Controls and Patterns of Depositional Facies across Great Bahama Bank*

Paul M. Harris[1], Sam J. Purkis[1], and Georgenes Cavalcante[2]

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Abstract

Our recent studies of Holocene sediments across the top of Great Bahama Bank (GBB) have focused on platform-wide mapping of sediment distribution, an analysis of the variable filling of accommodation space, a comparison between key ooid sand bodies, and an examination of whitings occurrences and mud production. Collectively, these quantitative-based studies were aimed to provide new insight into the variability of depositional facies that challenge subsurface interpretations. Missing from these analyses, however, has been a scrutiny of the physical controls over platform-top deposition, which, coupled with the enhanced mapping may provide even more robust quantitative comparative sedimentology and stratigraphy guidelines.

To explore these fundamental controls, we developed a hydrodynamic model for the GBB forced by prevailing ocean hydrodynamics surrounding the platform, including the Florida Current, and tides, winds, and atmospheric pressure. Current intensity and direction can be examined through high-resolution time steps, and the platform can be partitioned into zones of mean annual hydrodynamic energy. Areas of vigorous tidal exchange in the model correspond to localities where high-energy ooid shoal systems have developed along the platform-margin. There is a predictive relationship between increasing peak current velocity and increasing area of the sand body for the Cat Cays, Joulter Cays, Schooners Cays and TOTO areas. A connection between platform-top hydrodynamics and the formation/suppression of whitings is evidenced in the portion of GBB west of Andros Island suggesting a relationship between the production/deposition of platform-top lime muds and off-platform circulation patterns. Accommodation filling is related to platform topography and hydrodynamic flow. For instance, accommodation filling locally along the platform margin by grainstones in areas of high tidal exchange versus mud accumulation leeward of islands, or the development of hiatal areas in areas unsheltered by abundant islands, such as observed in the southern GBB.

A broader understanding of platform-top currents and their diverse controls can aid interpretation of the rock record, including the type and distribution of sediments accumulating on the platform top, the distribution of extensive hiatal surfaces (sites of non-deposition), and therefore identification of locations which have the potential to host the most complete depositional cycles.

Selected References

Harris, P.M., S.J. Purkis, and J. Ellis, 2011, Analyzing Spatial Patterns in Modern Carbonate Sand Bodies from Great Bahama Bank: Journal of Sedimentary Research, v. 81, p. 185-206.

Harris, P.M., S. Purkis, J. Ellis, P. Swart, and J.J.G. Reijmer, 2015, Mapping Bathymetry and Depositional Facies on Great Bahama Bank: Sedimentology, v. 62, p. 566-589.

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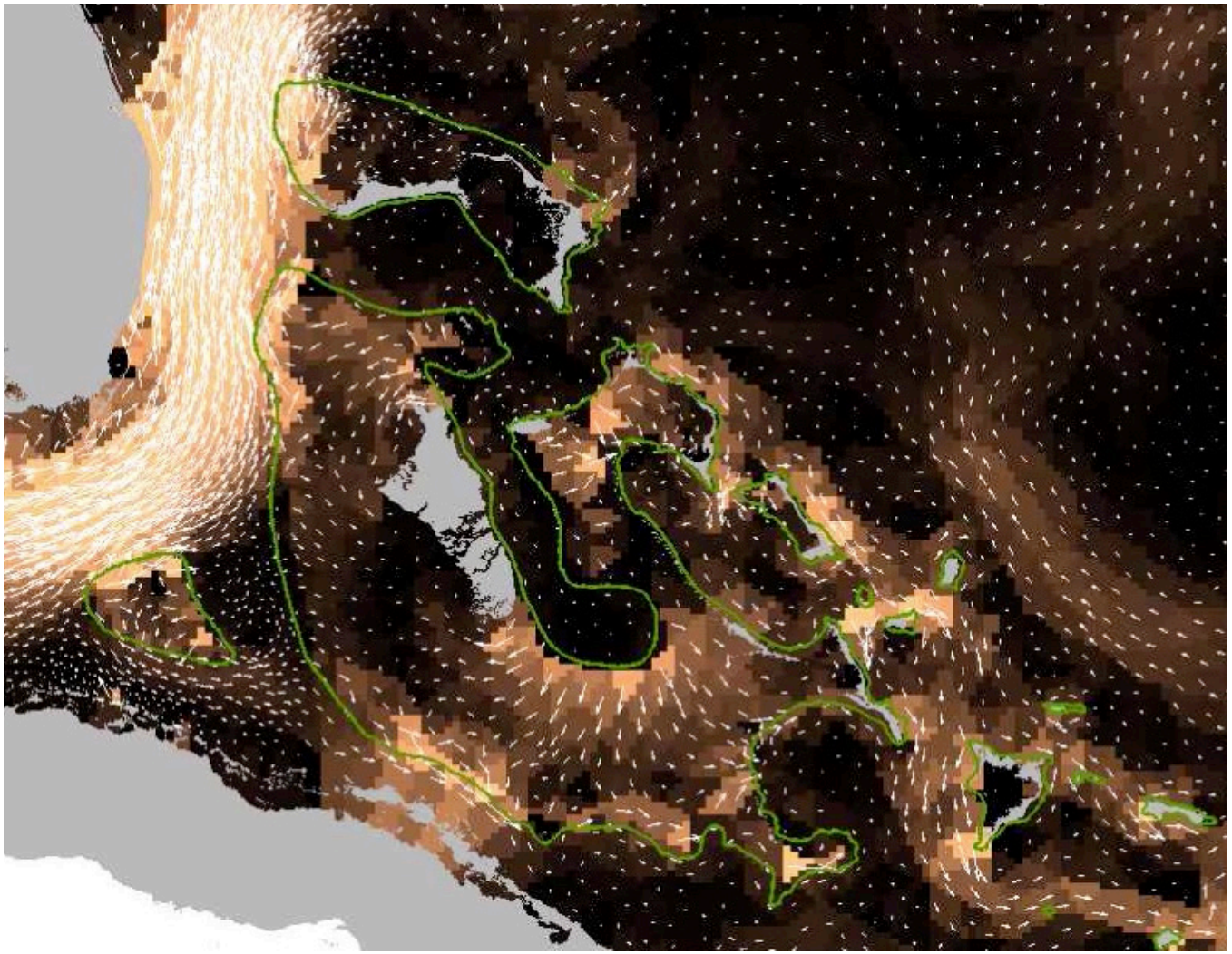
Purkis, S.J., G. Cavalcante, L. Rohtla, A.M. Oehlert, P.M. Harris, and P. Swart, 2017, Hydrodynamic Control of Whitings on Great Bahama Bank: Geology, doi:10.1130/G39369.1.

Controls and Patterns of Depositional Facies Across Great Bahama Bank



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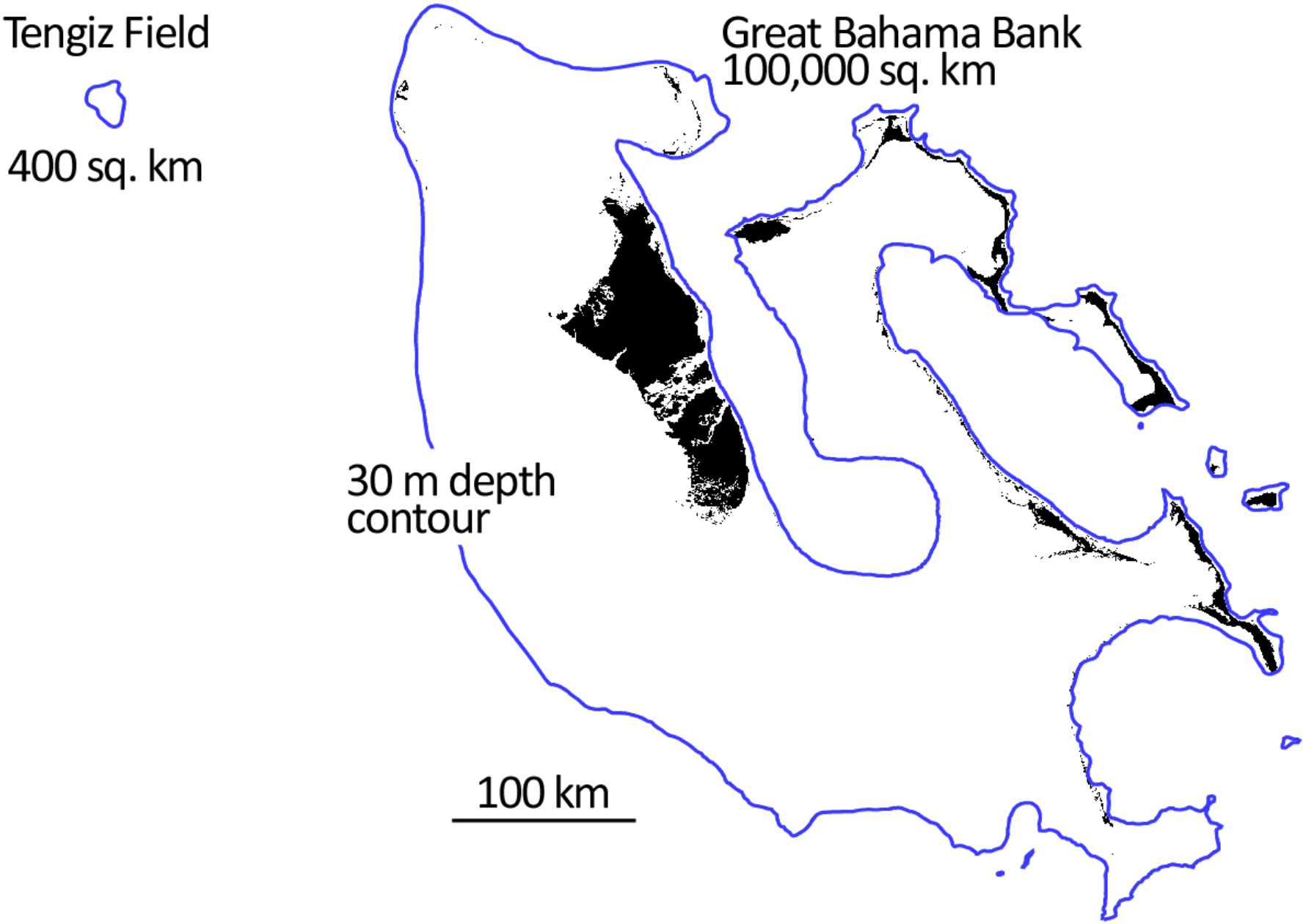
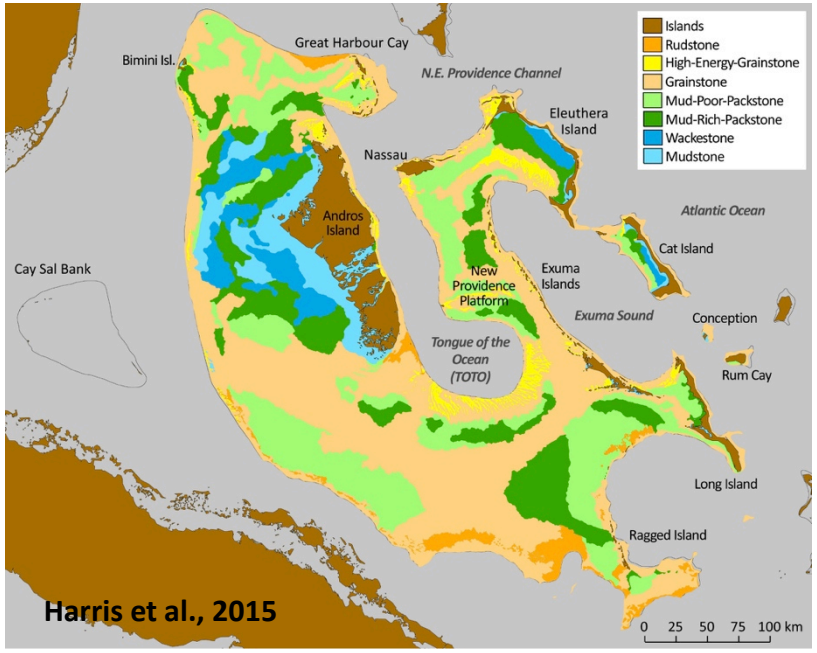
Key Findings:

