

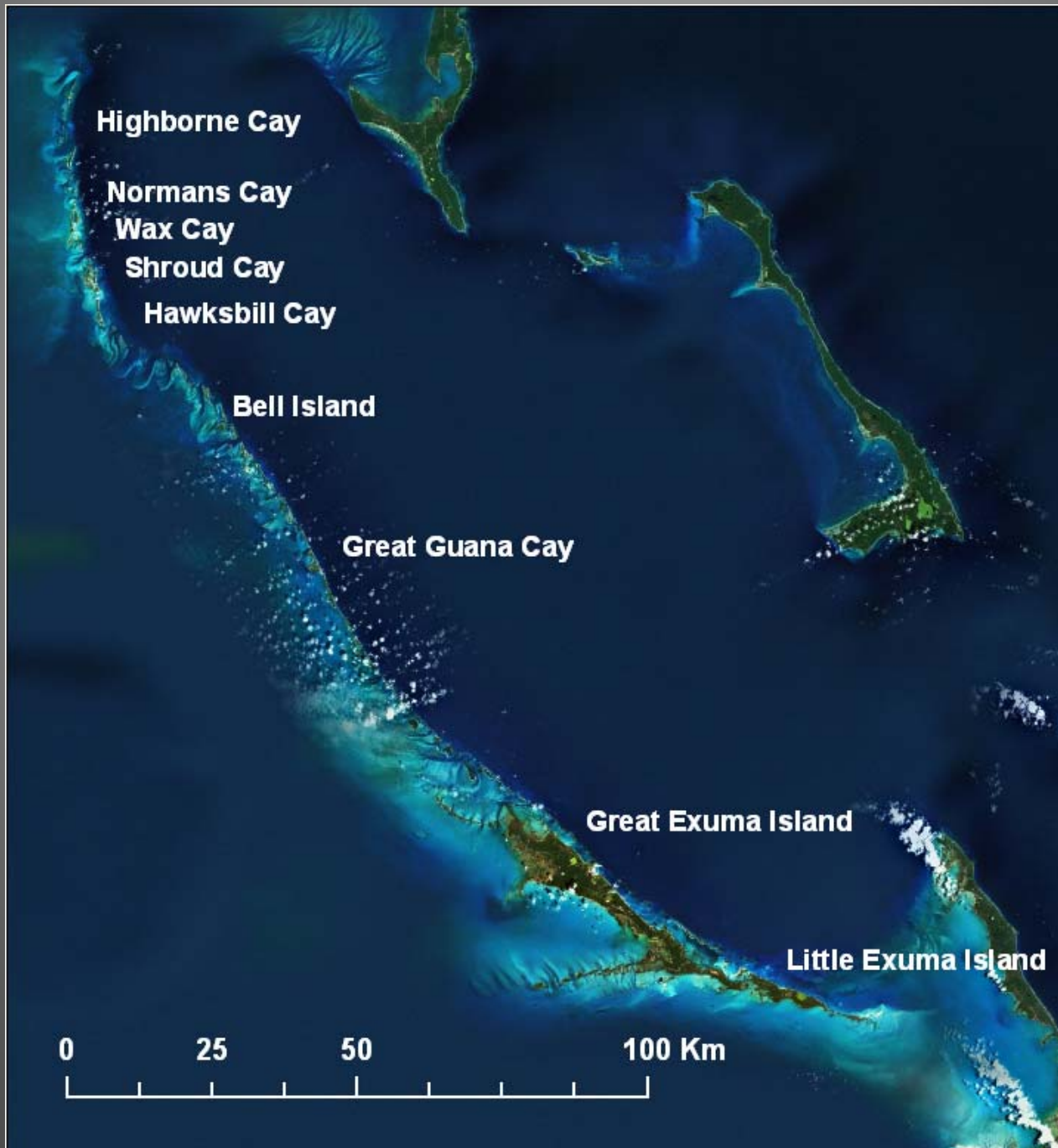
Satellite Imagery and Geological Interpretation of the Exumas, Great Bahama Bank - An Analog for Carbonate Sand Reservoirs



Paul (Mitch) Harris, *Chevron Energy Technology Company, San Ramon, CA*
James Ellis, *Ellis GeoSpatial, Walnut Creek, CA*

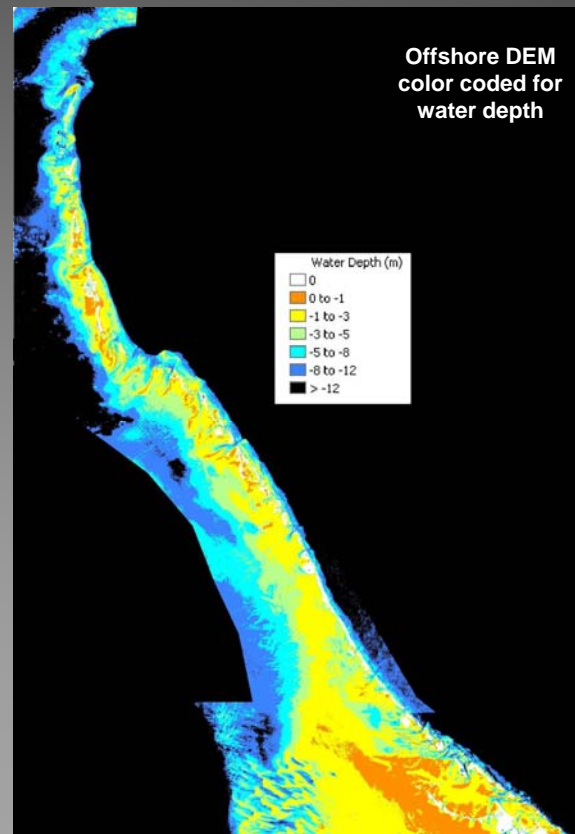
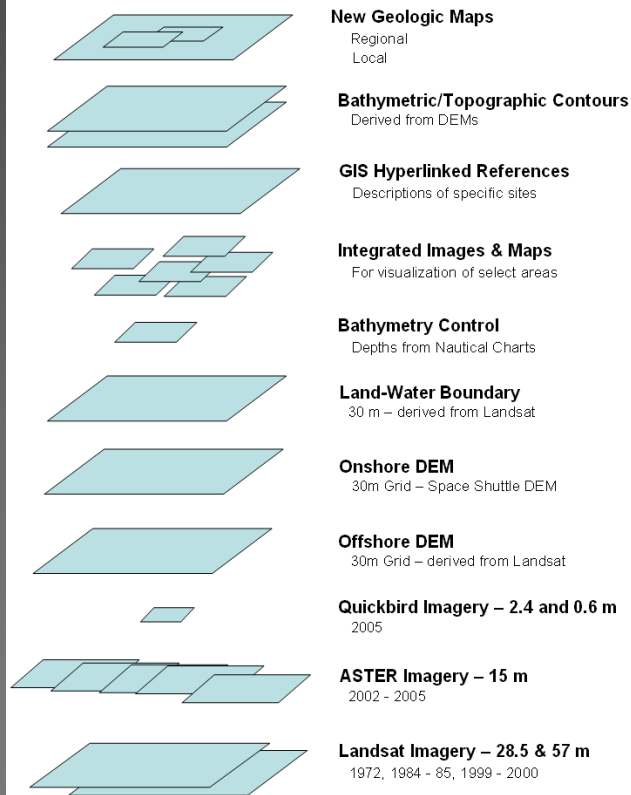
Rationale for Study

- The Exumas portion of Great Bahama Bank is an area of continuing interest to researchers in modern carbonates, an important training venue, and a valuable modern analog for understanding facies patterns in grainstone reservoirs.
- We hope to promote this interest by making readily available a set of processed satellite images, an onshore/offshore digital elevation model (DEM), and numerous examples of how this data can be visualized and used with an emphasis on better characterization and modeling of carbonate reservoirs.

