Temporal variations in bathymetry and morphology at Gray's Reef National Marine Sanctuary

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Abstract

NOAA's Gray's Reef National Marine Sanctuary, located on the mid-continental shelf off the Georgia coast (water depths ranging 14.8 to 22.0 m), was initially mapped in 2001, elucidating understanding of important marine habitats and providing means to conceptualize the recent and ancient geologic history of the southeastern United States continental shelf. New multi-beam data was collected during a 2011 research expedition on the NOAA *Nancy Foster* and was compared with previously collected data to better understand how the bathymetry of Gray's Reef has changed over time. Three-dimensional imagery and data processing were performed using CARIS HIPS/SIPS 7.1 software. The reef consists of mostly low-relief sandy bottom sediment interspersed with rocky outcrops and emergent limestone. Sediments have been eroded into ledges and low-relief features populated by a diverse community of fish and marine invertebrates. Observing how the morphology of these features change over time aids long-term habitat characterization not only at Gray's Reef, but also at other physiographical and ecologically similar areas.

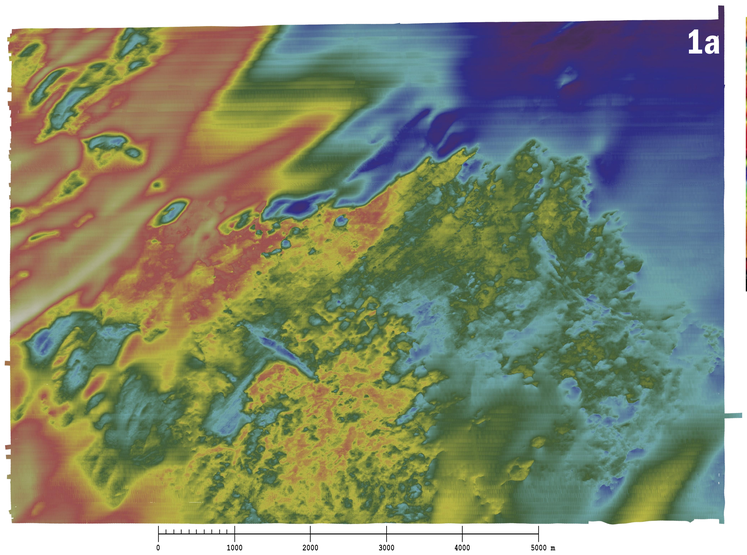
Background

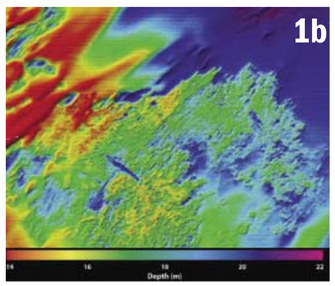
Gray's Reef National Marine Sanctuary (GRNMS) was designated as a national marine sanctuary on January 16,1981. Recent regulation passed on December 4, 2011 further partitioned the southern third of the reef as a designated research area allowing the development of controlled long-term habitat characterization studies. GRNMS is located 20 miles east of Sapelo Island, GA and comprises an area approximately 19.5 km² in size.

Gray's Reef consists largely of sandy bottom sediments interspersed with low-relief limestone reefs. The reef itself is not a product of reef-building corals, but rather the cementation of terrestrial and marine sediment between the late Miocene and Pleistocene. Kendall et al. (2007) further subdivided the area into flat sand, rippled sand, sparsely colonized live bottom, and densely colonized live bottom.

