Beach Monitoring and Storm Analysis on Treasure Island, Galveston Island and Bolivar Peninsula – CMP Cycle 9 Final Report

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Introduction

This is the final report for the CMP Cycle 9 project ***Beach Profiling from High Island to Freeport Jetties.*** This project was originally proposed by Dr. Thomas Ravens of the TAMUG Marine Systems Engineering Dept. and Dr. Ravens was the original project manager on this project. This project was transferred to Dr. Tim Dellapenna in Jan. 2006 by Dr. William Seitz, the TAMUG Dean of Research and Graduate Studies for completion. What is included in this report is the work done by Dr. Dellapenna's lab in completion and fulfillment of the contract.

In an ongoing effort to investigate coastal elevation changes as it relates to mean sea level along the upper Texas coastline, 34 survey profiles were completed in 2006 perpendicular to the shoreline beginning at Rollover Pass, Texas and ending at the jetties at Surfside, Texas. The surveys were completed to record accurate transect elevations from the dune line past the depth of closure. Permament and temporary benchmarks were selected with emphasis on accuracy, repeatability and efficiency.

Study Area

The research area is located on the upper Texas coastline. The profiles are separated into three sections, which are: 1) Rollover Pass to Galveston's North Jetty; 2) Galveston's South Jetty to San Luis Pass; 3) San Luis Pass to Surfside's North Jetty. A total of 34 cross-shore topographic beach profiles were collected with intervals of 2 miles (3.219 km). Each profile transect extends landward either from the primary dune or to another backshore limiting feature to a minimum offshore elevation of -6 meters (NAVD 88) which is approximately a length of 2 kilometers.

The inconsistent nomenclature of the profiles was inherited from previous research efforts along the upper Texas coast. For Bolivar and Follett's Island, the names of the profiles generally coincide with the distance in miles from the beginning of the transect of profiles, as measured in miles along the beach. The one exception to this is Bolivar Profile 19, which is actually only 18.2 miles along the beach from the beginning of the transect. For Galveston Island, the profiles begin with Profile 3 and are sequentially numbered as the physical number of the profile rather than the distance down the beach. These profile names apparently relate to other work that has been conducted along the beach and were retained for ease in making reference to his other work.

Methods

Three permanent benchmarks, located on the Galveston Seawall were selected for the primary base stations. These are located on the northeast end of the Seawall, 61st Street and the southwest end of the Seawall. The horizontal coordinates of these benchmarks were established by classical geodetic methods (Groundspeak Incorporated 2006; National Geodetic Survey 2006) and adjusted by the National Geodetic Survey in February 1996. The orthometric height was determined by differential leveling and adjusted by the National Geodetic Survey in March 1997. The Laplace correction (National Geodetic Survey 2006) was computed from DEFLEC99 derived deflections. The geoid height was determined by GEOID99. The dynamic height was computed by dividing the NAVD 88 geopotential number by the normal gravity value computed on the Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45 degrees latitude (G = 980.6199 gals.). The modeled gravity was interpolated from observed gravity values. The benchmarks located on the Seawall have historically held their position and elevation well (Groundspeak Incorporated 2006).

From these three permanent benchmarks a dense network of 12 geodetic control monuments were established prior to the start of the beach profiling program. Monuments were located at positions proximal to the cross-shore topographic profiles at 6 mile (9.656 km) intervals along the dune line to maintain a maximum distance of 2 miles (3.219 km) between base station GPS and rover GPS. These stations were established by the survey grade GPS receivers set in static mode to establish new bench marks with a accuracy level of Horizontal: 0.005 m + 1 ppm Vertical: 0.010 m + 2 ppm, Azimuth: <1 arcsecond. Observation Time: Ranges from 180 to 360 minutes depending on distance between GPS receivers and other environmental factors. The survey grade GPS Surveying System utilizes integrated WAAS/EGNOS aided navigation to locate the survey point, collect GPS data with the receiver's on-board software systems.

Each profile line was divided into two survey methods, which are: 1) A beach and surf survey by means of a survey grade GPS system; and 2) a nearshore survey combining an echo sounder with dual frequency GPS system. These two surveying data sets were combined to provide a complete bathymetric profile of the beach and shoreface.

Each cross section beach survey recorded a series of points of known easting, northing, and elevation, and yielded a position in 3 dimensions for every data point. Coordinates for geographic position are referenced to the Universal Transverse Mercator grid (UTM) and elevations are referenced to the North American Vertical Datum (NAVD); Specifically, UTM NAD 83, Zone 15, and NAVD 88, Geoid 99 for the datum. Two post processing differential GPS systems were used to collect data every second for the duration of each survey. A total of 34 surveys were conducted. The base station unit collected data in static mode while the roving unit, mounted on a 2 wheel dolly, operated in kinematic mode. The manufacturers claim a survey accuracy of 0.005m +1ppm for horizontal, and 0.010m + 2ppm for vertical with a satellite elevation mask of 10 degrees.

The nearshore and offshore portions of the survey were conducted with a jet ski instrumented with a Real-Time Kinematic-Global Positioning System (RTK-GPS) equipment and a two-way radio link. The RTK-GPS portion of the survey accuracy is estimated as within 1 cm in the horizontal and 2.5 cm in the vertical. Utilizing RTK-GPS for the hydrographic portion of the survey eliminated the need of adjusting elevation measurement for tide or squat. Position was determined by a WAAS-enabled GPS mounted on the Jet Ski, and RTK corrections were received from an onshore base station. An echo sounder with a 200 kHz pinger was employed to measure depth and adjusted by using local water temperatures and salinity to represent proper sound velocity in the water column. Jet Ski navigation was accomplished via a portable GPS receiver. The depth sounder was integrated in real time using Hypack Max, a state-of-the-art navigation and hydrographic surveying system.

Position and elevation data streams were brought together in the onboard computer and sent via UHF transmitter to a truck on the beach, which was positioned approximately at the end of the line. The truck was positioned so that it was as close as possible to the jet-ski and so that the transmitting antenna had as close to line of sight as possible. In the truck, a UHF antenna received the signal and transmitted it via serial connection to a laptop running Hypack navigational software. Position and elevation were logged in Hypack along with a time stamp and other variables. The cross track indicator function in Hypack was used to determine how far the jet-ski was from the predetermined survey and corrections were relayed to the jet-ski operator via handheld VHF radios.

Post processing of the survey data was completed in the Single Beam Max extension of Hypack. Appropriate transducer offsets were applied to the data before editing. Data from the track lines were displayed and spurious data points were deleted. Data was then exported as a text file for further analysis.

After editing, the data was loaded into Microsoft Excel and combined with the elevation data from the Ashtech survey. This data was then exported into ESRI ArcMAP for spatial analysis. Plan view maps were created displaying position and elevation data for each survey line. The

Excel data was also imported into Fledermaus for 3-D analysis. Images were generated for all the lines from both ArcMAP and Fledermaus.

Results

The surveys were divided into three sections, Bolivar Peninsula, Galveston Island and Follett's Island (called Surfside Profiles). Each profile is presented with a vertical image of the profile, a map view of the profile presented in contoured colors, and a base map showing the location of the profile along the transect. All profiles are contained in Appendices in this report. Bolivar Peninsula is Appendix A consists of profiles for Bolivar Peninsula, Appendix B for Galveston Island and Appendix C for Follett's Island.

Bolivar Peninsula

The Bolivar Peninsula profiles begin with Profile 1, which is adjacent to the North Galveston Jetty and ends with Profile 19, which is just on the north side of the northern Rollover Pass jetty and is actually about 18.2 miles up the beach from Profile 1. Profile 1 is anomalously flat in comparison to the subsequent profiles to the north. This probably results from its proximity to the North Jetty, which, since its installation, has caused extensive seaward advance in the location of the profile. Profile 19 is located just north of the Rollover Pass jetty and is less steep than the profiles to subsequent profiles to the south. In addition, there appears to be an offshore bar within Profile 19. Both features probably result from the proximity to the jetty.

Galveston Island

The Galveston Island profiles begin with Profile 3 and each are subsequently numbered in the order they exist rather than in reference to its position in distance from the beginning of the transect, as was done for Bolivar Peninsula and Follett's Island. Profiles 3 through 8 exist along the Seawall, profiles 9-18 are from west of the end of the Seawall. Profiles 3 is from East Beach where the beach is wide enough to contain a well established beach, as a result, the profile begins on the dune rather than the Seawall. Profiles 4-8 begin on the Seawall, and there is an abrupt change in elevation where the survey transitions from the Seawall to the beach. Profiles 9-18 are located along the "natural beach" west of the southwest end of the Seawall, and either begins on the dune or Geo-structure or other back beach barrier. Profiles 3-8 become progressively steeper to the west. The slope of Profiles 9-18 become progressively more gentle towards the west. This shows that the steepest profiles are at the end of the Seawall and in general, become progressively more gently sloped to the West. In addition, there is an abrupt transition in form between Profiles 14 and 15. Profiles 9-14 are very similar in shape, but Profiles 15 through 18 are much flatter than the profiles to the east.

Follett's Island (Surfside Profiles)

The Follett's Island profiles begin with Profile 1 and are numbered sequentially in reference to their position along the island in distance in miles from the beginning of the transect and end with Profile 15. Profile 1 contains three offshore bars which are low in relief. Profiles 3-11 contain a well established series of 2-3 offshore bars each. Profiles 13 and 15 are proximal to the Freeport Jetties, and the offshore bars have much lower relief.

Comparison with 2005 data

Originally this work was supposed to have been conducted in the summer of 2005, and subsequent surveys were to have occurred after the hurricane season. Unfortunately, Dr. Ravens was not able to successfully complete this project in the time required. Profiles had been collected from Galveston Island in 2002. The quality of this offshore data set is insufficient for scientific comparison. Below is a comparison with a partial profile which was extracted from the 2005 data set.

The 2006 surveys were compared with the partial surveys performed in 2005. The attached example is Galveston profile line 04 (Figure 1). The line is located approximately 2 miles southwest of the Galveston south jetty. This section of the Texas coastline elevation has been relatively stable in comparison with other areas along the Texas coast. The slight elevation increase in the surf is due to accretion from the south jetty, while the slight decrease of beach area can be attributed to the site being recently raked and sand being removed to other sites that are experiencing erosion. In regards to the profiles as a whole, in general there is an increase in steepness in individual grade elevation from the most northeastern profile transect to the most southwestern profile transect.

