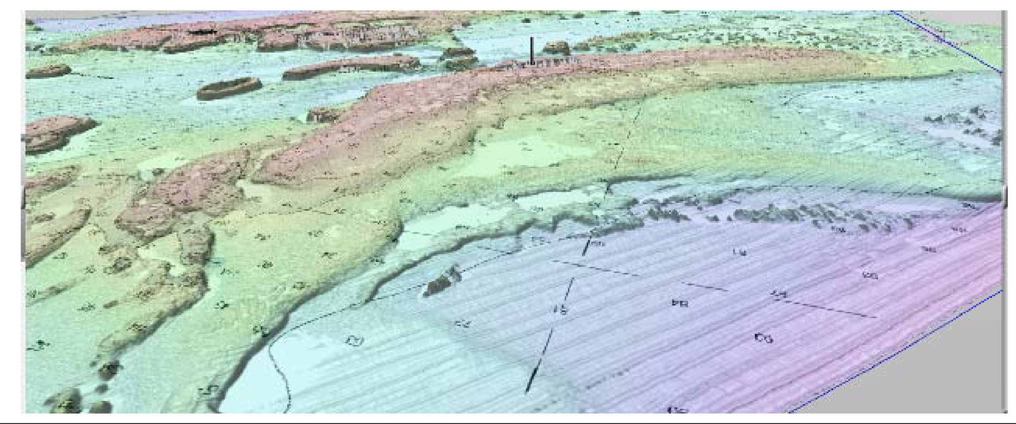
High-Resolution Seafloor Mapping of the Dry Tortugas National Park Using Side-Scan Sonar and Swath Bathymetry



Stanley D. Locker[1], Albert C. Hine[1], David Palandro[2] and Luke McEachron[2]

[1]College of Marine Science, University of South Florida, St. Petersburg, FL, USA

[2]Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission, St. Petersburg, FL, USA

Introduction

In an effort to support federal and state interests for habitat assessment and reef monitoring in the Dry Tortugas National Park (DRTO), a high-resolution swath bathymetry and side-scan sonar mapping project was recently completed using a Teledyne-Benthos C3D system that acquires co-registered side-scan backscatter (200 kHz) and swath bathymetry (decimeter-scale resolution). Almost all areas of the DRTO have been mapped, except for small areas along the northeast and east margins of the Park. These data provide detailed assessments of benthic habitats and morphology. The Florida Fish and Wildlife Research Institute merged the C3D bathymetry coverage with previous US Geological Survey LIDAR coverage to provide a seamless topo-bathymetric map at 1 m resolution. The National Park Service is using these data to upgrade their benthic habitat map.

The high-resolution side-scan backscatter provides detailed characteristics of bottom types such as seagrass, varying sediment texture, current influences, and types of coral/hard bottom settings that can be classified using ground truthing. The decimeter-scale bathymetry reveals detailed features as small as individual coral heads. The merging of backscatter and bathymetry provide unique perspectives on habitats. These data provide a baseline data set to assist change detection studies and ecosystem management within DRTO.

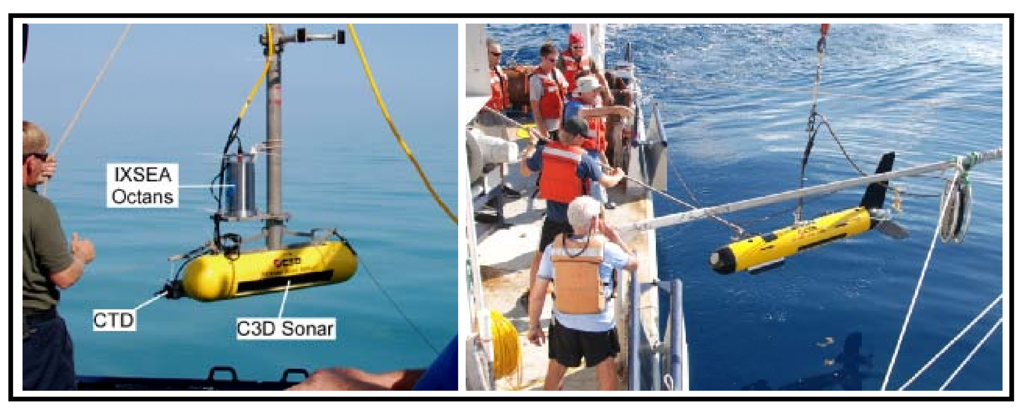


Figure 1. The C3D system - deployed in towfish or pole mount. DRTO survey used the pole mount.

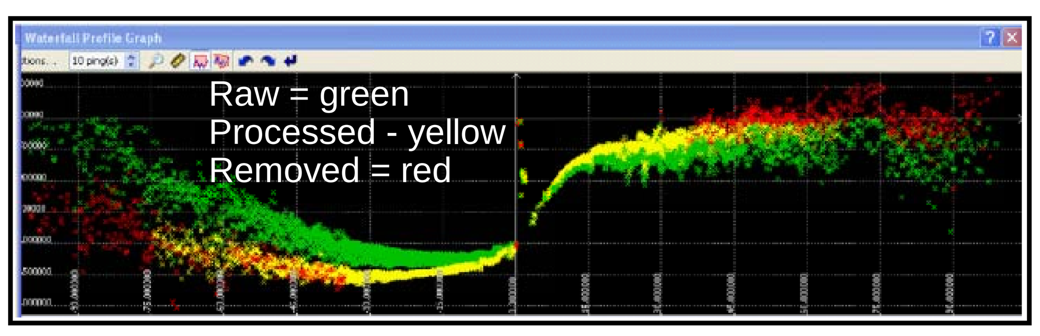


Figure 2. Typical bathymetric data density for 200m swath showing 10 pings.

