Examining Scarp Area Containing Manganese Nodules and Similar Geomorphology on the Blake Plateau

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Abstract

Multibeam sonar data were collected during NOAA OER expeditions EX1903 L2 (June), EX1906 (October), and EX1907 (November) aboard the NOAA Ship *Okeanos Explorer*, which allowed backscatter intensity and slope data to be analyzed to study the geomorphological aspects of the scarp areas in each study site. Dives 6 and 7 from ROV *Deep Discoverer* used high resolution imagery to record benthic sea life. Dive 7 footage revealed scarce sea life in the Northeast Scarp study site which contains bountiful amounts of manganese nodules, while Dive 6 contained abundant amounts of benthic sea life in a flat area a few kilometers south. Areas above all scarps appear significantly flat; data gathered from backscatter intensity and degrees of slope resulted in no backscatter-slope correlation for each study site. Northeast Scarp (NES), which includes the historically mined area, has relatively high intensity on the overlying flat area above the scarp. The resulting two other study sites: Central-North Scarp (CNS) and Southwest Canyon (SWC), have exceptionally similar slope, backscatter intensity, and geomorphological structure of flat areas above scarps to NES to conclude both CNS and SWC containing potential amounts of manganese nodules.

Background

This study's purpose was to gather scarp geomorphological information from bathymetric data and remotely operated vehicle (ROV) dive footage conducted by the National Oceanic Atmospheric Administration (NOAA) during their *Windows to the Deep 2019* study and the *2019 Southeastern U.S. Deep-sea Exploration*. The area of study is located off the US southeast coast, 237 km southeast of Charleston, SC and 324 km East-Northeast of Jacksonville, FL (Fig. 1A and 1B).

During the 1960's, Deepsea Ventures, Inc. experimented with deep sea mining instruments for manganese nodules, which has caused NOAA to intentionally choose this area to examine potential modern impacts. Deepsea Ventures, Inc. began the first test of deep sea mining at the Blake Bahama Plateau in 1970. The company, a subsidiary of Tenneco, Inc., used a steel pipe to harvest manganese nodules on the seafloor, engineering a dredge which raked the ocean bottom. Knowledge of organisms on the Atlantic seafloor was extremely limited at the time of the mining and therefore no environmental regulations were incorporated in the expedition (Wartenbaker, 1977).

In November of 2019, the NOAA Ship *Okeanos Explorer* mapped the experimental mining area located off the Southeast coast of the United States using multibeam sonar (Chaytor, 2019). Once mapped, NOAA's ROV captured video footage of a portion of the area mined in order to examine modern effects from the mining. Current understanding of the seafloor life in the Atlantic presents life as fragile and slow-growing, as seen in the stony coral *Lophelia pertusa* corals having an extremely slow growth rate and a lifespan of over 1,000 years (Oceana.org). A study of the longstanding geomorphological and biological impact from Deepsea Ventures, Inc. has yet to be conducted in present time to observe potential alterations from the historical mining experiment. This study examines the modern geomorphology of the historically mined area above a scarp, labeled Northeast Scarp (Fig. 1) and compares similar nearby scarps: Central-North Scarp and Southwest Canyon (Figs. 3 and 4), to better predict potential manganese nodule sites.

