

## Abstract

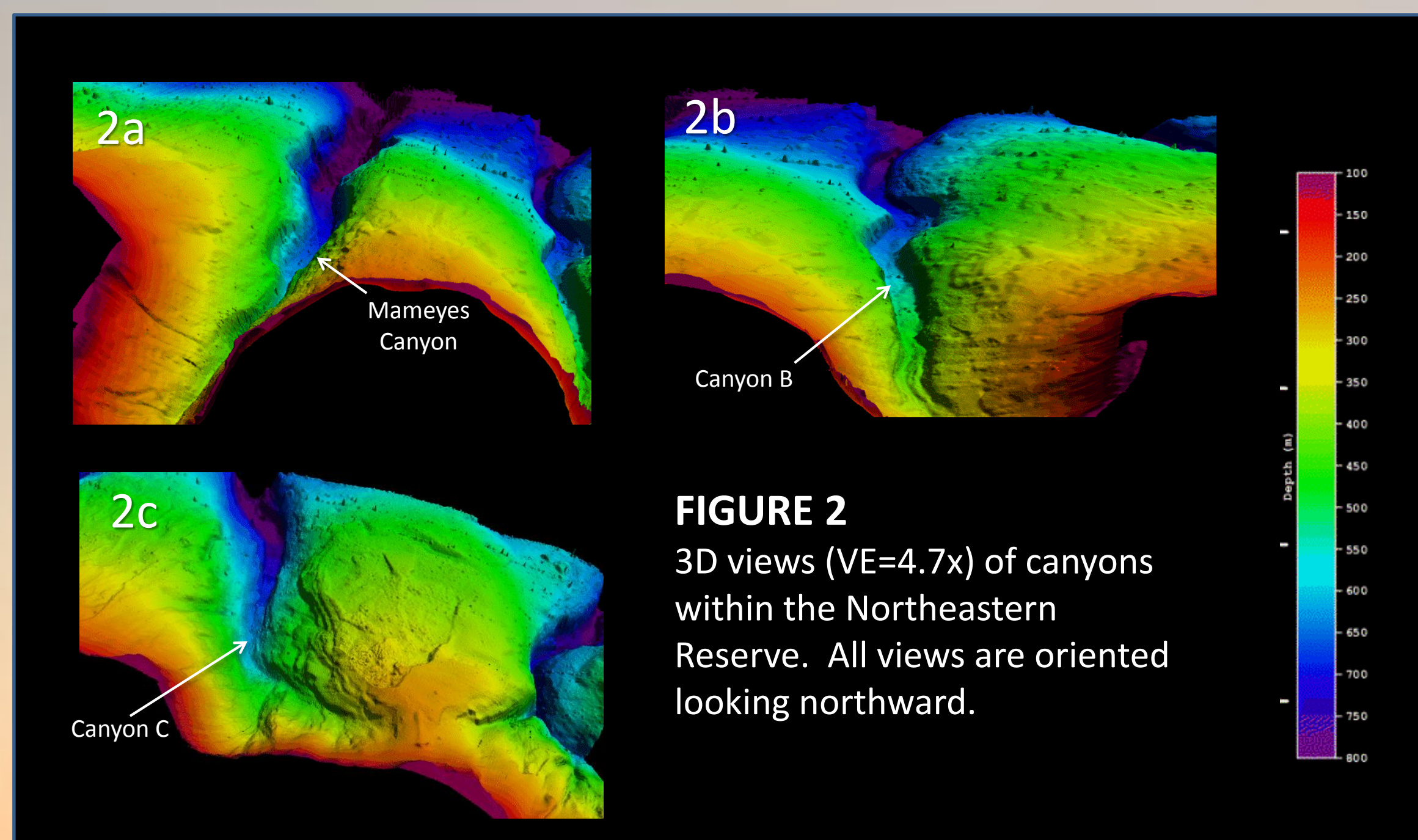
Seafloor geomorphology was examined for two distinct protected tropical habitats, located off the northeast coast of Puerto Rico within the Northeastern Grand Reserve Ecological Corridor, and off the southern coast of the nearby Isla De Vieques. These continental shelf and slope areas were surveyed in March 2013 from aboard the NOAA Ship *Nancy Foster* by NOAA chief scientist Timothy Battista. Multibeam sonar bathymetric data were collected using a Kongsberg EM1002, covering depths between 25 and 1150 m, and were post-processed using CARIS HIPS and SIPS 8.1. Approximately 866 species of coral reef fauna inhabit these protected areas, and significant concern has been raised as to their stability to withstand man made obstructions, global climate change, and natural hazards. Features of the Reserve and Vieques margins were characterized and compared, and include fore-reef edges of coral reef habitat on the continental shelf and submarine canyons that plunge approximately 900 m. These bathymetric 2D and 3D surfaces will be useful as baseline surveys to detect future changes to the critical protected areas.