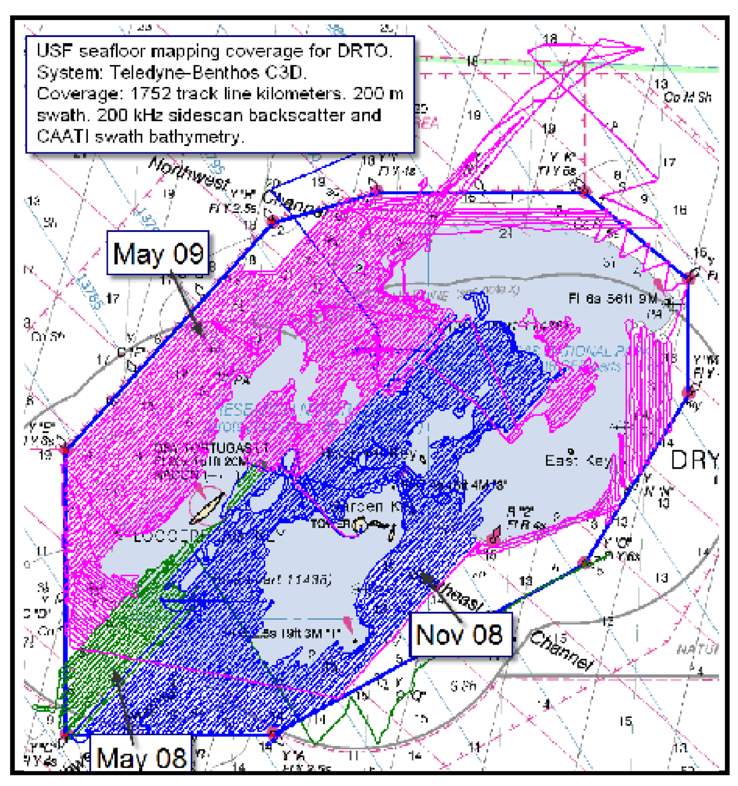


Figure 3. C3D survey track lines.

Methods

The College of Marine Science at USF has developed a high-resolution seafloor mapping capability based on a Teledyne-Benthos C3D interferometric sonar (**Figure 1**). The C3D acquires sidescan backscatter and swath bathymetry using tuned 200 kHz transmitting arrays and multiple receiver arrays. The swath bathymetry data is derived using Computed Angle-of-Arrival Transient Imaging (CAATI) processing of the sidescan-signal return impinging on a 6-receiver transducer array with varying angle. Resolution for both sidescan and bathymetry is decimeter scale and directly co-registered, allowing for exact comparison or merging of topography with backscatter imagery. The acquired bathymetry swath is 8-10 times water depth (**Figure 2**). An suite of interconnected hardware includes; IXSEA Octans (heave, surge, sway with 1cm resolution and 5cm or 5% accuracy; pitch, roll, yaw with 0.01 deg RMS; an IMO-certified fiber-optic gyrocompass with 0.01 deg resolution and 0.1 deg secant latitude RMS dynamic accuracy); a FSI NXIC flow-through CTD (sound velocity); and a Trimble dual-antenna SPS751/551 GPS (supporting satellite-based RTK-GPS using Omnistar HP). The C3D is deployed in either a fixed pole-mount or subsurface towfish. From the sea-surface pole-mount location the C3D has demonstrated ability to map as deep as 130 m water depth.

DRTO was surveyed using a 120 m line spacing oriented SW-NE (**Figure 3**). This grid was altered for efficiency or due to weather in a few areas. Primary software includes GeoDAS acquisition and CleanSweep processing software by Oceanic Imaging Consultants, Inc. GeoDAS provides data logging, navigation, quality control monitoring, and real-time mosaicking of sidescan backscatter, bathymetry, and amplitude of the bathymetric data (**Figure 4**). Cleansweep provides an interface to all data streams for post-processing of both sidescan and bathymetry data.

The C3D bathymetry was output at 1 m xyz to be combined with the LIDAR data, also at 1 m resolution. The merged LIDAR and C3D bathymetry shown here was gridded in Fledermaus to a 5 m cell size. A blended raster was created using the mosaic tool in ArcMap. The raster was finalized by using the fill command in ArcMap to fill sinks. The sidescan sonar backscatter was output at 1 m resolution for viewing the entire DRTO. High-resolution sidescan imagery for close-up views is about 25 cm resolution. Fledermaus was used to create 3D perspectives in this poster.

