

# Bathymetric Analysis of a complex promontory extending into the Gulf Stream off Charleston, SC: benthic habitats of Bulls Scarp

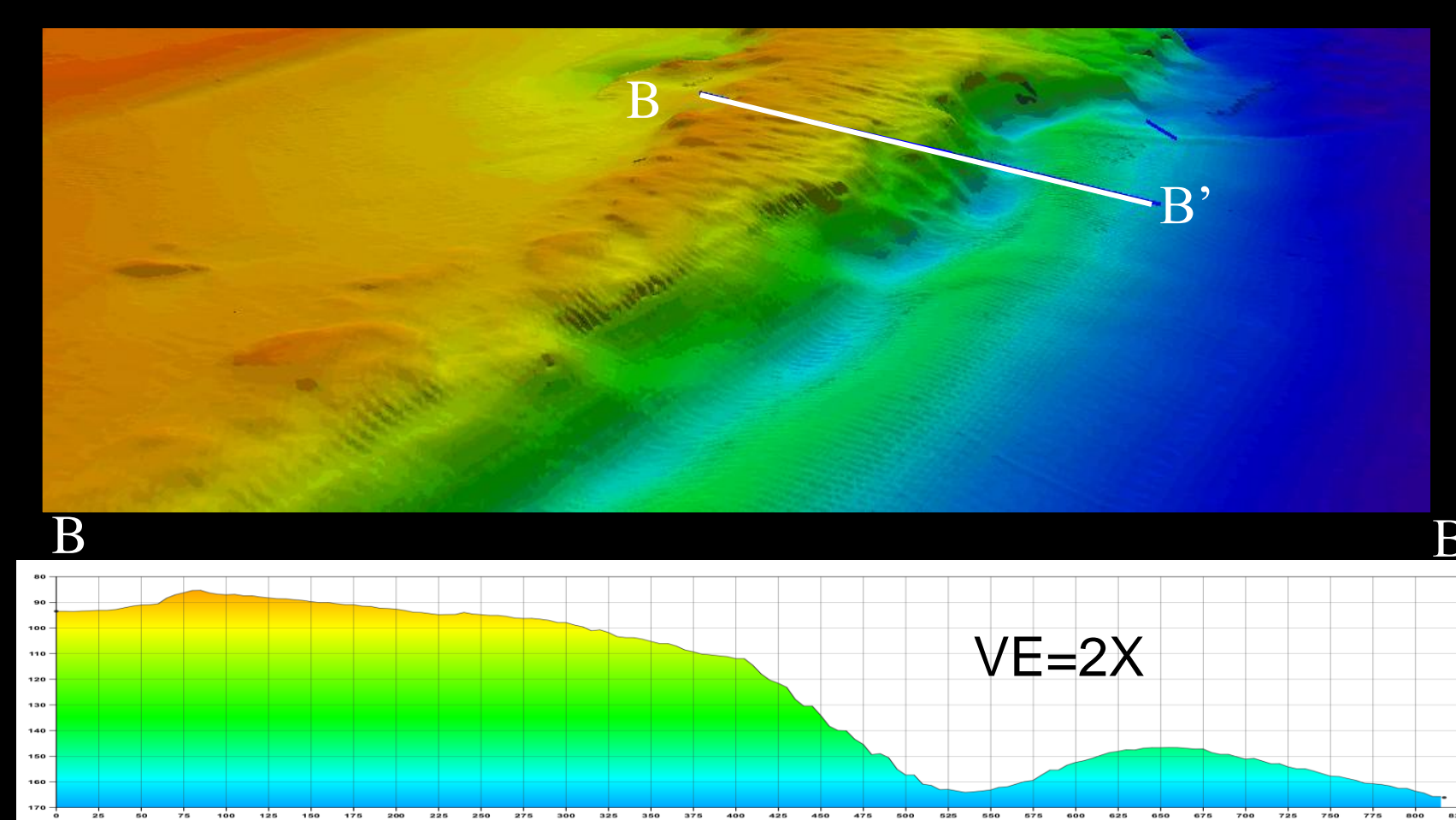
M. G. SMYTHE, P.J. BIERCE, L.R. SAUTTER and M.S. HARRIS  
College of Charleston Dept. of Geology and Environmental Geosciences



