BATHYMETRIC COMPARISON OF SUBMERGED HEADLAND FEATURES OF THE U.S. SOUTH ATLANTIC BIGHT

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Abstract

The geomorphology of three offshore submerged headlands was examined using multibeam sonar. These headlands occur along the north-south trending South Atlantic Bight (SAB) continental shelf edge, approximately 100 km east of the South Carolina and North Carolina coasts. The Gulf Stream runs northward along the SAB's shelf edge before deflecting eastward into the open ocean near Cape Hatteras. The three sites compared are Bull Scarp, in the southern-most location, Cape Fear Terrace, and the northern-most Cape Lookout Terrace. Depths of these features range from approximately 40 to 235 m. Multiple bathymetric features were analyzed, compared, and contrasted to characterize the seafloor along this dynamic continental shelf edge. Features include escarpments, sand waves and rocky reefs. Characterizing and describing these seafloor areas will allow for improved understanding of the relationship between seafloor geomorphology and the Gulf Stream, as well as their roles in providing flourishing fish habitats.

Background

Sonar data were originally collected by NOAA and the South Atlantic Fishery Management Council (SAFMC) aboard the NOAA Ship *Pisces,* as part of an annual Snapper and Grouper stock assessment of Marine Protected Areas (MPAs) in July 2013 (NOAA CIOERT). An MPA is an area on the seafloor defined on seafloor morphology, fish density, fish diversity, and spawning habitat (Schobernd and Sedberry, 2009). The area of study includes three separate submarine headland locations along the border of the north-south trending South Atlantic Bight, or SAB (Figure 1), at the edge of the continental shelf, approximately 100 km off the coast of South Carolina and North Carolina. The SAB is defined by the continental margin between Cape Hatteras, North Carolina and Cape Canaveral, Florida off the east coast of the United States. The SAB is the western barrier of the Gulf Stream current before the current is deflected into the open ocean to the east near Cape Hatteras (Atkinson, 2012). Comparisons among these three submerged headlands are necessary in order to understand the relationships between the seafloor and the current of the Gulf Stream. Also, analyses of these sites can shed light on why they and similar sites are such great fish habitats. The sites being analyzed are Cape Lookout Terrace (Fig. 2), the "Snowy Wreck" portion of the Cape Fear Terrace (Fig. 3), and Bull Scarp (Fig. 4).

Figure 1. Area of study off the eastern US coast. Each individual site is shown, below (yellow boxes).

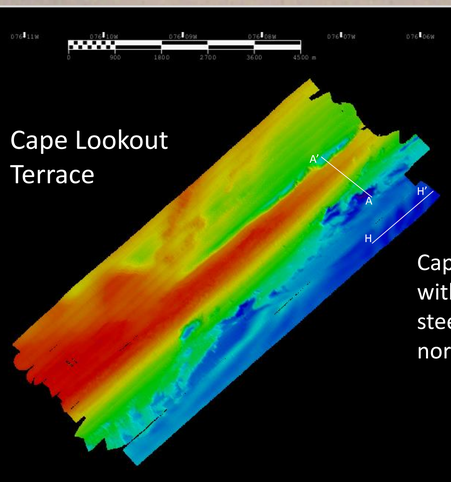
Methods

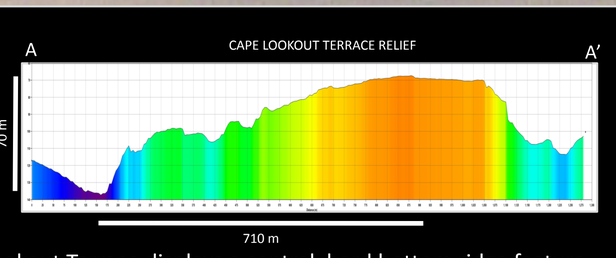
- NOAA and the South Atlantic Fisheries Management Council (SAFMC) originally conducted acoustic surveys using a SIMRAD ME70 multibeam sonar system on the NOAA Ship *Pisces* to acquire bathymetric data and provide background maps to guide ROV exploration at dive sites.
- CARIS HIPS & SIPS 8.1 was used to post-process raw data and produce three separate CUBE BASE surfaces, using a 4 meter resolution.
- A 5x5 meter interpolation using the six closest neighbors was applied.
- 3D BASE surfaces were analyzed at 3X and 5X vertical exaggeration (VE) to classify characteristics of each dynamic headland feature.
- Multiple profiles were created to compare depth, relief, and features using HIPS Profile tool.

Results

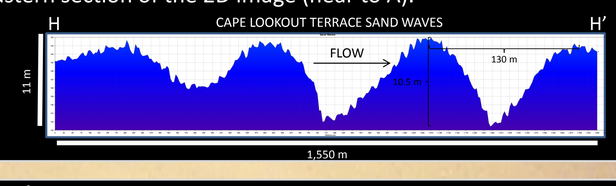
- Post-processed CUBE BASE surfaces show ledge-like, hard bottom features around the steep edges of the headlands.
- Profiles of scarp areas display steep slopes along the eastern, seaward edges of each feature (Figures 2, 3, and 4).
- The relief on both Bull Scarp and Cape Lookout Terrace is much more drastic than Cape Fear Terrace indicating stronger, more direct flow from the Gulf Stream.
- Cape Fear Terrace and Bull Scarp display sand waves oriented in different directions indicating turbulent flows, whereas the Cape Lookout Terrace sand waves indicate flow in only one direction (Table 1).