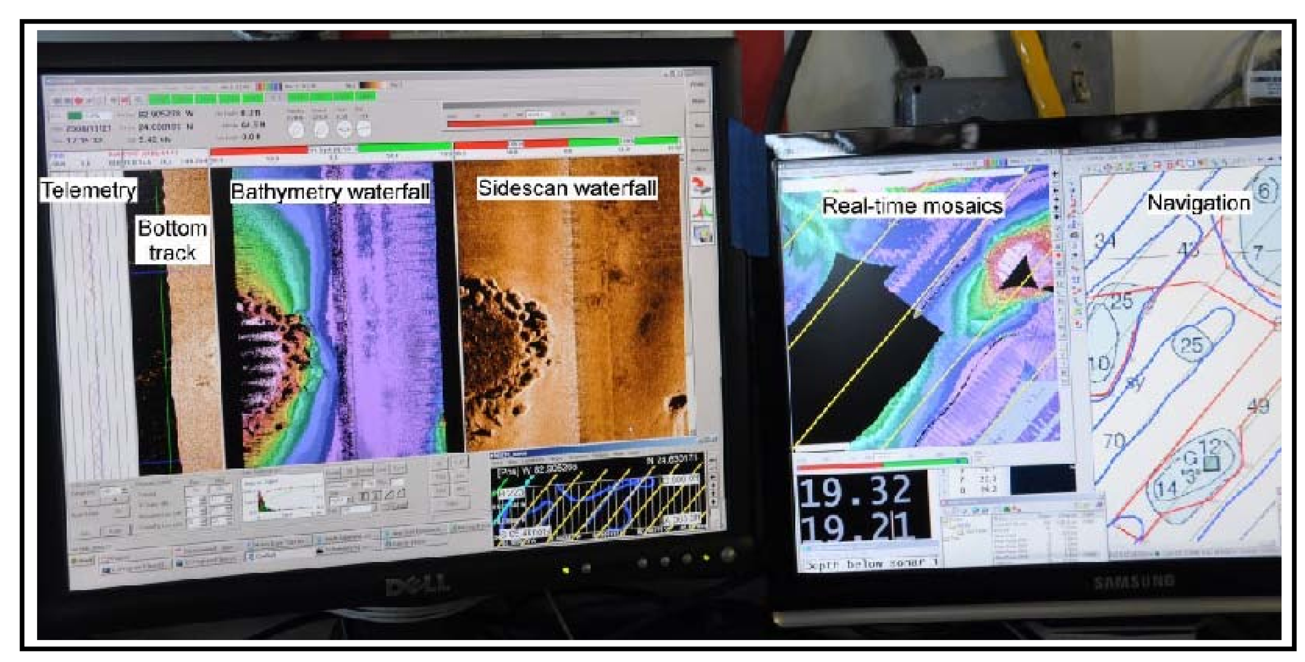


Figure 4. Shipboard GeoDAS acquisition and navigation.

Results

This presentation is based on 3 data set layers - USGS LIDAR bathymetry (**Figure 5**), C3D bathymetry (**Figure 6**), and C3D backscatter imagery (**Figure 8**). The merged LIDAR and C3D bathymetry are shown in (**Figure 7**). Finally, the sidescan backscatter is combined with the merged bathymetry (**Figure 9**).

Many different views and overlay options are available with the combined data sets. In this poster we want to emphasize the importance of merging bathymetry with the sidescan backscatter as a prelude to benthic habitat mapping. The textural characteristic of the backscatter greatly enhances the bathymetric features. Significant differences in bottom type – submerged aquatic vegetation (SAV), grain size, and roughness of the hard bottom/reefs are best displayed in the backscatter imagery. The high-resolution bathymetry from the C3D can also image decimeter-scale coral-reef topography.

Acknowledgements

This project was initiated through funding from the Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission, to the College of Marine Science, University of South Florida. Significant funding from The Florida Technology, Research and Scholarship Board to the College of Marine Science supported the development of the C3D sonar system and much of the DRTO survey direct costs.