## Background

The 67 survey lines that make up the Bulls Scarp study area were collected primarily to determine if the site is suitable for consideration as a marine protected area (MPA). MPAs are areas of seafloor identified based on reef morphology, fish density, fish diversity, and spawning habitat (Schobernd and Sedberry, 2009). Previous bathymetric surveys (SeaMap Program, College of Charleston) of the shelf near the project area reveal a relatively smooth bottom with areas of high-relief rocky outcrops. During the Pleistocene, algae, corals, bryozoans, and mollusks deposited during lower sea level are now the relict calcareous carbonate features that comprise the shelf-edge upper-slope reefs (Schobernd and Sedberry, 2009). In the last 20,000 years, sea level has risen from ~125 m up to the present, modifying the influences of terrestrial and oceanographic processes acting upon Bulls Scarp. The Gulf Stream in this area now flows in the deep water adjacent to Bulls Scarp, and the location of sand waves and current-scoured bottom provides information about the affects of the Gulf Stream on the seafloor today. In the past, icebergs were in the region as identified by iceberg plough marks 50-km north of the site.

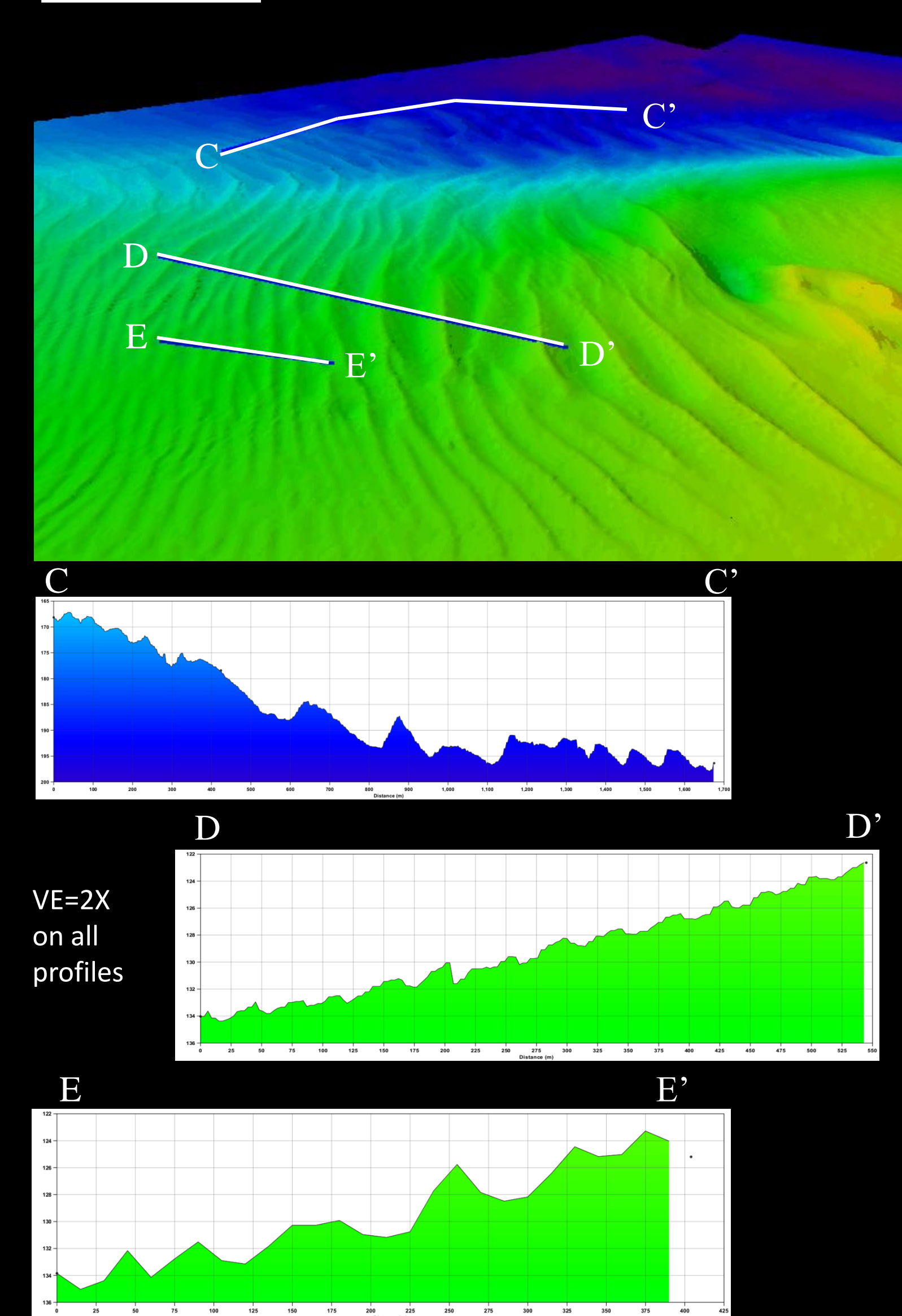
## Eddy Scour



**Figure 4**

3-D image (viewed looking north): Possible sediment transport occurs around rocky outcrops, directed by the turbulent Gulf Stream. An associated eddy scour does not allow sediment to build up at the toe of the 50 m-relief scarp. Profile B-B' shows the depression between scour and shoreward toe of the depositional bar in this profile has a relief of 55 meters over 140 meter horizontal distance. (Depth scale as in Fig. 1)

