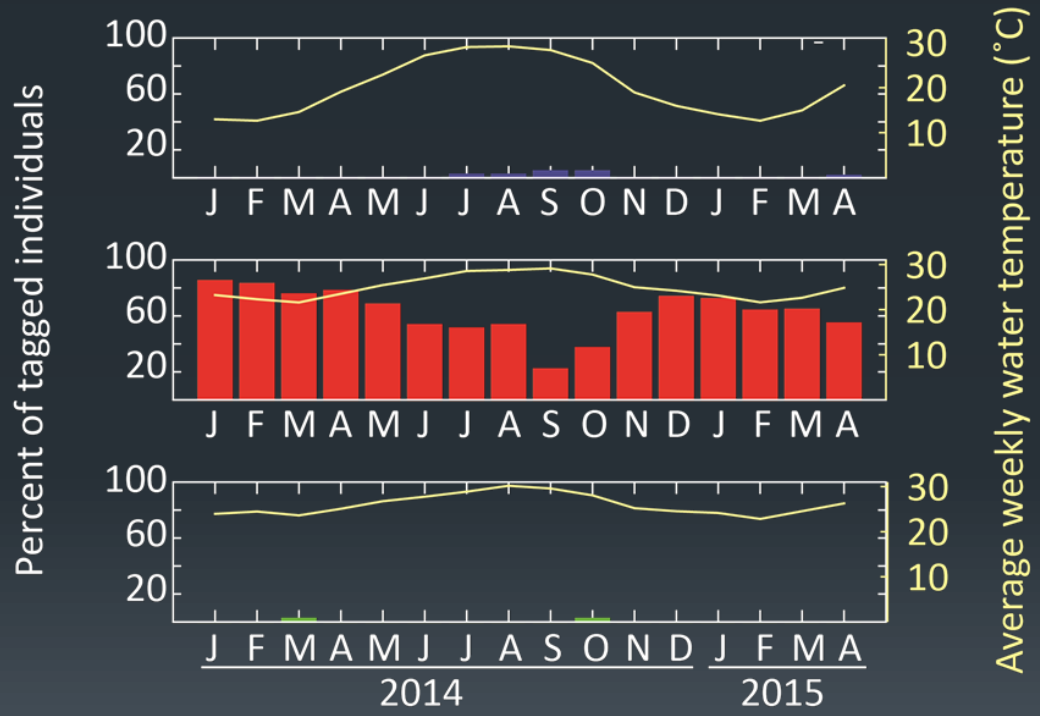
Created from Weekly Avg Positions

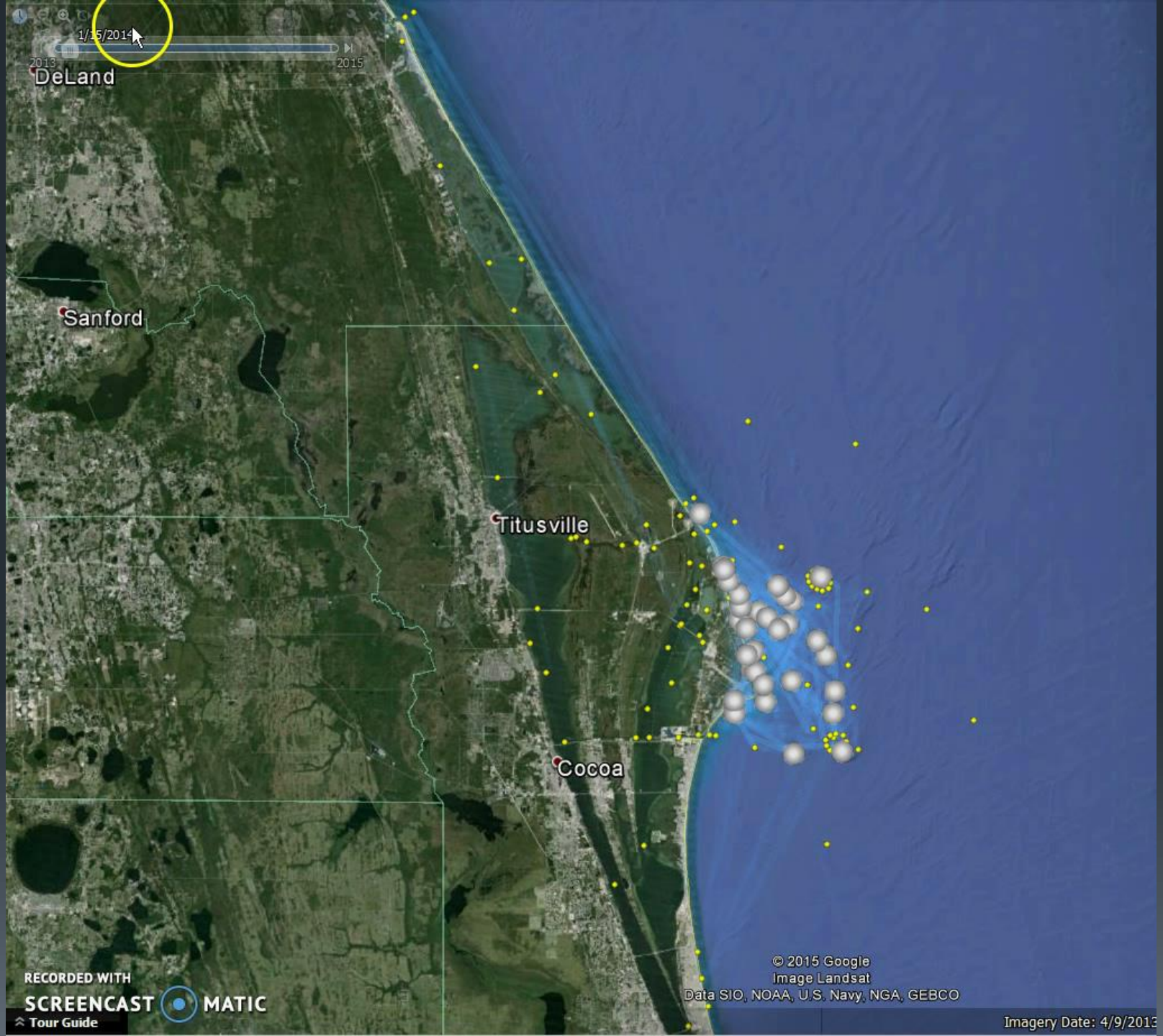
50% = Core Range



Red Drum


SC
GA
FL


Percent of tagged individuals
100
60
20
30
20
10
J F M A M J J A S O N D J F M A
2014
2015
Average weekly water temperature (°C)


1/15/2014
2013
2015
DeLand
Sanford
Titusville
Cocoa
© 2015 Google
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
RECORDED WITH
SCREENCAST MATIC
Tour Guide
Imagery Date: 4/9/2013

Summary: Red Drum

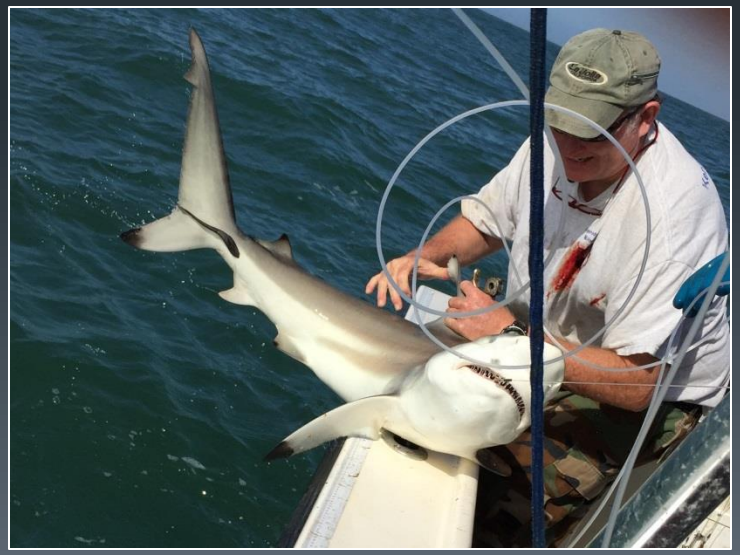
- Use variety of water depths (3-20 m)
- Utilize nearshore (1.5km) and offshore (up to 15km) receivers
- General presence all months of the year
- Preference for nearshore habitat (bight) in winter
- Even distribution nearshore/offshore warmer temps
- Detection at estuaries in GA
- Disappearance from Canaveral array coincides with spawning, return in November
- Intermixing with resident contingent - IRL

Summary: Coastal Sharks

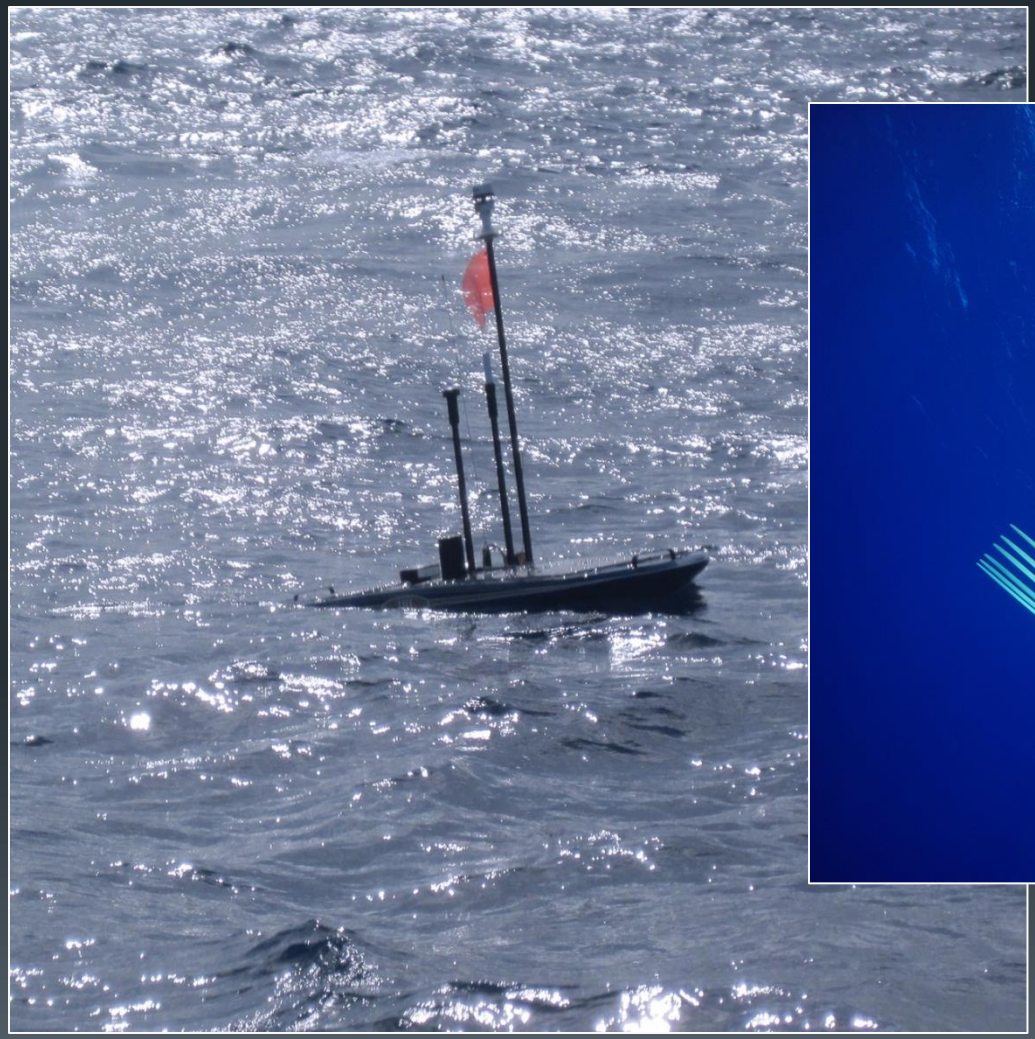
- Consistent annual movements
- Finetooth sharks
  - Spread in movements as temperatures increase
  - Detections in estuaries in GA, SC; none in Canaveral
  - Most move North March – October, some return in July
- Blacknose sharks
  - Fewer individuals detected outside of Canaveral
  - Detections outside Canaveral in Spring
  - More consistent year round presence

Analytical Framework

- Habitat Description/Characterization
- Fish Habitat Preferences at Cape Canaveral
- Residency at CSII Dredge Site vs. Chester Shoal Control (finer scale)
- Coastal Migrations and Seasonal Philopatry (regional scale)
- Abundance, Seasonal Use, Community Structure (longline)



Upcoming Work: Wave Glider



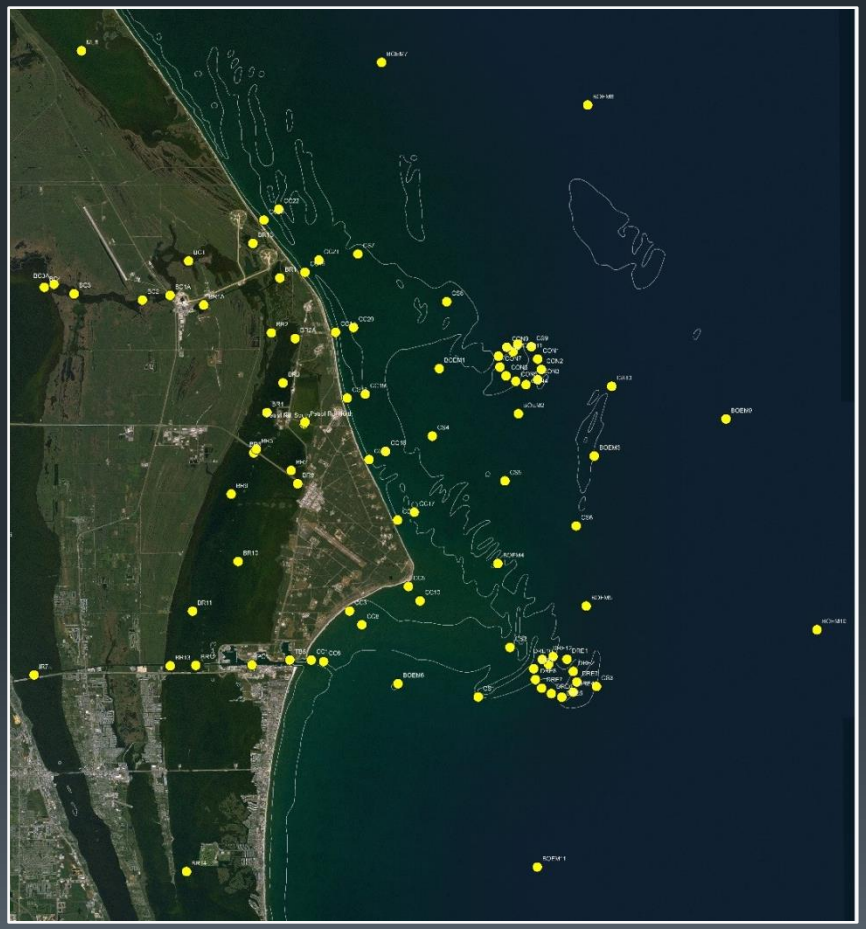
Wave Glider Technology

- Powered by Wave Energy and Solar
- Supports Varied Scientific Payloads
- Can Stay at Sea for Months
- Operates in High Sea States
- Runs Pre-Defined Transects
- Controlled Via Web Browser
- Real-Time Data Streaming

Feasibility Trial: Cape Canaveral Spring 2015

Sensors and Telemetry

- Mobile Acoustic Receiver:
  - Expands FACT footprint beyond fixed array
  - Use of adjacent non-shoal habitats
  - Range testing within fixed array
- Water Temperature Sensor
- Chlorophyll-*a* and Turbidity
- Wave Height Sensor
- Passive Hydrophone System



Glider Study: Core Objectives

- Systematically and repeatedly survey shoal edges and deeper sections of Canaveral Shoals
- Generate detailed environmental conditions with detections events to assess habitat preferences
- Extend the glider telemetry survey to areas outside the current FACT Array footprint to better quantify the true activity space and mobility of tagged animals
- Compare how fish reproductive activity differs between shoals and adjacent non-shoal habitats
- Document spatial and temporal patterns in water turbidity and how this varies in relation to shoal depth and wave heights at Canaveral

Thank you

Jennifer Culbertson, Geoff Wikel, Sally Valdes Bureau of Ocean Energy Management

Jane Provancha, Carla Bourtis, Russell Lowers, Karen Holloway-Adkins, Brenton Back, Shannon Gann Kennedy Space Center Ecological Program

Lynne Phillips NASA/Kennedy Space Center Environmental Program

Don George, Angy Chambers Air Force 45th Space Wing Natural Assets Office

LCDR Westermeyer, LCDR Gray Naval Ordnance Test Unit

Jessica Kutcher, Jennifer James MRC, Inc

Deb Murie University of Florida

Joy Young Florida Fish & Wildlife Conservation Commission

Chris Kalinowsky Georgia Department of Natural Resources

Steve Kessel Bimini Biological Field Station

Lydia Wilson Florida Institute of Technology

Mike Arendt, Elizabeth Miller, Bryan Frazier South Carolina Department of Natural Resources

Mike McCallister University of North Florida

Air Force Technical Applications Center (AFTAC), Cape Canaveral, FL

Fish collection and tagging under NMFS Biological Opinion (Permit F/SER/2011/05647) and the State of Florida Special Activity License SAL-12-0512A-SR, and protocols reviewed by KSC Institutional Animal Care & Use Committee (Protocol GRD-06-049)

Marine Minerals Program Science Exchange
New Orleans 2015

Characteristics of Sounds Emitted During High Resolution Marine Geophysical Surveys

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Dr. Steven Crocker
Naval Undersea Warfare Center
Underwater Sound Reference Division
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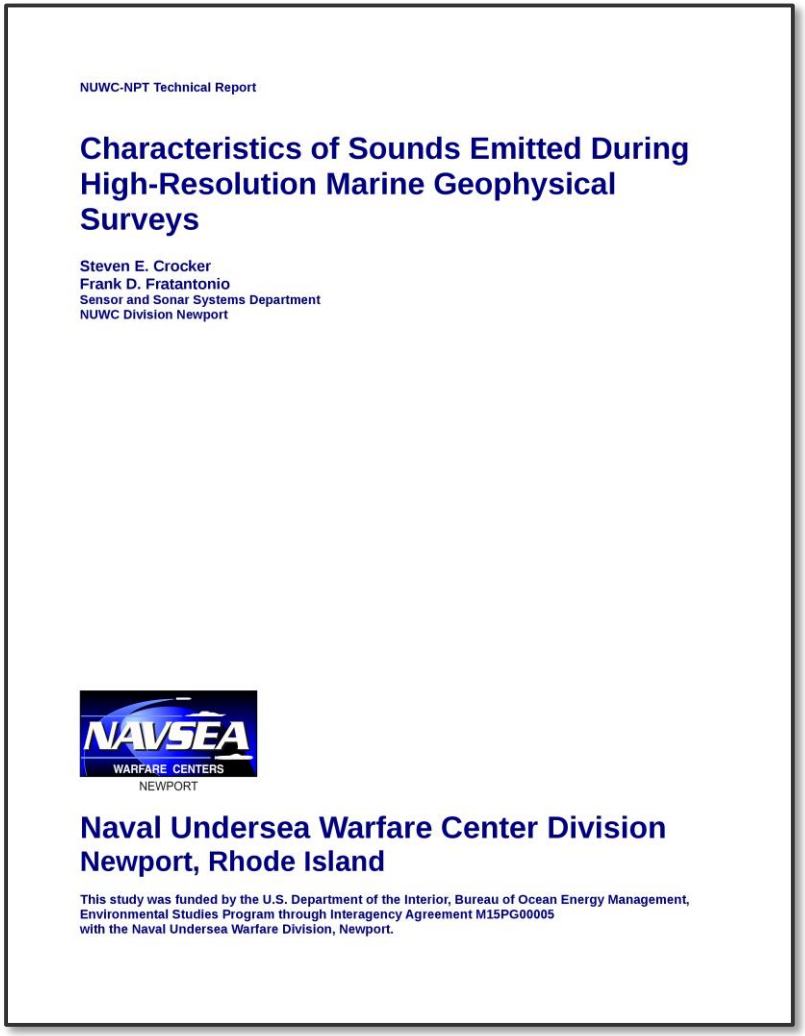
Acknowledgments

This study was funded by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program through Interagency Agreement M15PG0005 with the Naval Undersea Warfare Center Division Newport.

The United States Geological Survey (USGS) was essential in this study with their contribution of equipment, manpower and technical expertise during the testing.



NUWC-NPT Technical Report

Characteristics of Sounds Emitted During High-Resolution Marine Geophysical Surveys

Steven E. Crocker
Frank D. Fratantonio
Sensor and Sonar Systems Department
NUWC Division Newport

NAVSEA WARFARE CENTERS NEWPORT

Naval Undersea Warfare Center Division Newport, Rhode Island

This study was funded by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program through Interagency Agreement M15PG00005 with the Naval Undersea Warfare Division, Newport.

Background

Marine Mammal Protection Act

The MMPA prohibits, with certain exceptions, the **"take"** of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S.

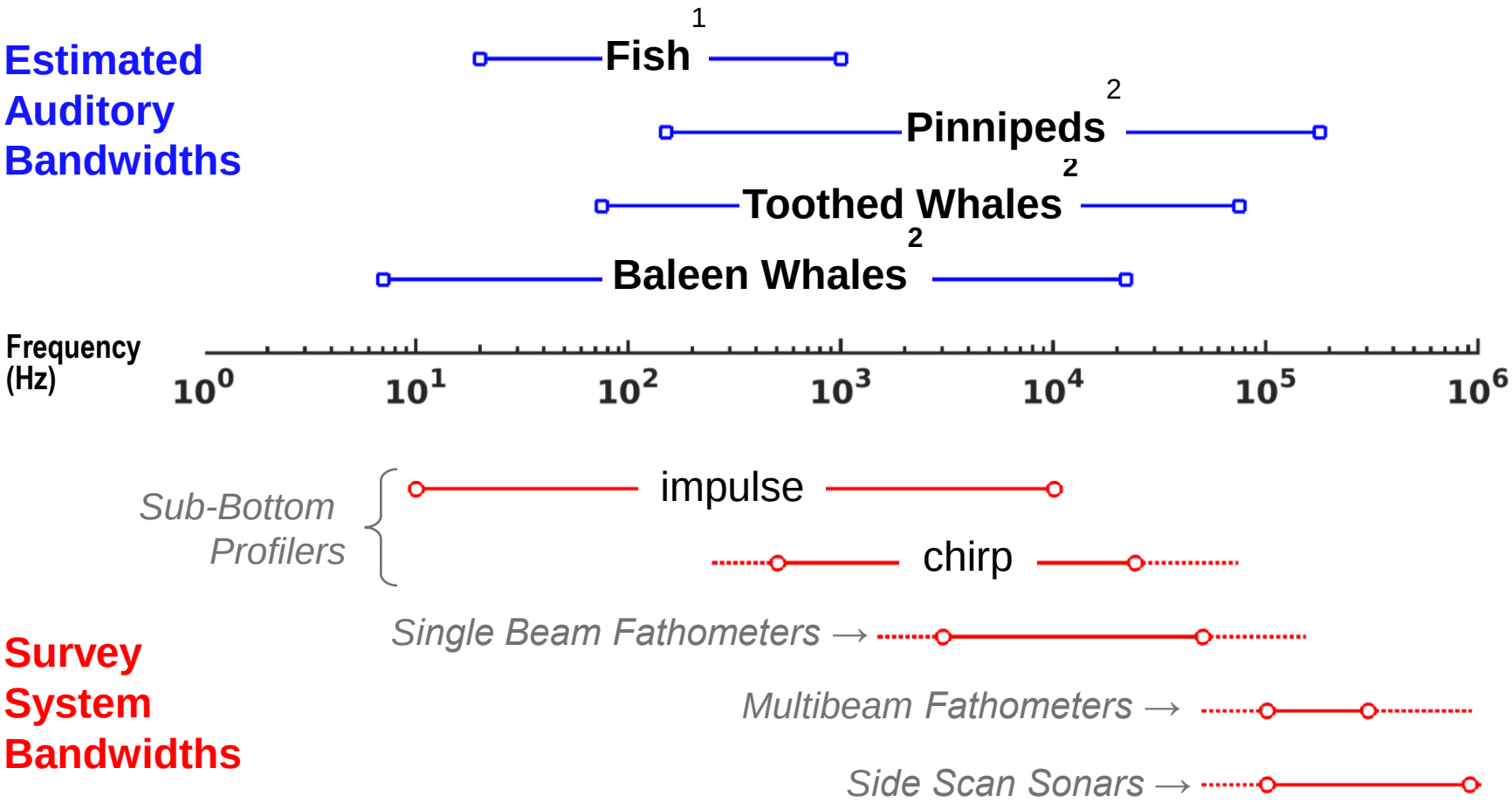
Definitions

Take: To harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.

Harass: Any act of pursuit, torment, or annoyance which - (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B].

Sources: Marine Mammal Protection Act (MMPA) Sec. 3 (18); http://www.nmfs.noaa.gov/pr/laws/mmpa/; http://www.boem.gov/BOEM-Science-Note-March-2015/

Acoustic Spectrum Usage



1) Hastings and Popper, 2005
2) Southhall et. al., 2007

Project Plan Development

- **BOEM realized that this project needed to address the following issues:**
  - Utilized by BOEM's 3 Programs - Oil & Gas, Marine Minerals and Renewables Programs
  - Wide range of source types and models
  - Concentrate on shallow water – primarily the continental shelf
  - Applicable throughout the US EEZ waters
  - The project couldn't measure every situation and that ultimately predictive acoustic modeling would be needed
  - Required measured data to "prove" or validate future analyses and environmental compliance documents
  - Needed to examine the entire acoustic scenario – source to receiver, near & far field issues, etc.
  - Needed to examine current "hot" issues – harmonics and subharmonics, SPL and SEL, etc.
- **BOEM recognized that USGS had similar issues and approached them to team on this project.**
- **BOEM identified a 3 Phased approach to minimize technical uncertainties:**
  - **Phase I** – Quantify what the sources were actually producing
  - **Phase II** – In-situ measurements at three general depths (10, 30, and 50-100m), in areas with 2 sediment types if possible. Utilize Phase I data to optimize the test planning.
  - **Phase III** – Use results from Phases I & II to examine the acoustic propagation models and the supporting databases currently to identify which should be used in this shallow water situation and to identify recommendations for best practices in their employment.

Project Schedule

- **<u>Phase I</u>** – Calibrated Source Measurements
  - Measurements completed.
  - Draft Report in review.
  - Final Report available in April 2015

- **<u>Phase II</u>** – At-Sea System Measurements
  - Participants Selected.
  - Measurements at 5 Mid-Atlantic Sites in June/July 2016

- **<u>Phase III</u>** – Acoustic Propagation Modeling Analysis
  - RFP released in Summer 2016, for FY 2017 start (funding permitting).
  - To be completed in early FY 2018.

Study Objective

Given the scientific questions and uncertainty about the potential impact of noise in the marine environment, a number of regulatory requirements and precautionary mitigation strategies are being applied to lower energy geophysical surveys.

The U.S. Bureau of Ocean Energy Management is working to ensure that environmental mitigation requirements are scientifically supported, cost effective, operationally feasible and impact reducing. The Bureau is advancing this objective by characterizing the acoustic energy radiated by geophysical survey systems used in shallow bodies of water under U.S. jurisdiction.

The objective of this study is to characterize the acoustic fields radiated by marine geophysical survey systems as a critical first step to understanding the potential impacts to marine ecosystems.

Geophysical Survey Systems

Seafloor Mapping		*Sub-Bottom Profiling*	
System	*Description*	*System*	*Signal*
Echotrac CV100	Single Beam Fathometer	AA* 200	Impulse
Reson 7111	Multibeam Fathometer	AA* 251	Impulse
Reson T20-P	Multibeam Fathometer	AA* S-Boom	Impulse
Sea Swath Plus	Interferometer	FSI** Bubble Pulse	Impulse
Klien 3000	Side Scan Sonar	EdgeTech 424	FM Chirp
Klien 3900	Side Scan Sonar	EdgeTech 512i	FM Chirp
EdgeTech 4200	Side Scan Sonar	Knudsen 3202	FM Chirp

*Applied Acoustics, Ltd.
**Falmouth Scientific, Inc.

Reported Parameters

Source level (rms 90%)	dB re 1μPa@1m
Peak acoustic pressure	dB re 1μPa@1m
Peak-to-peak acoustic pressure	dB re 1μPa@1m
Sound exposure level	dB re 1μPa^{2}s@1m
Spectrum level	dB re 1μPa^2/Hz@1m
Effective (90%) pulse width	seconds
Half-power (3 dB) bandwidth	Hz
Beam patterns	dB
Half-power (3 dB) beam width	degree
10 dB beam width	degree
Principal side lobe level	dB
Principal side lobe location	degree

Sub-Bottom Profiling Systems

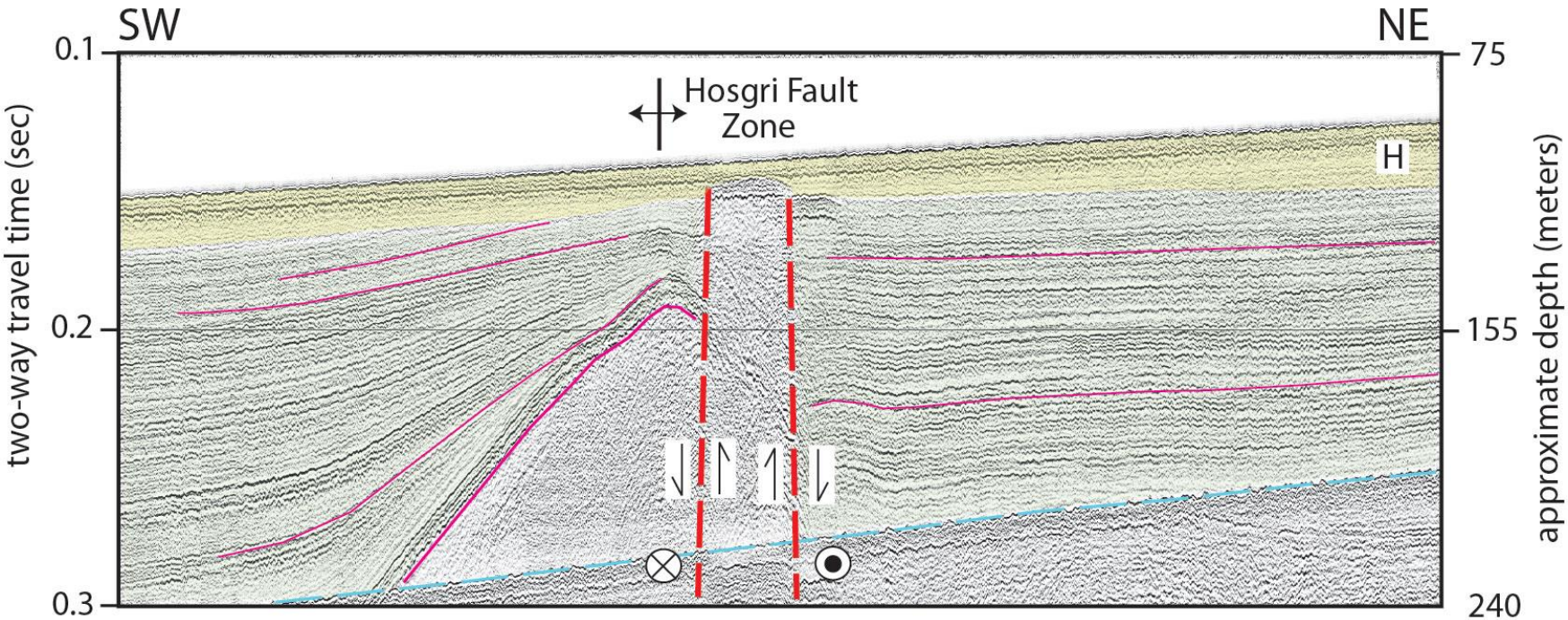
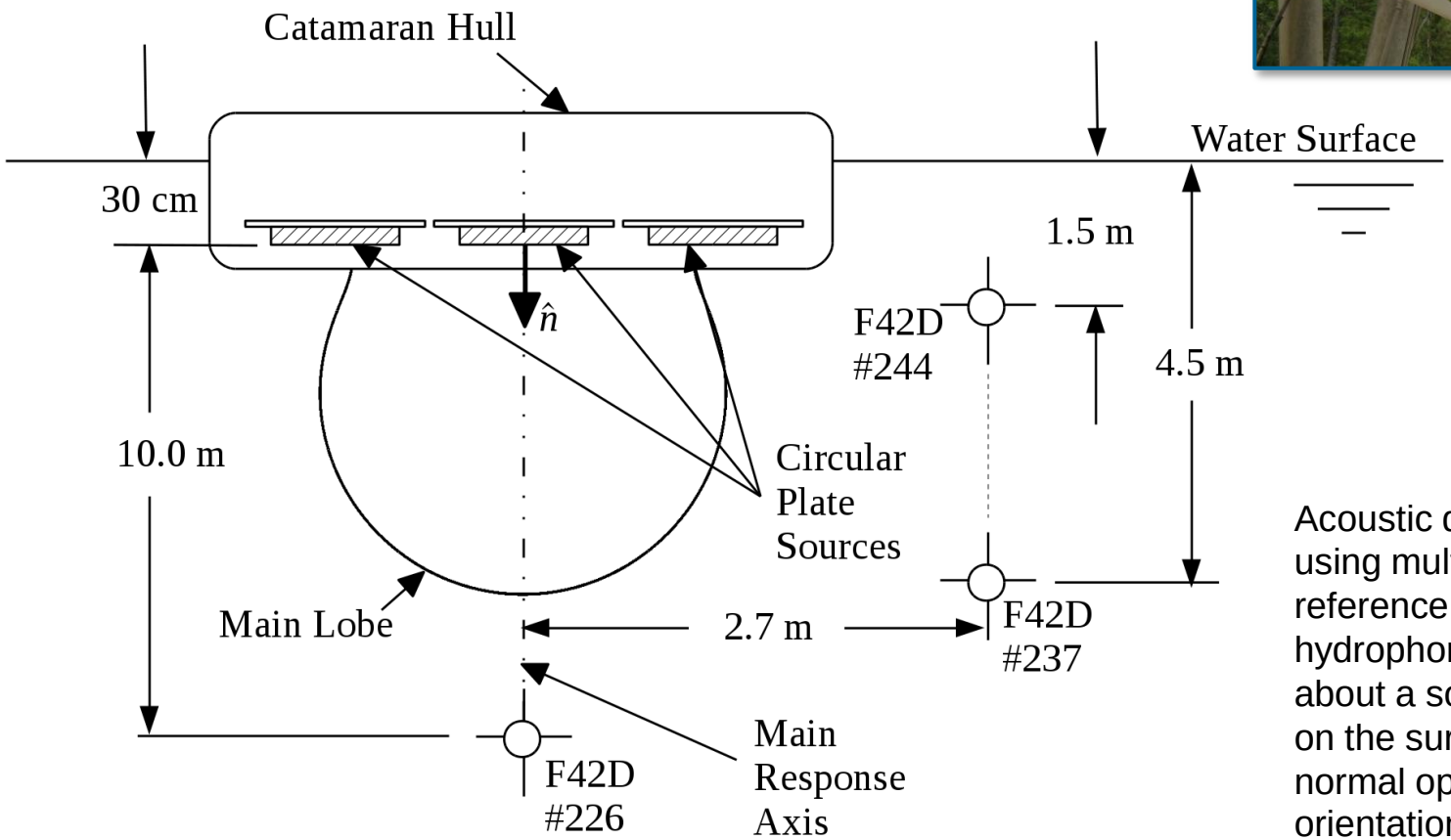


Image: United States Geological Survey

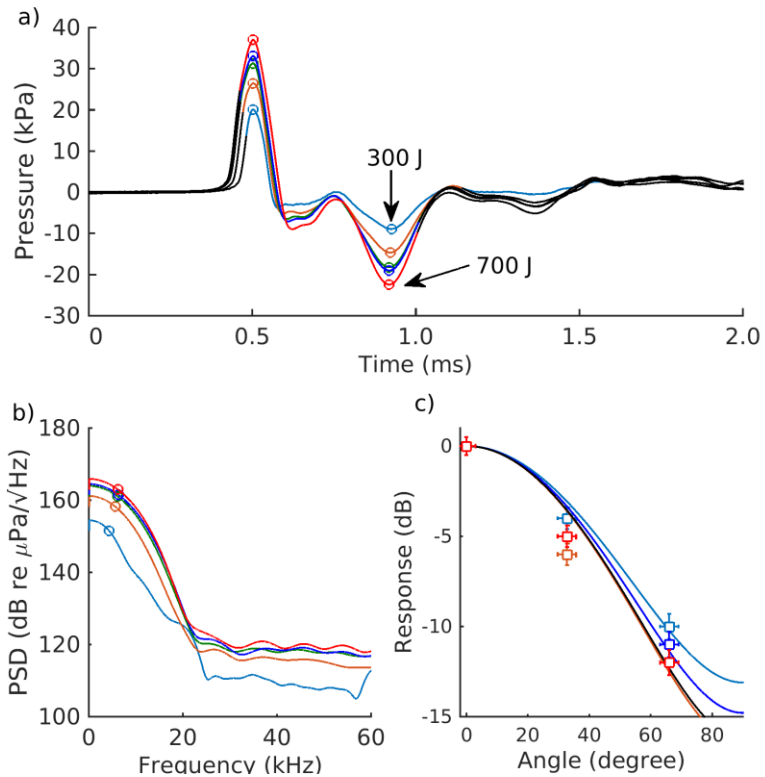
Applied Acoustic S-Boom Sub-Bottom Profiler



Acoustic data collected using multiple calibrated reference standard hydrophones distributed about a source deployed on the surface in its normal operating orientation

Applied Acoustic S-Boom Sub-Bottom Profiler

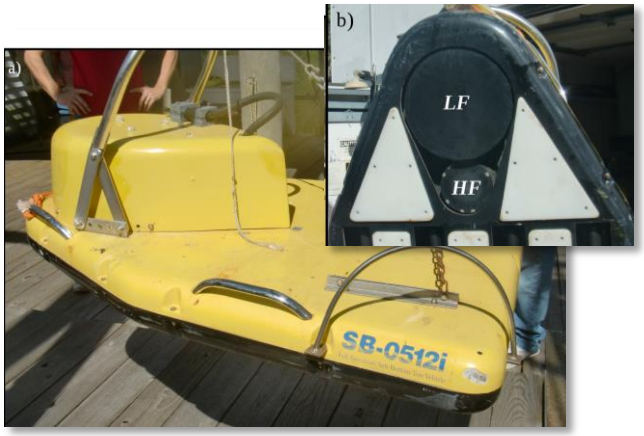
Signal characteristics measured for a wide variety of user selected operating modes

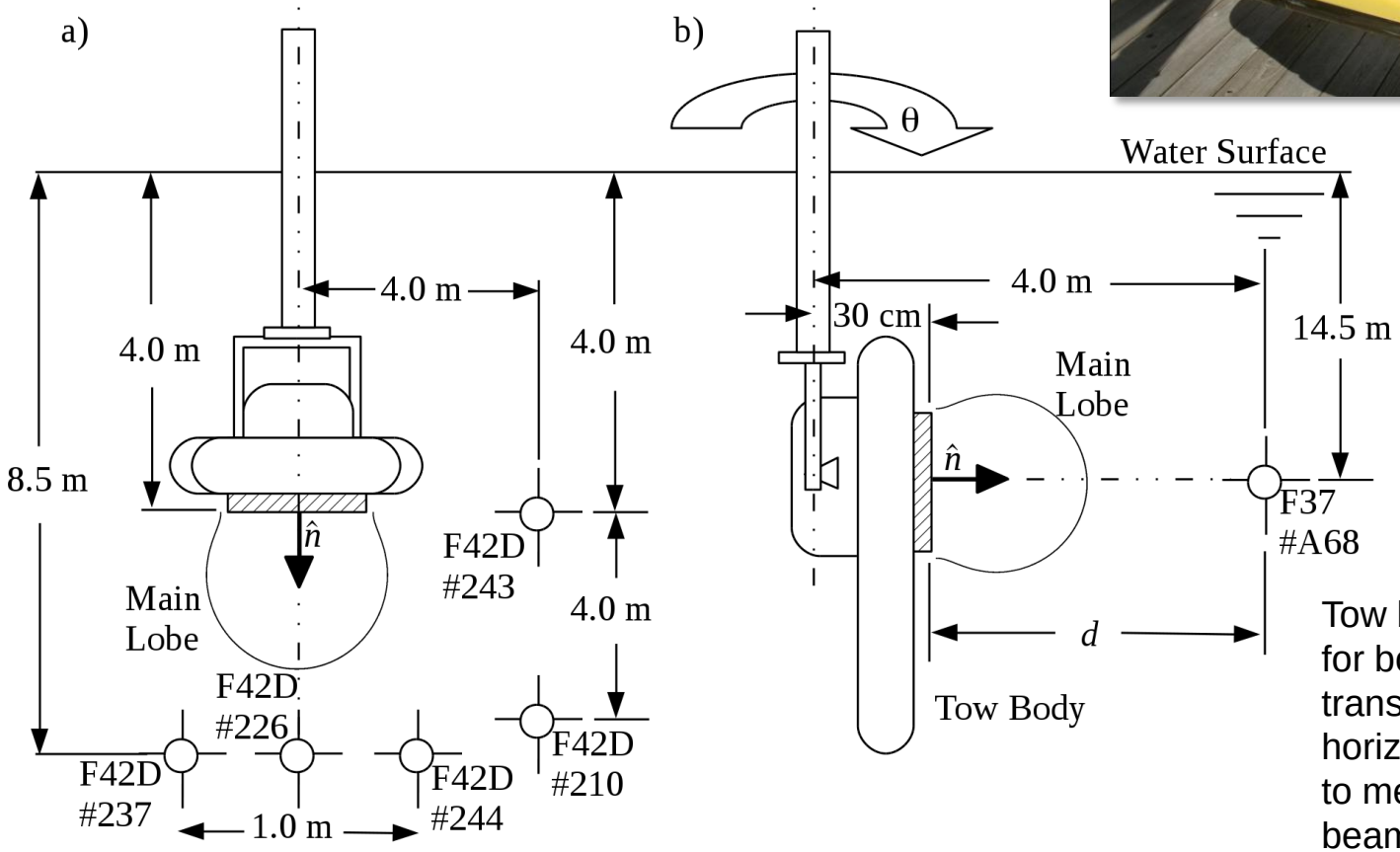


Source Setting (Joules)	Source Level (dB re 1μPa@1m)				Pulse Width (ms)	Bandwidth 3 dB (kHz)	Beam Pattern	
	Pk-Pk	Pk	RMS	SEL			ka	MRA Width 3 dB (deg)
100 (1)	202	199	189	157	0.6	7.5	1.2	N/A
100 (2)	202	199	187	157	1.1	4.4	2.1	98
100 (3)	199	196	185	155	1.2	3.3	2.6	78
100 (12)	203	200	190	158	0.6	9.1	3.0	66
100 (13)	203	200	188	157	0.8	5.4	3.1	64
200 (1)	203	201	191	159	0.7	5.7	0.6	N/A
200 (2)	204	201	190	160	1.0	4.4	2.1	98
200 (3)	202	199	187	158	1.2	3.5	2.5	82
200 (12)	205	202	192	160	0.7	6.4	2.9	67
200 (13)	205	202	189	160	1.3	4.1	2.8	70
300 (1)	207	203	195	164	0.8	4.5	0.0	N/A
300 (2)	208	204	195	164	0.9	4.6	2.1	98
300 (3)	206	202	193	163	0.9	4.0	2.1	98
300 (12)	209	205	196	165	0.8	4.8	2.5	80
300 (13)	209	205	194	165	1.1	4.1	2.7	75
300 (123)	209	206	194	165	1.1	4.3	3.1	62
400 (12)	212	208	200	168	0.6	6.1	2.7	75
400 (23)	212	208	199	168	0.8	5.0	2.9	68
400 (13)	212	208	197	168	1.2	4.0	2.6	78
400 (123)	212	208	200	168	0.7	5.6	3.2	60
500 (12)	213	209	202	170	0.7	5.5	2.6	76
500 (23)	214	209	201	170	0.8	4.8	2.8	71
500 (13)	213	209	199	170	1.2	3.8	2.5	80
500 (123)	214	210	202	170	0.6	6.1	3.2	61
600 (12)	214	209	202	170	0.6	5.7	2.5	81
600 (23)	214	210	201	171	0.9	4.6	2.8	71
600 (13)	214	209	200	170	1.2	3.6	2.5	80
600 (123)	214	210	203	171	0.6	6.3	3.2	60
700 (123)	216	211	205	172	0.6	6.2	3.2	61

NOTE: (1) Forward Plate, (2) Middle Plate, (3) Aft Plate

EdgeTech 512i Sub-Bottom Profiler





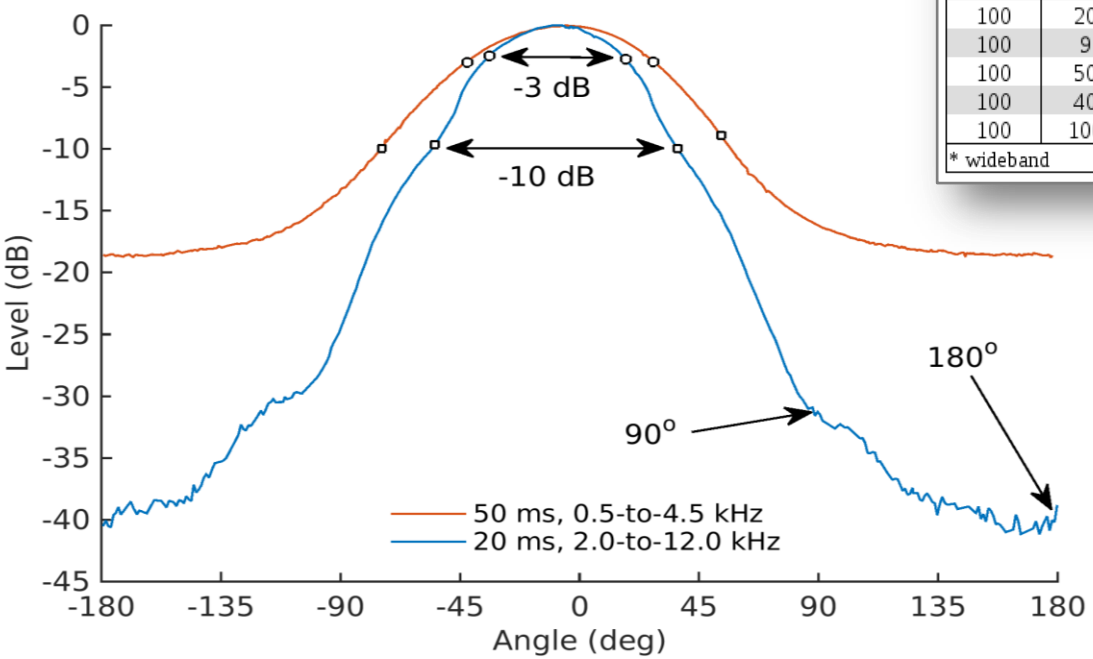
Tow bodies arranged for both normal (vertical) transmission and for horizontal transmission to measure acoustic beampatterns with an angular resolution on the order of one degree.