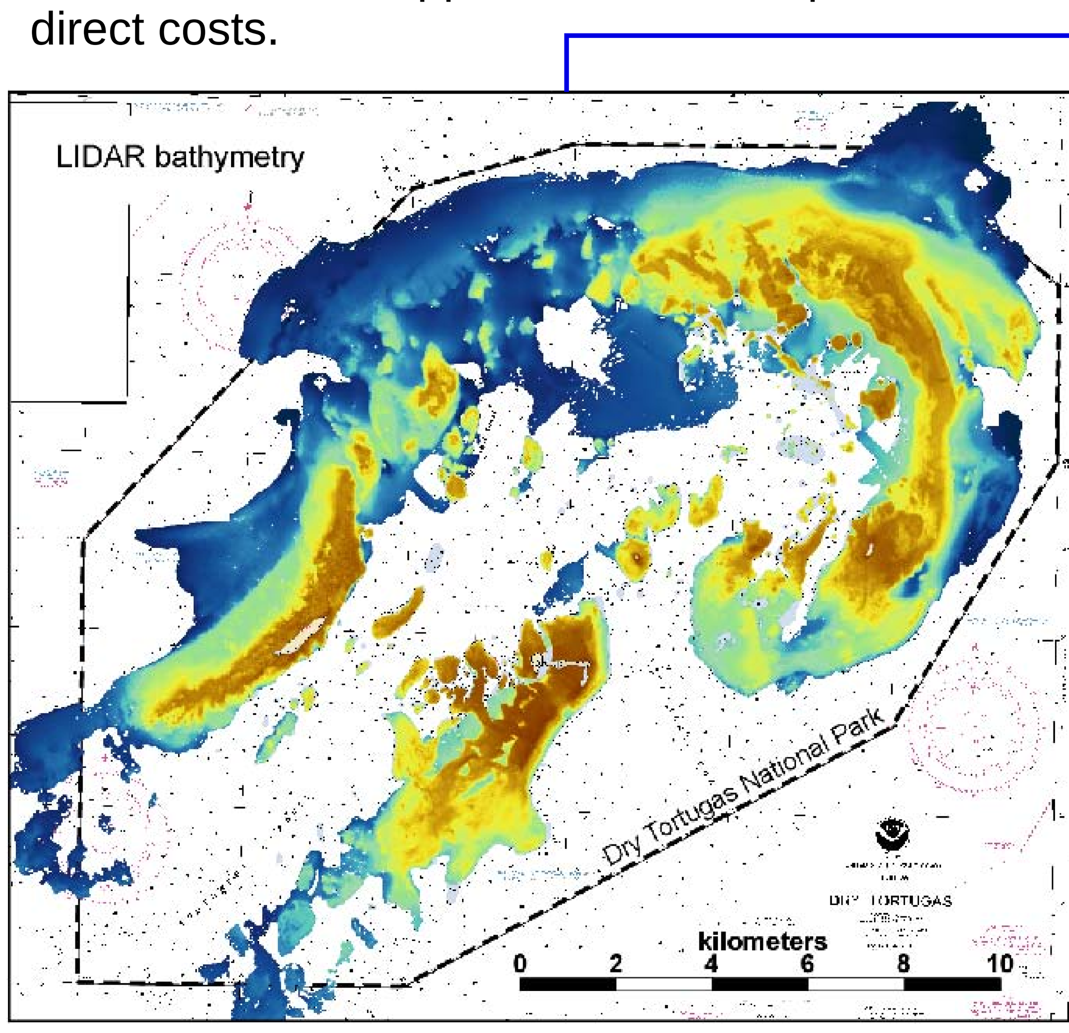


Figure 5. USGS LIDAR bathymetry. (Brock et al.,2006, USGS-NPS-NASA EAARL Submarine Topography - Dry Tortugas National Park, USGS Open-File Report 2006-1244)

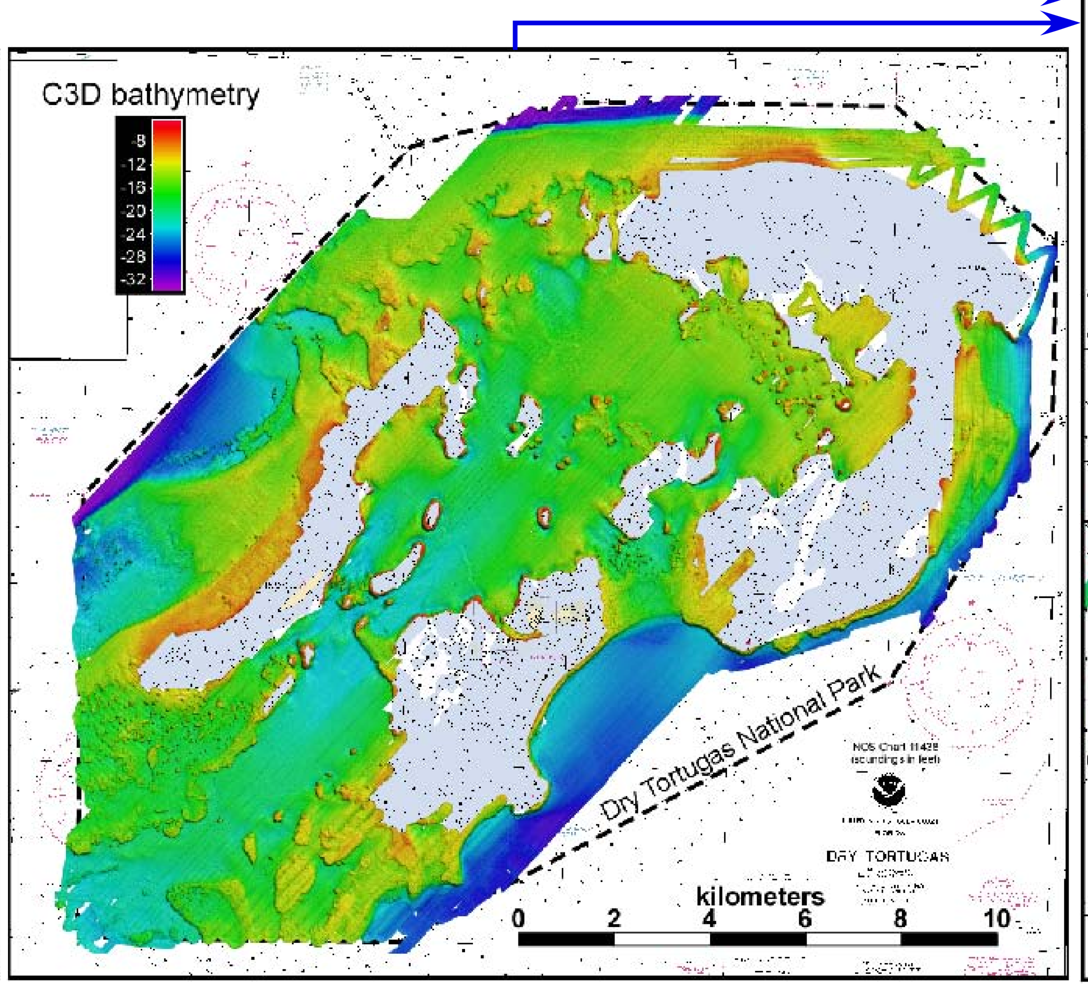


Figure 6. USF C3D bathymetry.

