Substrate Classification of Puerto Rico's Northern Continental Slope Submarine Canyons
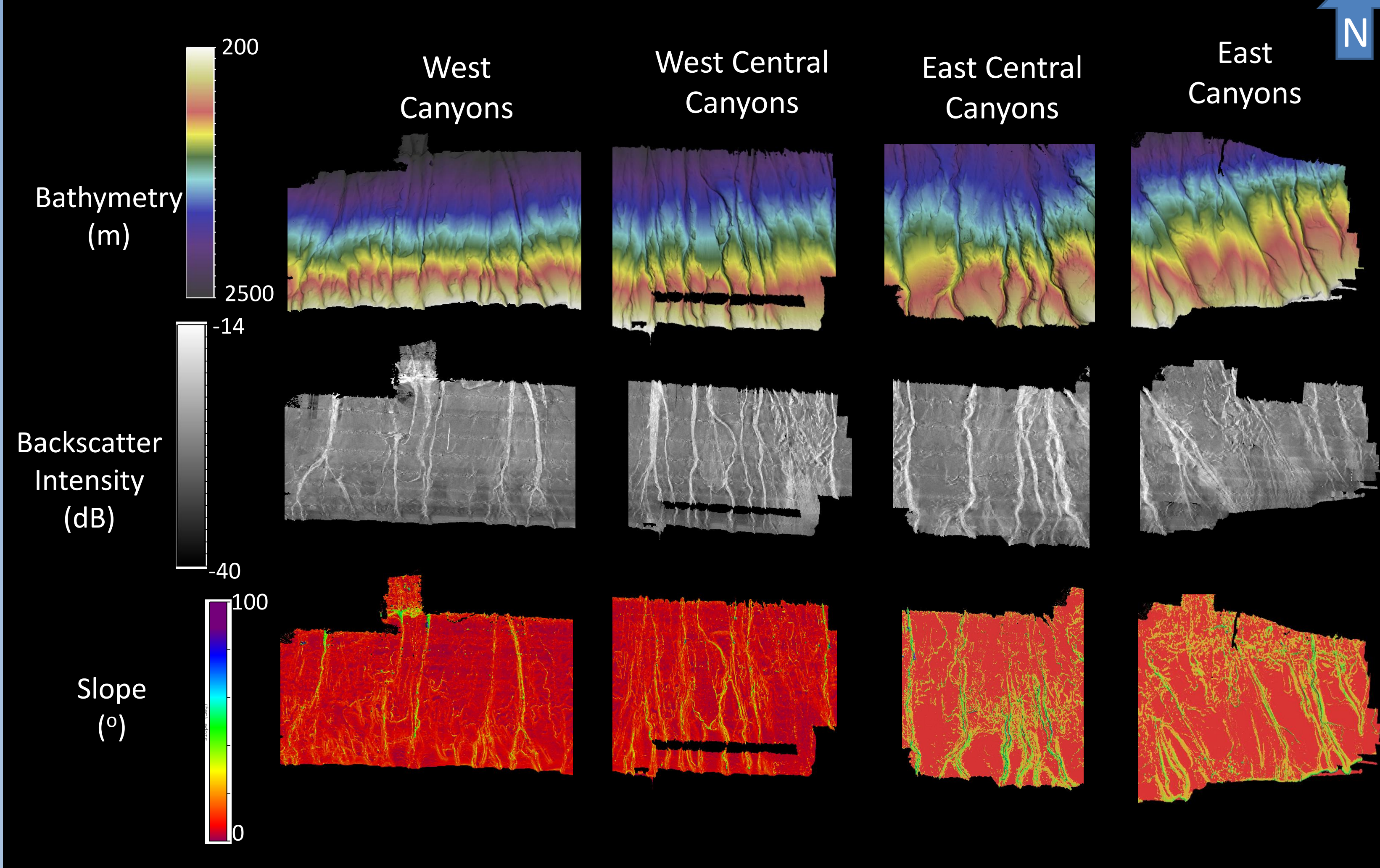
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NOAA Ship *Okeanos Explorer*