Discussion

Each of the three sites was surveyed in a few sequential days or on a single day, providing nearly synoptic data sets. For Bolivar Peninsula, the profiles in general are relatively flat, resulting from the very low slope of the inner shelf along the upper-most Texas coast. The slope increases away from both the North Galveston Jetty and the Rollover Pass area. With the middle profiles in this series of profiles, at the base of the steepest portion of the beach there is a wide section of the profiles, averaging 500 m wide, which appears to contain a series of broad bars.

For Galveston Island, the best developed offshore bars are proximal to the southwest end of the Seawall both to the east and west in Profiles 8-11, with Profile 9 being the profile to the west of the end of the Seawall. The end of the Seawall also is where the profiles are the steepest. The presence of these bars may suggest that where the beach is over steepened, sand is stored both to the east and west, proximal to the position of this over sweetening. There is also an abrupt change in shape between Profiles 14 and 15, with Profiles 15-18 being much flatter offshore.

The profiles are proximal to San Luis Pass and the shape of these profiles is probably largely influenced by tidal pass rather than beach processes.

Follet’s Island Profile 1 is proximal to San Luis Pass and is a relatively flat profile in comparison to the subsequent profiles to the west. Profiles 3-11 are from the main section of the island and each of these profiles are quite similar in shape and form and they each contain a series of 2-3 offshore bars. These profiles were all collected in a two day period, providing a synoptic view of the system. Profiles 13 and 15 are proximal to the Freeport Jetty the lower relief of these profiles as well as the lack of well established offshore bars probably is a function of the trapping of sand behind the jetties.

Conclusions

Although these surveys were collected on three separate sections of the coast, there are some similarities which hold true in each case. These include the observation that proximal to jetties, the profiles have the gentlest slopes. The steepest slopes in each case appear to be the furthest away from these jetties. These profiles also tend to have the best developed offshore bars. The steepest slopes from any area are those collected at the end of the Galveston Seawall and the flattest are from the north side of the Galveston Jetty (Bolivar Profile 1) and Galveston Profile 18 collected at San Luis Pass. It should be noted that this report contains only one set of profiles. Normal studies of nearshore processes contain a large time series of such profiles to reach more meaningful conclusions.

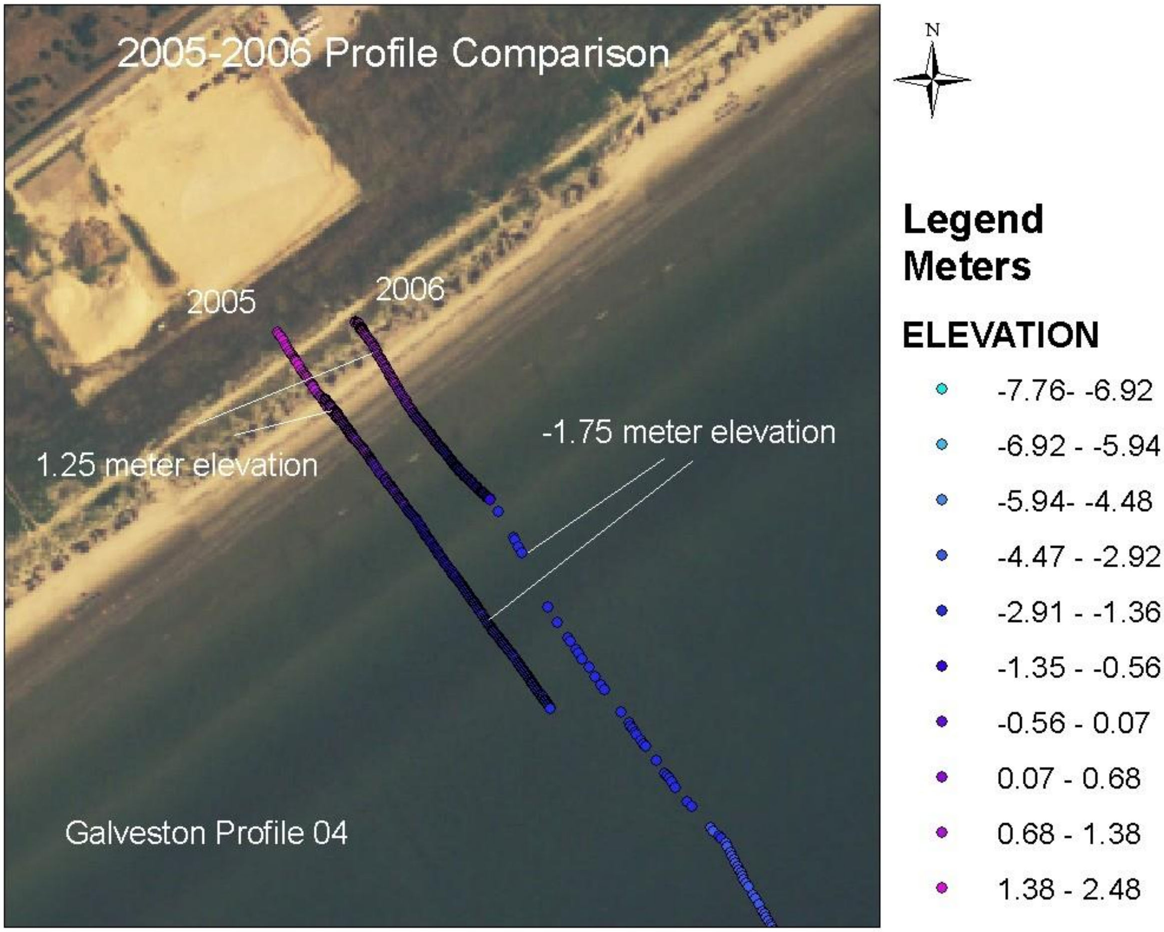
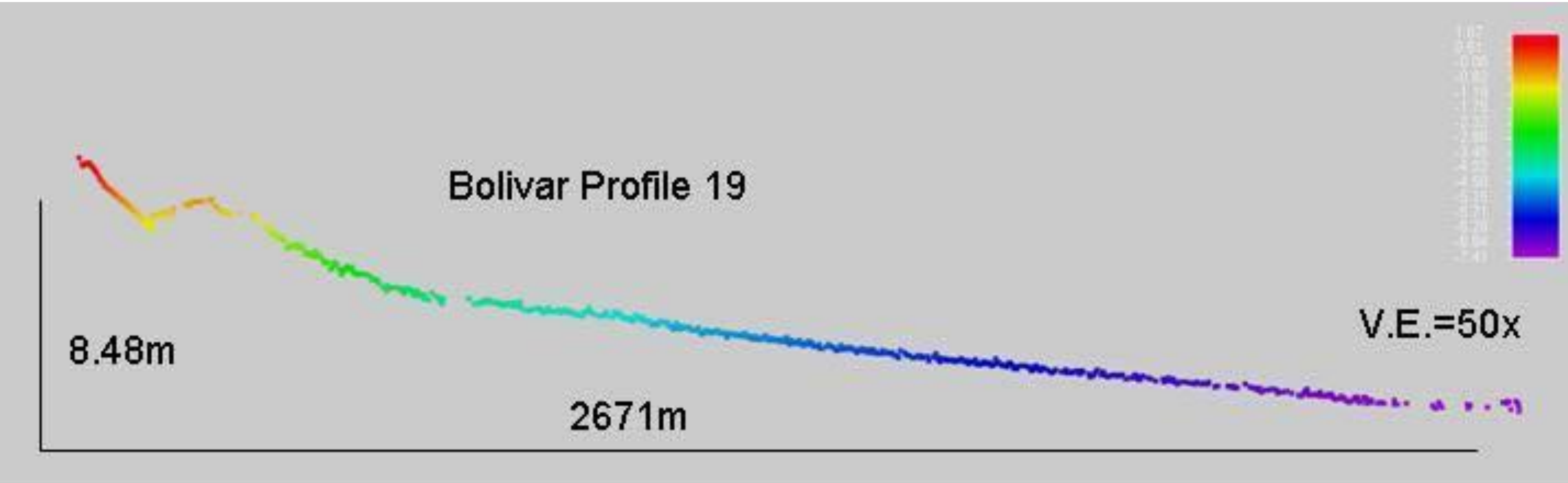
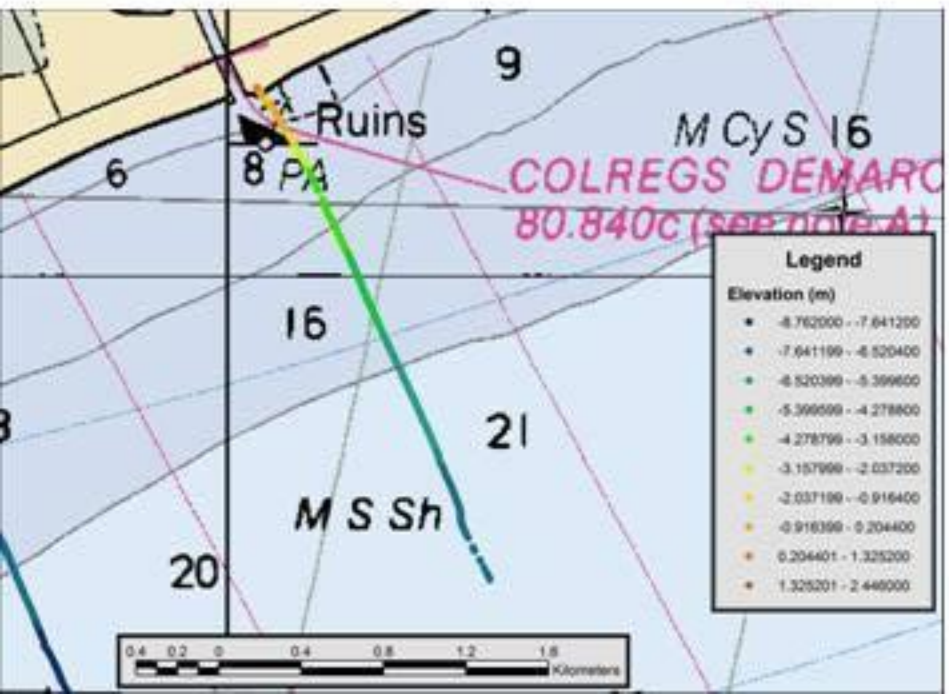


Figure 1- Comparison of the 2005 and 2006 data, note that in general there is an increase in steepness in individual grade elevation from the most northeastern profile transect to the most southwestern profile transect.

