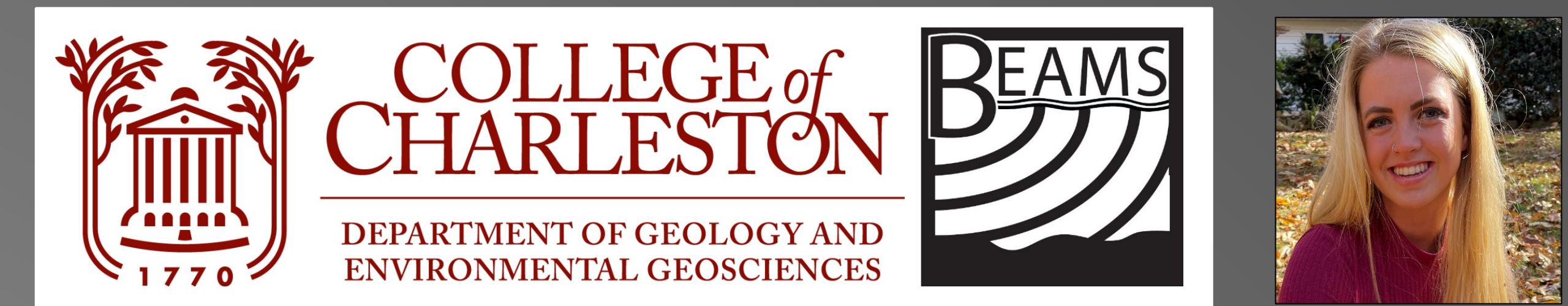


Characterization of Meandering Channels and Sand Bodies off Savannah, Georgia

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ABSTRACT

The Research Vessel (R/V) *Savannah* collected data in a series of mapping expeditions off the Savannah, Georgia coast during 2015, 2016, and 2019 on 4 separate sites identified as fish diversity hotspots by the SC DNR. These 4 sites were named North, Central, South Central, and South Site for the study's purpose. Multibeam data revealed large, low relief sand ridges at each site, along with meandering channels on North Site and South Central Site, and sand waves on Central Site and South Site. Previous studies showed a similar sites off the South Carolina coast: one with a drowned forest and lower peat level and another 100 km south with meandering channels (Donahue, 1995 and Harris et al., 2013). Various studies have identified large sand ridges as transgressive shorelines formed during periods of sea level fall that were subsequently drowned during a marine transgression. While the purpose of this study was not to identify the sites as transgressive shorelines, it is important to note the similarities between them. The purpose of this study is to characterize the 4 study sites and to identify characteristics that could be used to identify other potential areas of fish biodiversity. MARMAP imagery will be used to ground-truth the data.

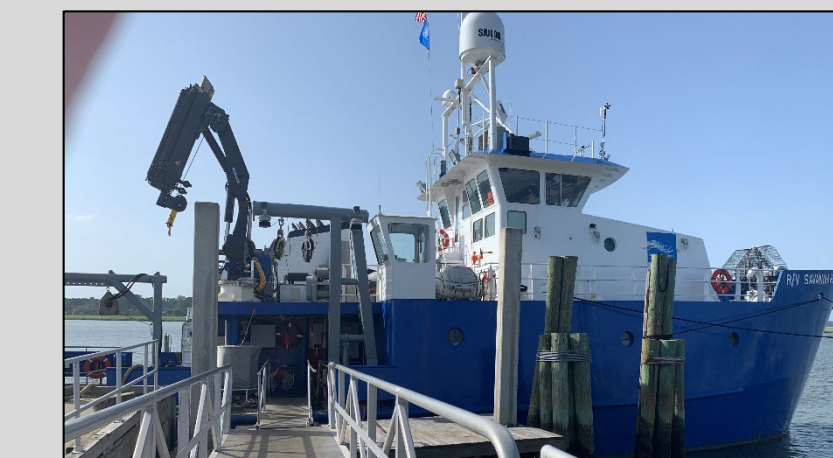
BACKGROUND

The Research Vessel (R/V) *Savannah* conducted a series of three seafloor mapping expeditions for the BEAMS Program in 2015, 2016, and 2019. These cruises took place on the mid-continental shelf, about 32 km offshore of Savannah, Georgia in water depths of 20 to 30 m. Multibeam sonar data collected on the cruises revealed hard-bottom substrate with large sand bodies and meandering channels cut through the rock in all areas surveyed. These areas have been designated as known fish habitat hot spots by the South Carolina Department of Natural Resources (SCDNR) Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program because the seafloor's slight vertical relief and hard bottom-substrate allow invertebrates to attach to the seafloor. Previously, an area on the South Atlantic Bight (SAB) off Georgetown, South Carolina was documented by Donahue (1995) to have over fifty cypress stumps offshore at depths of approximately 19 m and a lower peat level of 23 m, indicating a drowned forest that was age-dated at approximately 11.5 thousand years old. These stumps were likely preserved during a rapid marine transgression. More recently, a meandering channel, known as Transect Meanders, was found approximately 100 km south of the drowned forest at similar water depths, cut into hard substrate along with massive sand deposits (Harris et al., 2013). Due to its similar depths and proximity to shore, the meandering channel is also thought to be of similar or slightly younger age to the northern cypress stumps (Harris et al., 2013).

The purpose of this study is to characterize and compare four areas mapped by the BEAMS Program between 2015 and 2019 and to identify substrate characteristics that could signify additional diversity hotspots. Using state-of-the-art mapping programs, bathymetry, backscatter intensity, slope, and aspect are used to examine and compared among the four sites.

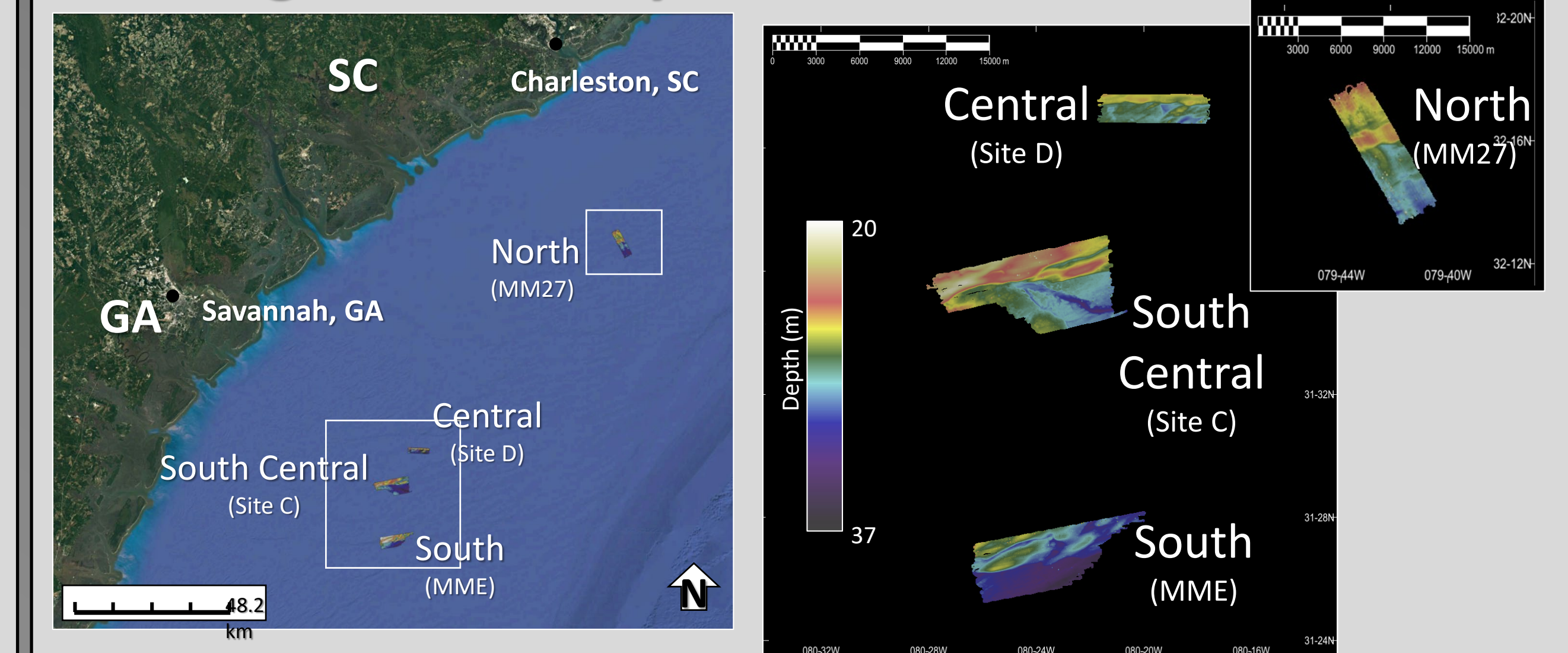
METHODS

- Multibeam sonar data were collected by the BEAMS program on the R/V *Savannah* in 2015, 2016, and 2019. Four study areas were examined.
- Tide files were generated from tidesandcurrents.noaa.gov to correct for tidal variations in the multibeam data.
- Raw multibeam sonar data were post-processed using CARIS HIPS and SIPS 11.3 and 1m resolution CUBE BASE surfaces were generated.
- Bathymetric surfaces were used to create classified slope and aspect surfaces.
- 1m resolution backscatter intensity mosaics were generated and classified into high, medium and low intensity classes.
- Depth profiles were generated across geomorphological features at each study site.
- Multiple 3D images were made at each site.
- Fish species abundance data from both trawls and traps were downloaded from SCDNR MARMAP's database.
- Bathymetry, backscatter intensity, slope, and aspect were visually compared among the four study sites to characterize each site.