Abstract

NOAA scientists conducted a study aboard the NOAA Ship *Okeanos Explorer* from March till May in 2015 to survey the northern continental margin of Puerto Rico using multibeam sonar. The study area covered 180 km of the continental slope, which included many submarine canyons of different morphologies. These canyons exhibit 2000 m of vertical relief over a distance of 50 km, illustrating the slope's steep gradient. Bathymetry, slope, and backscatter surfaces were generated using CARIS HIPS and SIPS 10.2. Geomorphic features and substrate variations were recorded and classified from exposed rock to unconsolidated sediments. These data and mapped surfaces were used to identify possible deep-sea coral habitat locations as well as potential demersal fish habitats.
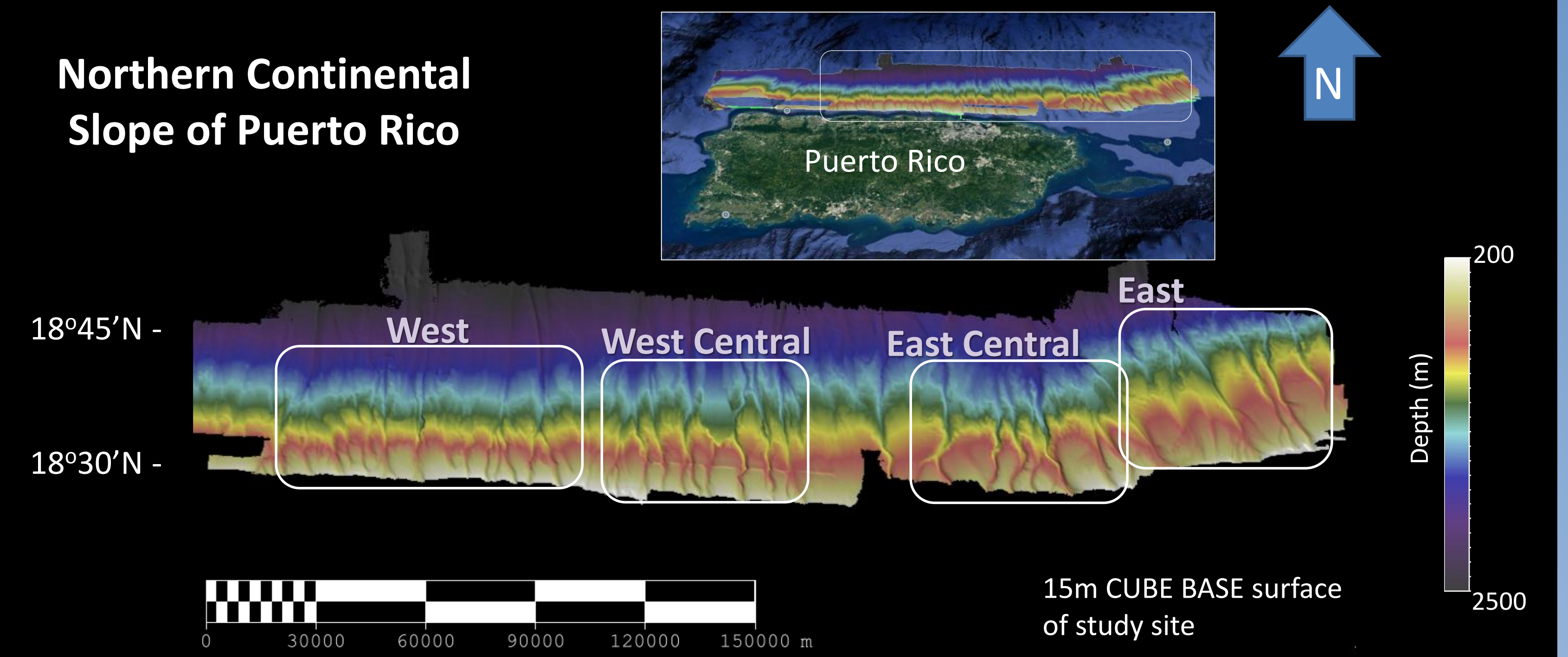
FIGURE 2.
3D views (VE=3.0x) of West – East canyons located on the Northern Continental margin, showing surfaces of Bathymetry, Selected Depth 800-1600 m, Backscatter Intensity, and Slope.