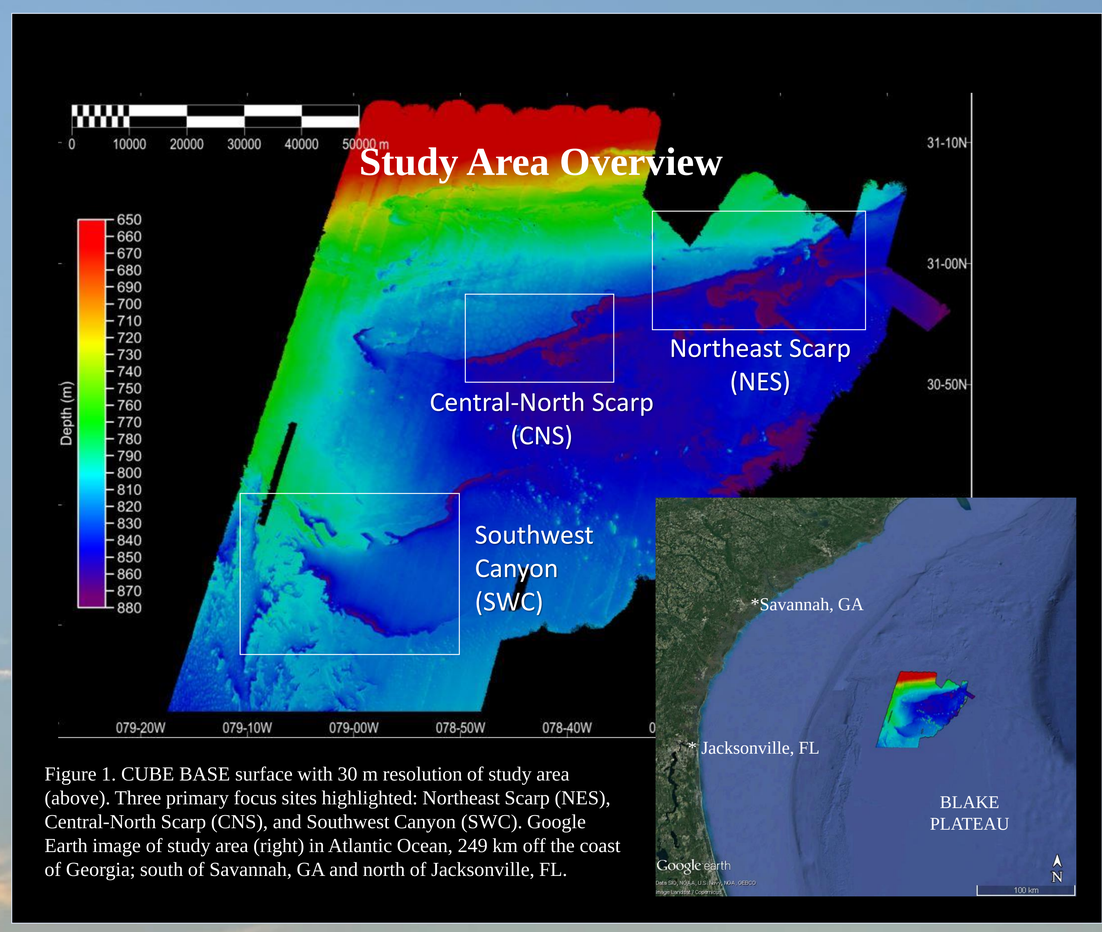


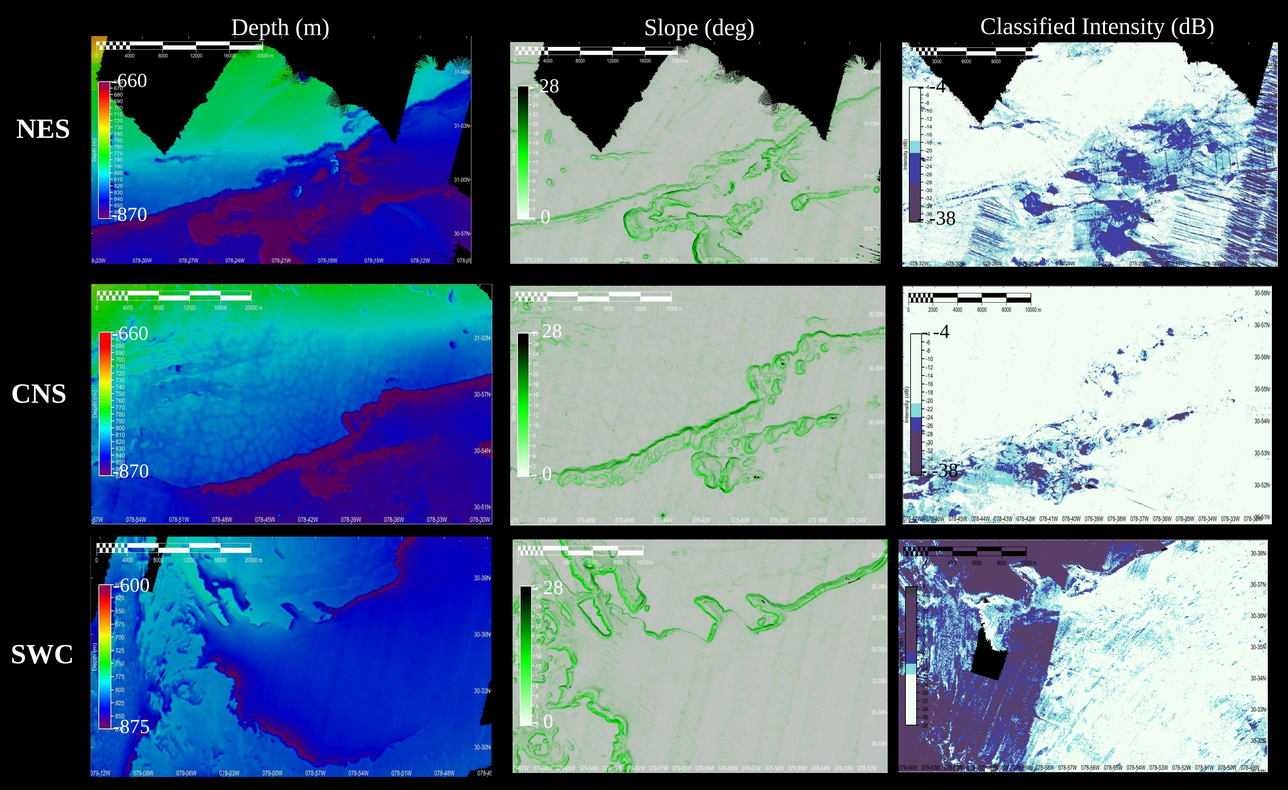
Figure 1. CUBE BASE surface with 30 m resolution of study area (above). Three primary focus sites highlighted: Northeast Scarp (NES), Central-North Scarp (CNS), and Southwest Canyon (SWC). Google Earth image of study area (right) in Atlantic Ocean, 249 km off the coast of Georgia; south of Savannah, GA and north of Jacksonville, FL.

Methods

- Multibeam sonar data were collected in 2019 on cruises EX1903 L2 (June), EX1906 (October), and EX1907 (November) aboard the NOAA Ship *Okeanos Explorer* with a Kongsberg EM302 multibeam echosounder.
- EX1907 Dive 6 and 7 utilized the ROV *Deep Discoverer* to capture high-resolution video imagery of benthic habitats on the seafloor and geomorphological features of a historical deep sea mining area.
- CARIS HIPS and SIPS 11.2 was used to post-process raw multibeam sonar data and to render CUBE bathymetric, slope, aspect, and backscatter surfaces with 30m resolution.
- Two study sites were chosen based on their geomorphological similarity to a third study site which included the historical mined area: a broad flat area above a scarp.
- Slope, aspect, and backscatter were classified, slopes and distances were measured, and 3D images and profiles were constructed.
- Geomorphology of all three sites was compared to predict presence of manganese nodules at the two study sites without dive footage.
- ROV dive videos were inspected to analyze benthic life at the historically mined site (EX1907 Dive 7) and the similar flatness in between two mounds south (EX1907 Dive 6).

Study Sites

Figure 2. 2D CUBE BASE surfaces with 30 m resolution, with slope and classified backscatter intensity surface for each of the three study sites.