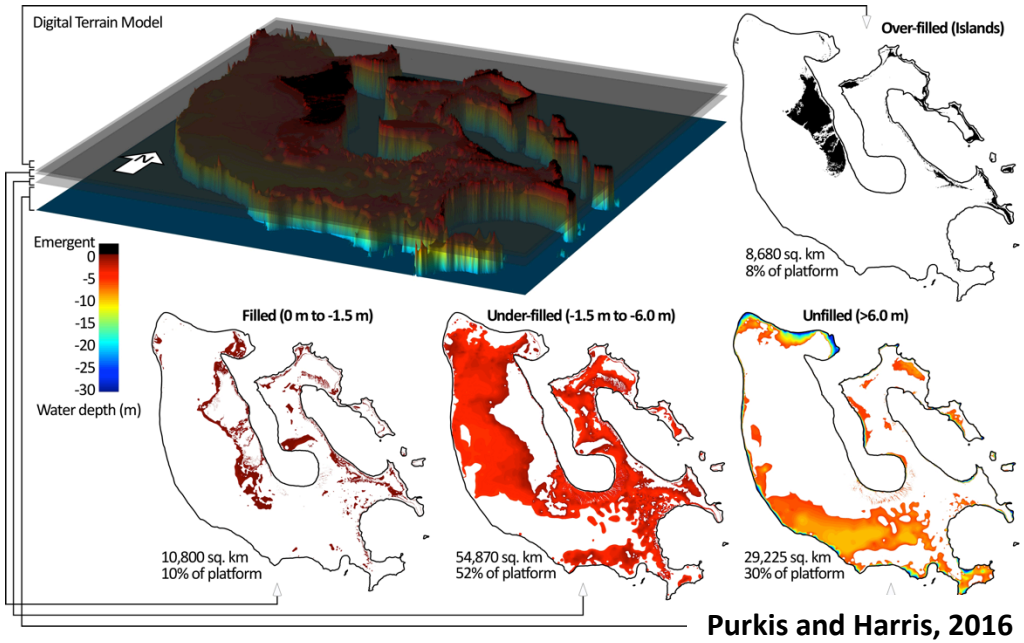
- A hydrodynamic model for the shallow platform top of Great Bahama Bank (GBB) is used to further address fundamental controls over platform-wide sedimentation and facies heterogeneity.
- Areas of vigorous tidal exchange across the platform margin in the model correspond to high-energy ooid shoal systems and a relationship exists between peak current velocities and the size of ooid sand complexes.
- Accommodation filling is related to platform topography and hydrodynamic flow.
- Lessons from GBB for the interpretation of facies heterogeneity and facies correlation for fossil platforms.