West Canyons | West Central Canyons | East Central Canyons | East Canyons

Bathymetry (m) — 200 / 2500
Backscatter Intensity (dB) — -14 / -40
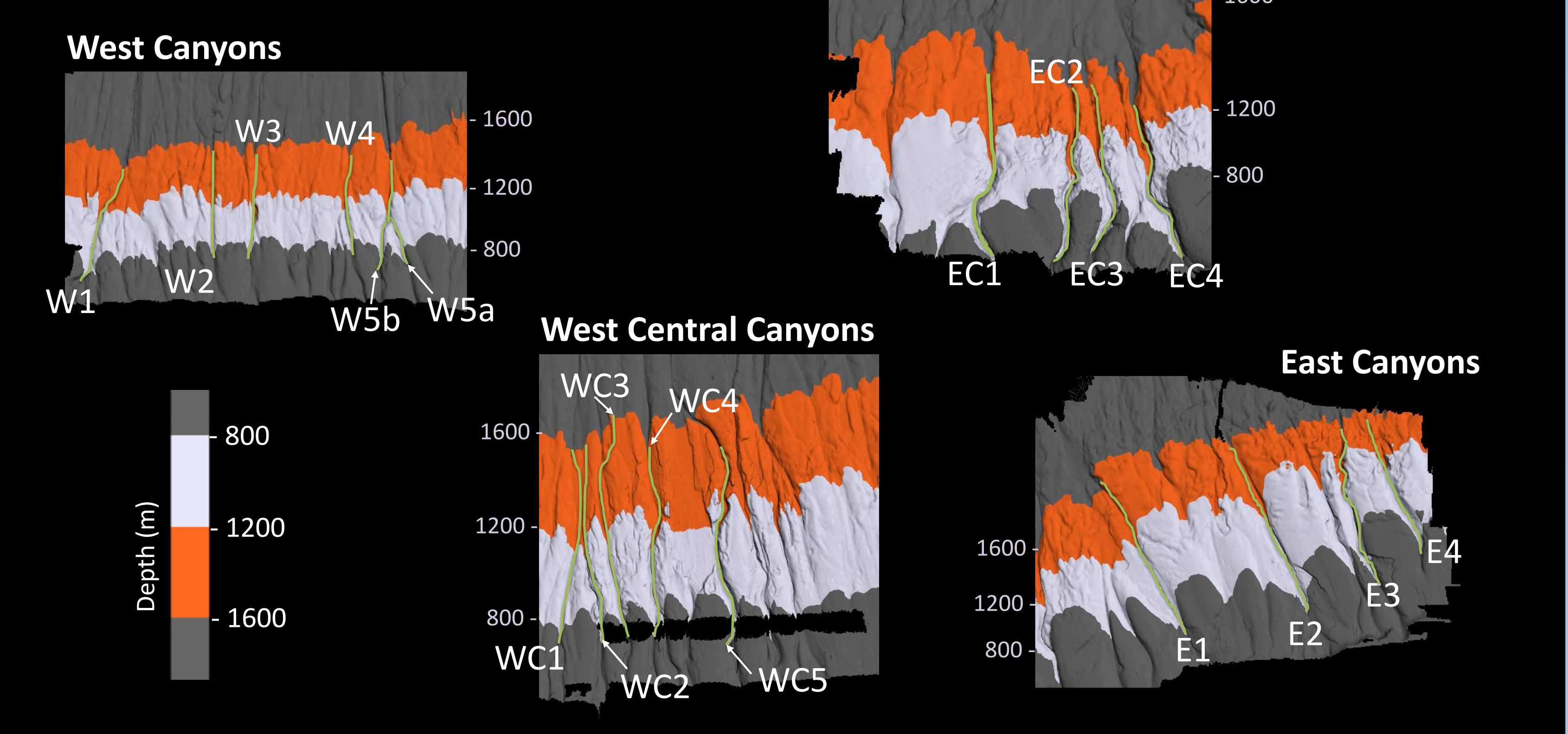Slope (°) — 100 / 0

Background

The northern continental slope of Puerto Rico is characterized by a steep gradient in which depths drop to 2000 m within 50 km offshore (Figure 1). Hernandez-Avila (2014) concluded that deep-sea corals in the Caribbean Sea show the greatest diversities and abundance between depths of 200 to 2000 m, and seem to prefer consolidated ocean floor. Deep sea corals supply habitat and protection for numerous crustaceans and fish species in an environment where habitat is not readily found (Etnoyer, 2010). Corals either live within "coral mounds," or live as individuals along consolidated substrates (Lutz and Ginsburg, 2005).