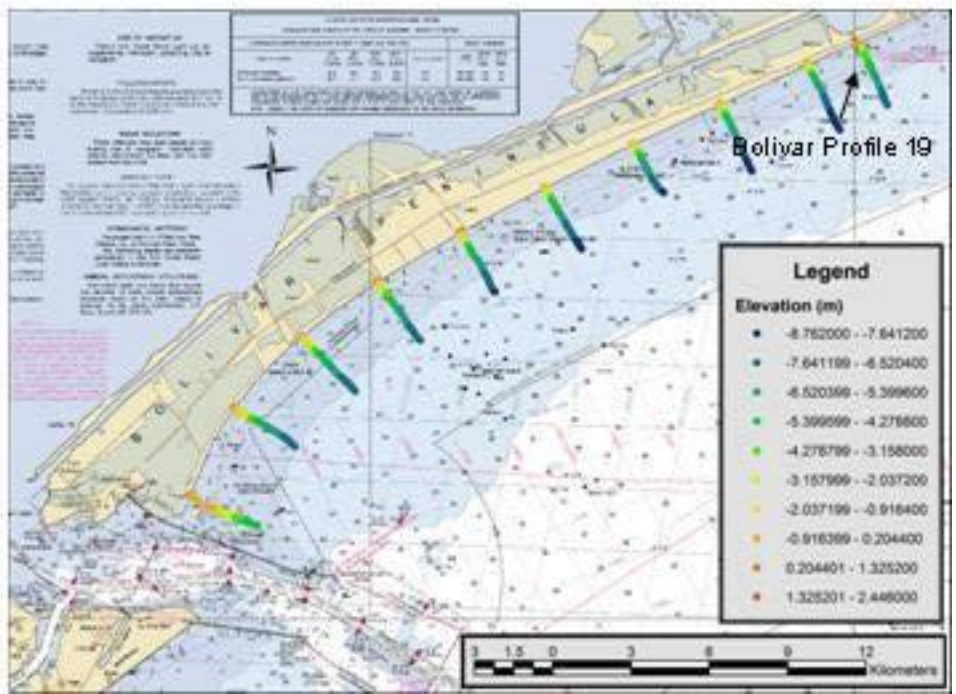
Appendix A Bolivar Peninsula Profiles



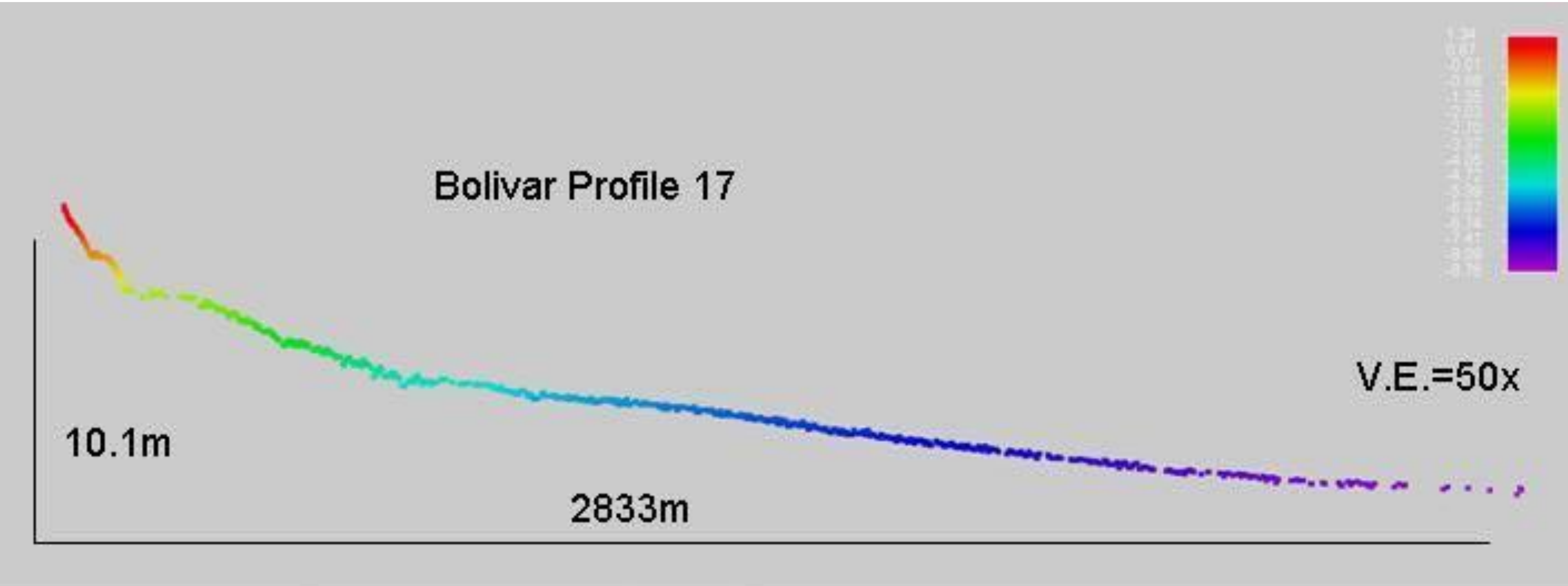
Bolivar Profile 19
8.48m
2671m
V.E.=50x

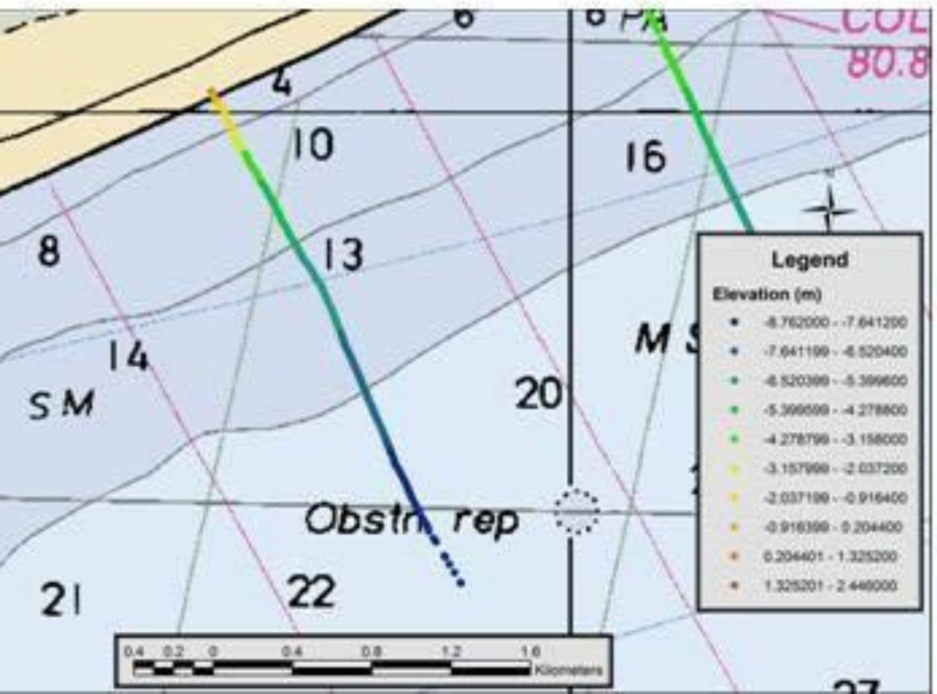


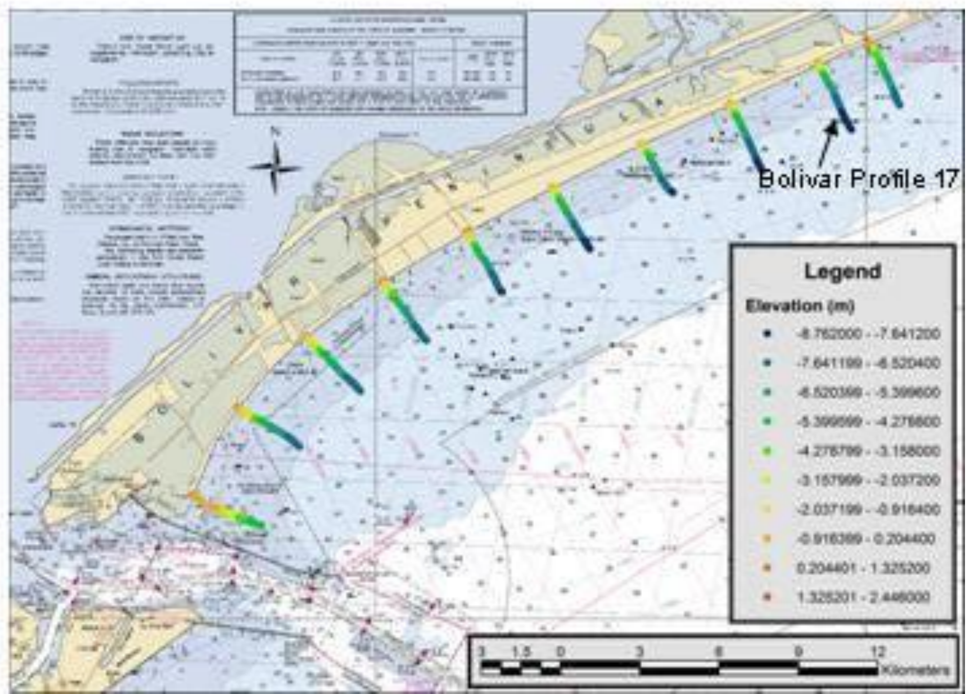
Ruins
9
6
8 PA
M Cy S 16
COLREGS DEMARC
80.840c (see note A)
16
21
M S Sh
20
Legend
Elevation (m)
-8.762000 - -7.641200
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
0.4 0.2 0 0.4 0.8 1.2 1.6 Kilometers



Bolivar Profile 19
Legend
Elevation (m)
-8.762000 - -7.641200
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
3 1.5 0 3 6 9 12 Kilometers


Bolivar Profile 17
V.E.=50x
10.1m
2833m


Legend
Elevation (m)
-8.762000 - -7.641200
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
Kilometers