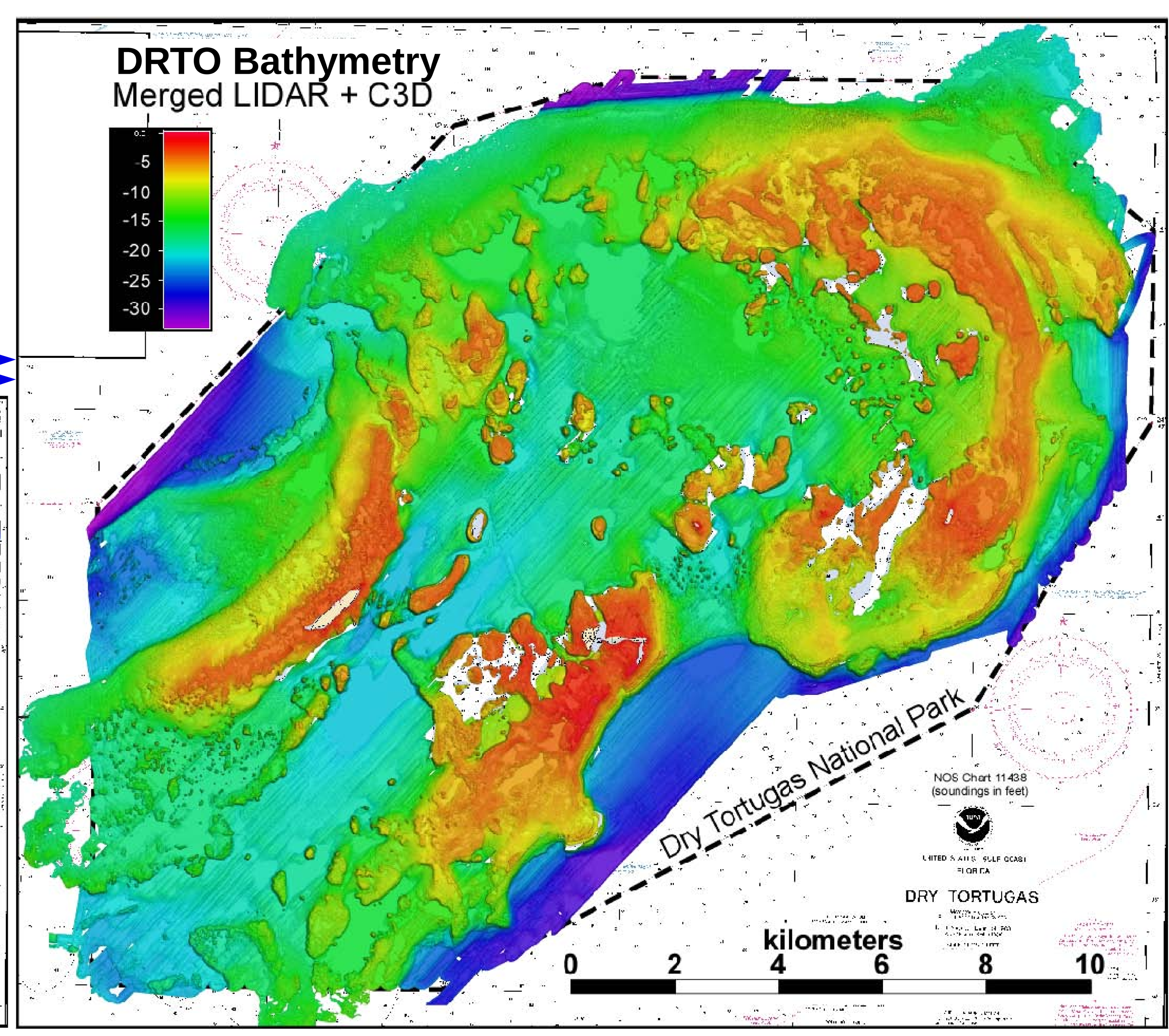


Figure 7. Merged LIDAR and C3D processed at FWRI.