Deep-sea corals have been located off the western coast of Puerto Rico where the substrate is rugged (Quattrini et al., 2015). Investigation of substrate along the north slope of Puerto Rico could determine if deep-sea corals inhabit the region. For this study, backscatter intensity and slope were used to define areas of hard substrate between 800 and 1600 m water depths suitable for possible deep-sea coral attachment and habitat.

Northern Continental Slope of Puerto Rico

Puerto Rico

West | West Central | East Central | East

18°45'N
18°30'N

Depth (m) — 200 / 2500

15m CUBE BASE surface of study site

FIGURE 1. Study Area
The North Continental Slope of Puerto Rico is off Puerto Rico's northern shore in the Caribbean Sea. The study areas include four visibly different morphological canyons types: West, West Central, East Central, and East
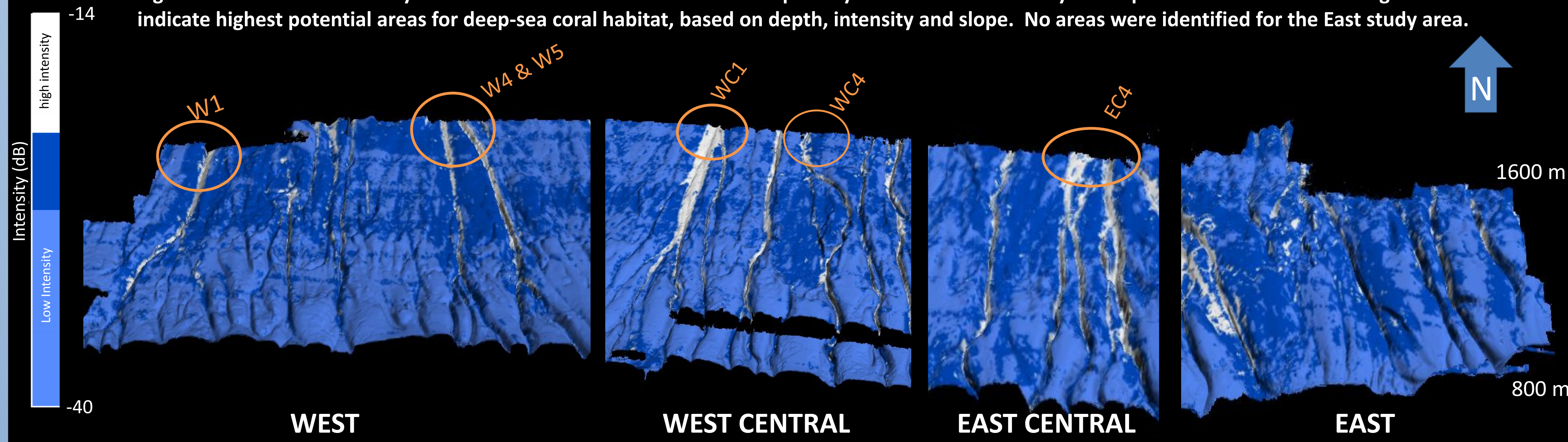
FIGURE 3. Profiles for all canyons examined in this study, showing the 800, 1200 and 1600 m depths defined by the white and orange areas. Each canyon's ID is shown.

West Canyons — W1, W2, W3, W4, W5a, W5b
East Central Canyons — EC1, EC2, EC3, EC4
West Central Canyons — WC1, WC2, WC3, WC4, WC5
East Canyons — E1, E2, E3, E4

Depth (m) — 800 / 1200 / 1600

Methods

Multibeam sonar bathymetry and backscatter intensity data were collected on two separate voyages in 2015 by the NOAA Office of Ocean Exploration and Research (OER) on board NOAA Ship *Okeanos Explorer (Cruises* EX1502L2 and EX1503L1), using a Kongsberg EM302 multibeam echosounder. Data were post-processed in CARIS HIPS and SIPS 10.2 to make a 15 m CUBE BASE, backscatter intensity, and slope surfaces for analysis. Backscatter intensity data were classified and used to determine which areas would likely have consolidated or hard substrate, and would be most ideal for deep coral habitat. Slope layers were also produced to test correlation of slope angle to backscatter intensity. The study region contained 19 canyons within the coral abundance range of 200 - 2000 m. Based on the data collected, slope and intensity data measurements could only be observed at depths 800, 1200, and 1600 m along profile transects.