Discussion

Minimum and maximum depths have remained stable since 2001, but noticeable sediment infill can be seen at lower depths bordering ridge scarps. The original 2001 line data were unavailable for processing so an estimated depth scale was used to contrast with the cleaned 2011 data to identify areas of the reef that have been altered since the last survey. The greater depth areas, especially those shown in figures 4 and 7, display slight decreases in depth. The propensity of this sanctuary to experience tropical storms and hurricane force winds coupled with the reef's shallow depth create seasonal fluctuations in sediment transport as well as increased hard bottom erosion. The overall sediment transport profile is complex—warm Gulf Stream currents, river discharge from the coast, storm currents, and colder upwelled waters in the Atlantic interact to distribute sediment across the reef. We are still working with backscatter data to ascertain bottom hardness in order to establish whether the large rippled sand areas have migrated substantially over time and exposed more areas of the carbonate platform.





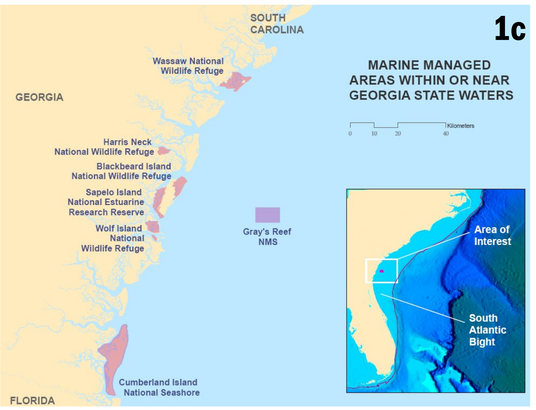
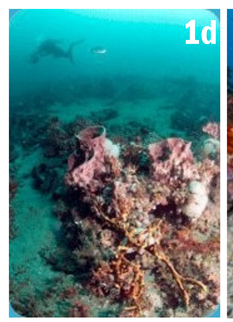
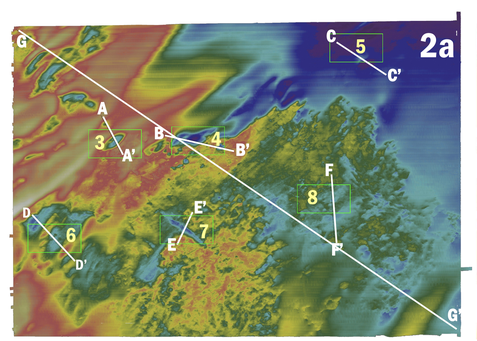


FIG 1a: 2-D image of Gray's Reef from 2011 multibeam data, depth range 14.2 to 23.2 meters; **FIG 1b**: 2-D image from 2001 multibeam data, depths range 14 to 22 meters (McFall and Alexander, 2001); **FIGS 1c-e**: Geographic locality of GRNMS and underwater photos featuring some of the benthic biota present in the sanctuary (all images courtesy of NOAA).





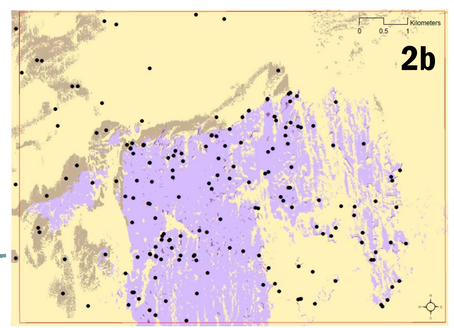
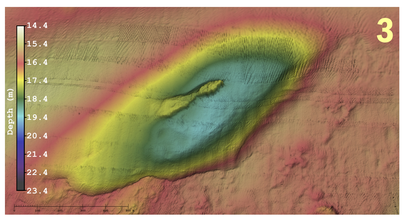
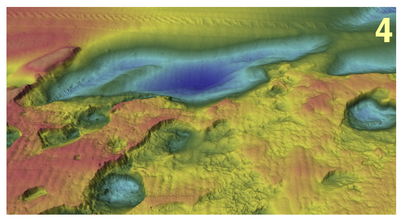
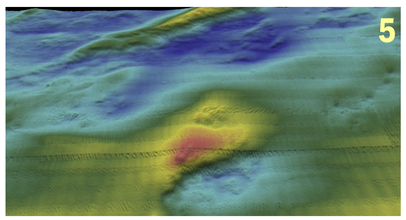
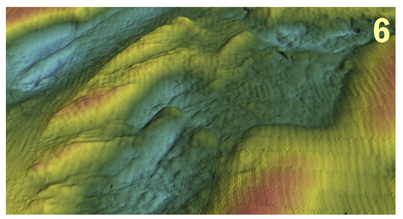