## Introduction

The Northeast Grand Reserve Ecological Corridor is located off the coast of Puerto Rico, northeast of San Juan. This area exhibits distinguishing submarine canyons, with changing channel width, depth and substrate. In 2013, scientists conducted a biological study on this area and captured underwater photos and videos using a remotely operated vehicle (ROV). These data were later used to help develop benthic habitat maps, to describe features of northeastern Puerto Rico's habitat (CCMA, 2013).

Isla De Vieques lies 21 km east of Puerto Rico. This undulating island is 34 km long and 5 km wide. In the early 1940s more than two-thirds of the island were annexed by the U.S. Navy, ultimately closed to the public (Riegl, 2008). Due to the timespan that the Navy used these areas as training facilities, there is little known regarding previous substrate composition (Clark and Wilcock, 2000).

Seafloor geomorphology was examined for these two distinct protected tropical habitats. The purpose of this study was to characterize and compare the margins of the Reserve and Vieques within themselves, and to each other. Baseline surveys generated from 2D and 3D surfaces are a staple to identifying alterations in these areas.

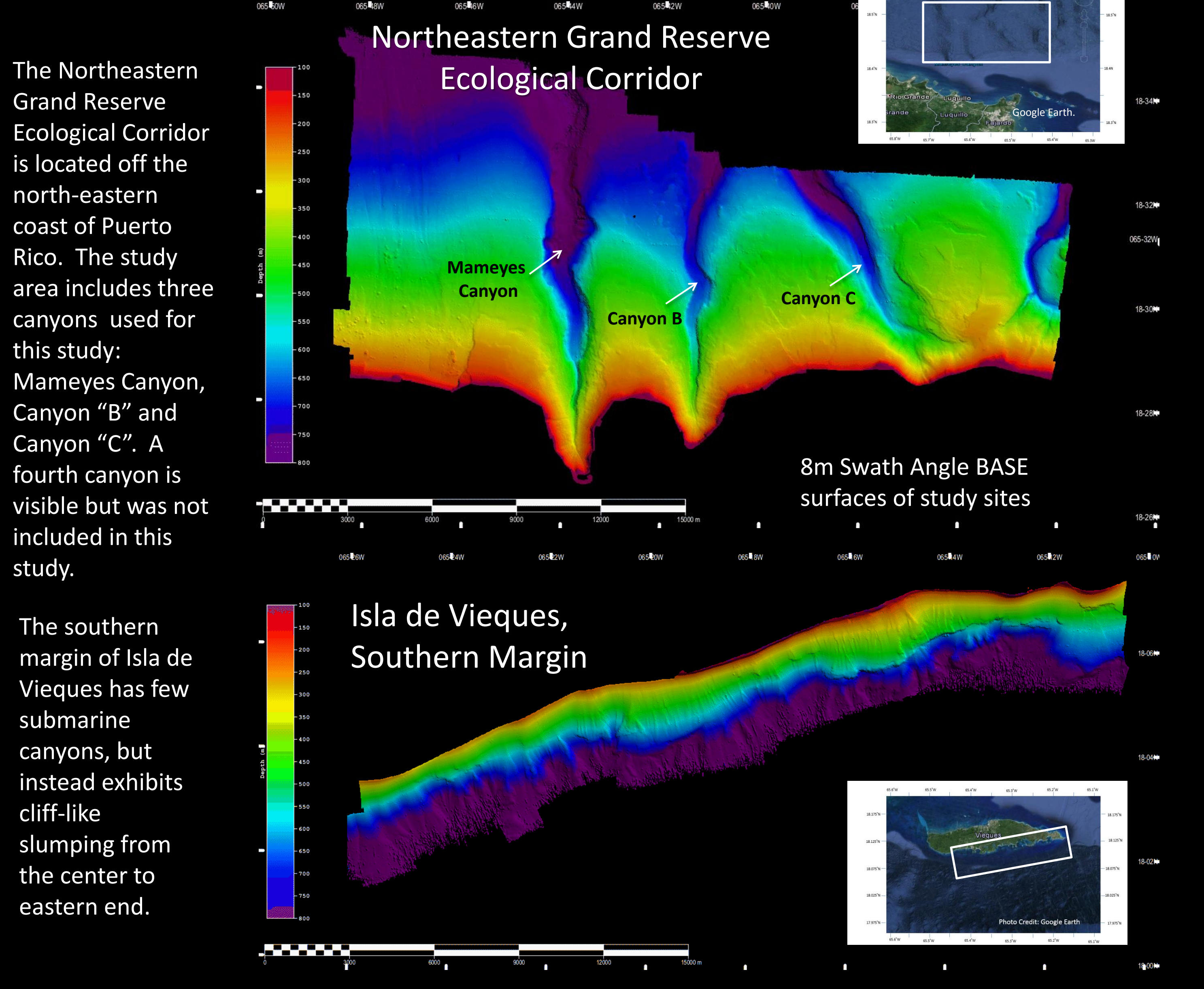


**FIGURE 2**  
3D views (VE=4.7x) of canyons within the Northeastern Reserve. All views are oriented looking northward.

## Methods

Multibeam sonar data were collected by the NOAA Ship *Nancy Foster*, and downloaded from NOAA National Geophysical Data Center for cruise NF-13-02. Data were post-processed in CARIS HIPS and SIPS 8.1 to make a Swath Angle BASE surface for analysis. Distance and digitizing profile tools were used for quantitative analysis on dominant canyons within the area of interest. Observations on slumping and orientation were also made.