R/V Savannah

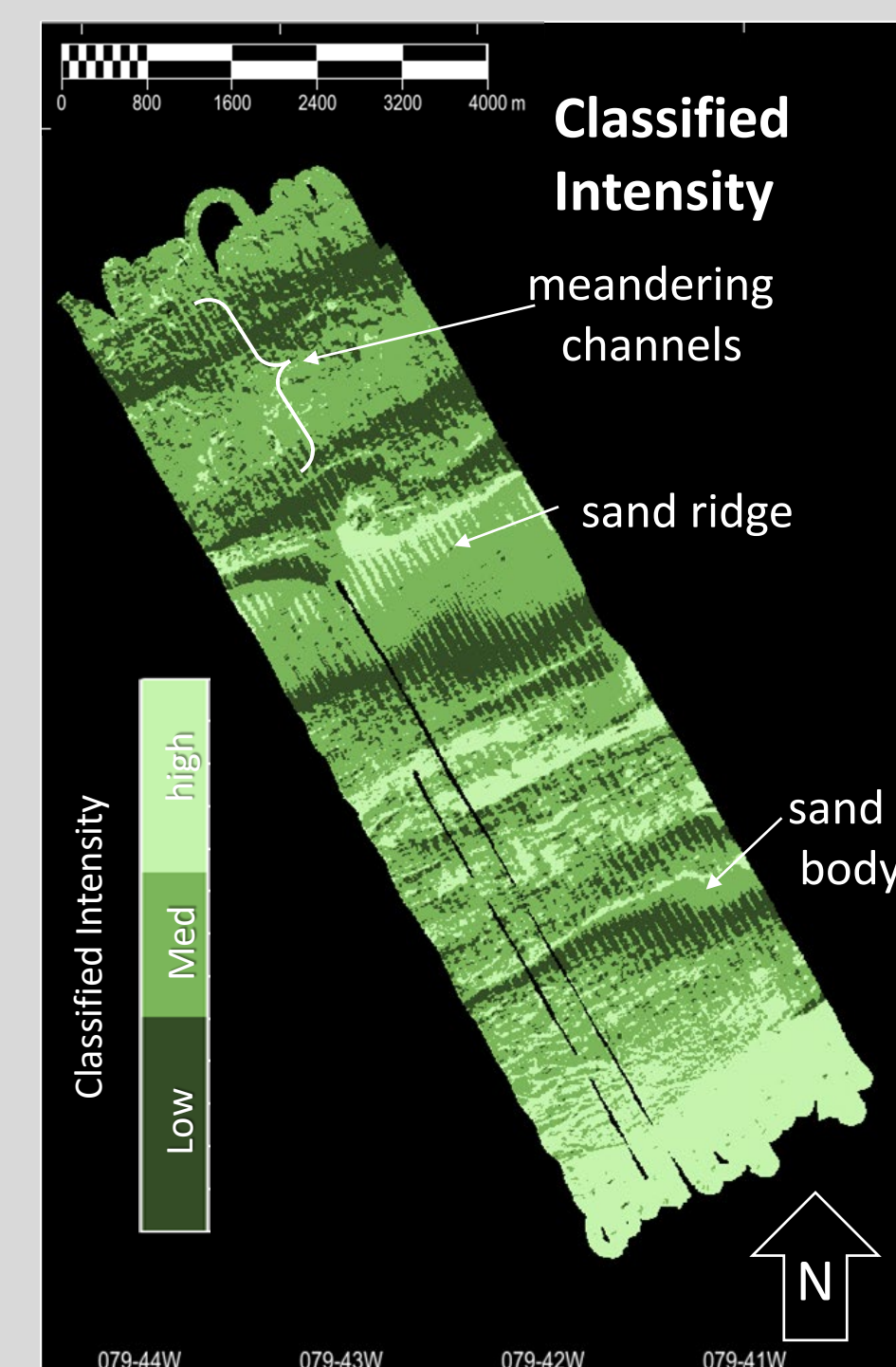
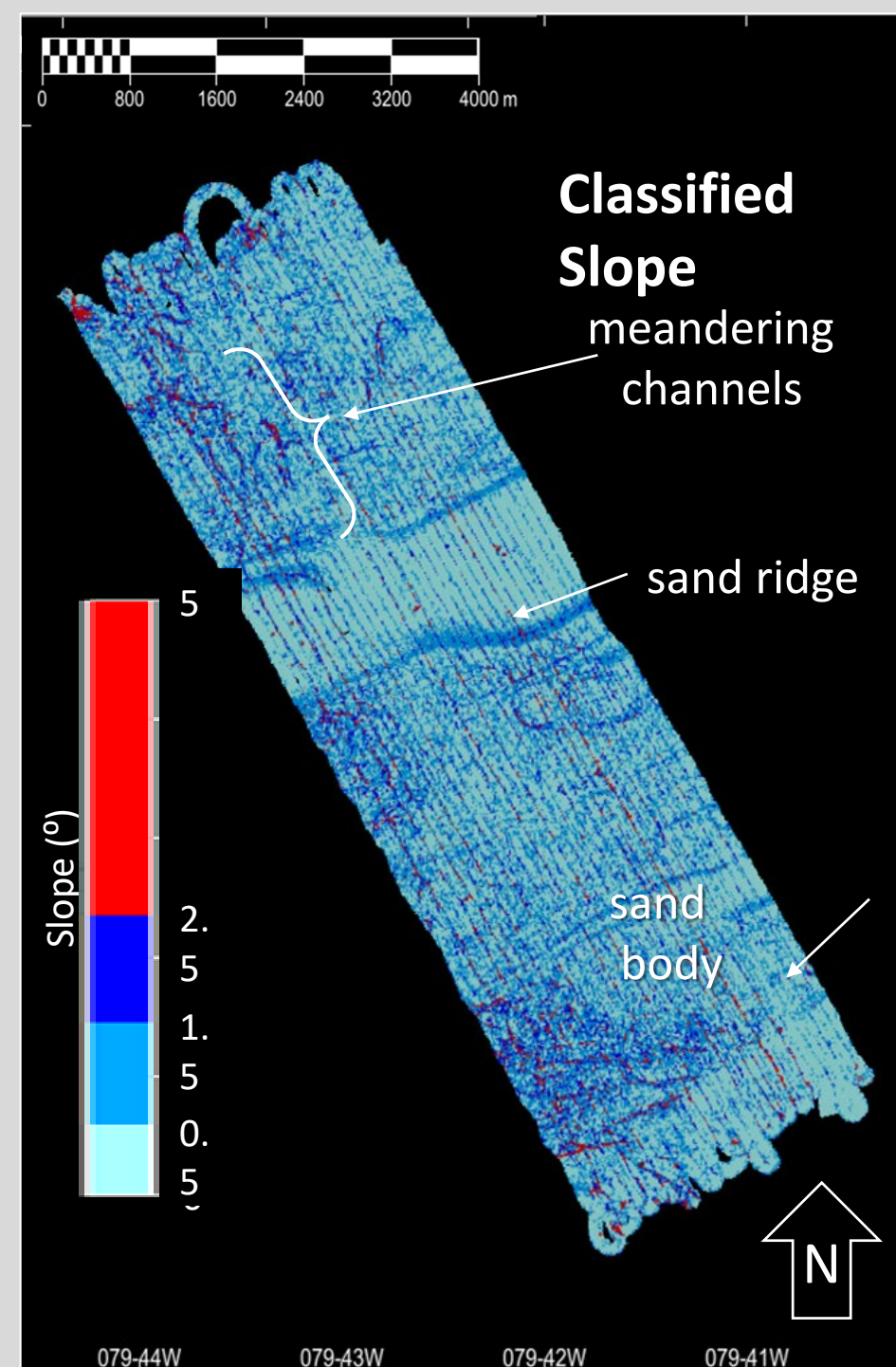
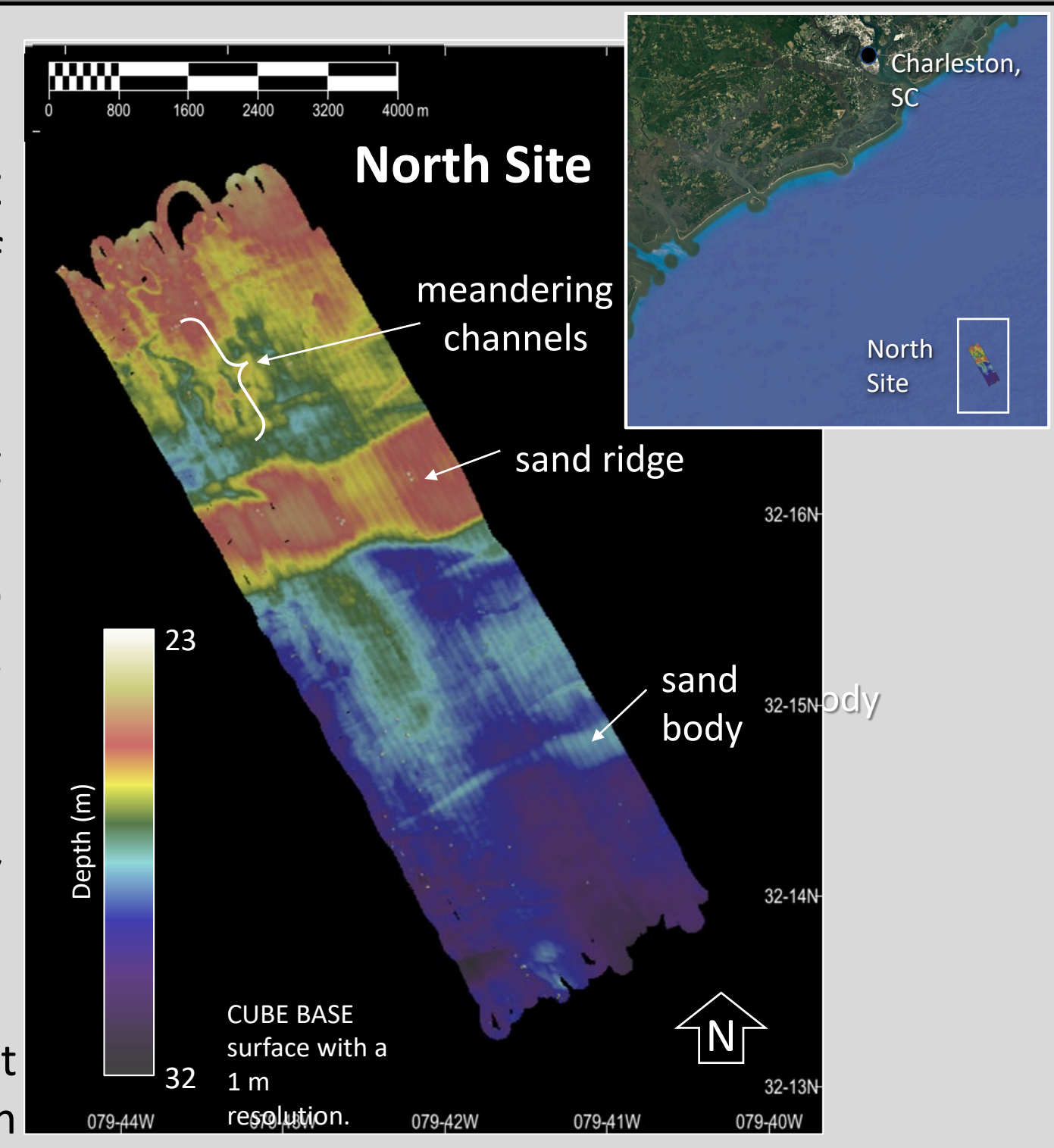
Figure 1. Study Area and Site Locations



Original SC DNR study site names were (from north to south) MM27, Site D, Site C, and MME. For better clarity, the sites have been renamed as North, Central, South Central, and South, respectively (Fig. 1). Depths of these four sites range from 20 to 37 m. (Left) Google Earth view of 4 study sites on the continental margin off Charleston, SC and Savannah, GA. White boxes show the 4 study sites. (Right) The study sites are shown at the same scale and depth color range. Original site names used by SCDNR are shown in parentheses. See figure above left for location of site North relative to the other 3 sites.