Bolivar Profile 17
Legend
Elevation (m)
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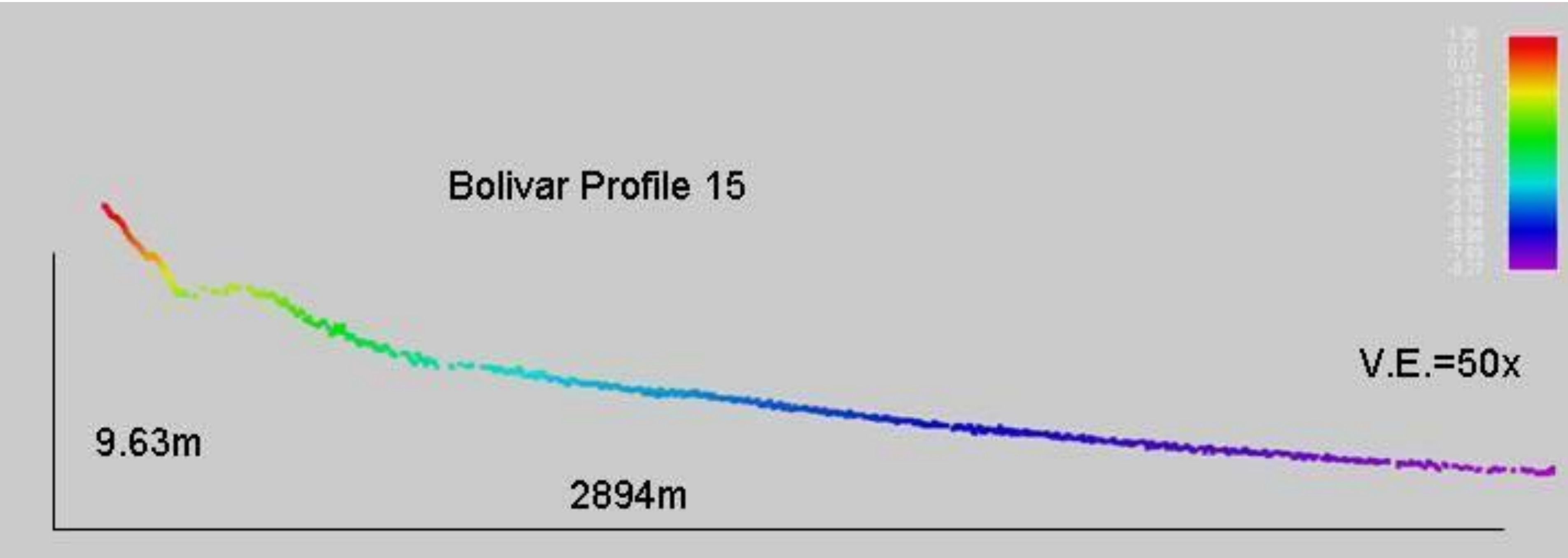
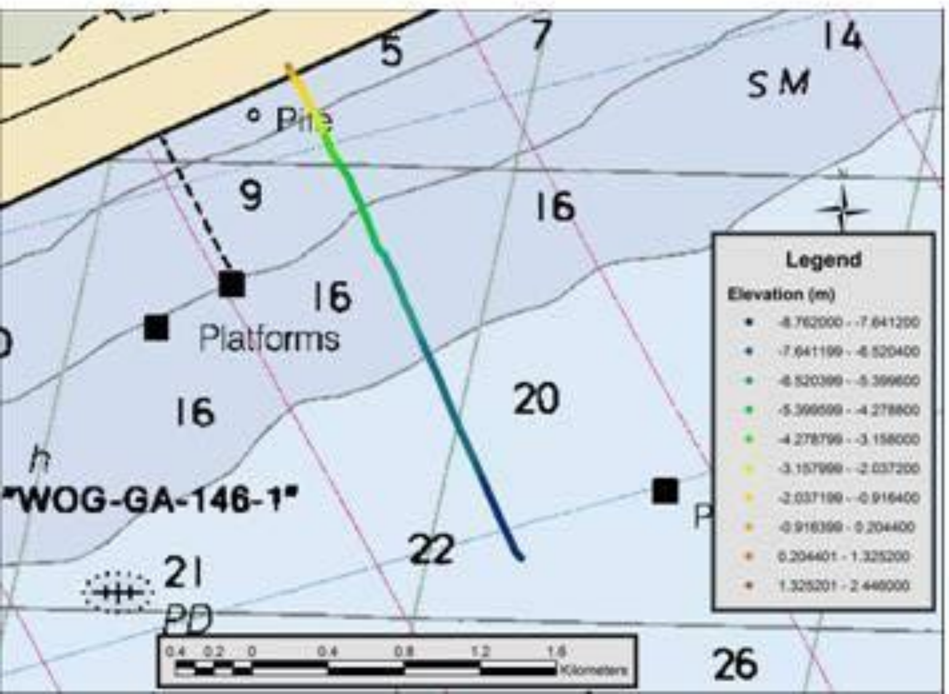
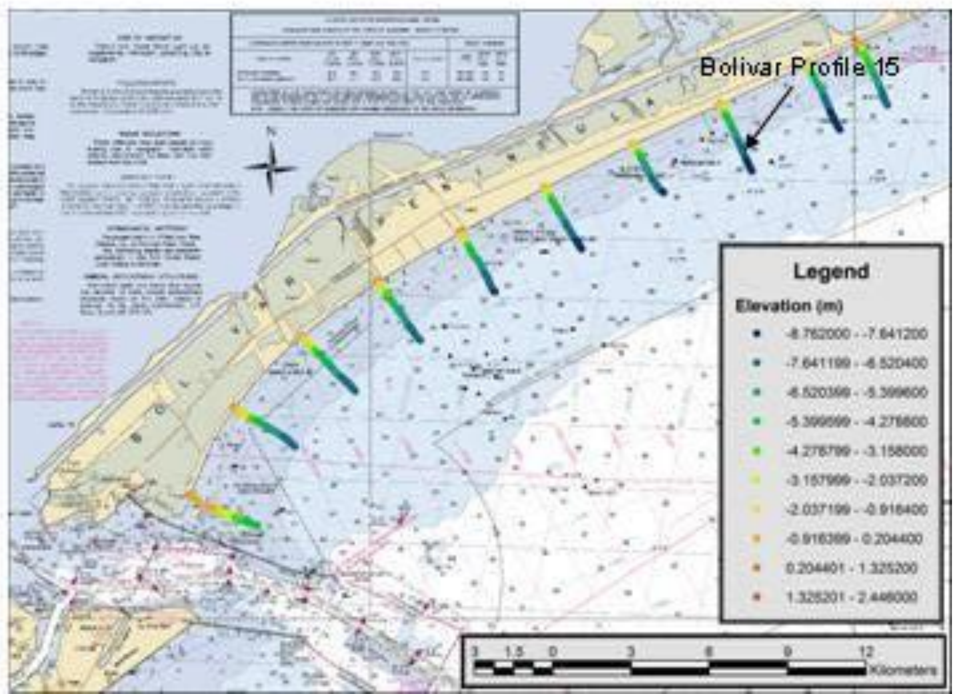
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
Kilometers


Bolivar Profile 15
V.E.=50x
9.63m
2894m


5
7
14
S M
Pile
9
16
16
Platforms
16
20
h
"WOG-GA-146-1"
22
21
PD
26
Legend
Elevation (m)
-8.762000 - -7.641200
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
0.4 0.2 0 0.4 0.8 1.2 1.6 Kilometers


Bolivar Profile 15
Legend
Elevation (m)
-8.762000 - -7.641200
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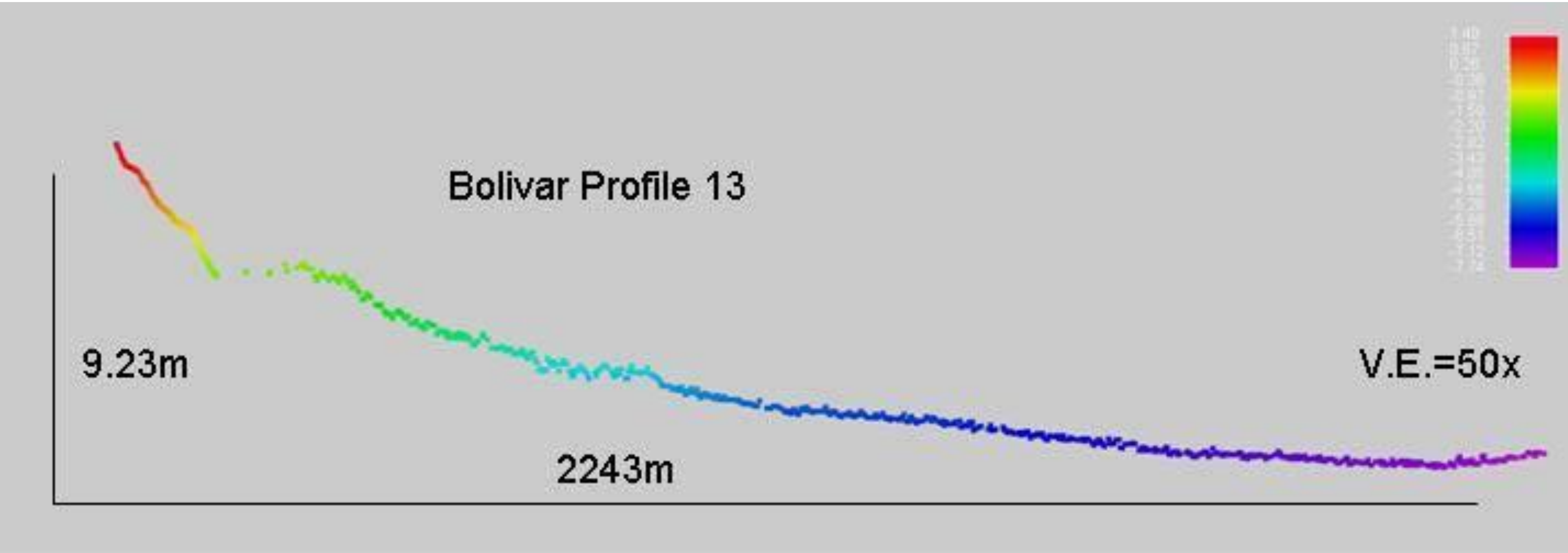
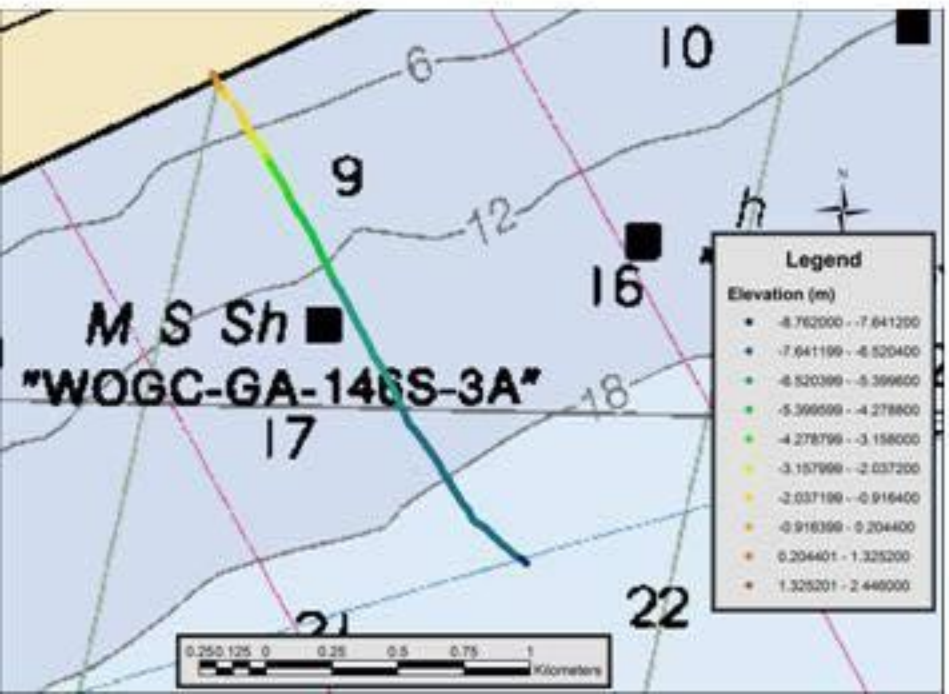
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
3 1.5 0 3 6 9 12 Kilometers