## Sand Waves



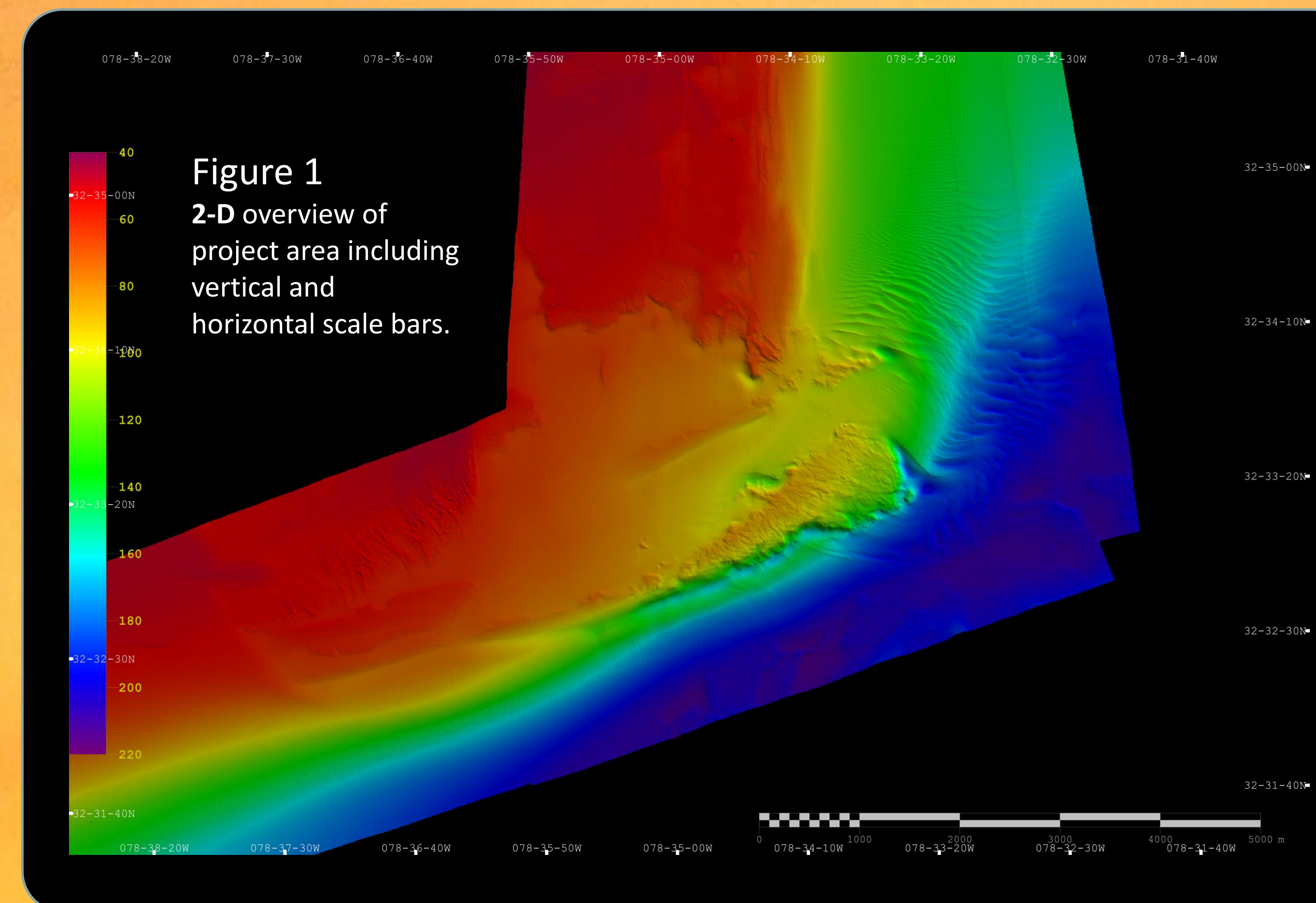
**Figure 5**

3-D image (viewed looking southeast): Sand waves up to 10 m high trend north east, but vary in symmetry, indicating different flow directions within the Gulf Stream.

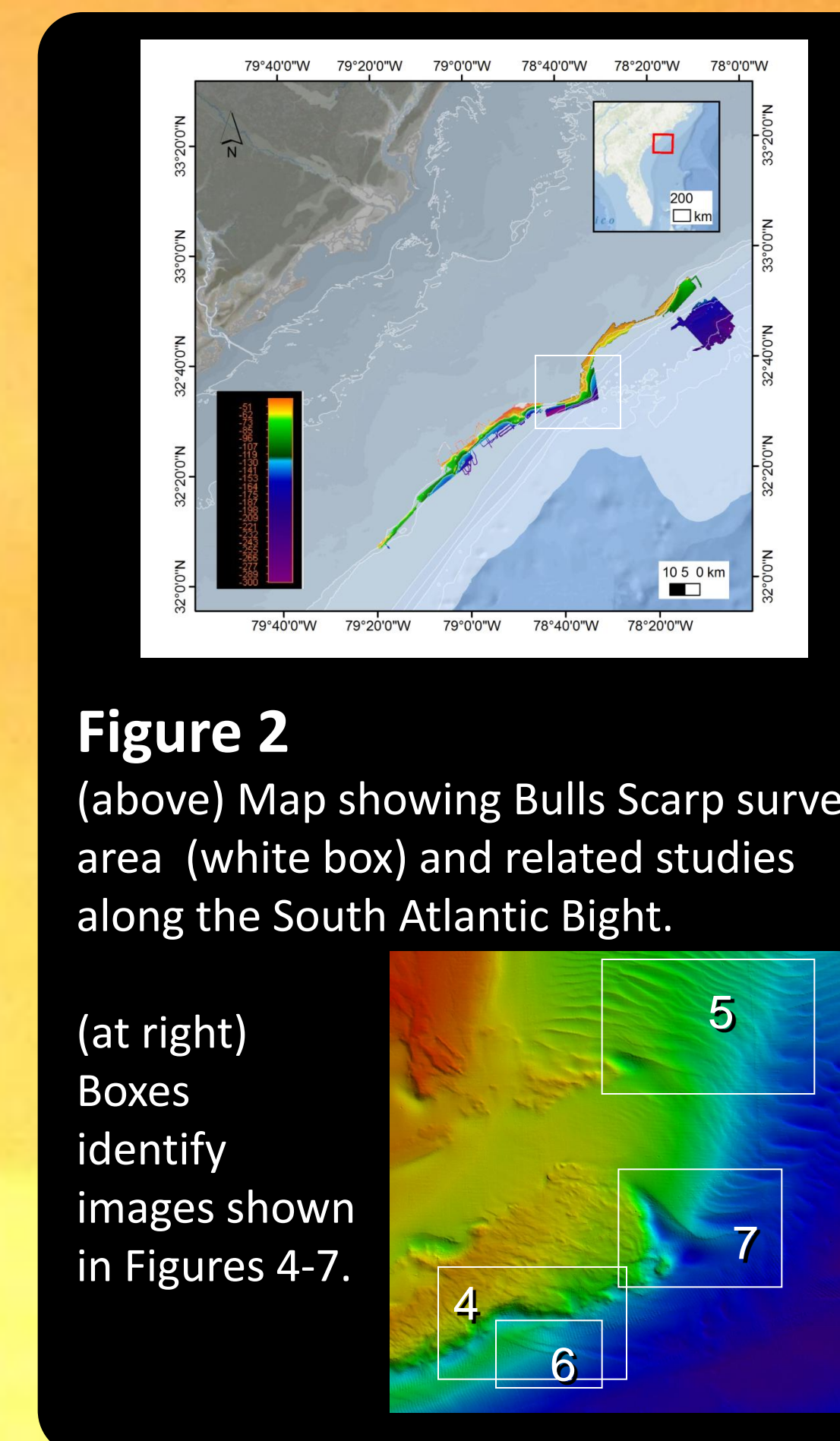
Profiles C-C' and D-D' illustrate alternating flow northward and southward, respectively, while profile E-E' shows symmetric sand waves, indicating bi-directional flow. Sand wave morphology suggests a large-scale eddy is formed as the Gulf Stream encounters the Bull Scarp promontory. Future surveys would reveal migration rate of sand wave field through time. (depth scale as in Fig. 1)