EdgeTech 512i Sub-Bottom Profiler

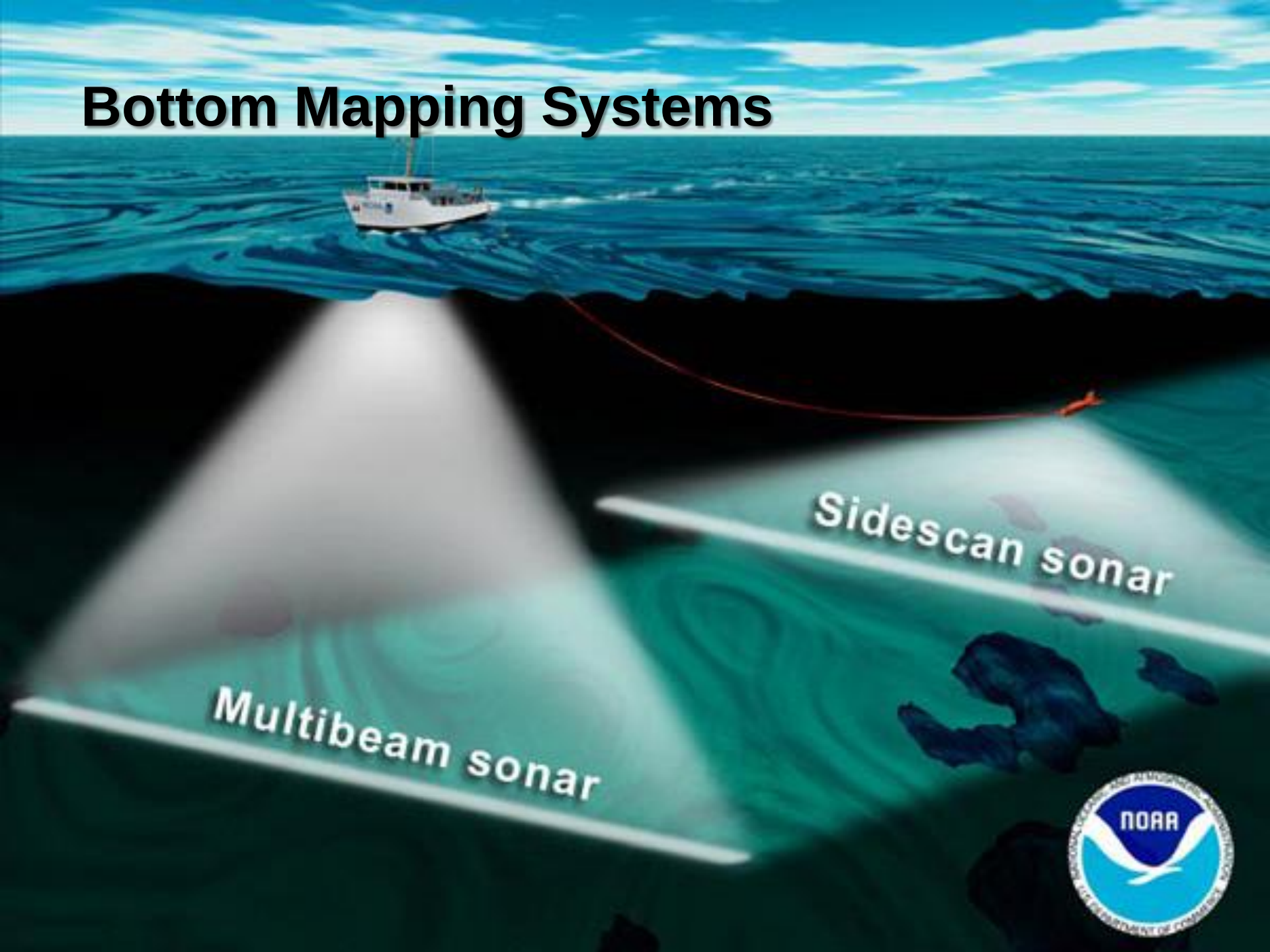
Beam patterns measured, with summaries tabulated for user selected operating modes

Source Settings			Beam Width (degrees)		Attenuation (dB)	
Power (%)	Pulse Width (ms)	Bandwidth (kHz)	-3 dB	-10 dB	90°	180°
100	20	2.0-to-12.0	51	91	31	40
100	40	1.0-to-6.0	66	112	27	31
100	5	1.0-to-10.0	65	110	29	32
100	20	0.7-to-12.0	60	99	26	29
100	5	0.5-to-8.0	70	108	25	26
100	30	0.5-to-7.2	71	112	24	26
100	20	0.5-to-7.0*	71	127	20	26
100	9	0.5-to-6.0	65	108	23	25
100	50	0.5-to-4.5	70	128	16	19
100	40	0.4-to-4.0*	80	153	15	20
100	100	0.5-to-2.7	74	150	16	22

* wideband



Bottom Mapping Systems



Multibeam Sonar

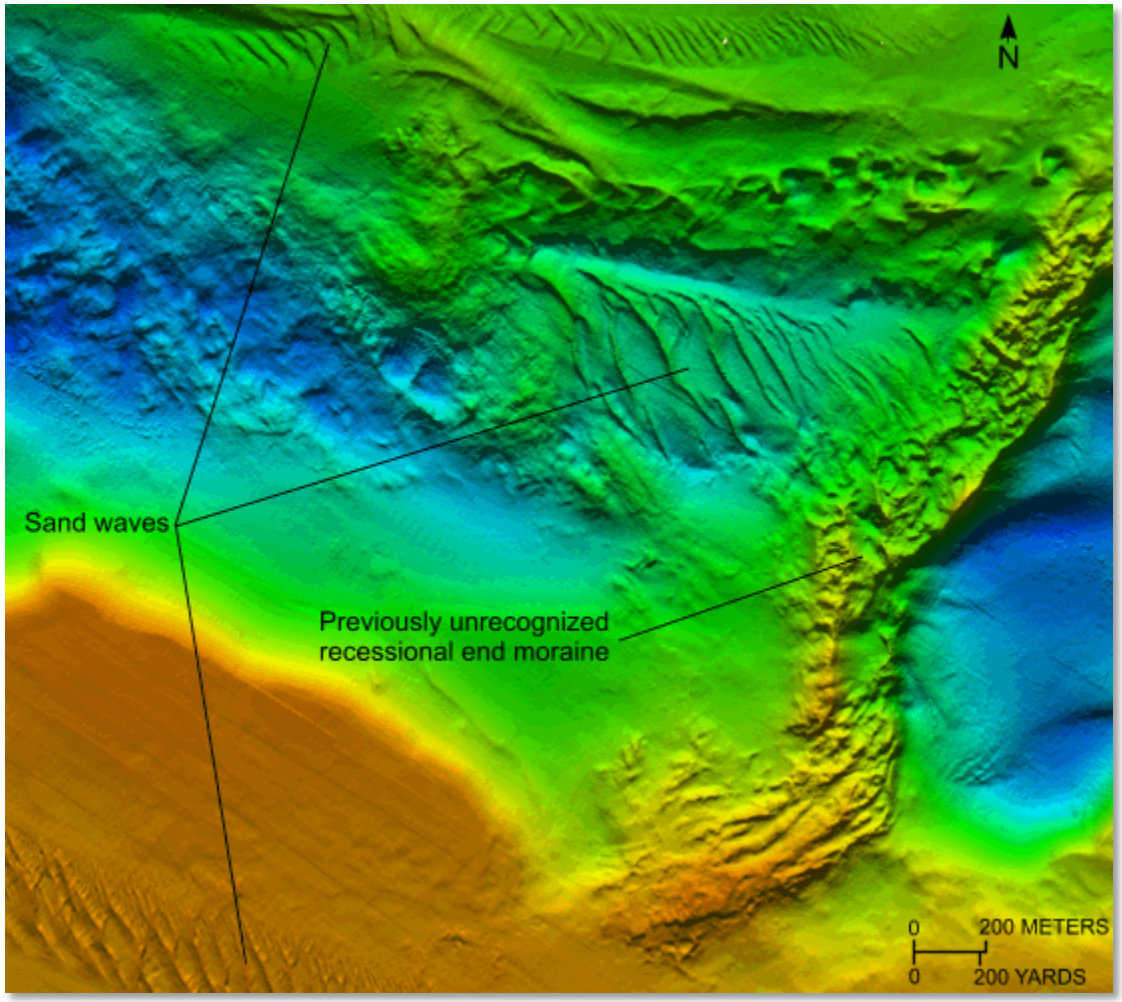
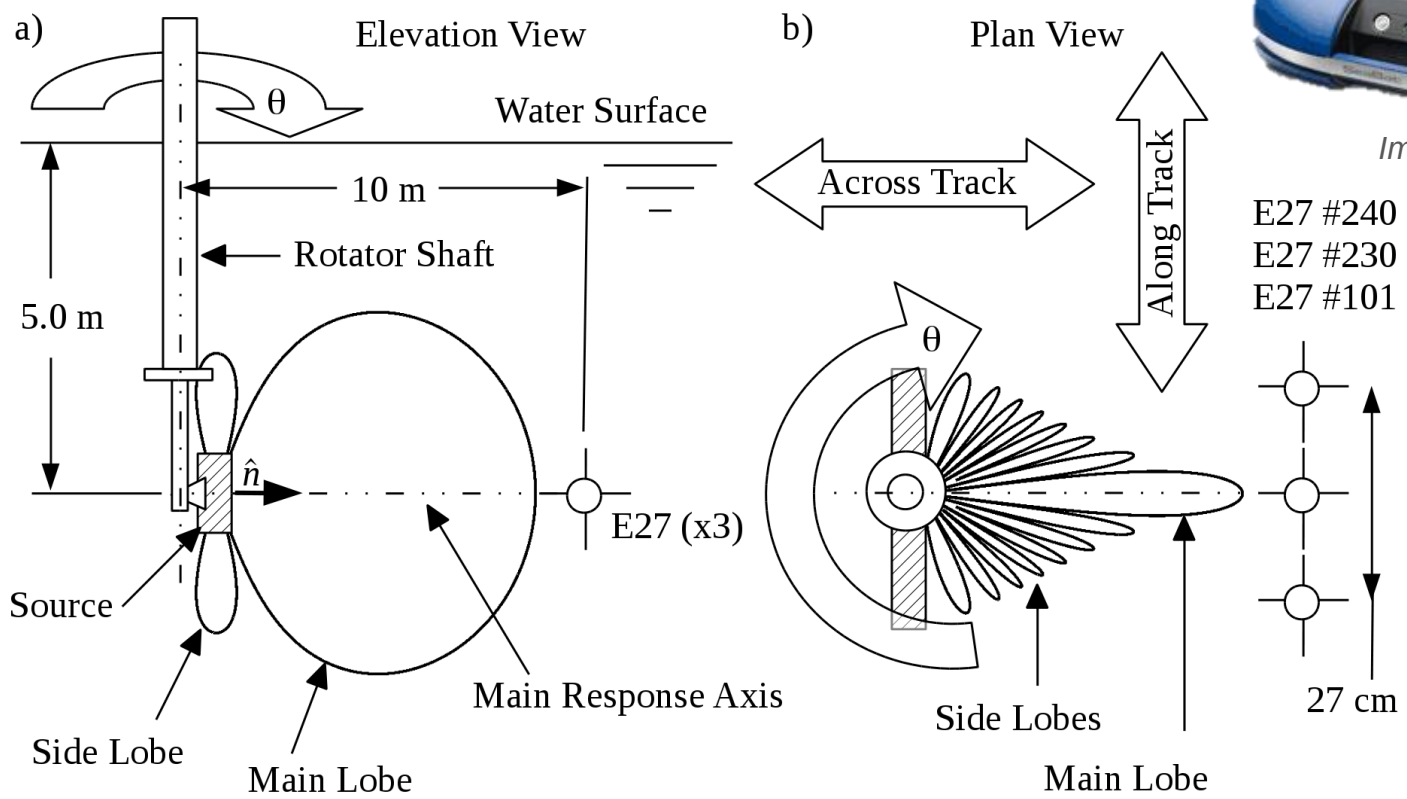


Image: United States Geological Survey

T20P Multibeam Fathometer

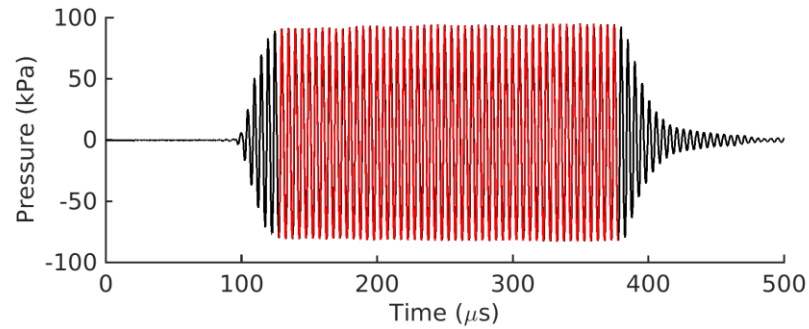
Image: Teledyne Reson

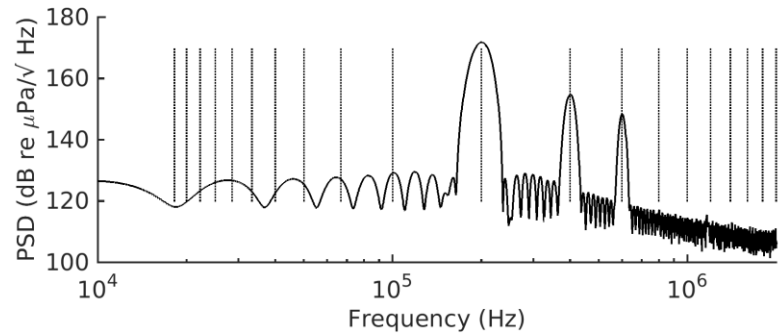


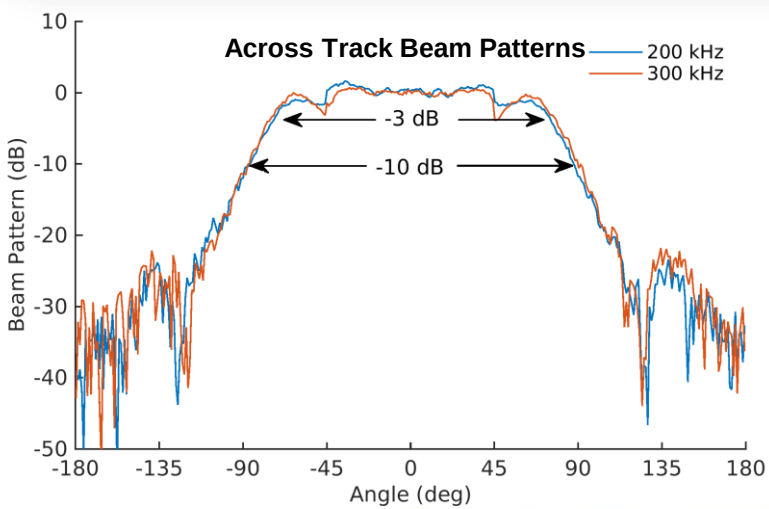
Geometry for measurement of along track beampatterns using closely spaced calibrated reference standards to improve resolution of narrow beam widths.

T20P Multibeam Fathometer

Source Settings			Source Level (dB re 1μPa@1m)				Effective Pulse Width (μs)
Freq. (kHz)	Source Level (dB)	Pulse Width (μs)	Pk-Pk	Pk	RMS	SEL	
200	220	300	226	221	218	182	250
200	205	300	213	208	204	168	248
200	190	300	193	187	184	150	254
300	220	300	232	227	221	185	253
300	205	300	215	210	205	169	252
300	190	300	197	191	185	149	254
400	220	300	229	223	220	184	254
400	205	300	214	208	204	168	257
400	190	300	197	191	185	150	269







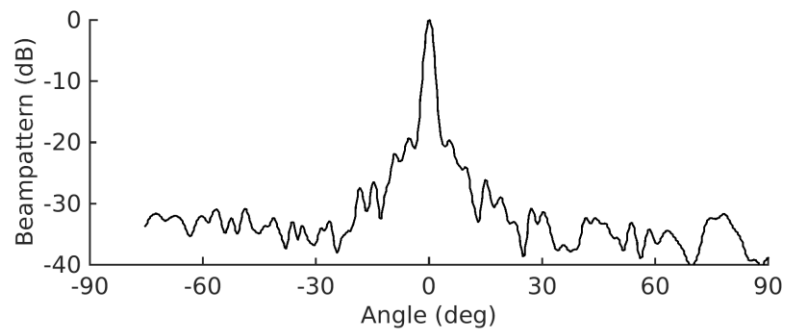
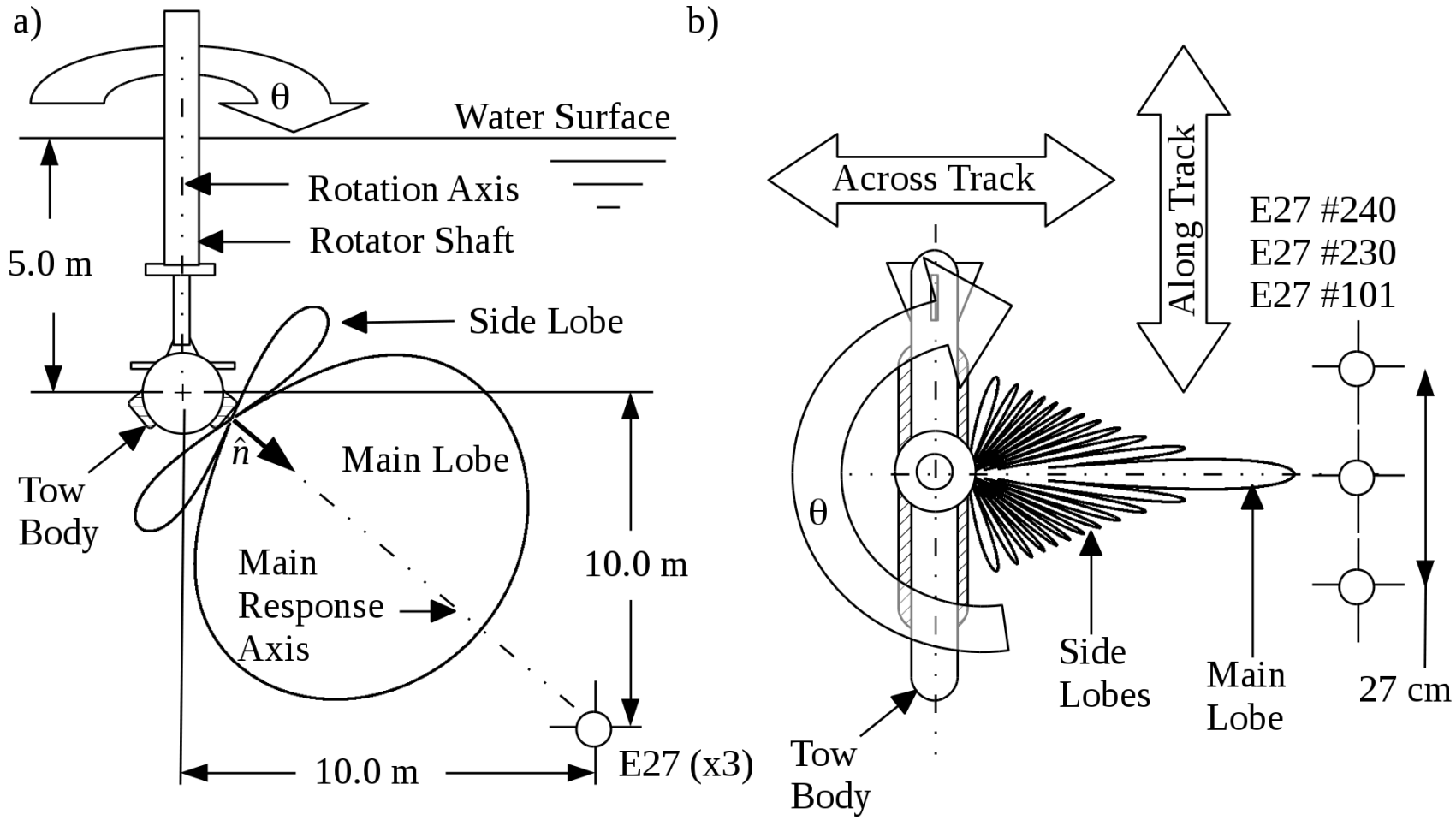


Image: National Oceanic and Atmospheric Administration (USA)

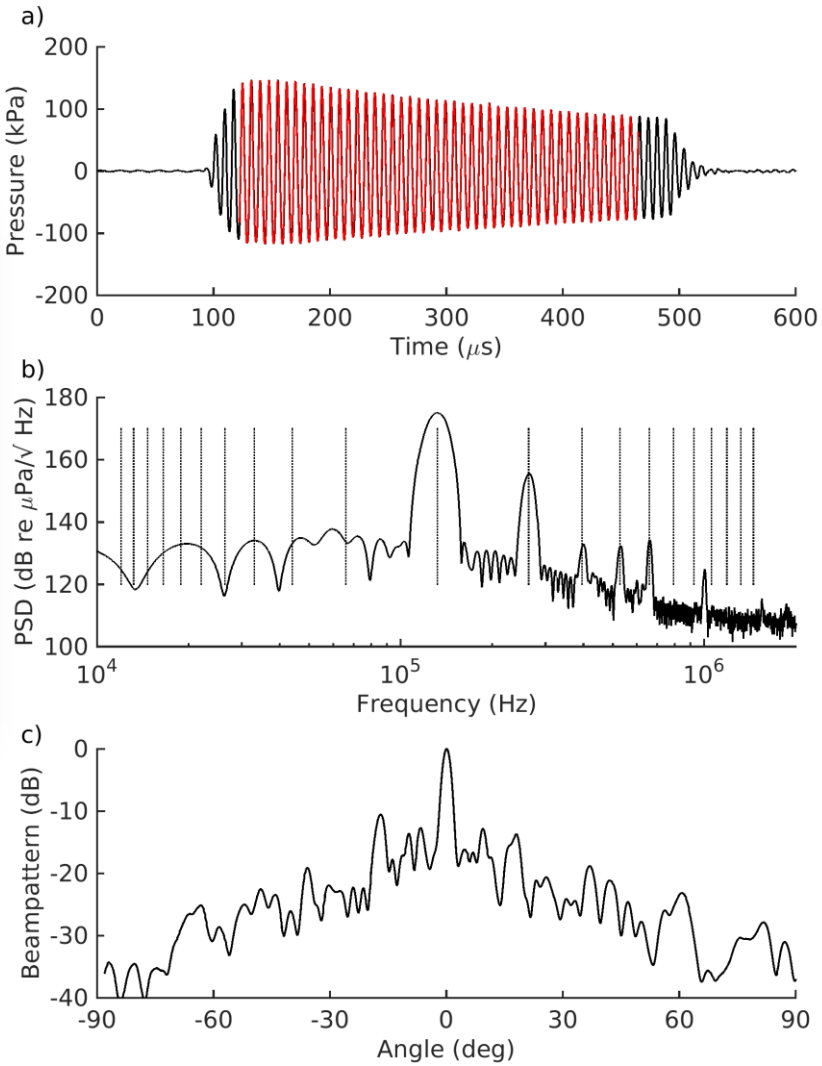
Side Scan Sonar

Klein 3000 Side Scan Sonar

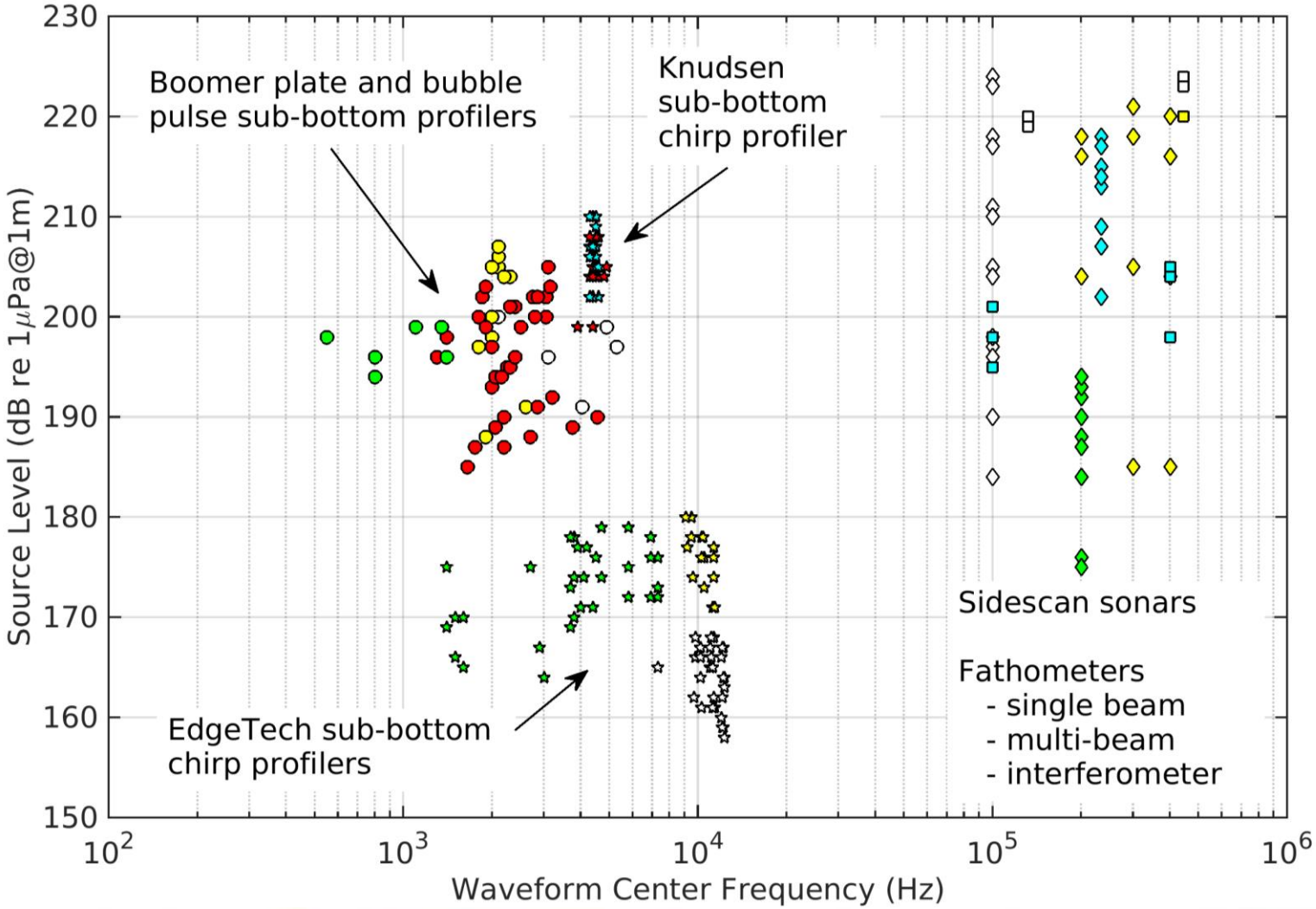


Klein 3000 Side Scan Sonar

Source Settings			Source Level (dB re 1μPa@1m)				Eff. Pulse Width (us)	Main Lobe Width (3 dB) (deg)	Max. Side Lobe	
Freq. (kHz)	Pulse Width (us)	Range (m)	Pk-Pk	Pk	RMS	SEL			Angle (deg)	Level (dB)
132	50	25	229	224	219	176	44	2.4	-16	-10
132	50	50	229	224	220	176	44	2.4	-17	-9
132	50	100	229	224	220	176	42	2.2	-17	-10
132	50	400	230	225	220	176	44	1.9	-17	-10
132	50	600	230	225	220	176	44	2.2	-17	-9
132	100	100	230	224	220	179	81	2.1	-17	-10
132	200	200	230	225	220	182	168	1.8	-17	-10
132	400	400	230	224	219	184	343	1.7	-17	-11
132	400	600	230	224	219	184	343	1.8	-17	-11
445	25	50	233	227	224	177	21	1.2	-5	-16
445	25	600	233	227	223	177	21	0.8	-5	-17
445	100	100	233	227	223	182	88	1.2	-5	-19



Measurement Summary



Conclusion

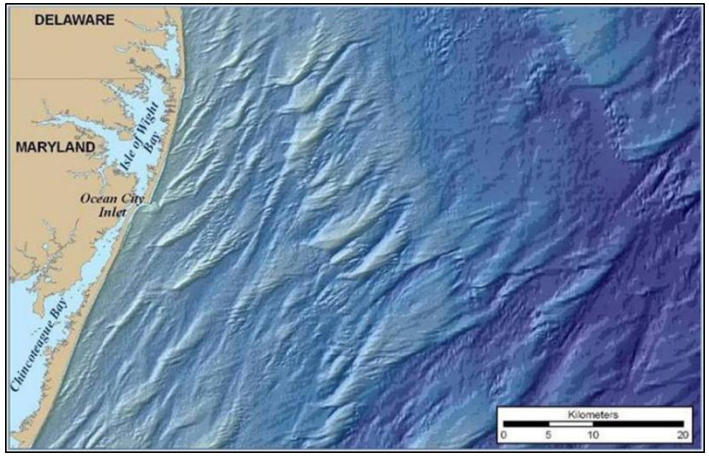
Information to support estimation of environmental impacts associated with the operation of high-resolution, marine geophysical survey systems is not usually available in the vendor data.

The Bureau of Ocean Energy Management funded a study, performed by the Underwater Sound Reference Division and U.S. Geological Survey to acquire and analyze calibrated acoustic source data for a number of commonly used geophysical survey systems.

The full report will be posted to: http://www.boem.gov/Studies/

Interested persons can also request to receive a copy by contacting the author at steven.crocker@navy.mil

Characterization of Underwater Sounds Produced by Trailing Suction Hopper Dredges during Sand Mining and Pump-out Operations



Jennifer Culbertson, Division of Environmental Assessment
Bureau of Ocean Energy Management

By

Kevin J. Reine and Douglas Clarke , US Army Engineer Research and Development Center,

Charles Dickerson , Bowhead Information Technology

And

Geoff Wikel, Division of Environmental Assessment

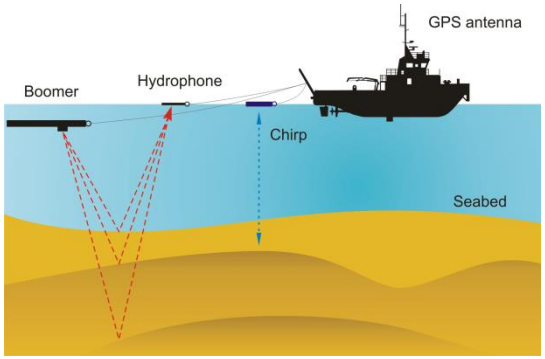
Bureau of Ocean Energy Management

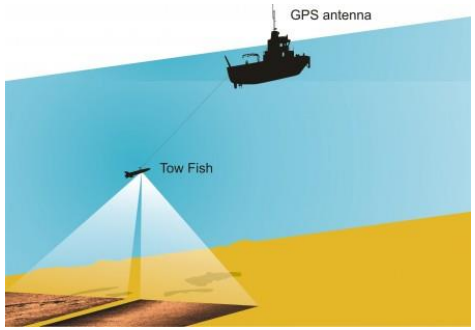
BOEM 2014-055

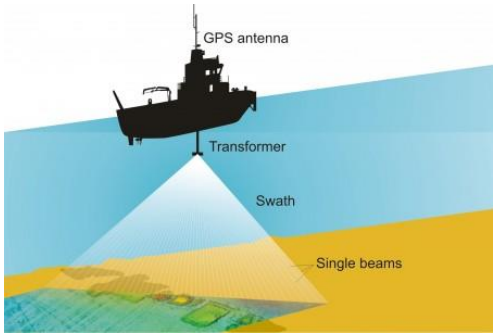
ERDC/EL TR-14-3

Why Sound Studies?

- Electro- mechanical sources include:
  - boomers; chirp sub- bottom profilers; side-scan sonar; and single, swath, and multi-beam bathymetric fathometers
- Source levels generally range from 170 to 240 dB re 1 µPa @1 m (peak-to-peak) at frequencies ranging from less than 300 Hz to several hundred kilohertz
- Uncertainty about the potential impacts associated with noise in the marine environment
- Regulatory requirements and precautionary mitigation strategies are being applied to lower energy geophysical surveys.

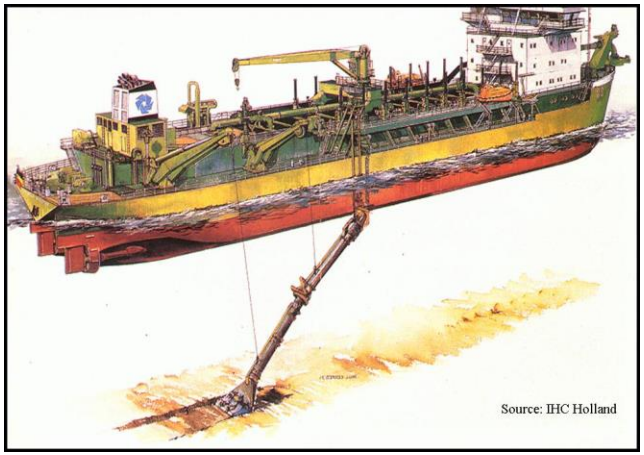






http://ets.wessexarch.co.uk/recs/how-we-study-the-seafloor/geophysical-survey/

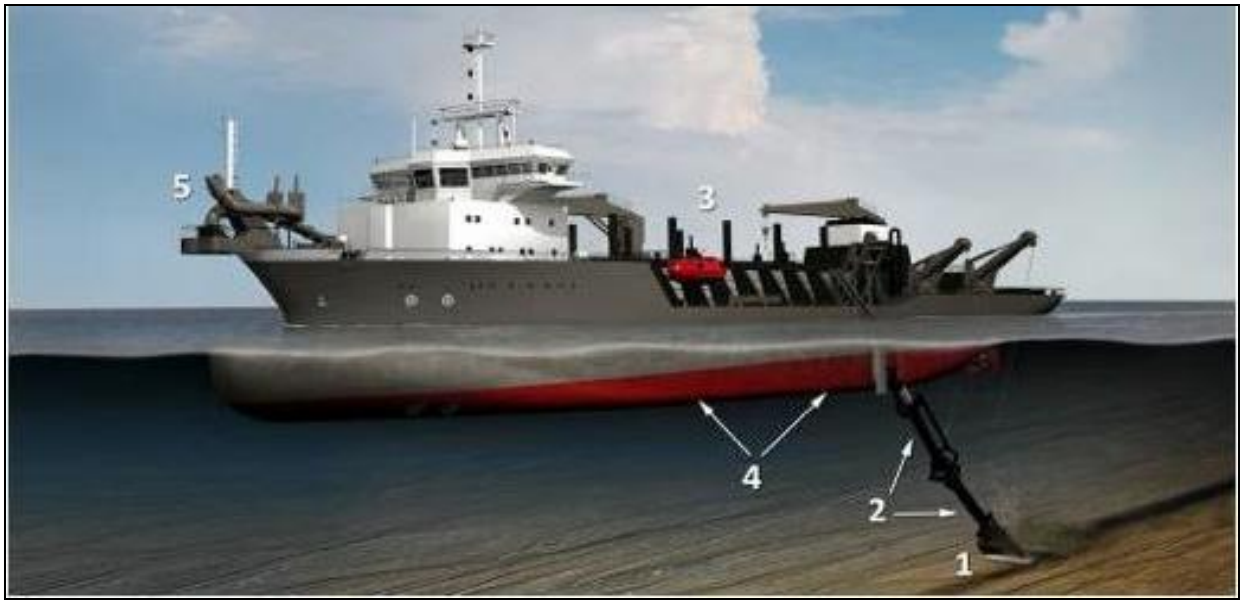
Hopper Dredging



- Trailing suction hopper dredge (TSHD) is commonly used in dredging operations to support beach nourishment operations
- Self-propelled seagoing vessels
- Hydraulically remove sediment from the seafloor through dragheads
- Dragheads are “trailed” beneath the dredge
- Large suction pumps transport the sediment from the seafloor into one or more hoppers.
- TSHD pumps out the material through pipes using a floating booster pump barge to the desired location

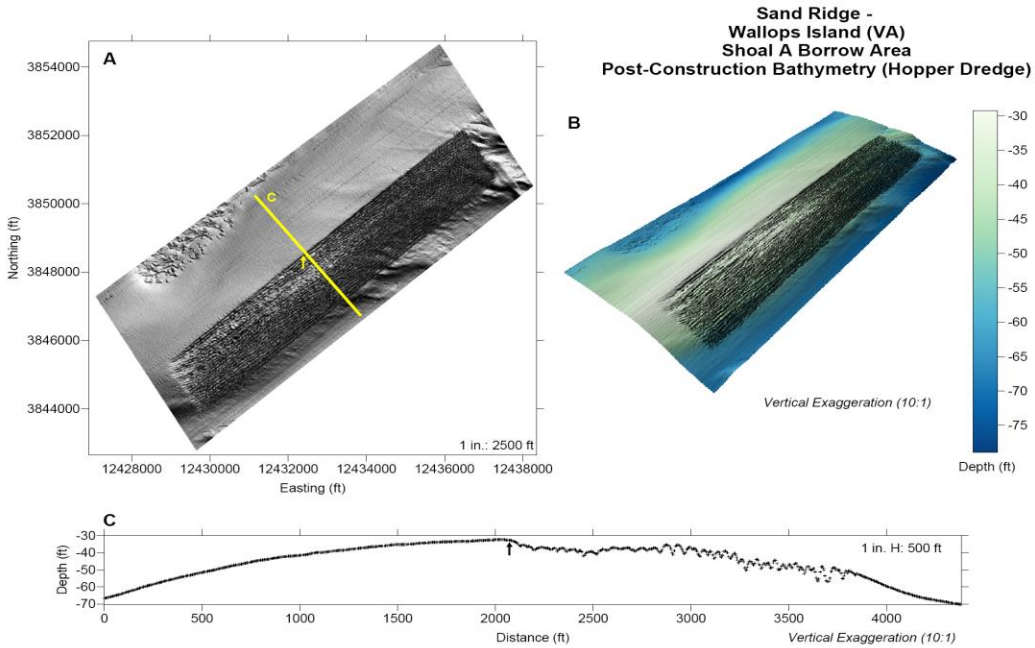
Noise Producing Factors

1) sounds arising from the removal of material
2) sounds produced by suction pipes and pumps, and the movement of dredged material through the dragarm
3) deposition sounds associated with loading of the material into the hopper
4) sounds associated with the dredge machinery itself
5) sounds associated with the off-loading of material from the hopper for placement on the beach



Background and Objectives

- This is within audible range of listed spp of whales (7Hz-22 KHz) and sea turtles (100-1000 Hz) (Southall et al. 2007; Ketten and Bartol 2005).
- As well as fish (50-1500 Hz)
- May affect communication, foraging, predator evasion, navigation
- Hopper dredge sound is continuous within low frequency range (<1200 Hz)
- **Objective: Characterize underwater sound associated with TSHDs within borrow ar**

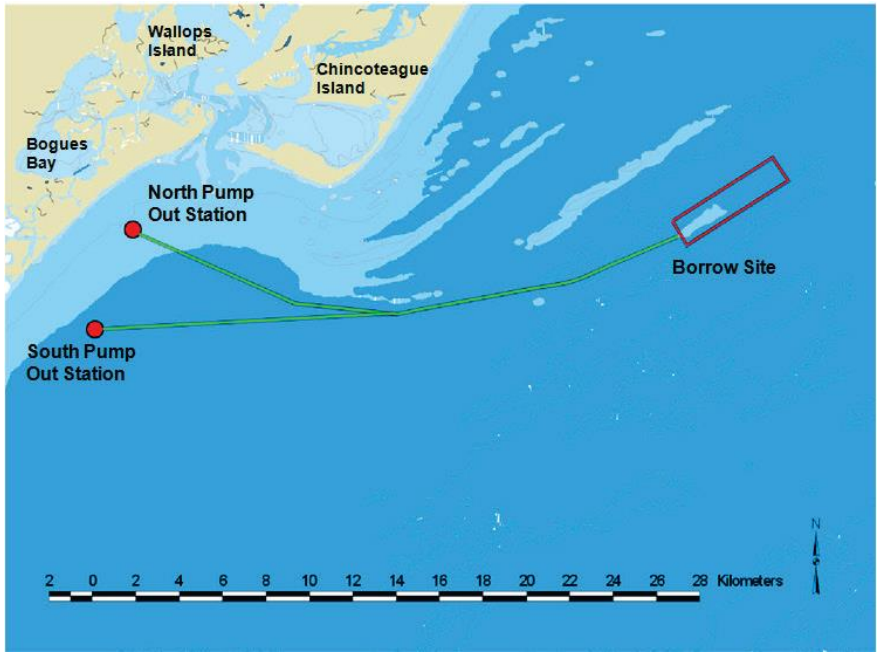


Harassment Levels

- NMFS issues compliance criteria for underwater sound pressure thresholds for fish and marine mammals
- Different target spp have different tolerance levels
- Different mitigation measures may be effective for avoidance of:
  - Level A harassment = subjected to potential injury
  - Level B harassment = behavioral disturbance
- Measured in Sound Pressure Levels (SPLs): a logarithmic measure of the effective sound pressure of a sound relative to a reference value.
- It is measured in decibels (dB) above a standard reference level (re1µPa)
- NMFS recognizes:
  - 160 dB re1µPa to be SPL for Level B from an impulsive noise source (pile driving)
  - 120 dB re1µPa to be SPL for Level B from a continuous noise source
  - 180-190 dB re1µPa to be SPL for Level A
- Relevance of 160 dB re1µPa criteria in odontocetes and pinnipeds exposed to pulsed sounds not well established

Wallops Island, VA

- NASA Project
- 3.1 million cy of OCS sand
- Shoal A (25-30 ft MLW)
- 3 hopper dredges (Dodge Island, Padre Island, Liberty Island)



Hurricane Sandy Beach Damage on South Wallops Island, Looking South

Methods

- Listening platforms (hydrophones and data recorder) at 10 ft (ULD) and 30 ft (LLD)
- Recordings were made from May 3-13, 2012
- Survey vessel drifted freely during session
- Distances from monitoring vessel to sound source were measured every 15 sec with range finder
- GPS coordinates were logged
- Band pass filters were used to reduce wave associated noise and echosounders on dredge plant

Methods

- Measurements were obtained at various orientations between the dredge and the LP, including the following:
  - LP directly astern of the dredge (dredge advancing away from the LP)
  - bow (dredge approaching the LP)
  - and either the port or starboard side of the dredge
- Ambient noise also measured (23,480 ambient data measurements)
- Total of 77 dredge recording sessions
- Monitoring ranges (25-5100 m) varied for each vessel and dredge activity (typically did not exceed 2 km.)

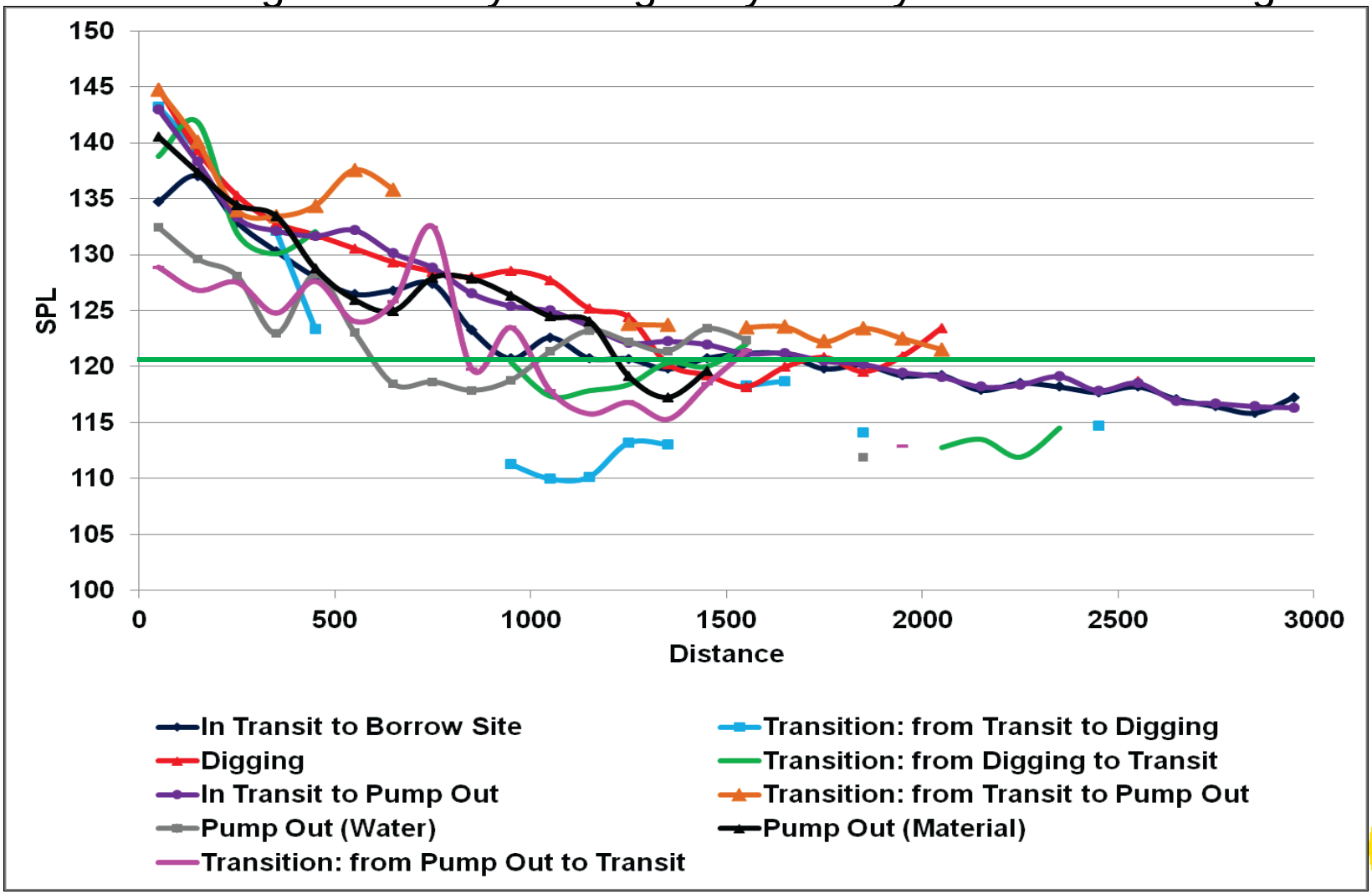
Results

- Ambient SPLs averaged 117 dB re 1µPa across all sampling days, sites, water depths, and weather conditions.
- Noise levels from dredging were greatest at lower frequencies (<500 Hz)
- The highest SPLs were associated with the larger of the 3 dredges (*Liberty Island*) while transiting up to 14 knots
- Pump-out of water and material also resulted in higher noise levels for *Liberty*
- At 150 m from the source, the only dredging activity with an SPL above 141 dB was the dredge in transition from digging to transit (SPL = 141.8 dB, SL = 176.1 dB re 1 µPa-1 m)
- *Padre* was quietest for most activities
- Dredging operations during this study were 12-14 dB quieter than aggregate mining (186-188 dB re 1µPa at 1m)

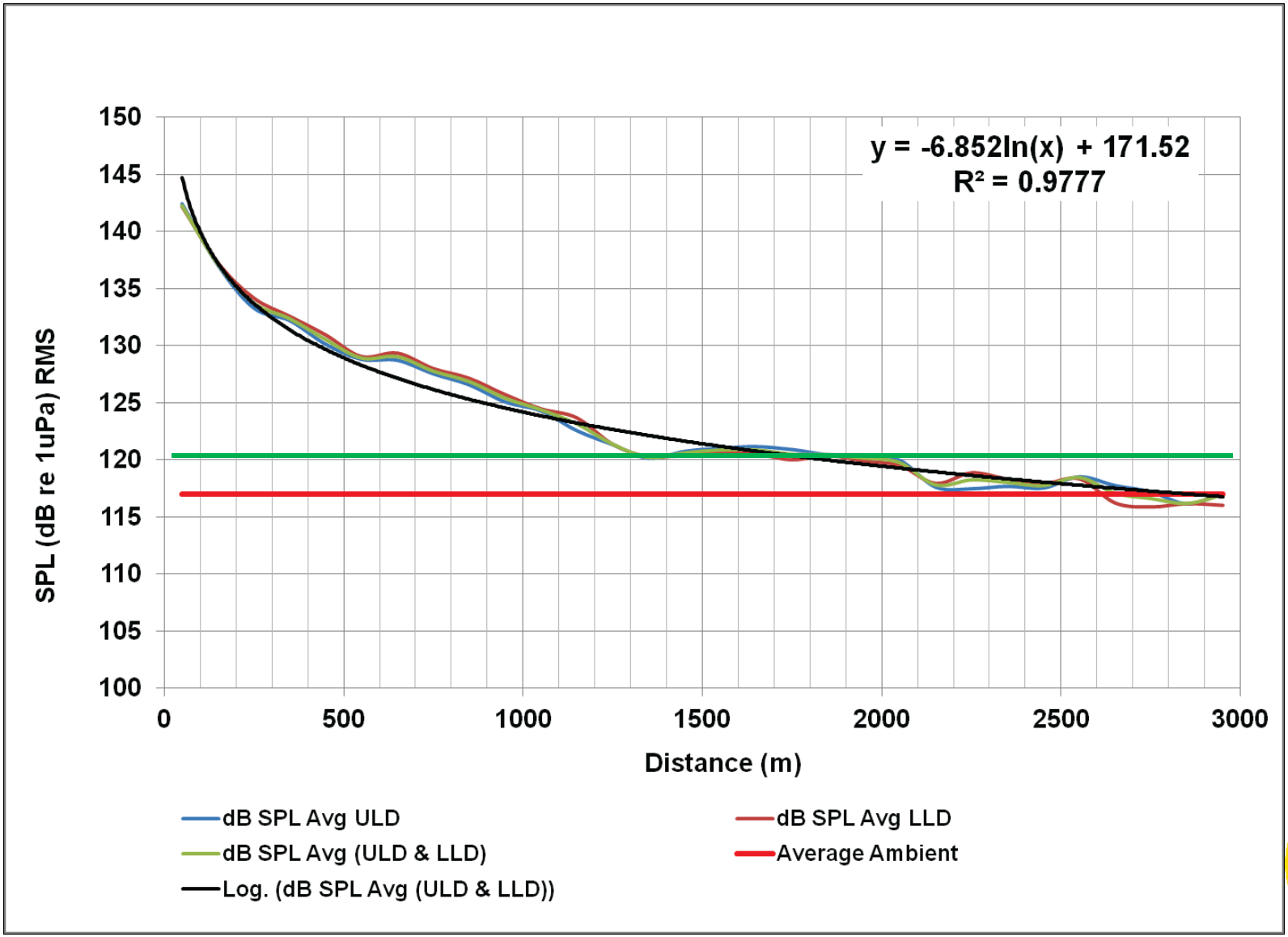
Great Lakes Dredge and Dock Company

SPL (dB rms) versus distance by dredging activity

- SPLs logarithmically averaged by activity for all three dredges.