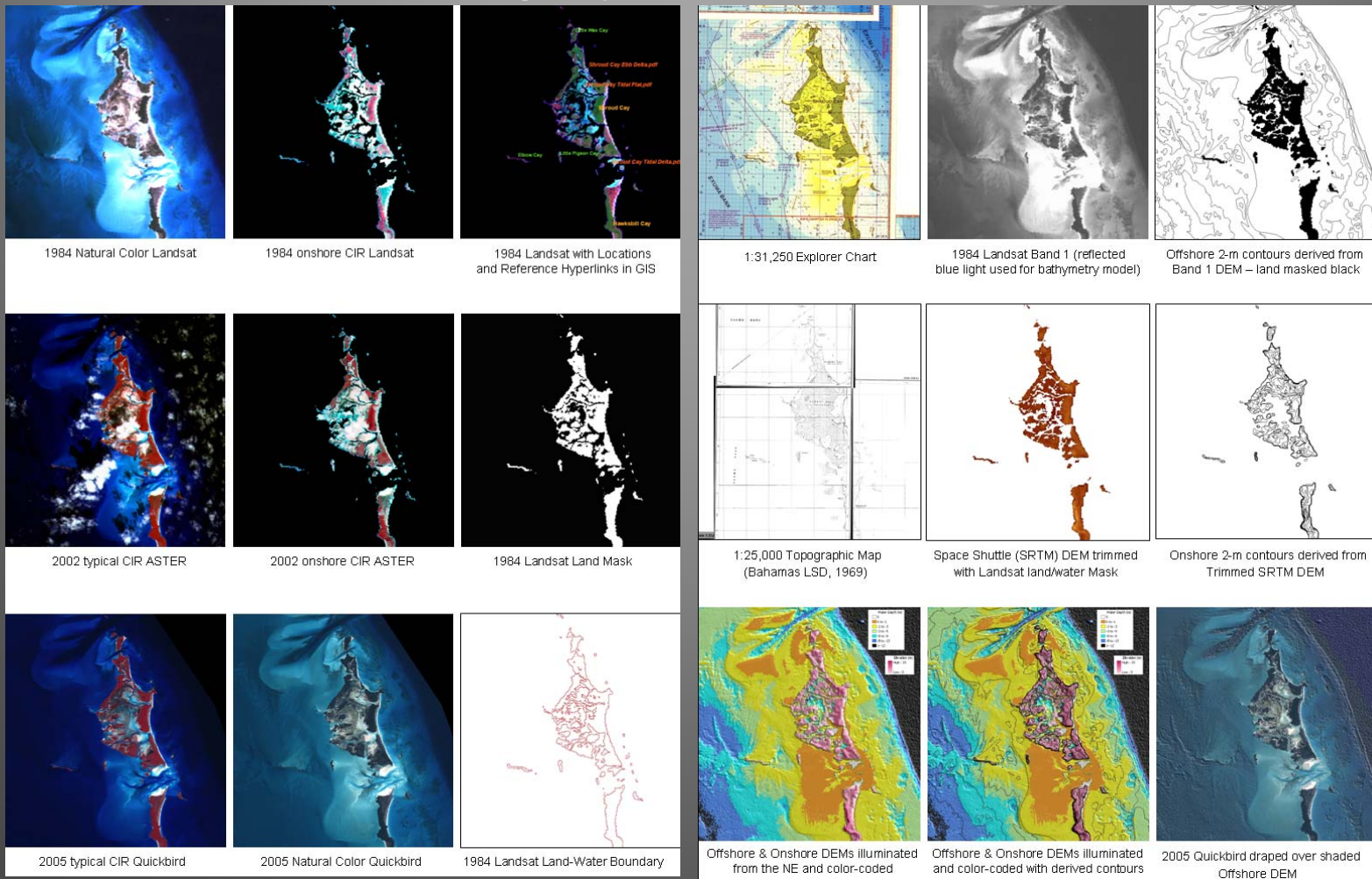


Exumas GIS, Images and Maps

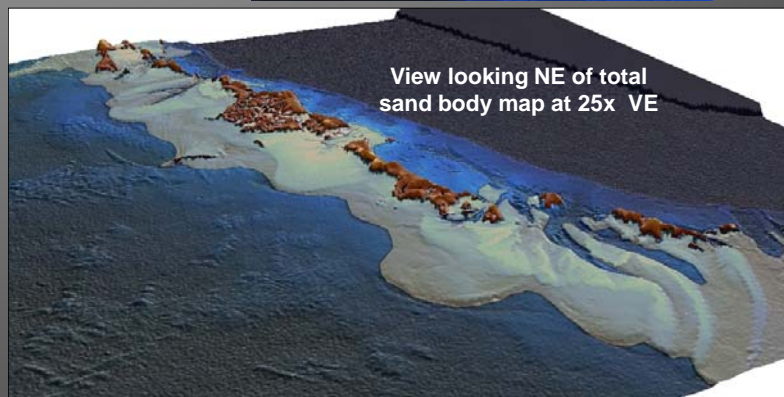
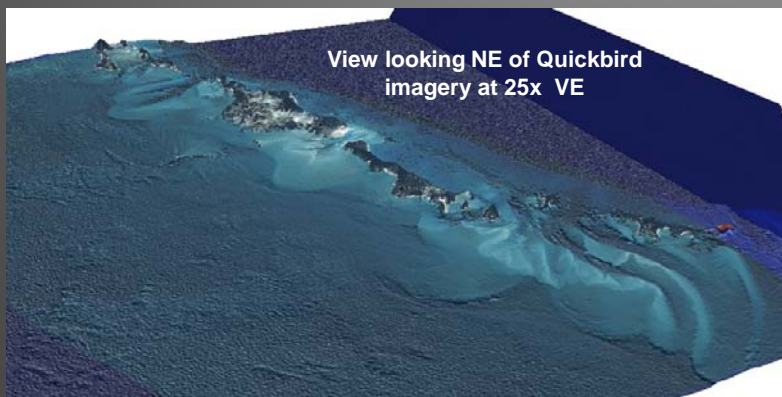
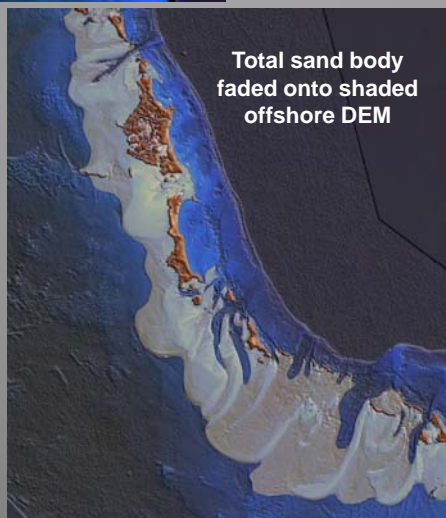
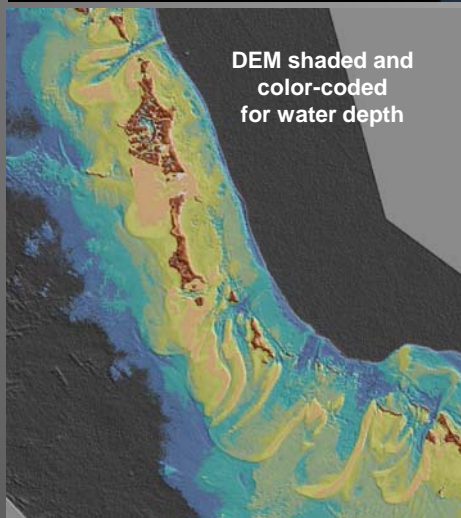
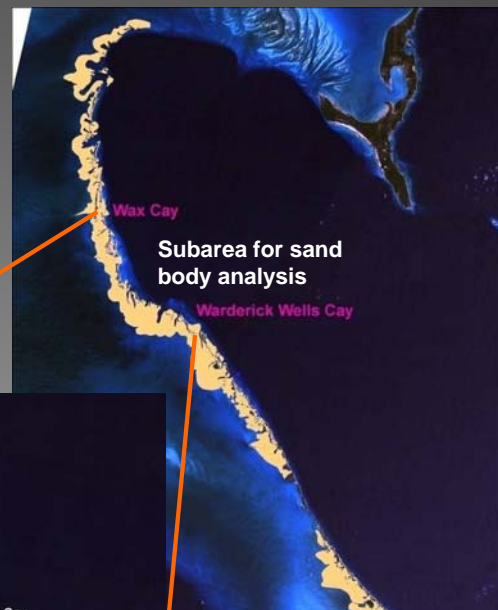
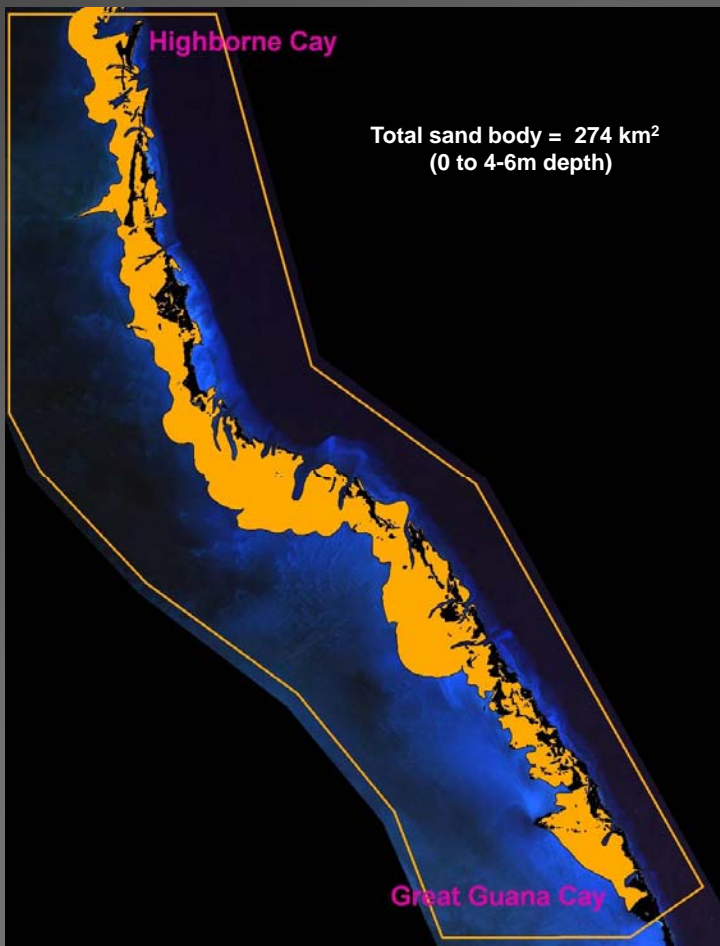