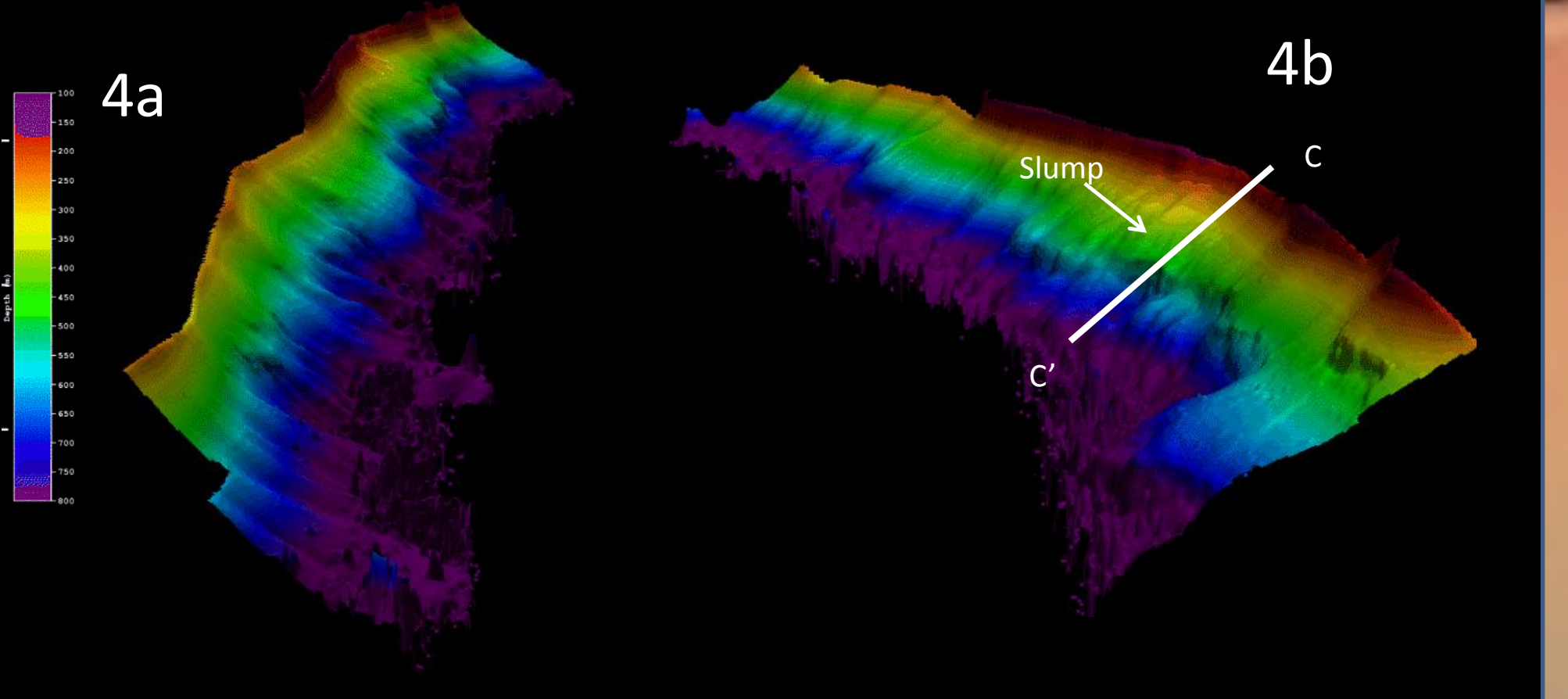
**FIGURE 1:** Location of Study Sites



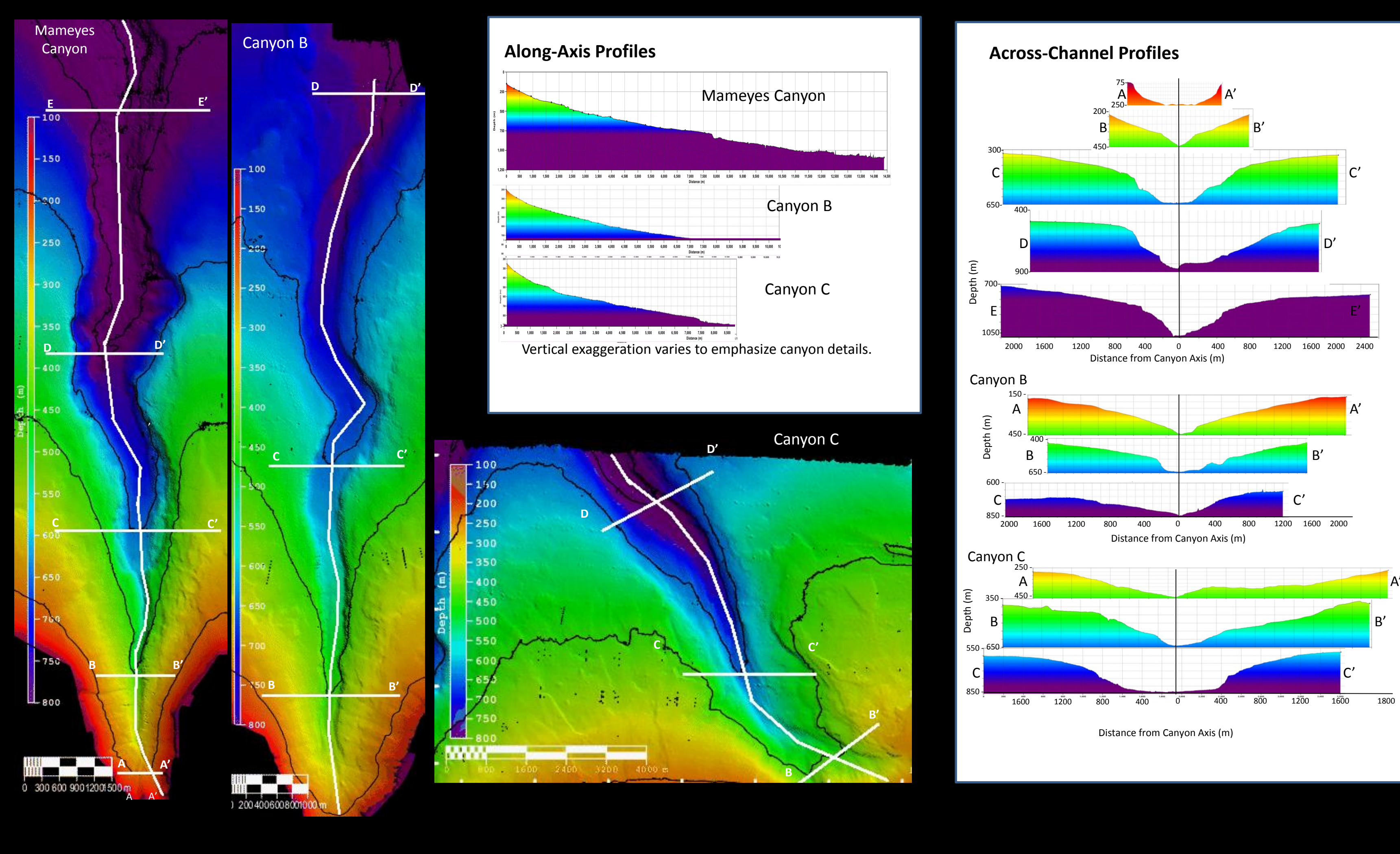
The Northeastern Grand Reserve Ecological Corridor is located off the north-eastern coast of Puerto Rico. The study area includes three canyons used for this study: Mameyes Canyon, Canyon "B" and Canyon "C". A fourth canyon is visible but was not included in this study.