## Abstract

Bulls Scarp is a cape-like promontory located at the continental shelf edge, 100 km off the coast of Charleston, SC. Multibeam sonar data collected in July 2011 aboard the NOAA Ship *Nancy Foster* reveal a variety of complex bathymetric features. The 1.8 by 10.9 km survey area ranges in water depths from 40 to 210 m. Data were analyzed using CARIS HIPS and SIPS 7.1 software and reveal seafloor features including sand waves, current scours, depressions, a small canyon, multiple ledges and a possible iceberg plough mark – the southern-most feature of its kind identified in the western North Atlantic. This survey fills a gap along a 100 km section of the 50 m isobath of essential fish habitat within the South Atlantic Bight. Such bathymetric information is contributing to the designation of possible essential fish habitat and marine protected areas.



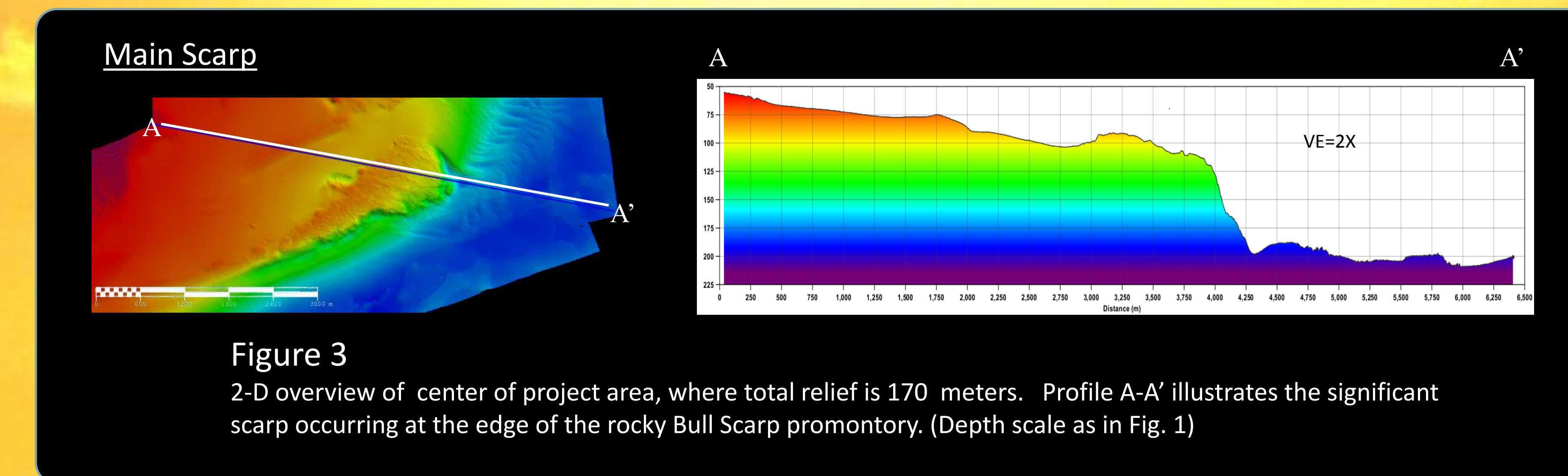
**Figure 1**  
2-D overview of project area including vertical and horizontal scale bars.