Results

- Four morphologically different canyon types were identified based on geographic grouping of visual similarities and data measurements.
- Along-axis profiles show that canyon gradients decrease moving from west to east throughout the study area (Figure 6).
- Within the 800 – 1600 m coral habitat depth range, highest backscatter intensity returns were found between 1400 and 1600 m for all four canyons areas, whereas the lower intensity readings were mainly found at depth range between 800 – 1000 m.
- Canyons from the West, West Central and East Central sections had more area with high intensity backscatter than the East section (Figure 4).
- There was no correlation between slope and intensity along the canyon axis across the study area (Fig. 5).

Figure 4. Backscatter intensity classification of Puerto Rico's north slope canyons. Note that the canyons slope toward the north. Orange circles indicate highest potential areas for deep-sea coral habitat, based on depth, intensity and slope. No areas were identified for the East study area.

W1 | W4 & W5 | WC1 | WC4 | EC4
WEST | WEST CENTRAL | EAST CENTRAL | EAST

Intensity (dB) — -14 / -40
1600 m / 800 m

FIGURE 6: Representative profiles for each study area. All profiles show the length of each canyon between 800 and 1600 m water depth (VE= 2.0x). West Canyon Profiles have the greatest gradient. Gradient decreases moving eastward along the margin.

All profiles VE = 2x

West Profile — Canyon Gradient = 0.070 — 0 to 11,500
West Central Profile — Canyon Gradient = 0.057 — 0 to 15,000
East Central Profile — Canyon Gradient = 0.052 — 0 to 16,000
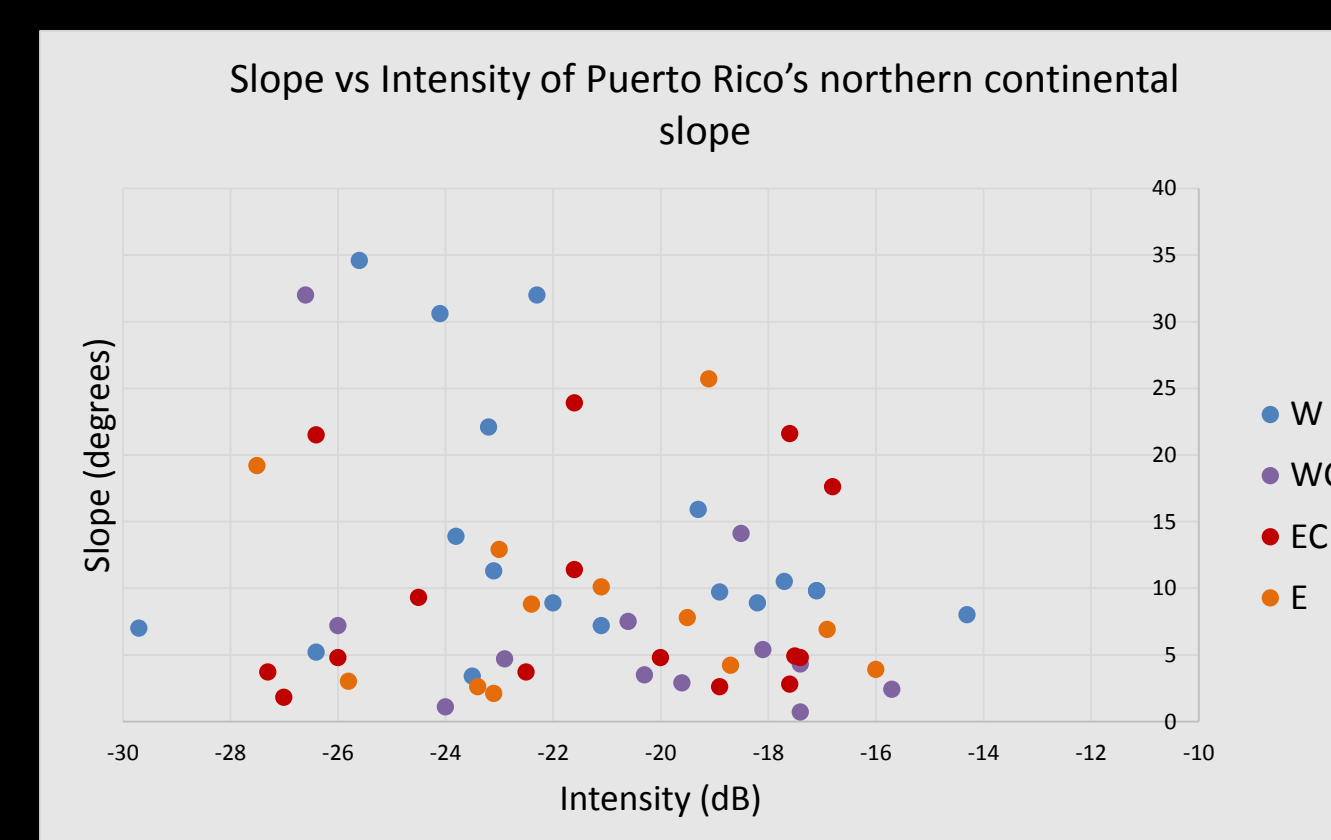East Profile — Canyon Gradient = 0.043 — 0 to 19,000