Profiles with Classified Backscatter

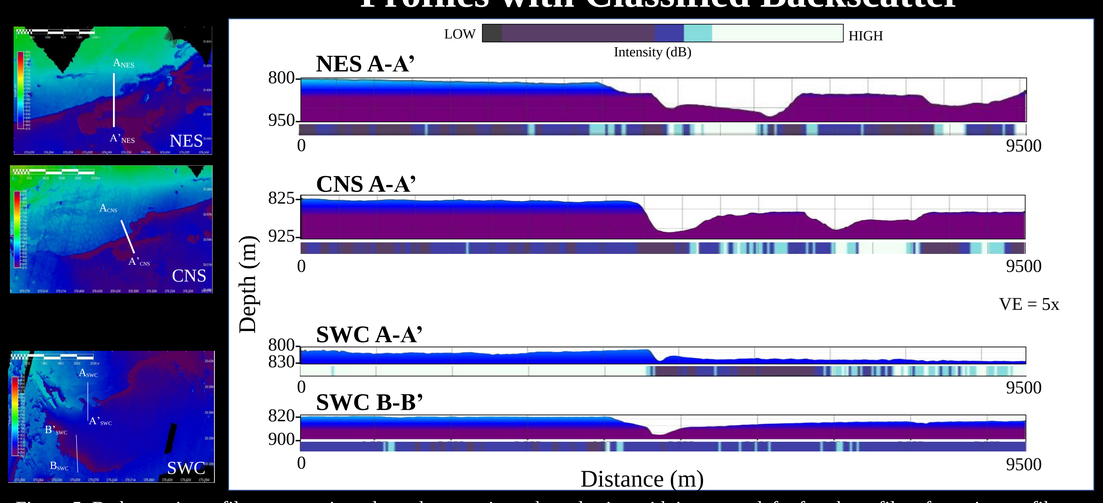
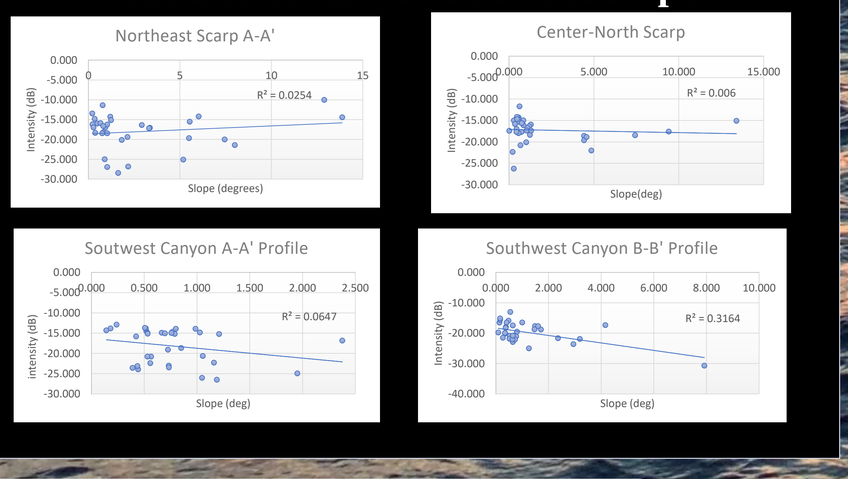


Figure 5. Bathymetric profile cross sections through scarps in each study site, with images to left of each profile referencing profile overview of the study site. Classified intensity colored bars represent backscatter intensity relative to location of profile.

Backscatter as a Function of Slope

Figure 6. Scatter plots of data collected along cross section profiles showing backscatter intensity versus slope with applied linear trendlines. All values were acquired using the Tooltip function in CARIS HIPS and SIPS 11.2. Sites NES, CNS, and SWC A-A' demonstrate negative correlations of backscatter with slope while SWC B-B' reveals a relatively less extreme negative correlation.