**Figure 2**

(above) Map showing Bulls Scarp survey area (white box) and related studies along the South Atlantic Bight.

(at right) Boxes identify images shown in Figures 4-7.



**Main Scarp**

**Figure 3**

2-D overview of center of project area, where total relief is 170 meters. Profile A-A' illustrates the significant scarp occurring at the edge of the rocky Bull Scarp promontory. (Depth scale as in Fig. 1)

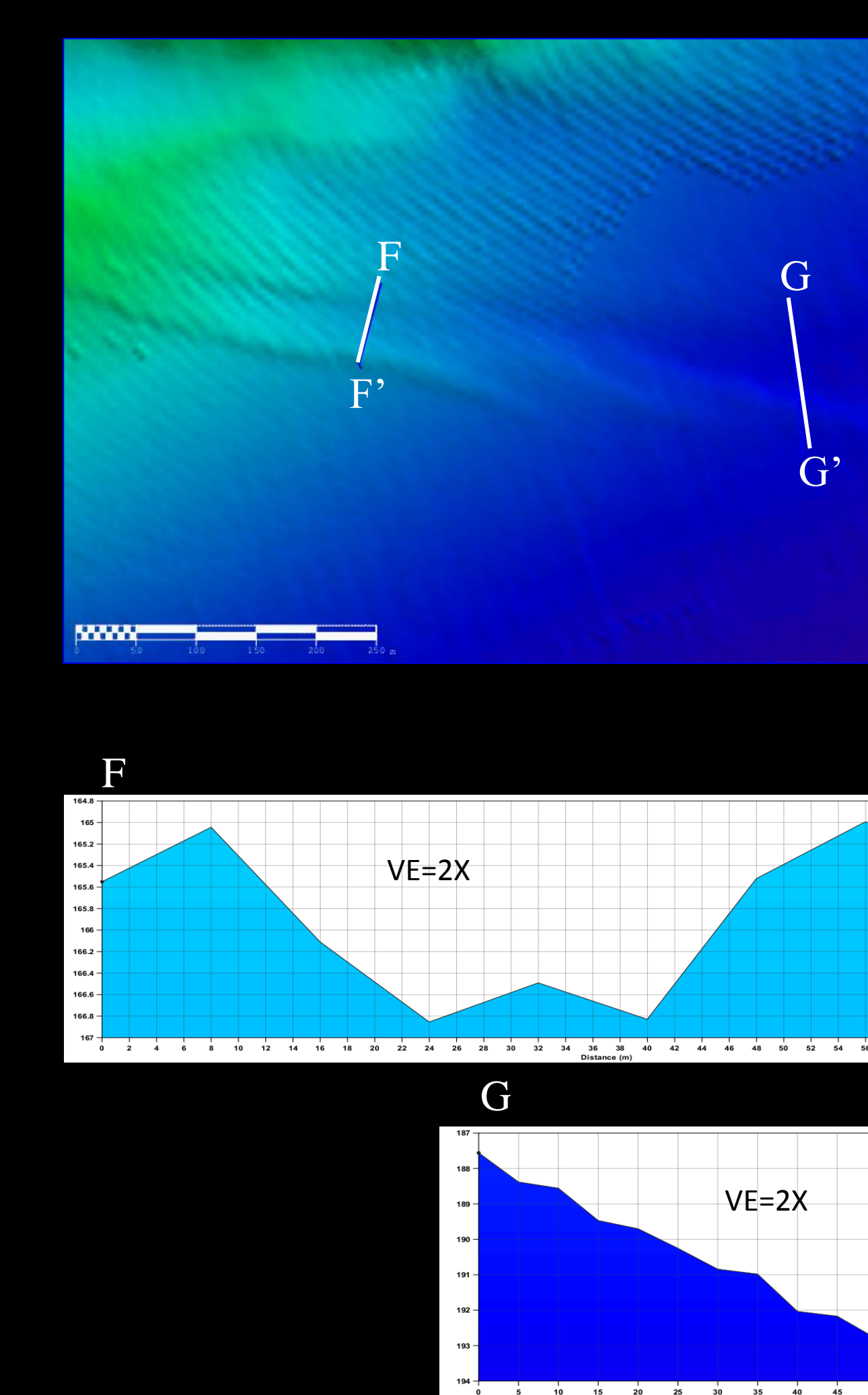
## Field Methods for Surface Results

- Used CARIS HIPS & SIPS 7.1 to produce Swath Angle BASE surface, using a 5 meter resolution.
- Applied a 5x5 meter interpolation using the closest eight neighbors.
- The goal was to balance fine resolution with minimum amount of interpolation over areas that received less coverage where ship track lines were spaced farther apart.
- Cross sections made over features of interest using the HIPS Profile tool
- Heave artifacts in the raw data are the result of the Applanix POS/MV 320 V4 gyrocompass not correctly applying heave offsets to the original datasets.

## Discussion

- Understanding the distribution of bathymetric features on the shelf-edge and upper-continental slope can assist with understanding the erosional and depositional patterns and Gulf Stream flow patterns around Bulls Scarp.
  - Sand wave field has implications for speed and strength of the Gulf Stream.
    - Northward transport in main flow of Gulf Stream
    - Southward transport in eddy behind Bulls Scarp
  - Eddies and current flow deflections, combined with complex habitats are important for biodiversity
  - Sediment movement around nose of Bulls Scarp follows the Gulf Stream flow gradients
  - Sediment smooths surfaces by filling in holes and covering rocky outcrops.
  - Areas above sediment infill remain rugged as erosional features.
- The high-relief incised canyon is now being modified by modern Gulf Stream processes and may have been a fluvial channel accentuating lineaments on the shelf during the last (and previous) glacial maximum.
- Possible iceberg plough marks may provide evidence of glacial fed coastal currents that penetrated further south than previously described.
  - Previous work records southwest-trending furrows at depths of 170-200 m just north of this survey area (Hill, 2008)
- Does Bulls Scarp fit the criteria for an MPA?
  - Relief classifications are the first step for designating essential fish habitats and MPA's.
  - High-relief bio-eroded rocks are ideal for sessile marine invertebrates, relating to the higher abundance and greater variability of reef fish (Schobernd and Sedberry, 2009).
  - Highly diverse, closely spaced habitats are abundant in the area