GIS Stack of Images & Maps for Exumas



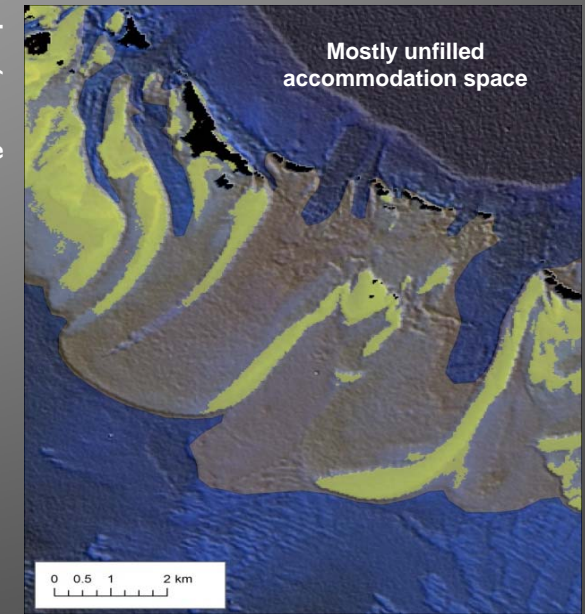
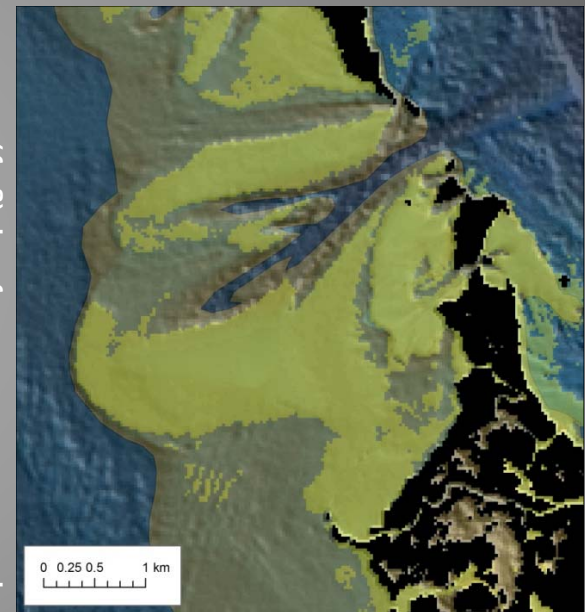
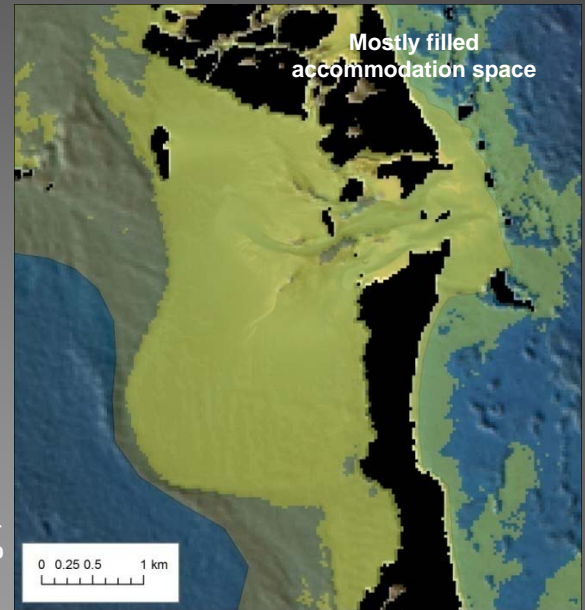
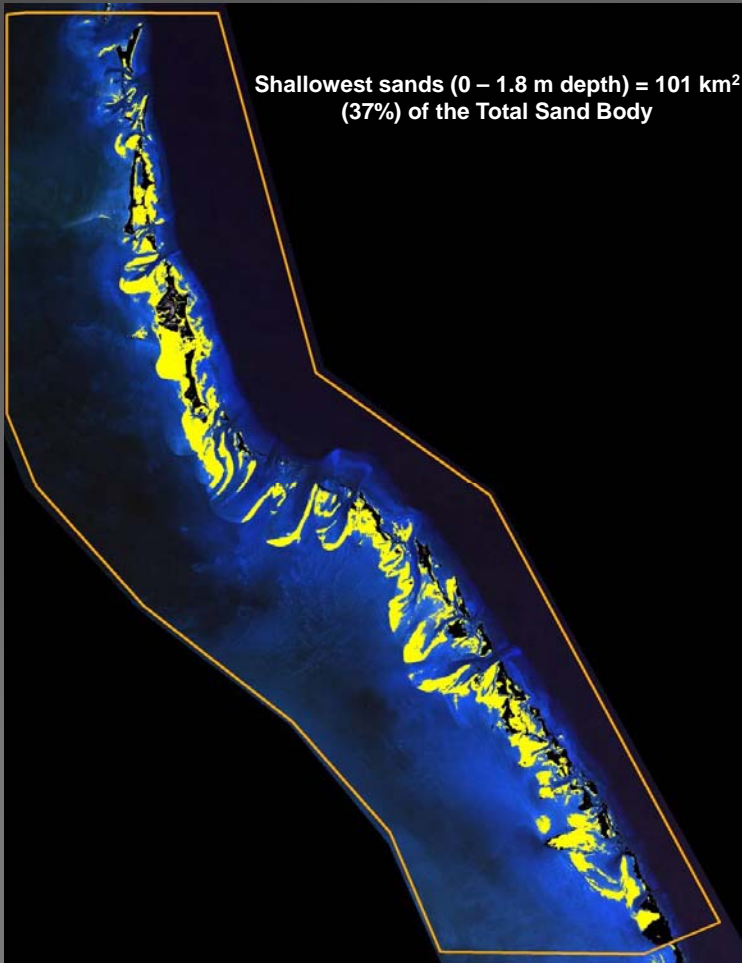
Overview of satellite images, maps and enhanced DEM in the Exumas GIS