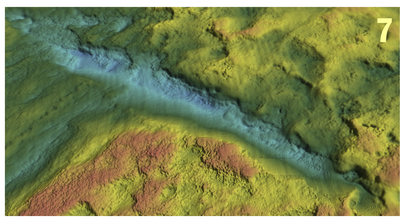
FIG 2a: Reference figure with inset image locations and profile lines; **FIG 2b**: Spatial distribution of bottom types (modified from Kendall et al. 2007). We overlaid this figure with figure 2a to roughly correlate bottom type to bathymetry. All 3-D images are viewed facing north. The depth scale has been adjusted slightly for each 3-D image to better enhance the inset's features. Profiles are all rendered at the same scale, matching the 2-D image in Fig. 1a.

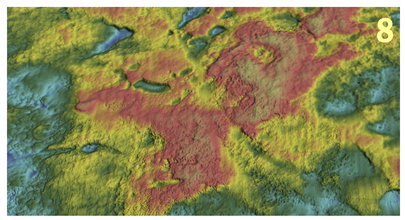


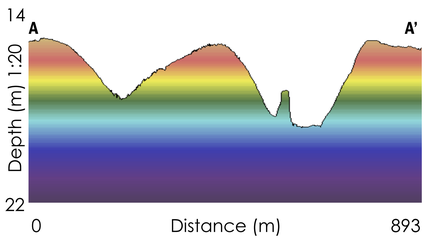


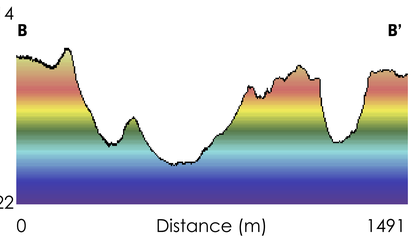


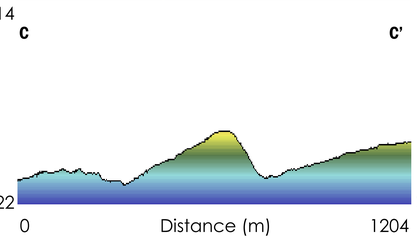


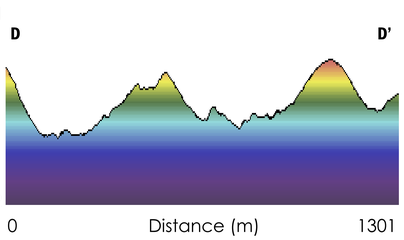


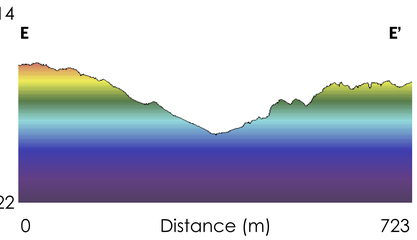












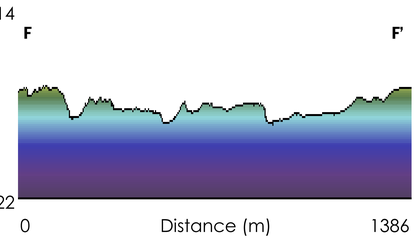


FIG 3: 3-D image 20x vertical exaggeration, depth range 14 to 22 m; **Profile A-A'**, 893 m. Ripple sand dominates most of the image with small flat sandy areas forming NW of the central window—like feature. The window and its tower -like feature seen between 550 and 600 m on the profile likely indicate a limestone substrate buried by increased sand deposition, possibly due to proximity to terrestrial source material. No noticeable change in morphology based on comparisons with the 2001 reef image were observed.