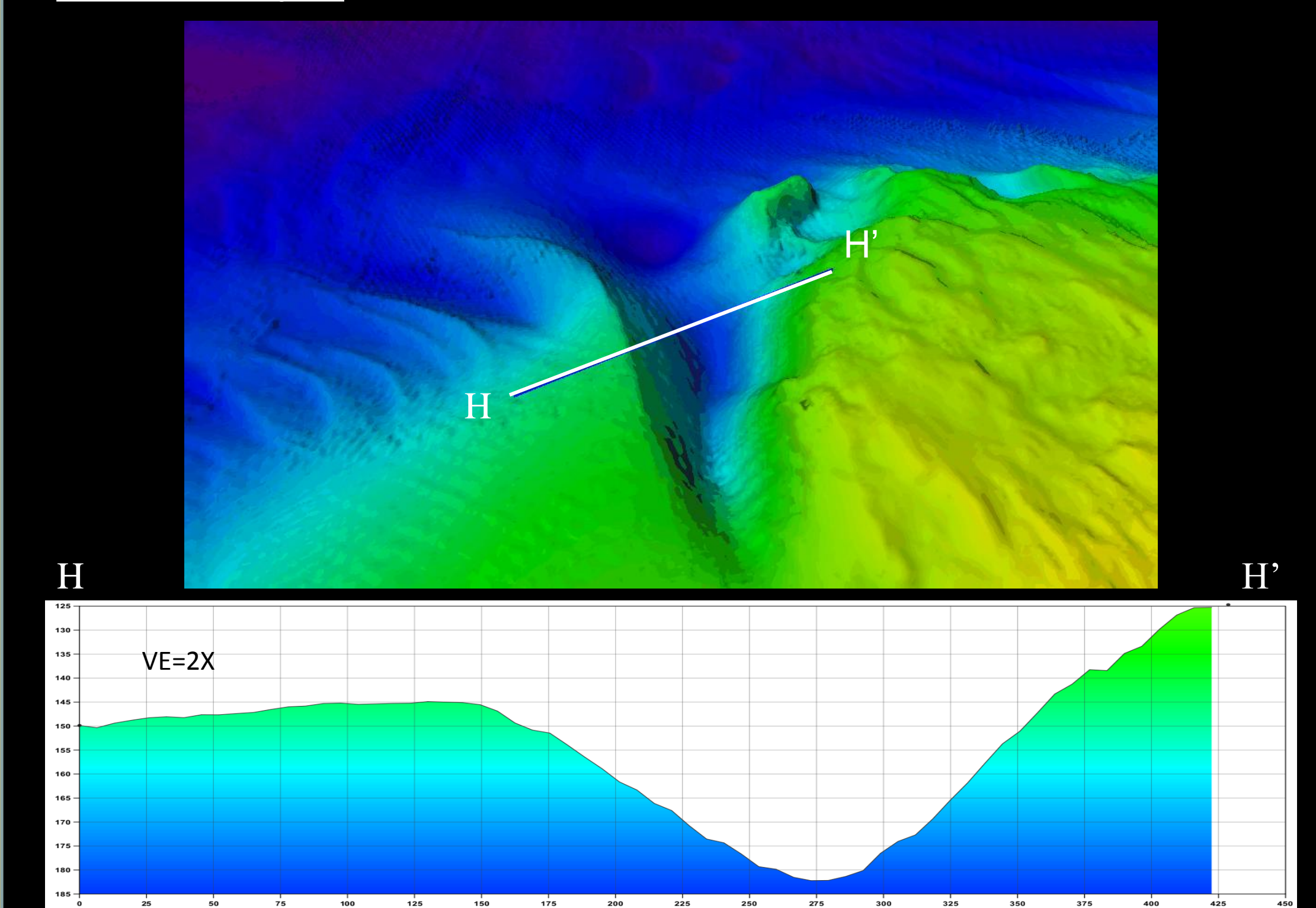
## Iceberg Scour



**Figure 6**

2-D image: An apparent iceberg ploughmark through sediments is seen at the base of the scarp, possibly created from an iceberg coming in contact with the ancient continental shelf during the last glaciation (~18,000 ybp). Similar ploughmarks have been identified north of Bulls Scarp in previous bathymetric analyses of the South Carolina coast (Hill, 2008). This is possibly the southern-most iceberg scour in the western North Atlantic. (Depth scale as in Fig. 1)

## Incised Canyon



**Figure 7**

3-D Image (viewed looking southeast): This small canyon-like feature has a maximum relief of 58 m over a distance of 150 m. It is a possible paleo-channel that may have been formed as a lineament from extensional faulting, and modified or incised as a scour feature from turbidity currents. A sediment shadow was created as a result of Gulf Stream flow around the most seaward promontory. (Depth scale as in Fig. 1)

## References

- Hill, J. C., Gayes, P.T., Driscoll, N.W., Johnstone, E. A. and Sedberry, G. R. (2008). Iceberg scours along the southern U.S. Atlantic margin. *Geology* 36.6: 447.
- Schobernd, C. M., & Sedberry, G. R. (2009). Shelf-edge and upper-slope reef fish assemblages in the South Atlantic Bight: habitat characteristics, spatial variation, and reproductive behavior. *Bulletin of Marine Science*, 84(1), 67-92.

## Acknowledgments

Thanks to NOAA and the crew aboard the NOAA Ship *Nancy Foster*, and to CARIS USA. Special thanks to the College of Charleston Department of Geology and Environmental Geoscience, the CofC Seamap Program, Dr. Norm Levine and Josh Mode (CARIS USA).