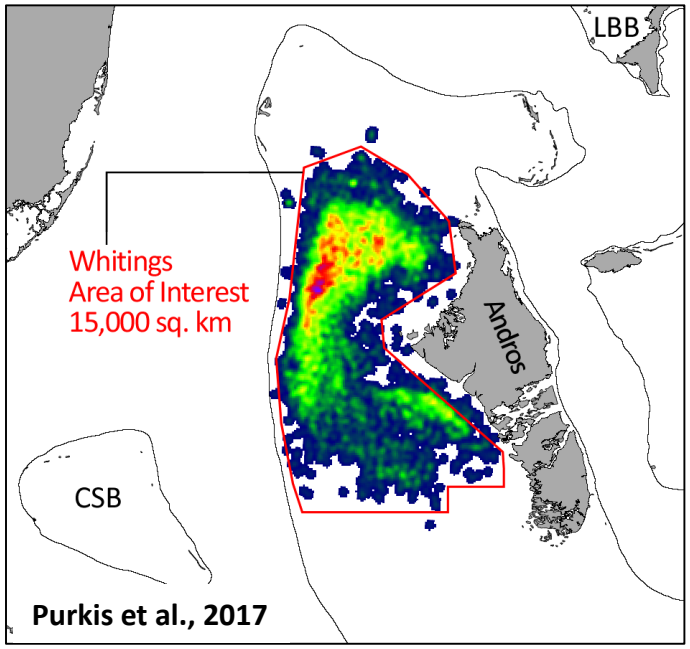
Platform Correlations are Challenging

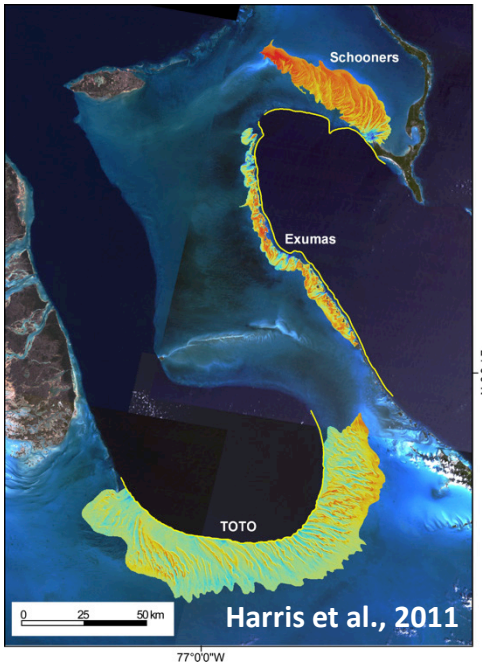


Our Recent Focus on GBB





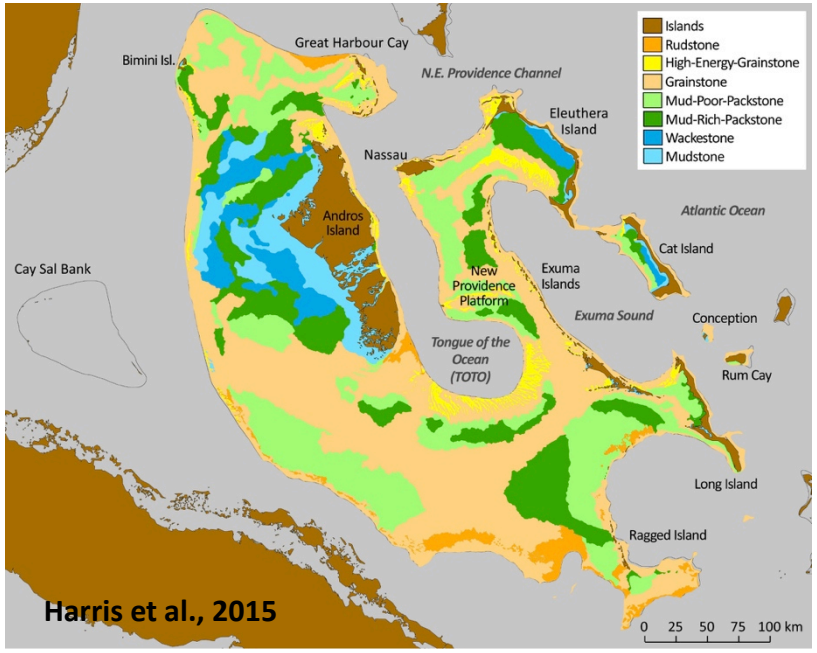


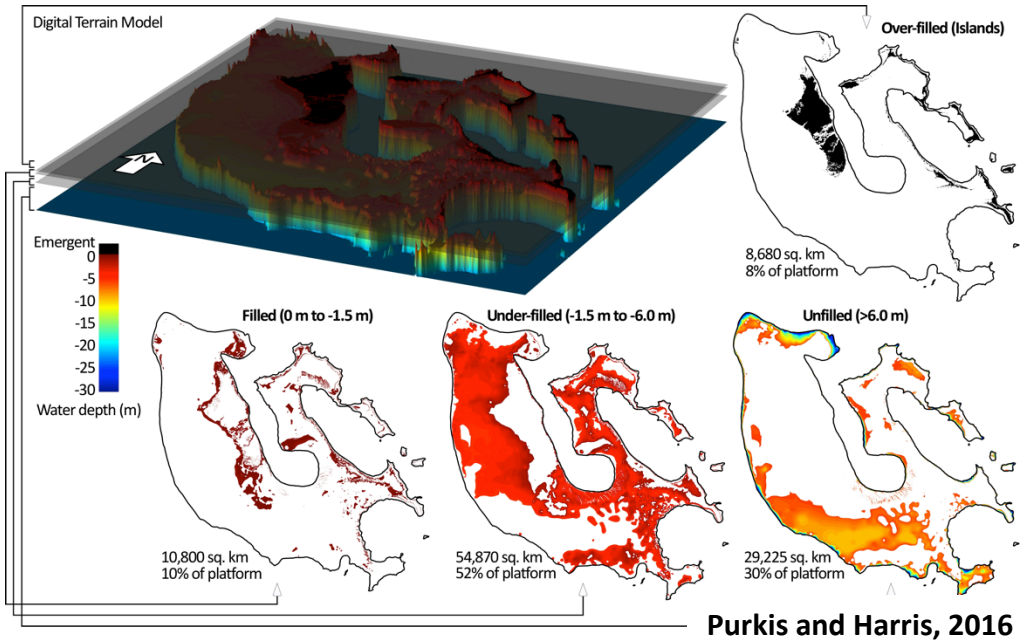


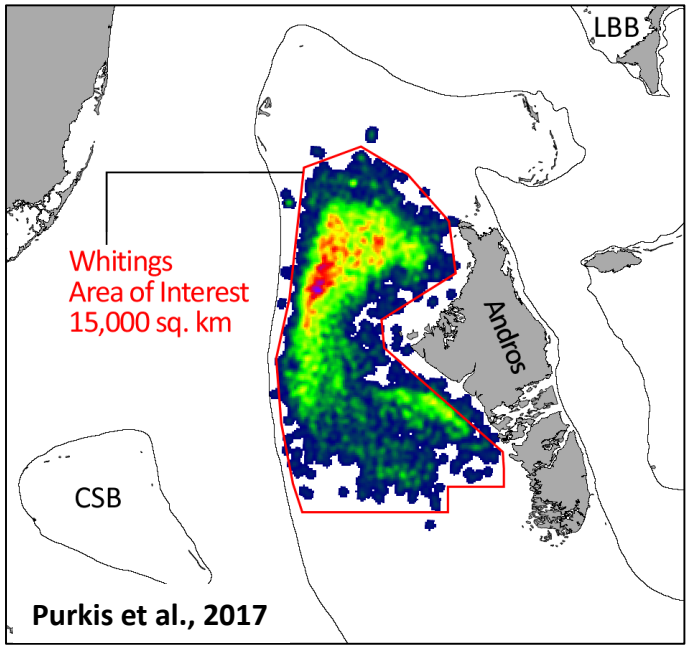
Collectively, these quantitative-based studies are aimed to provide new insight into the variability of depositional facies that challenge:

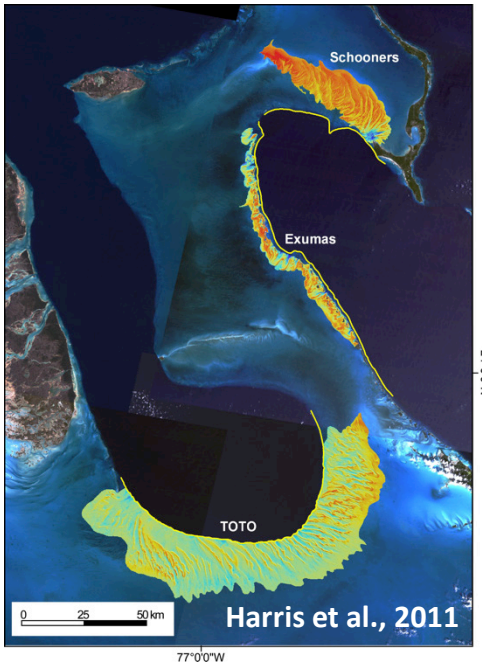
a) subsurface correlations,
b) development of rock- and log-based geologic models, and
c) building of reservoir models.