SPL (dB re 1 µPa RMS) versus distance for all dredges and dredging events combined



Order of SL by activity

Dredge	Dredging Event	SPL Distance (m)[1]	SL[2]	Attenuation Distance (km)[3]	Peak Frequencies (Hz)
Liberty	Transition–Digging to Transit	150	178.7	2.5	100, 600, 1000
Liberty	Transit to Borrow Area	450	178.2	2.45	150, 1000
Liberty	Transit to Pump Out	350	176.2	2.65	400, 1100
Liberty	Pump-out Material	150	176.0	1.2^	200, 500, 1200
Liberty	Pump-out Water	450	175.1	1.2^	250, 400, 1000
Liberty	Transition–Transit to Pump-out	150	175.3	1.1	150, 500, 800, 1500
Dodge	Sediment Removal	150	174.5	1.55	100, 700-800
Dodge	Transition–Transit to Digging	150	174.3	1.85	500, 800
Liberty	Sediment Removal	50	174.2	1.65	200, 500, 1100
Dodge	Transit to Borrow Area	150	173.8	2.75	200, 700
Padre	Sediment Removal	150	173.0	2.05	150, 250, 500
Padre	Pump-out Material	150	172.0	ULD-1.35; LLD[4]	150, 600, 1000
Liberty	Transition—Pump-out to Transit	450	171.0	1.1	200, 500

Conclusions

- The log averaged SPL was 171.52 dB for all dredges and operations monitored
- Peak source levels did not exceed NMFS Level A criterion for injury/mortality to pinnipeds or marine mammals (190 and 180 dB re 1µPa at 1m respectively)
- Noise levels did exceed the Level B criterion for harrassment (120 dB re 1µPa at 1m)
- Generally underwater sounds decreased to 120 dB within 1.2 km from source
- Remained at 120 dB out to 2.1 km from source
- Higher or lower source levels may be expected for activities in different sediment (e.g. gravel instead of sand, or silty (mud) sediment instead of sand or gravel) and at different water depths
- Ambient levels averaged 117 dB which is just 3 dB below current criteria

Other sound sources

- Source levels for aggregate excavation operations range from 186-188 dB re 1µPa-1m.
- SLs during excavation operations in this study were 12-14 dB quieter than those reported for the aggregate mining.
- SLs estimated in the present study are similar to those generated from the small 1,300-yd^3 hopper dredge *Atchafalaya* (172-180 dB)
- Sounds produced by intermediate-size hopper dredges would fall in the lower range of SLs generated by large commercial ships (181-189 dB re 1 µPa-1m)

Future Research

BOEM and USGS Partnership to study Source and Propagation Character of Electro-mechanical Geophysical Sources

Three Steps:

1. Characterization of geophysical sources:
   - Partnership with the Navy (NAVSEA)
   - Characterize sources in acoustic tank
2. In-situ field measurement and verification of geophysical sources
3. Improvement of acoustic propagation models and/or their implementation

THANK YOU

Report location:
http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5380.pdf

Contact info:
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Late Quaternary Paleovalleys and Archaeological Potential on the Outer Continental Shelf Offshore Louisiana

Paul V. Heinrich[1], Richard P. McCulloh[1], Michael Miner[2], Robert Paulsell[1], and Riley Milner[1]

[1]Louisiana Geological Survey, Louisiana State University, Baton Rouge
[2]Bureau of Ocean Energy Management, Gulf of Mexico Region, Marine Minerals Program, New Orleans

Sponsor:
U.S. Bureau of Ocean Energy Management (BOEM)

- Conducts extensive technical and environmental reviews of energy exploration and production projects to minimize impacts on coastal-marine habitats, resources, and infrastructure.
- Manages non-energy ocean minerals and sediment obtained from the ocean floor.

Premise

- Sea-level lowering up to 120 m eustatic (90 m relative) below present during Pleistocene glaciation, and specifically the timing of the last glacial episode and subsequent deglaciation, created a potential for archaeological resources on the continental shelf.
- Interest in archaeological potential on submerged continental shelves exposed in the late Pleistocene has increased worldwide, inaugurating a new era and subdiscipline focused on submarine archaeology at subsequently drowned sites (SPLASHCOS Web site: Bailey et al., 2014).
- Valley and delta sediments deposited on the shelf during the last glaciation may host cultural/archaeological sites that survived marine erosion and reworking during postglacial sea-level rise.
- Fluvial sediments filling the paleovalleys are potential sources of sand for long-term coastal nourishment.

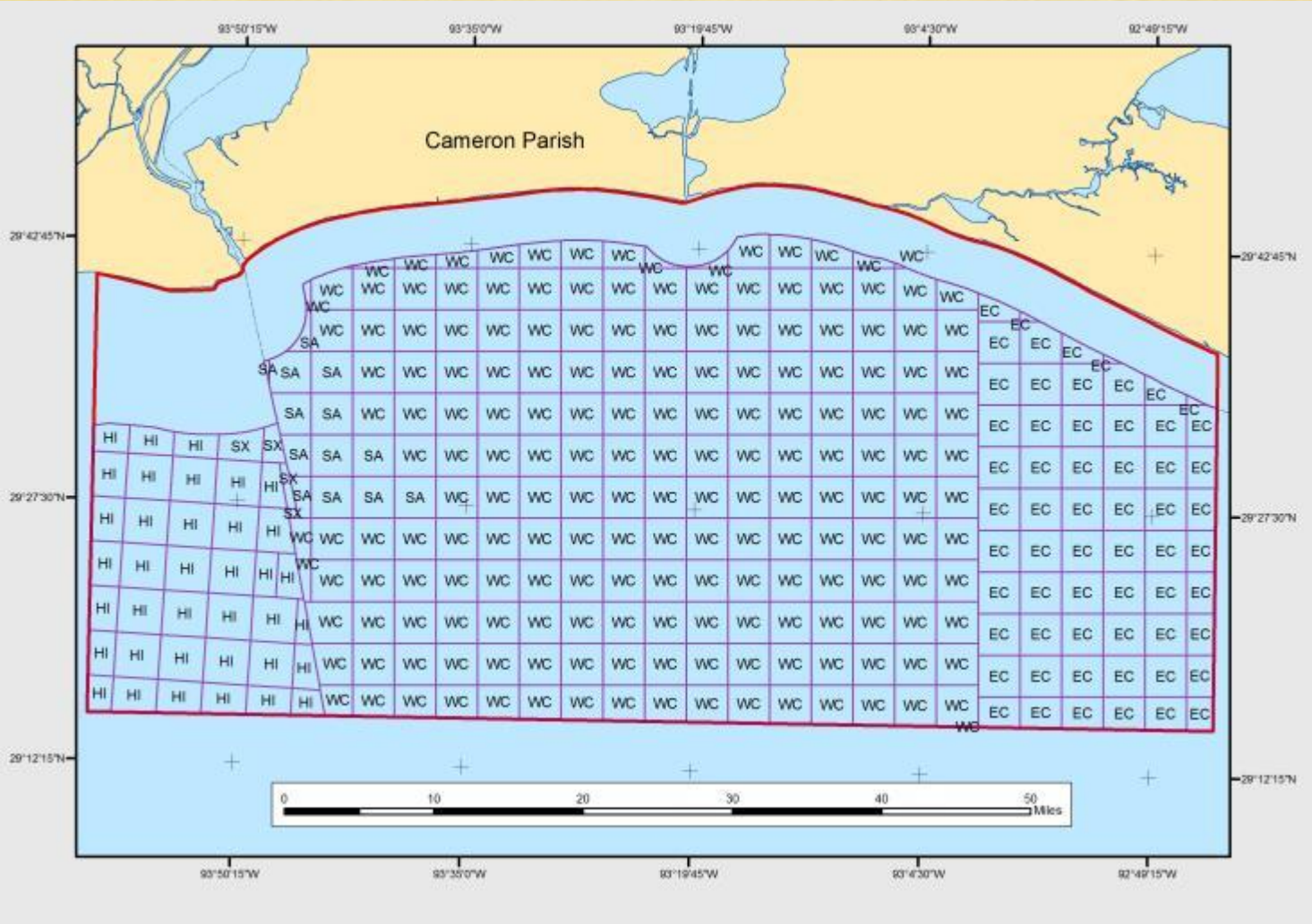
I. Synthesize Offshore-Block Hazard Surveys

- Digital synthesis and compilation of legacy maps of paleovalleys in offshore-block hazard surveys spanning 40 years; initial focus on development of a GIS of hazard-survey content (Robert Paulsell). Most are small-scale maps that are not very useful for analysis.
- Development of digital data primarily from raster geophysical maps that exist as Portable Document Format (PDF) files. Some geophysical data came as CAD files.

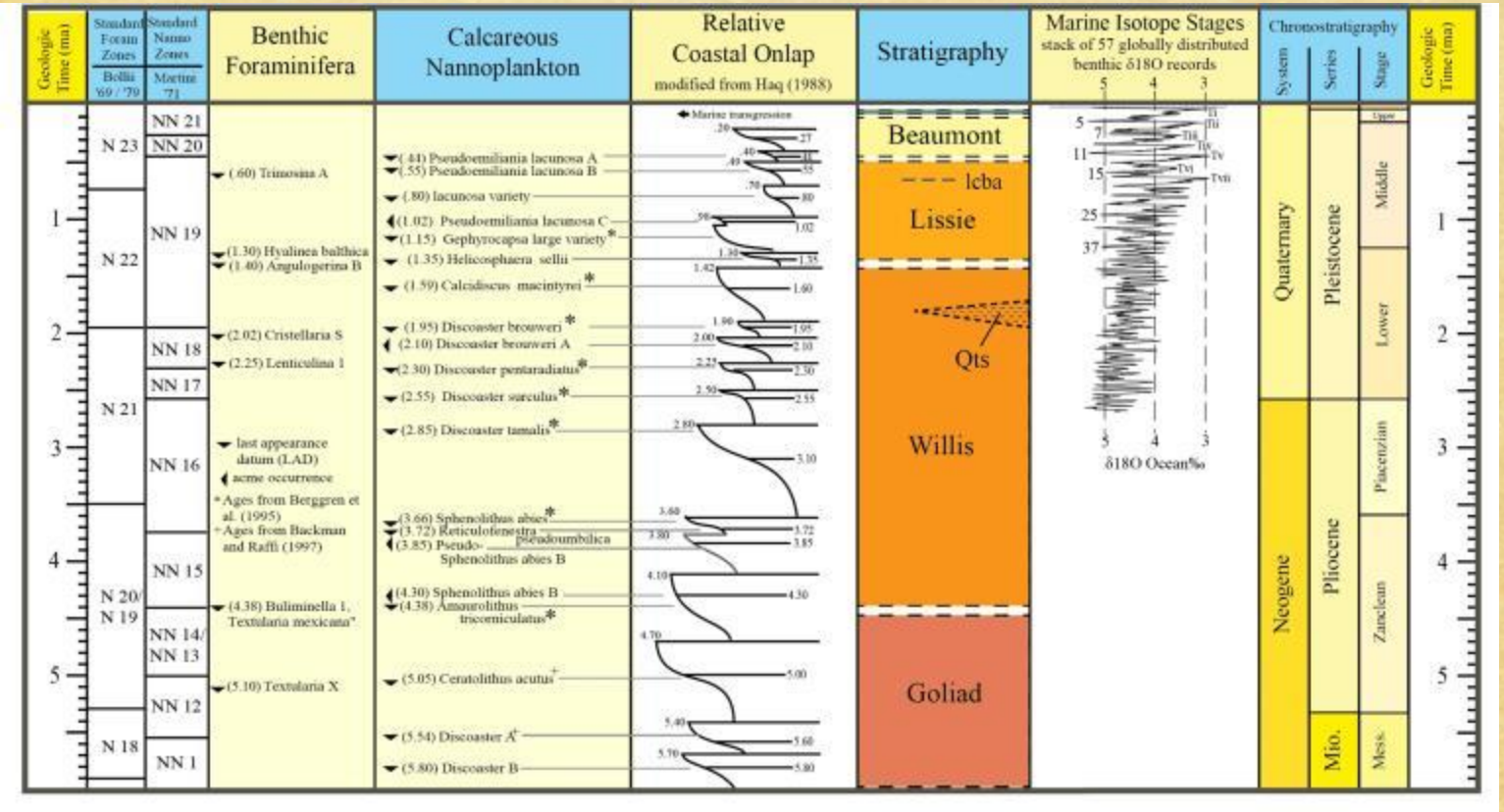
II. Identify Paleolandscapes With Potential for Preserved Archaeological Sites

- Review of seismic records traversing the study area for configurations potentially favorable for human habitation.
- In North America archaeological potential is restricted to a narrow interval between onset of human occupation (~20,000 B.P.?) and initiation of flooding by deglaciation during Marine Isotope Stage 2 (~19,000 B.P.).

2013–14 Study Area

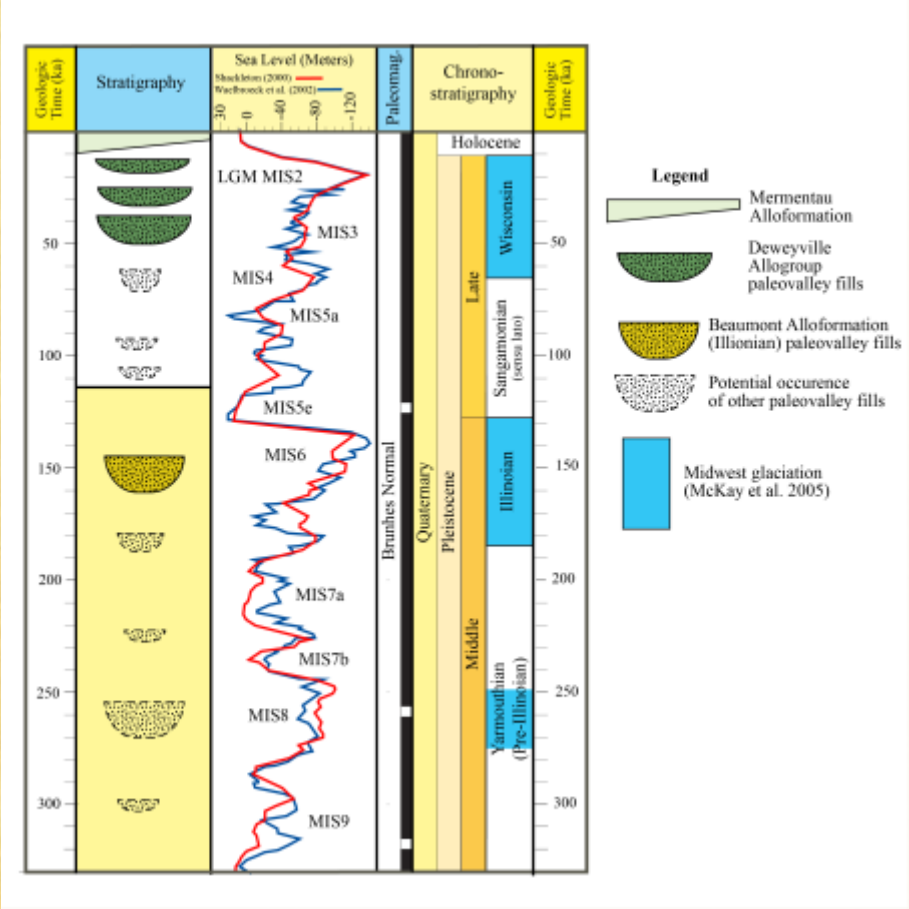


Late Neogene–Pleistocene Chronostratigraphy Southwest Louisiana and Southeast Texas



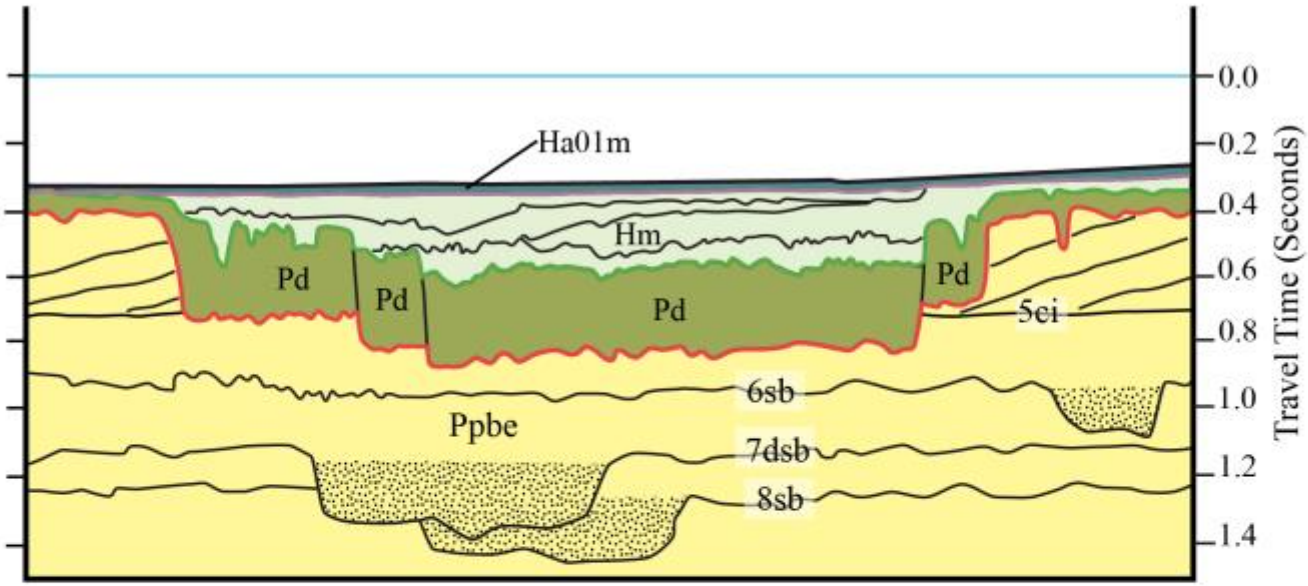
Paul Heinrich, Louisiana Geological Survey, LSU

Late Pleistocene Chronostratigraphy Southwest Louisiana and Southeast Texas



Paul Heinrich, LGS, LSU

Stratigraphic Units, SW Louisiana Area (Reinterpreted from Thomas, 1991)



Ha01m = unnamed alloformation 1, (marine sediments)
Hm = Mermentau Alloformation
Pd = Deweyville Allogroup
Ppbe = Beaumont Alloformation

Beaumont Paleovalley Fills

post-glacial ravinement surface
Holocene-Pleistocene surface (OIS 2 sequence boundary)
Trinity - Sabine unconformity

5ci = OIS 5 condensed interval
6sb = OIS 6 sequence boundary
7dsb = OIS 7d sequence boundary
8sb = OIS 8 sequence boundary

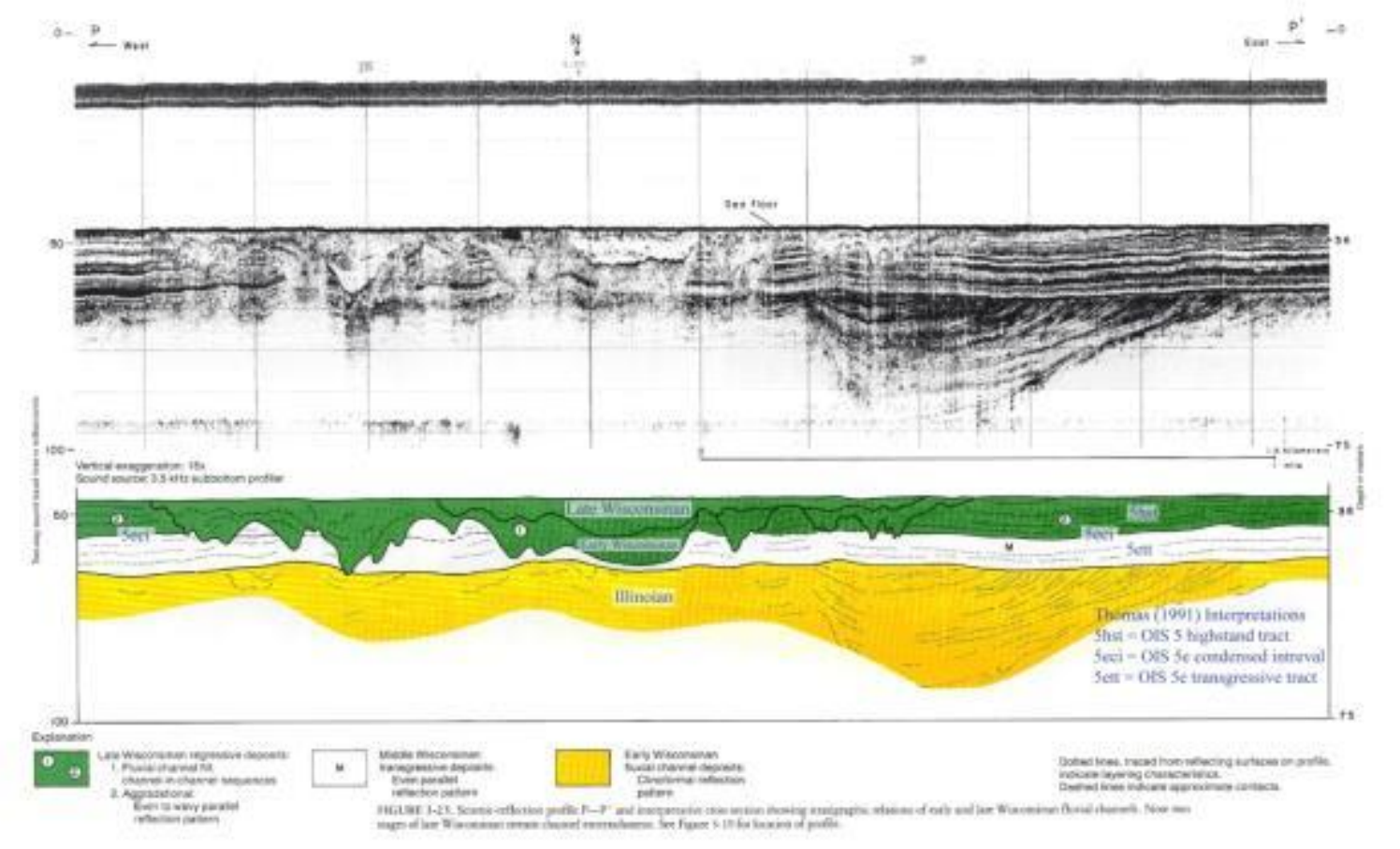
Cross-section Across Trinity - Sabine Paleovalley. Reinterpreted from Thomas (1991) PhD dissertation

Paul Heinrich, LGS, LSU

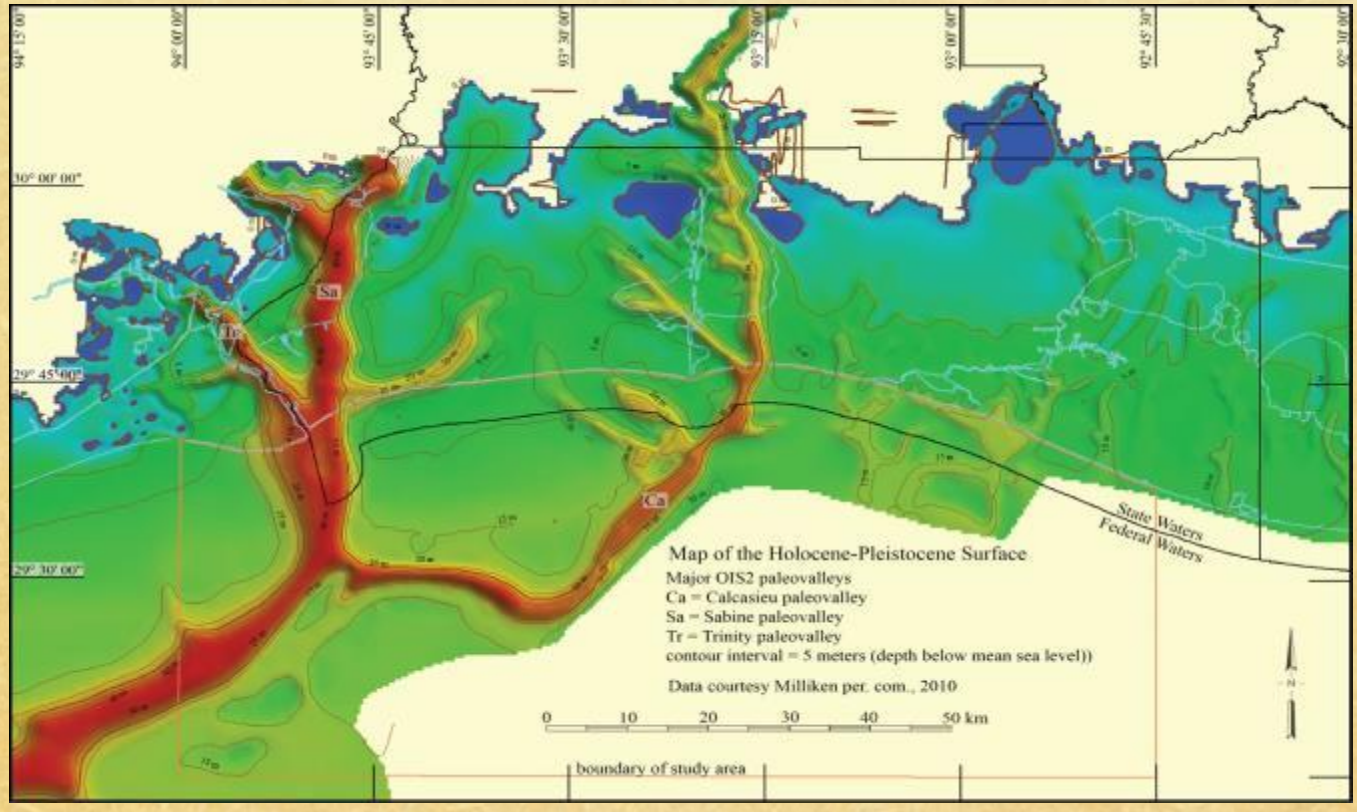
Suter and Berryhill's Interpretations

- Their "Early Wisconsinan" paleovalleys lie below the OIS 5e condensed interval. Therefore they are actually Illinoian in age.

- There exists significant disagreement in both extent and distribution between the "Late Wisconsinan" paleovalleys mapped by Suter and Berryhill and the ones seen in the BOEM block survey map compilation



Holocene–Pleistocene Surface (5-m Contour Interval; data from Milliken, 2010)



Paul Heinrich, LGS, LSU (data from Milliken, personal communication, 2010)

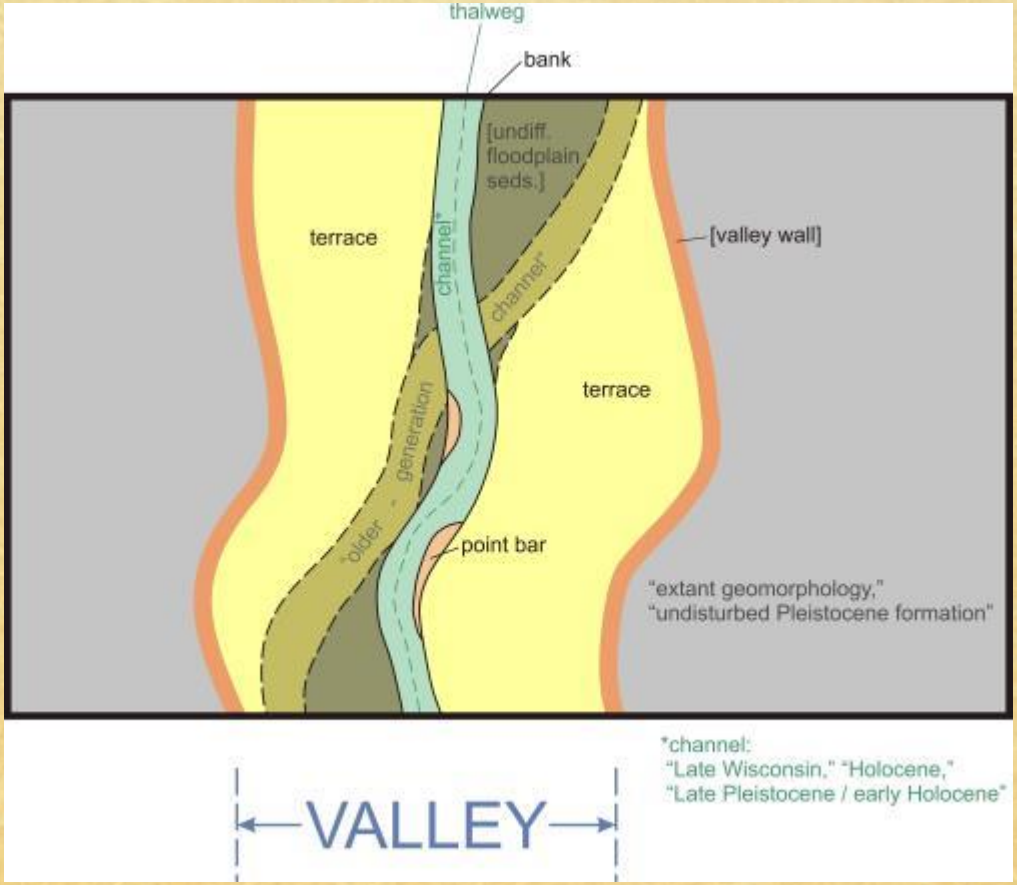
I. Synthesize Offshore-Block Hazard Surveys: 40 Years of Nomenclature Differences

- Buried Channels 4'-12' below seafloor
- Avoidance Zone possible problem for prehistoric site
- Late Wisconsin River Valley
- Preserved Alluvial Terrace
- Holocene channel – Bank and Thalweg
- Early Wisconsin Channel cut and fill 6'-13' below seafloor
- Older Generation channel fill and cut
- Approximately 45' below seafloor
- Geomorphological features suggesting potential location of archeological site
- Late Wisconsin channel Bank and Thalweg
- Natural Levee- Archeological avoidance zone
- Deep valley fill
- Estuary fill at 10' BML
- Buried Late Wisconsin channel and Thalwegs
- Buried channels 2'-4' below seafloor with Thalwegs
- Normal Faults
- Possible Buried channel near seafloor
- First generation buried channel and Thalwegs
- Second generation channel 2'-4' below seafloor and Thalwegs
- Early Holocene Fluvial channel
- Late Pleistocene/Early Holocene Fluvial channel
- Late Pleistocene Channelized Area
- Early Wisconsin Fluvial Channel
- Early Wisconsin Floodplain
- Depth of Deepest Portion of channel
- Cut and Fill channel segments with distinct margins
- Cut and Fill channel segments
- Late Pleistocene/Early Holocene Channel
- Point Bar in channel
- Alluvial Terrace
- First generation channel
- Second generation channel
- Cut and Fill channel segments
- Buried Channel Margins
- Thalwegs of prominent channel segments
- Channel margins within main channels
- Isolated first generation channel
- Buried river banks
- Probable Bar Deposits within channel
- Undisturbed Pleistocene Formation
- Channel cut and fill (First generation)
- Channel cut and fill (Second generation)
- First generation channels approximately 50'-65' below seafloor with Thalwegs
- Second generation channel approximately 15'-30' below seafloor with Thalwegs
- Third generation channel approximately 2'-5' below sea floor with Thalwegs
- First Second generation channels
- Cut and fill channel segments
- Extant Geomorphology
- Channel Cut and Fill
- Channels Buried 5' below seafloor
- Prominent channel cuts within main channels
- Channels buried 40'-45' below seafloor
- Paleochannel at base of Isopach
- Late Wisconsin channels Thalwegs
- Buried channels 8'-12'
- Outline of relict Paleochannel
- Limit of Deweyville Terrace
- Late River channel – Thalwegs
- Middle River channel – Thalwegs
- Early River channel – Thalwegs
- Channel first generation
- Channel second generation

Robert Paulsell, LGS, LSU

Paleovalleys vs. Paleochannels

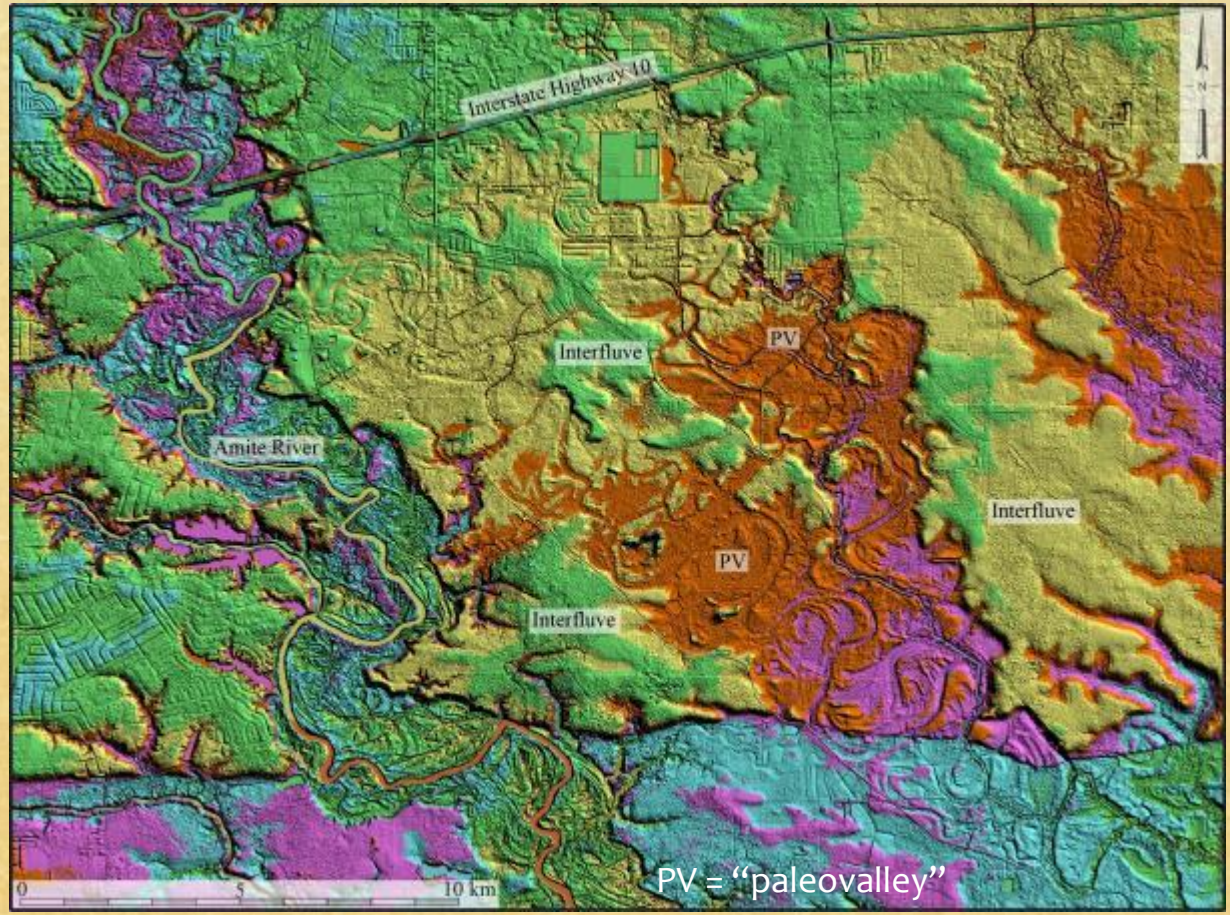
- Multitude of terms mostly boils down to a handful of basic feature types.
- A majority of the features interpreted as paleochannels on the offshore-block hazard maps appear to be paleo*valleys*.



R. P. McCulloh, LGS, LSU

Amite River Valley, Channels; Paleovalley, Paleochannels: Width of Upland Tributary Valleys ≈ Width of Amite River Channels)

Baton Rouge fault



Baton Rouge fault

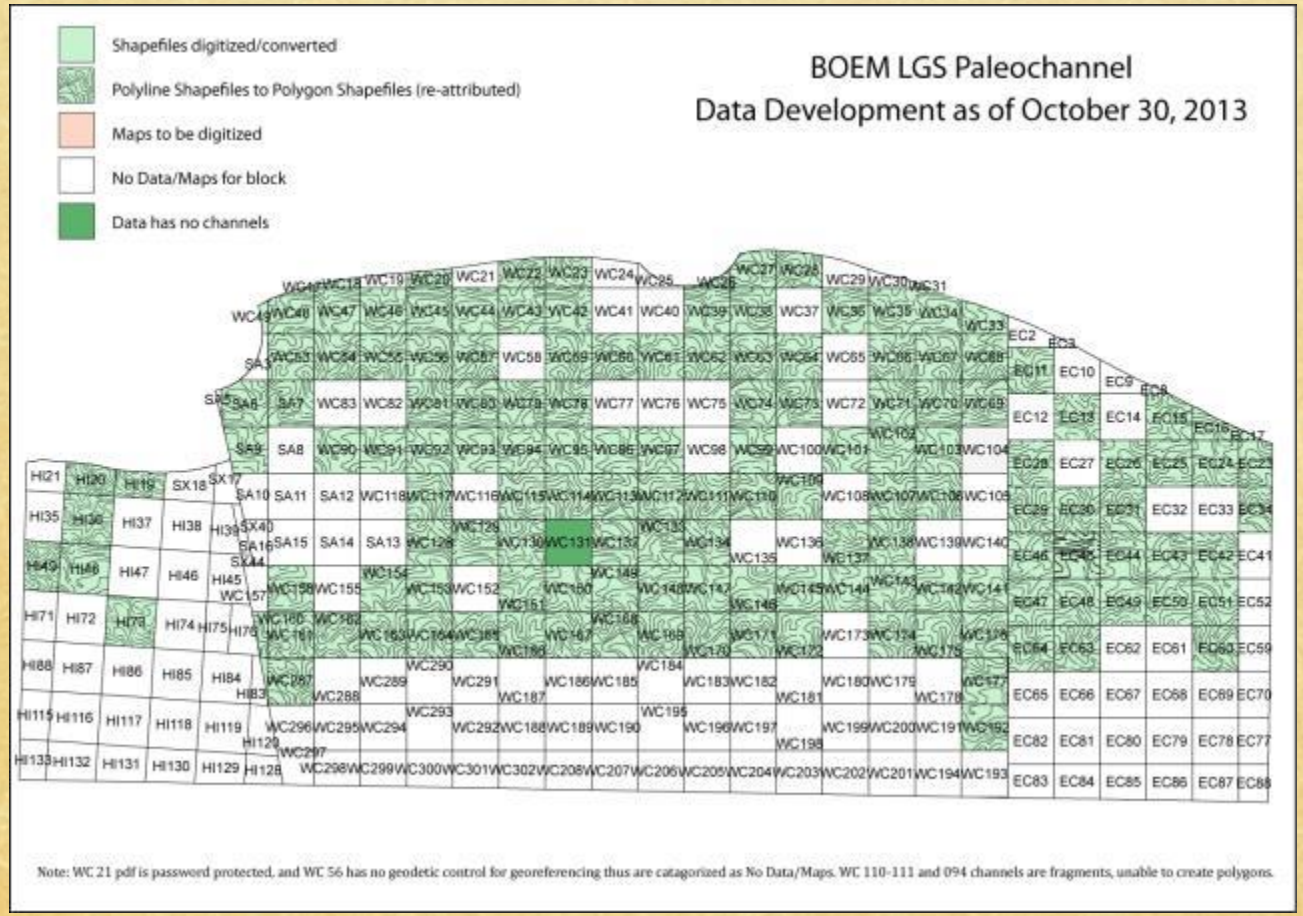
LiDAR DEMs courtesy of Atlas: The Louisiana Statewide GIS (http://atlas.lsu.edu/)

Paul Heinrich, LGS, LSU

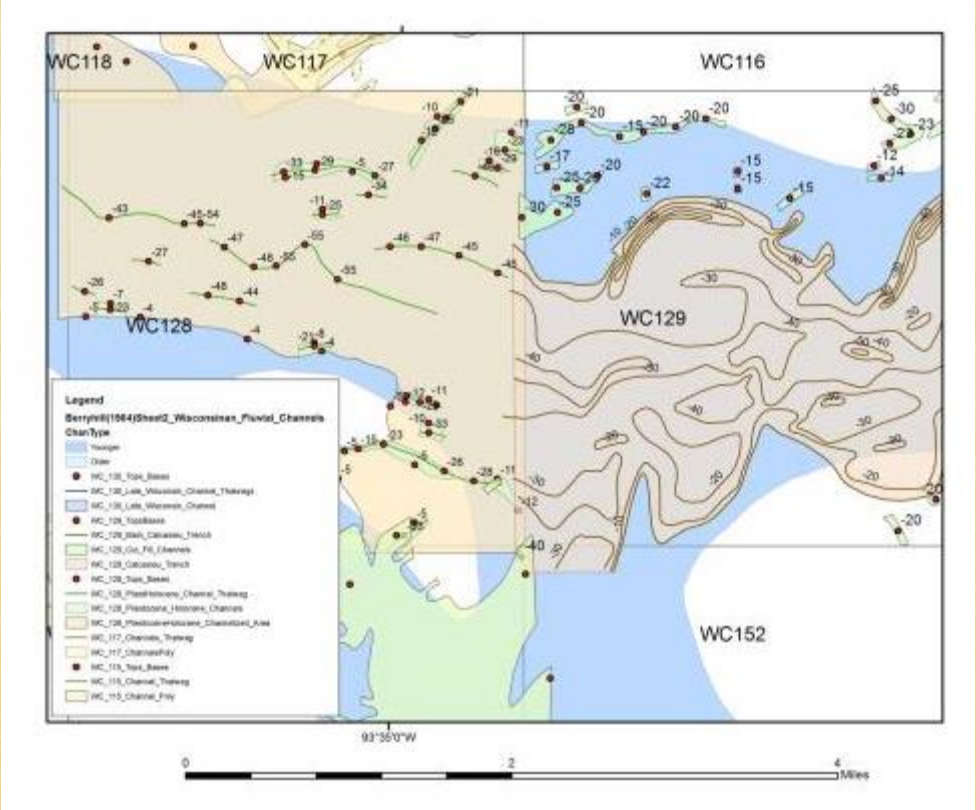
GIS Problems

- Inconsistencies with nomenclature on block maps
- Different interpretations by different geologists
- Reference depths below mudline (not subsea elevations)
- Poor resolution of some block maps
- Little useful data contained in some cases
- Complexity of most maps precludes use of automated line-following technology
- Different hard copy data formats

Data Development Coverage



Data Correlation
(Continuity of Features; Edgematching)

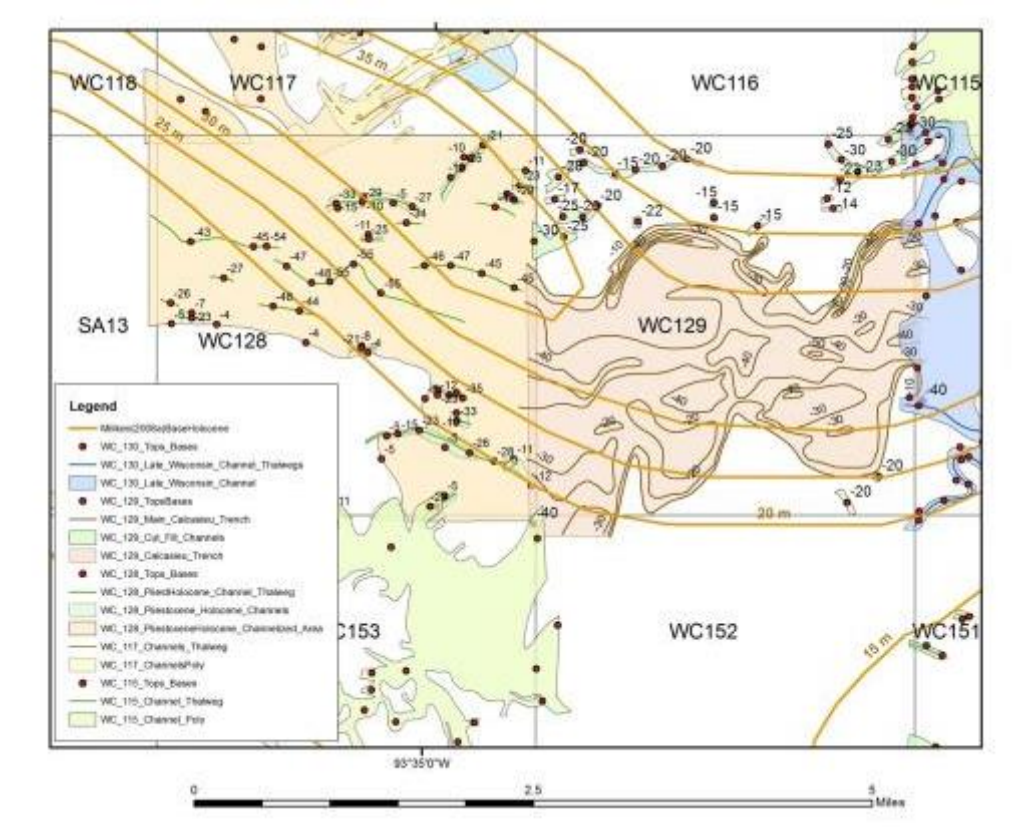


Bathymetric, Seafloor, and
Near-Seafloor Map,
Block 128 West Cameron Area
KC Offshore, L.L.C., Prairieville, La.

Isopach and Channel Map,
Block 129 West Cameron Area
GEOTEX Co.

Robert Paulsell, LGS, LSU

Correlation along Edges and with Milliken's (2010) Calcasieu Paleovalley (Good Correlation)



Bathymetric, Seafloor, and
Near-Seafloor Map,
Block 128 West Cameron Area
KC Offshore, L.L.C., Prairieville, La.

Isopach and Channel Map,
Block 129 West Cameron Area
GEOTEX Co.