The southern margin of Isla de Vieques has few submarine canyons, but instead exhibits cliff-like slumping from the center to eastern end.

**FIGURE 4:** 3D views (VE=2.9X) of Vieques viewed from different directions. 4a) Looking northeast along the study area's central portion; 4b) looking southwest from the easternmost portion of the study area. A prominent slump and location of profile C-C' are shown.



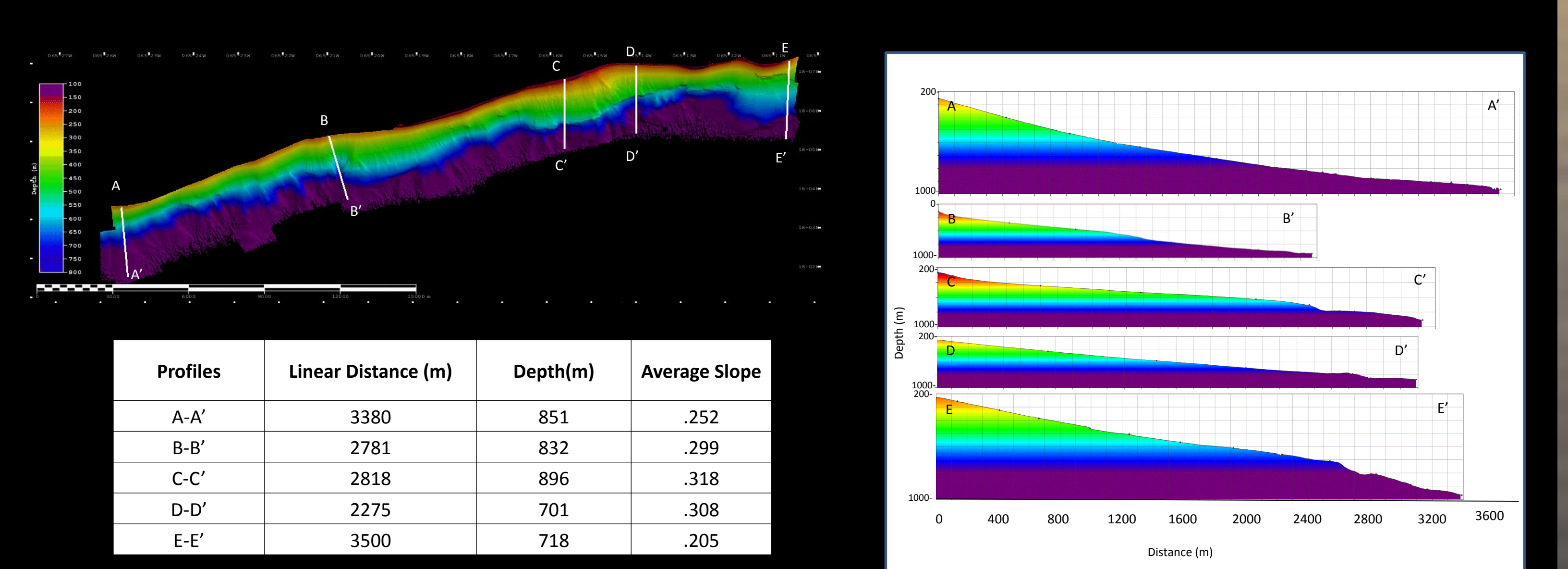
**FIGURE 3:** Cross-sectional profiles of the Northeastern Grand Ecological Reserve Corridor's incised canyons made along canyon axes (middle figures) and across-channel (figures at right) at specific isobaths along the sides of each canyon at 240, 440, 640, 840, and 1040 m (Table 1). All profile locations are shown on the 2D BASE surfaces to the left and below.