Our Recent Focus on GBB



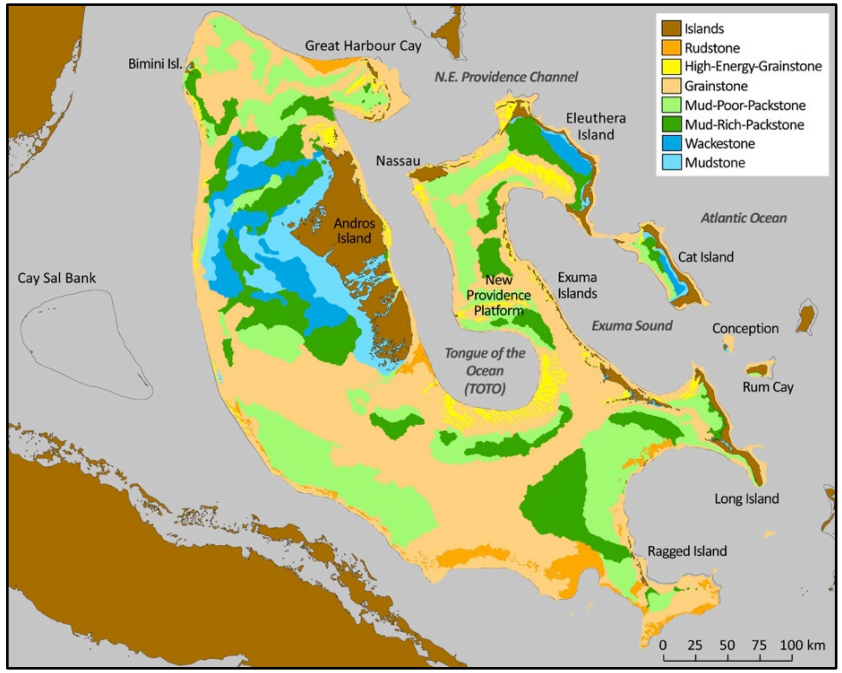


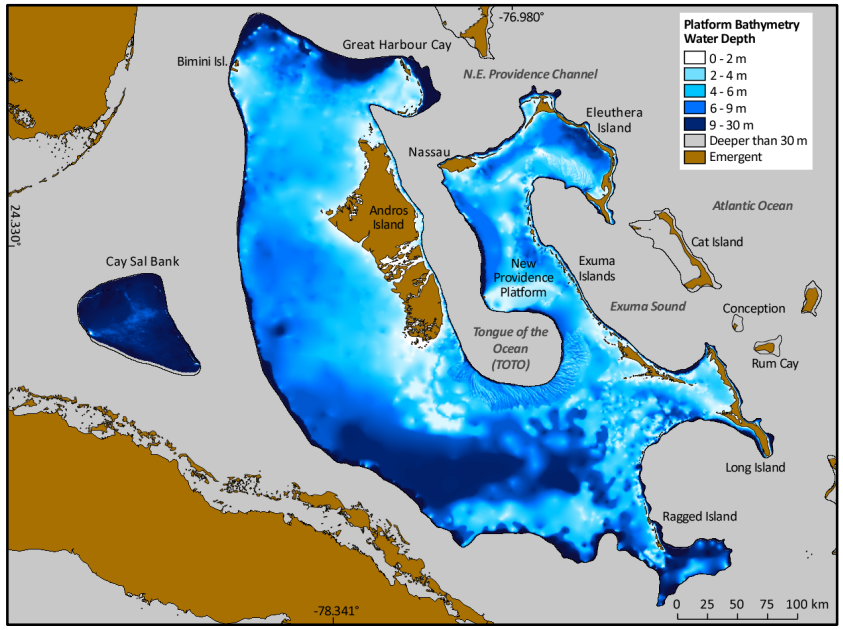




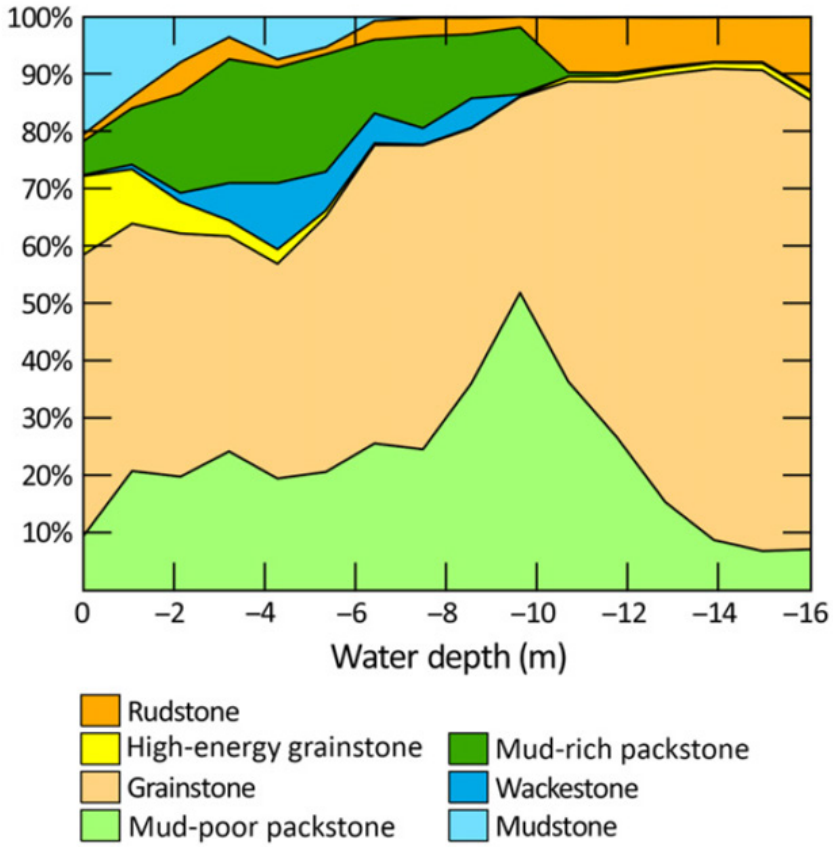
Missing from these studies, however, has been a scrutiny of the physical controls over modern platform-top deposition, which, coupled with the enhanced mapping may provide even more robust quantitative comparative sedimentology and stratigraphy guidelines for interpretation of the ancient.