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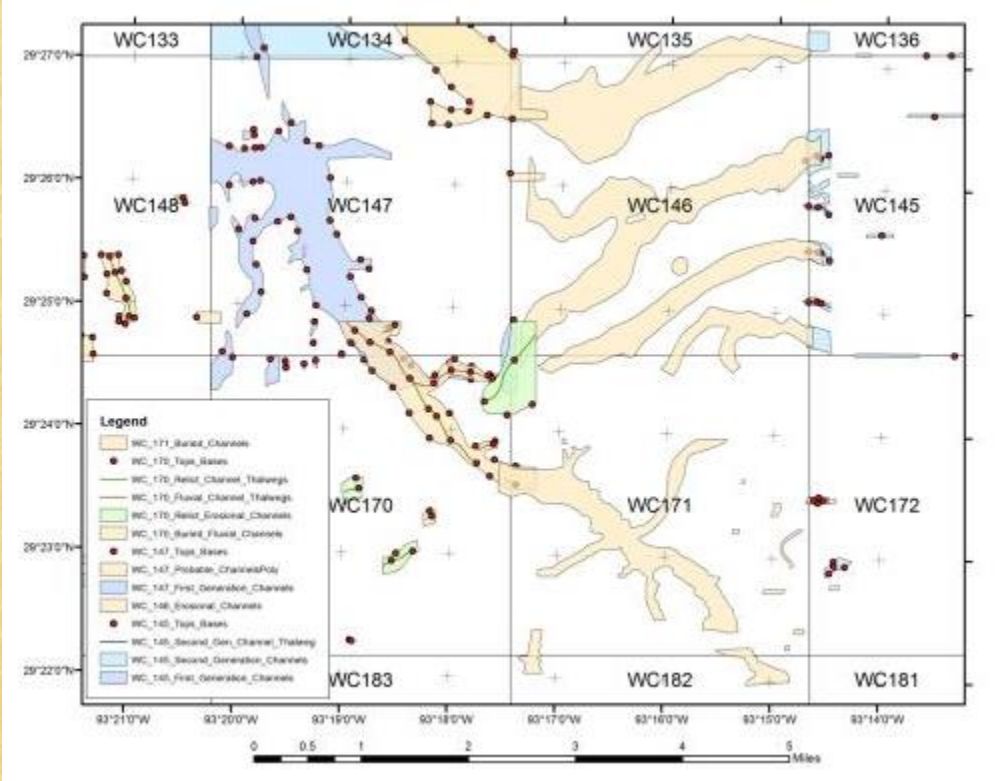
Good Interpretive Correlation

Archeological & Hazard Map,
Block 147 West Cameron Area
Fugro GeoServices, Inc., Lafayette, La.

Hazard Map,
Block 146 West Cameron Area
John E. Chance & Associates, Inc.



Anomaly Map,
Block 170 West Cameron Area
Cochrane Technologies, Inc., Lafayette, La.

Archeological & Hazard Map,
Block 171 West Cameron Area
Fugro GeoServices, Inc., Lafayette, La.

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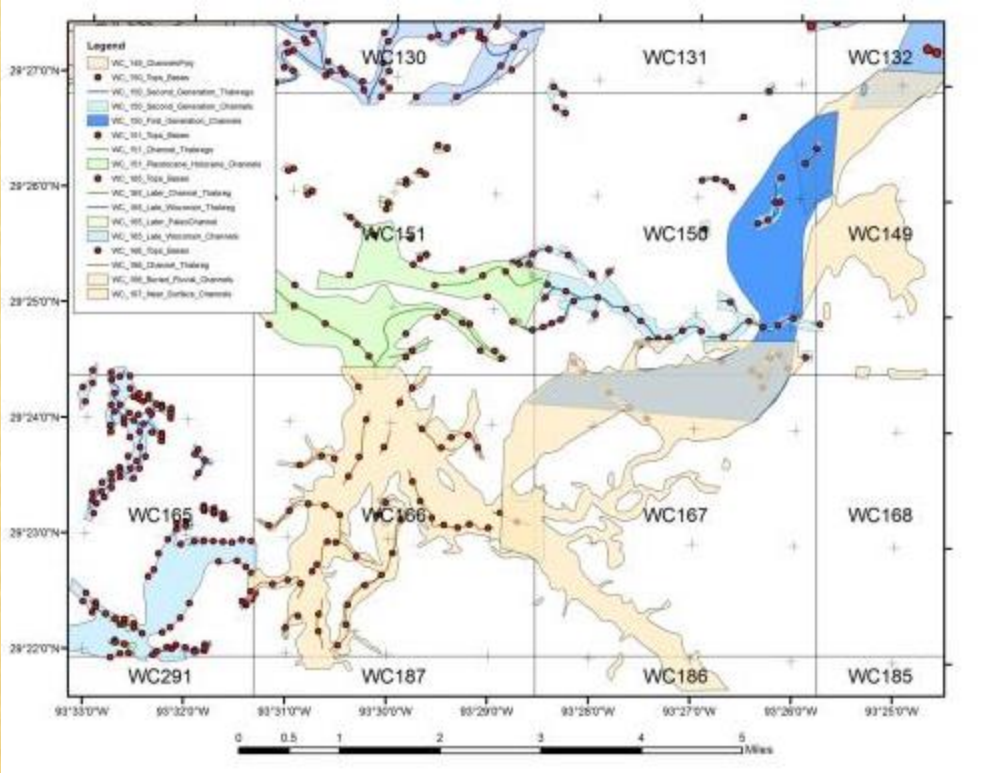
Good Interpretive Correlation (?—Edgematching)

Channels,
Block 151 West Cameron Area
Tesla Offshore, L.L.C., Prairieville, La.

Archeological & Hazard Map,
Block 150 West Cameron Area
Fugro GeoServices, Inc., Lafayette, La.



Near-Seafloor Features Map,
Block 166 West Cameron Area
Kinsella, Cook & Associates, Inc., Baton Rouge, La.

Archeological & Hazard Map,
Block 167 West Cameron Area
John E. Chance & Associates, Inc., Lafayette, La.

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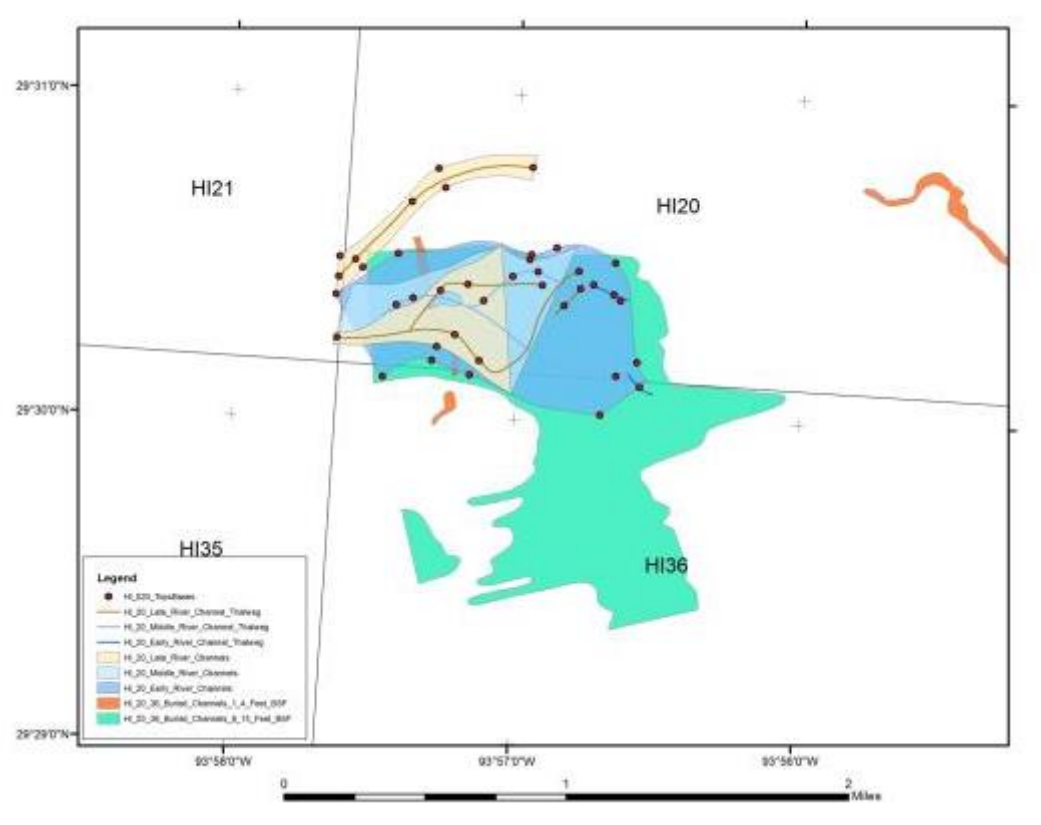
Dwindling Interpretive Correlation



Archaeological & Hazard Map,
Block 20 & 36, High Island Area
Fugro GeoServices, Inc., Lafayette, La, La.

Bathymetric, Seafloor, and
Near-Seafloor Map,
Block 20 High Island Area
Thales GeoSolutions, Inc., Prairieville, La.

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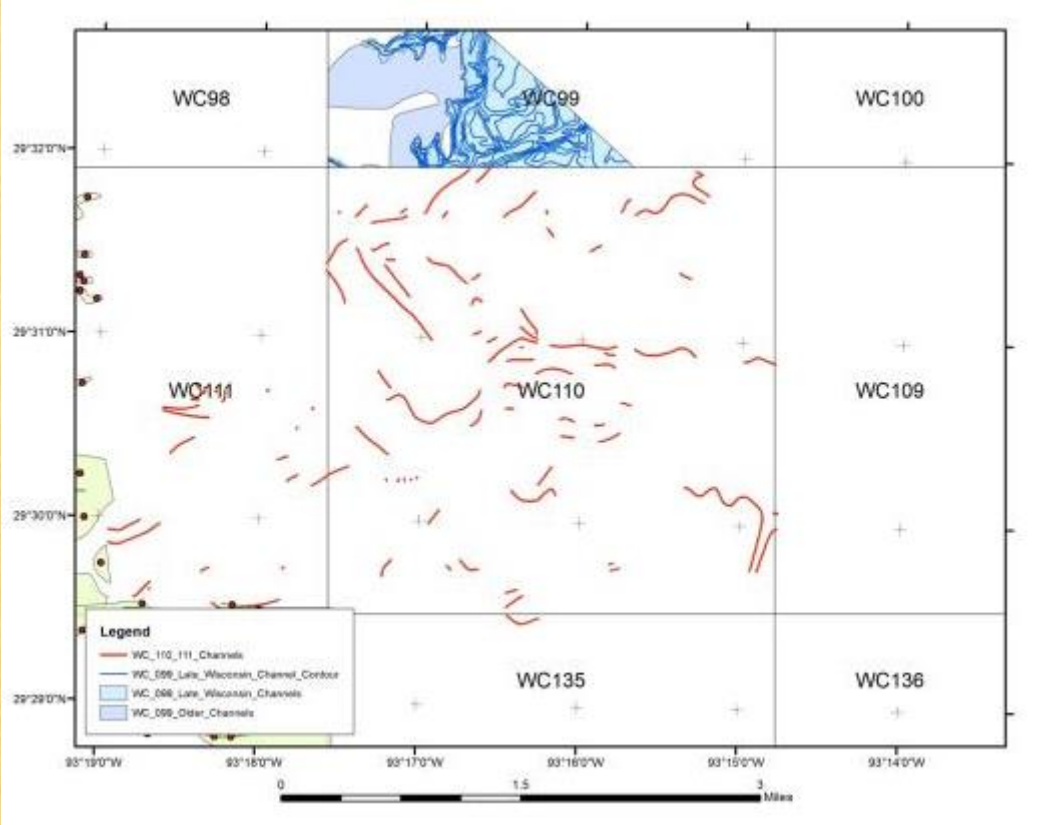
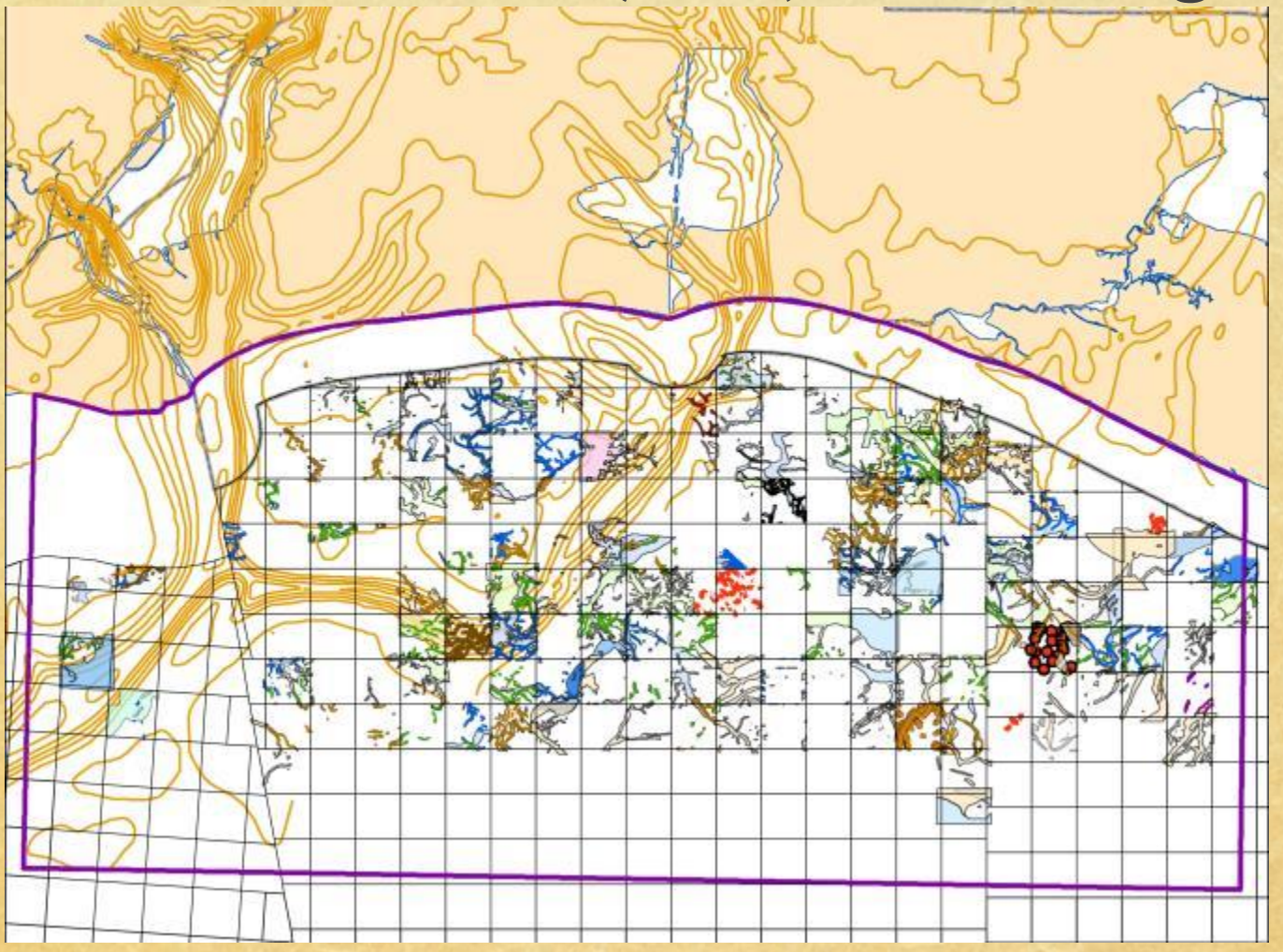
No Obvious Correlation (Unuseful Data)



Isopach and Shallow Geologic Features Map,
Blocks 110 & 111 West Cameron Area
GEOTEX Co.

Robert Paulsell, LGS, LSU

Paleovalleys in Block Hazard Surveys: Synoptic View of Synthesized Features, with Milliken's (2010) Contouring



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Final GIS Synthesis of Offshore-Block Hazard Surveys:

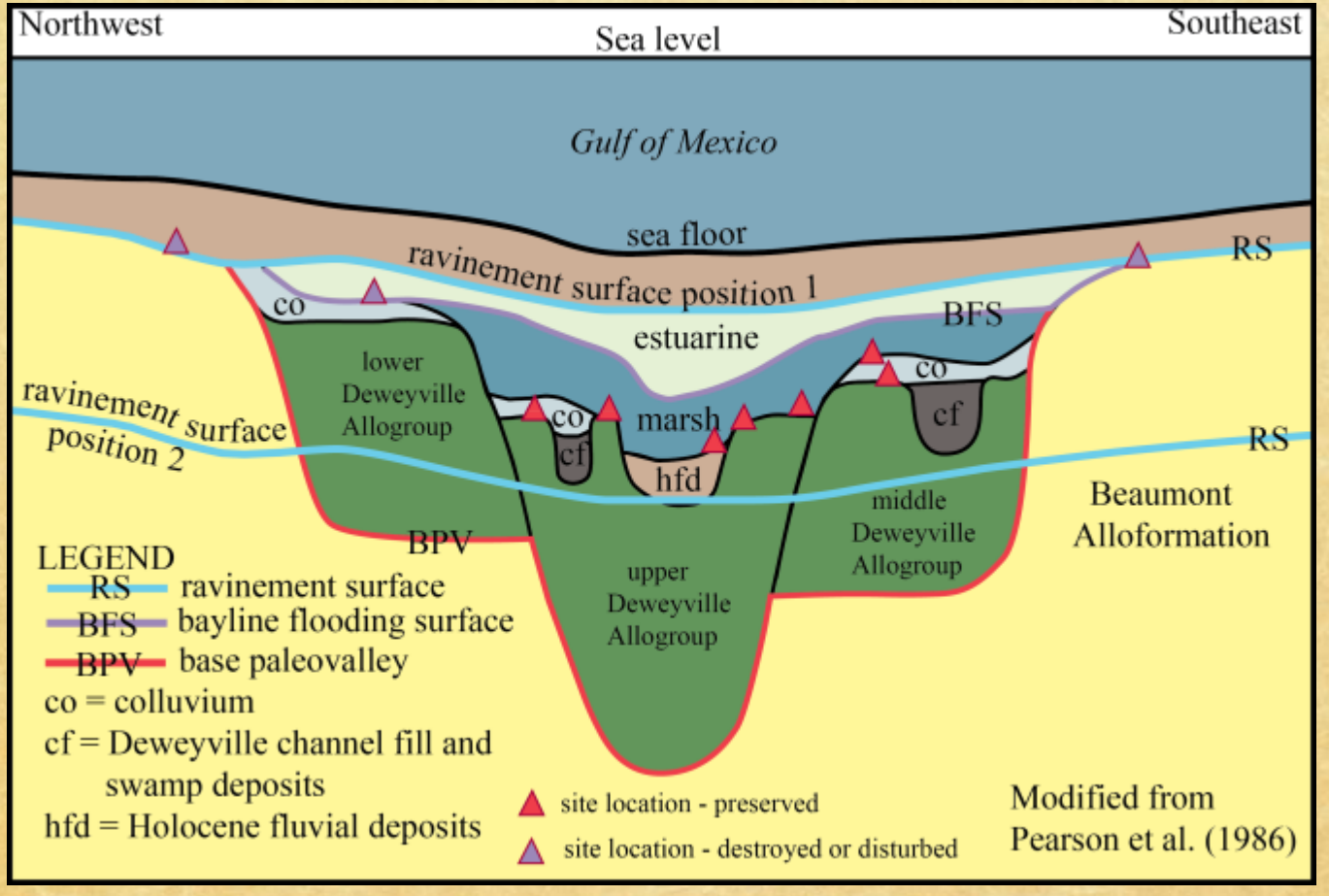
- Completed review of maps from 350 offshore-block hazard surveys, digital synthesis of 122 surveys (228 unusable—!).
- Despite problematic variability of source information, availability in one GIS should have value as a reference resource.
- Most mapped features appear to be smaller valleys of upland tributaries draining interfluves.
- Identified some portions of larger/wider features:
  - In western study area, correlate with Sabine and Calcasieu paleovalleys.
  - In eastern study area, no correlation with obvious known features (but basis unclear).

II. Identify Paleolandscapes With Potential for Preserved Archaeological Sites: Seismic Records (USGS Data Series 93, 526)

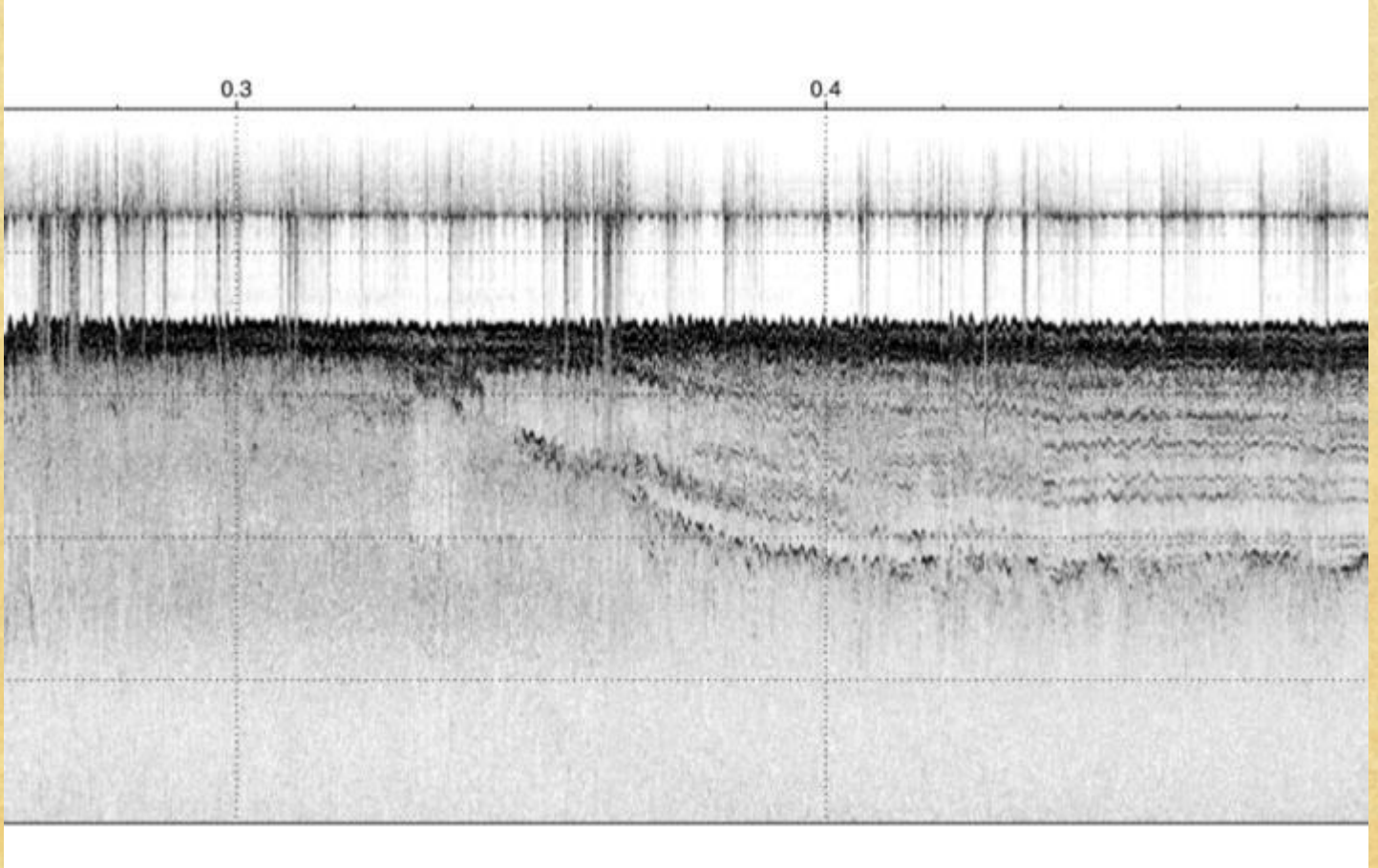
“Favorable” Paleolandscapes: Operational Criteria (Juxtaposition of High & Low Ground— Access to Water + A Measure of Safety From It)

- Valley-wall settings (big valleys)
- Surfaces within/adjacent to lenticular channeloid features
- Mounds and adjacent sags
- Faults with “rollover” anticlinal structures
- Subsea elevations shallower than 0.03 s (−45 m or ~ −150 ft)

Key On: Paleovalley Incisions That are Deep Relative to Level of Marine Erosion (Pearson et al., 1986)

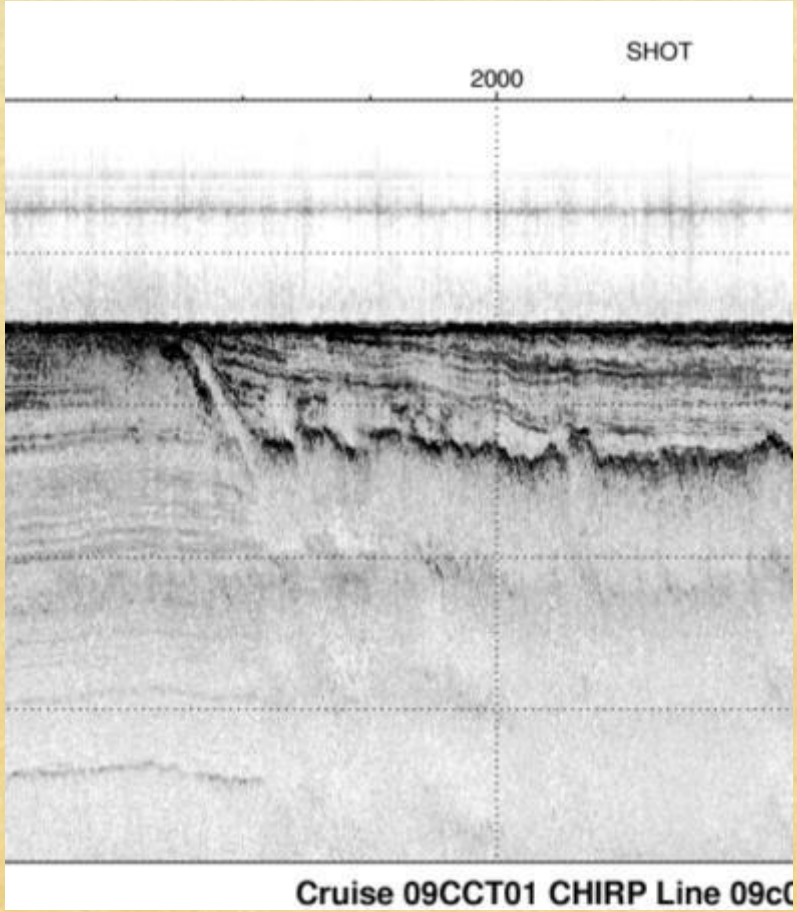


Paleolandscapes on Seismic Records, SW Louisiana: Sabine Valley Wall



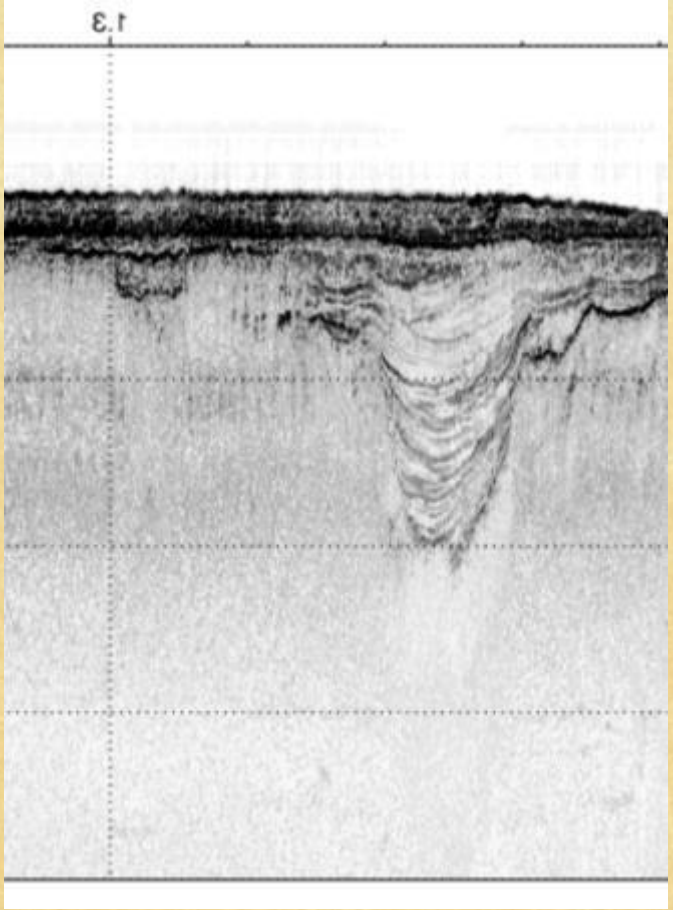
Line 09c11 excerpt, U. S. Geological Survey Data Series 526 (Forde et al., 2010)

Paleolandscapes on Seismic Records, SW Louisiana: Sabine Valley Wall (2)



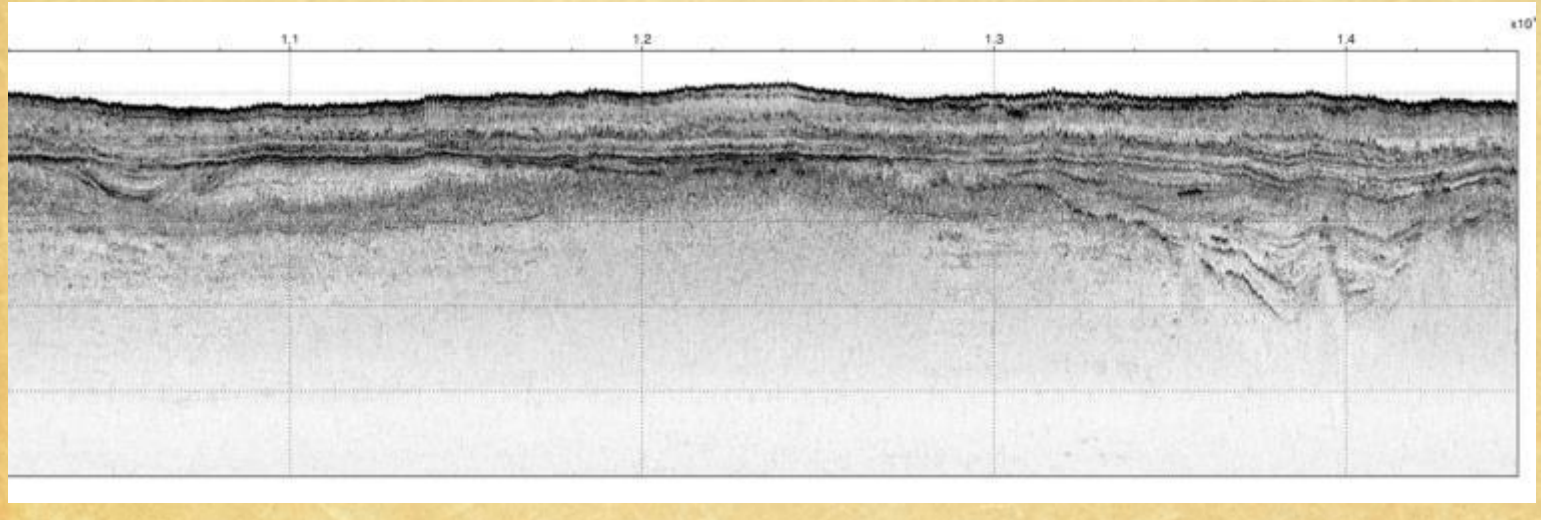
Line 09c03 excerpt, U. S. Geological Survey Data Series 526 (Forde et al., 2010)

Paleolandscapes on Seismic Records (*cont'd.*): Channeloid Forms



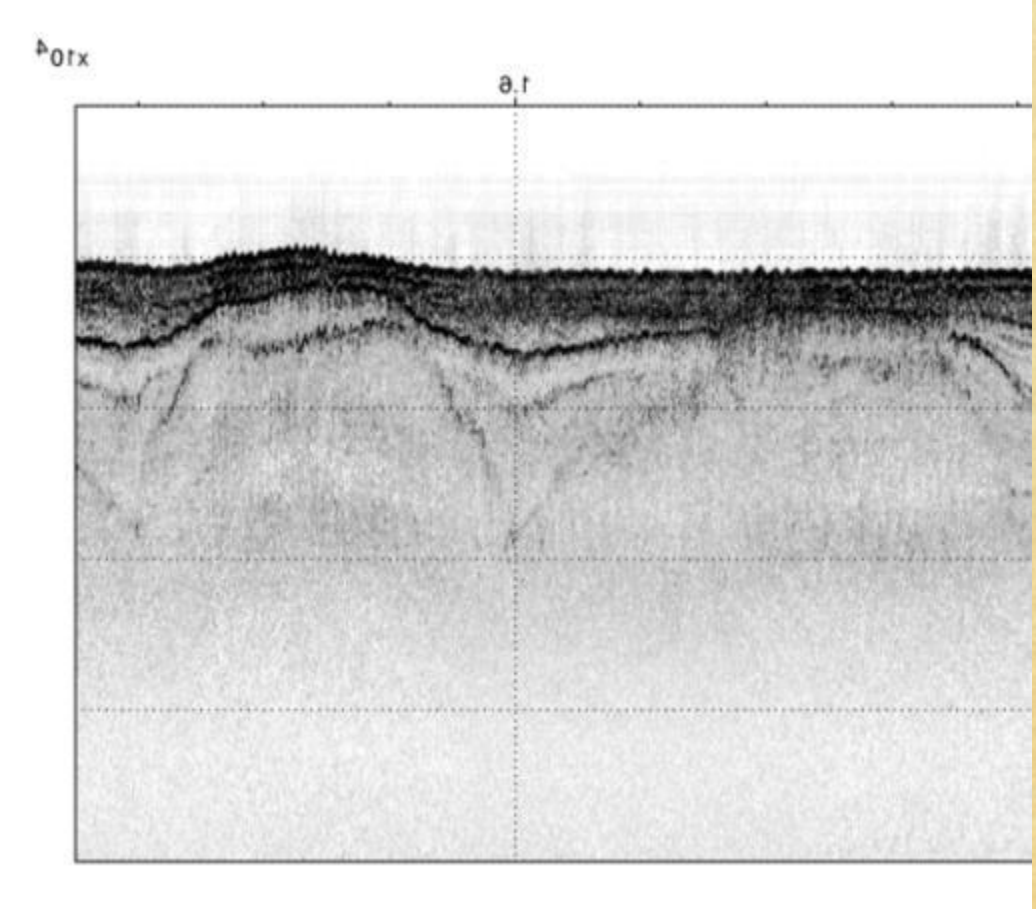
Line 09c30 (horizontally flipped) excerpt, U. S. Geological Survey Data Series 526 (Forde et al., 2010)

Paleolandscapes on Seismic Records (*cont'd.*): Channeloid Forms (2)—One Too Truncated, One Not . . .



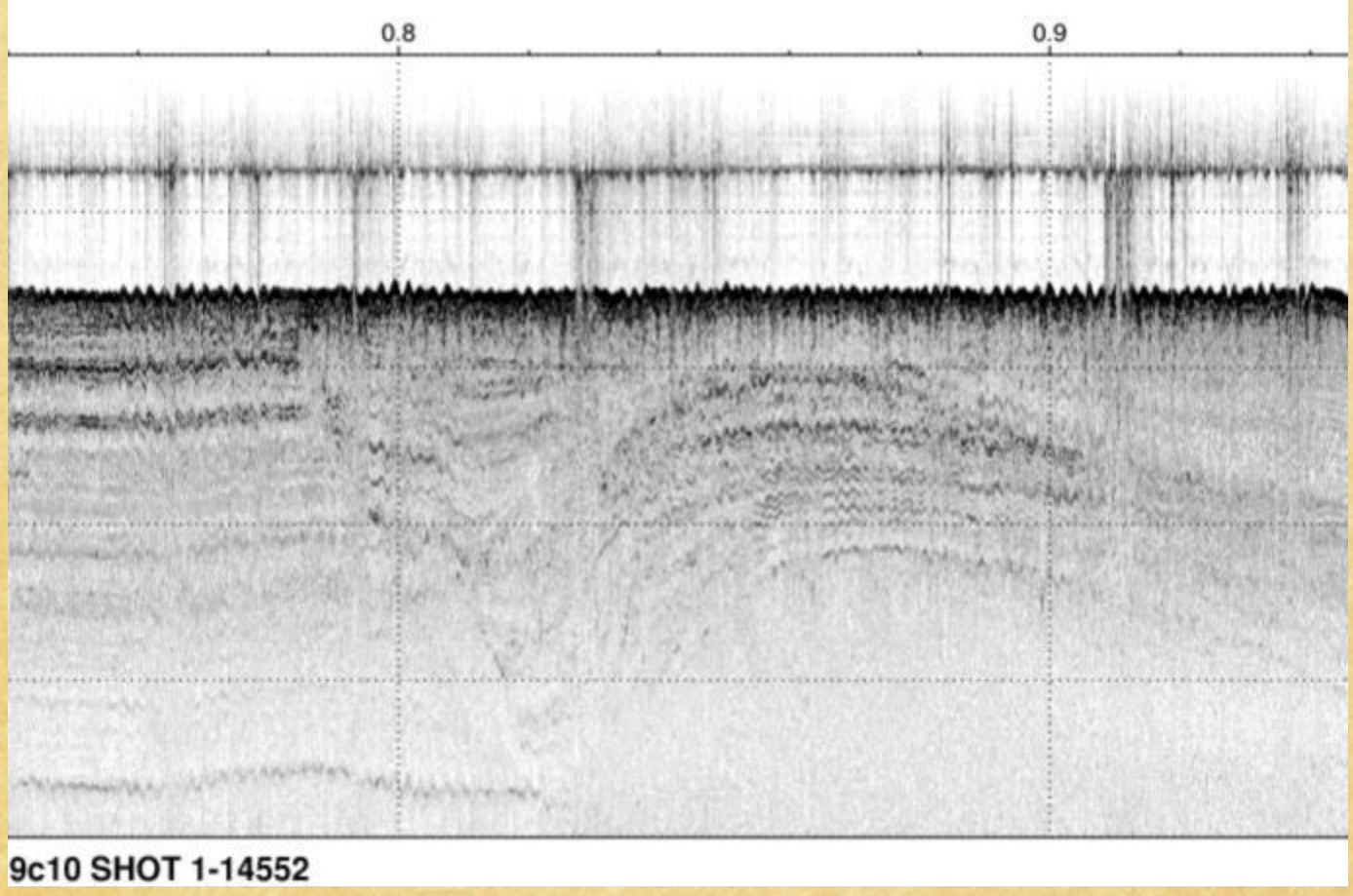
Line 09c39 excerpt, U. S. Geological Survey Data Series 526 (Forde et al., 2010)

Paleolandscapes on Seismic Records (*cont'd.*): Mounds & Adjacent Sags



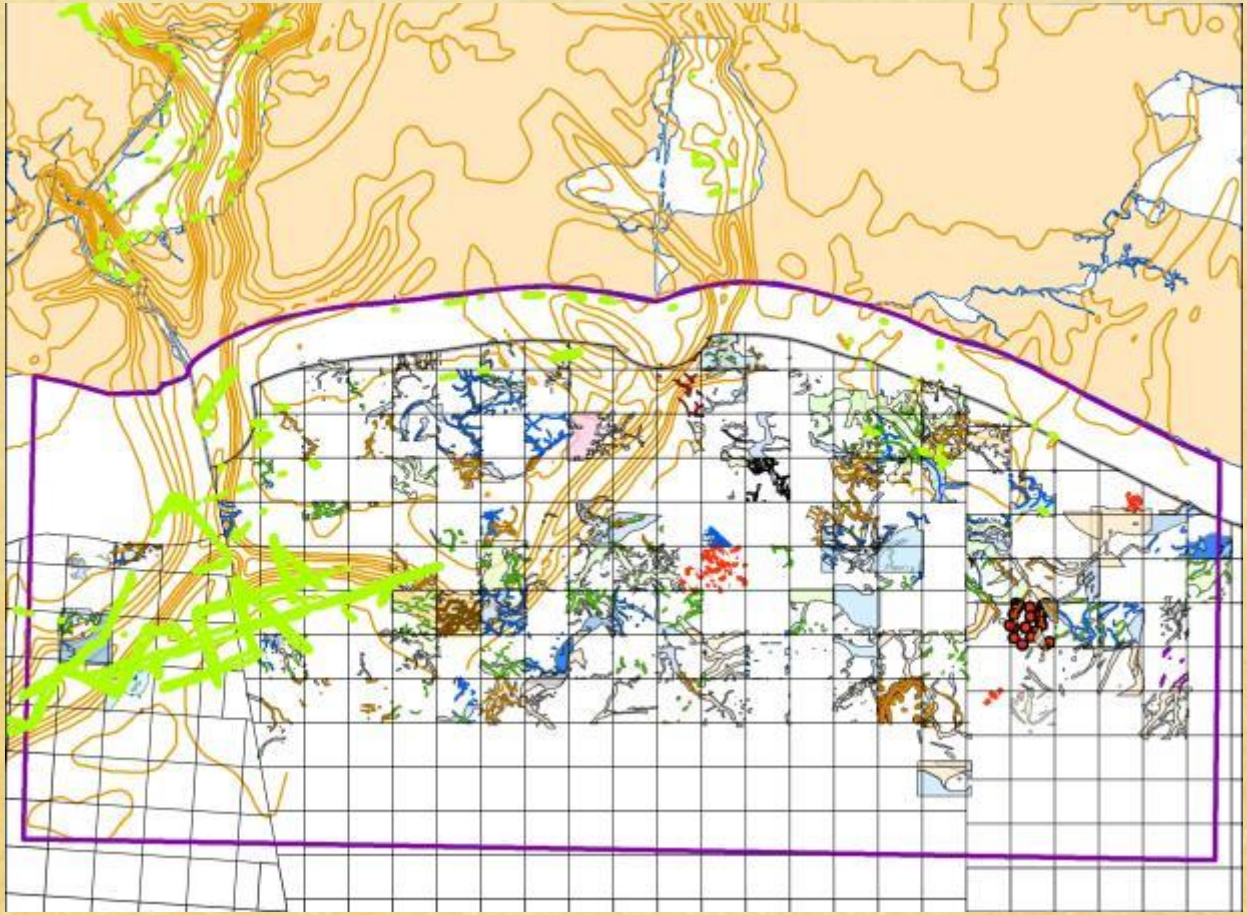
Line 09c25 (horizontally flipped) excerpt, U. S. Geological Survey Data Series 526 (Forde et al., 2010)

Paleolandscapes on Seismic Records (*cont'd.*): Upthrown Block of Fault Zone, "Rollover" Structure on Downthrown Block



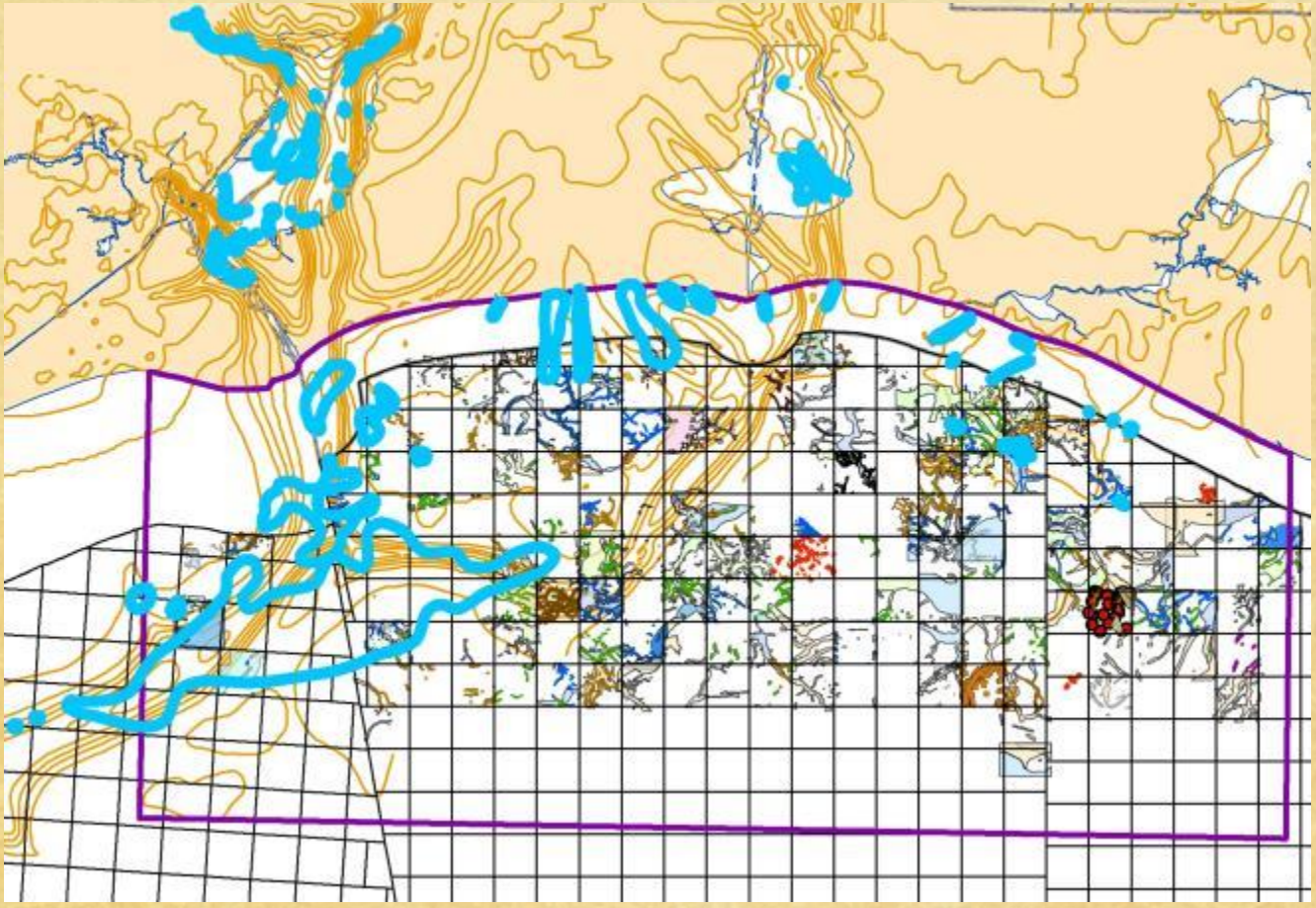
Line 09c10 excerpt, U. S. Geological Survey Data Series 526 (Forde et al., 2010)

Paleolandscapes on Seismic Records: Plot of Raw Intercepts



Data Sources: USGS Data Series 93 (Calderon et al., 2004), USGS Data Series 526 (Forde et al., 2010)

Paleolandscapes on Seismic Records: Interpretive Aggregation of Intercepts



Data Sources: USGS Data Series 93 (Calderon et al., 2004), USGS Data Series 526 (Forde et al., 2010)

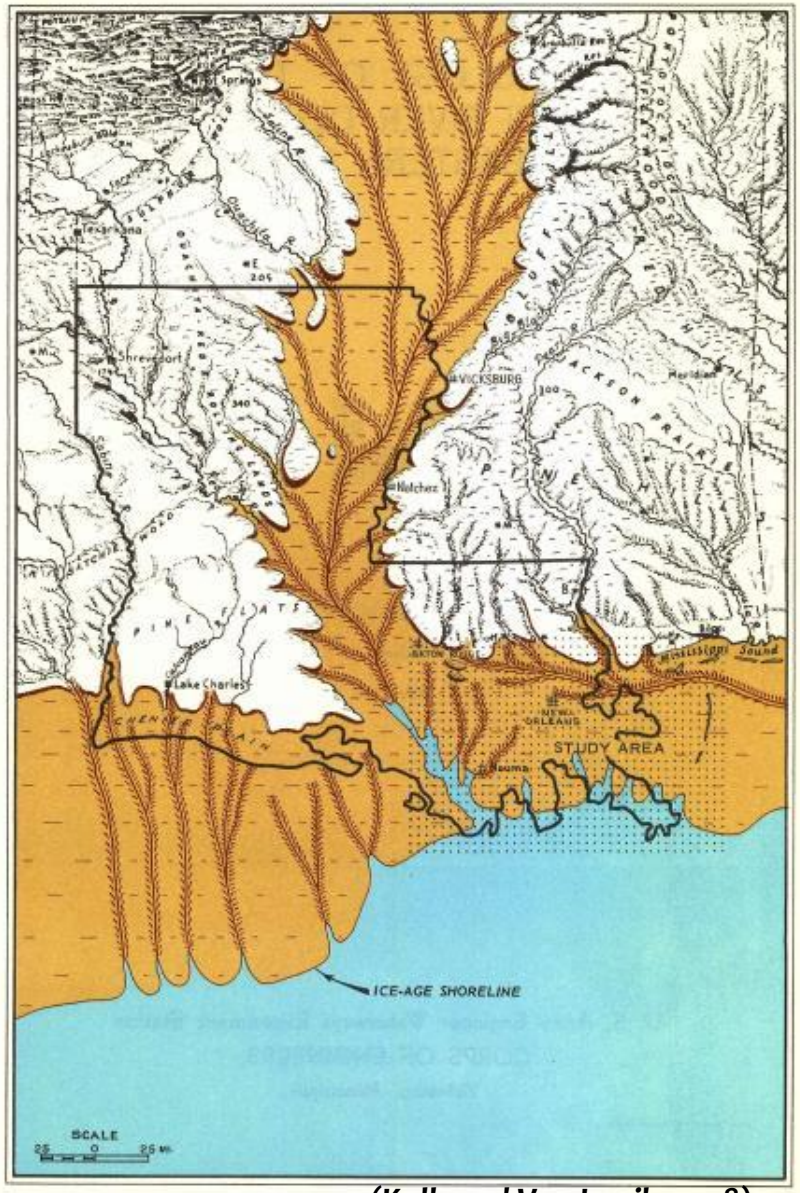
Paleolandscapes With Potential for Preserved Archaeological Sites: Conclusions

- Preservation of "favorable" paleolandscapes on the continental shelf offshore SW Louisiana depends on sufficiently-deep incision by prospective-aged drainage courses (as predicted by Pearson et al., 1986).
- Most "favorable" paleolandscapes on the shelf appear to be associated with the largest drainage courses: Sabine and Calcasieu
  - makes sense (larger courses incise deeper);
  - but: possible sampling bias (larger courses are where most seismic lines are shot).