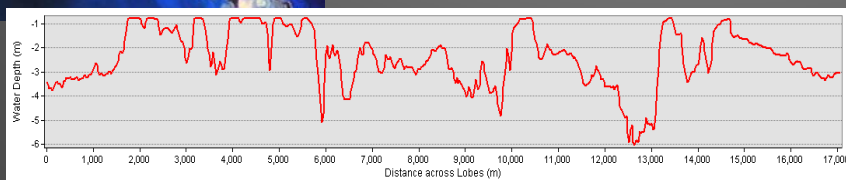
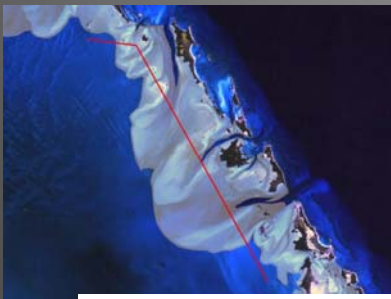
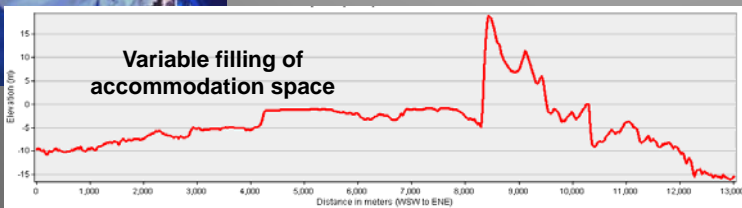
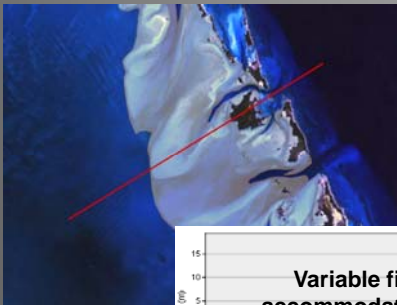
Analyzing the Total Sand Body (= Potential Reservoir)



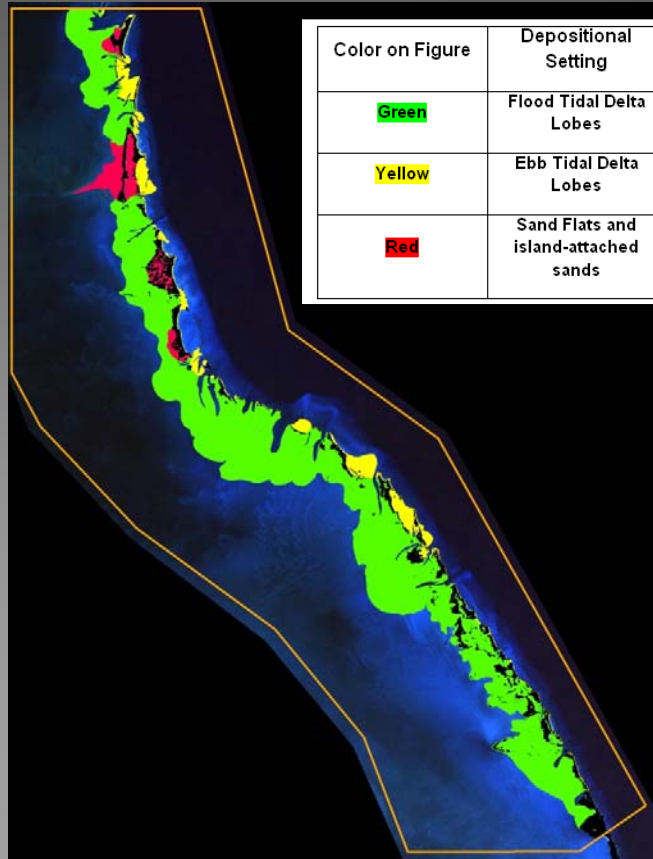
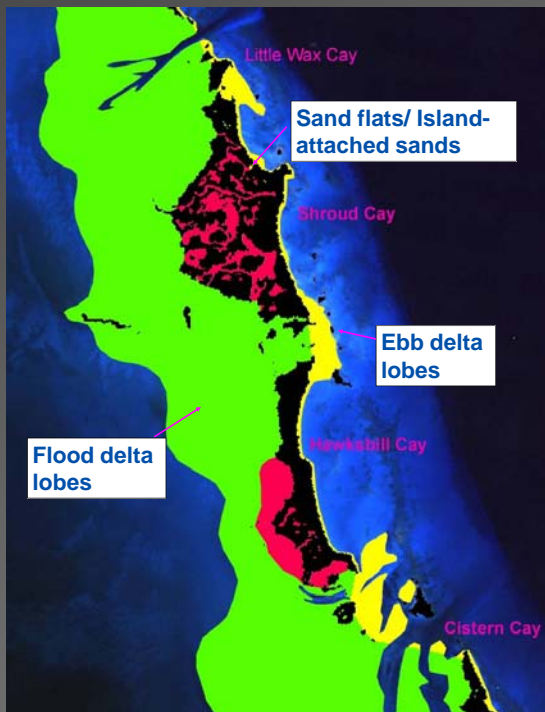
Analyzing the Shallowest Sands (= Best Reservoir)



Shallowest sands (yellow) superimposed on total sand body map (gray) and Landsat image; islands shown as black.