Bolivar Profile 13
9.23m
V.E.=50x
2243m


10
9
16
17
22
6
12
18
h
M S Sh
"WOGC-GA-146S-3A"
Legend
Elevation (m)
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-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
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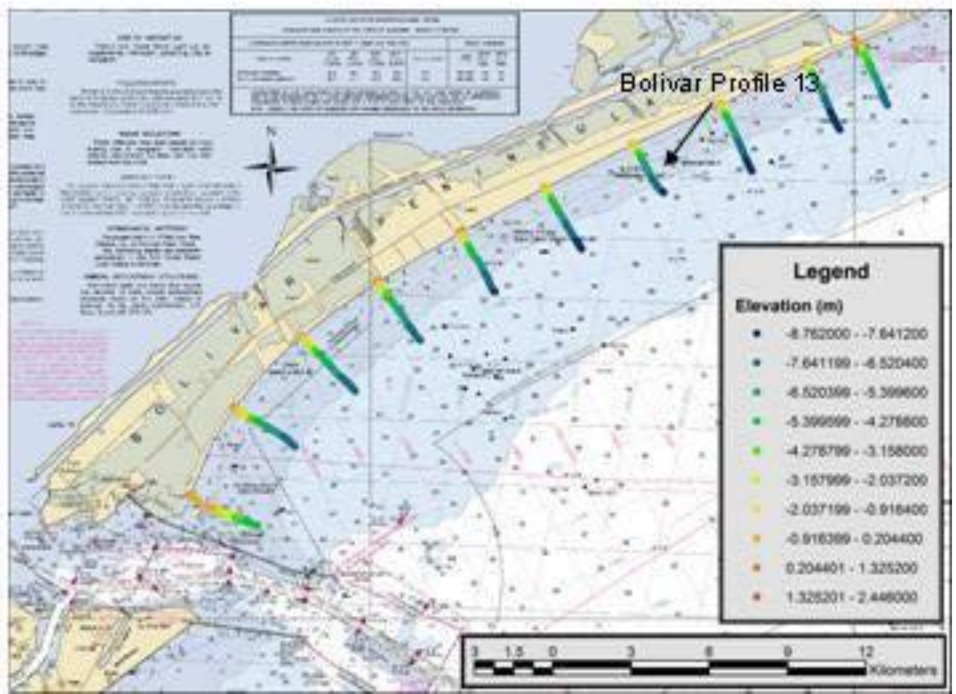
0.204401 - 1.325200
1.325201 - 2.446000
0.25 0.125 0 0.25 0.5 0.75 1
Kilometers


Bolivar Profile 13
Legend
Elevation (m)
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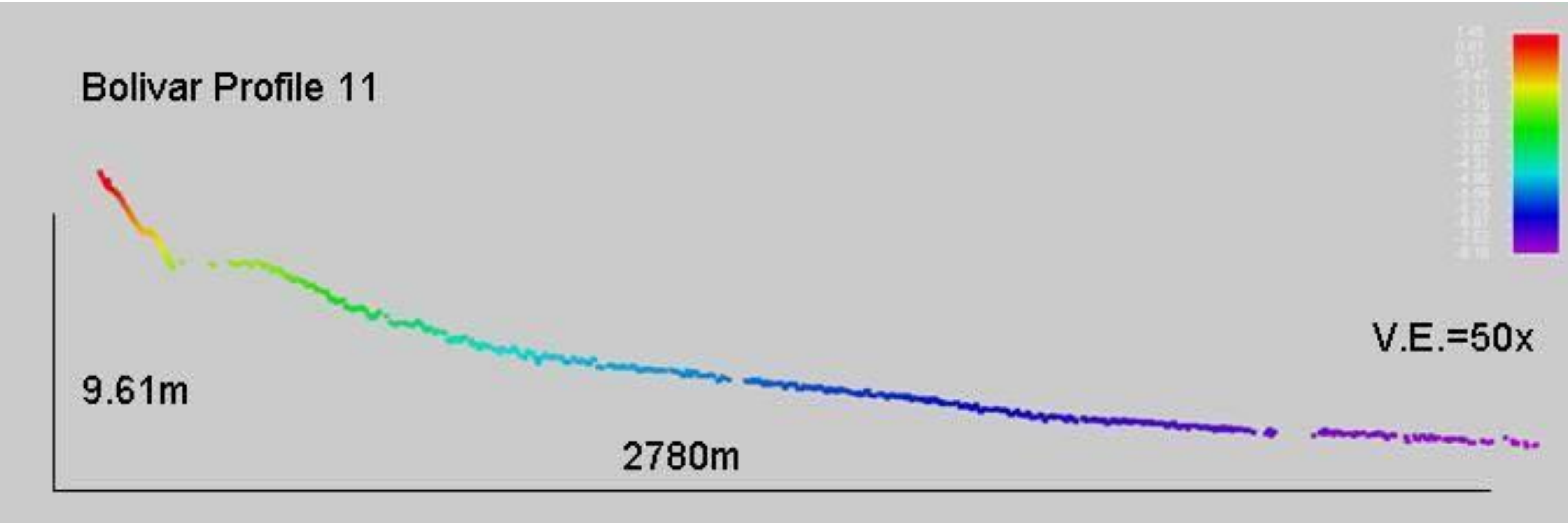
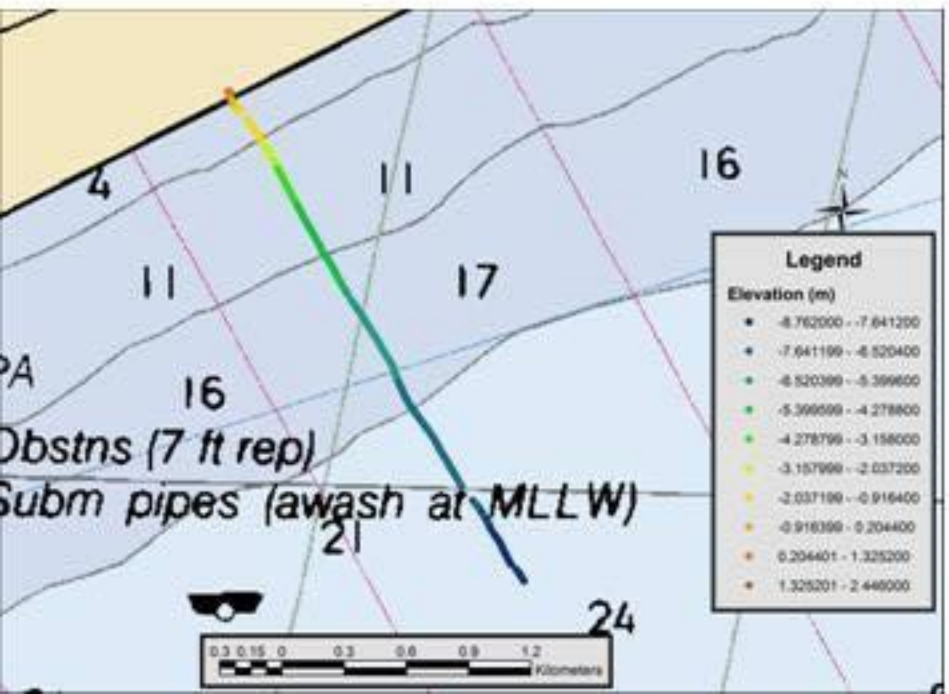
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
3 1.5 0 3 6 9 12
Kilometers