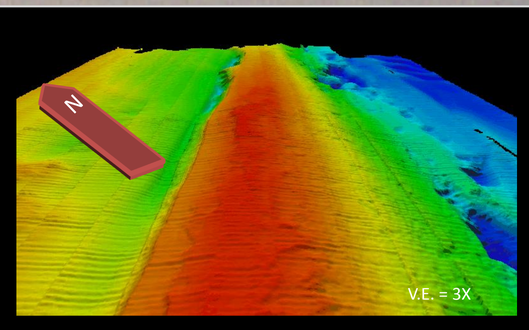
Figure 2.





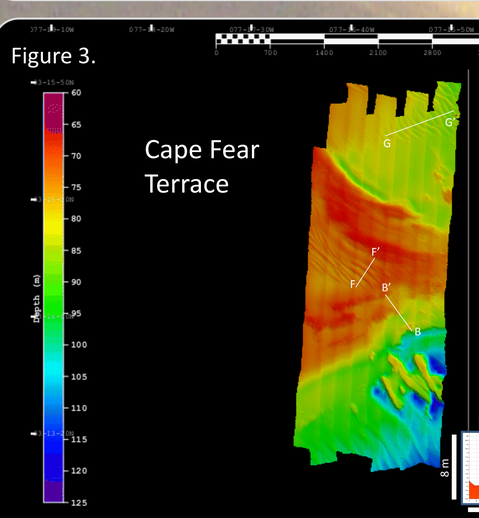
Cape Lookout Terrace displays a central, hard bottom ridge feature with a total relief of 70 m on the eastern Gulf Stream contact. The steep, rocky escarpment is bordered by a series of sand waves on the northeastern section of the 2D image (near to A).

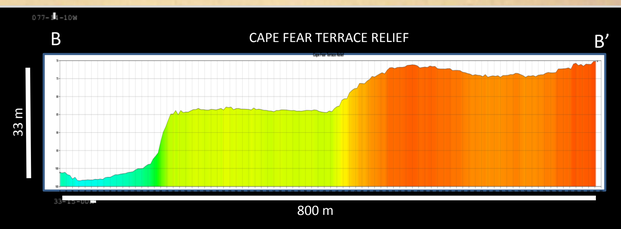




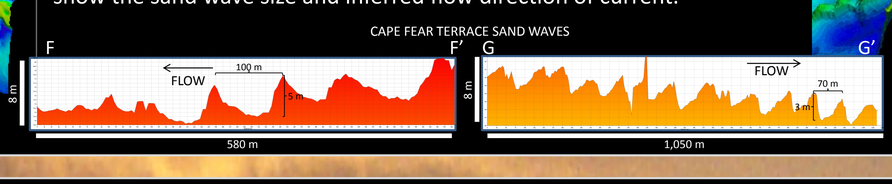
3D Image: Raised, hard-bottom ridge on the Cape Lookout Terrace defined by a steep escarpment to the southeast edge (right) as well as a small drop-off to the more sandy, landward side.

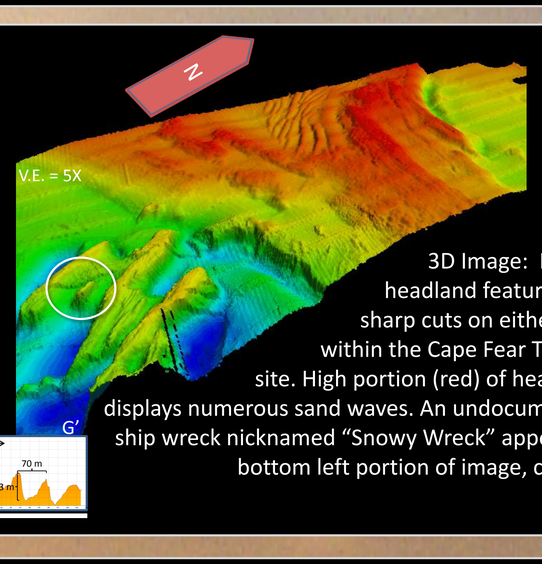
Figure 3.





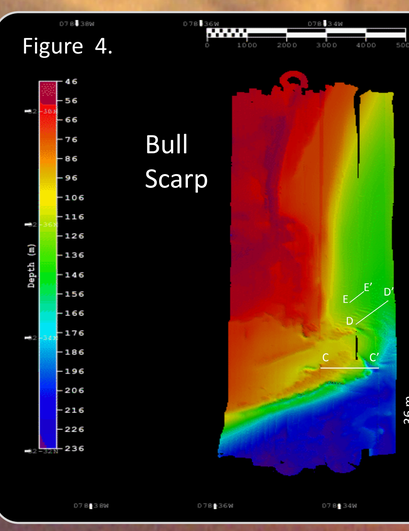
The Cape Fear Terrace consists of a headland with escarpments on either side reaching up to 33 m relief. Centered on the top of the headland, sand waves occur. In the southern portion of the map, the undocumented "Snowy Wreck" sits within the Gulf Stream current. The sand wave profiles show the sand wave size and inferred flow direction of current.