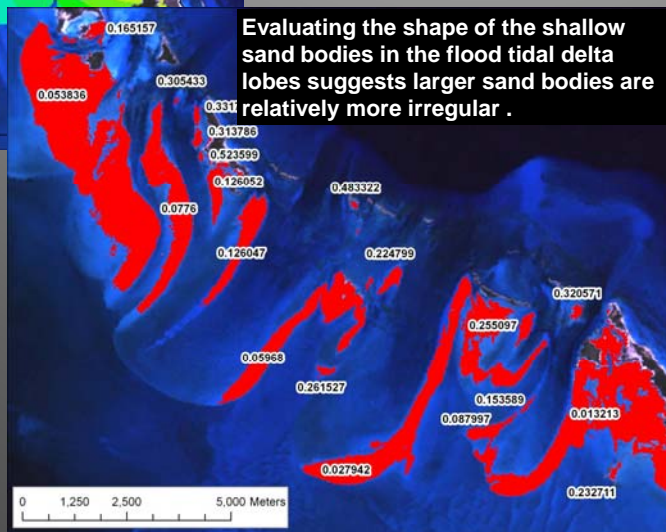
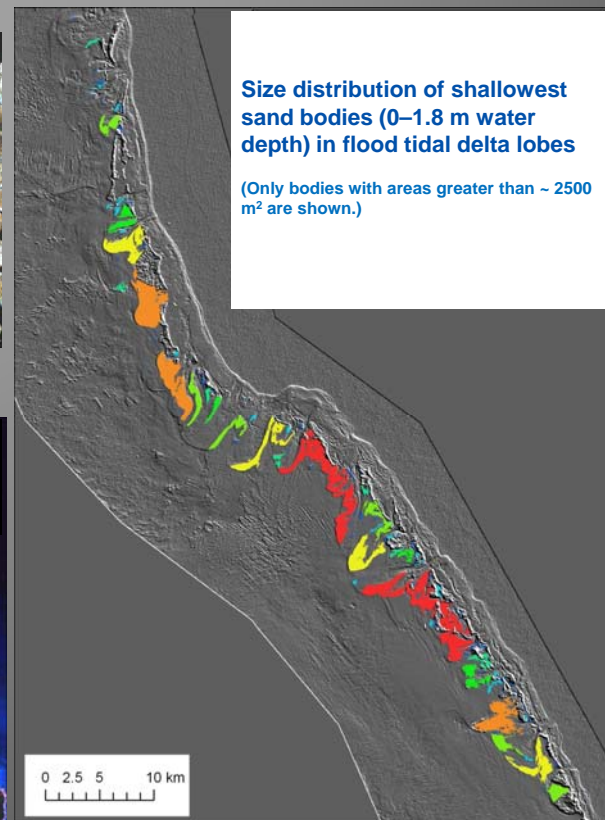
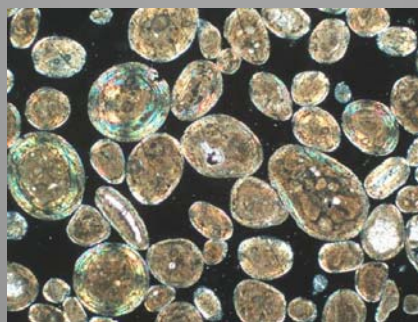
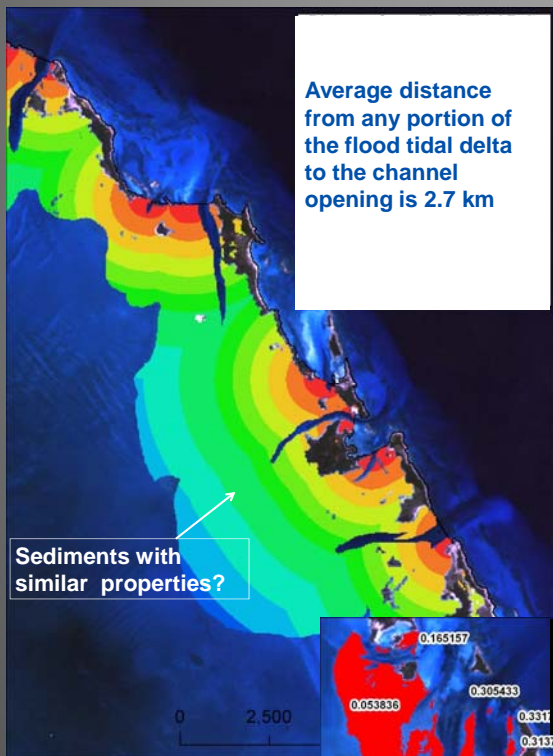