Acknowledgements

- Funding through Cooperative Agreement / Award No. M12AC00020 between BOEM and the Louisiana Geological Survey.
- P. V. Heinrich thanks Dr. K. T. Milliken for use of her data.

Questions?



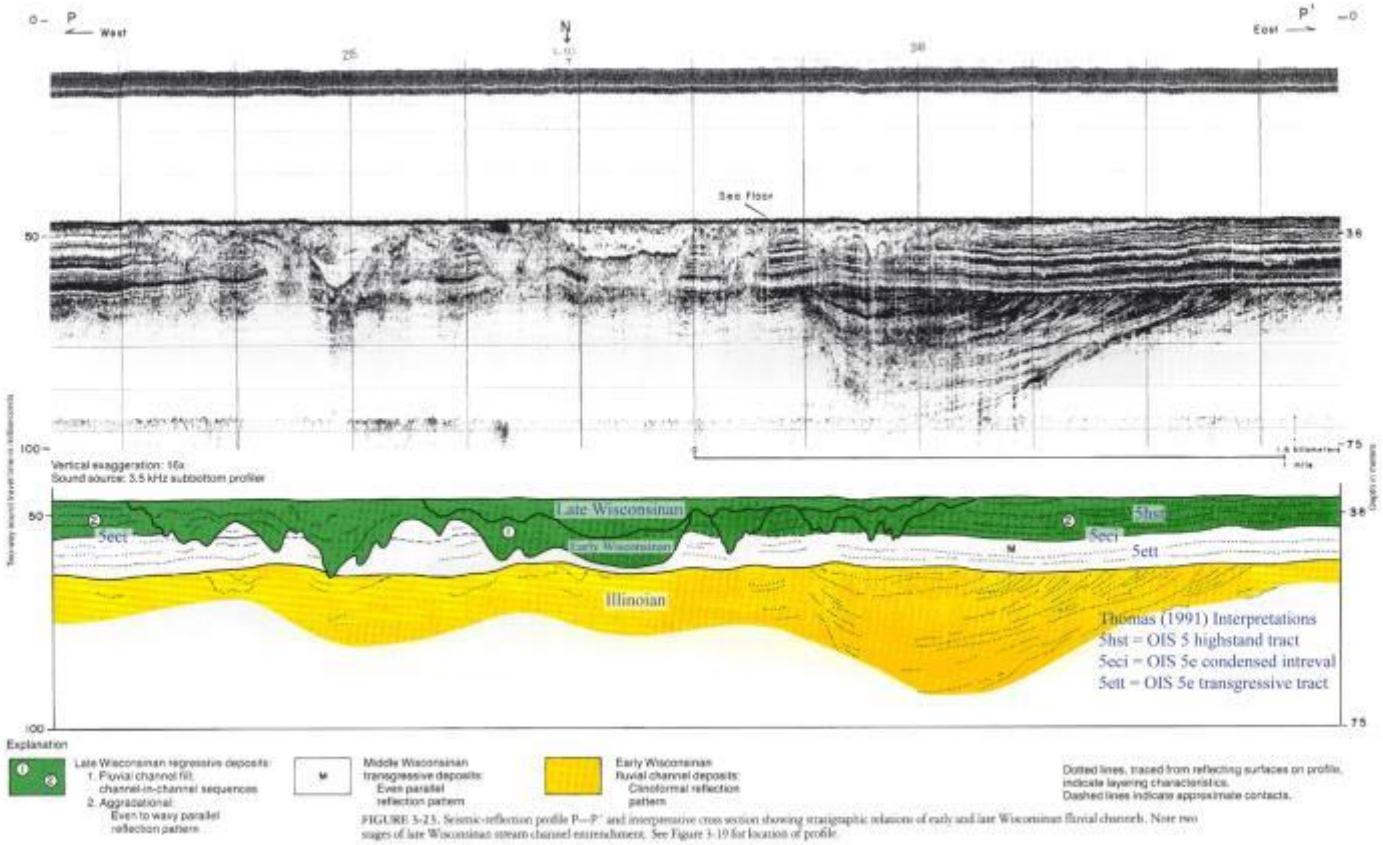
Frontispiece. Mississi

(Kolb and Van Lopik, 1958)

Appendix

Suter and Berryhill's Interpretations

- Their "Early Wisconsinan" paleovalleys lie below the OIS 5 condensed interval. Therefore they are actually Illinoian in age.



Site Preservation in Paleovalleys

Depth of ravinement (marine erosion) surface, depth of paleovalley, or combination of both, will control preservation of archaeological deposits. Modified from Pearson et al. (1986)

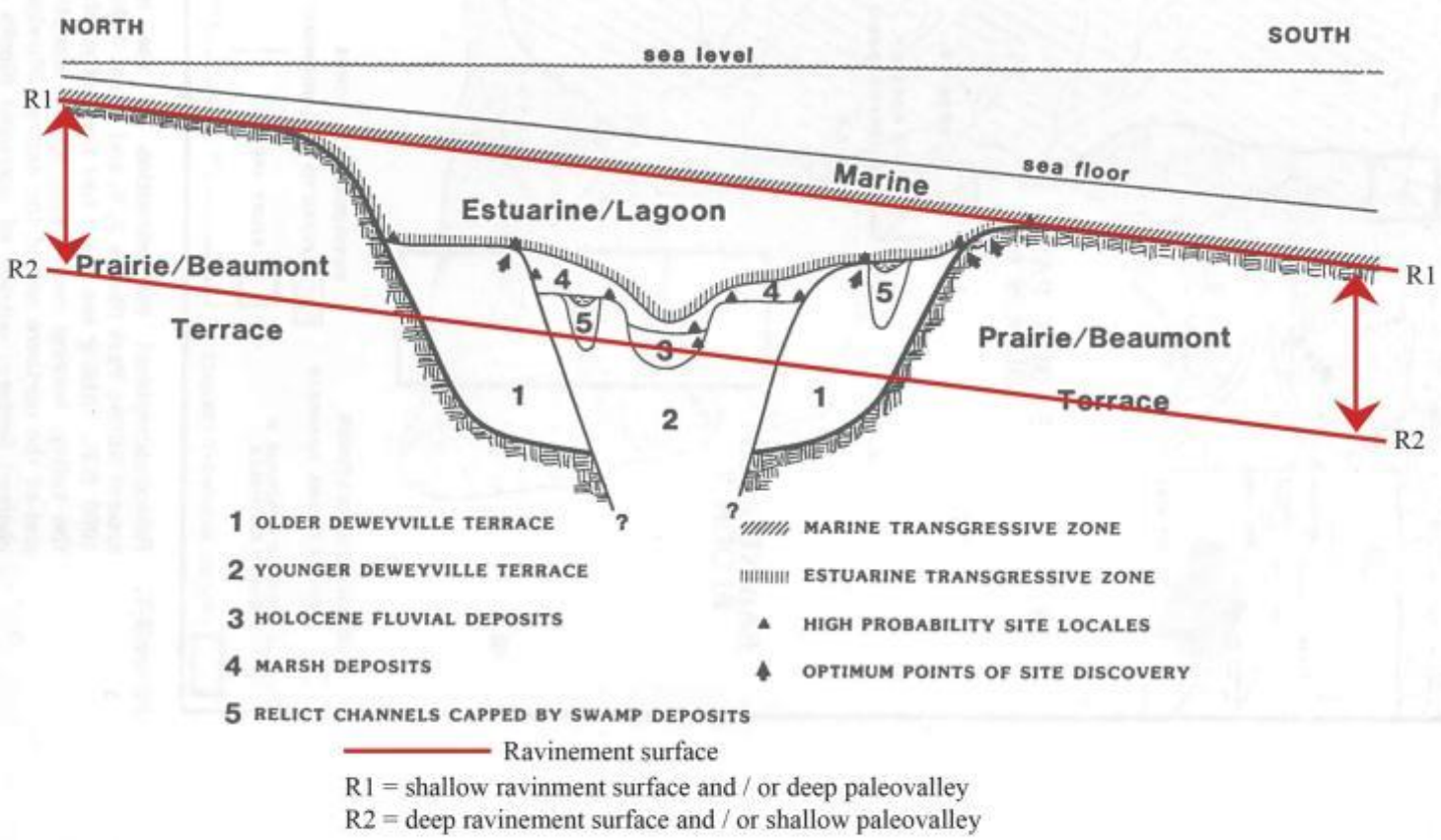
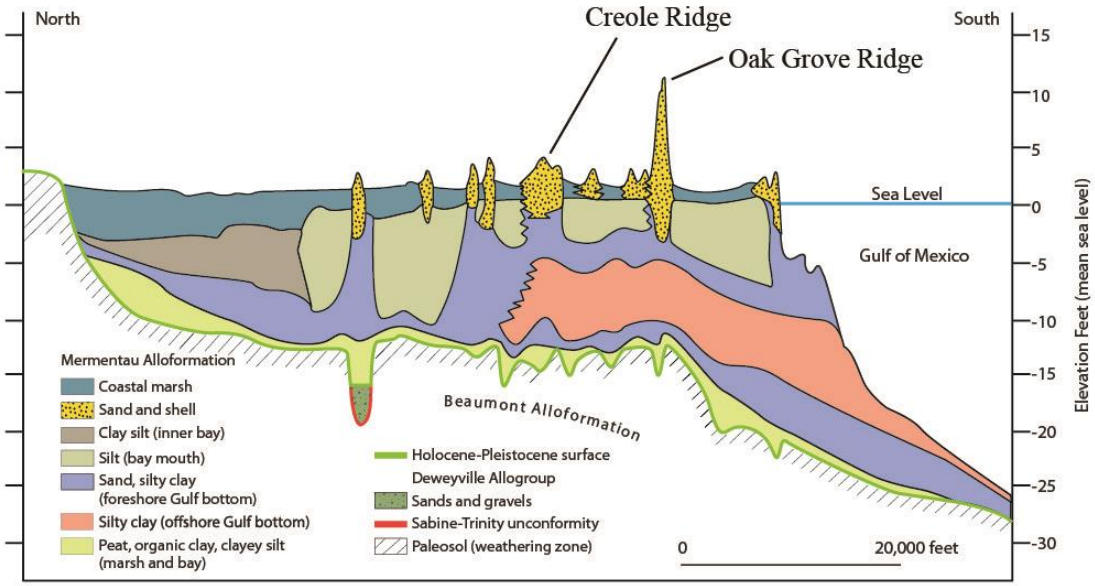


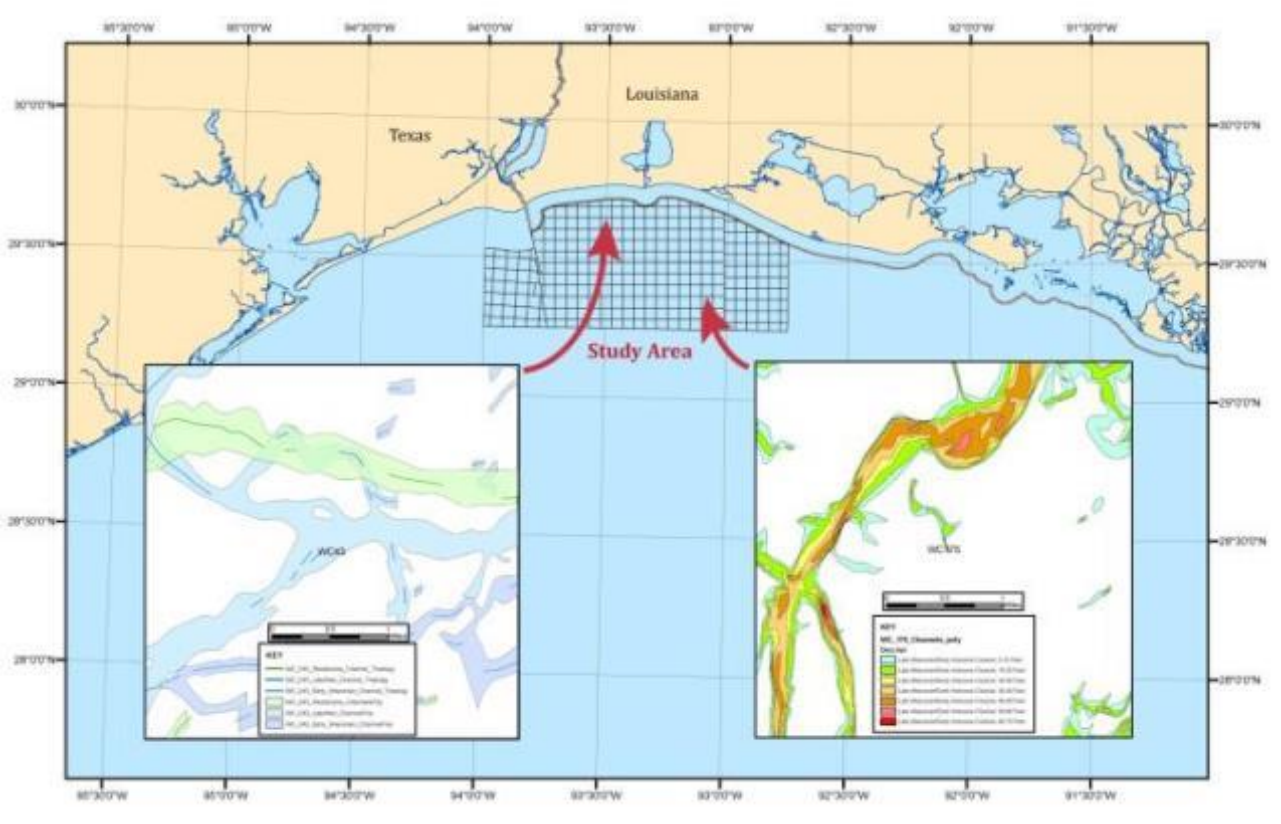
Figure 6-8. Graphic model of site occurrence and preservation potential depicted as a cross section of the offshore Sabine River valley.

Mermentau Alloformation and SW Louisiana Chenier Plain Dip Section Redrawn and Adapted from Gould et al. (1959)



Heinrich et al. (2015)
CPRA-2013-TO11SBO1-DR

Different Hard Copy Data Formats



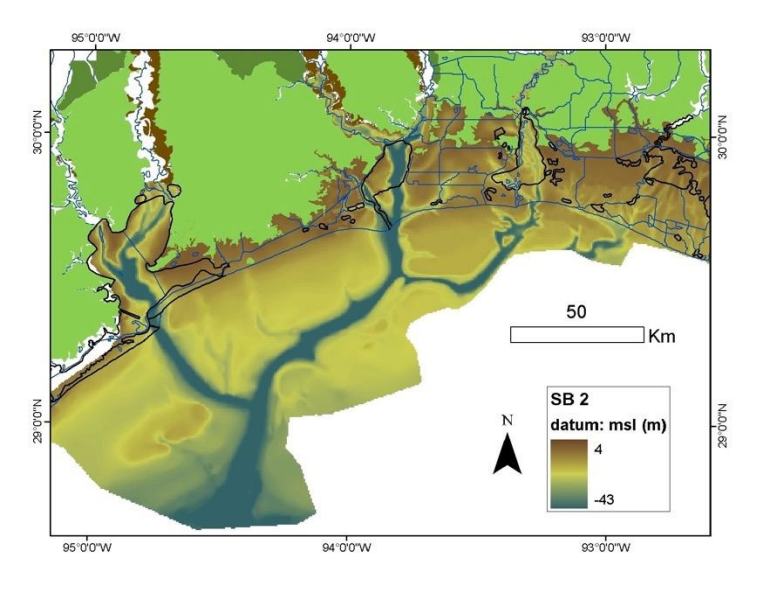
Near Sea-floor Features Map,
Block 43 West Cameron Area
KC Offshore, L.L.C., Prairieville, La.

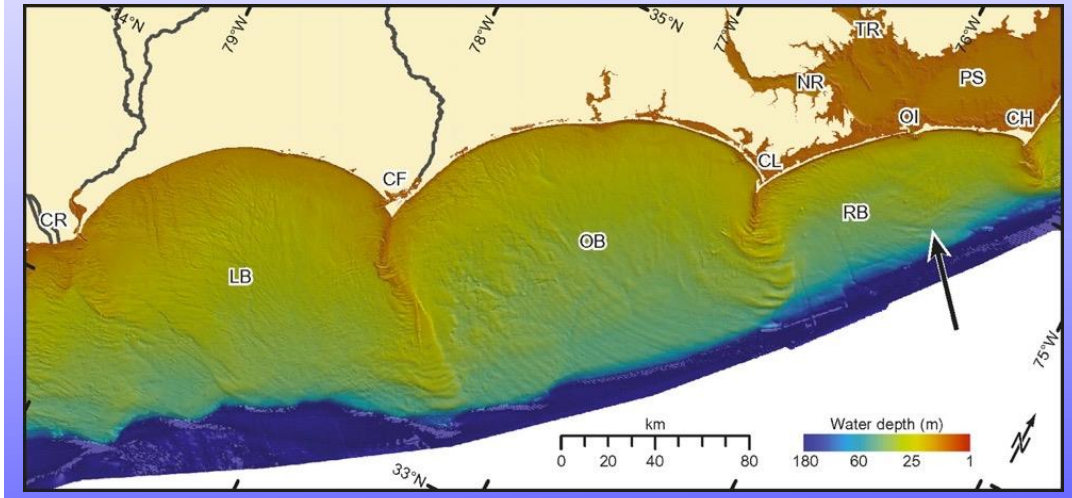
Isopach and Shallow Geologic Features Map,
Block 175 West Cameron Area
Thales GeoSolutions, Inc., Houston, Tx.

Robert Paulsell, LGS, LSU

Understanding the Habitat Value and Function of Shoal/Ridge/Trough Complexes to Fish and Fisheries on the Atlantic and Gulf of Mexico Outer Continental Shelf- Geological Framework

Tim Dellapenna
Texas A&M University

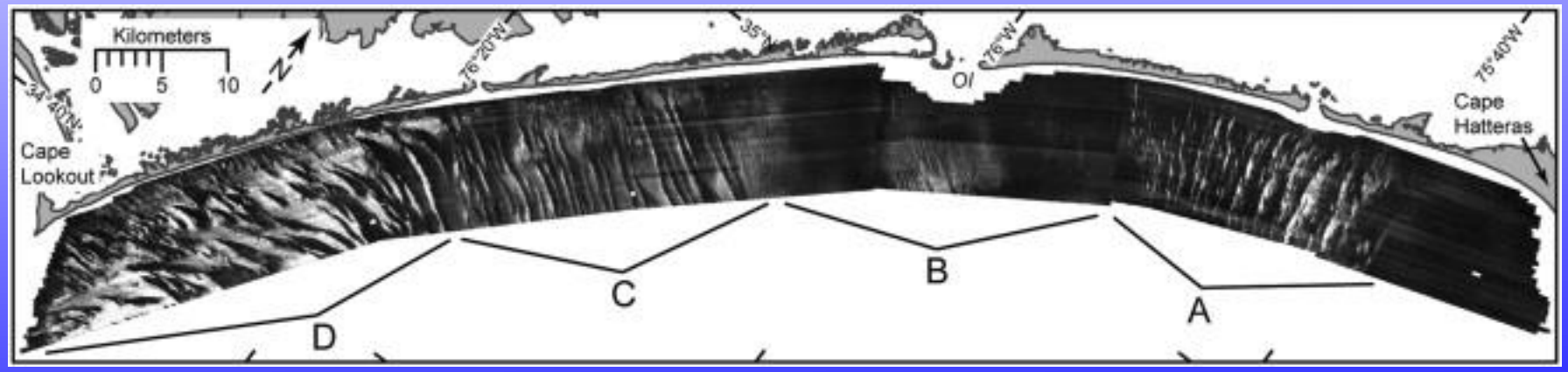




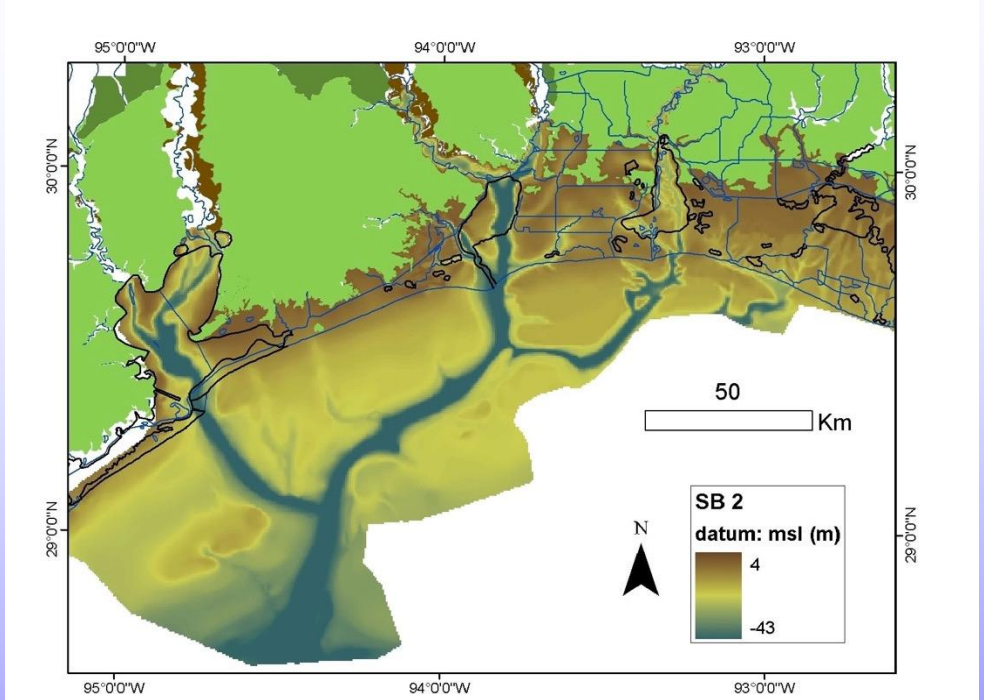
Department of
Oceanography
Texas A&M University
College of Geosciences

Talk Overview

- Overview of regional geological framework
- Regional Physical Oceanographic differences
- Shoal Classifications, examples and geological controls on habitat structuring

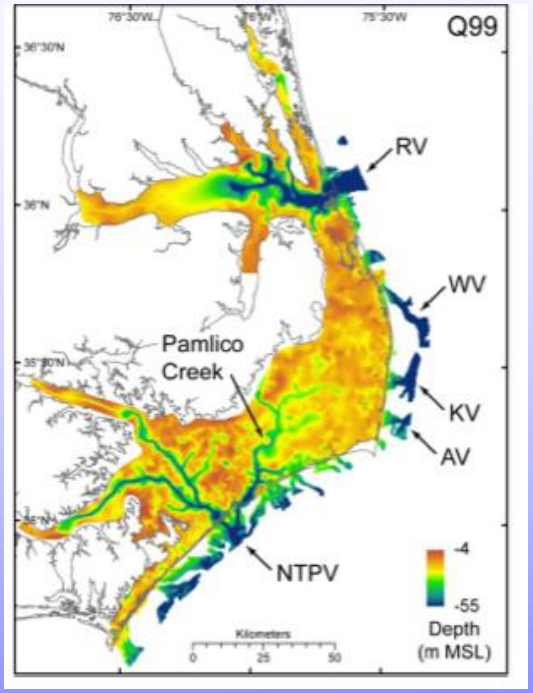


Sea Level Rise and Shoal Formation



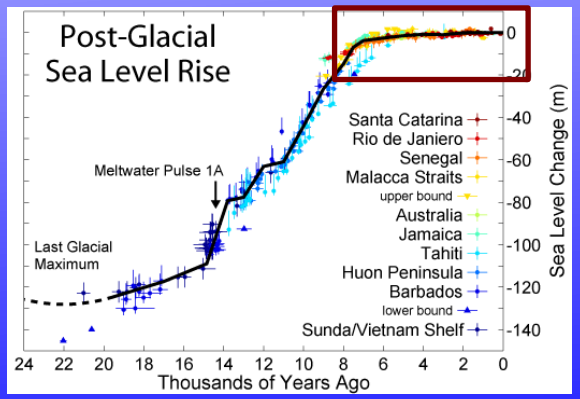
Ancestral Calcasieu, Sabine and Trinity river valleys

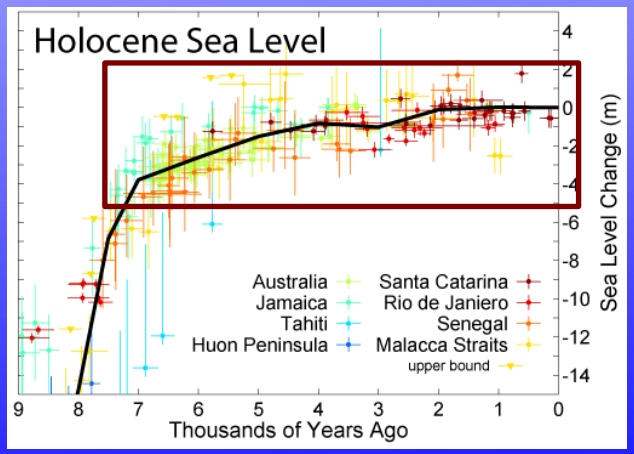
(Anderson, 2014) http://rice.gulf.edu

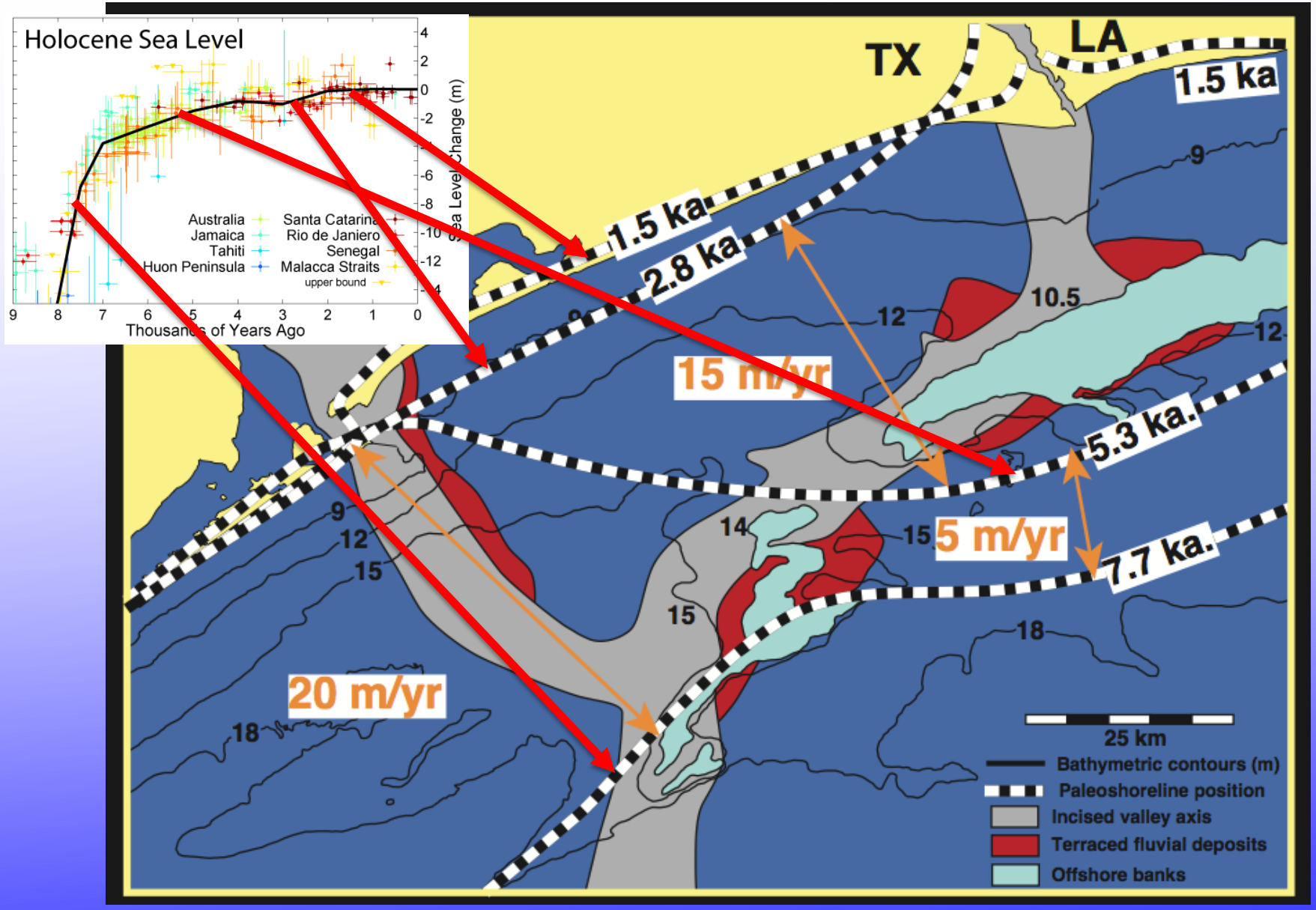


(Thieler et al., 2014)

Period when shoals formed

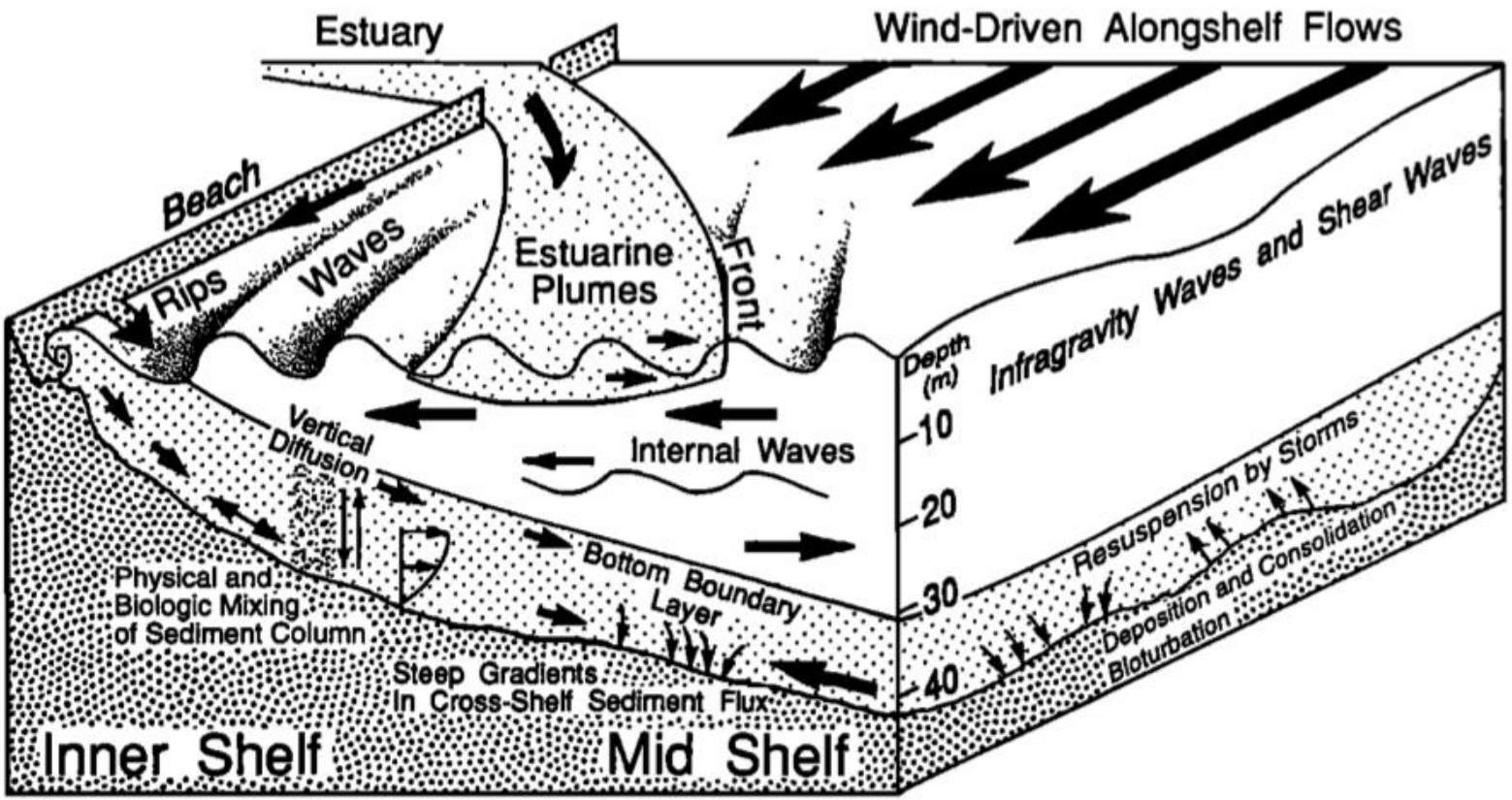






Shoreline change in western Louisiana and east Texas during the middle to late Holocene (modified from Gould and McFarlan, 1959; Thomas and Anderson, 1994; Rodriguez et al., 2004; Anderson et al., 2014)

Regional Physical Oceanographic Differences Between Shoals



Conceptual diagram illustrating the major physical processes responsible for across-shelf particulate transport (Nittrouer and Wright, 1994)

Shelf Morphodynamics

Physical Oceanographic Processes that control sediment transport and ultimately control the fluxes of sediment and shapes of the profiles of continental shelves:

1. Wind-driven along-shelf and across shelf flows (upwelling/downwelling)

1. Surface gravity waves

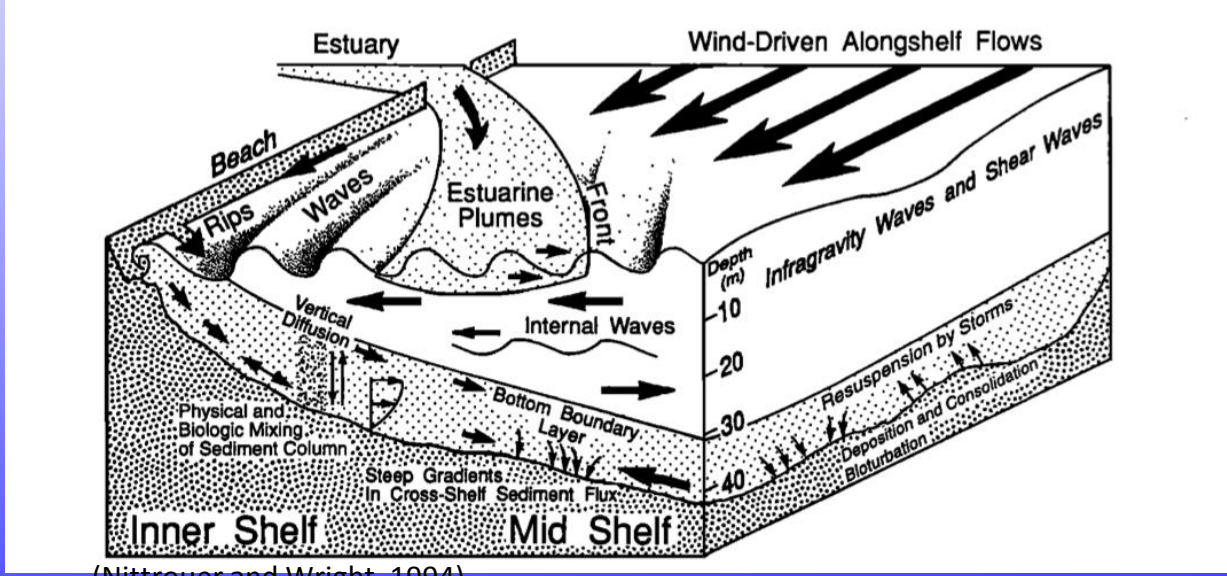
2. Tidal currents

3. Internal waves

4. Infragravity oscillations

5. Buoyant plumes

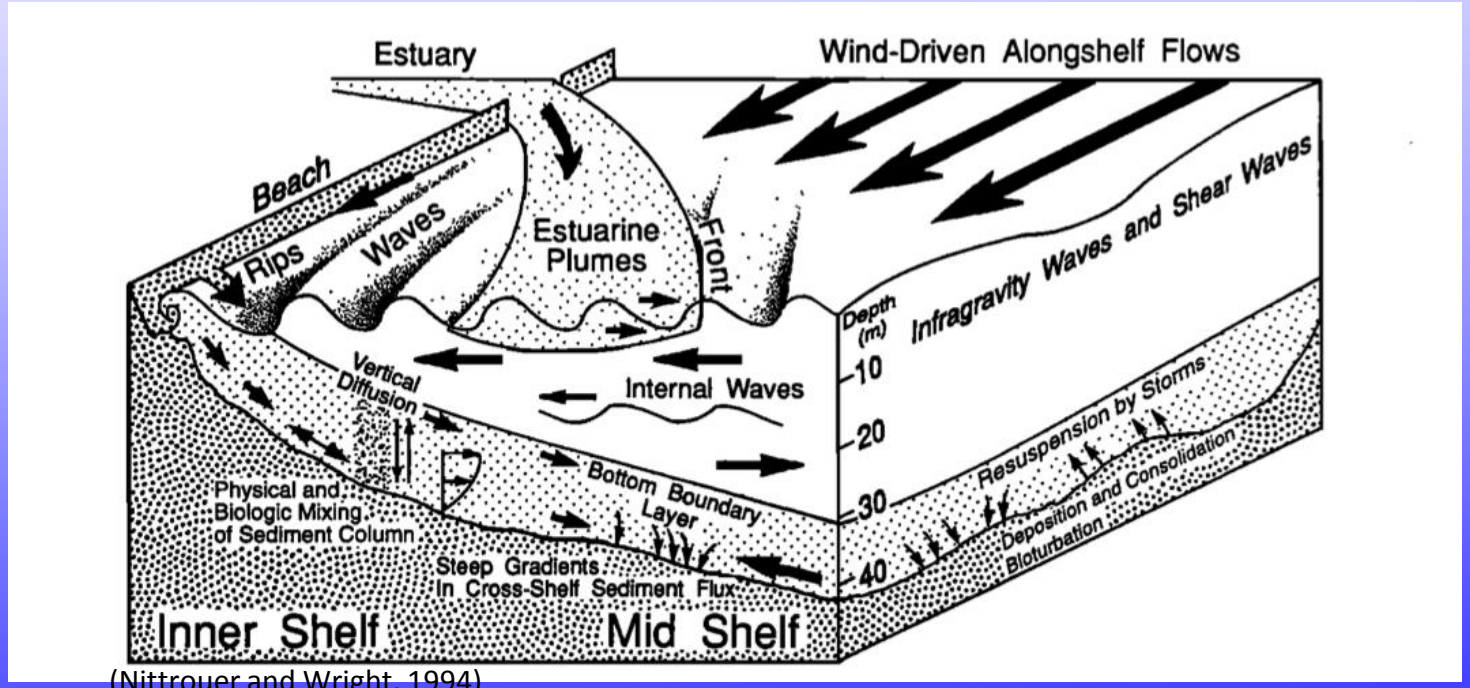
6. Wave-driven surf zone processes



(Nittrouer and Wright, 1994)

Shelf Morphodynamics-continued

- Process gradients are steep across inner shelf
- Relative intensities and net directions of the different types of flow change across shelf, with depth

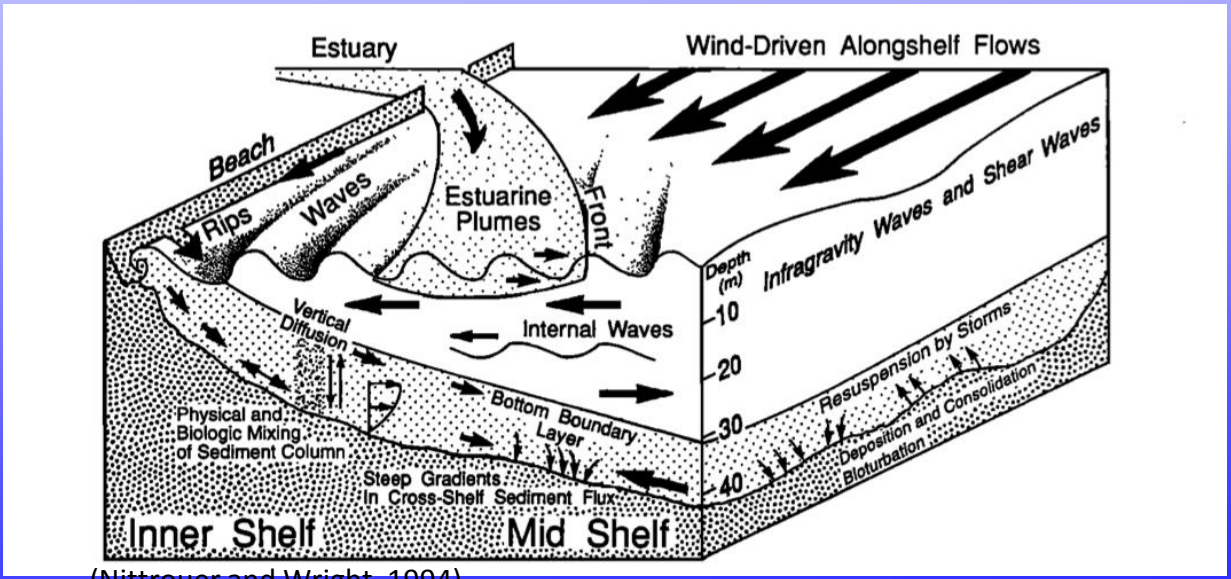


(Nittrouer and Wright, 1994)

Shelf Morphodynamics

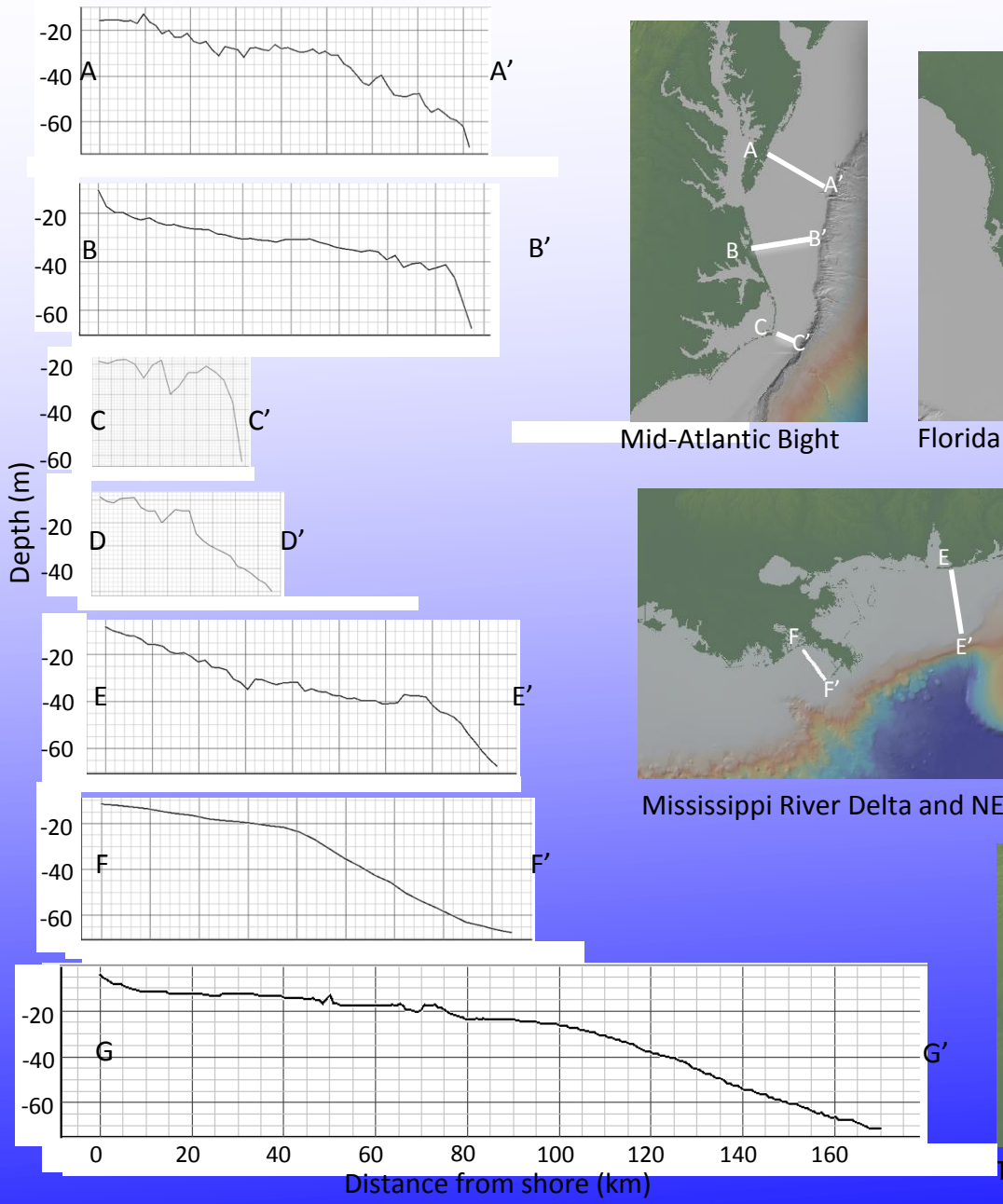
- Inner-continental shelf: from the seaward side of the surf zone (~2-3 m) to 30-50 m (Wright, 1995)

- Both coasts are:
  - passive continental margins
  - Wave dominated
  - Bathymetric profiles of the shelf are in an equilibrium "in balance" between input of wave dynamics and sediment transport



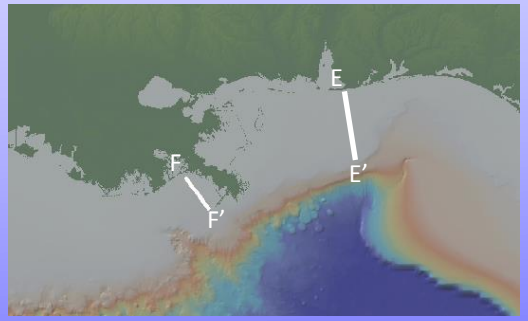
(Nittrouer and Wright, 1994)