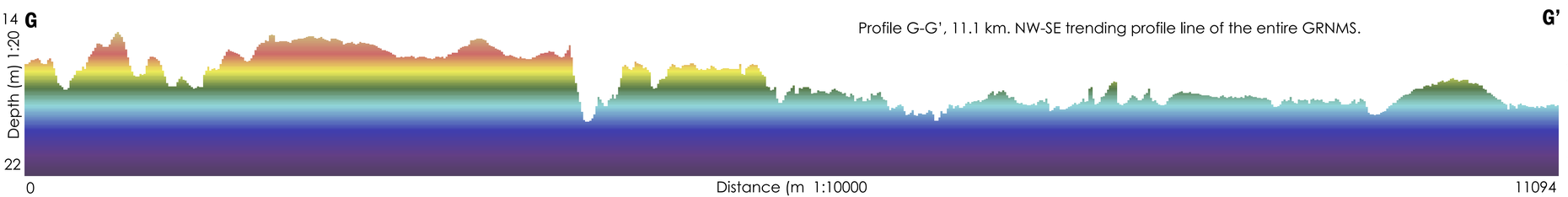
FIG 4: 3-D image 20x vertical exaggeration, depth range 14 to 22 m; **Profile B-B'**, 1491 m. Several windows pock-marking the terrain have greater relief than figure 3a indicating a shift from rippled sand to loose sandy bottom with hard bottom reef emerging in greater detail. The profile displays the relative jaggedness of the eroded limestone traced with sandy sediment. A slight decrease in depth in the 2011 imagery indicates some sediment infill at the base of the ridge features.

FIG 5: 3-D image 20x vertical exaggeration, depth range 14 to 22 m; **Profile C-C'**, 1204 m. This area displays a return to a rippled sand dominant landscape with some flat sandy bottom also present. The low relief domed feature is possibly an older limestone ridge that experienced either increased erosion or reduced deposition. We slightly altered depth scale on this image to highlight the ridge bathymetry.

FIG 6: 3-D image 20x vertical exaggeration, depth range 14 to 22 m; **Profile D-D'**, 1301 m. Three prominent limestone ridges are seen here with smaller ridges interspersed between. A combination of ripple sand, flat sand, and sparsely colonized bottom, especially between the central and SE ridge, can be seen. Ripple sands are featured in the bathymetry between the NW and central ridge more than between the central and SE, but sparsely colonized bottom could probably be characterized there as well.

FIG 7: 3-D image 20x vertical exaggeration , depth range 14 to 22 m; **Profile E-E'**, 723 m. The incised feature running NW-SE consists of ripple sand bottom with sparsely colonized bottom sediments along the surrounding area. Based on the 2001 image there is noticeably greater sediment infill within the incised depression compared with the 2011 image.

FIG 8: 3-D image 20x vertical exaggeration, depth range 14 to 22 m; **Profile F-F'**, 1386 m. This area is comprised mostly of ripple sands and sparsely colonized bottom sediments. The ridges in the area are relatively low in relief with a linear feature running through the center of the area potentially indicating a scoured region.



Profile G-G', 11.1 km. NW-SE trending profile line of the entire GRNMS.

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References

- Gray's Reef National Marine Sanctuary. 15 Feb. 2012 <http://graysreef.noaa.gov/>.
- Kendall, M.S., L.J. Bauer and C.F.G. Jeffrey. 2007. Characterization of the Benthos, Marine Debris and Bottom Fish at Gray's Reef National Marine Sanctuary. Prepared by National Centers for Coastal Ocean Science (NCCOS) Biogeography Team in cooperation with the National Marine Sanctuary Program. Silver Spring, MD. NOAA Technical Memorandum NOS NCCOS 50. 82 pp. + Appendices.
- McFall, G. and Alexander, C. 2001. Gray's Reef National Marine Sanctuary. Multibeam image.