Analyzing the Sand Body by Environment

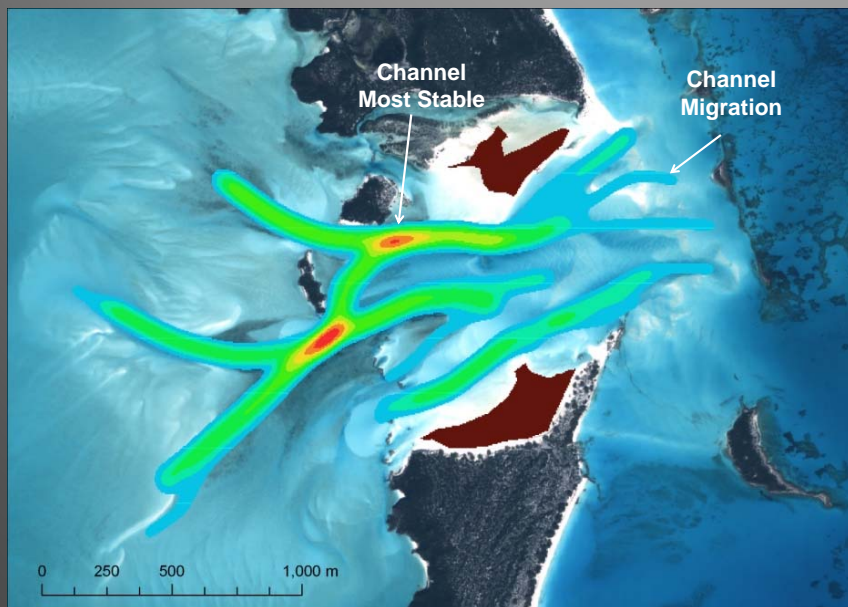
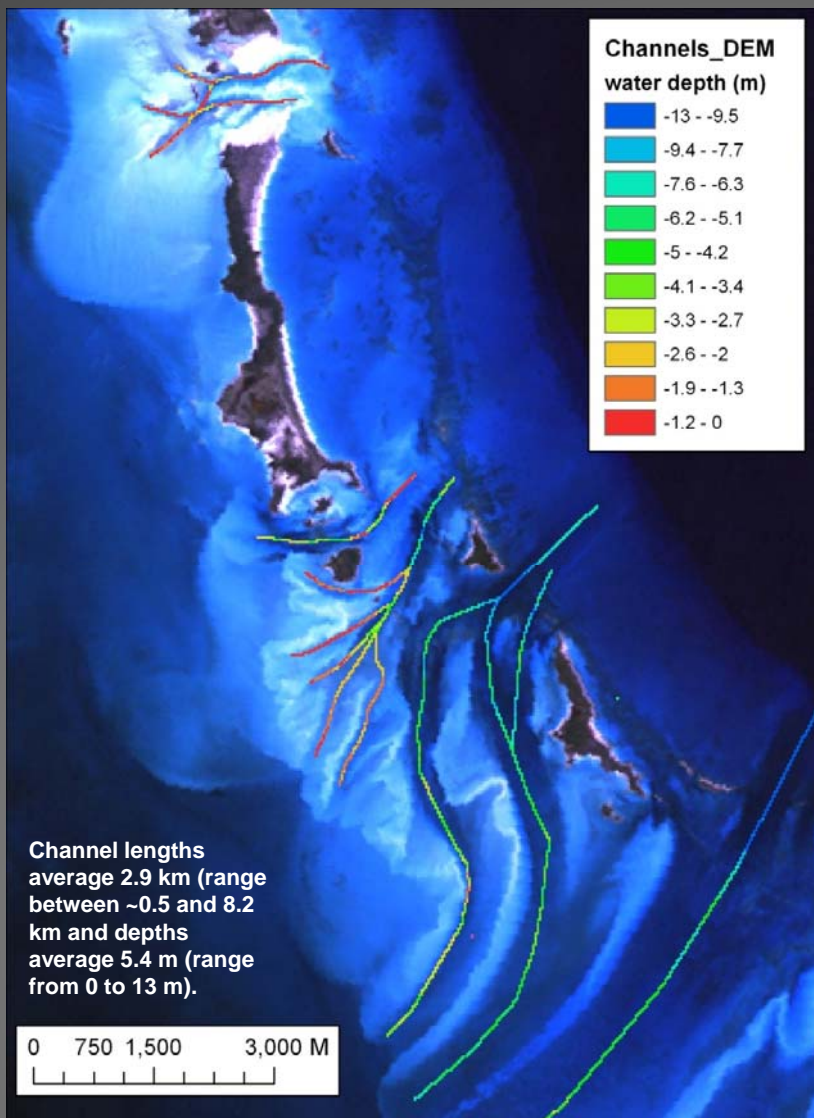


Color on Figure	Depositional Setting	Area (km ²)	Area (%)
Green	Flood Tidal Delta Lobes	273.2	85.3
Yellow	Ebb Tidal Delta Lobes	29.6	9.2
Red	Sand Flats and island-attached sands	17.4	5.4

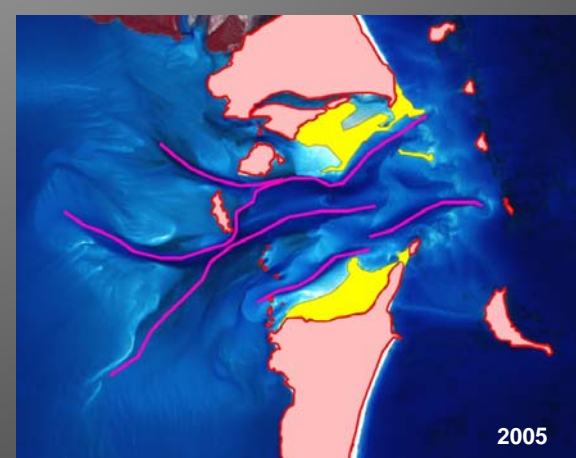
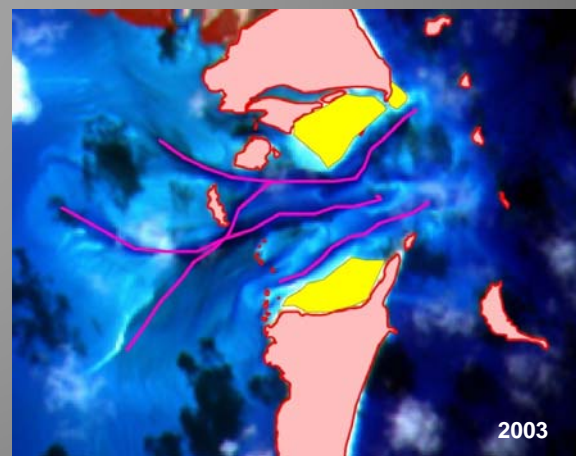
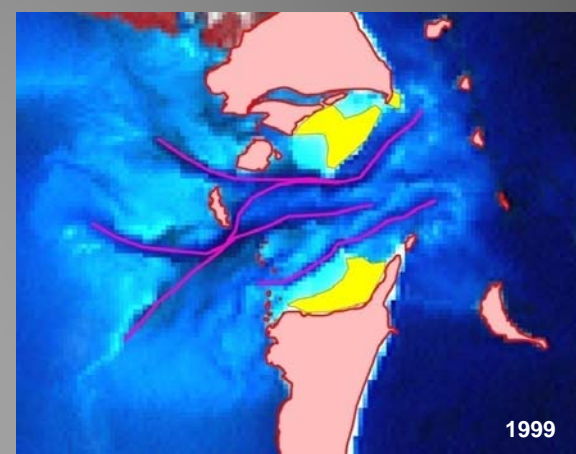
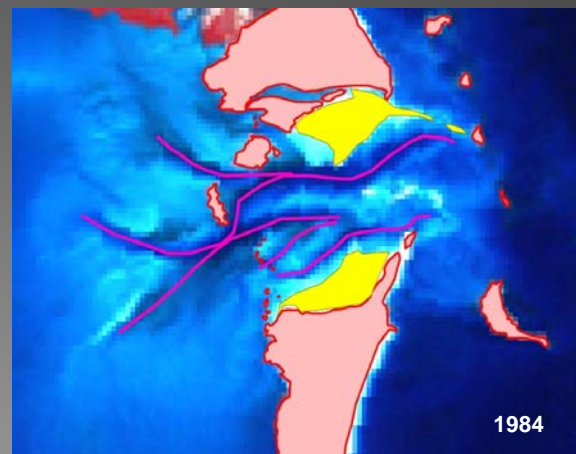
Flood tidal delta lobes comprise 85% of the total sand body



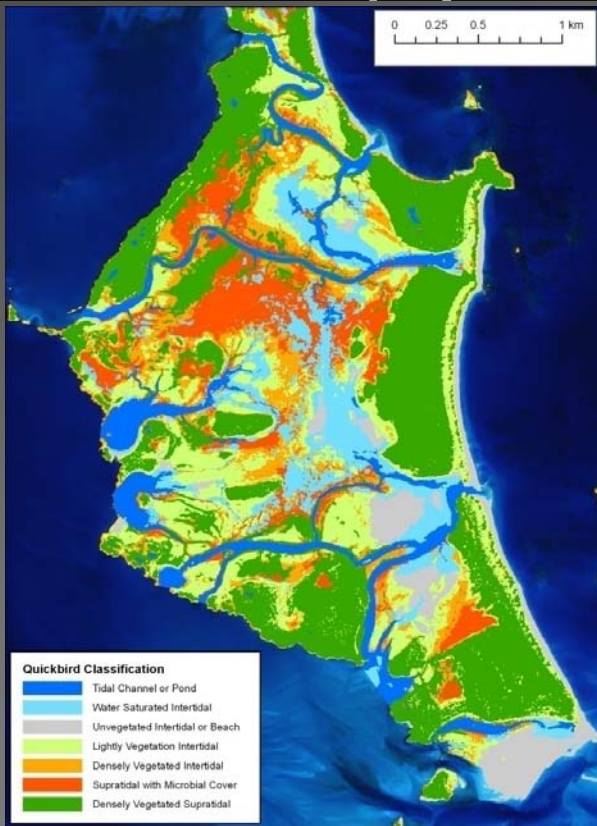
Analyzing Tidal Channels (= Potential Compartmentalization)