Discussion

In this study of Puerto Rico's northern slope, the association of backscatter intensity with slope was analyzed for the deep-sea coral habitat depth range of 800 to 1600 m. Although no correlation between slope and intensity was found (Figure 5), high intensity backscatter areas was used as an indicator of potential habitat for deep-sea corals. These areas with high intensity readings signify greater consolidated substrate and were identified as the best possible locations for deep-sea corals to inhabit, marked in Figure 4. Canyons in areas West, West Central and Central East possess the most similarities to having a rugged, hard substrate and hold the highest potential for deep-sea coral habitat.

Classification of deep-sea coral habitat characteristics of slope and substrate type should be better determined so future ROV dive time can be minimized. Data collection of current velocities and water column properties would also be beneficial because strong currents supply the coral with their food source of plankton, along with sweeping away unconsolidated sediments. Additionally, understanding where deep-sea corals are located would be useful for planning dredging and trawling operations, so accidents that destroy deep-sea coral habitat would no longer occur.

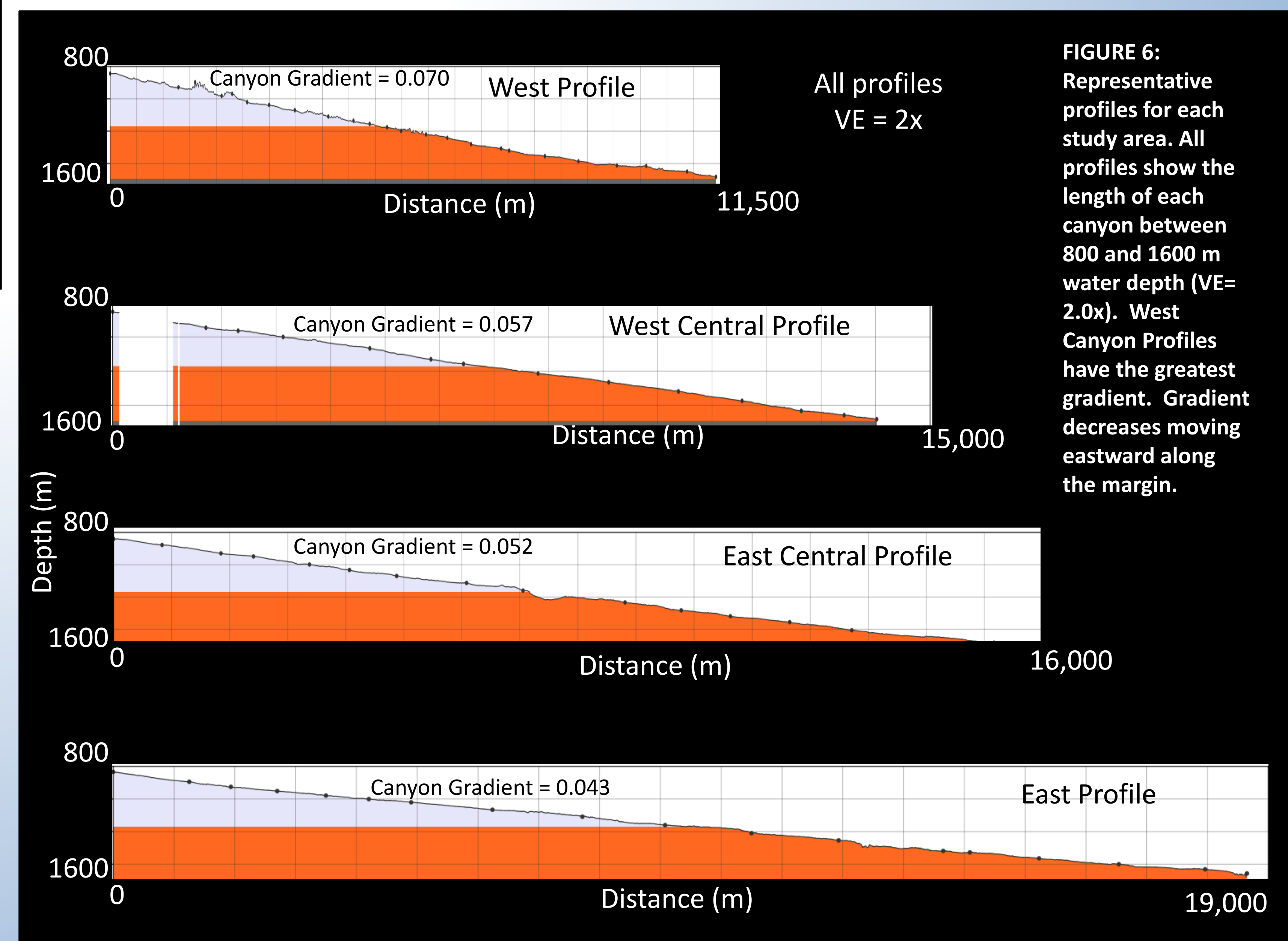**Figure 5. No correlation was found between Slope and Intensity along the canyon profile axis.**