Bolivar Profile 11
9.61m
2780m
V.E.=50x


4
11
11
16
17
16
21
24
Obstns (7 ft rep)
Subm pipes (awash at MLLW)
Legend
Elevation (m)
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-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
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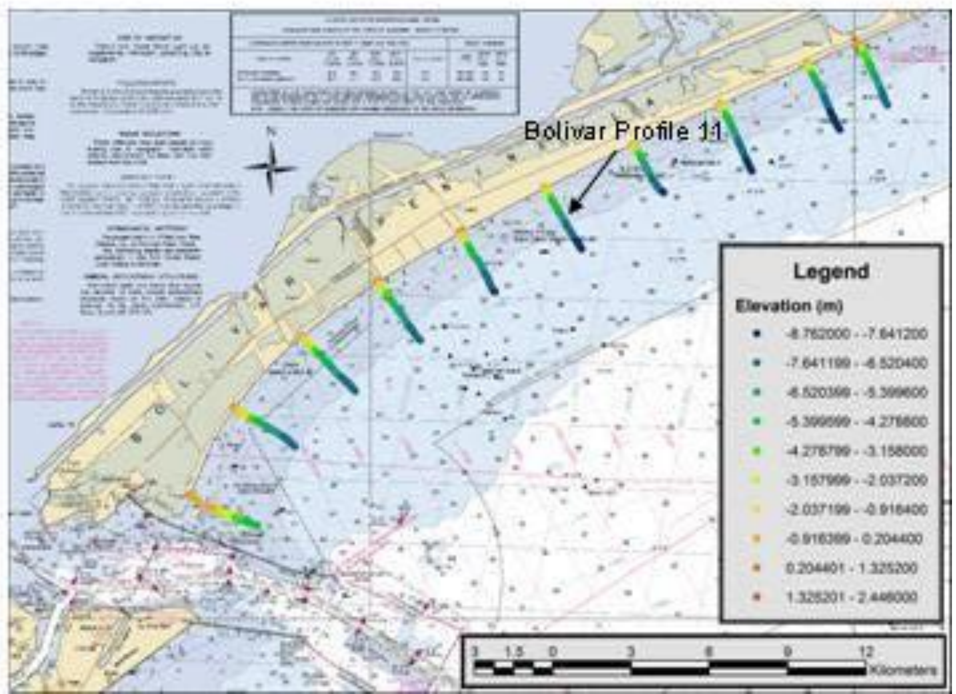
1.325201 - 2.446000
0.3 0.15 0 0.3 0.6 0.9 1.2
Kilometers


Bolivar Profile 11
Legend
Elevation (m)
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-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
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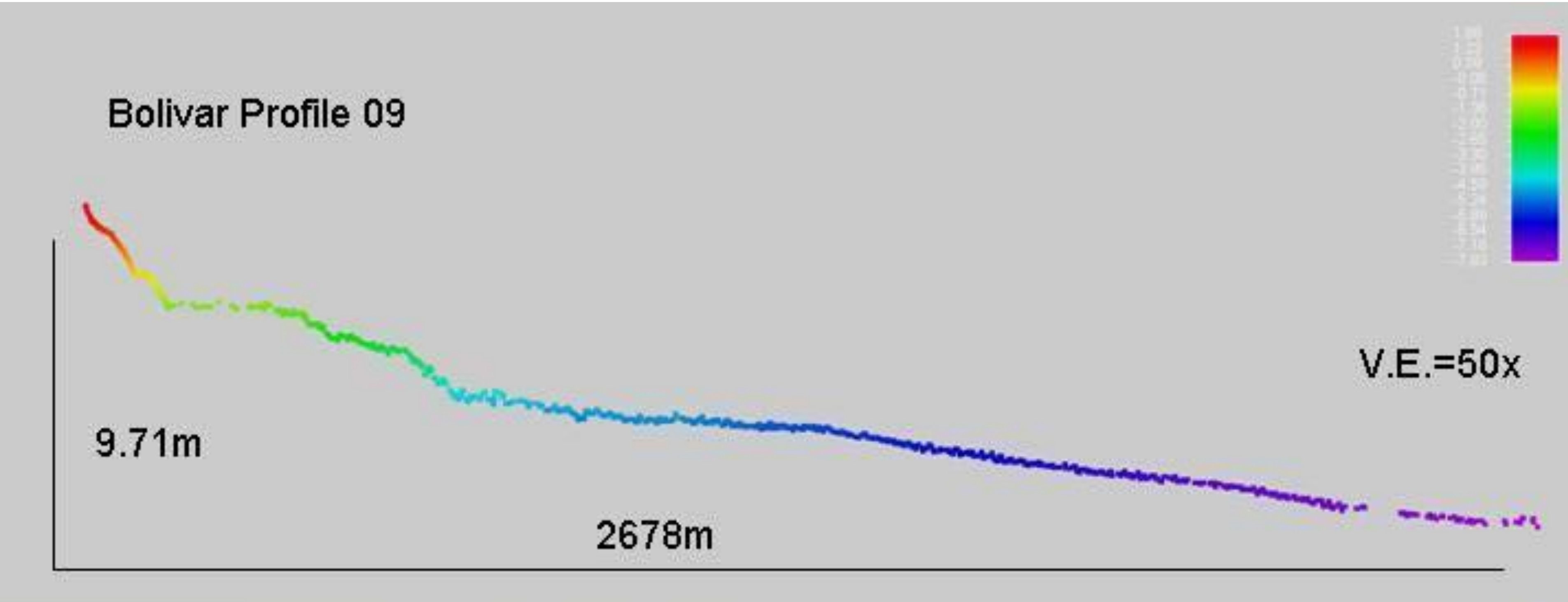
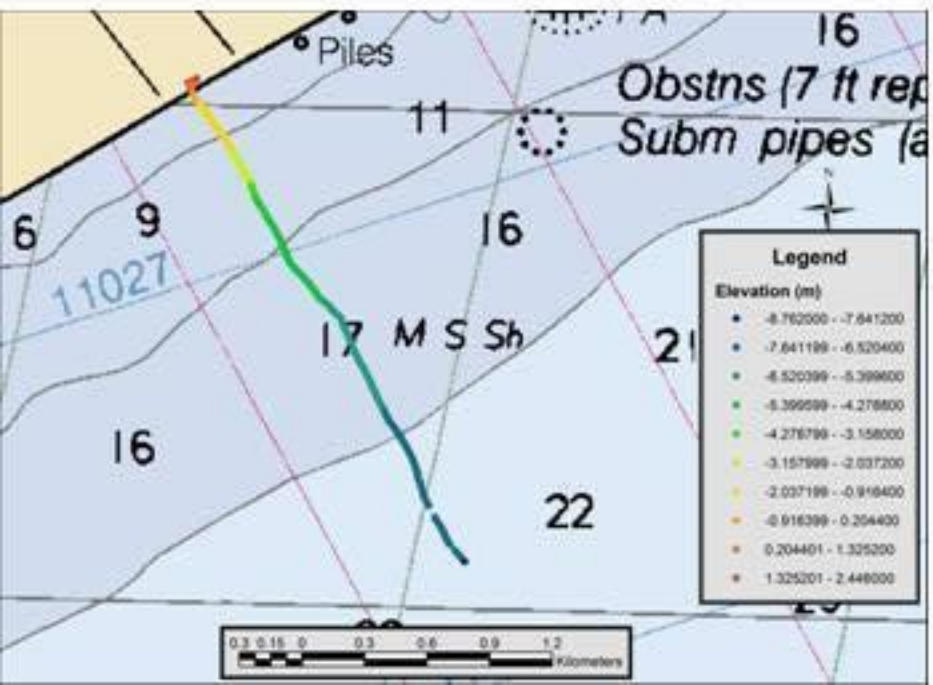
3 1.5 0 3 6 9 12
Kilometers


Bolivar Profile 09
V.E.=50x
9.71m
2678m


Piles
Obstns (7 ft rep
Subm pipes (a
11027
17 M S Sh
Legend
Elevation (m)
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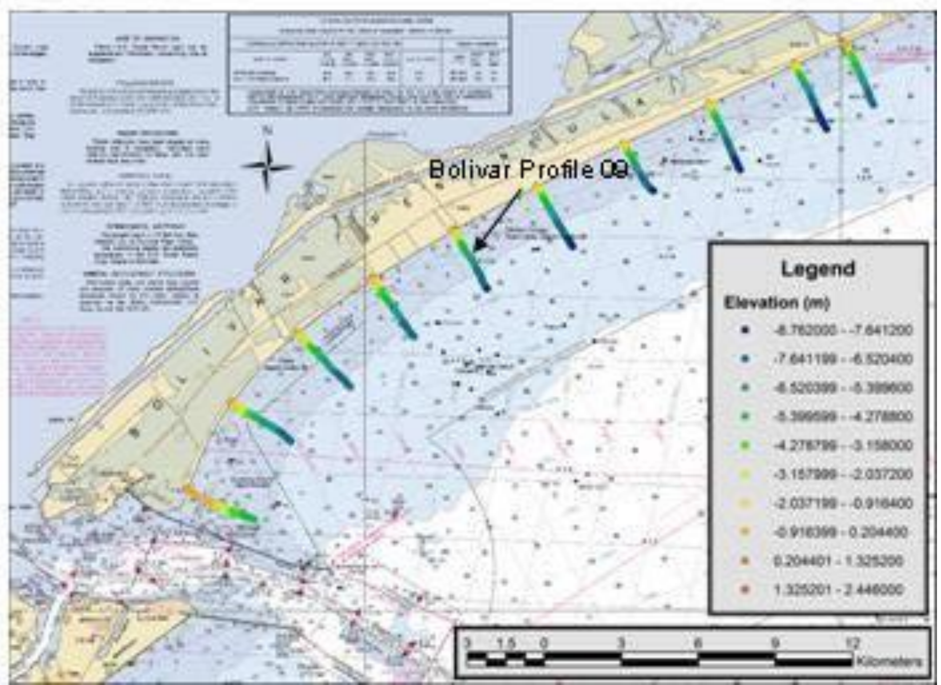
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
0.3 0.15 0 0.3 0.6 0.9 1.2
Kilometers