Figure 2. North Site

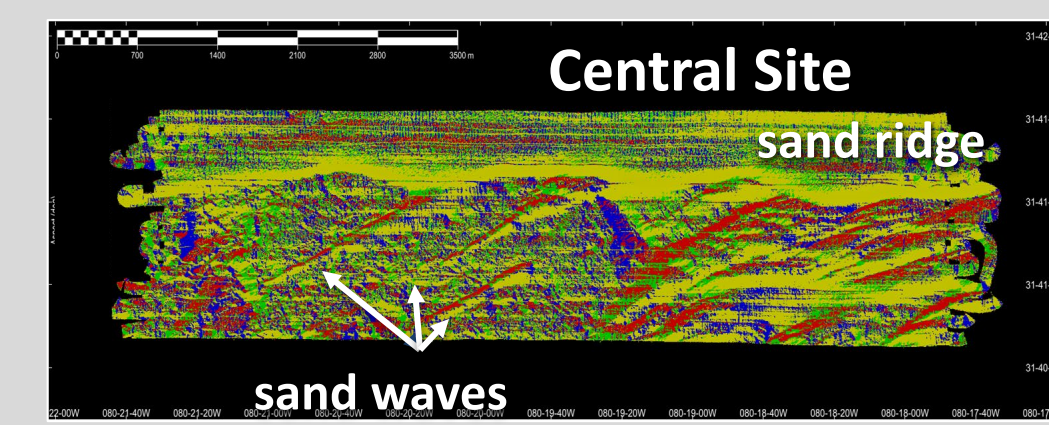
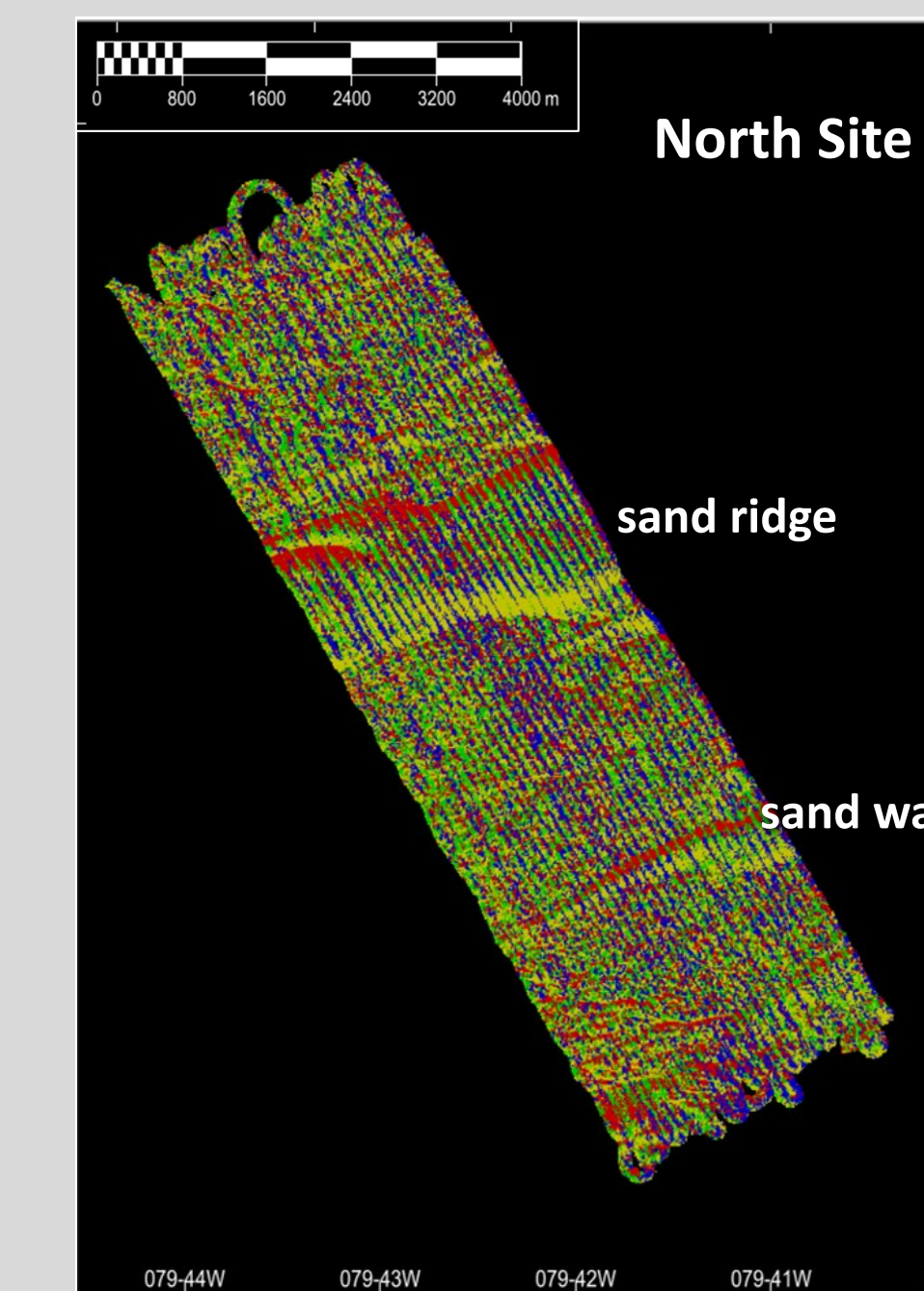
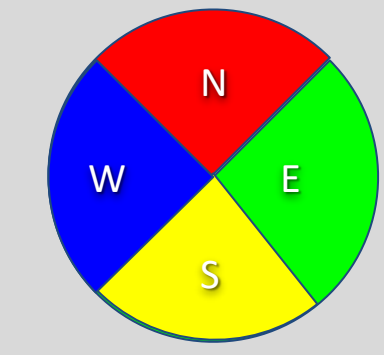
North Site lies 80.5 km off the SC coast, 64.4 km southeast of Charleston, where depths range 23 to 32 m (right). This site has numerous features including meandering channels in its northwestern portion. These channels are 1 m deep and 80 m wide. In the central area, a low-relief (2 m) 1.2 km wide sand ridge occurs, trending southwest-northeast. The lower, deeper half of the study site has a second smaller sand body, parallel to the main sand ridge (Note that the along-track striping was not possible to remove using either refraction editor or by editing the sound velocity curve.)



The slope surface (above left) illustrates the site's very low gradient (<5°), with steepest areas along the ridge's edges and walls of the meandering channels. The sand wave's northwest edge is steeper, suggesting northwestern migration. Classified Intensity (above right) shows highest intensities occurring along the sand ridge's northern edge and the meandering channels, and lowest intensities are found on the ridge's southern edge. An apparent association exists between high slope and low intensity on the sand ridge's southern edge, however, the ridge's northern edge and the channels are both high slope and high intensity.

Figure 6: Aspect Surfaces

Aspect was divided into 4 color quadrants that represents north, south, east and west slope orientation directions. All sites are shown at the same scale.