Slope vs Intensity of Puerto Rico's northern continental slope

Slope (degrees) vs Intensity (dB) — W, WC, EC, E

Table 1: Depth, slope and intensity values along profile West – East

Canyons	800 m Intensity (dB)	800 m Slope (°)	1200m Intensity (dB)	1200m Slope (°)	1600m Intensity (dB)	1600m Slope (°)
W1	-23.1	11.3	-23.8	13.9	-19.3	15.9
W2	-25.6	34.6	-18.2	8.9	-18.9	9.7
W3	-22.3	32.0	-14.3	8.0	-17.7	10.5
W4	-24.1	30.6	-22.0	8.9	-23.2	22.1
W5a	-26.4	5.2	-21.1	7.2	-17.1	9.8
W5b	-29.7	7.0	-23.5	3.4	-17.1	9.8
WC1	-24.0	1.1	-17.4	4.3	-15.7	2.4
WC2	-26.0	7.2	-20.6	7.5	-19.6	2.9
WC3	-22.9	4.7	-18.1	5.4	-17.4	0.7
WC4	-26.6	32.0	-20.3	3.5	-18.5	14.1
EC1	-27.3	3.7	-17.6	21.6	-21.6	2.8
EC2	-26.4	21.5	-16.8	17.6	-21.6	11.4
EC3	-21.6	23.9	-17.5	4.9	-18.9	2.6
EC4	-24.5	9.3	-17.4	4.8	-22.5	3.7
EC5	-2.7	1.8	-26.0	4.8	-20.0	4.8
E1	-18.7	4.2	-21.1	10.1	-16.0	3.9
E2	-25.8	3.0	-22.4	4.8	-23.0	12.9
E3	-16.9	6.9	-23.4	2.6	-19.5	7.8
E4	-23.1	2.1	-19.1	25.7	-27.5	19.2

References
Hernandez-Avila, I. (March 26, 2014) *Pattern of Deep-Water Coral Diversity in the Caribbean Basin and Adjacent Southern Waters: An Approach based on Record from the R/V Pillsbury Expedition.* PLOS ONE. Online research article
Lutz, S. J. and Ginsburg, R.N. (January 3, 2005) *State of Deep Coral Ecosystems in the Caribbean region: Puerto Rico and the U.S. Virgin Islands.* NOAA. Online research article
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Etnoyer, Peter J. (2010) *Deep-Sea Corals on Seamounts.* The Oceanography Society, Volume 23, Number 1. Online journal