Bolivar Profile 09
Legend
Elevation (m)
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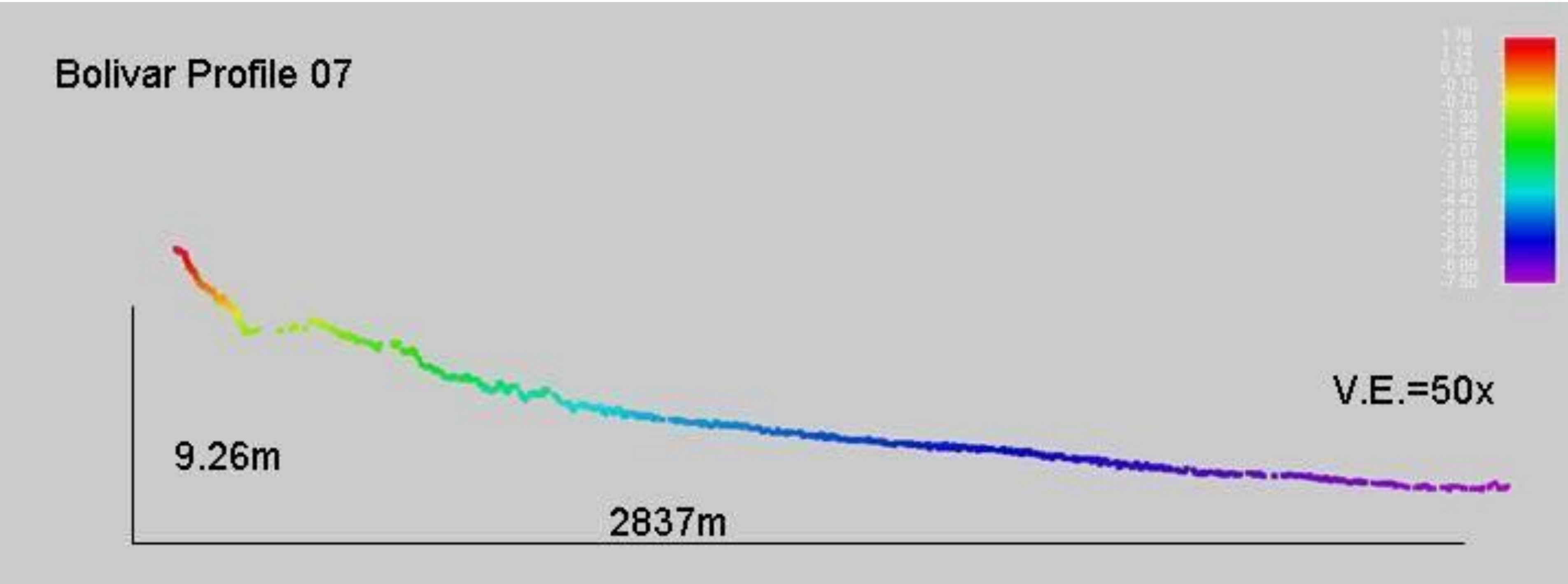
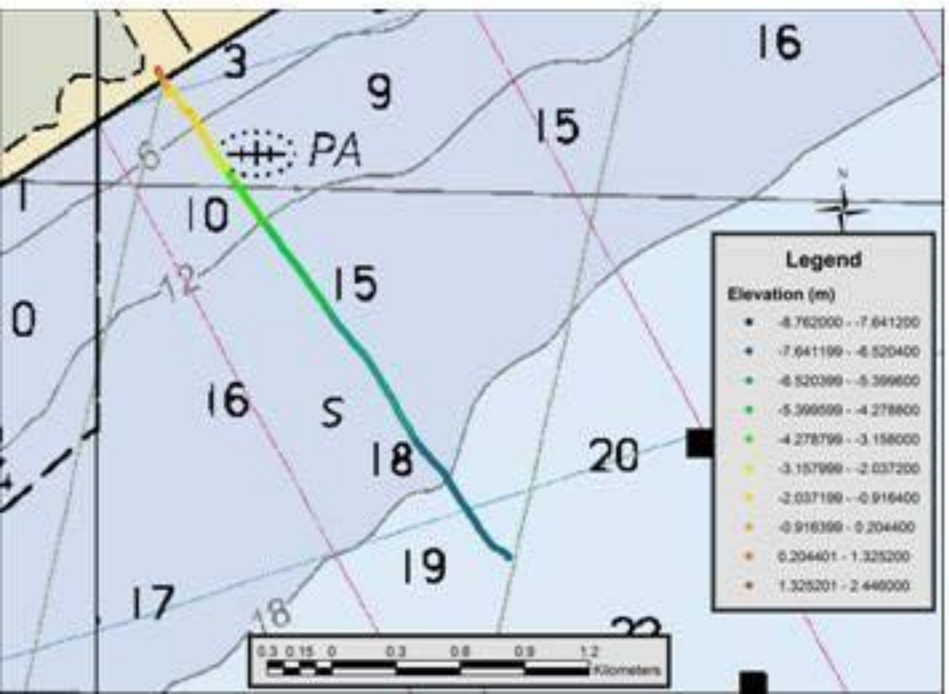
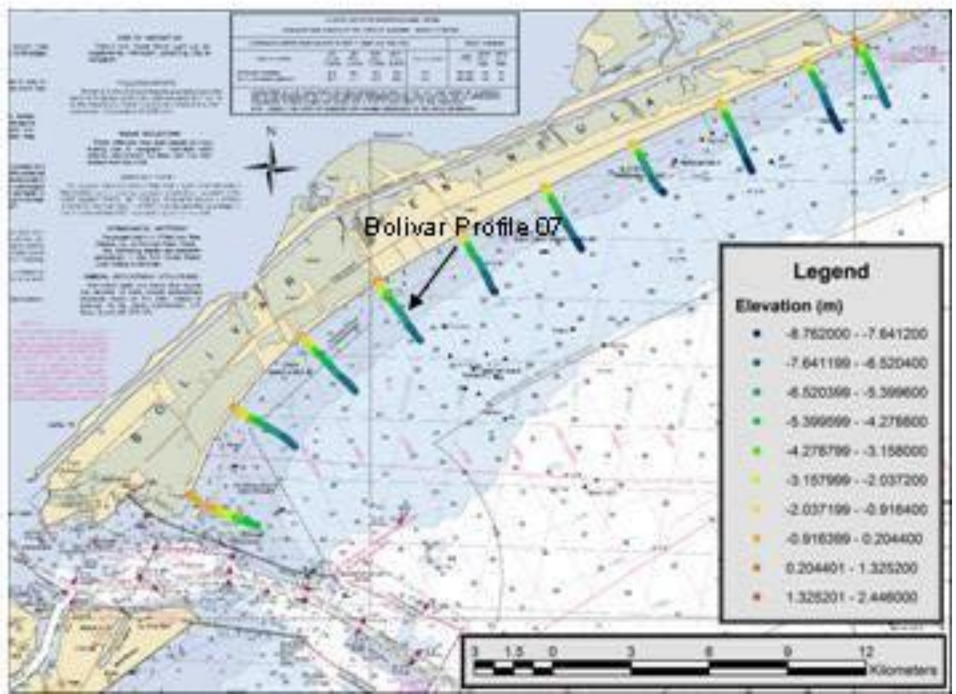
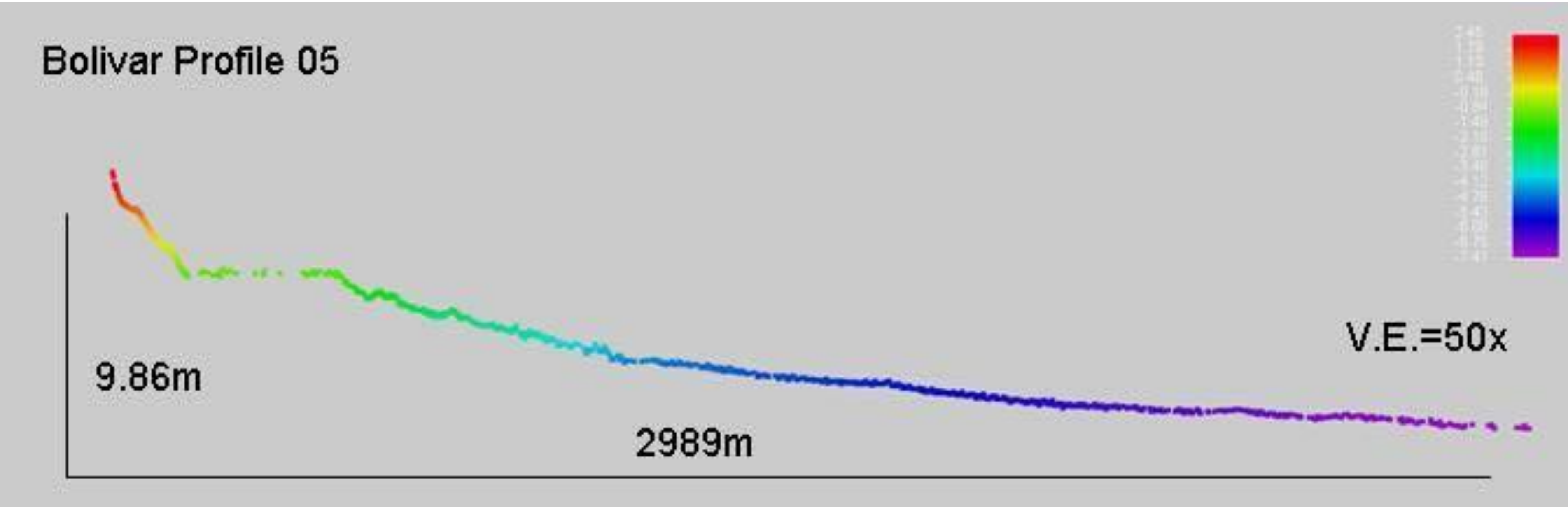
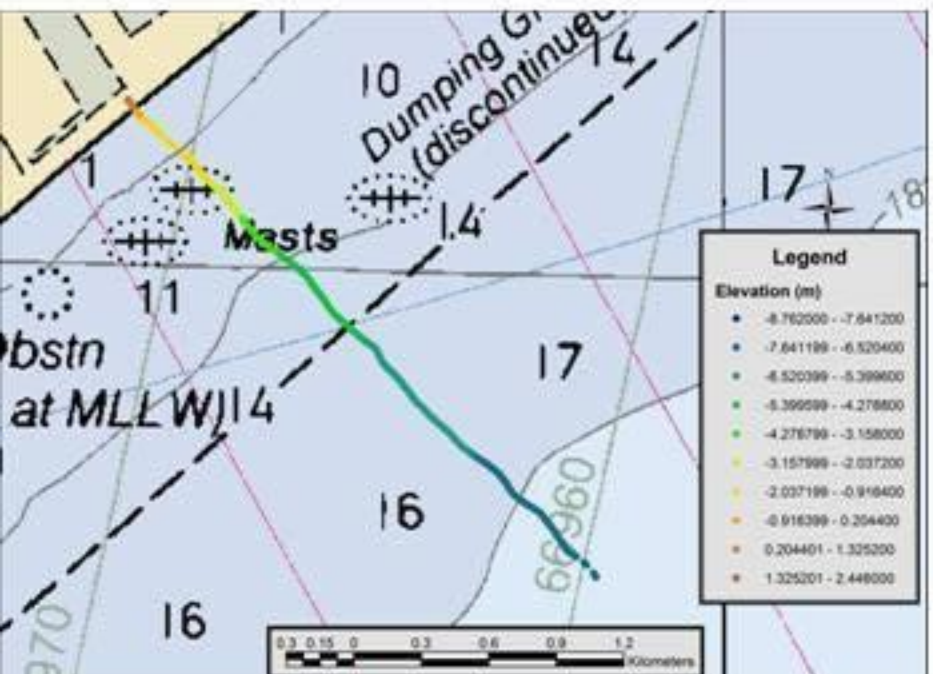
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
3 1.5 0 3 6 9 12
Kilometers