Changes in channels and emergent sand bars/beaches



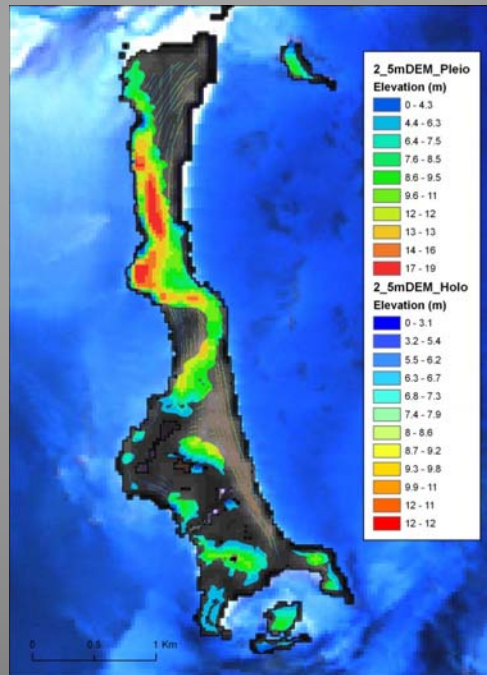
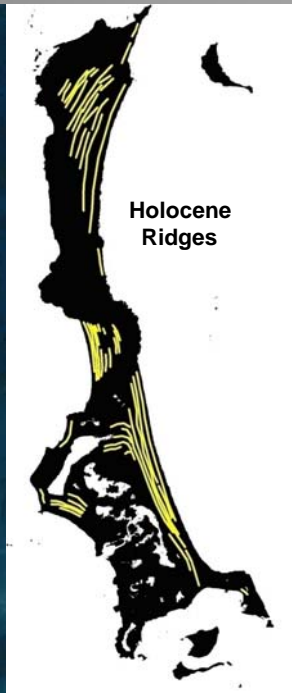
Analyzing Islands (= Diagenesis & Heterogeneity)



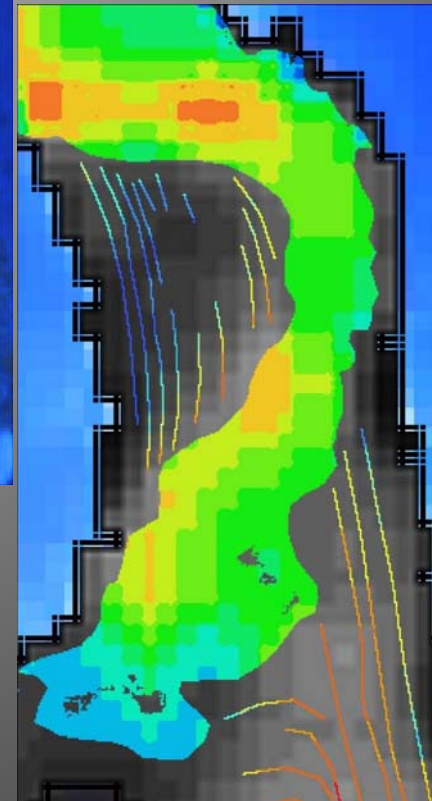
		Area (m ² and %)	
Tidal Channel or Pond	Blue	712,552	9.1
Water Saturated Intertidal	Light Blue	819,360	10.5
Unvegetated Intertidal or Beach	Light Gray	532,045	6.8
Lightly Vegetated Intertidal	Light Green	1,431,510	18.3
Densely Vegetated Intertidal	Orange	873,919	11.2
Supratidal with Microbial Cover	Red	759,842	9.7
Densely Vegetated Supratidal	Green	2,700,046	34.5
TOTAL		7,829,274	100.0

Sand Flat Mapping Using Spectral Classification

Analysis of Island Topography



Holocene ridges have elevations from near sea level to 12 m (mean elevation of 7.7m) while Pleistocene landforms have elevations from near sea level to 19 m (mean elevation of 9.3m)



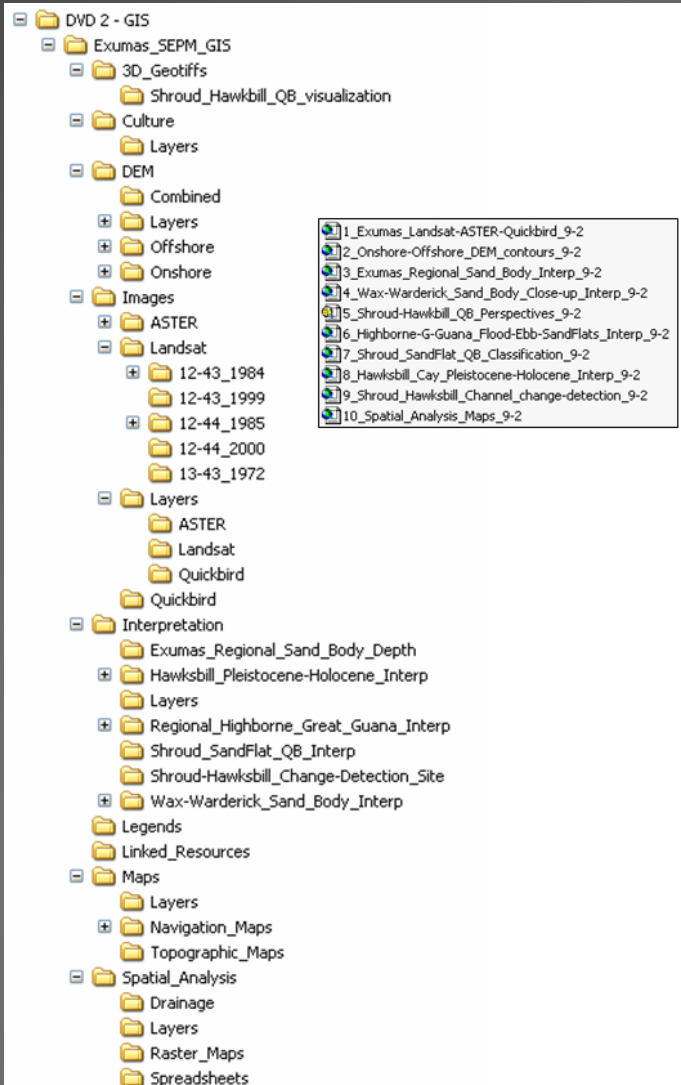
Analysis of Island Age

Pleistocene & Holocene Statistics

Hawksbill Cay

Land Area	2.8 km²
Pleistocene	1.07 km² (38%)
Holocene	1.73 km² (62%)
Holocene Ridges	17.6 km total length ; ~320 m average length