Inner-continental Shelf Profiles of Major Shoal Areas

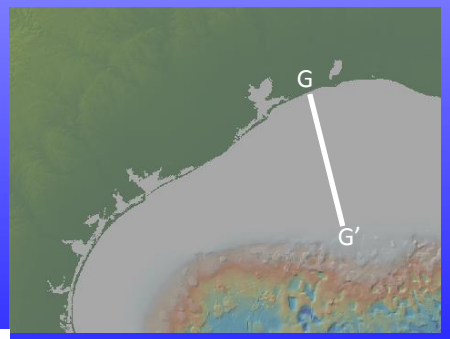


Mid-Atlantic Bight

Florida Atlantic Coast

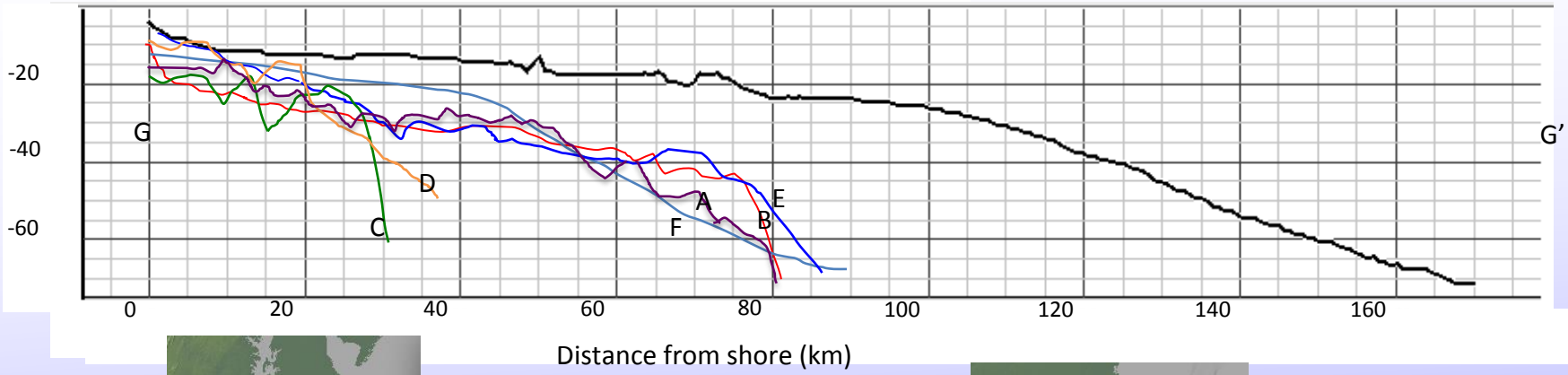


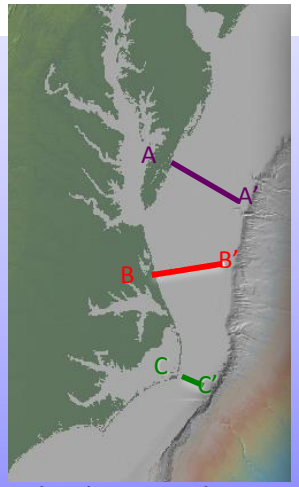
Mississippi River Delta and NE Gulf of Mexico



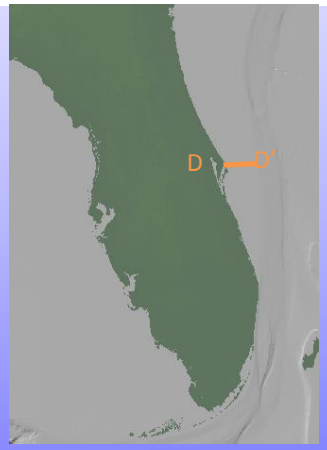
Texas-Louisiana Shelf NW Gulf of Mexico

Inner-continental Shelf Profiles of Major Shoal Areas

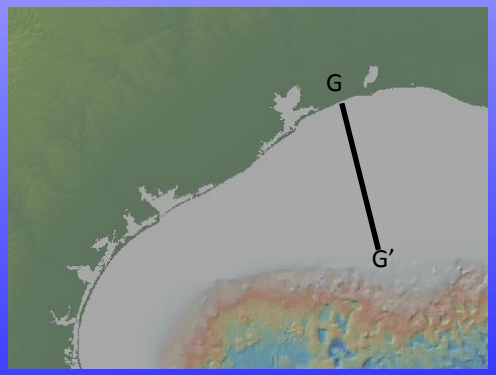




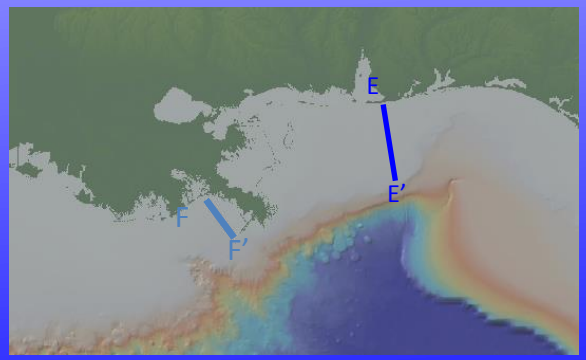
Mid-Atlantic Bight



Florida Atlantic Coast

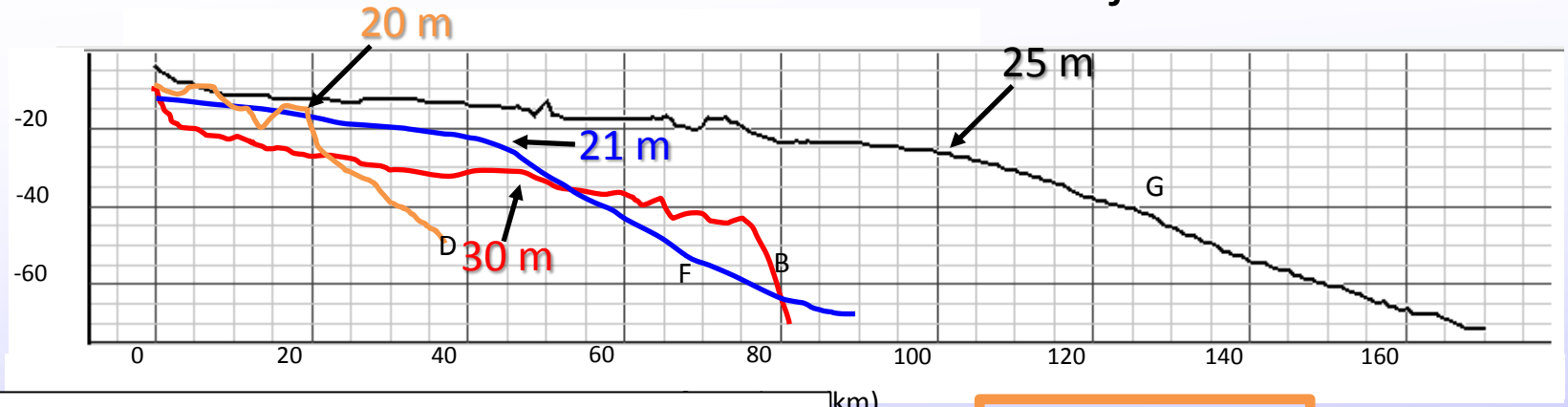


Texas-Louisiana Shelf NW Gulf of Mexico

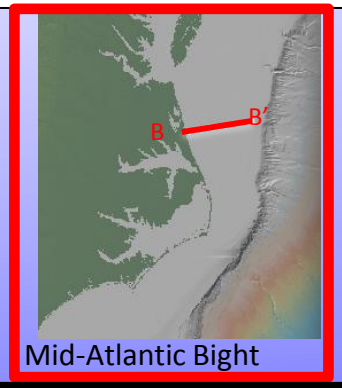


Mississippi River Delta and NE Gulf of Mexico

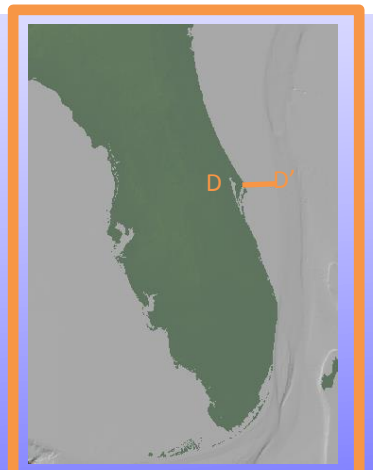
Inner-continental Shelf Profiles of Major Shoal Areas



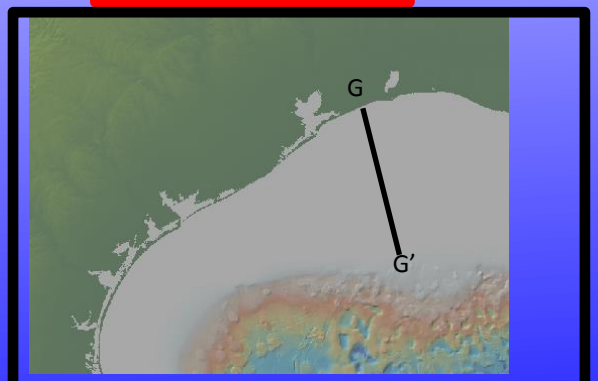
Break in slope represents position where wave orbital velocities become depth limited



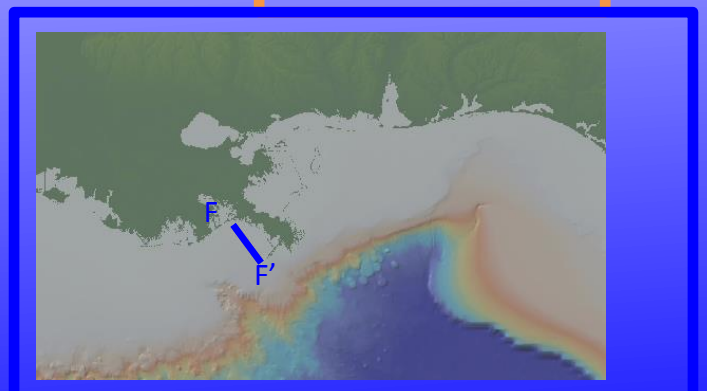
Mid-Atlantic Bight



Florida Atlantic Coast

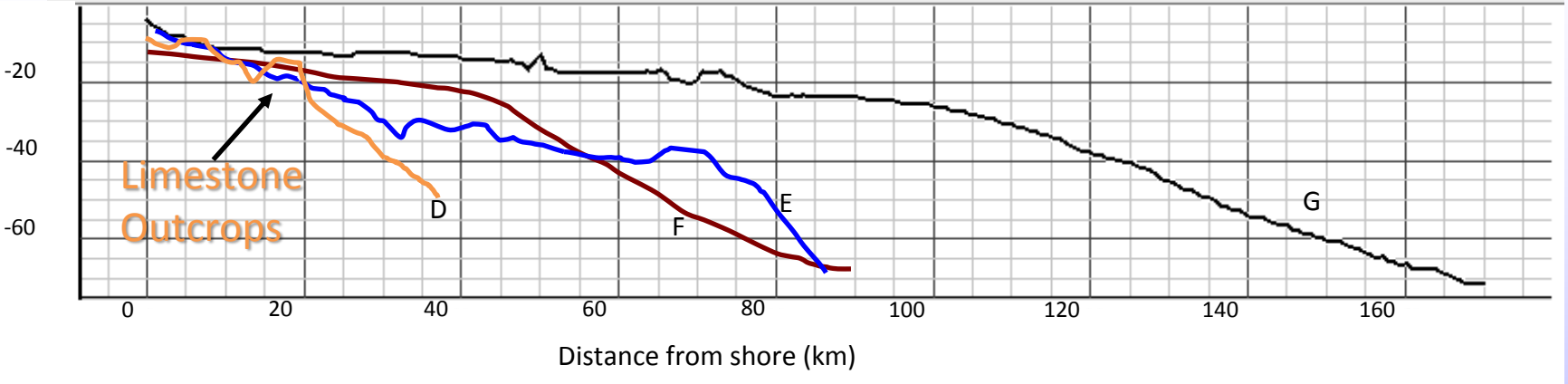


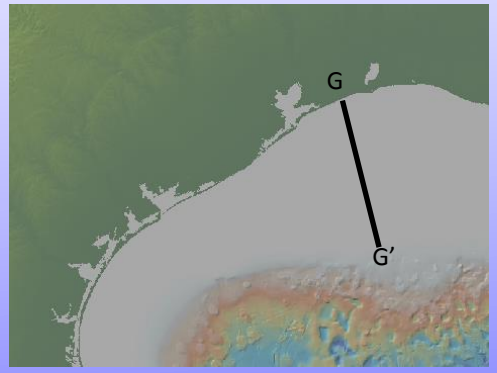
Texas-Louisiana Shelf NW Gulf of Mexico



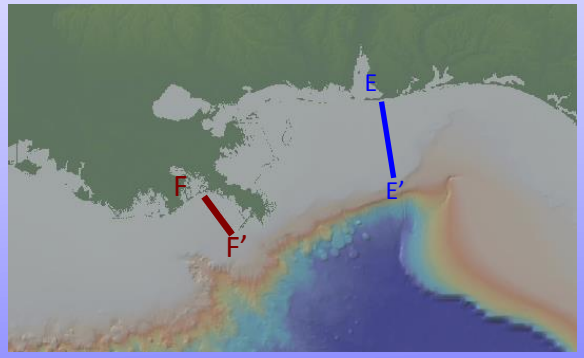
Mississippi River Delta and NE Gulf of Mexico

Inner-continental Shelf Profiles of FL and GOM

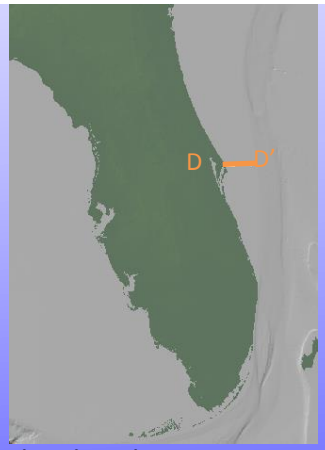




Texas-Louisiana Shelf NW Gulf of Mexico



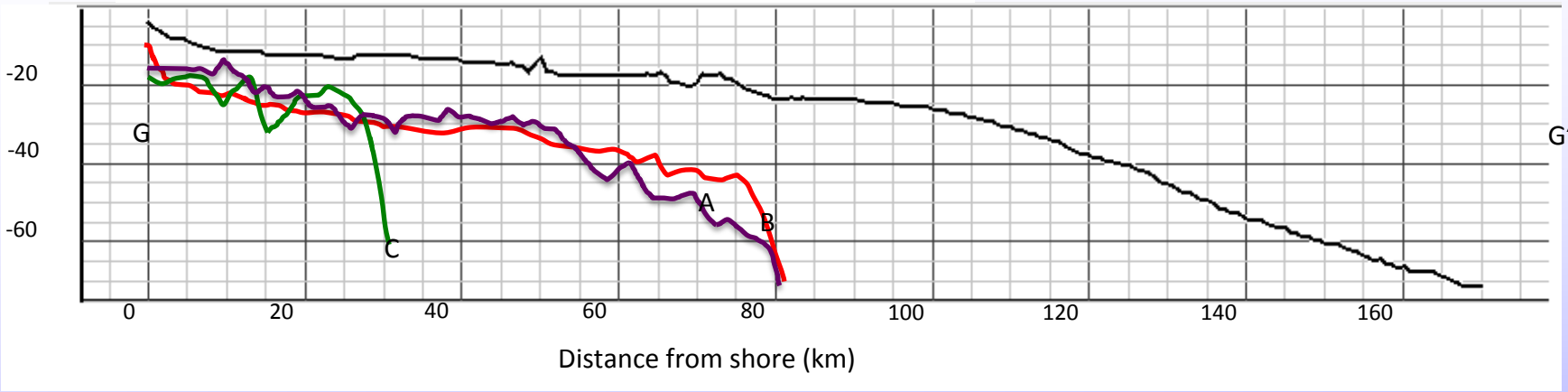
Mississippi River Delta and NE Gulf of Mexico

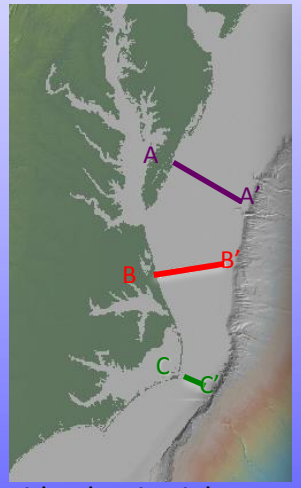


Florida Atlantic Coast

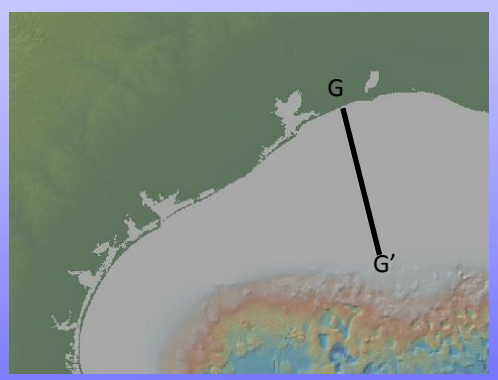
- Florida peninsula is a carbonate platform- limestone outcrops on shelf
- Overall, GOM shelf is wide and has much lower gradient slope than Atlantic
- Shelf widest and flattest at LA-TEX border
- Mississippi delta westward, shelf is mud dominated, only sand is on shoals
  - This is different than Atlantic shelf
- Wider shallower shelf means larger area within wave base during storms

Inner-continental Shelf Profiles of Outer Banks





Mid-Atlantic Bight



Texas-Louisiana Shelf NW Gulf of Mexico

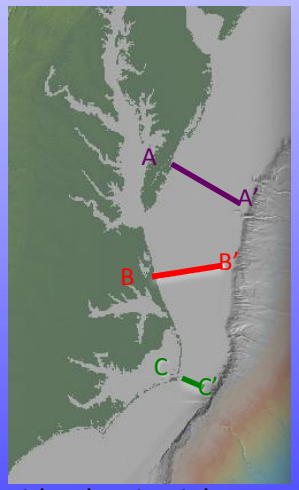
- Shelf slope much greater than central GOM
- Each profile has comparable slope
- Major differences between profiles is width of shelf
- C-C' shape largely controlled by Cape Associated Shoals

Regional Physical Oceanographic Differences Between Shoals

Atlantic Coast vs Gulf of Mexico

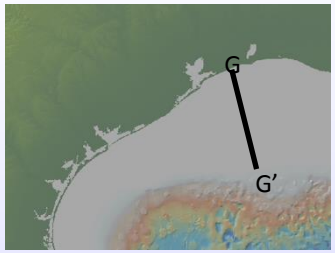
Atlantic Coast

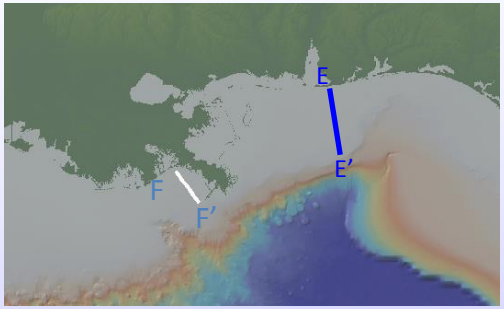
- Passive margin
- Weak tidal flow
  - When combined with wind can result in high bed stress and erosion
- Storm dominated
  - Wind driven wave resuspension
    - Extratropical storms
      - Northeasterns-winter storms
      - Strong on shore component
    - Hurricanes-normally generate smaller waves than northeasterns
      - Storm impact variable depending on strike direction



Mid-Atlantic Bight

Regional Physical Oceanographic Differences Between Shoals





Gulf of Mexico

- Passive margin
- Weak tidal flow
- Processes different east and west of Mississippi Delta
  - Storm dominated Wind driven wave resuspension
    - Extratropical storms
      - Winter storms-northern fronts
        - Average- 46 cold fronts per year
      - Eastern Gulf
        - Weak onshore component- fetch limited impacts minimal
      - Northwestern Gulf- greater impact-further south, as orientation of the coast changes
    - Hurricanes- major source of energy for erosion and sediment transport
      - Single event can create 50-100 years or more of “fairweather” erosion
      - In Texas, average of a storm strike somewhere along the coast every 1.5 y, with same location averaging a strike every 25 y

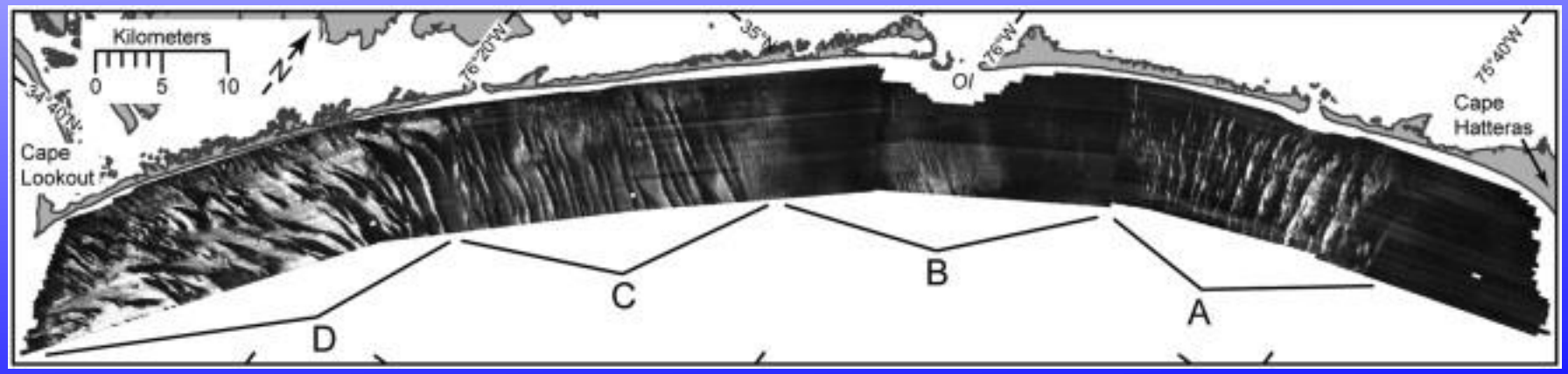
- Proximal to Mississippi Delta-river plume creates stratified water column, reduces shelf wave energy

Shoal Definitions

Shoal- natural, underwater ridge, bank, or bar consisting of, or covered by sand or other unconsolidated material rising from the bed of a body of water to near the surface.

For middle Atlantic and across northern Gulf of Mexico, offshore shoals are sedimentary deposits, typically sand or gravel dominated (Finkl and Hobbs, 2009).

Shoal complex- more than one shoal



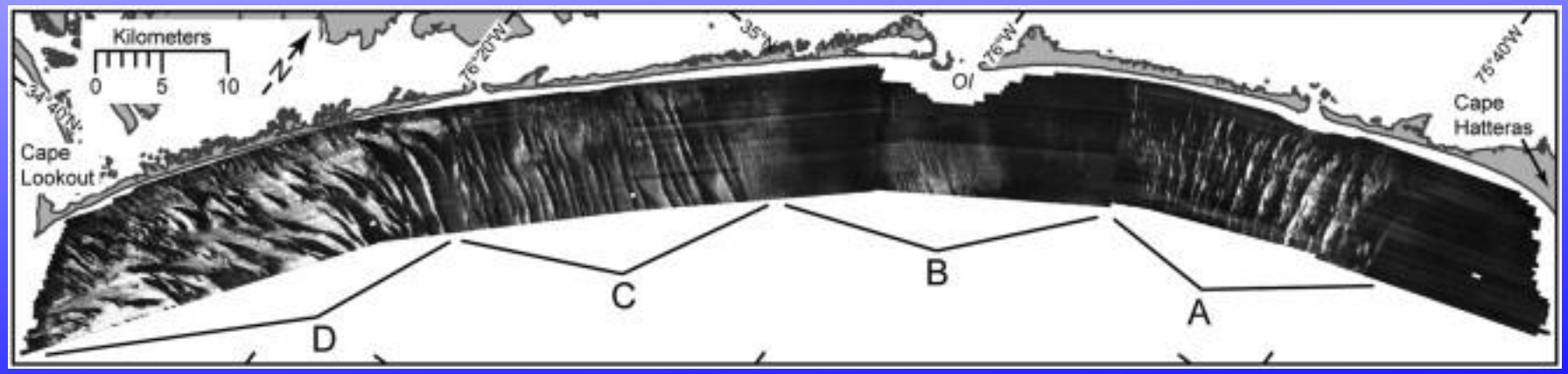
Shoal Types

For the middle Atlantic and northern Gulf of Mexico Inner-continental shelf, shoals can be subdivided into three broad categories:

1. Shoals associated with stranded coastal Holocene sedimentary deposits

2. Active and relict Cape Associated Shoals

3. Sorted Bedforms

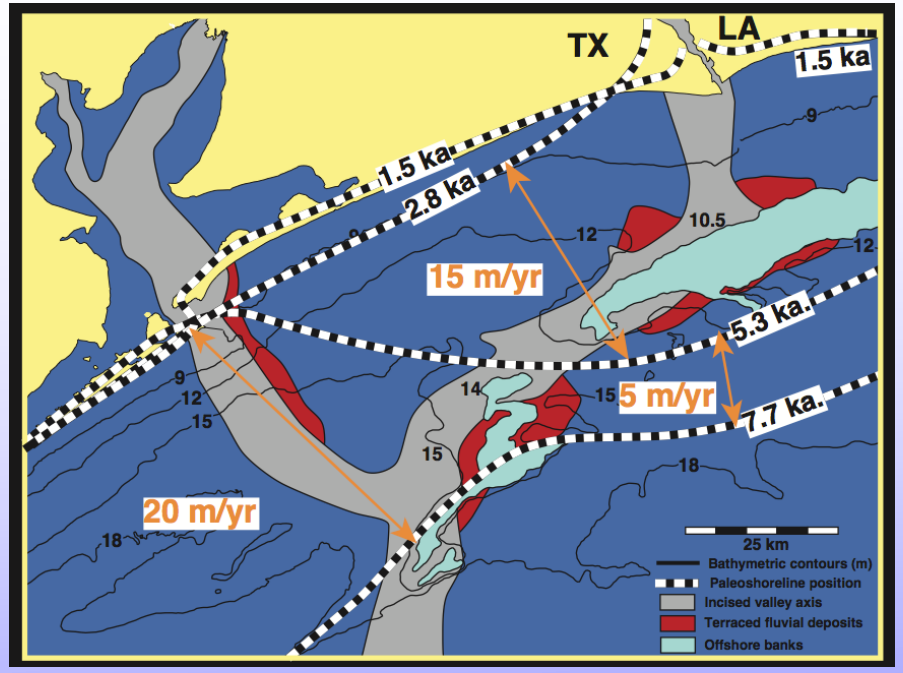


Shoals associated with stranded coastal Holocene sedimentary deposits- Gulf of Mexico style shoals

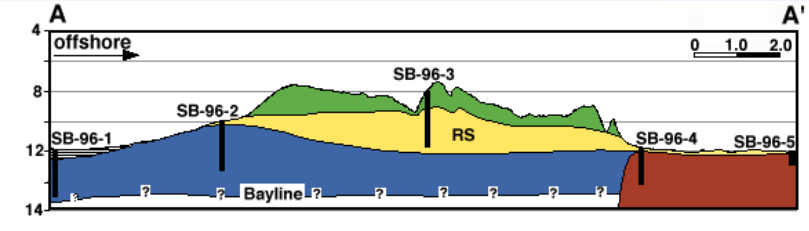
- Formed from stranded/relict coastal deposits
- Exposed by ravinement
  - Ravinement-erosion to wave base of inner continental shelf during sea level rise
    - Typically removing upper 5-7 m of original deposit
    - Deposit is what is left after ravinement

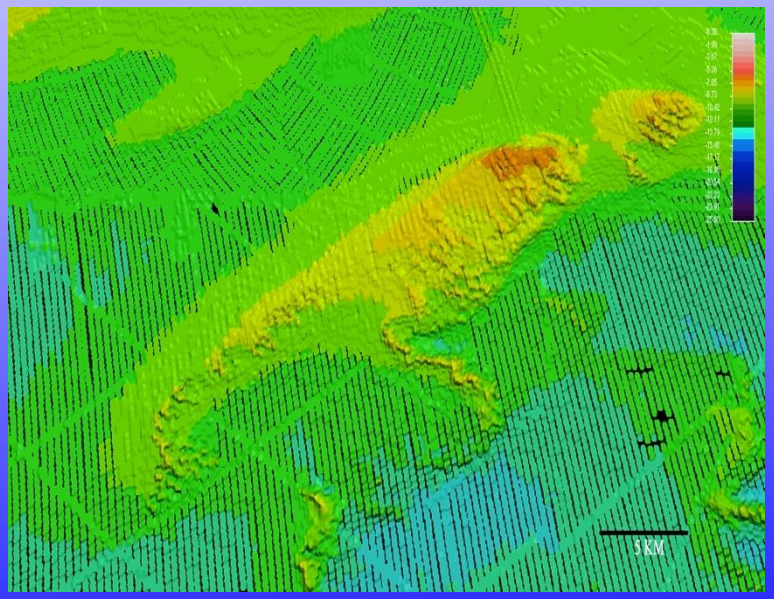
- Shoal that are deposits proximal to and sourced from stranded Holocene deposits
  - Direct linkage between shoal and deposit

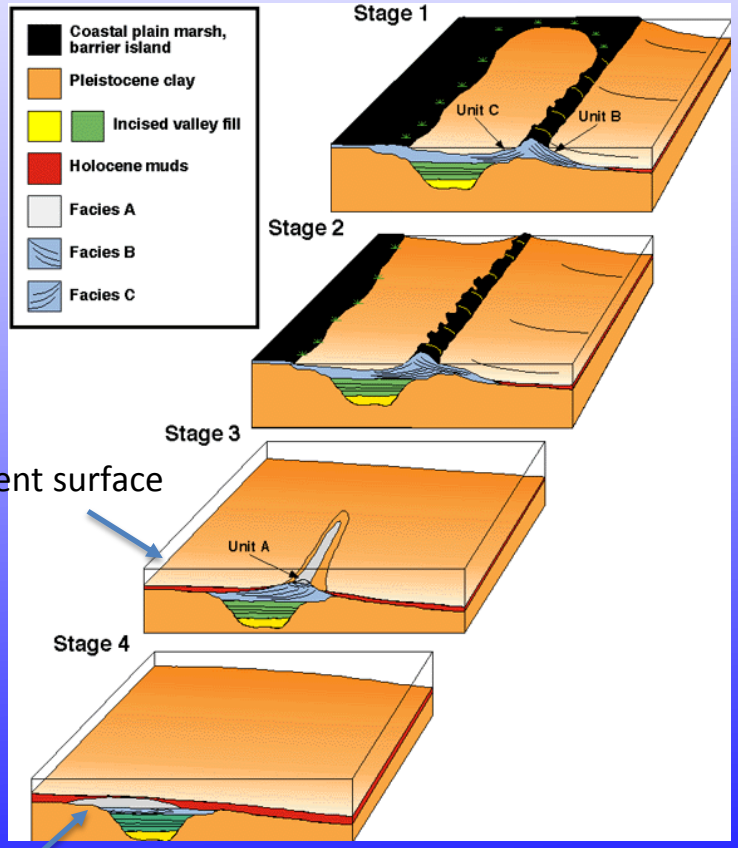
Sabine Bank- Classic example of stranded Holocene deposit



638 x 10^6 m^3 of sand (Dellapenna et al., 2010)



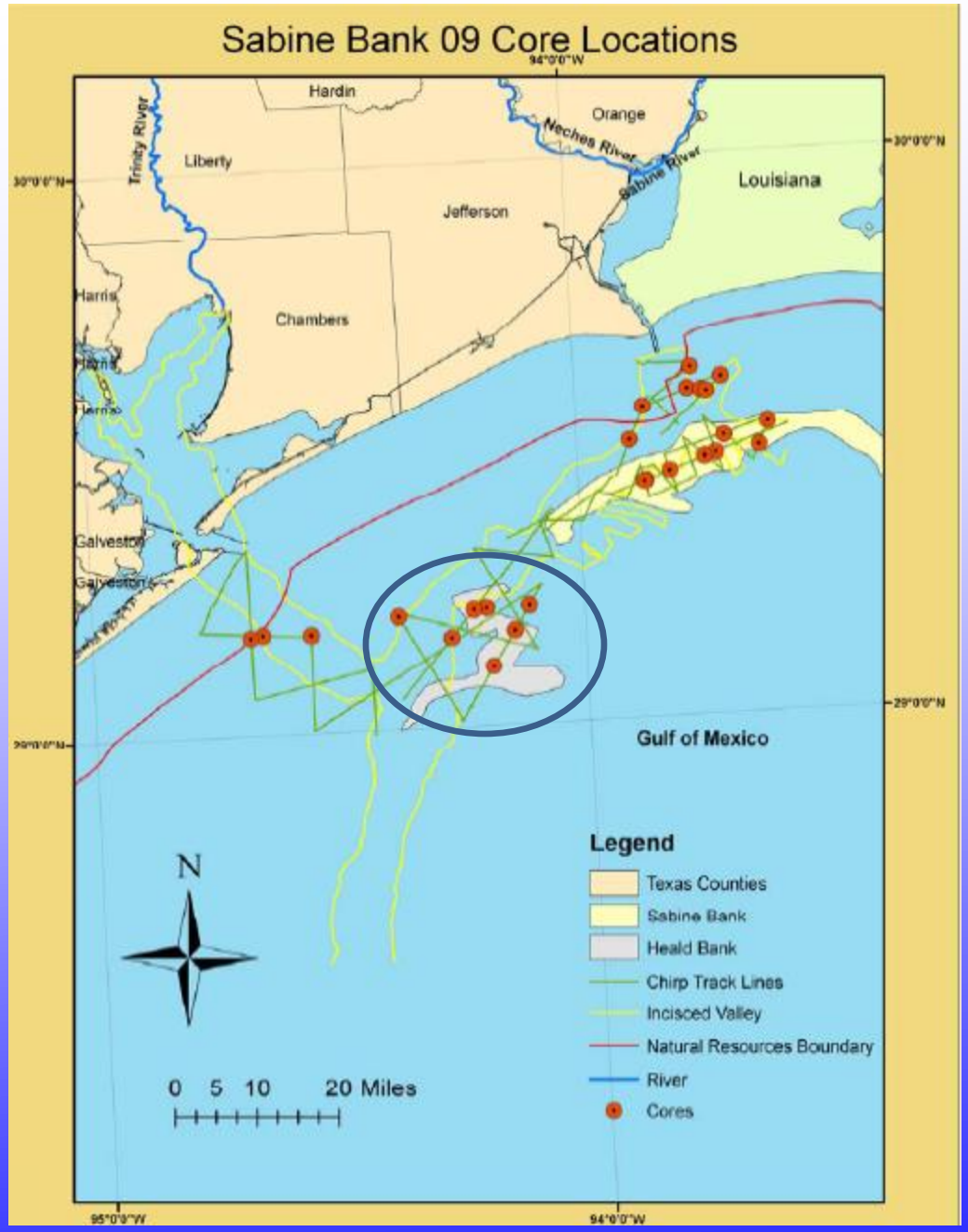


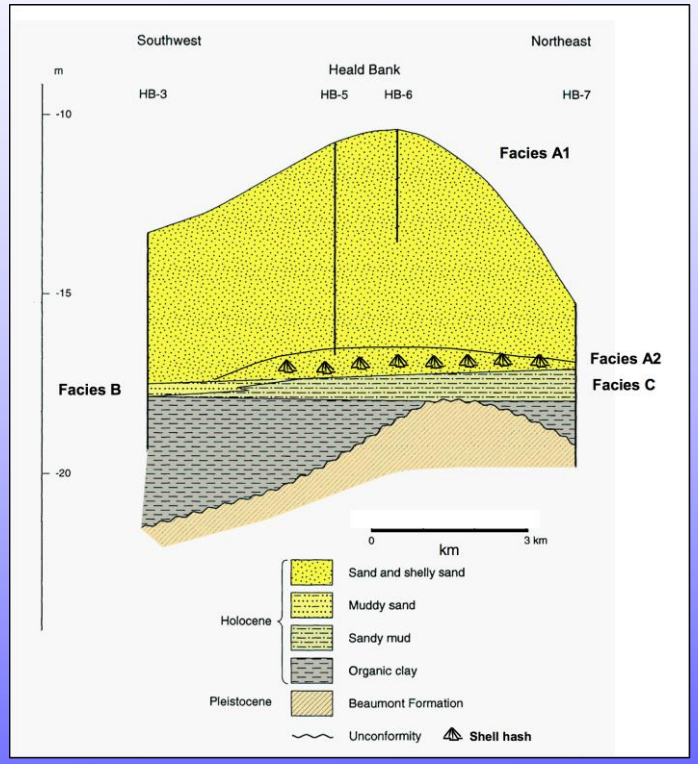


Ravinement surface

Shoal after ravinement

Heald Bank

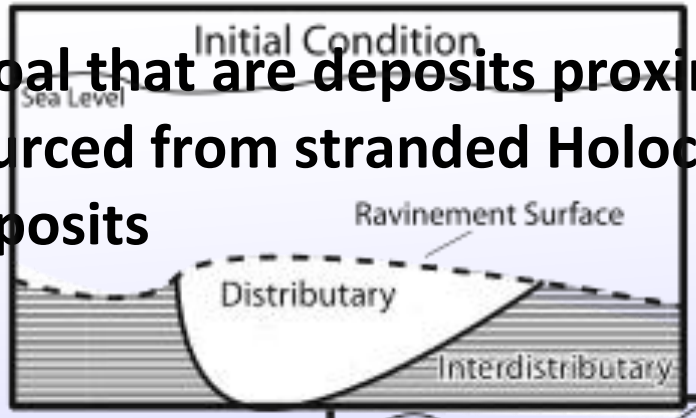


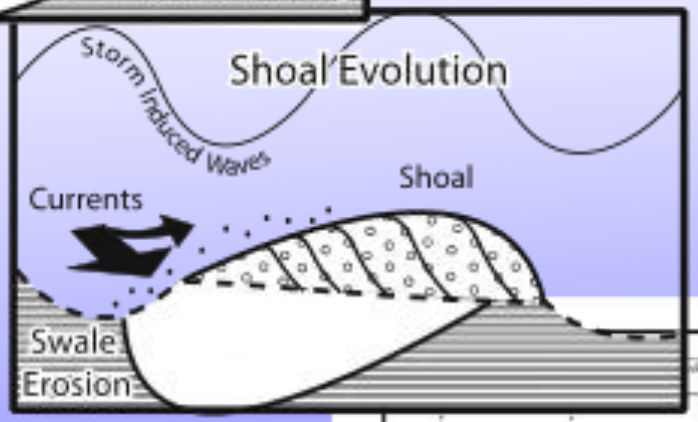


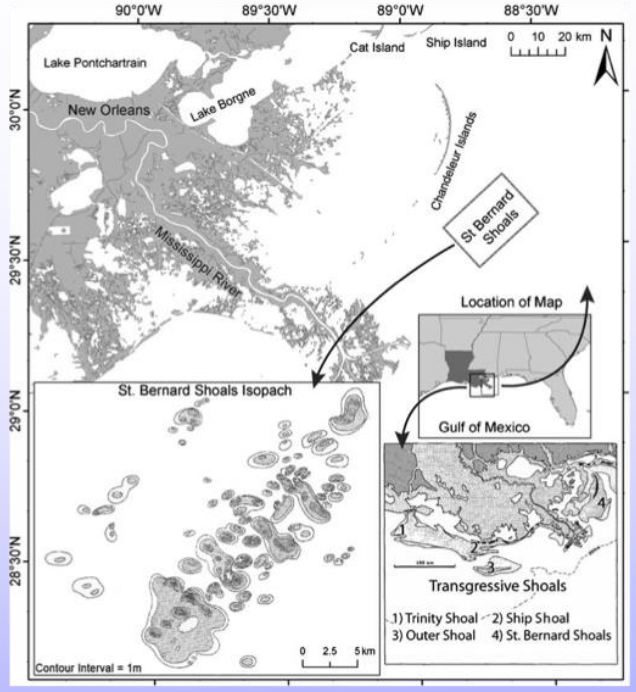
- Relict Holocene Bayhead delta

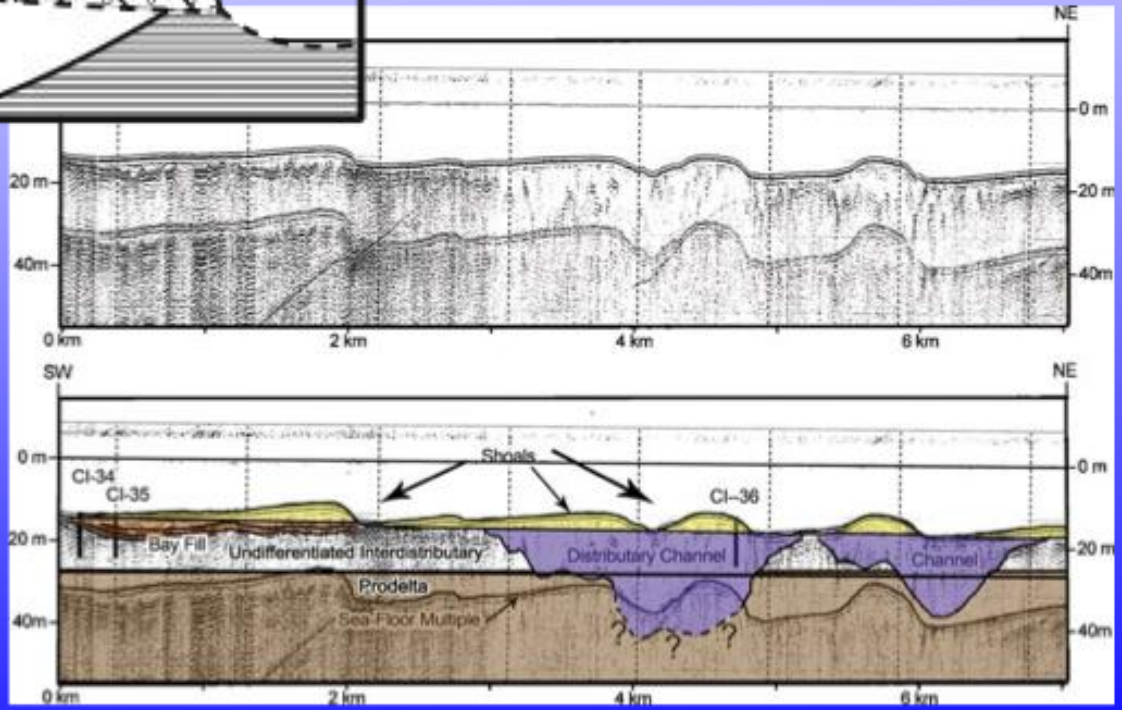
81×10^6 m^3 of sand
(Dellapenna et al., 2010)

Shoal that are deposits proximal to and sourced from stranded Holocene deposits

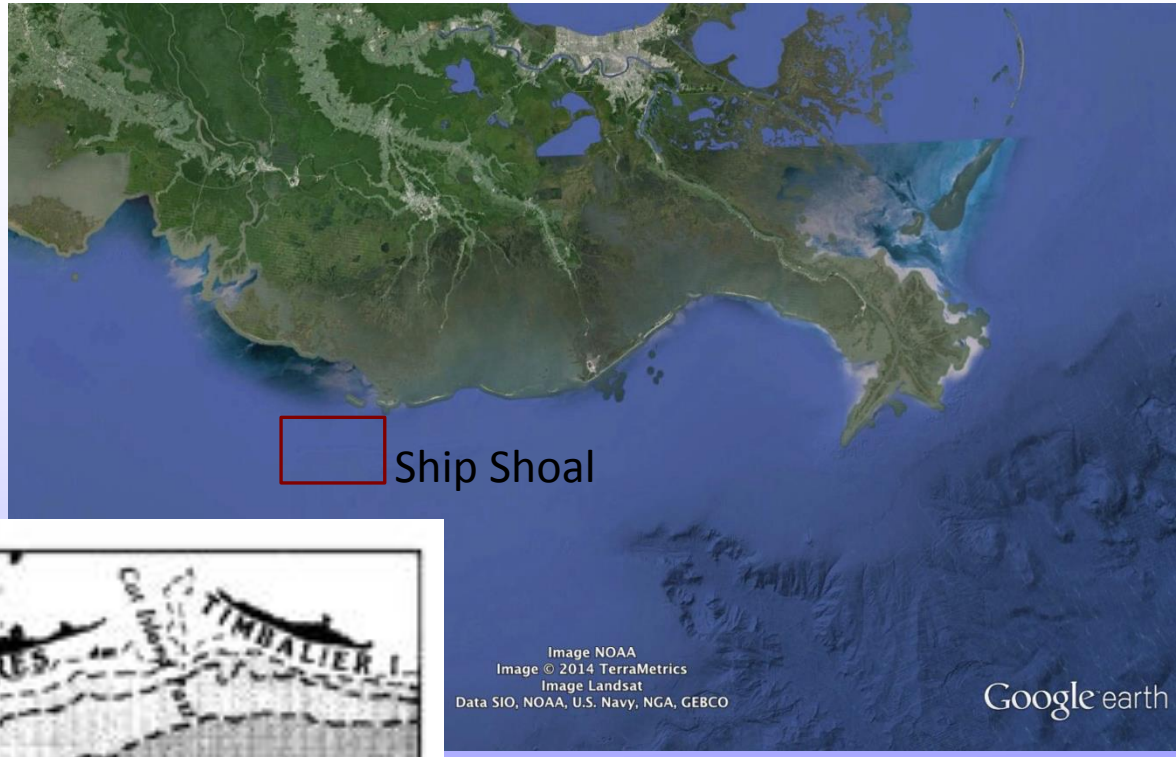


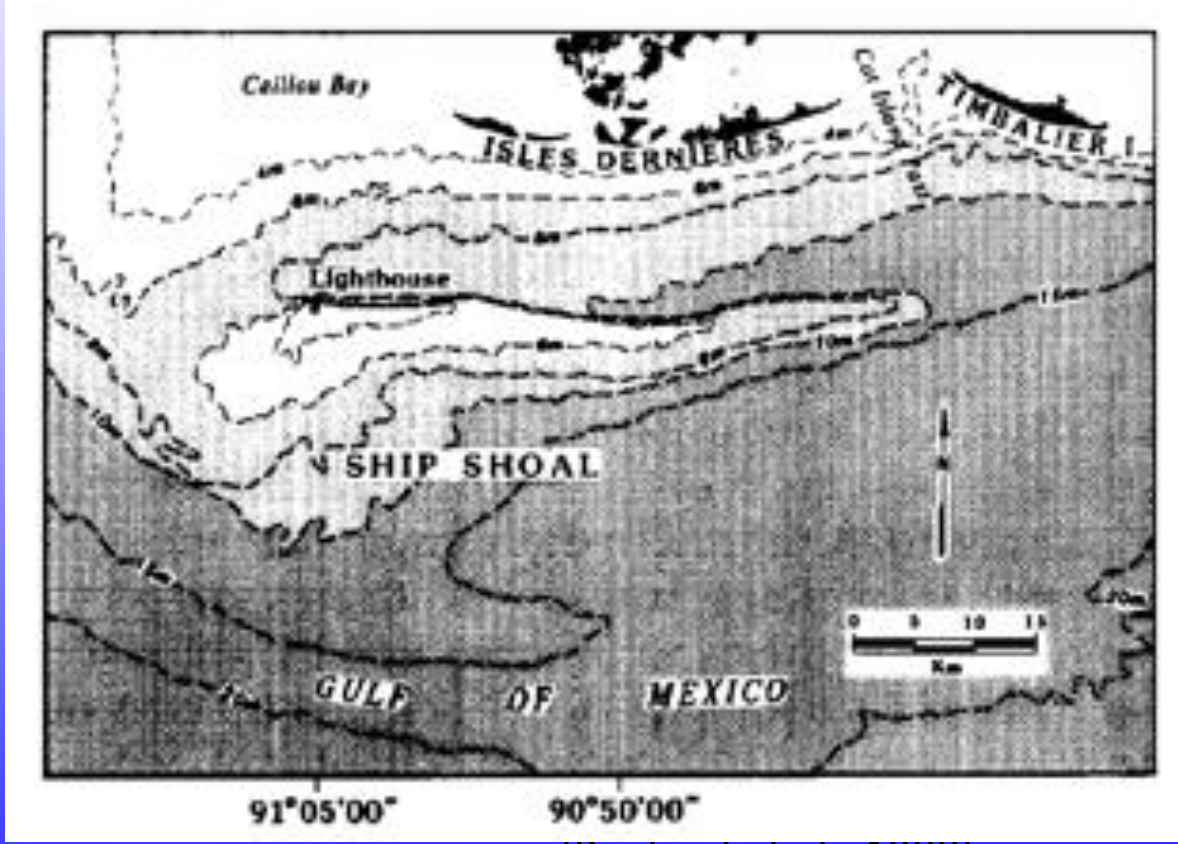






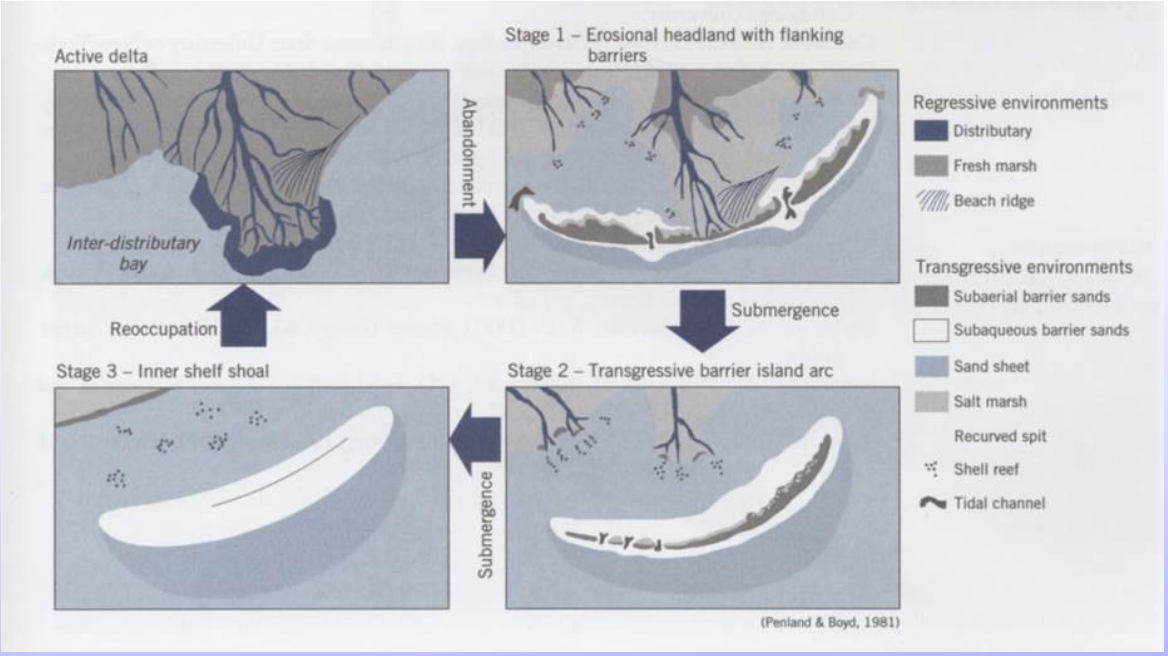
(Rogers et al., 2009)