Water Depth and Facies

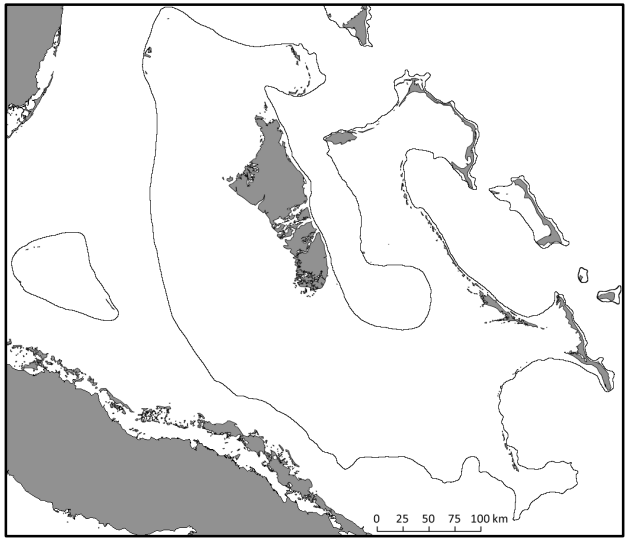


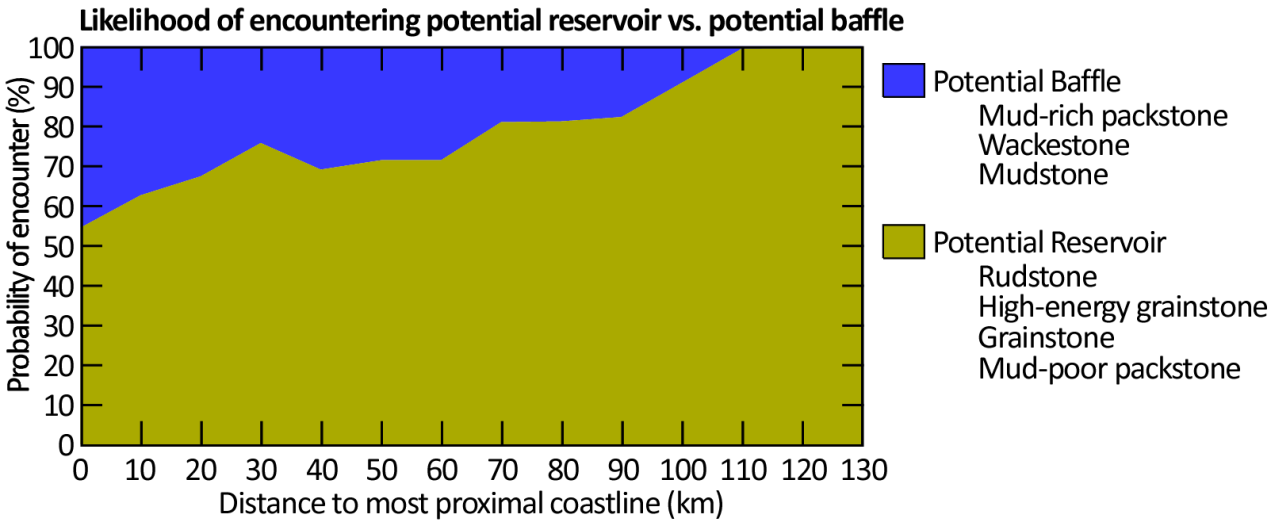


Facies character is poorly delimited by water depth

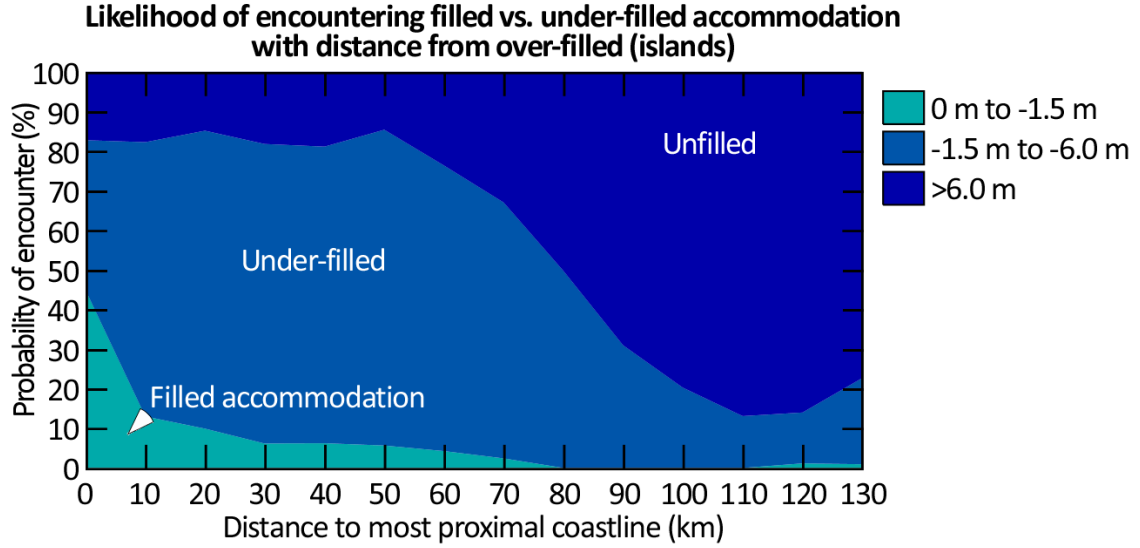


Importance of Islands to Accommodation Filling



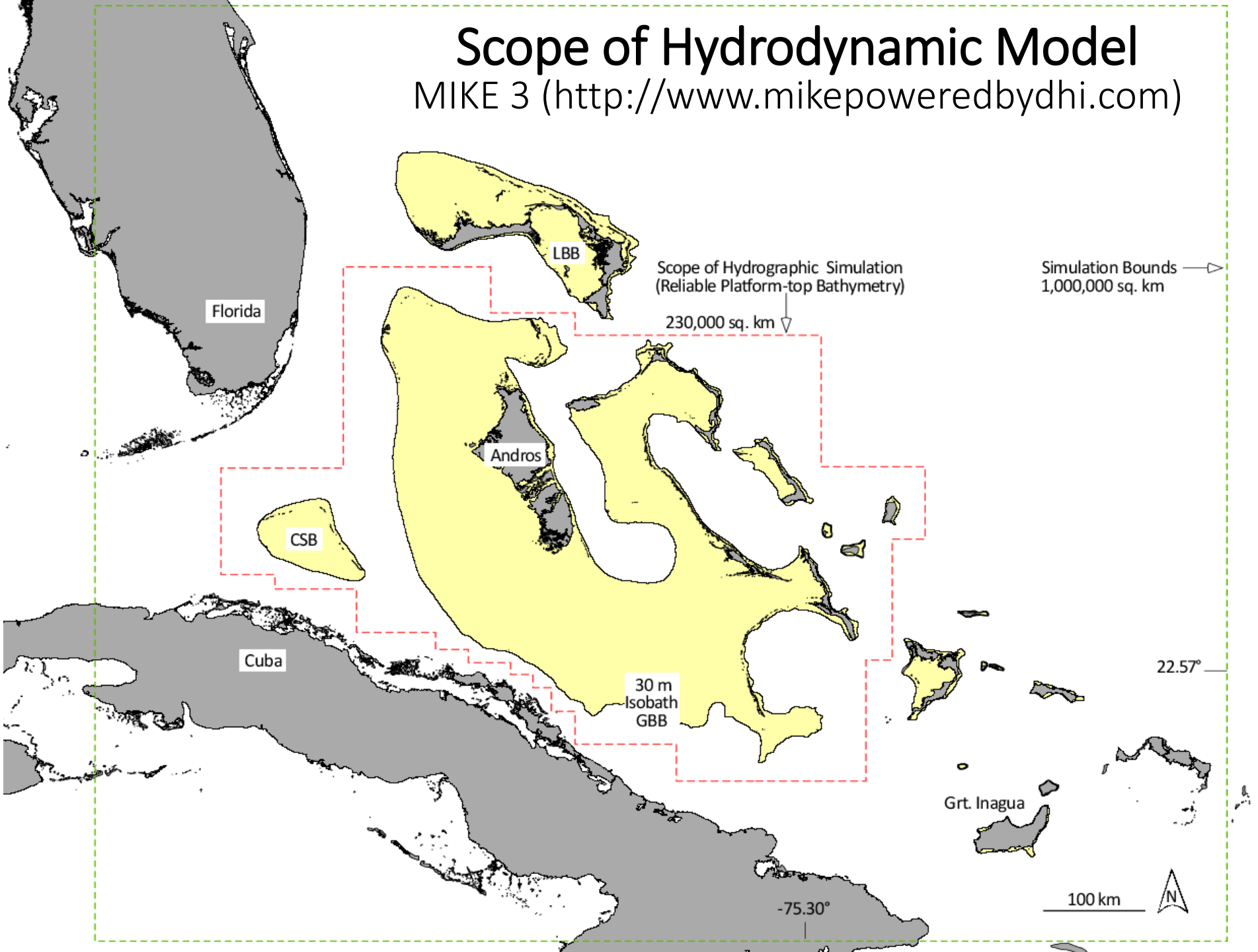


Islands exert a strong influence over sediment type and amount



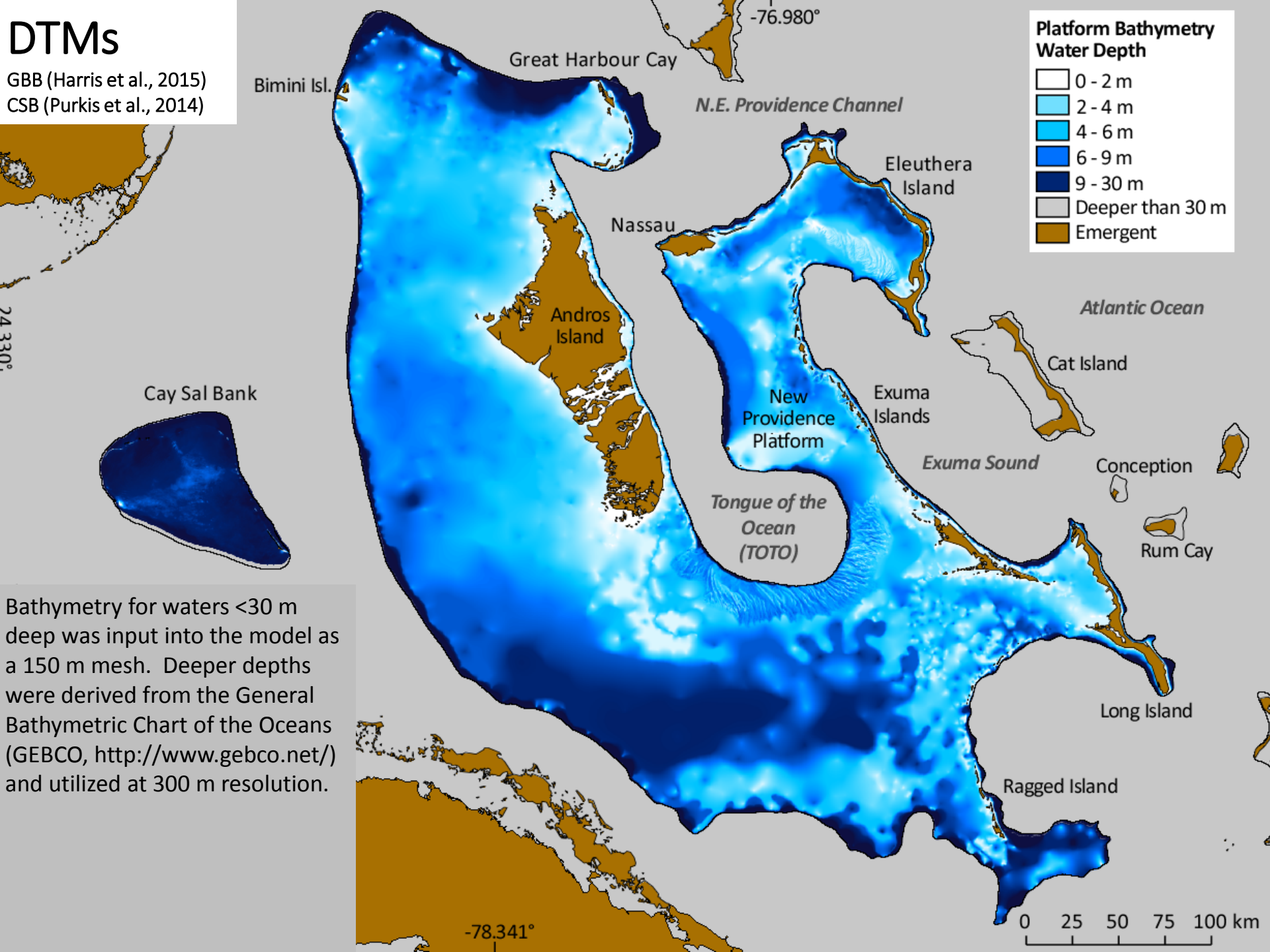
Scope of Hydrodynamic Model

MIKE 3 (http://www.mikepoweredbydhi.com)



DTMs

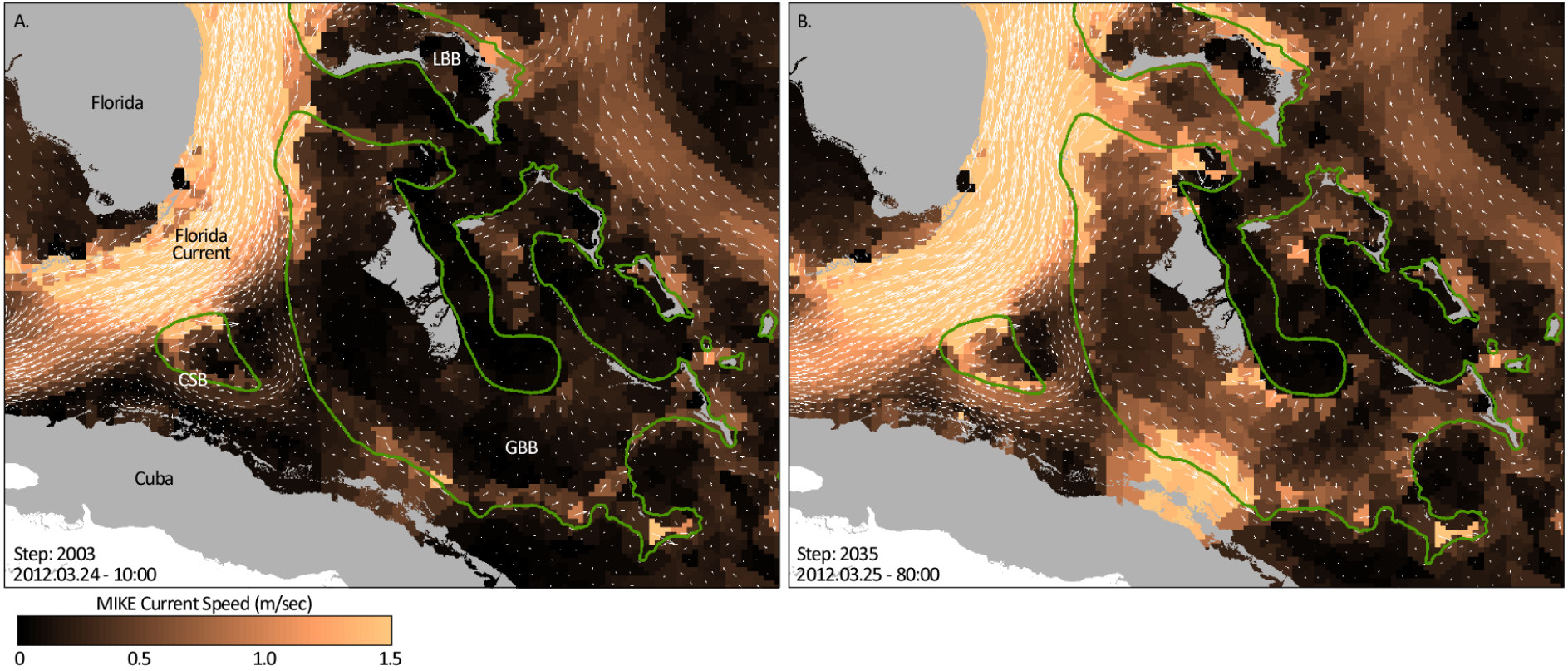
GBB (Harris et al., 2015)
CSB (Purkis et al., 2014)