Canyon	Width at 240 m	Width at 440 m	Width at 640 m	Width at 840 m	Width at 1040 m	Length (m)	Depth (m)	Avg. Slope	Sinuosity
Mameyes Canyon	1000	1455	3520	3275	4100	14300	1130	.079	.95
Canyon B	N/A	3610	3060	3200	N/A	10495	850	.081	.96
Canyon C	N/A	3675	3790	3600	N/A	8562	897	.105	.98

**Table 1:** Reserve canyon dimensions, slope and sinuosity at specific wall isobaths at A-A' through E-E'. All values are in meters.

**FIGURE 5:** Profiles of the Isla de Vieques study area were made to compare slopes (Table 2).



Profiles	Linear Distance (m)	Depth(m)	Average Slope
A-A'	3380	851	.252
B-B'	2781	832	.299
C-C'	2818	896	.318
D-D'	2275	701	.308
E-E'	3500	718	.205

**Table 2:** Fore-reef margin characteristics.

## Discussion & Conclusion

Submarine canyons on passive margins are primarily formed by the erosion that is induced by sediment flows, as well as easterly trade winds, tidal currents, hurricanes, submarine landslides, and even biological reworking (Obelcz, 2013). In this particular study, channel morphology might be influenced by tide fluctuations, as a large portion of sediment comes from upstream (Clark and Wilcox, 2000). The Northeastern Grand Ecological Reserve clearly has a downstream trend in canyon widening, which can be explained by a frequency and/or grain-size of fluvial-sourced sediment flow passing through the canyons (Obelcz, 2013). The canyon that would be impacted most would be Mameyes Canyon, as it is directly connected to Puerto Rico by the Rio Mameyes.

The southern margin of Isla de Vieques has differences in slope throughout the area, but has similar characteristics on either end of the field (Profiles A-A' and E-E', Fig. 5), which increase towards the center. Throughout this study area, there are places with significant slumping of sediments, which are located between 518 and 685 m water depths, and the combination of shallow waters and lower slope may create safe habitats for fauna. Slumps are observed along most of Isla De Vieques in many cases. Steeper slopes allow for a higher energy of sediment transport. Present data are the most important pieces of information to know in order to estimate future continental shelf and slope changes (Clark and Wilcock, 2000).

## Results

### Northeastern Grand Ecological Reserve

- Mameyes Canyon is the longest of the 3 submarine canyons examined, with a cumulative distance of 14,154 m, and it has the greatest depth (1130 m). Canyon B is shallowest (850 m) and Canyon C is the shortest (8562 m)(Fig. 3 and Table 1).
- There is an increase in canyon width as the depth increases (Fig. 3).
- Mameyes Canyon is the most sinuous with a value of .98 (Table 1).

### Isla De Vieques

- This area is mainly characterized by slope changes eastward, having the greatest slope at point C-C'.
- Slopes throughout this study are directly affected by slumping (Figure 4b)
- The average slopes of B-D is .308, while the average slopes of A and E are .205. The difference between these averages is .08.

## References Cited

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