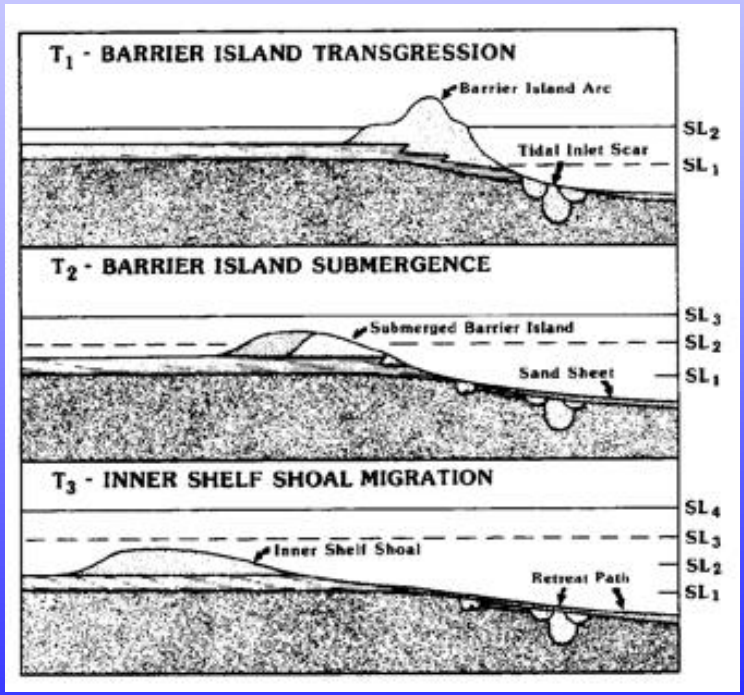


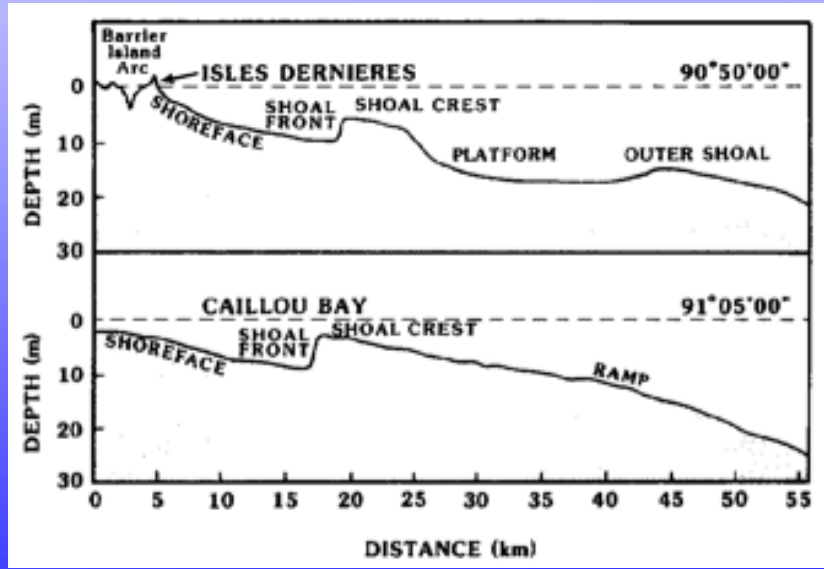


(Penland et al., 1988)

Ship Shoal Model

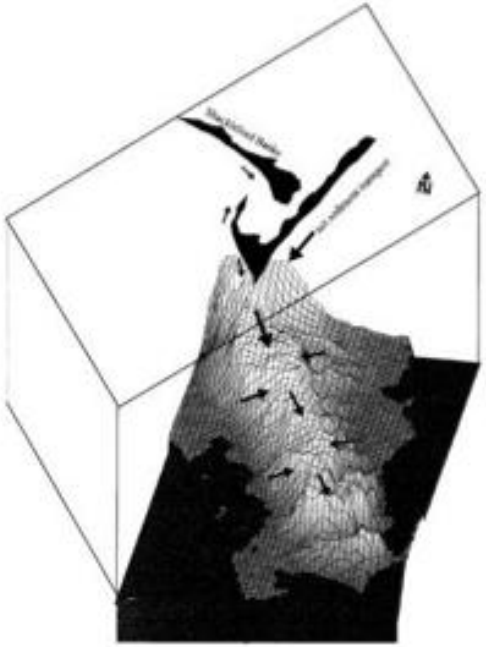


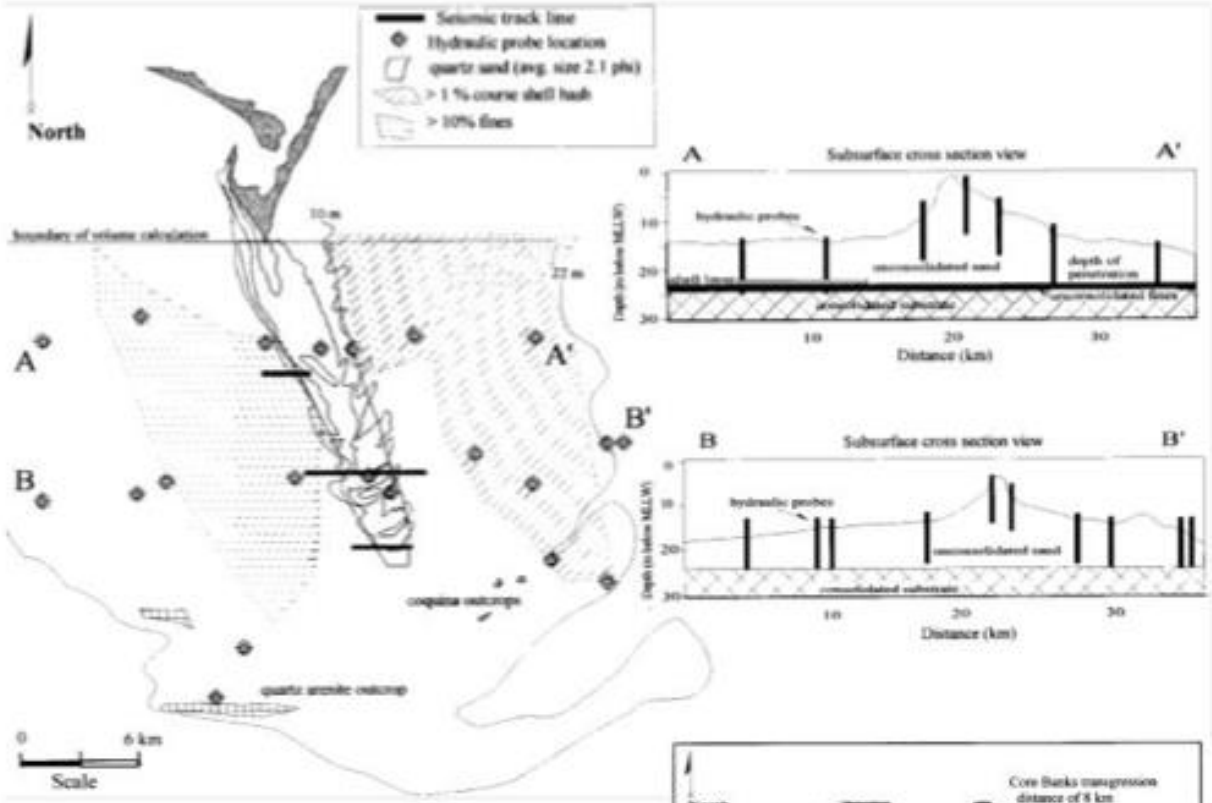


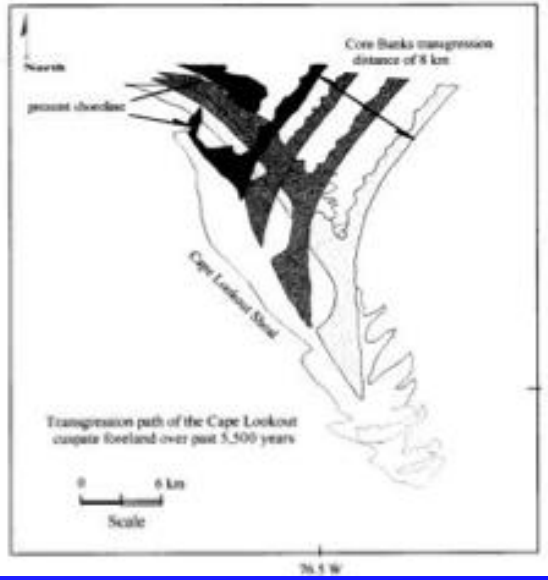


(Penland et al., 1988)

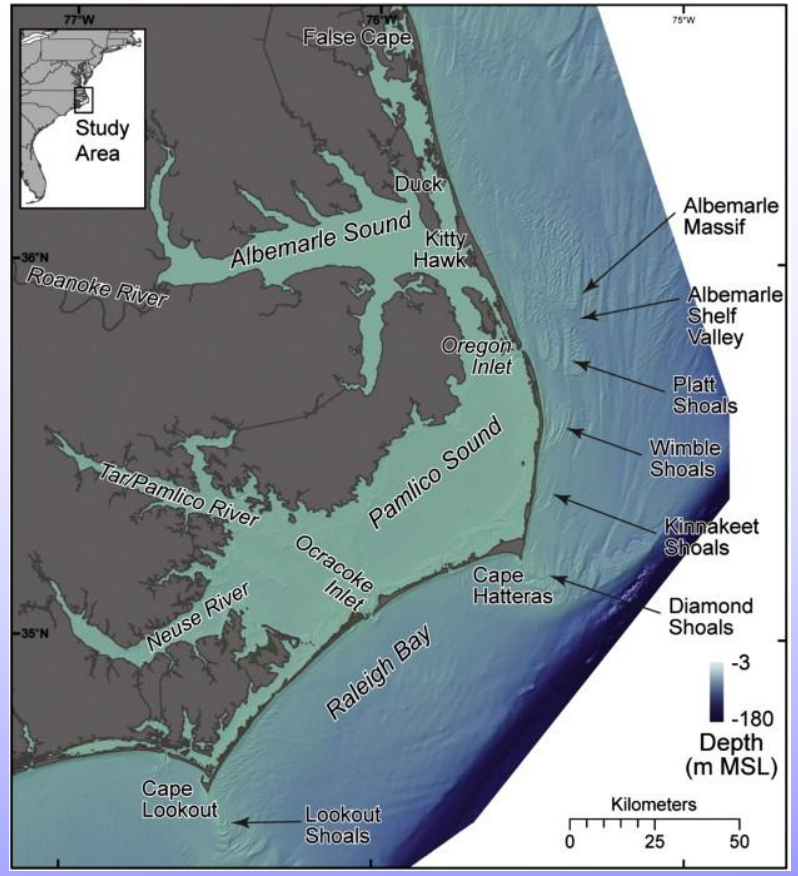
Cape associated shoal: Cape Lookout Shoal- North Carolina



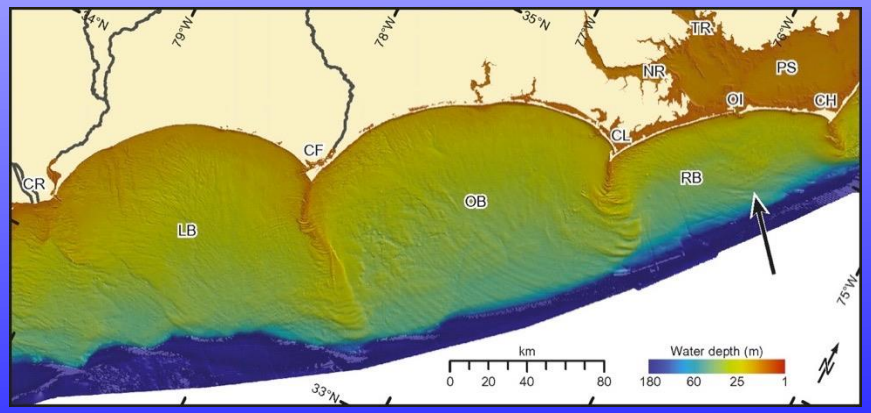




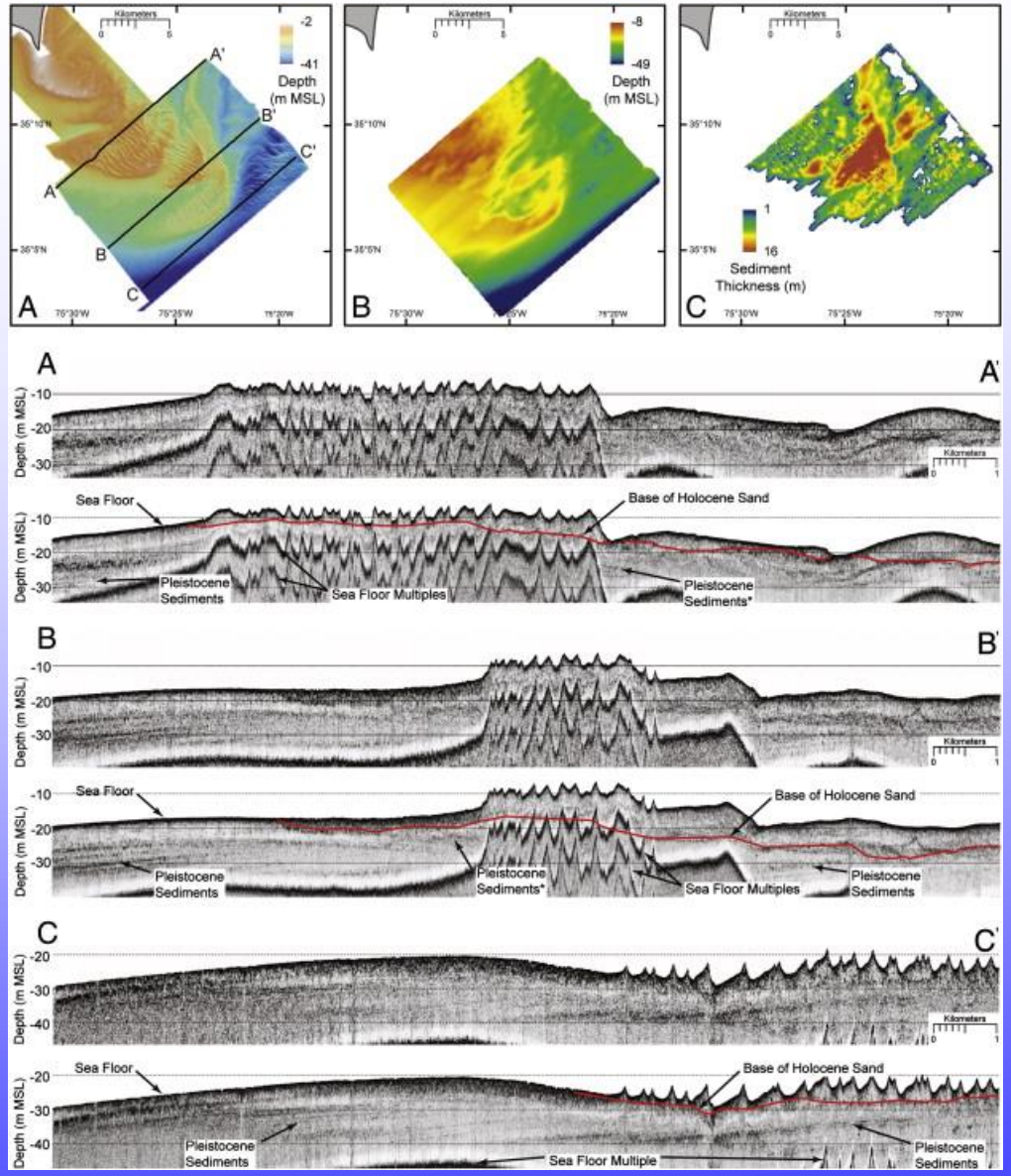
- Cuspate capes result form convergence of longshore drift
- Cape shoals form from offshore transport of the longshore drift
- String of progressively younger shoals form as a result of landward retreat of cape (McNinch and Wells, 1999)



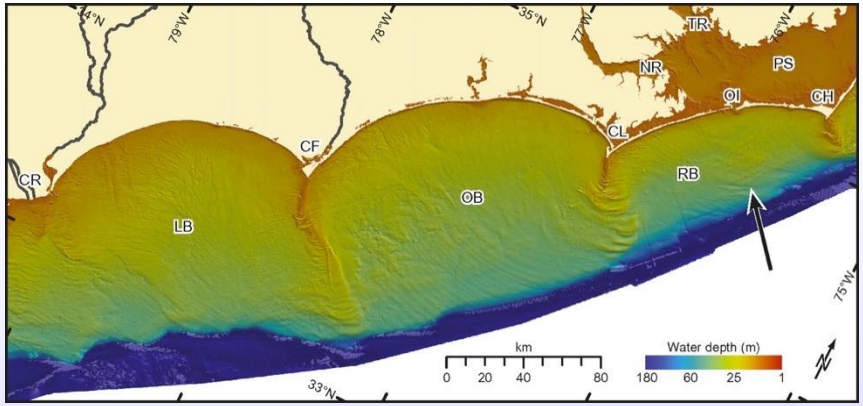
(Theiler et al., 2014)

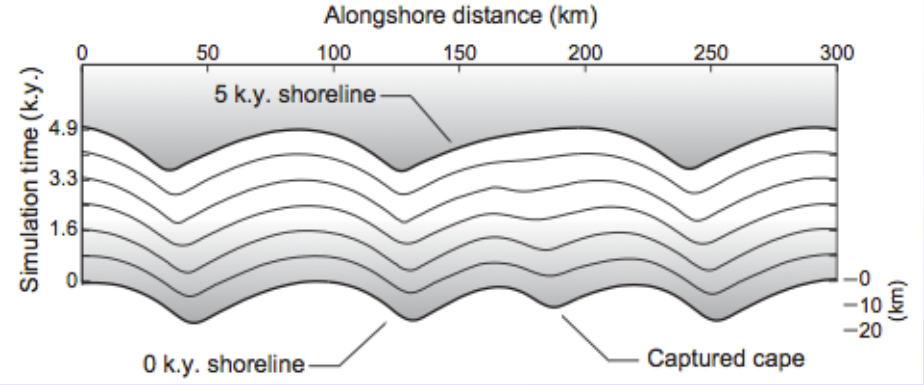


(Theiler and Ashton, 2010)

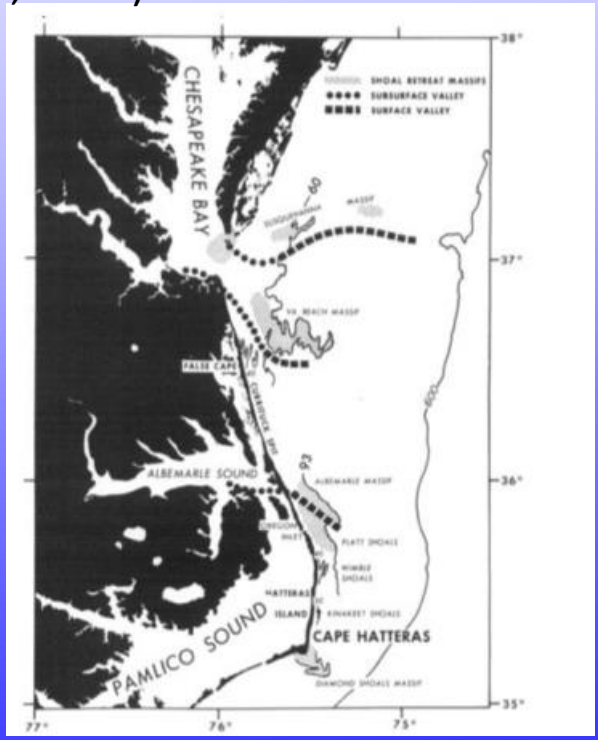


(Theiler et al., 2014)

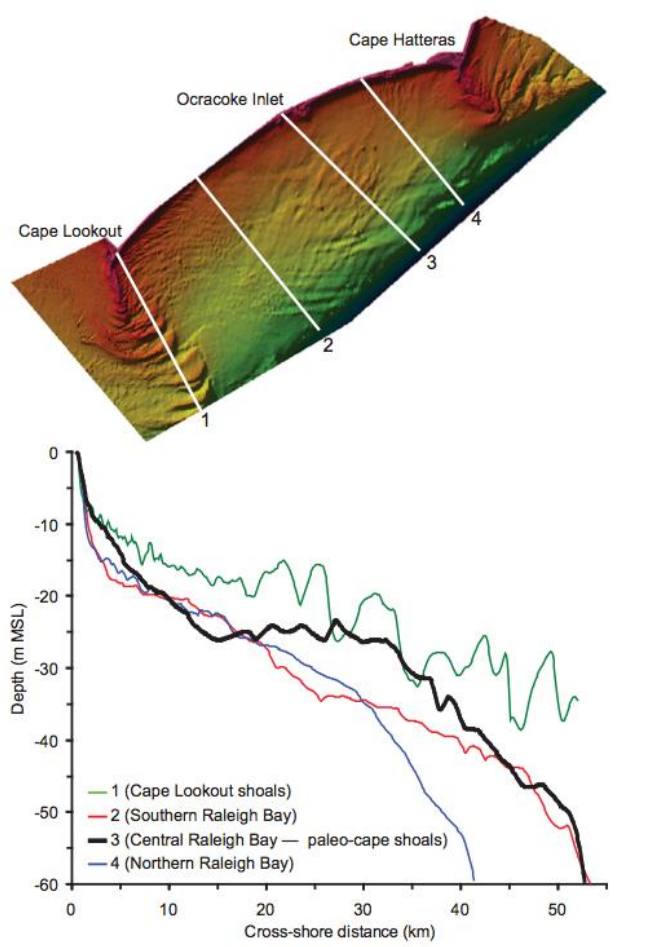




Retreat Massif Shoals (aka Swift et al. (1978) = Abandoned Cape Associated shoals (Thieler and Ashton, 2010)



(Swift et al., 1978)

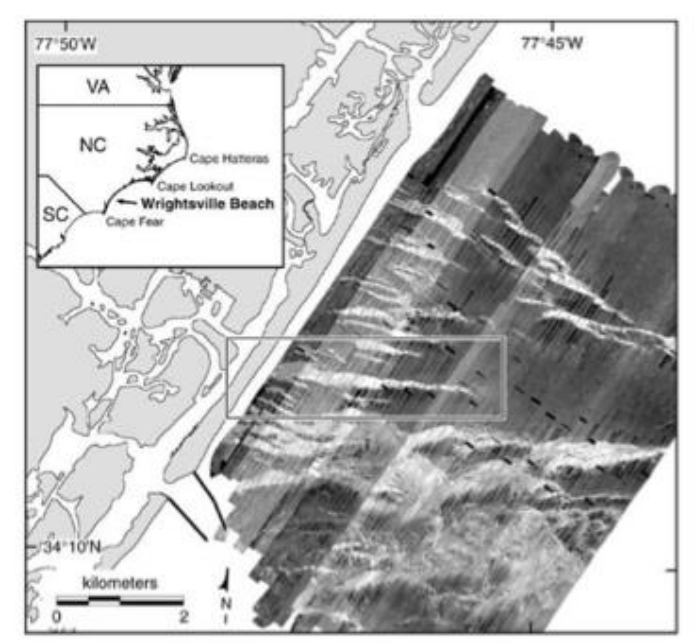


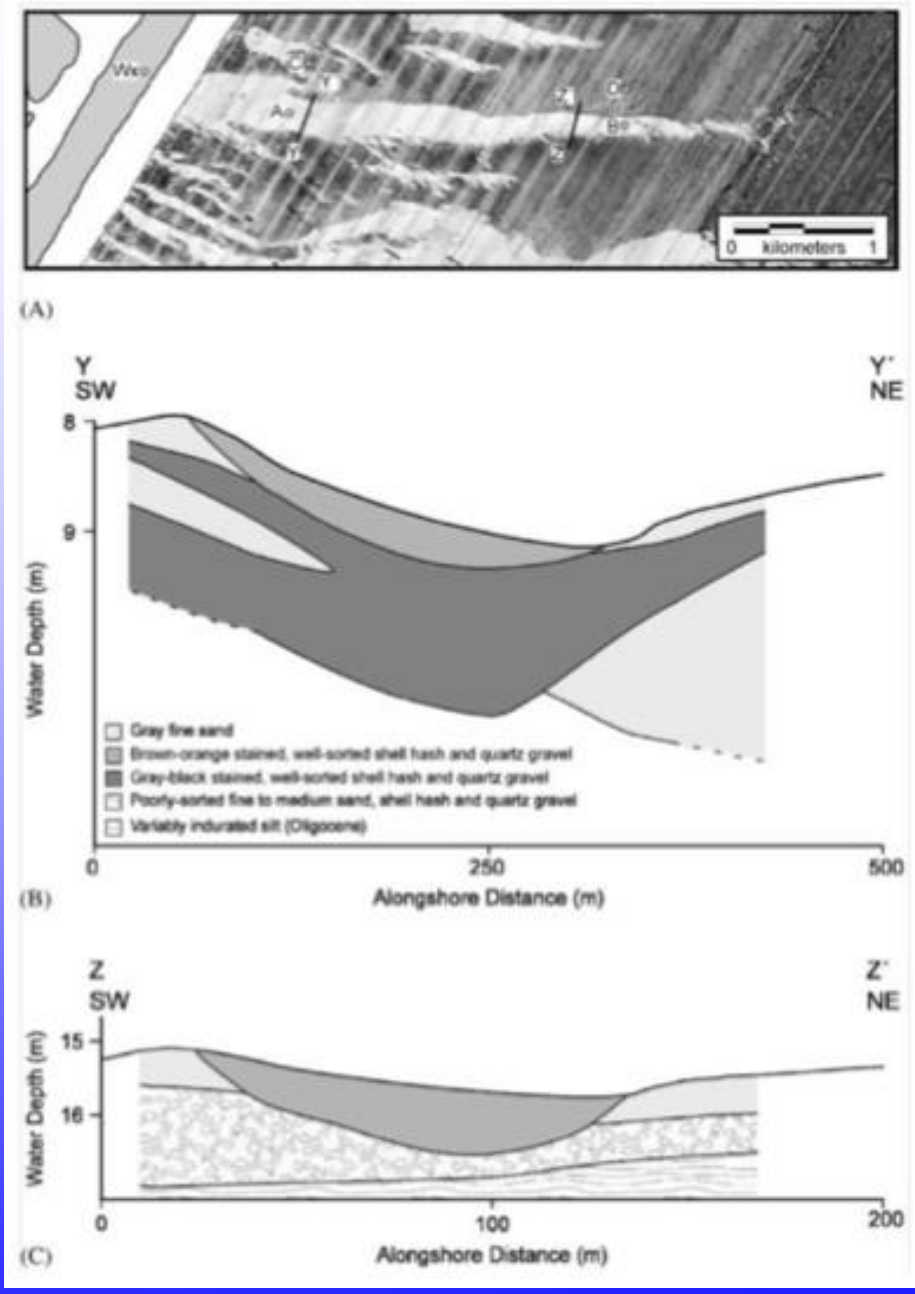
(Theiler and Ashton, 2010)

Sorted Bedforms-

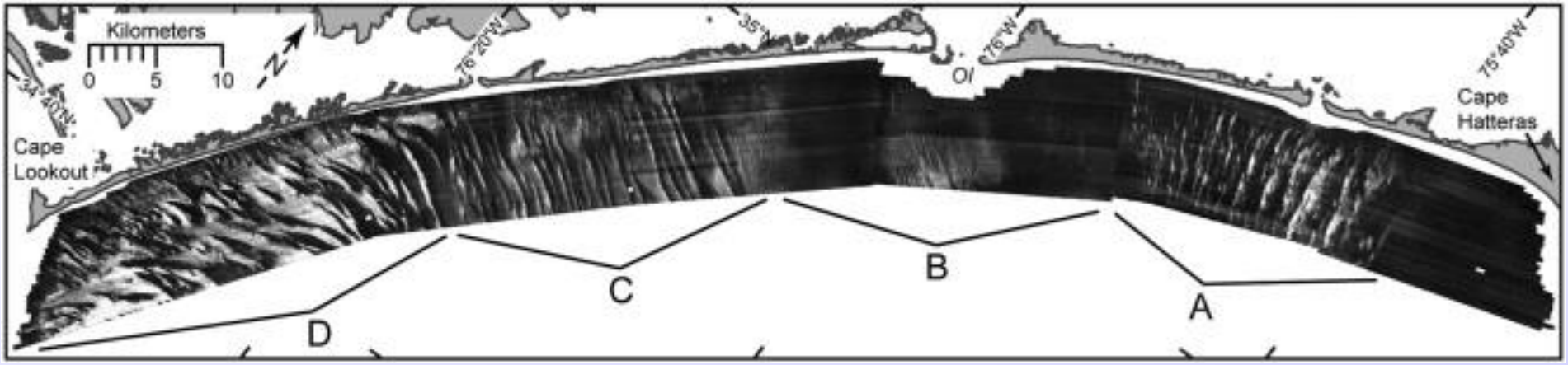
Also called rippled scour depressions

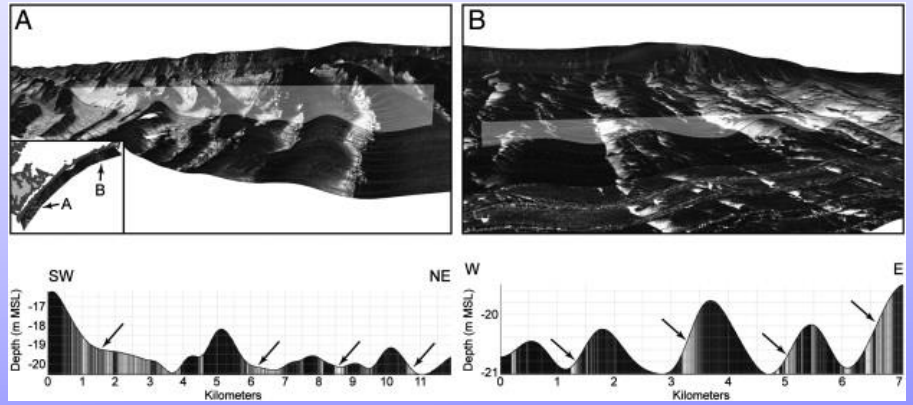
- Symmetrical to asymmetrical
- Coarser flanks facing updrift, into direction of dominant suspended sediment transport
- Ridges between troughs are composed of finer sediment (fine sands and muds)
- Low relief features (~1m)
- Trough widths 100-200 m





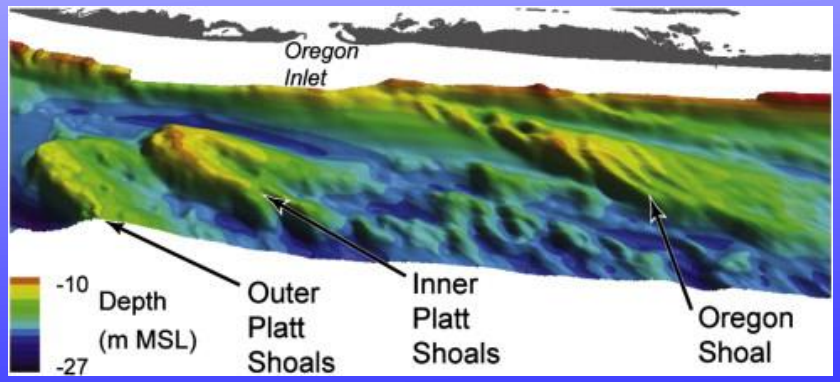
(Guitierrez et al., 2005)

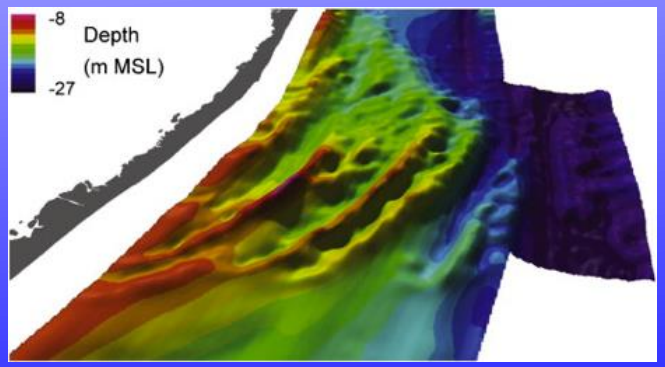




- Thieler et al., 2014 reveals/suggests that:
  - Sorted Bedforms
  - Ridge and swale
  - Ridge and trough
  - Shore attached and detached ridges

  All part of a continuum of shelf deposits

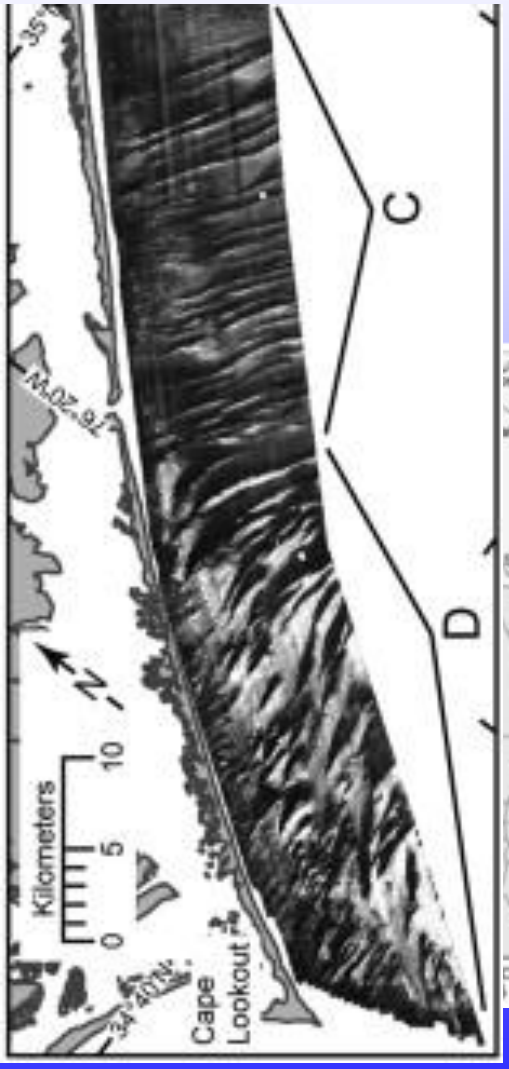




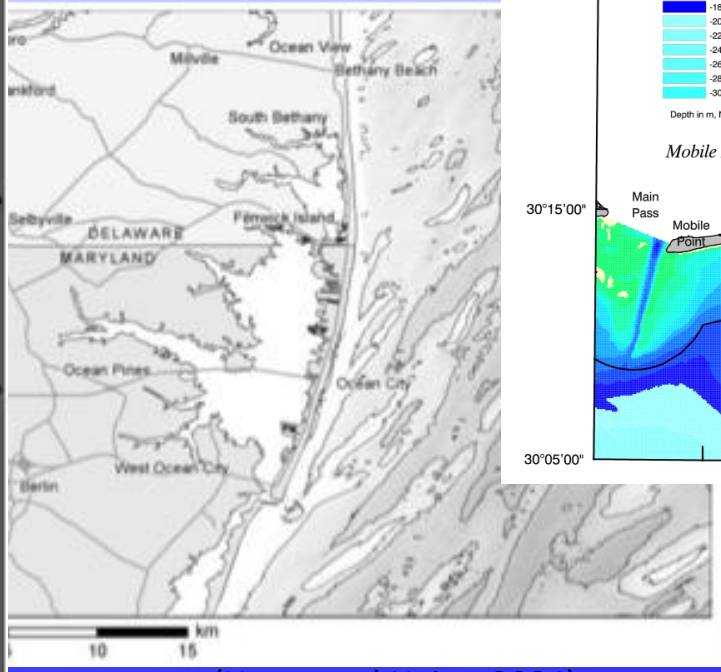
(Theiler et al., 2014)

Thieler et al., 2014 reveals/suggests:

- Sediment starved inner shelves with coarse and fine sediments-sorted bedforms dominant (e.g. Raleigh Bay, NC)
- As sediment availability increases, shoreface attached ridges dominate
- Do not see these features along northwestern GOM-likely because of high mud load

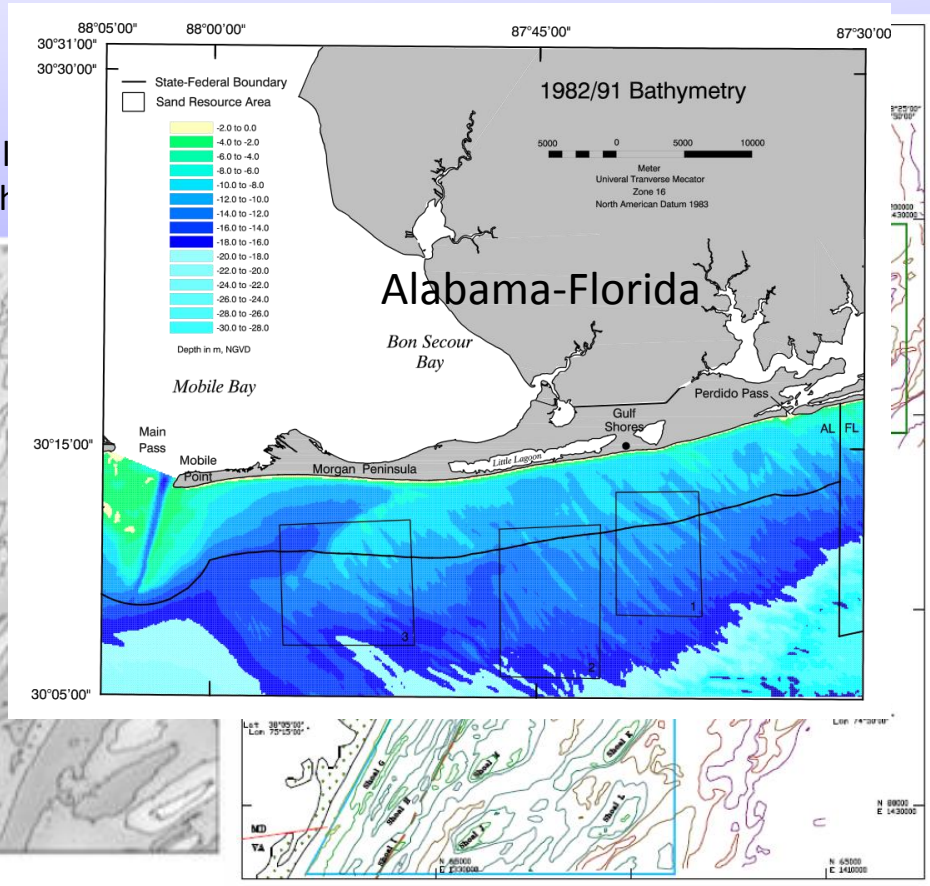


Ridge and Swale Shoal
Maryland-Delaware Sh

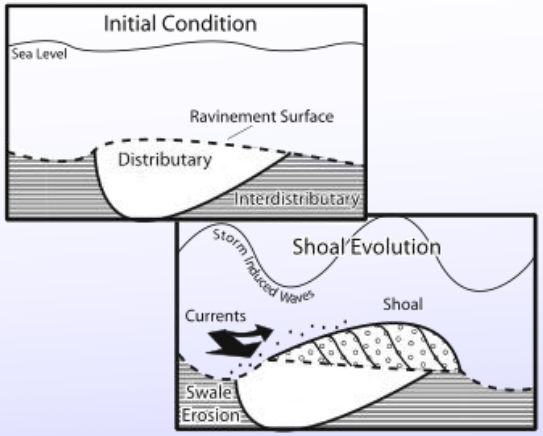


(Hayes and Nairn, 2004)

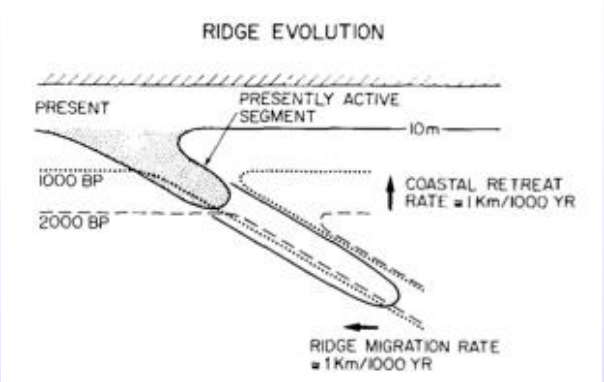
Ridge and Swale Shoals:
Maryland-Delaware Shelf



(Conkwright and Gast, 1995)

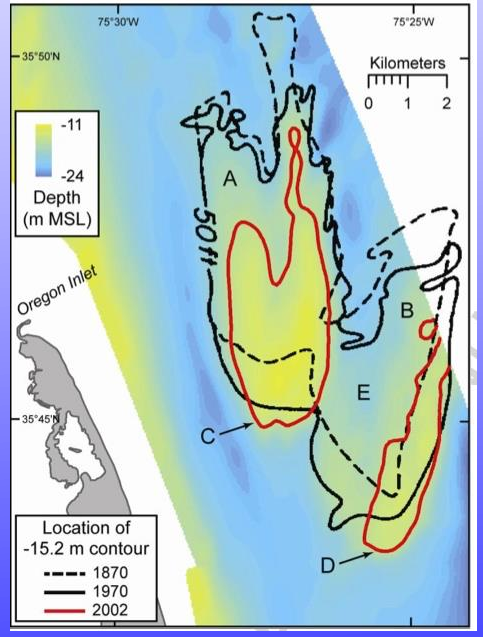


(Rogers et al., 2009)

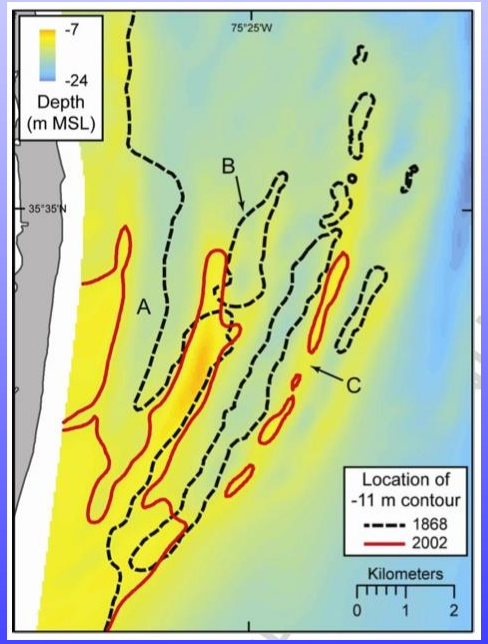


Migration = 1 m/y (Swift and Field, 1981)

A

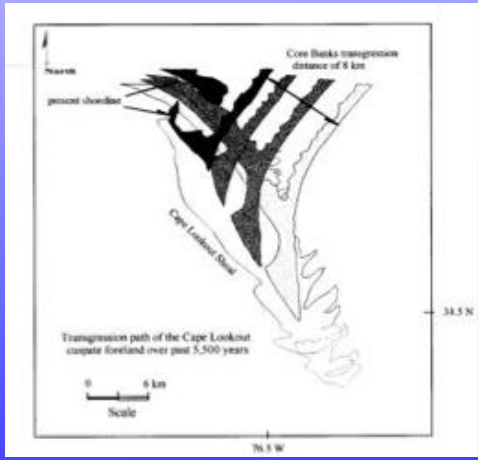


B



Shoal movement between 1868 and 2002- A) 15-22.4 m/y;
B) 3.7 m/y migration (Theiler et al., 2014)

Shoal migration over past 5,500 y
~1 m/y

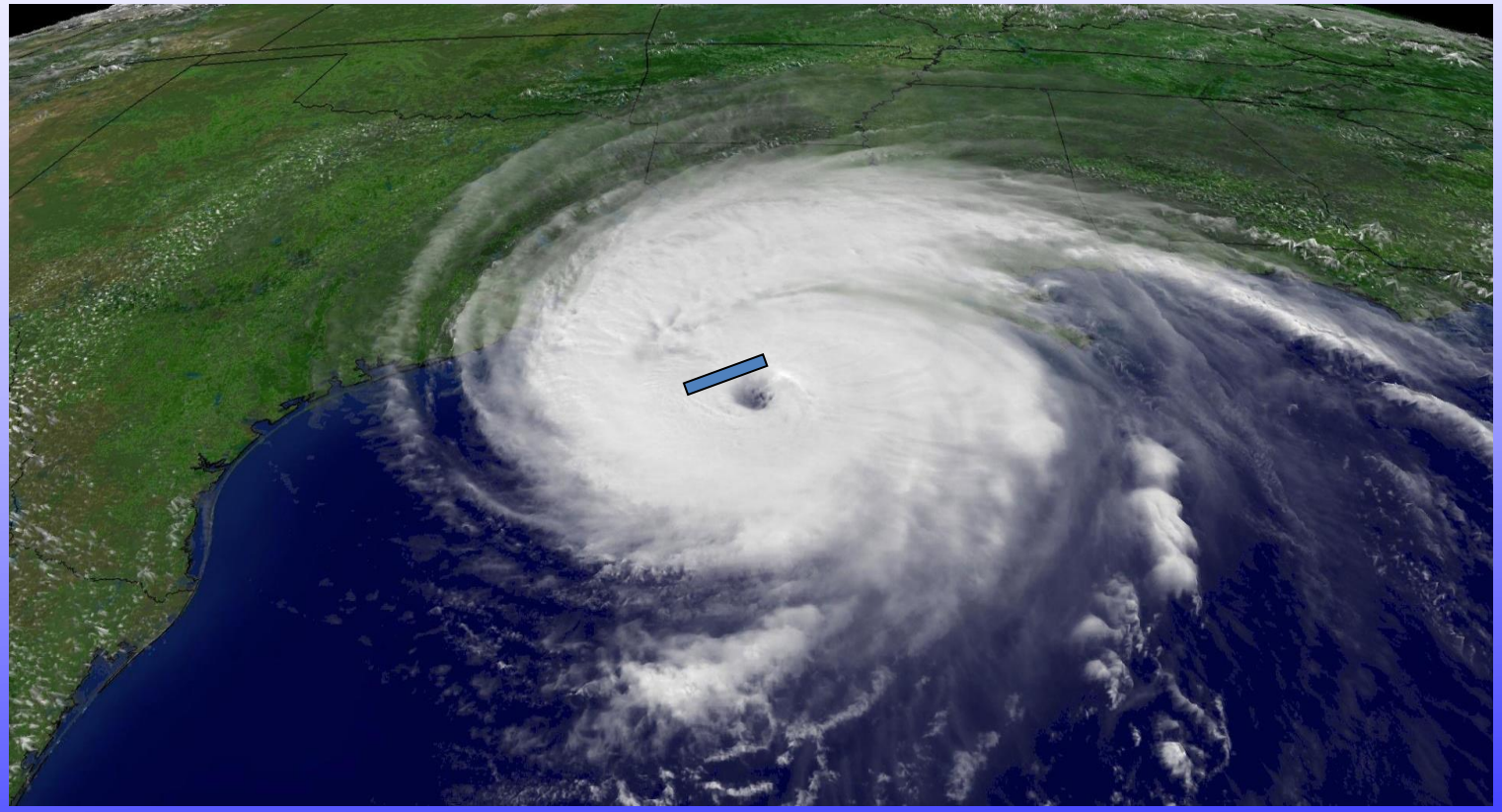


(McNinch and Wells, 1999)