Results

Geomorphology and Backscatter Observations:

- Areas above each site's scarp are relatively flat with slopes never exceeding 3°. Flat areas above scarp extend for thousands of meters (Figs. 2, 3, 4, 6).
- Scarps for all 3 study sites contained slopes ranging from 14° to 16°, with some extremely small areas measuring up to 18°.
- At all 3 study sites, the broad, flat areas above each scarp have relatively high backscatter intensities, whereas scarp bases have lower backscatter intensities (Figs. 2, 3, 4).
- NES is characterized by high backscatter intensity where historical mining of manganese nodules occurred, with CNS and SWC sharing similar geomorphology structure and backscatter intensities (Figs. 2, 3).
- Along A-A' profiles, backscatter intensities were not correlated with slope for any of the three study sites (R^2 values were 0.025, 0.006, and 0.0647, respectively), however, a moderate negative correlation was observed along SWC profile B-B' (R^2 = 0.316) (Figs. 5 and 6).

ROV Dive Video Observations:

- EX1907 Dive 7 at NES revealed abundant manganese nodules along the flat area above the scarp with scarce occurrences of biota (Fig. 7A), however EX1907 Dive 6 revealed vast amounts of benthic life on relatively similar flat ground but contained no visible manganese nodules compared to EX1907 Dive 7 (Fig. 7B).

ROV Dive Comparison Images

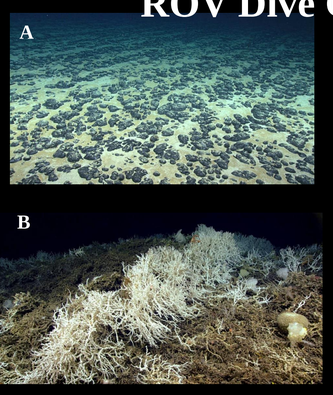


Figure 7. A) Video frame-grabs from ROV *Deep Discoverer* during EX1907 Dive 7 above the Northeast Scarp. Little to no benthic life with extraordinary amounts of large to small manganese nodules occur in rows, most likely from Deepsea Ventures, Inc. dredging operations, whereas (B) EX1907 Dive 6 a few kilometers south of the NES scarp, shows the marked contrast of benthic life between ocean bottoms with similar flatness in between a mound, which is a thick accumulation of dead corals (Sautter et al, p.82).

Discussion

All three study sites contain scarps and revealed no correlation between backscatter intensity and slope along cross-sectional profiles (Fig. 6). These data provide additional evidence that backscatter intensity and slope cannot be reliably correlated in benthic habitats and their geomorphology. High backscatter intensity is shown above the flat areas of all scarps, most likely the result of reflection off underlying hard substrate and abundant manganese nodules (Fig. 2). The occurrence of these nodules was verified in the area above the NES scarp from ground truth evidence (Fig. 7A). At NES, hundreds of manganese nodules are aligned in rows, presumably the result of Deepsea Venture, Inc.'s experimental dredging in the 1960s, over 50 years ago (Fig. 7A). This section of abundant manganese nodules reveals little to no benthic life (Fig. 7A), enticing potential modern mining as there would be minimal biological impact. As of yet, no research has been conducted on whether the low level of benthic life is a cause from the historical mining.

Although current ground truth evidence is unavailable for CNS and SWC, comparisons of NES' geomorphological structure, backscatter intensity, and slope to CNS and SWC, indicate both CNS and SWC are extremely similar, suggesting they may also have manganese nodules. As the three study sites share similar geomorphology and backscatter intensity, the small amount of benthic life documented for NES is in all likelihood exhibited in CNS and SWC. In order to determine whether Deepsea Venture, Inc.'s experimental mining has affected seafloor life, research investigating CNS and SWC's similar geomorphology and intensity above their scarps to NES would be needed. This future investigation, such as ground truthing, would assist in comparing whether the high intensities of the study sites account for manganese nodules, and whether the similar geomorphology provides equal amounts of low life.

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