Submarine Canyon Geomorphologic Characterization on Browns Bank off the Scotian Shelf

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BACKGROUND

Submarine canyons cover 11.2% of continental slopes worldwide and have an array of different sedimentary environments (Fernandez-Arcaya 2017). Sediments found in canyons can provide information on temporal changes to the continental shelf that may result from both geologic events as well as environmental changes (Fernandez-Arcaya 2017). Browns Bank is a portion of the Scotian Shelf continental margin located off the coast of the Gulf of Maine and south of Nova Scotia. Browns Bank has many submarine canyons, most of which are home to several habitats of marine biota and include the Vazella Sponge Grounds in the bank's northern region. Because of the canyons' proximity to the Northeast Channel off the Gulf of Maine, cold-water corals and sponges are found on areas of hard substrate where currents create ideal habitat conditions (King and Kenchington 2018). Due to the region's high biodiversity, Browns Bank's canyons are an important area for conservation, and a portion of this area has been named as a Marine Protected Area under the Oceans Act. The purpose of this work is to identify potential areas of interest in conservation of cold-water corals and sponges through the analysis of varying canyon morphology and substrates.

Figure 1. Study Area and Site Locations

Browns Bank canyons have varying depths and canyon morphology. Three canyon complexes were examined, here referred to as North, Central, and South Canyons. Although these sites are within ~50-80km of one another, they have varying geomorphologies.

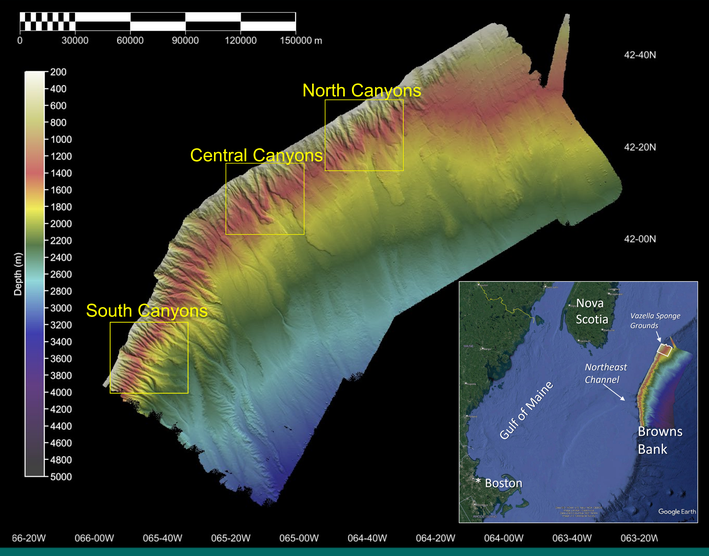
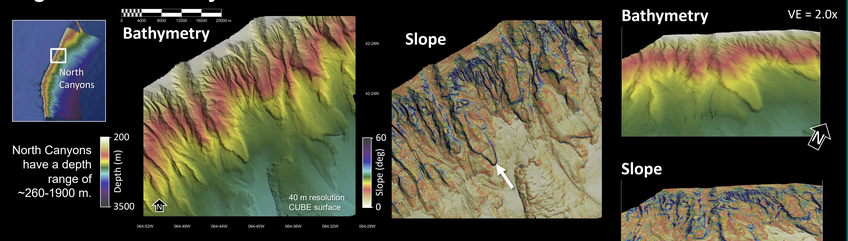
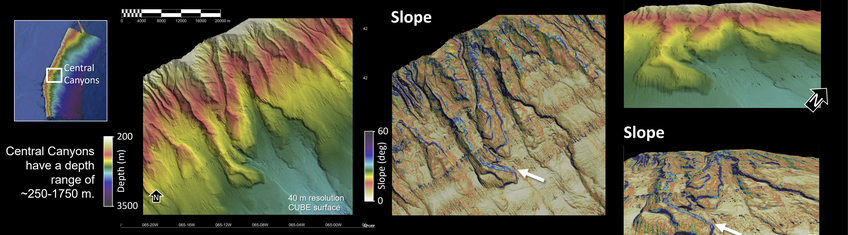