Sediment transport on Shoals

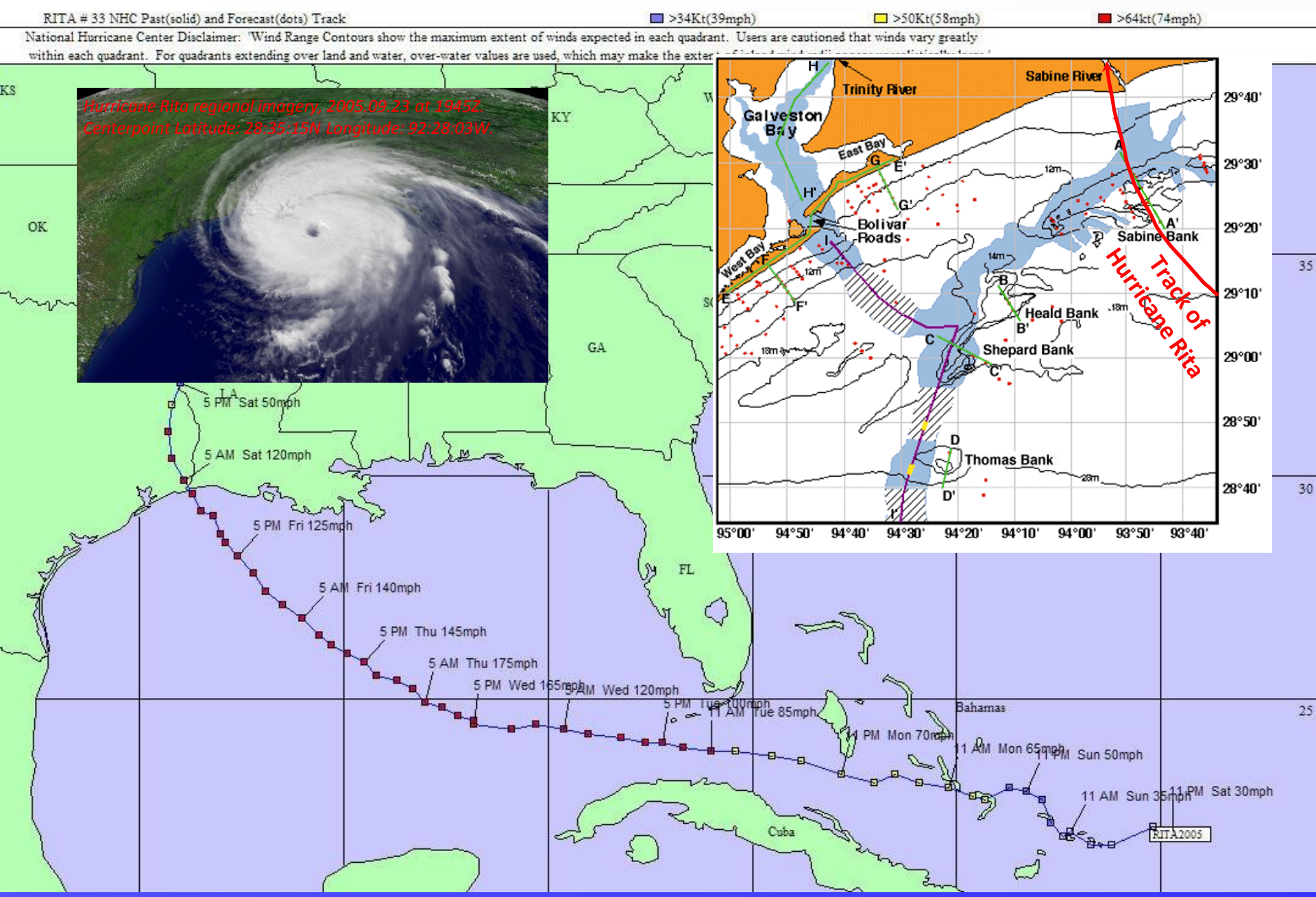
Across all shoals, sediment transport primarily results from wave resuspension

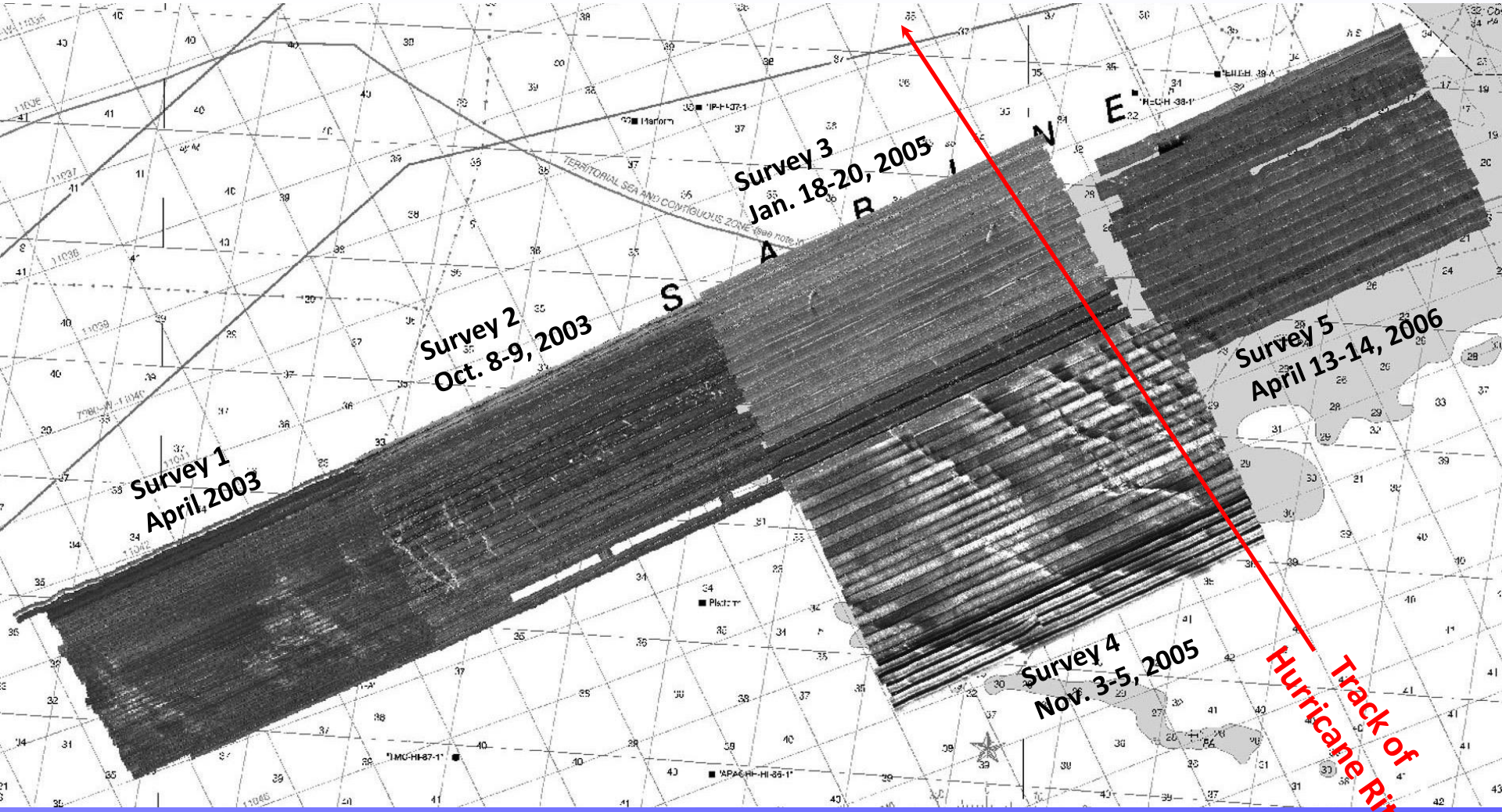
- The deeper the water, the less susceptible the shoal is to reworking
- Hurricanes are the big game changer (at least in the GOM).



Hurricane Rita regional imagery, 2005.09.23 at 1945Z. Centerpoint Latitude: 28:35:15N Longitude: 92:28:03W.

http://www.nnvl.noaa.gov/cgi-bin/index.cgi?page=items&ser=109800


RITA # 33 NHC Past(solid) and Forecast(dots) Track
>34Kt(39mph)
>50Kt(58mph)
>64kt(74mph)
National Hurricane Center Disclaimer: 'Wind Range Contours show the maximum extent of winds expected in each quadrant. Users are cautioned that winds vary greatly within each quadrant. For quadrants extending over land and water, over-water values are used, which may make the exter
Hurricane Rita regional imagery, 2005-09-23 at 1545Z.
Centerpoint Latitude: 28.35.15N Longitude: 92.28.03W.
KS
KY
OK
GA
LA
FL
Bahamas
Cuba
5 PM Sat 50mph
5 AM Sat 120mph
5 PM Fri 125mph
5 AM Fri 140mph
5 PM Thu 145mph
5 AM Thu 175mph
5 PM Wed 165mph
5 AM Wed 120mph
5 PM Tue 100mph
11 AM Tue 85mph
11 PM Mon 70mph
11 AM Mon 65mph
11 PM Sun 50mph
11 AM Sun 35mph
11 PM Sat 30mph
RITA2005
Trinity River
Sabine River
Galveston Bay
East Bay
West Bay
Bolivar Roads
Sabine Bank
Heald Bank
Shepard Bank
Thomas Bank
Track of Hurricane Rita
29°40'
29°30'
29°20'
29°10'
29°00'
28°50'
28°40'
95°00'
94°50'
94°40'
94°30'
94°20'
94°10'
94°00'
93°50'
93°40'


Survey 1
April 2003
Survey 2
Oct. 8-9, 2003
Survey 3
Jan. 18-20, 2005
Survey 4
Nov. 3-5, 2005
Survey 5
April 13-14, 2006
Track of
Hurricane Rita

0.6 0.3 0 0.6 1.2 1.8 2.4
Miles

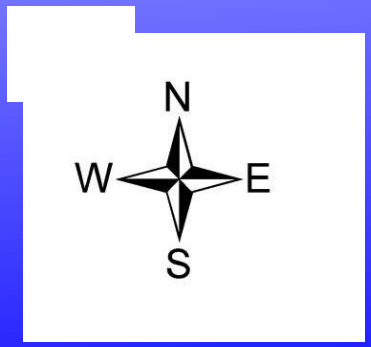
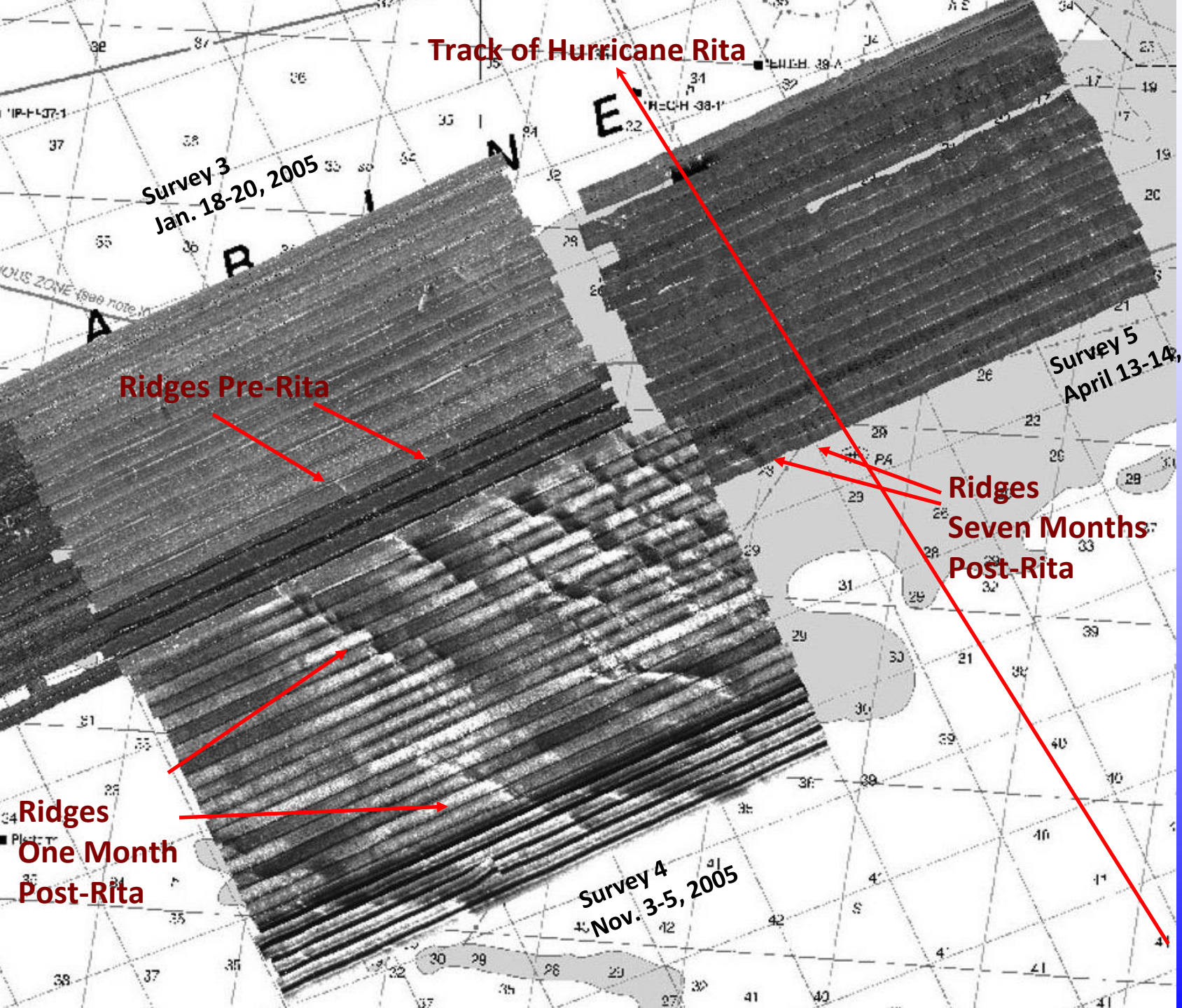
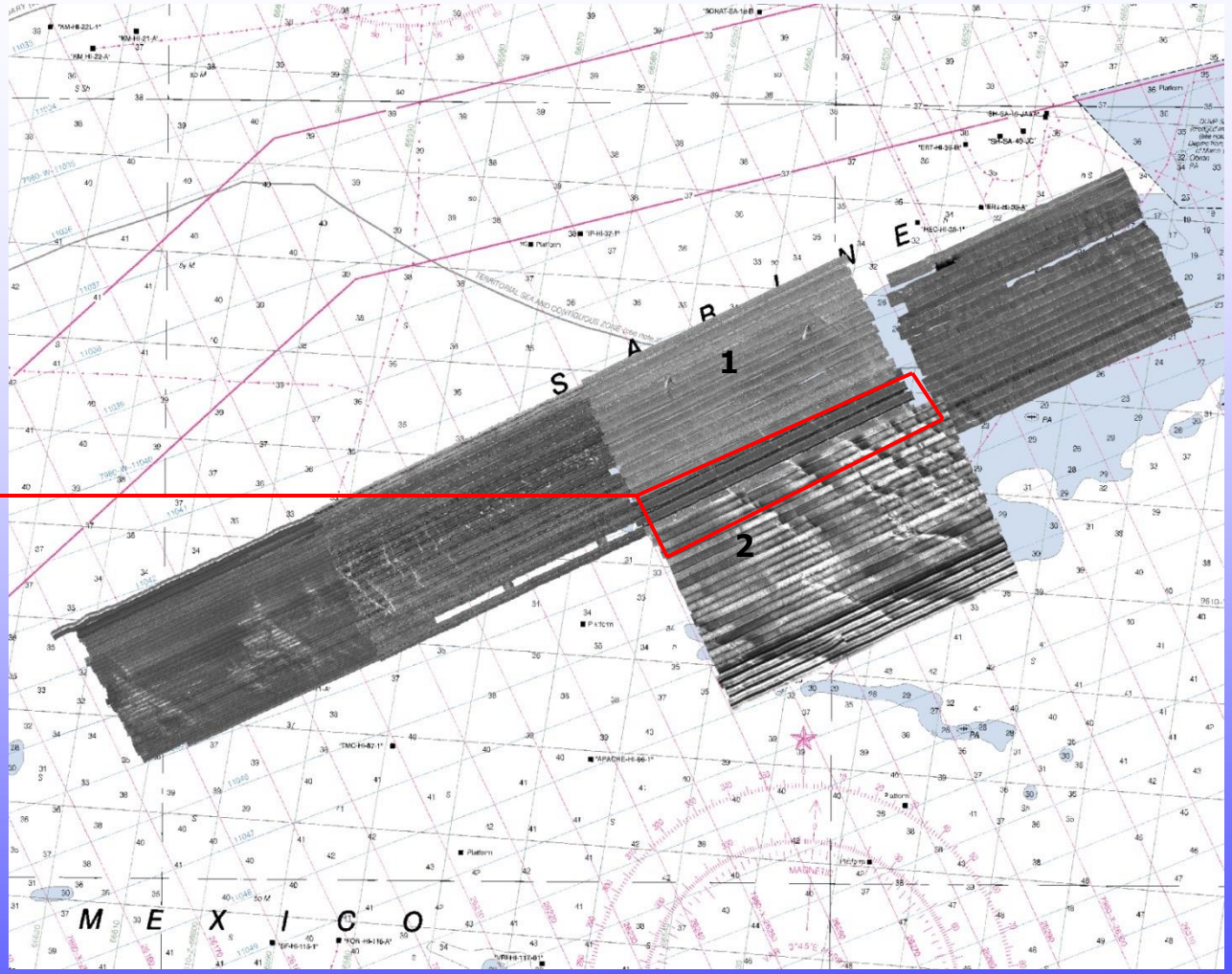

N
W
E
S

Figure 16


Track of Hurricane Rita
Survey 3
Jan. 18-20, 2005
Ridges Pre-Rita
Survey 5
April 13-14, 2006
Ridges
Seven Months
Post-Rita
Ridges
One Month
Post-Rita
Survey 4
Nov. 3-5, 2005

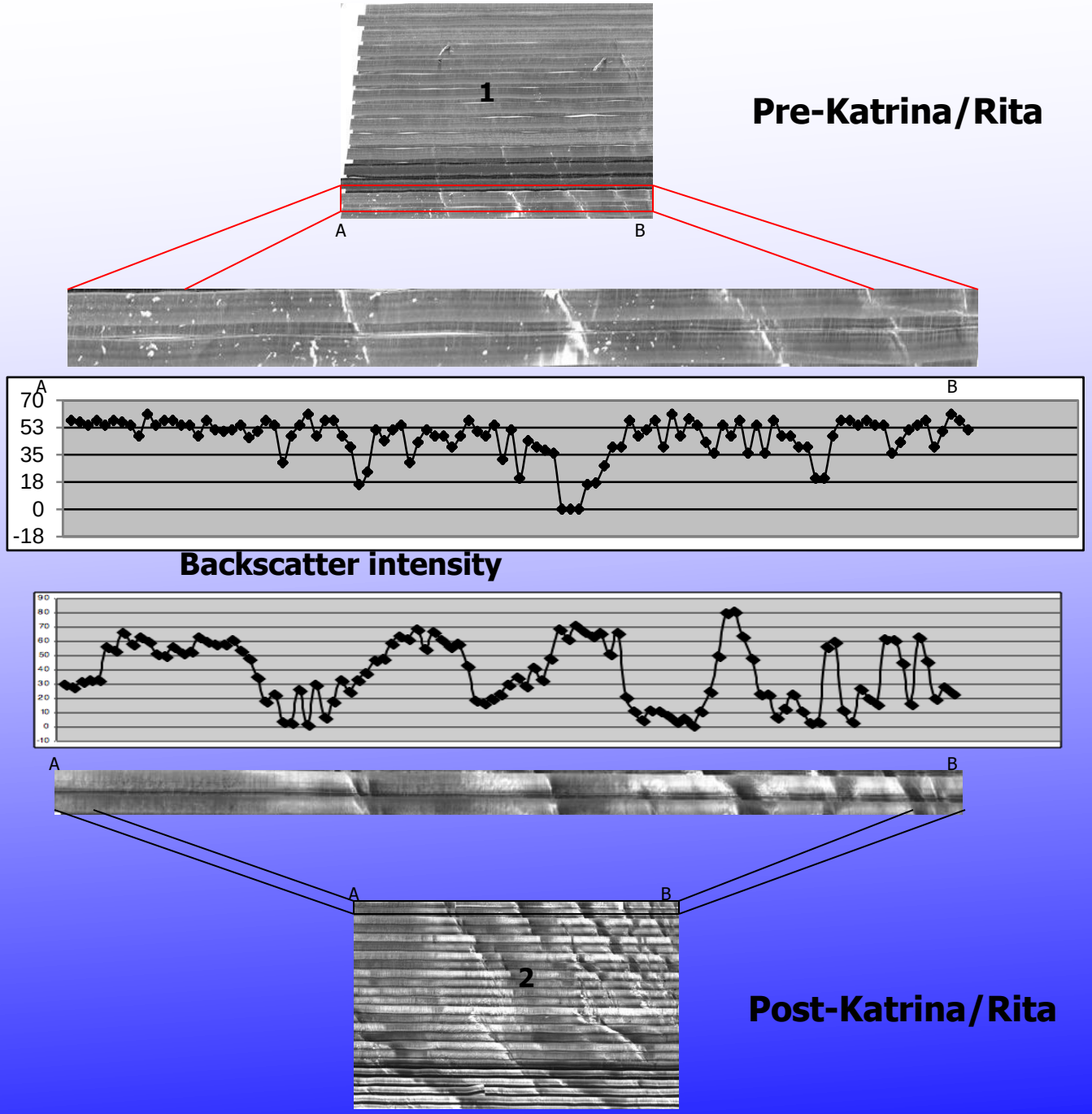
Sabine Bank Sorted Bedform Backscatter Time Series Analysis

Significant Overlap of Ridges



Survey 1 was collected before Hurricanes Katrina and Rita (Jan 2005).
Survey 2 was collected shortly after Hurricanes Katrina and Rita (Nov 2005)

Created by: Scott Hiller


1
Pre-Katrina/Rita
A
B
A
B
70
53
35
18
0
-18
Backscatter intensity
90
80
70
60
50
40
30
20
10
0
-10
A
B
A
B
2
Post-Katrina/Rita

Summary

- Crests of ridges appeared prior to Hurricane Rita
- Entire ridge structure exposed 1 month after Rita
- Ridges re-buried 7 months later

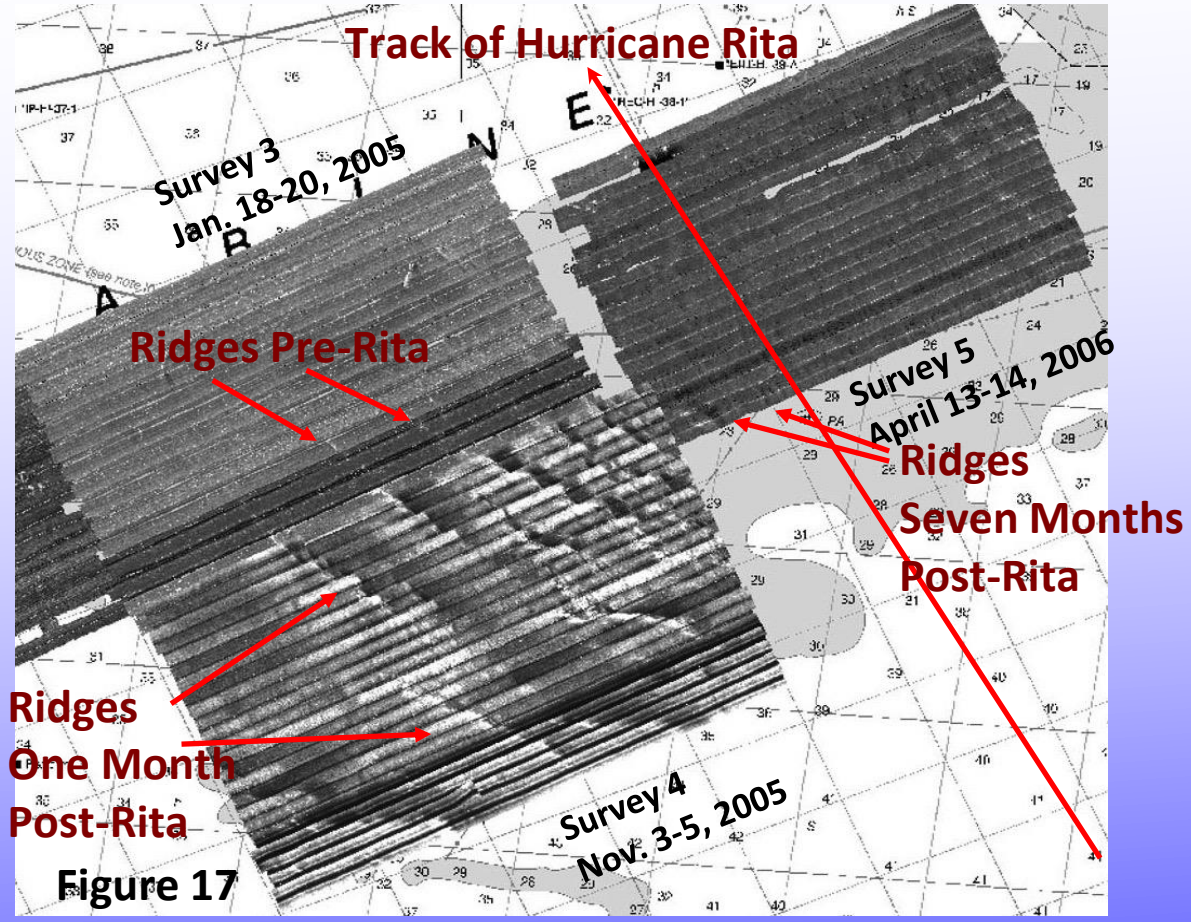


Figure 17

Conclusions

- East coast shelf sediment transport driven by extratropical nor'easters
- Gulf of Mexico sediment transport driven by tropical storms/hurricanes
  - Northwestern also driven by northern frontal passage

- Middle Atlantic shelf narrower and steeper than GOM shelf

- Three primary shoal types:
  - Relict Holocene and Holocene deposit sourced shoals
    - Dominant shoal type in GOM
  - Cape Associated Shoals
    - Retreat Massif Shoals likely relict Cape Associated Shoals
  - Ridge and Swale and Sorted Bedforms create a continuum of shoals
    - Sediment starved- sorted bedforms
    - Sediment abundant-ridge and swale
    - Found nearly everywhere except west of Mississippi Delta-
      - Likely either too much mud or buried under mud

  - Sediment transport-redistribution a feature/factor of all shoals
    - Function of water depth
    - Wave energy
    - Sediment availability

MISSISSIPPI STATE UNIVERSITY™

DEPARTMENT OF AGRICULTURAL ECONOMICS

Economic and Geomorphic Comparison of OCS Sand vs. Nearshore Sand for Coastal Restoration Projects

Rex Caffey (LSU), Ioannis Georgiou (UNO),

Dan Petrolia (MSU), Michael Miner (BOEM)

Given December 2, 2015

BOEM MMP Science Exchange, New Orleans

Funding

- Cooperative Agreement between BOEM MMP and Louisiana Coastal Marine Institute
- Project began 9/1/2015
- LSU lead institution with subawards to MSU & UNO

- Economics: Caffey (LSU) & Petrolia (MSU)
- Geology / Engineering: Georgiou (UNO) & Miner (BOEM)

Motivation

- Demand for dedicated dredging in US more than doubled in past decade
  - Coastal LA: ~90 million yd^3 needed for barrier shoreline and wetland restoration over next 50 years
- Two main sources of sediment:
  - Nearshore: limited quantity & quality
  - OCS: potentially higher quality & cost
- Economic tradeoffs between these sources have not be systematically treated
- Overall Objective: quantify the quality and value of OCS sand for restoration projects relative to alternative sources

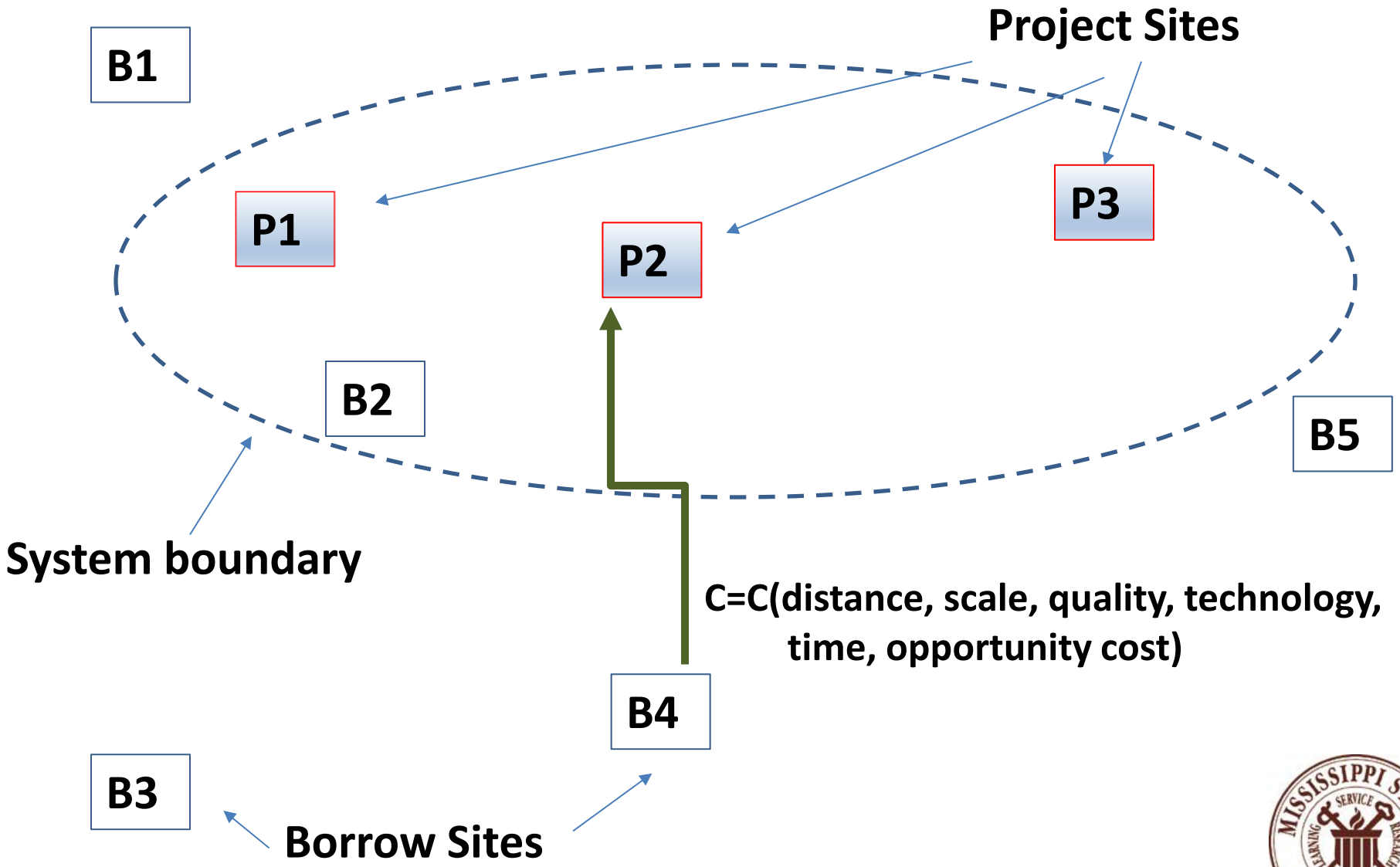
Specific Objectives: Economics

- Estimate cost as function of sediment location, suitability, technology, and other key variables
- Combine cost function with non-monetary benefit metric (e.g., volume) to predict cost-effectiveness for each candidate borrow source and representative project site
- Develop case-studies to illustrate economic tradeoffs between and within sediment location, suitability, and technology

Specific Objectives: Geomorphic

- Analyze and compare quality of nearshore vs. OCS sediment resources
- Summarize existing works on impacts of dredging closer to shore
- Quantify benefits of supplementing coastal sediment budget with external sediment resources
- Compare outcomes of representative projects using both nearshore and OCS resources
- Create matrix categorizing sediment type based on suitability for project type

Conceptual Diagram



Conceptual Diagram - Visual

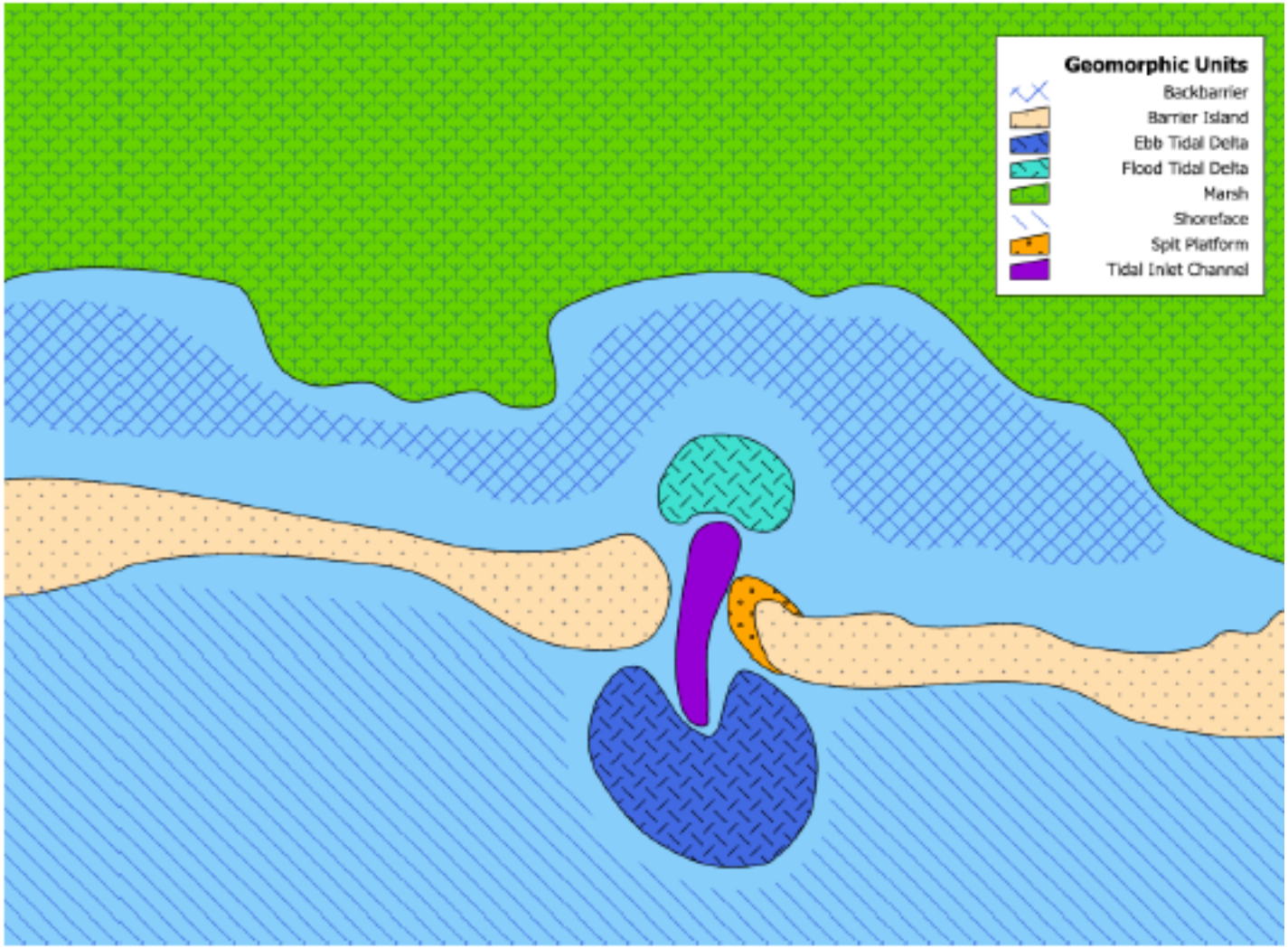


Figure 1. Conceptual diagram of the coastal geomorphic units investigated within this sediment management study.

Sand Sources

- In-System
  - State waters (non-renewable)
- Out-of-System
  - OCS sand (non-renewable)
  - Lower Miss riverine bar deposits (renewable?)
  - USACE maintenance dredging (renewable)
    - Current / BUDMAT
    - Potential / BUDMAT
  - Other?
    - Atchafalaya River? (renewable)
    - USACE dry storage facilities? (non-renewable)

Cost Function Arguments / Constraints

- Uncertainty associated with quantity and quality of sand at each borrow site
- Sediment retention at project site
- Depth of overburden
- Handling/re-handling due to staging
- Oil/gas infrastructure, cultural resource, ecological resource constraints
- Federal / state permitting
- Opportunity costs / conflicting uses

Key Tradeoffs

- OCS / out-of-system:
  - Distant (-)
  - Greater depth (-)
  - Oil/gas infrastructure (-)
  - Longer federal permitting process (-)
  - Higher quality (+)
  - Higher quantity (+)
  - Less overburden (+)
  - New sediment introduced to system (+)
  - Little/no opportunity costs ? (+)
  - More technology options ? (+)
- Nearshore / in-system:
  - Proximal (+)
  - Shallow depth (+)
  - Oil/gas infrastructure (-)
  - Shorter state permitting process (+)
  - Lower quality ? (-)
  - Limited quantity (-)
  - More overburden ? (-)
  - No new sediment introduced to system (-)
  - Greater opportunity costs (-)
  - Fewer technology options ? (-)

Questions / Suggestions?

BOEM
Bureau of Ocean Energy Management

Mississippi State University

LSU
Louisiana State University

The University of New Orleans

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Ecological Function and Recovery of Biological Communities within Dredged Ridge-Swale Habitats in the South-Atlantic Bight

CESU: Cooperative Ecological Studies Unit

University of Florida and BOEM

UF CESU Collaborative Team

- UF Fisheries & Aquatic Sciences Program, SFRC
  - Debra Murie
  - Robert Ahrens
  - Patrick Baker
  - Don Behringer
  - Ed Phlips
  - Daryl Parkyn
  - Michael Dickson (Project Biologist)
- UF Department of Geological Sciences
  - Peter Adams
- UF Civil & Coastal Engineering Department
  - Arnoldo Valle-Levinson

Path of Hurricane Sandy (Oct 2012)

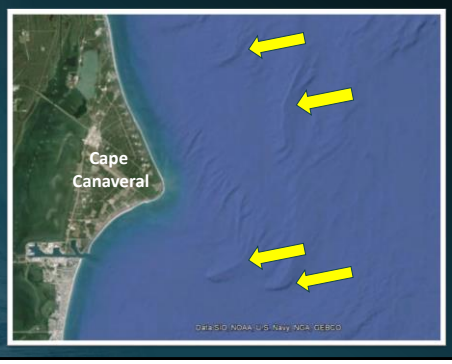
(Photo Credit: Eric Blake, National Hurricane Center)

Cocoa Beach, Florida

Before Hurricane Sandy….and After

(Photo Credit: Paula Berntson, Brevard County Natural Resources Management Dept)

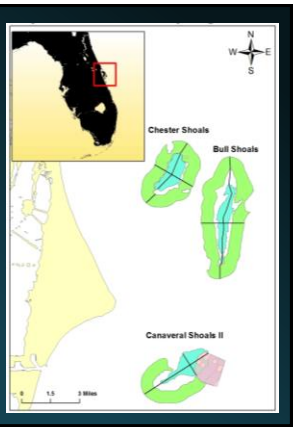
Offshore sand shoals



Sand shoals off Cape Canaveral

Reference Shoals

Dredged Shoal



Dredge vessel off Canaveral Shoal II (Nov 2013-March 2014)

Study Goals

- Monitor the effects and recovery of sand dredging activities on biological communities of ridge-swale habitats
- Determine functional biological services that are potentially compromised by dredging sand; determine degree of impact
- Investigate the mechanism of recovery of invertebrate and fish communities associated with the ridge-swale habitats

Biological Sampling

Temporal Framework:
- Annual
- Seasonal (Spring, Summer, Fall, Winter)
- Diel (Day/Night differences)

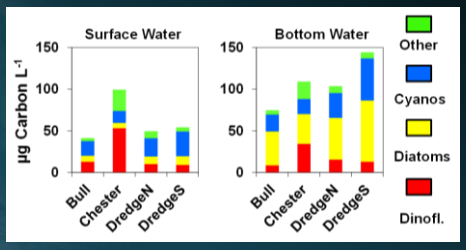
Spatial Framework:
- Reference Shoals versus Dredged Shoal
- Ridge versus Swale

Biological Sampling

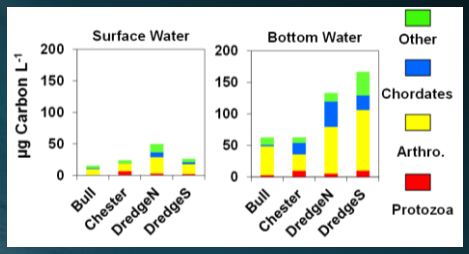
Approach focused on the trophic interactions among biota with an emphasis on the dynamics of prey availability, patterns of habitat use, and biomass and bioenergetic coupling.

Food Web Components:
- Phytoplankton
- Zooplankton
- Invertebrates (Benthic grabs, trawls)
- Fishes (Trawls, acoustic tagging and tracking)

Phytoplankton Biomass (Summer 2014)



Zooplankton Biomass (Summer 2014)

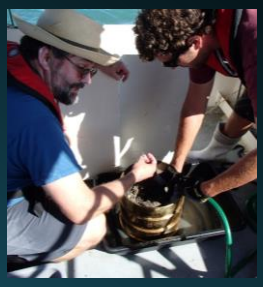


Benthic Invertebrates

Modified Young Grab

Benthic Grab Sampling

Taking cores before disturbing grab



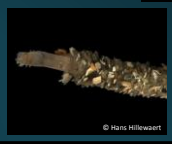
Washing sediment through sieve series

Polychaetes

- Polychaete worms are one of the two dominant groups
- Count data extremely variable, but at the upper end, 100s/m^2 for a single species
- Several methodological problems with worms
- Several abundant families

Onuphidae

Chaetopteridae



Oweniidae

Crustacea: Amphipoda

- Comparable to polychaetes in numerical abundance, taxonomic diversity, and biomass
- Difficult to identify but less fragmented than polychaetes

Bathyporeiidae

Haustoriidae

Phoxocephaliidae

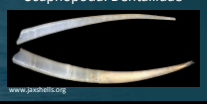
Mollusca

- Most common mollusks are about one order of magnitude less abundant (counts) than polychaetes
- Large body mass; may dominate by biomass

Gastropoda: Olivellidae

Gastropoda: Nassariidae

Scaphopoda: Dentallidae



Bivalvia: Tellinidae

Chordata: Cephalochordata

- Lancelet *Branchiostoma caribaeum*
- Variable densities
- Active

Photo Credit: H. Gee

Benthic Grab Sampling Habitat Classification

Trawl Invertebrates
Acetes americanus

Photo Credit: Brenda Bowling, Texas Parks and Wildlife Department)

Trawl Invertebrates

Various small shrimp species

Roughneck Shrimp

Gastropods and hermits crabs

Photo Credit: Danielle Plus)

Trawl Fishes: Sciaenidae Croakers

Photo Credit: www.inlandseafood.com)

Atlantic Croaker

Photo Credit: www.hooked-in.com)

Spot Croaker

Trawl Fishes: Sciaenidae (plus larval sciaenids)

Photo Credit: Brenda Bowling, Texas Parks & Wildlife

Banded Drum

Photo Credit: Jim Franks, GCRL

Silver Seatrout

Common Trawl Fishes

Leopard Searobin

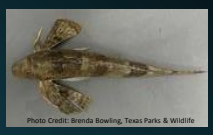


Photo Credit: Brenda Bowling, Texas Parks & Wildlife

Band Cuskeel

Photo Credit: Fishbase.org

Lizardfish

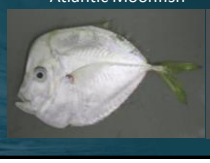
Photo Credit: flickr.com

Common Trawl Fishes

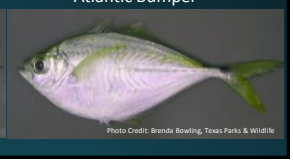
Fringed Flounder

Blackcheek Tonguefish

Atlantic Moonfish



Atlantic Bumper



Winter Trawling: Canveral Shoals II
(% Abundance: 40 species total)

Common Name	Day	Night (2-3 X)
Atlantic Croaker	20.5	35.8
Larval sciaenids	24.2	0.4
Silver Seatrout	14.9	1.1
Atlantic Moonfish	8.4	0
Atlantic Bumper	6.5	0
Fringed Flounder	3.7	6.5
Banded Drum	3.3	11.9
Leopard Searobin	1.9	8.1
Spot Croaker	1.4	6.5

Target Species for Tagging

Smooth Butterfly Ray

Summer Flounder

Acoustically Tagged Fish

Common Name	Sonotronics	Vemco
Smooth Butterfly Ray	20	8
Gulf Flounder	9	1
Summer Flounder	6	
Southern Stingray	6	
Clearnose Skate	4	
Southern Flounder	3	
TOTAL	48	9

Environmental and Oceanographic Sampling

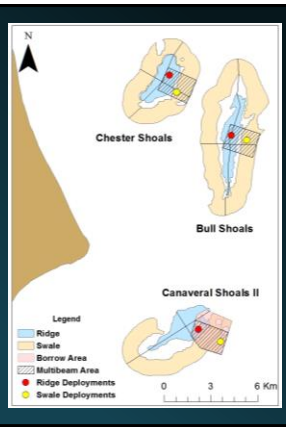
What are the physical changes that occur as a result of sand dredging and subsequent recovery?

- Water quality
- Bathymetry changes
- Habitat classification based on sediments, depth, etc.
- Sand movement: currents, tides, storm events, etc.

Multibeam hydroacoustic surveys

Reference Shoals

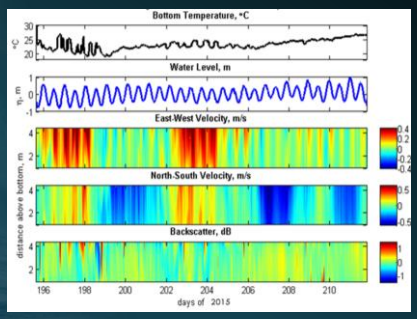
Dredged Shoal



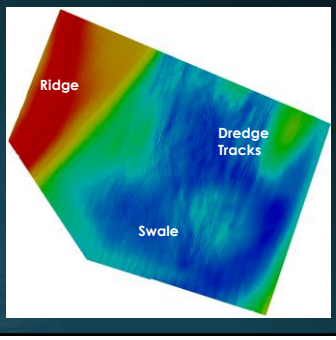
Oceanography
Acoustic Doppler Current Profilers (Towed and Moored)

Moored Downward-facing ADCP

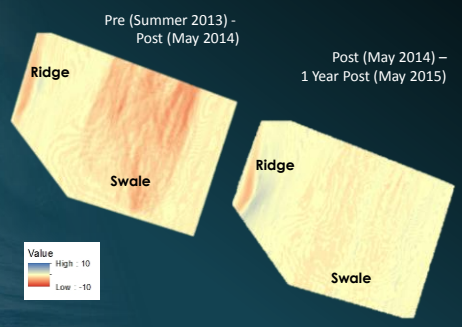
Moored ADCP: Canaveral Shoal



Multibeam Hyrdroacoustics for Bathymetry: Canaveral Shoals



Bathymetry: Net Gain/Loss (Preliminary Data)



Recovery?

Return to pre-dredge community assemblages?

or

Return to comparable, functional community assemblages?

Ecosystem Analyses

- Trophic pathways using isotopes
- Trophic pathways using Ecopath-Ecosim-Ecospace models
  - Compare short-term versus long-term recovery trajectories for dredged areas

Labor-intensive study…..

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