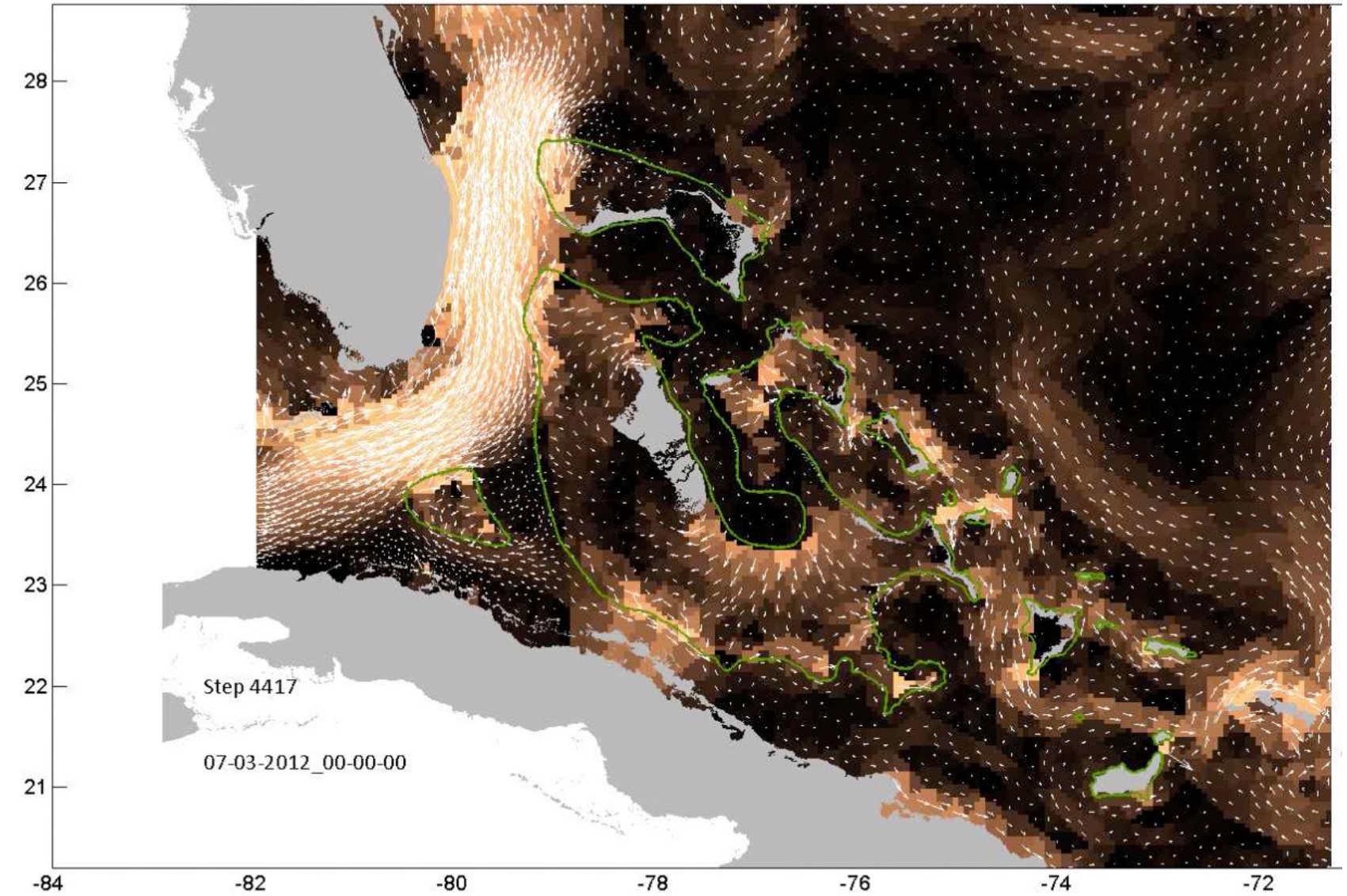
Bathymetry for waters <30 m deep was input into the model as a 150 m mesh. Deeper depths were derived from the General Bathymetric Chart of the Oceans (GEBCO, http://www.gebco.net/) and utilized at 300 m resolution.

MIKE 3 – Hydrodynamic Model

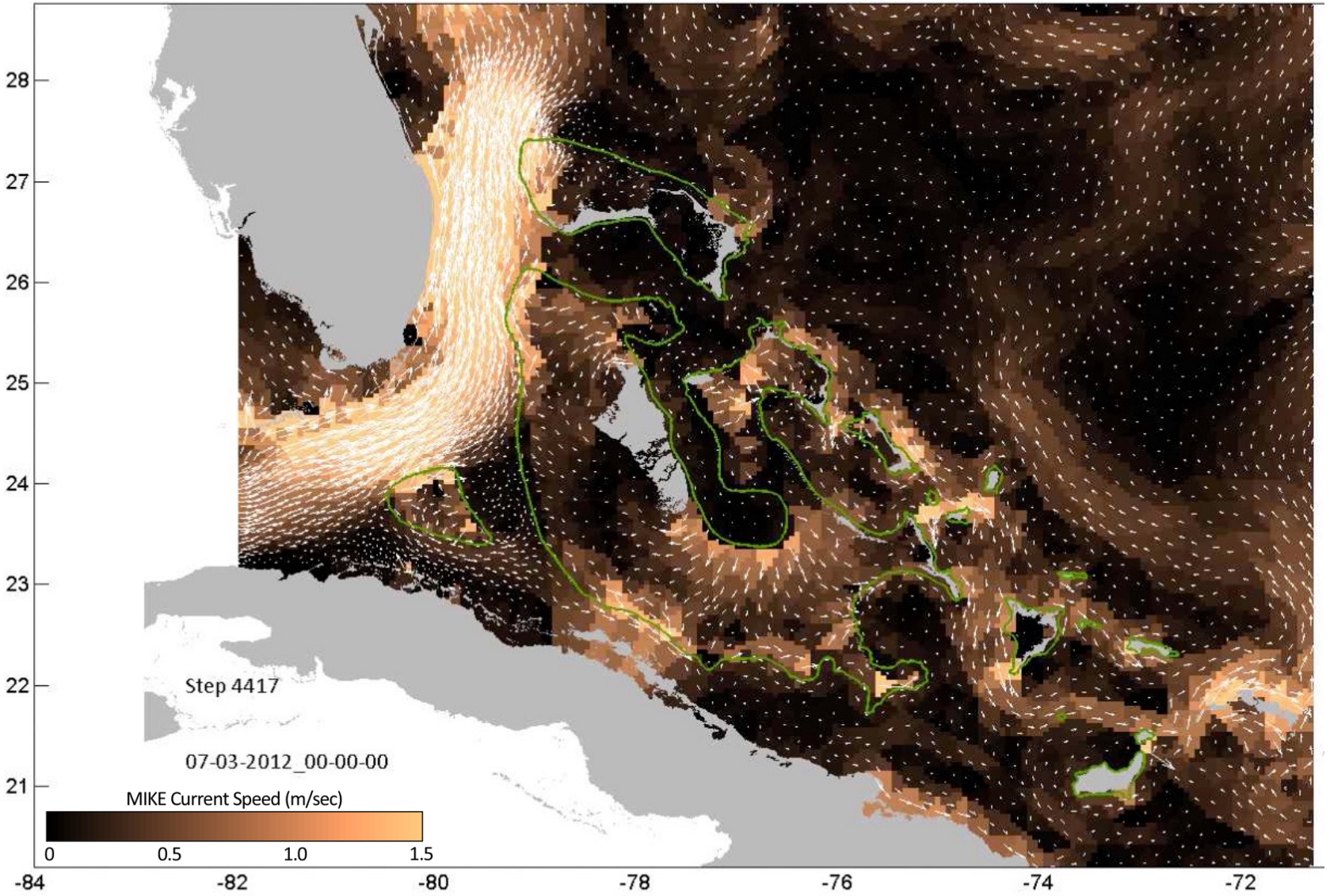
- Run for 1 Jan 2012 to 1 Jan 2013, with warm-up period of 1–31 December 2011
- Run with 16 layers in the vertical domain with a time-step of 1 min
- Forced by prevailing ocean hydrodynamics surrounding the platform, including the Florida Current, captured at a resolution of 0.08 × 0.08°
- Tides, winds and atmospheric pressure captured at a resolution of 0.25 × 0.25°
- Wind data computed as 1-hour average of the effective wind at an altitude of 10 m
- Fields were derived from the Computational and Information Systems Laboratory (CISL) Research Data Archive (https://rda.ucar.edu).



MIKE 3 – Hydrodynamic Model



Hydrodynamic Flow and Ooid Sand Bodies



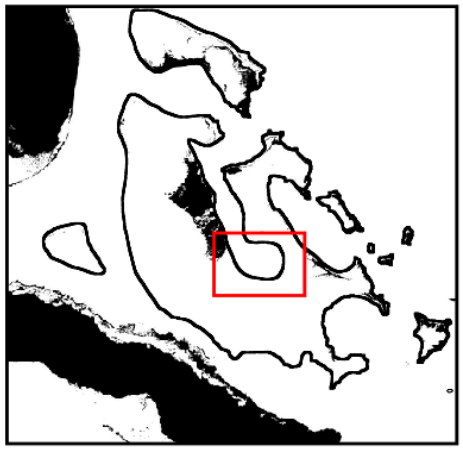
Areas of vigorous tidal exchange in the model correspond to localities where high-energy ooid shoal systems have developed along platform-margin.