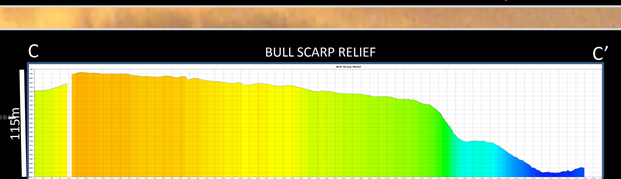




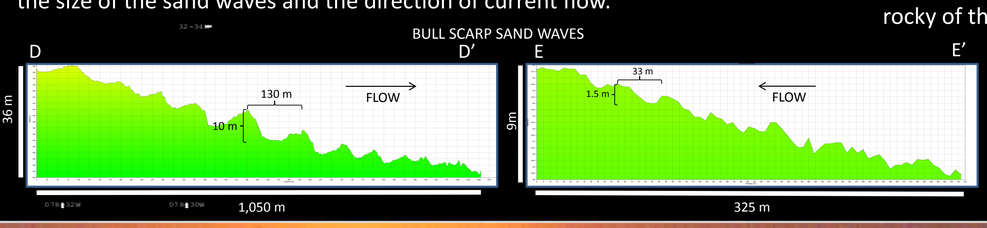
3D Image: Raised headland feature with sharp cuts on either side within the Cape Fear Terrace site. High portion (red) of headland displays numerous sand waves. An undocumented ship wreck nicknamed "Snowy Wreck" appears in bottom left portion of image, circled.

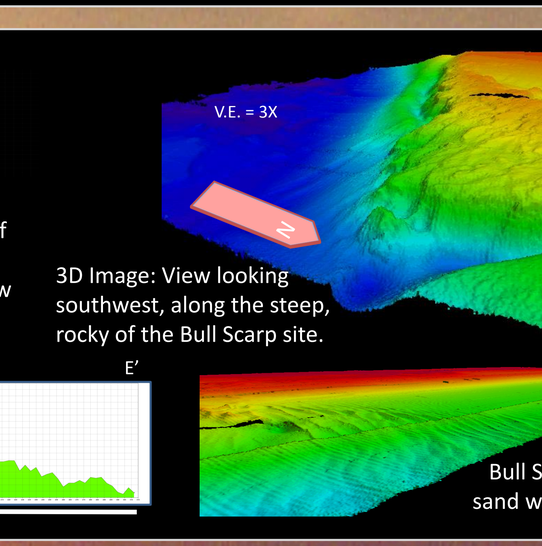
Figure 4.





Bull Scarp is the largest survey area with the most drastic features, with total relief of nearly 200 meters. A large series of sand waves is created by the powerful Gulf Stream in the eastern portion of the 2D image. Below, the sand wave profiles show the size of the sand waves and the direction of current flow.





3D Image: View looking southwest, along the steep, rocky of the Bull Scarp site.

Profile	Wave Height (m)	Wave-length (m)	Interpreted Flow direction
H-H'	10.5	425	With Gulf Stream (NE)
G-G'	3.0	70	With Gulf Stream (NE)
F-F'	5.0	100	Eddy (SW)
E-E'	1.5	33	Eddy (SW)
D-D'	10.0	130	With Gulf Stream (NE)

Table 1
Measurements taken from each sand wave profile give indication on Gulf Stream current strength and direction of flow.

Discussion

The bathymetric features of the seafloor allow for some interpretation as to how these features have reacted with the powerful Gulf Stream current and why they are flourishing fish habitats. The hard, rocky escarpments show where the Gulf Stream cuts and erodes into the rock. The nearby sand waves are a result of the sediment transport effect the Gulf Stream has on these shelf edge sites. The range of the more powerful Gulf Stream current's impact on the sites can be defined by the change from rocky escarpments through the sand wave fields to the soft, flat, sandy bottom areas. In the Bull Scarp and Cape Fear Terrace sites, sand wave morphologies indicate that they appear to be influenced by eddy currents in the opposite direction of the Gulf Stream, leading to sediment transport to the south. Sand waves found on the Cape Lookout Terrace are in the Gulf Stream which indicates a movement of the sand to the north with the current. This means that not only is the Gulf Stream current scouring the shelf edge, but it is also transporting sediment to these areas. No evidence of eddy flow was found on the Cape Lookout Terrace site. Further mapping of the area may be required to identify eddy features.

As for the fish habitats, the rocky, high-relief reefs present along the escarpments could provide an ideal environment for the types of fish found there. The Gulf Stream, flowing northward, likely carries a plethora of nutrients and smaller prey into these areas allowing for a thriving snapper and grouper community. Further mapping of the South Atlantic Bight and the entirety of the continental shelf edge would allow for a greater, more comprehensive understanding of the Gulf Stream's impact on these formations and the shelf edge as a whole, as well as its impact on the ever-important fisheries reserves.

Acknowledgements

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