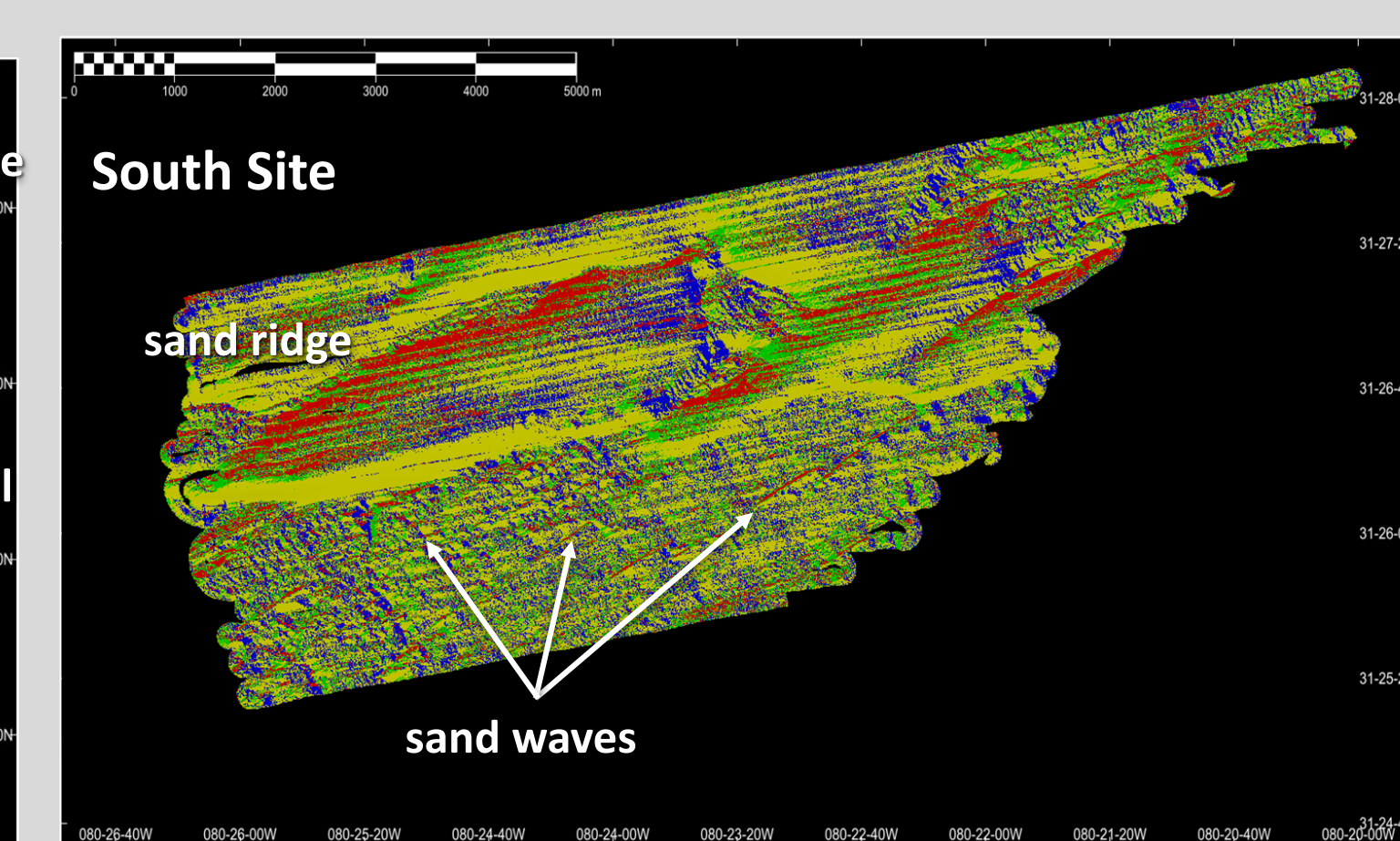
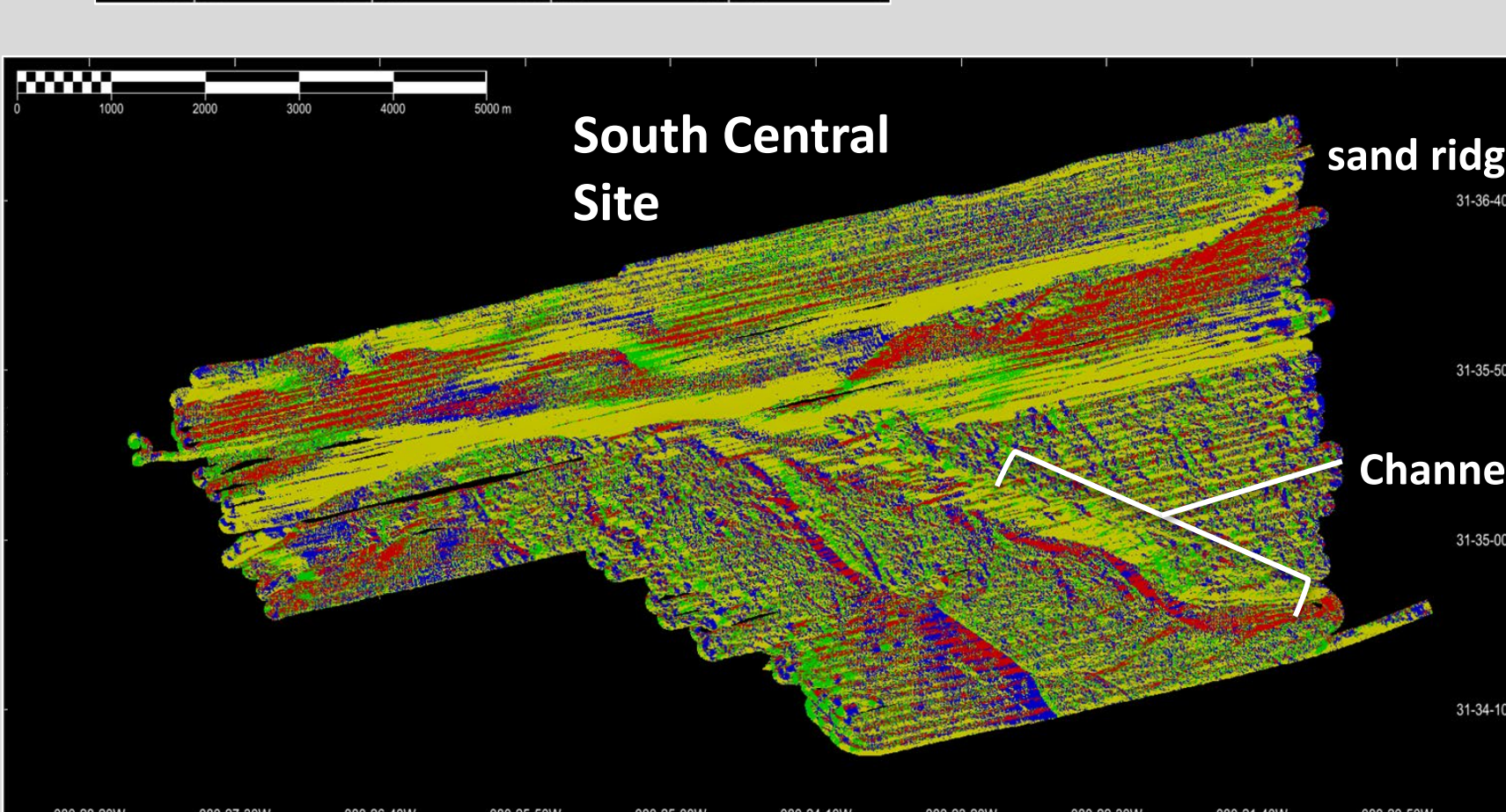


North Site (left)

The ridge and wave's deeper edges are oriented southward (yellow) (left), while their shallower edges are oriented northward (red). The wave's shallow edge is steeper.

Central Site (above)

The ridge's edge is oriented southward (yellow). The steep sides of the sand waves are oriented northward (red) while the gradual sides are oriented southward (yellow).



South Central Site (Above Left)

The ridge edge, sand body's steep edge and channel's east wall are oriented southward (yellow), while the channel's west wall and sand body's gradual edge are oriented northward (red).

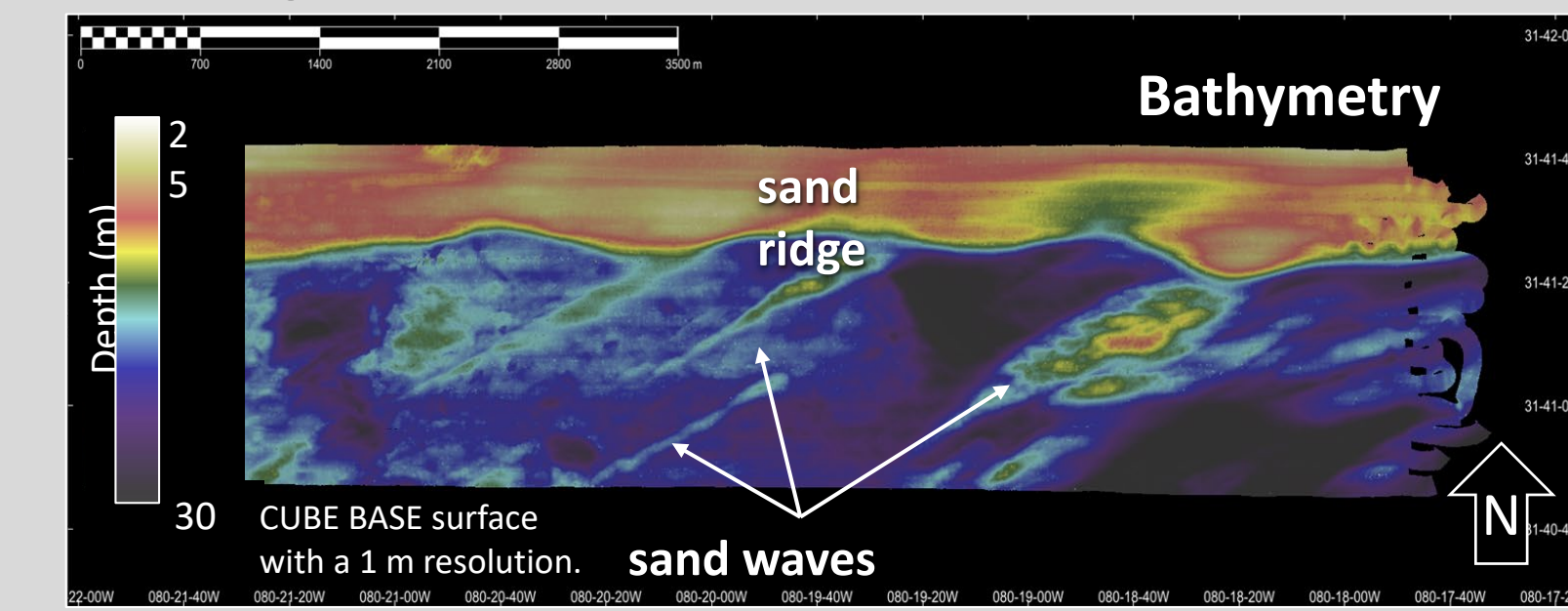
South Site (Above Right)

The ridge's edge is oriented southward (yellow), as are the sand waves gradual edges. The sand wave's steep sides are oriented northward (red).