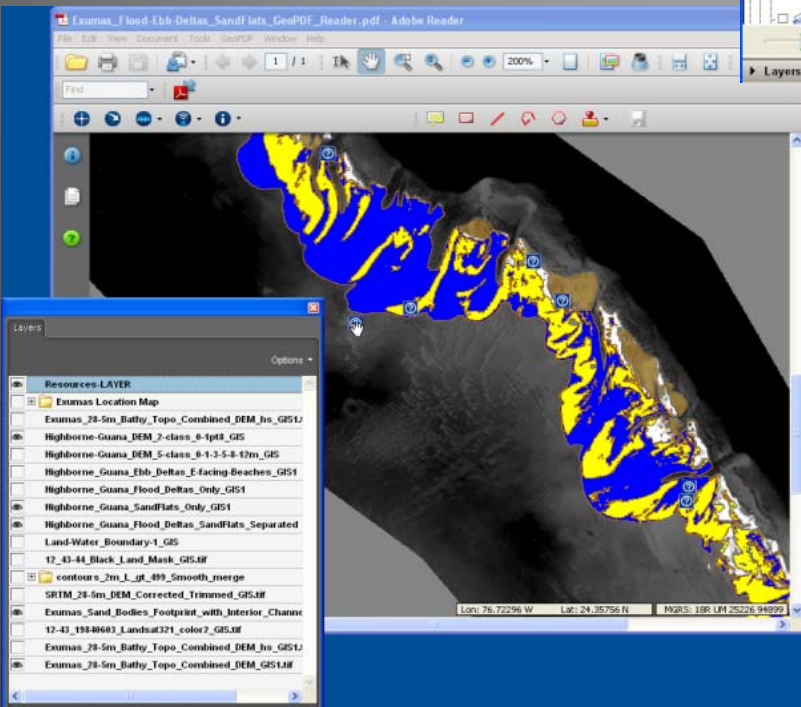
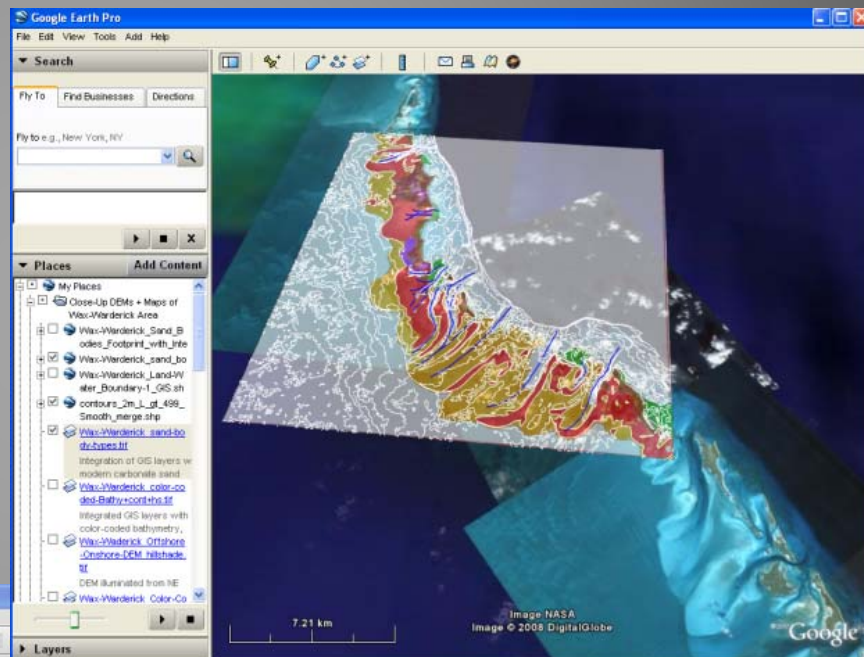
Knowledge Transfer



Full-resolution satellite imagery and maps in GIS format (with ESRI ArcGIS 9.2 mxd and sdx project files), GeoPDFs, and GoogleEarth images are available as part of a digital publication from SEPM. The organization of the digital files is shown to the left.



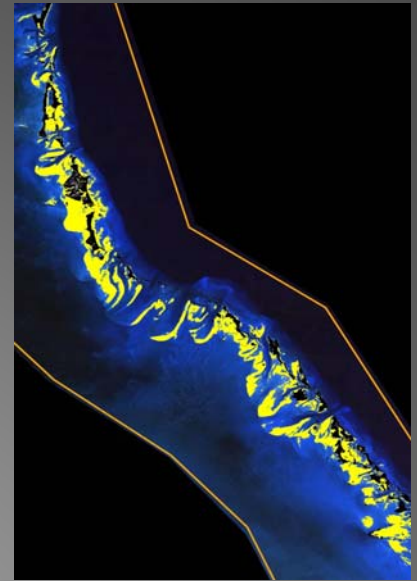
A GIS layer transferred out of the GIS and displayed in GoogleEarth.



The GIS stack of geologic maps transferred out of the GIS and into Adobe Reader using GeoPDF, enabling image and map comparison, location, measurement, and interpretation to be done outside of GIS.

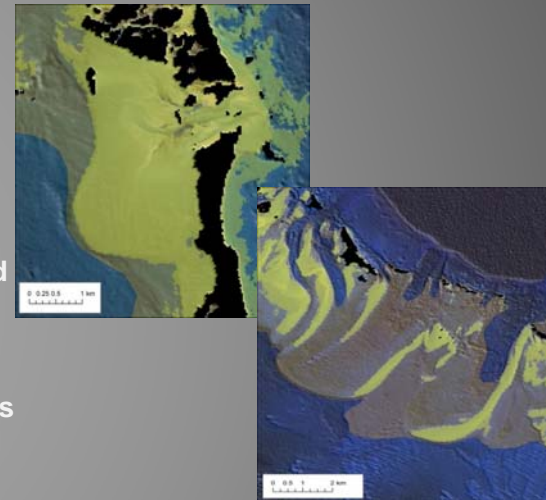
Exploration-Scale Insight

- Exumas show spatial variability of depositional facies and early diagenetic overprint that create stratigraphic traps and reservoir heterogeneity
- A linear belt of mostly ooid sand, approximately 5-10 km wide and 170 km long, paralleling the platform and set back from the platform margin
- 37% of the sands are forming in the shallowest waters and would likely have the best reservoir quality
- The largest facies aerially are flood tidal delta lobes extending several kilometers onto the platform



Reservoir Heterogeneity Insight

- Small-scale patterns of heterogeneity are controlled by islands and tidal channels and their influence on the focusing of tidal and wind energy
- Where islands and channels are complex, bankward-directed lobes of sand are not uniform in their development and have their shallowest portions as sinuous, linear features
- Elsewhere, the islands and channels are more regular and the active shoals between are organized into better-formed and more uniformly shallow flood tidal deltas



Reservoir Modeling Insight

Quantitative relations like the following are essential for building facies-based models:

- Shallowest sands comprise 37% of the total sand body
- Larger deposits of “shallowest sands” are up to ~8 km²
- Larger sand bodies are more irregular in shape than smaller ones
- Flood tidal delta lobes represent 85% of the total sand body
- 52% of the shallowest sand bodies have areas greater than ~2500 m² and 8% are larger than 100,000 m²
- These largest deposits are highly sinuous and maintain connectivity
- Tidal channels, which may potentially isolate or compartmentalize reservoir zones, average 2.9 km in length