Figure 2. North Canyons



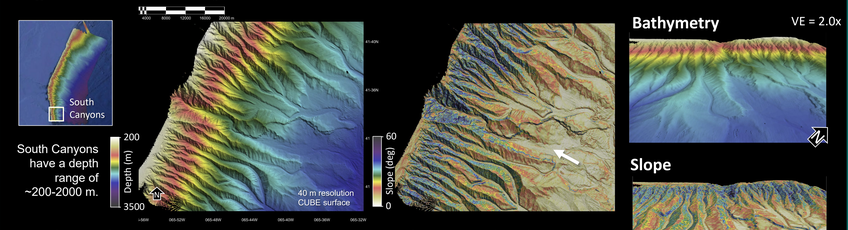
The North Canyons site has a depth range of ~260 to 1900 m with approximately 16 canyons of varying morphology. Three canyons cut into the shallow Scotian Shelf. High relief areas are found on walls of canyon channels with slopes ranging 0 to 60º. The southeast edge of a prominent lobed feature (see white arrow) has a ~60º slope, suggesting it is a collapsed, erosional scarp.

Figure 3. Central Canyons



Of the 3 sites, Central Canyons site has the fewest concentration of canyons (~9), none of which have a shelf origin. Canyon geomorphology varies from those of both the North and South Canyons sites, including a broad, ~6.5 km wide expansion of the channel in the deeper portion (850-1200 m) of the site. There is a feature that may be a scarp in the process of having its south-west flank collapse, where a block of the sediment is slowly sliding into deeper depths, this process is indicated by the arrow. The south-west flank hat has not collapsed and that keeps the lower portion of the canyon narrow before expanding outwards.

Figure 4. South Canyons



The South Canyons site has the highest density of canyons (>20), though only one cuts up onto the shelf. These canyons are much narrower and are also shorter in length and steeper.
This area's proximity to the Northeast Channel off the Gulf of Maine may have an impact on the amount of unconsolidated sediment that makes up a steeper slope, where less unconsolidated sediment is able to settle in this area, leaving more consolidated substrate exposed as a result.

Figure 5. Classified Backscatter Intensity

Classified backscatter shows the intensity of sonar returns of portions of the North, Central, and South Canyons' substrate. Lightest blue indicates a high intensity return, while the medium and darker blue indicate medium and low intensity returns, respectively. All three canyons had a similar pattern of high intensity returns found in the canyon channels, indicating hard substrate such as rock faces, while relatively low intensities between canyons suggest more unconsolidated sediment such as mud. High intensities are also found at the foot of most canyons.

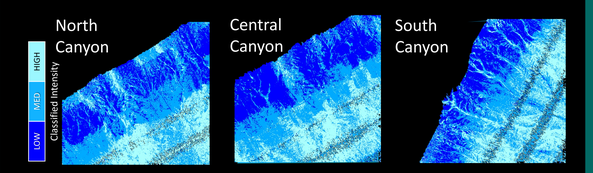
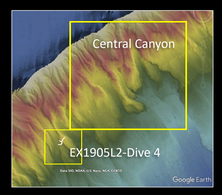
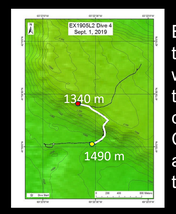


Figure 8. ROV Dive images



(left) The substrate near the base of the canyon wall is the combination of mud as well as a variety of sizes of rocks.

(below) The dive footage also provides a view of some of the biota in this area, which include a mushroom coral and sea star.



EX1905L2 - Dive 4 made by the ROV *Deep Discoverer* was used to establish ground truth for the substrate character ~15km south of Central Canyon. This dive ascended a steep canyon wall then traveled across the ridge.

METHODS

- Multibeam sonar data were collected by the NOAA Ship *Okeanos Explorer* during expedition 1905L1 using a Kongsberg EM302.
- HD video footage retrieved during expedition 1905L2 by the ROV *Deep Discoverer* was used to provide ground-truth for substrate and benthic habitats.
- CARIS HIPS and SIPS 11.4 used to create high definition 40 m resolution bathymetric and slope surfaces as well as classified backscatter intensity mosaics.
- Axis and cross-canyon depth profiles generated through CARIS to analyze canyon width and shape at varying depths.
- Canyon symmetry measurements generated to compare canyon morphology and symmetry among sites.