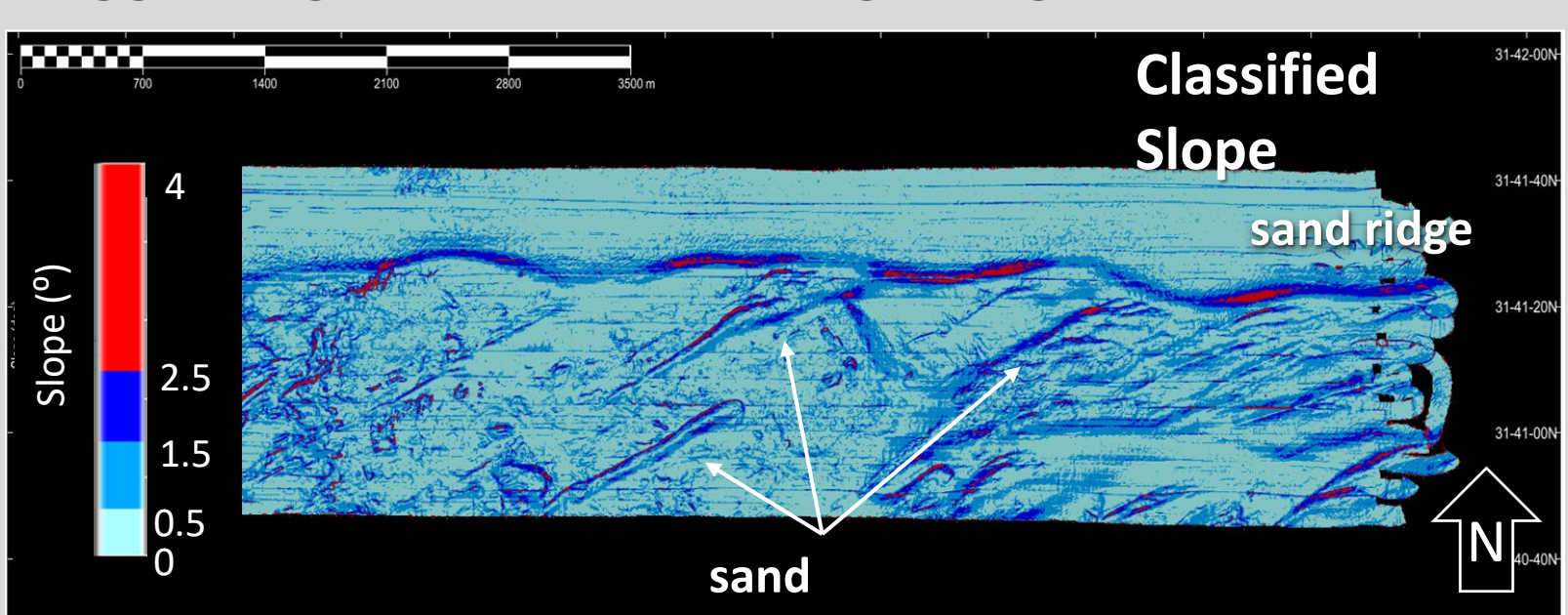
All sand ridges have the same slope orientation, suggesting an association between them. Additionally, all sand waves have a steep edge oriented northward and gradual side oriented southward, indicating they all have northward migration. No significant differences are seen between sites.

Figure 3. Central Site

Central Site lies 80 km off the GA coast, 88.5 km southeast of Savannah, where depths range 25 to 30 m (right). (Below) A large east-west sand ridge was found along the site's northern edge. This ridge is approximately 3 m high, and at least 7 km long and 0.7 km wide. Several sand waves of varying size occur at an angle to the ridge, oriented northeast-southwest. They are approximately 2.1 km in length and range from 1 to 3 m in vertical relief.



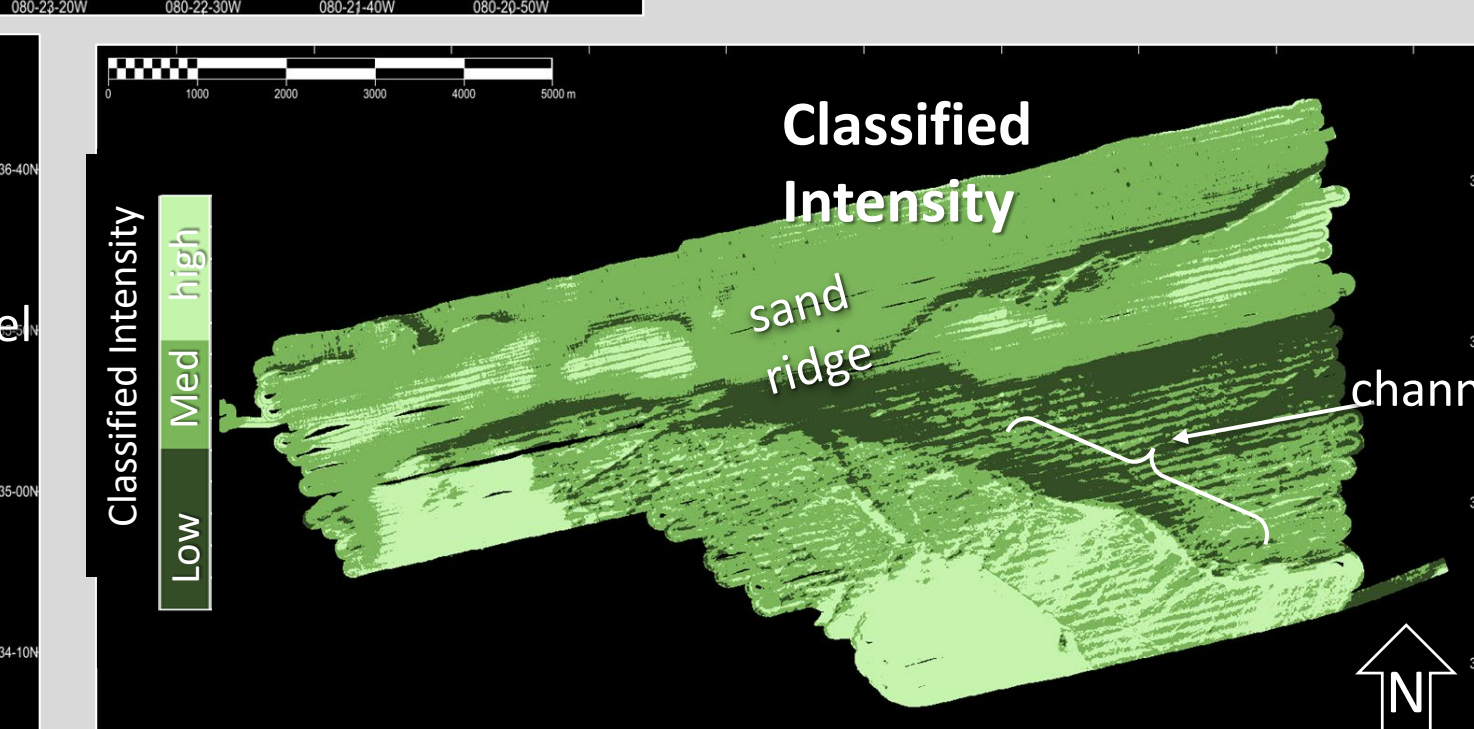
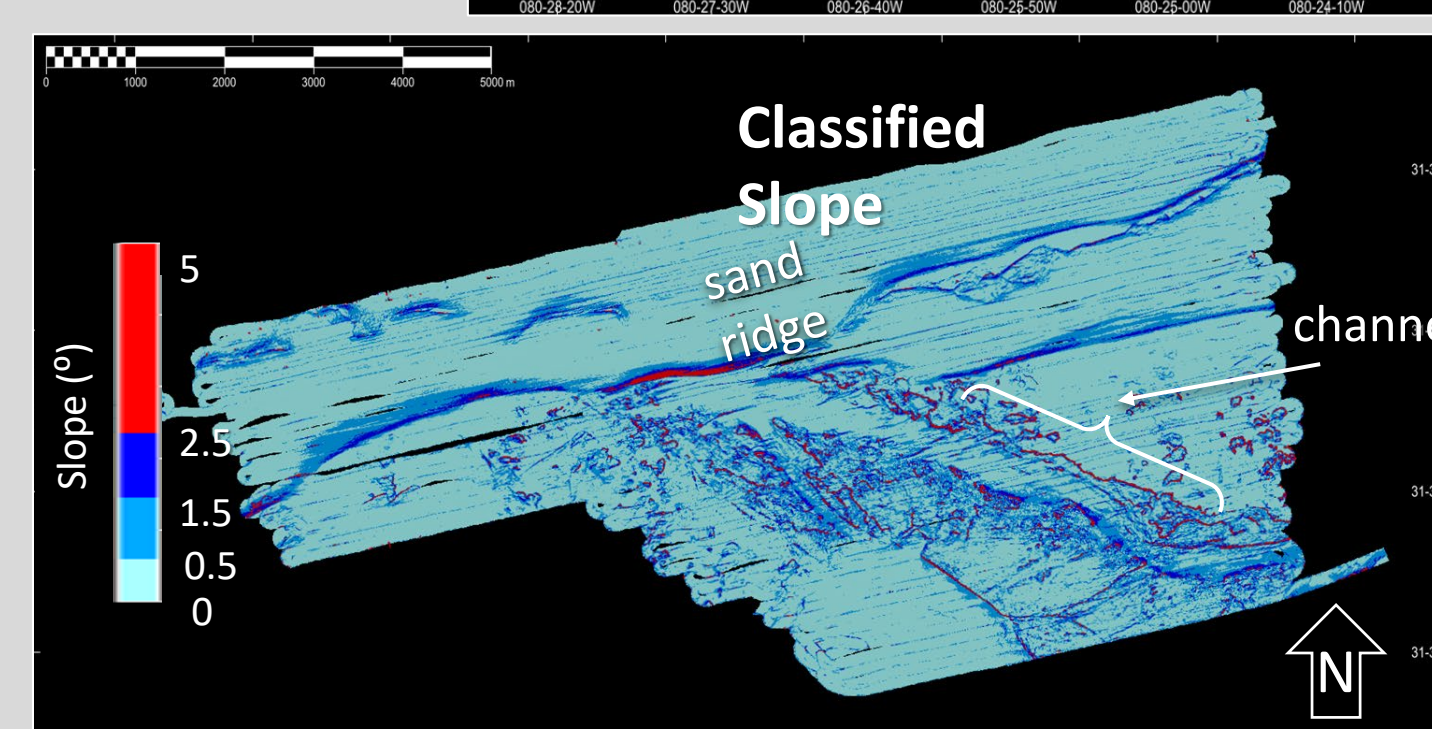
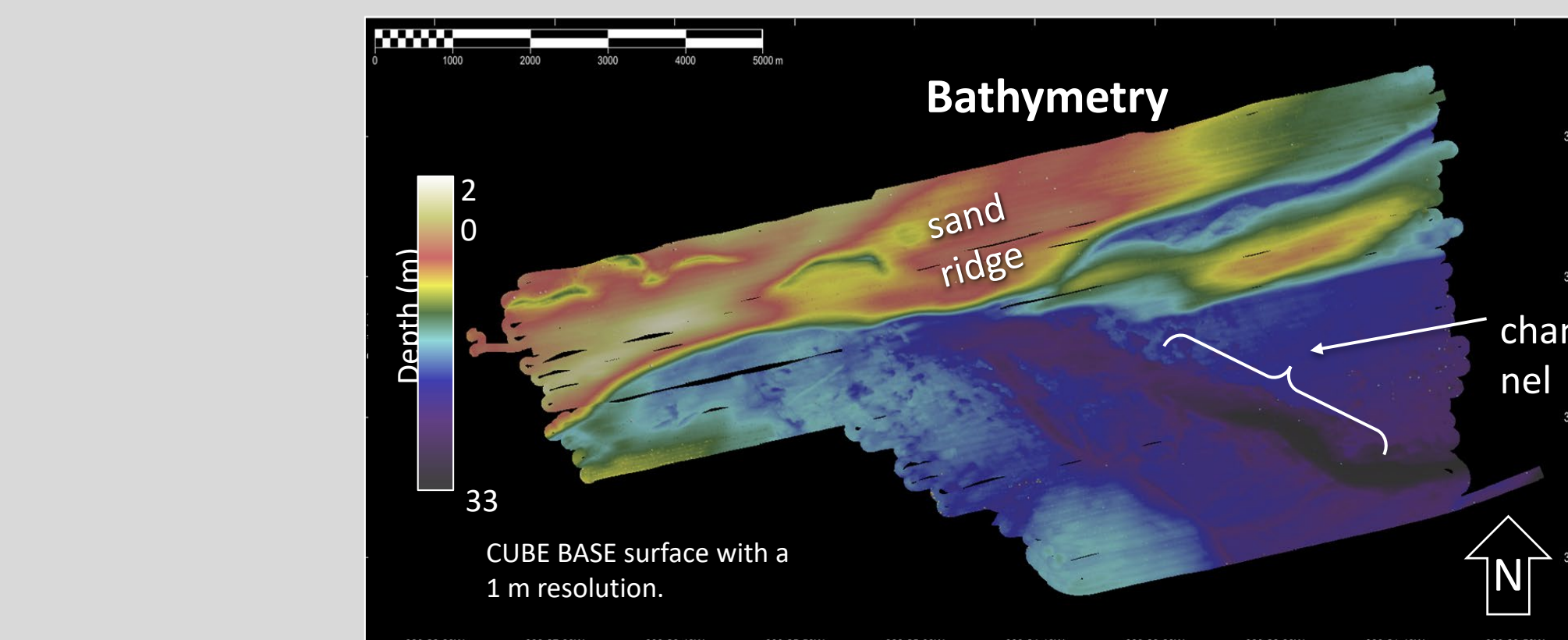
(Below) Note the very low gradient of the site (<4°), below. The ridge's edge and sand waves are relatively high (red) to medium-high (dark blue), below. The northwestern sides of the sand waves are steeper than the southeastern sides, suggesting the waves are migrating northwest.