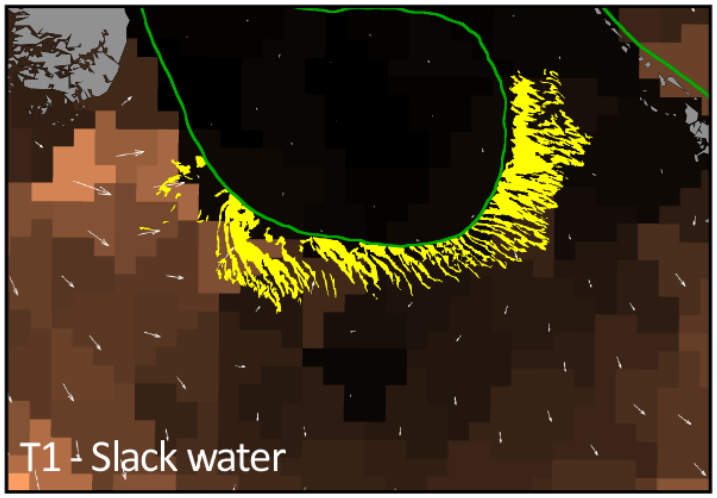
e.g., Note current movement through the TOTO and Joulter Cays sand bodies.

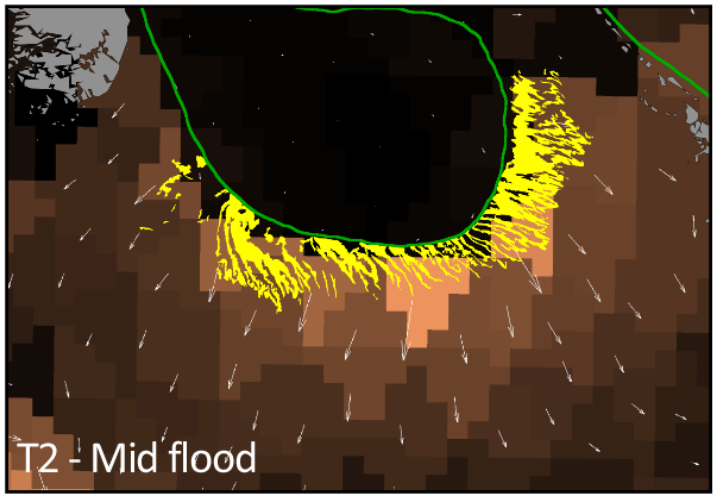
Hydrodynamic Flow and Ooid Sand Bodies

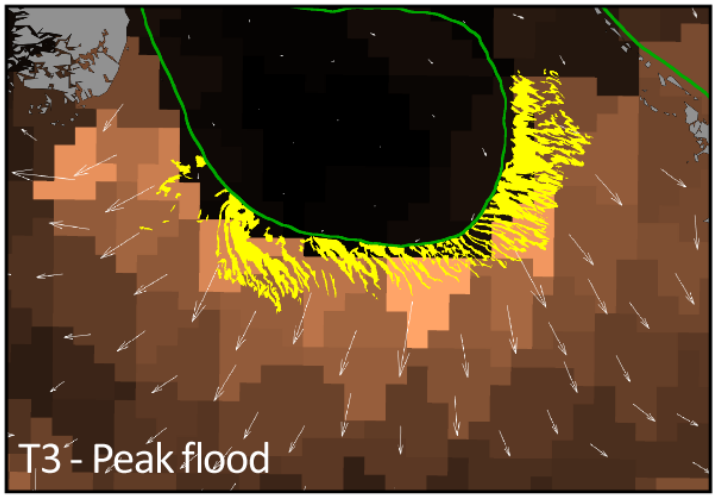
Tidal Cycle in TOTO

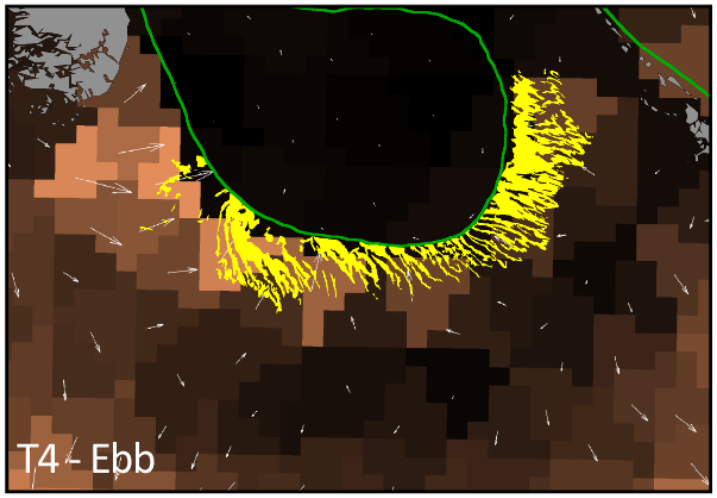
20th June, 2012











MIKE current velocity

>1.0 (m/s)
0.8
0.6
0.4
0.2
0

N

25 km

Land

High-energy grainstone

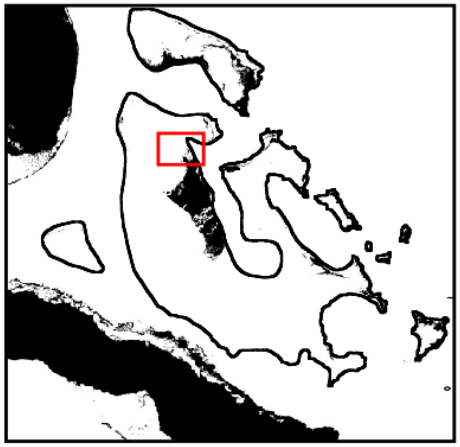
30 m bathy contour

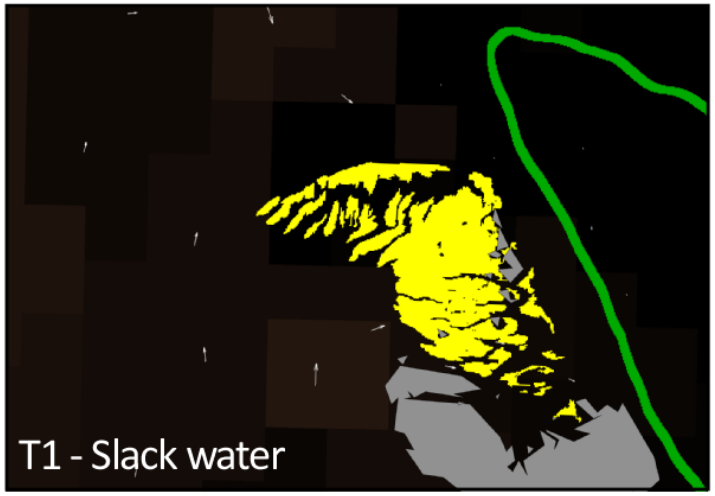
~6 hr. cycle

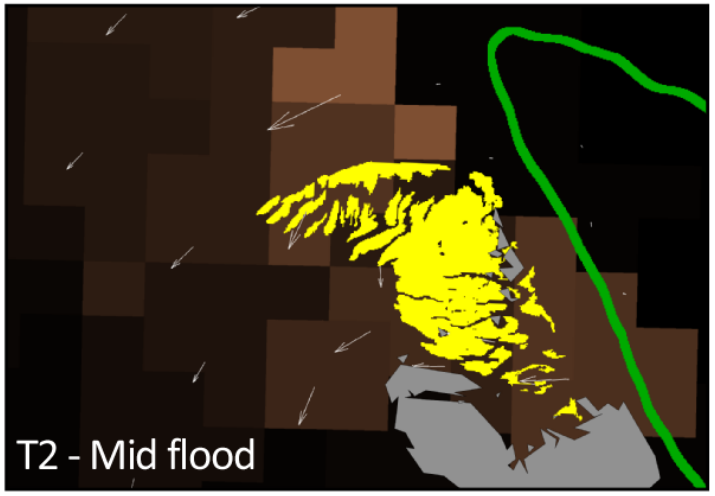
Hydrodynamic Flow and Ooid Sand Bodies

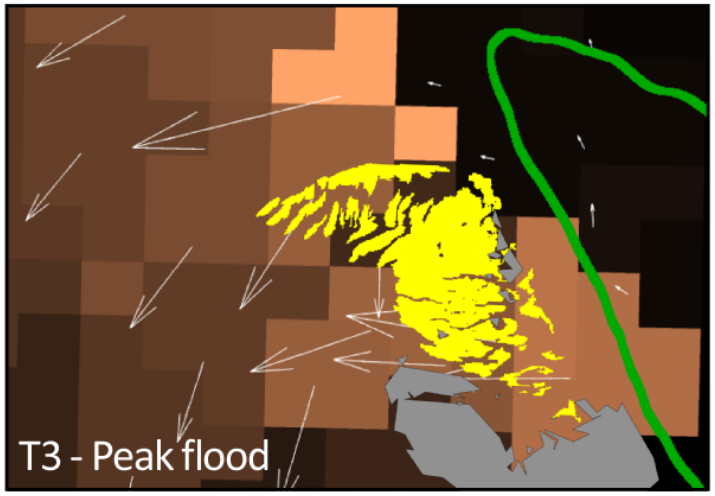
Tidal Cycle at Joulters

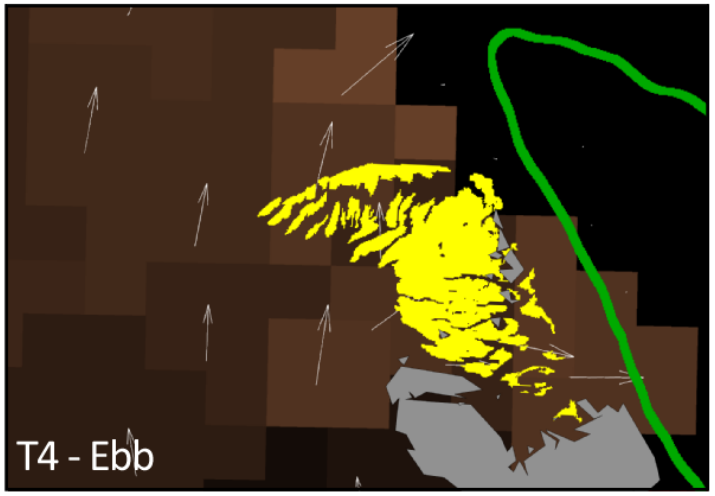
3rd July, 2012











MIKE current velocity

>1.0 (m/s)
0.8
0.6
0.4
0.2
0

N

10 km

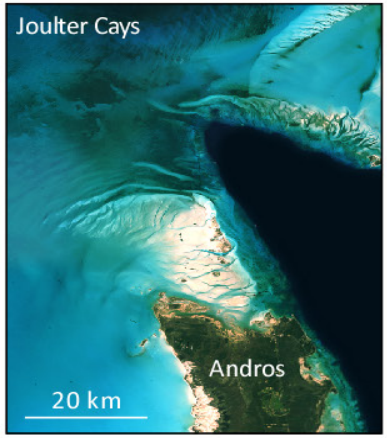
Land

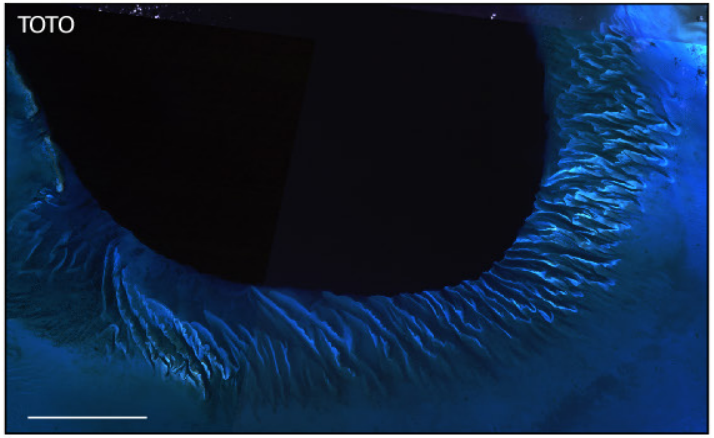
High-energy grainstone