ACKNOWLEDGEMENTS

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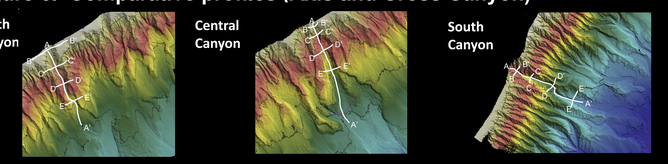
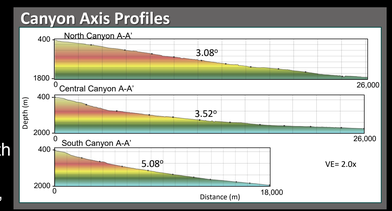
NOAA Ship *Okeanos Explorer*

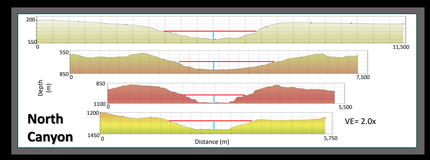
Figure 6. Comparative profiles (Axis and Cross Canyon)



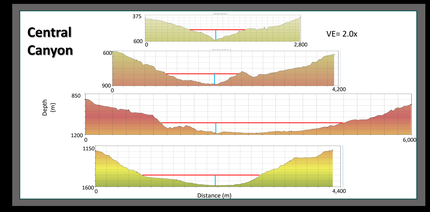
Canyon axis profiles A-A' (right) are drawn from a 400 m depth along each canyon's thalweg (deepest channel point). 4 cross-channel profiles were drawn at 300 m contoured thalweg depth intervals.



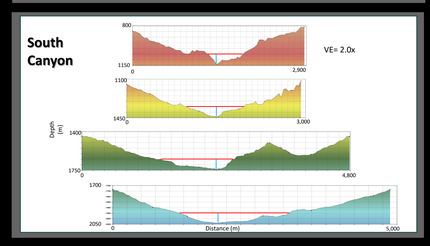
(right) All canyons are similar in VR, (1400 to 1600 m), and North and South have canyon length of 26 km. South Canyon has a shorter length of 18 km, making it the steepest of the three canyons with a slope of 5.08º compared to 3.08 and 3.52º of North and Central Canyons, respectively.



Compared to the other canyons, North Canyon has significantly broader channel floors with channel widths ranging ~1400-2750 m. The channels are nearly symmetric throughout the canyon.

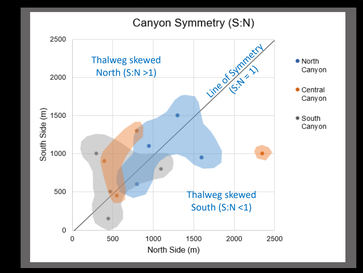


Central Canyon has channel widths ranging from 1000 to 3350 m. The thalweg is slightly skewed both to the north (at thalweg depths 900 and 1600 m) and south (at depth 1200 m).



South Canyon has significantly narrower canyons with widths ranging from ~900-1900 m across. There is a skew to the south (at thalweg depths 1150 and 2050 m), and northward skew (at depths of 1450 and 1750 m).

Figure 7. Canyon Channel Symmetry



Using measurements from 100 m above the thalweg (Fig. 6) at depths along the main axis, the ratio of channel South Side to North Side distances is used to examine channel symmetry. Channels are nearly symmetric at many depths. However, there are also a few sections that are skewed to the north as well as the south. Many of the channels are only moderately skewed, but Central Canyon has one outlier section that is more southward skewed.

SUMMARY

North, Central, and South Canyons have varying geomorphologies. North Canyon has broadest canyon floor, possibly due to the canyon substrate consisting of more unconsolidated sediment filling in the channels. Central Canyon also has moderately broad channels. North Canyon's channels are more symmetrical than those of either Central or South Canyons. Both the North and Central Canyons include scarps that may indicate partial collapse of canyon walls. There is a higher contrast in backscatter intensity between the steep and flat areas, with the higher relief areas being a more defined edge around the canyon as seen in the slope surfaces. All three canyons have overall similar backscatter patterns where the highest intensities are found in the channels of the canyons, while there is lower intensities on the ridges of the canyons. This could suggest that the pattern of sediment distribution off the continental slope among all three areas could have some similarities.

The South Canyons site has the most variation in geomorphology, as its canyons are notably narrower and steeper. The classified backscatter also shows that there is a concentrated area of high intensity returns in the canyon channel, which could indicate hard substrate. The slope surfaces show a prominence of high relief canyon walls, which could be related to the possible hard substrate in this site. Because of this hard substrate, the South Canyon would be a likely place for cold water corals and sponges to be found.

REFERENCES

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