Generating a Classified Intensity surface (backscatter mosaic) was not possible for this site.

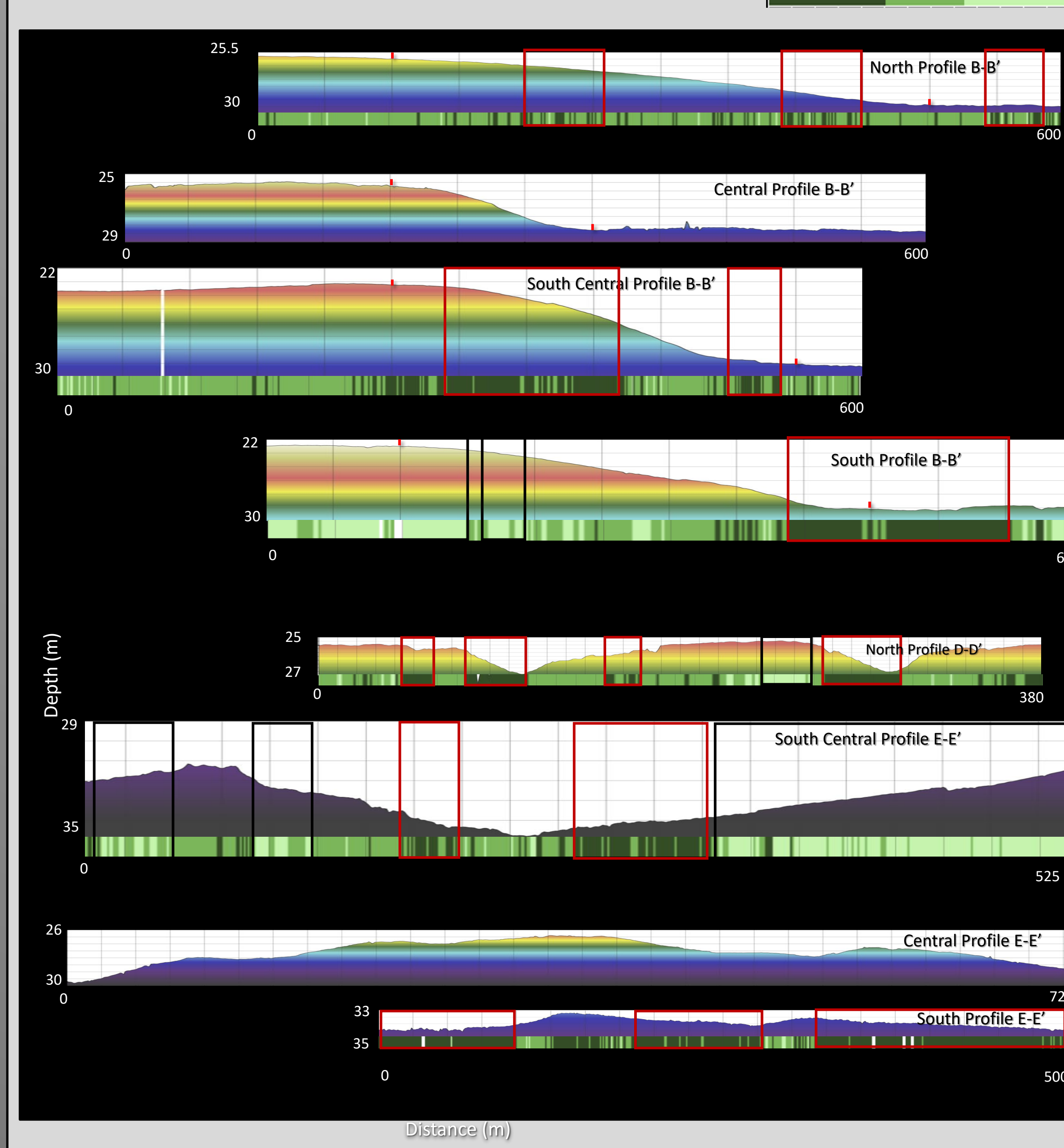
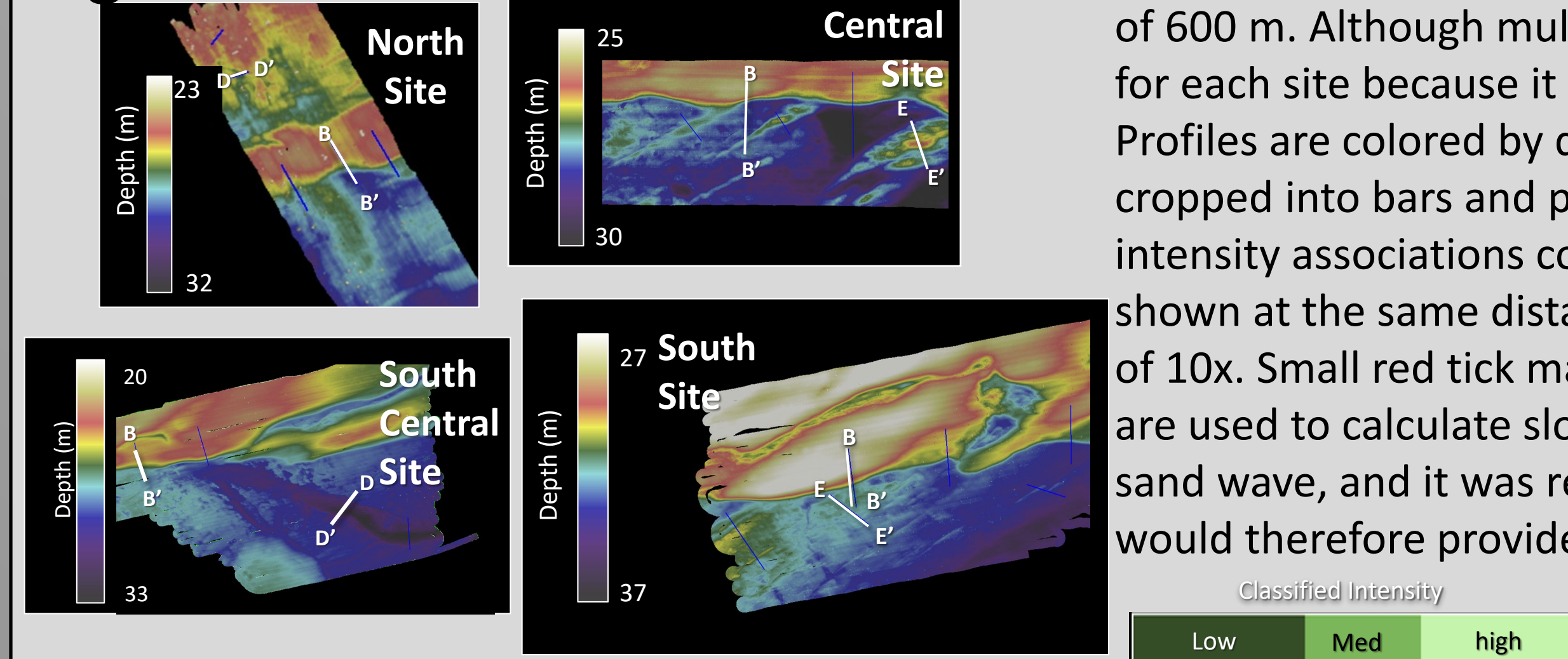
Figure 4: South Central Site

South Central Site lies 64 km off the GA coast, 64.4 km southeast of Savannah, where depths range 20 to 33 m. (left) A large northeast-southwest sand ridge was found along the site's northern edge. This ridge is approximately 4 m in relief, and at least 11 km long and 3 km wide. A smaller, parallel sand body occurs off the ridge, but will be considered part of the ridge. A low area exists between the sand body and ridge. A 4 m deep and 1 km wide incised channel is located within the site's southern portion, and runs northwest-southeast. The channel is straighter, wider, and deeper compared to North Site's channel. In the southwest corner, there is an area that is 2 m shallower than the surrounding seafloor.