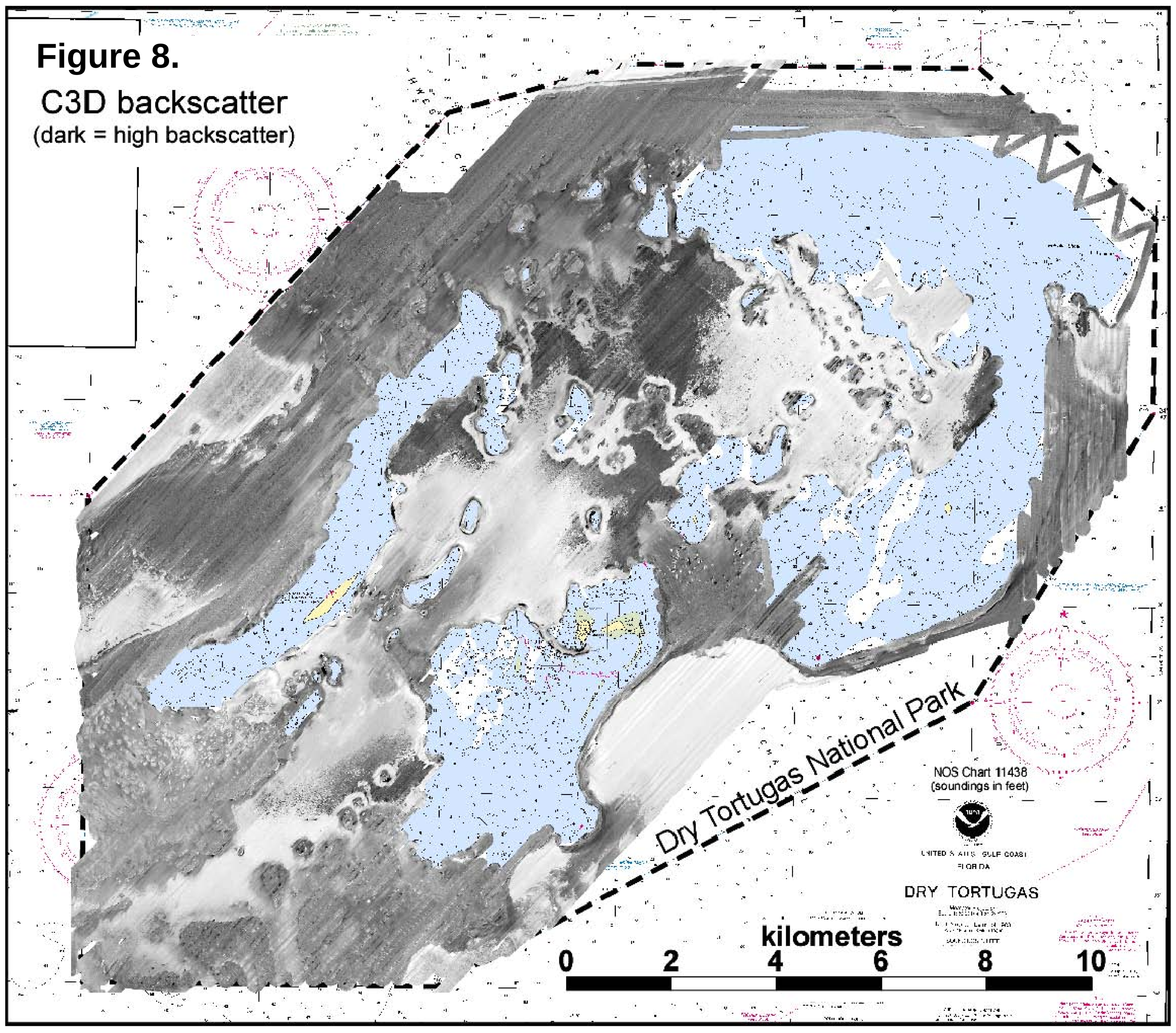


Figure 8.
C3D backscatter
(dark = high backscatter)
Dry Tortugas National Park
NOS Chart 11438
(soundings in feet)
DRY TORTUGAS
kilometers
0 2 4 6 8 10