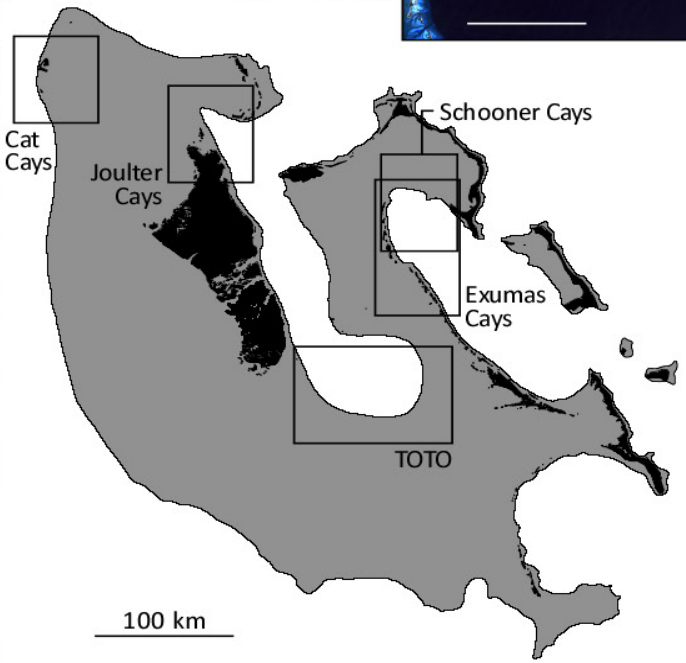
30 m bathy contour

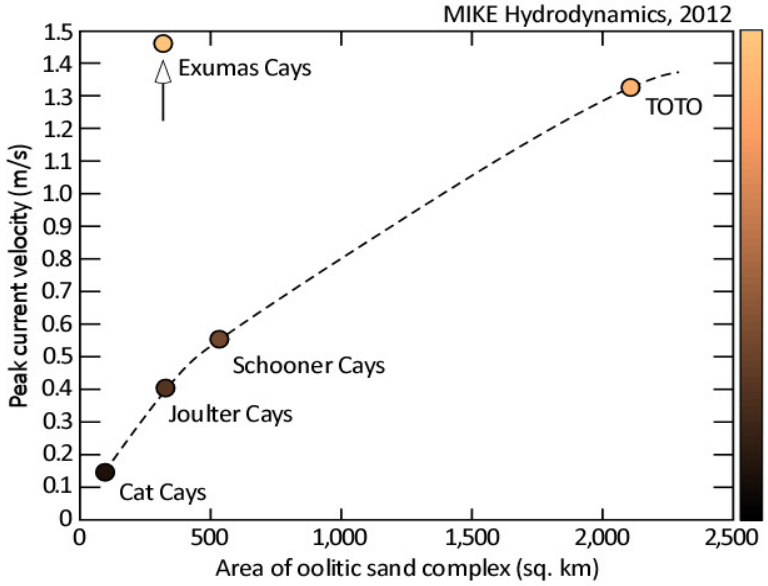
~6 hr. cycle

Hydrodynamic Flow and Ooid Sand Bodies









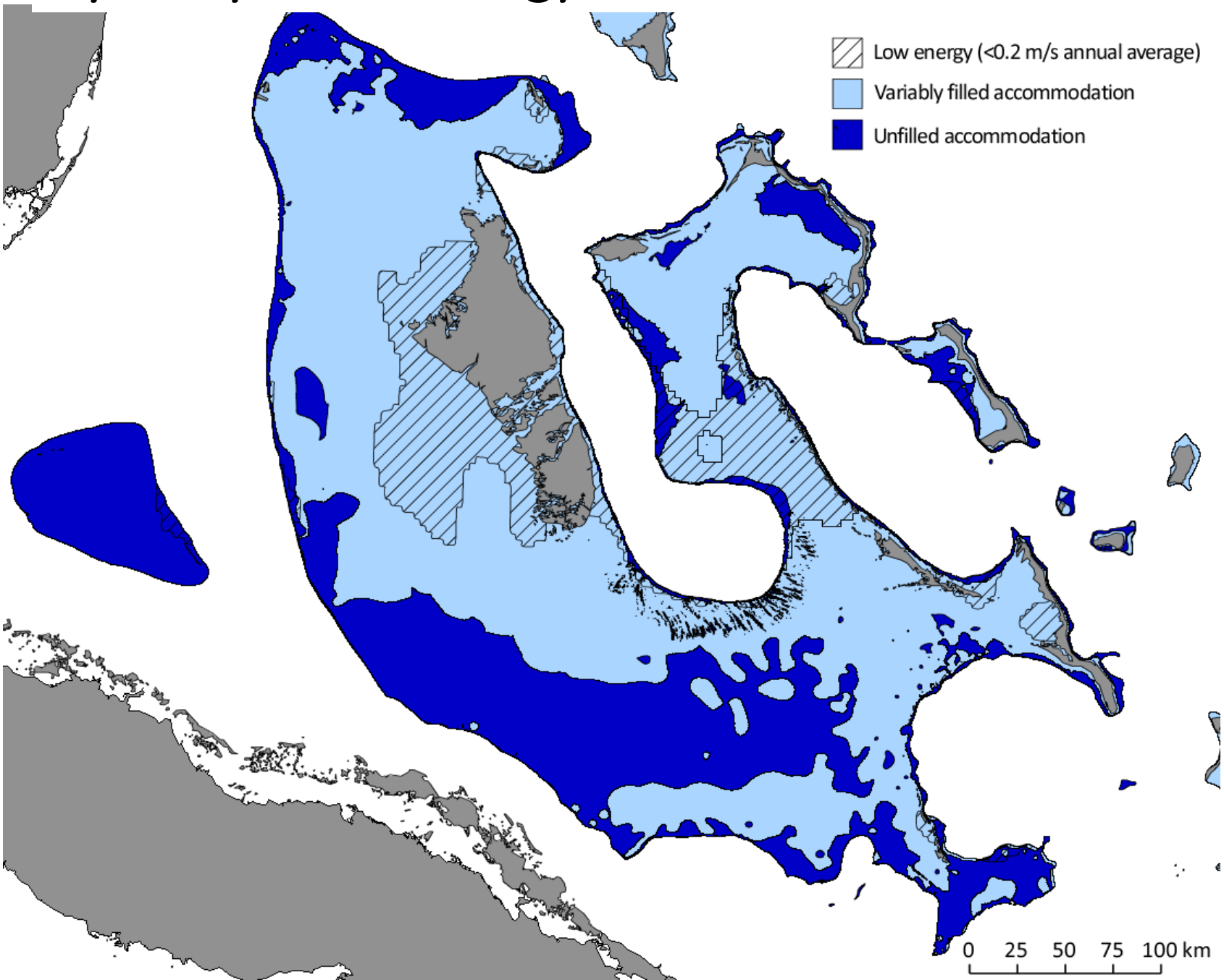
There is a predictive relationship between increasing peak current velocity and increasing area of the sand body.

- Doubling the peak current velocity increases the area of the sand body by a factor of three (super linear)

Presenter's notes: Locations and Landsat views on GBB where ooid sand bodies are developing today – the Cat, Joulters, Exumas and Schooners Cays and Tongue of the Ocean (TOTO). Plot in lower right compares the area of the various sites with peak current velocities from the MIKE model (http://www.mikepoweredbydhi.com).

GBB Zones of Average Annual Hydrodynamic Energy

Hydrodynamic Energy and Accommodation Fill



Key Findings:

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