The Classified Slope surface (above left) illustrates the site's very low gradient (<5°), with steepest areas along the ridge's central southern edge where it intersects the channel, and the channel bottom is flat. Classified Intensity (above right) shows the sand body's top, channel walls, and a large southwestern area have high intensity. The channel's bank, ridge's low area, and ridge's edge have low intensity. An apparent association exists between high slope and low intensity on the ridge's edge, however, the channel walls are both high slope and high intensity (above left and right).

Figure 7: Profiles

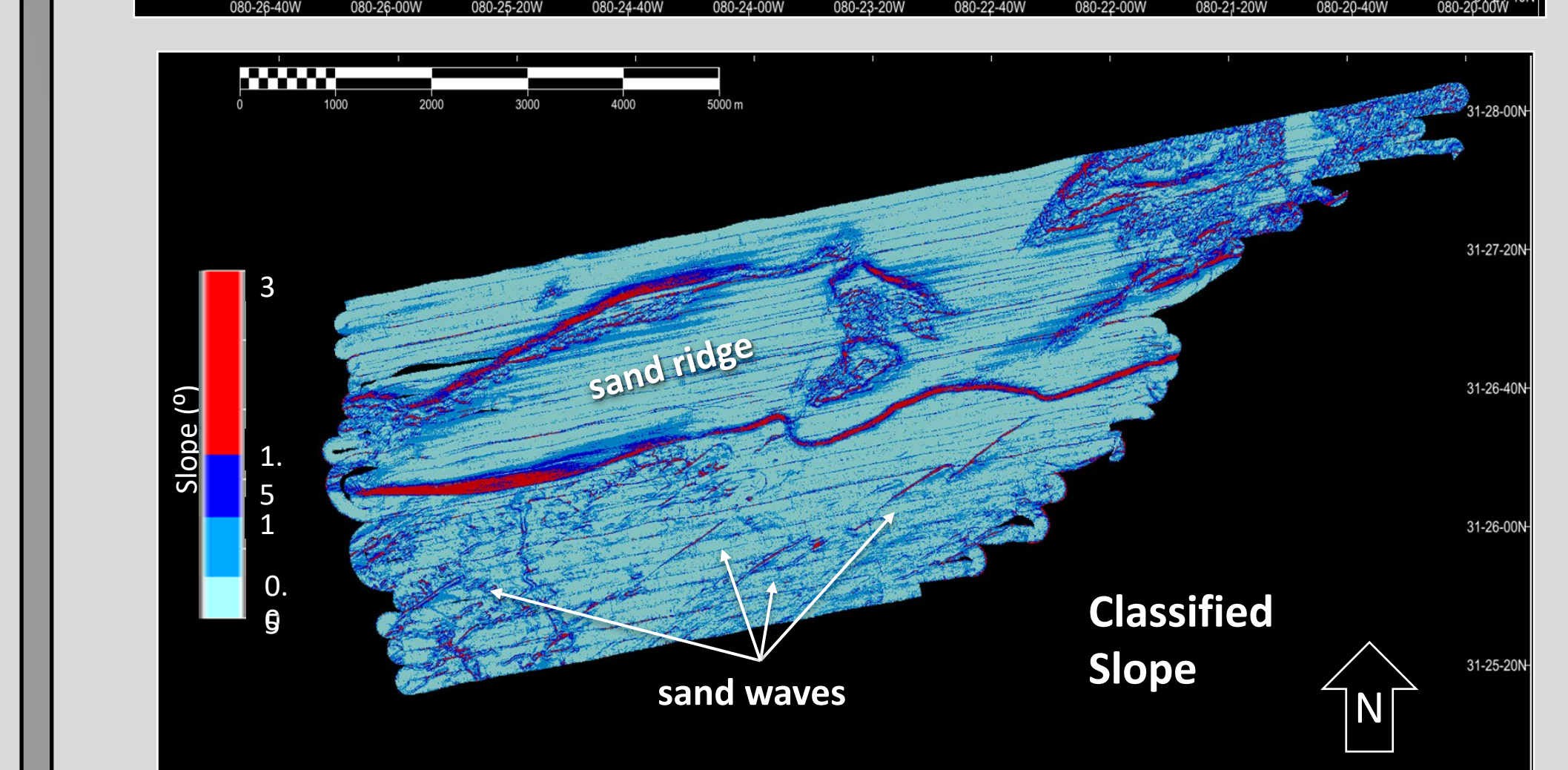
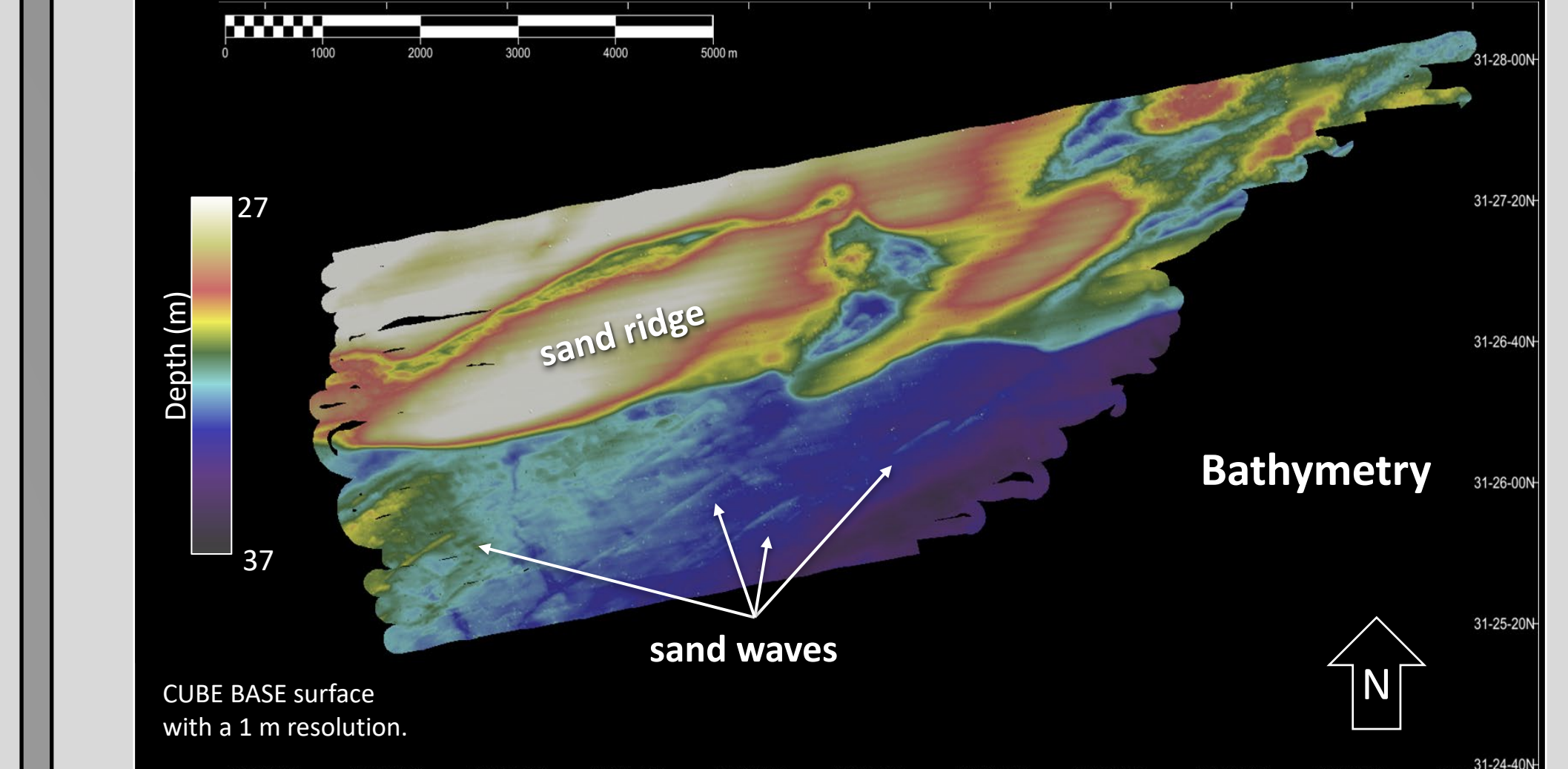


All depth profiles were made from the ridge top to the ridge's base, over a distance of 600 m. Although multiple profiles were taken across the ridges, B-B' was chosen for each site because it crossed the approximate middle of the ridge's mapped area. Profiles are colored by depth. Classified intensity profiles were generated, then cropped into bars and placed below the depth profiles so that sand ridge slope and intensity associations could be analyzed qualitatively. Profile location maps are not shown at the same distance or depth scale. All profiles have a vertical exaggeration of 10x. Small red tick marks indicate the beginning and end of the ridge edge and are used to calculate slope. Central Site's E-E' profile is displayed as it is the middle sand wave, and it was relatively between the width and height of D-D' and F-F' and would therefore provide the best basis of comparison.