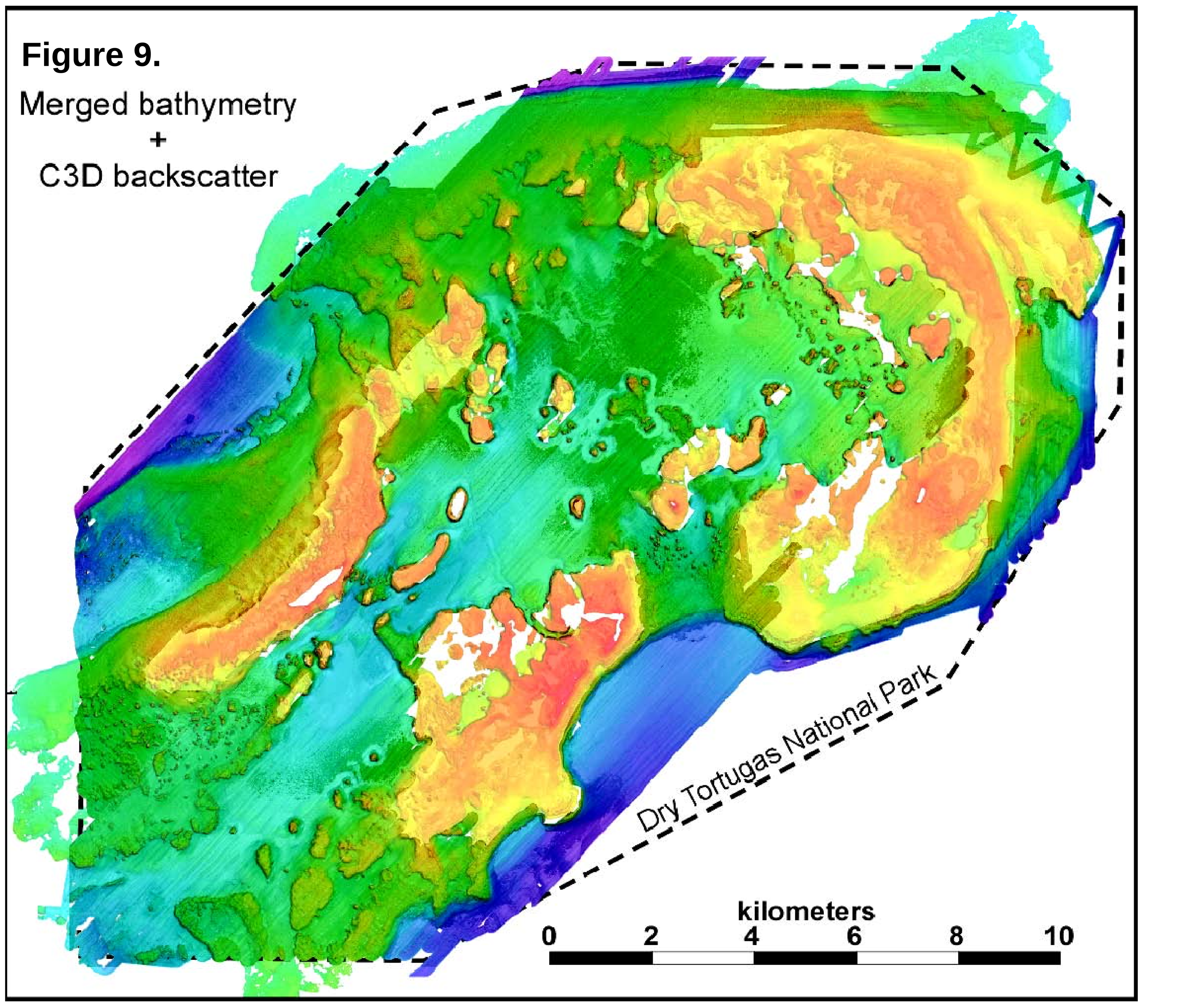
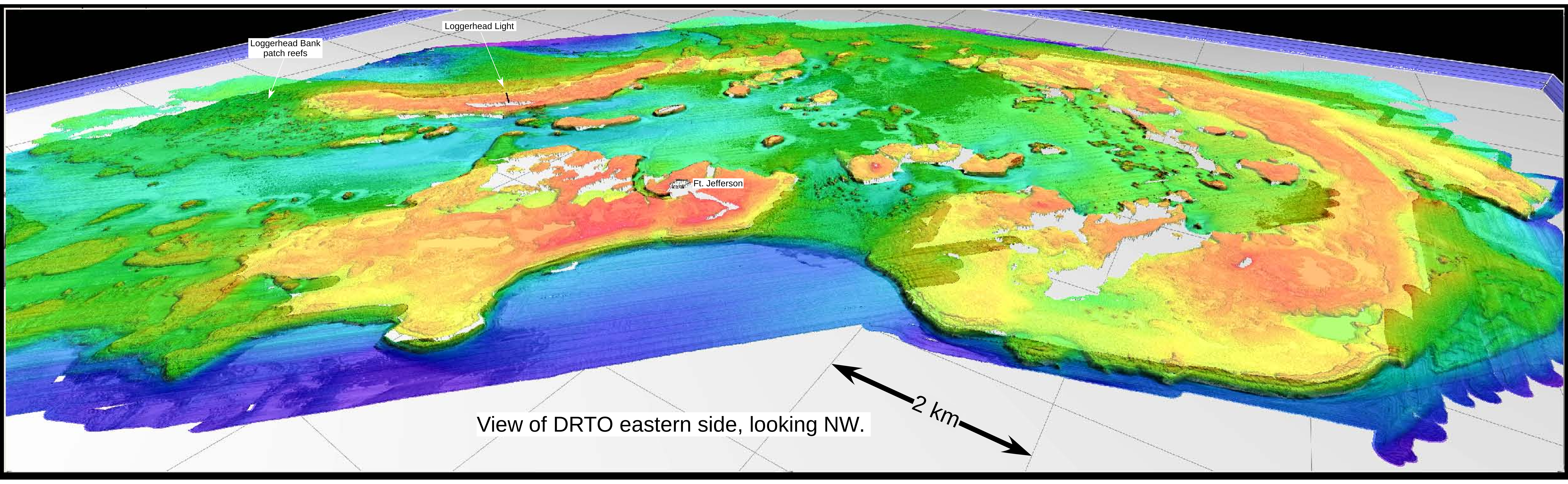
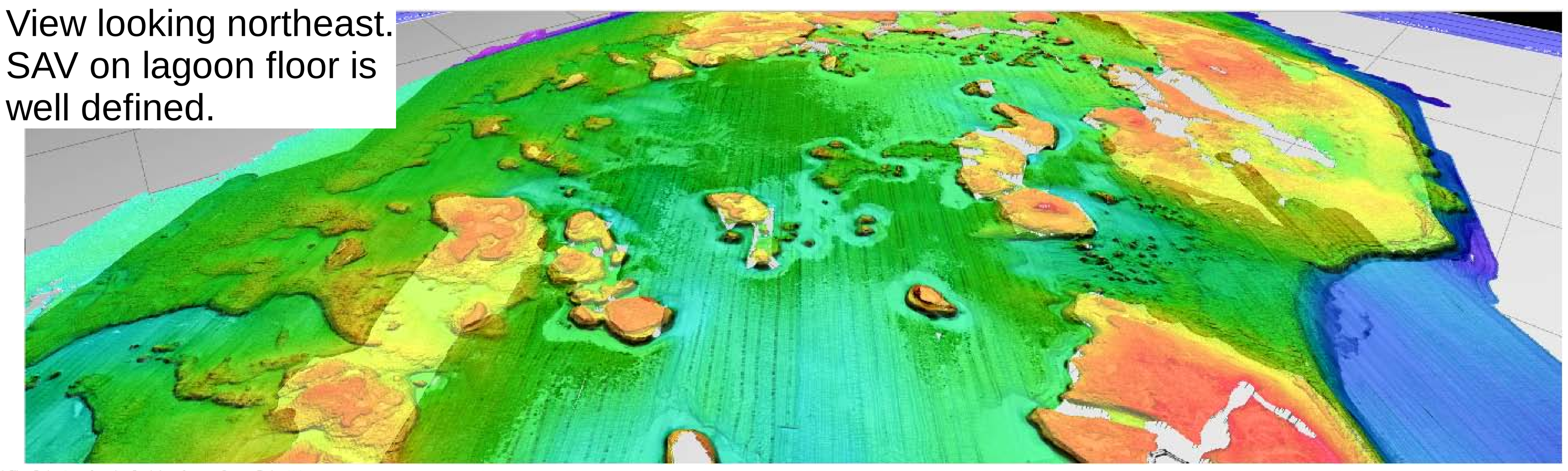


Figure 9.
Merged bathymetry
+
C3D backscatter
Dry Tortugas National Park
kilometers
0 2 4 6 8 10


Loggerhead Bank
patch reefs
Loggerhead Light
Ft. Jefferson
2 km
View of DRTO eastern side, looking NW.


View looking northeast.
SAV on lagoon floor is
well defined.