North and South Central Site's ridge top are both primarily medium intensity, indicating semi-consolidated sand that is being compacted but pressure. South Site's ridge also has medium intensity areas, but its ridge top is mainly high intensity, suggesting further sand consolidation. North and South Central's ridge edge have medium intensity with large low intensity areas showing unconsolidated sand. South Site's ridge edge has medium intensity, likely due to the increased compaction. All sites ridge's base have large low intensity areas from loose sand falling down the slope. South and South Central Sites ridge edges have the highest slope, 1.15°, while North Site has the lowest, 0.5°. South Site has a 1.1° slope. North Site and South Central Site both contain distinctive channels. These profiles emphasize the differences in channel widths. The meandering channels of North Site are significantly narrower and overall have lower vertical relief than the South Central Site's channel. At both channel's banks have high intensity, suggesting hard-bottom (black boxes). On the South Central Site, the southern channel wall (right side of profile) also has high intensity. Low intensity (red boxes) within the channel's bottom, implying that loose sediment is filling the channels. Central Site and South Site both have sand waves that extend from the sand ridge at an angle. Central Site has 3 distinct waves while South Site has several small waves. The Central Site's sand wave is wider than South Site's wave and has a higher vertical relief (4 m and 2 m respectively). Central site has no backscatter data, so no associations between sand wave's morphology and intensity can be seen. South Site is primarily low intensity (red boxes), indicating unconsolidated sand, but the steep side does have medium intensity areas, suggesting more compact sand.

Figure 5: South Site

South Central Site lies 64 km off the GA coast, 88.5 km southeast of Savannah, where depths range 27 to 37 m. (Below) A large northeast-southwest sand ridge composed of a series of smaller sand bodies 3 to 5 m in relief was found along the site's northern edge. Low areas exist between sand bodies. The ridge is at least 10 km long and 2 km wide. Several low relief (<1 m) sand waves also occur parallel to the sand ridge.



The site has a very low gradient (<3°), with steepest areas the ridge's edge and the ridge's low areas. The sand waves' northern edges are steeper, suggesting a northern migration. Highest intensities occur on the ridge top and sand waves, suggesting the ridge and waves are composed of unconsolidated sand. Lowest intensities are along the ridge's edge and the ridge's low areas, indicating hard-bottom. An apparent association exists between high slope and low intensity on the ridge's edge and low areas (see above and below). However, on the sand waves, an association between high slope and high intensity exists (see above and below).

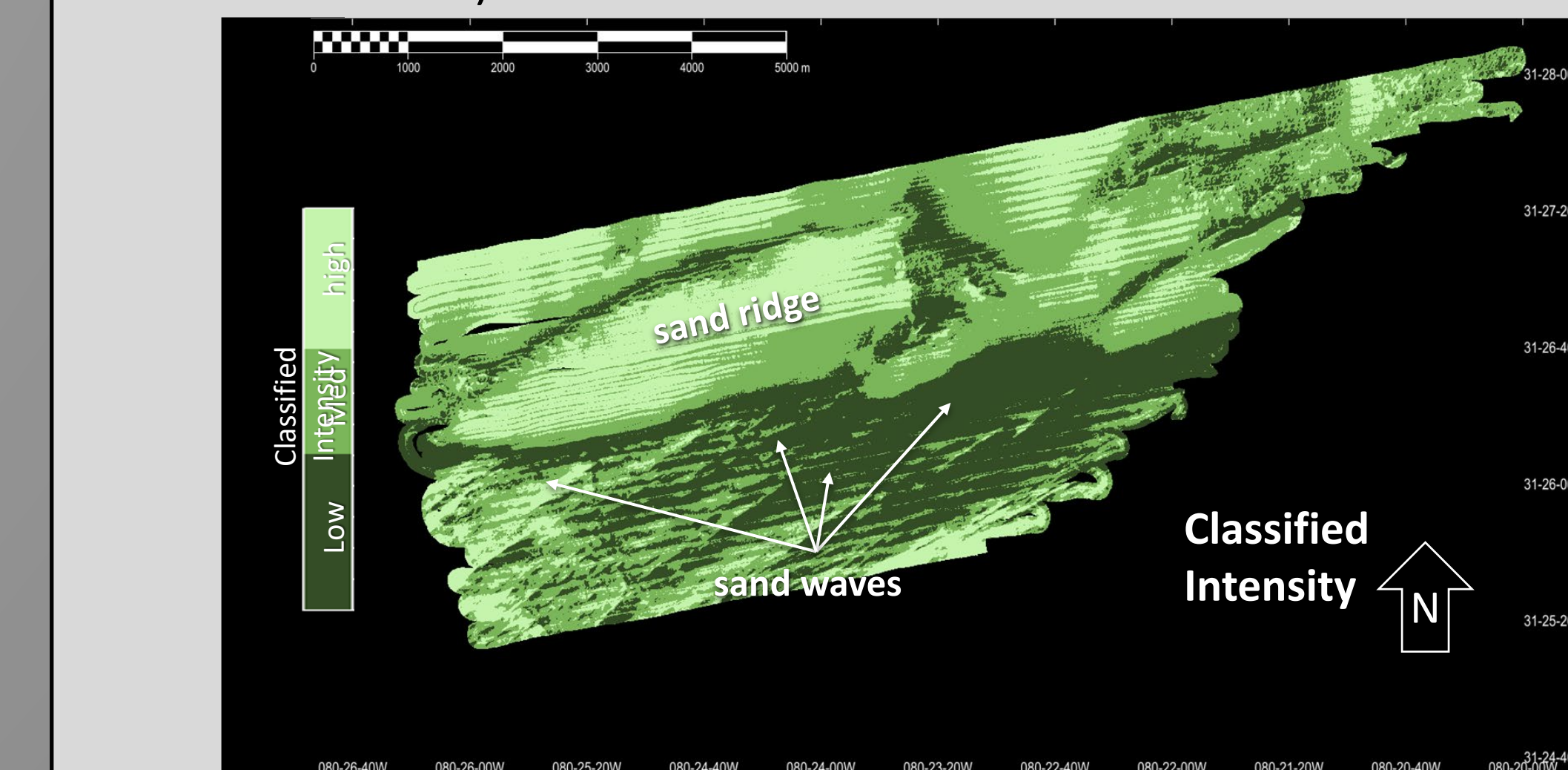
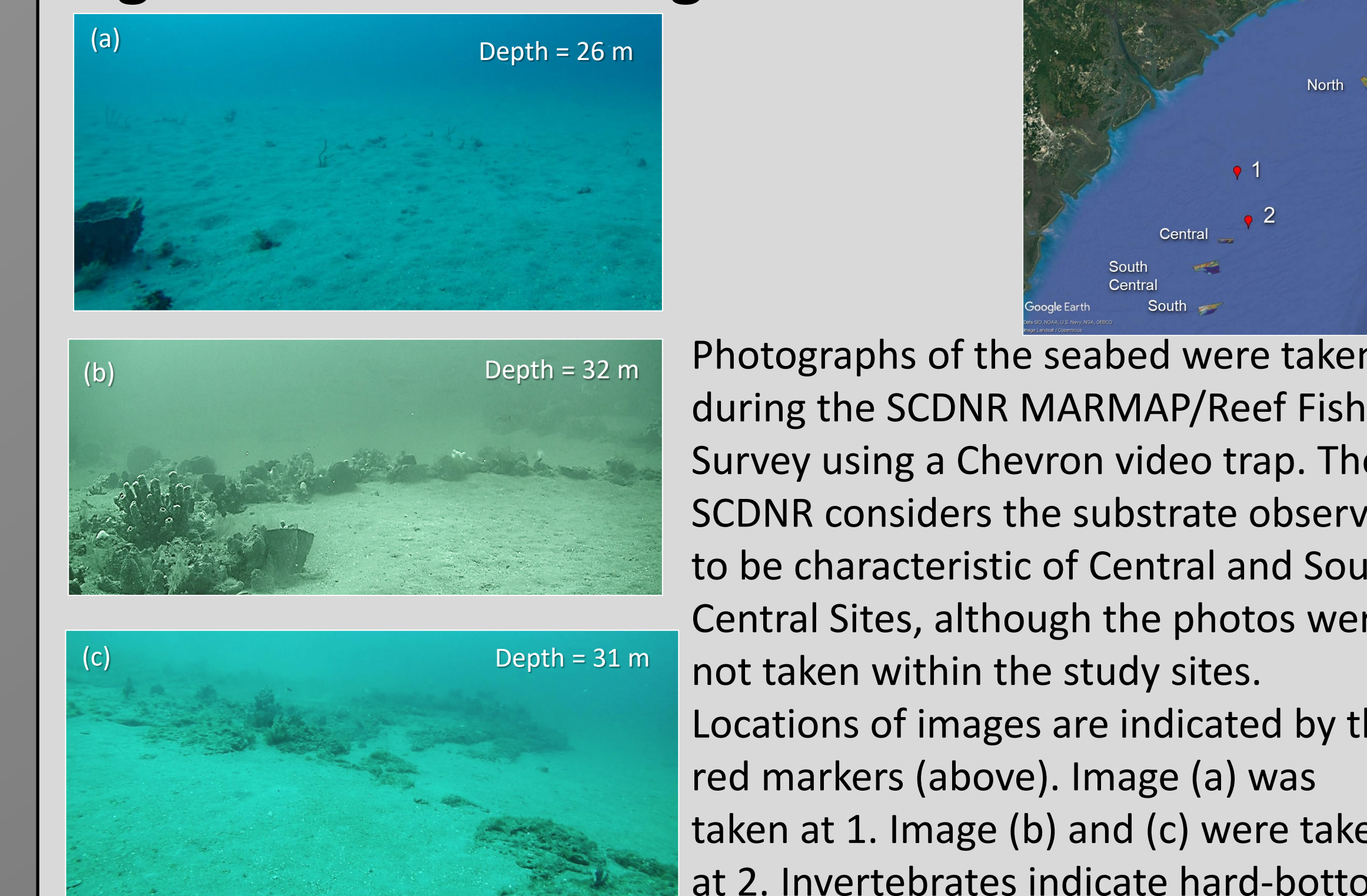


Figure 8: Bottom Images



Photographs of the seabed were taken during the SCDNR MARMAP/Reef Fish Survey using a Chevron video trap. The SCDNR considers the substrate observed to be characteristic of Central and South Central Sites, although the photos were not taken within the study sites. Locations of images are indicated by the red markers (above). Image (a) was taken at 1. Image (b) and (c) were taken at 2. Invertebrates indicate hard-bottom.

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