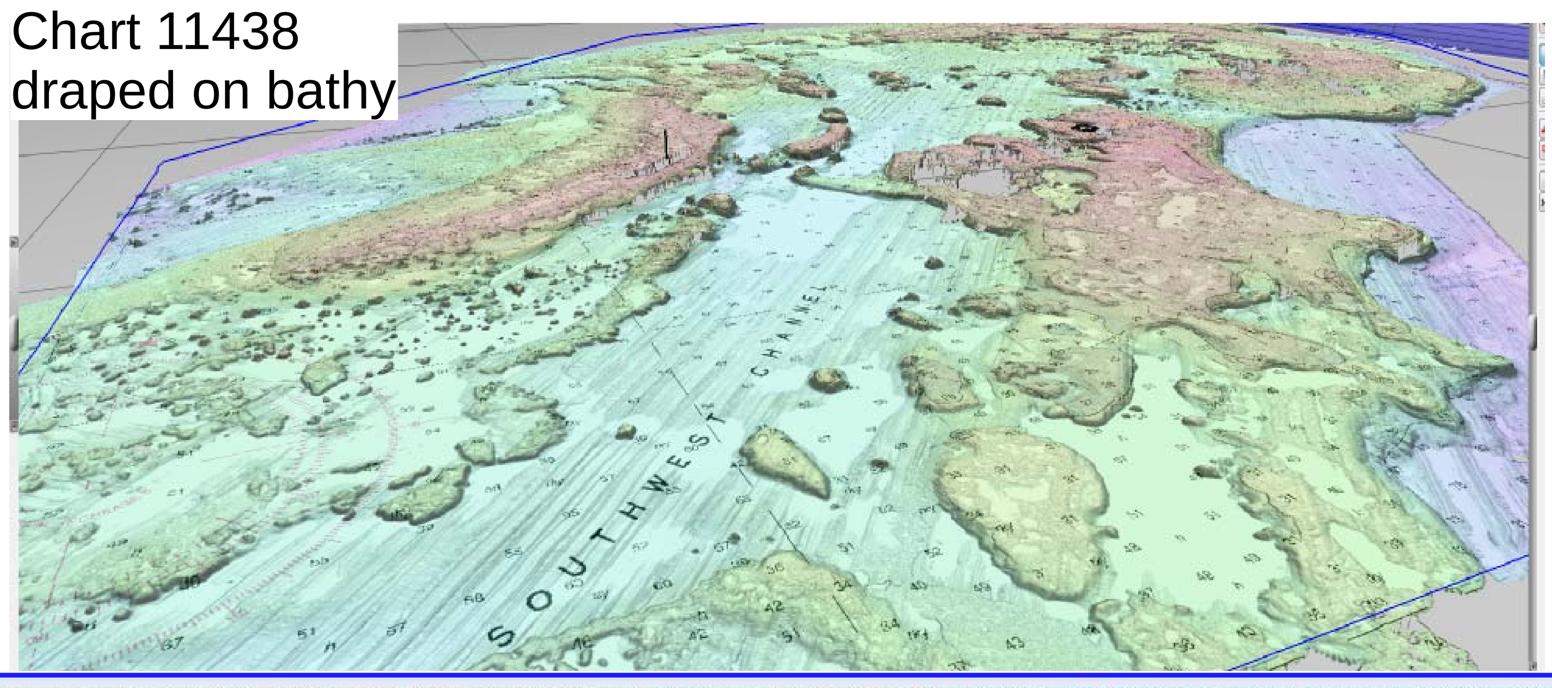
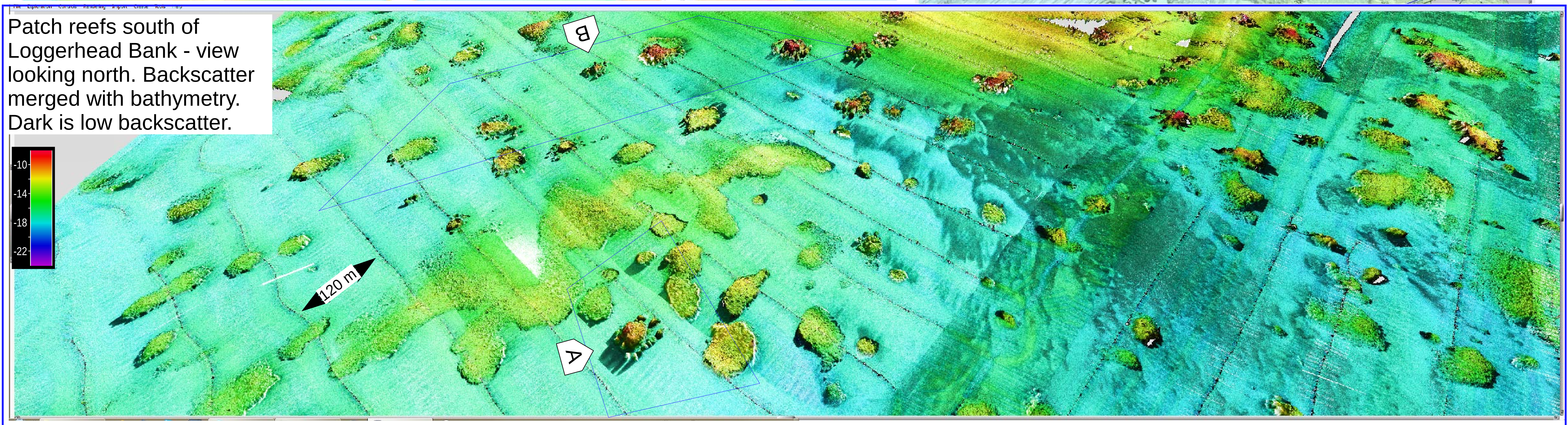


Chart 11438
draped on bathy


Patch reefs south of
Loggerhead Bank - view
looking north. Backscatter
merged with bathymetry.
Dark is low backscatter.
-10
-14
-18
-22
B
120 m
A


Close-ups of
"Stonehenge" and
"Biscuit" patch reefs.
See location above.
A
B
120 m