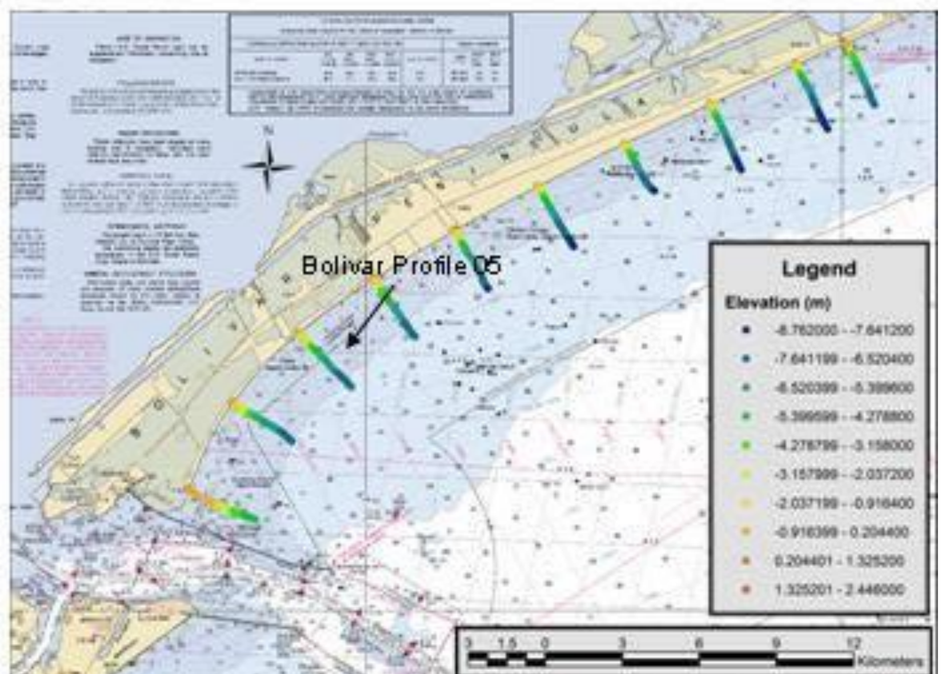

Bolivar Profile 07
V.E.=50x
9.26m
2837m

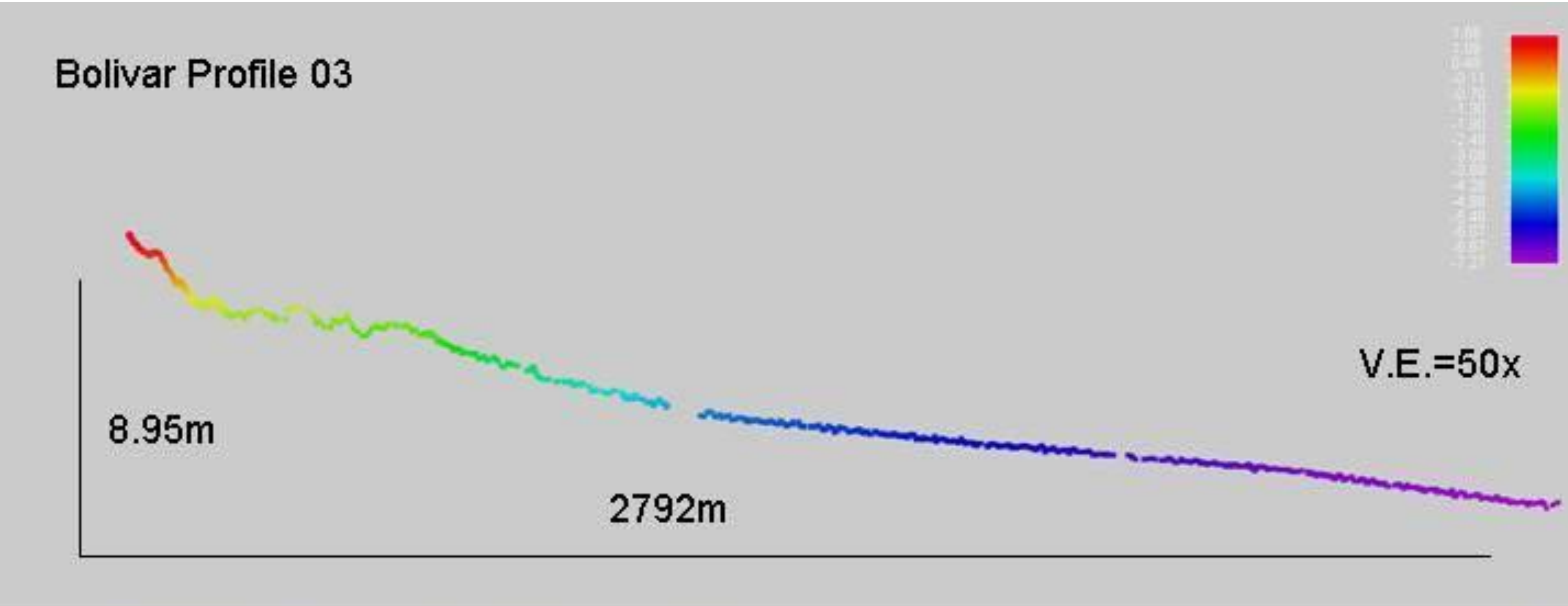

Legend
Elevation (m)
-8.762000 - -7.641200
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
Kilometers

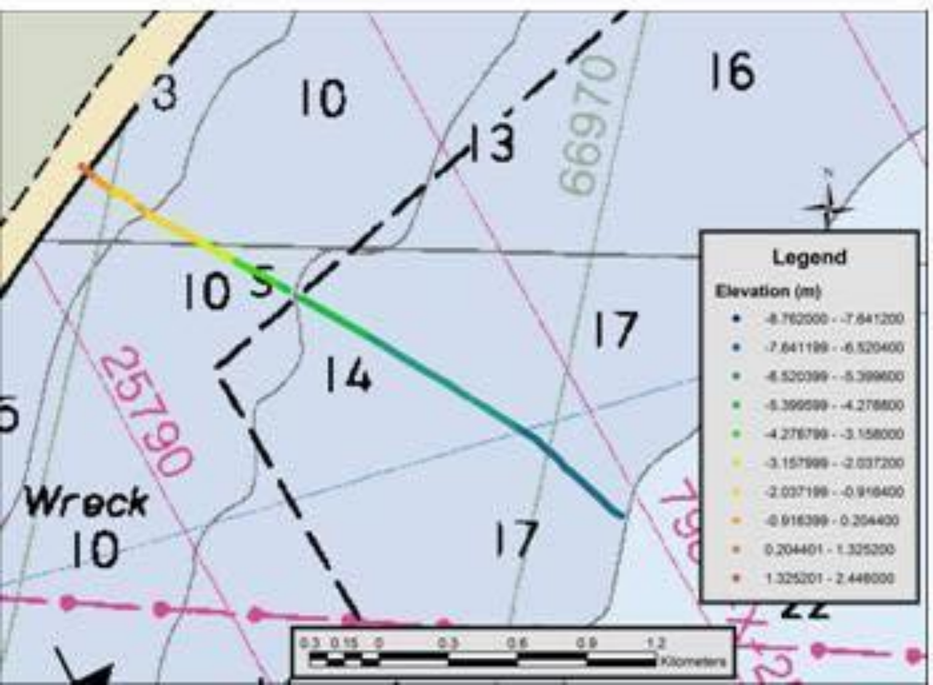

Bolivar Profile 07
Legend
Elevation (m)
-8.762000 - -7.641200
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
Kilometers

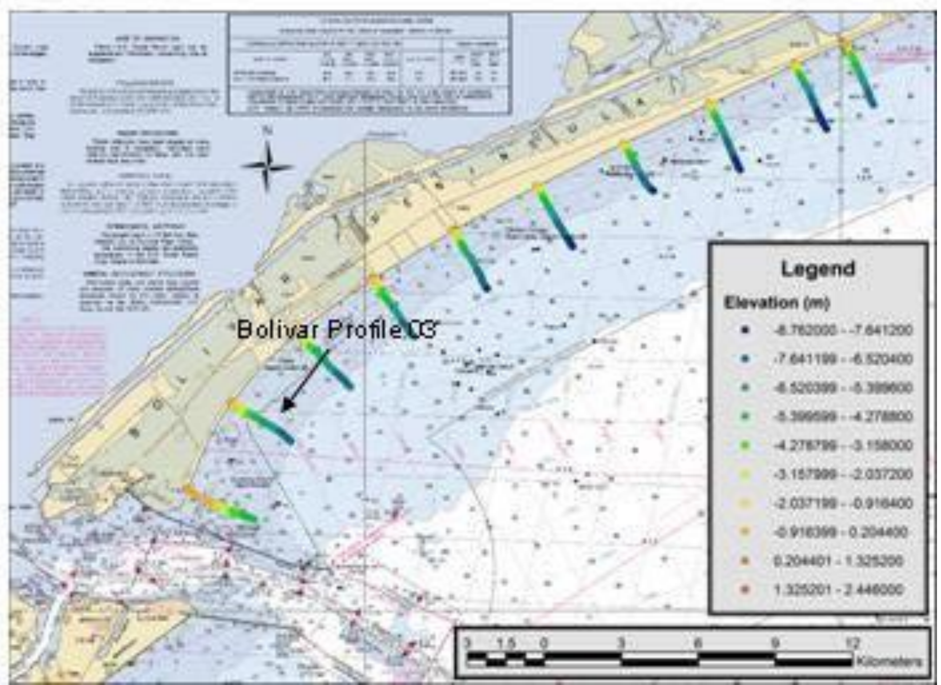

Bolivar Profile 05
9.86m
2989m
V.E.=50x

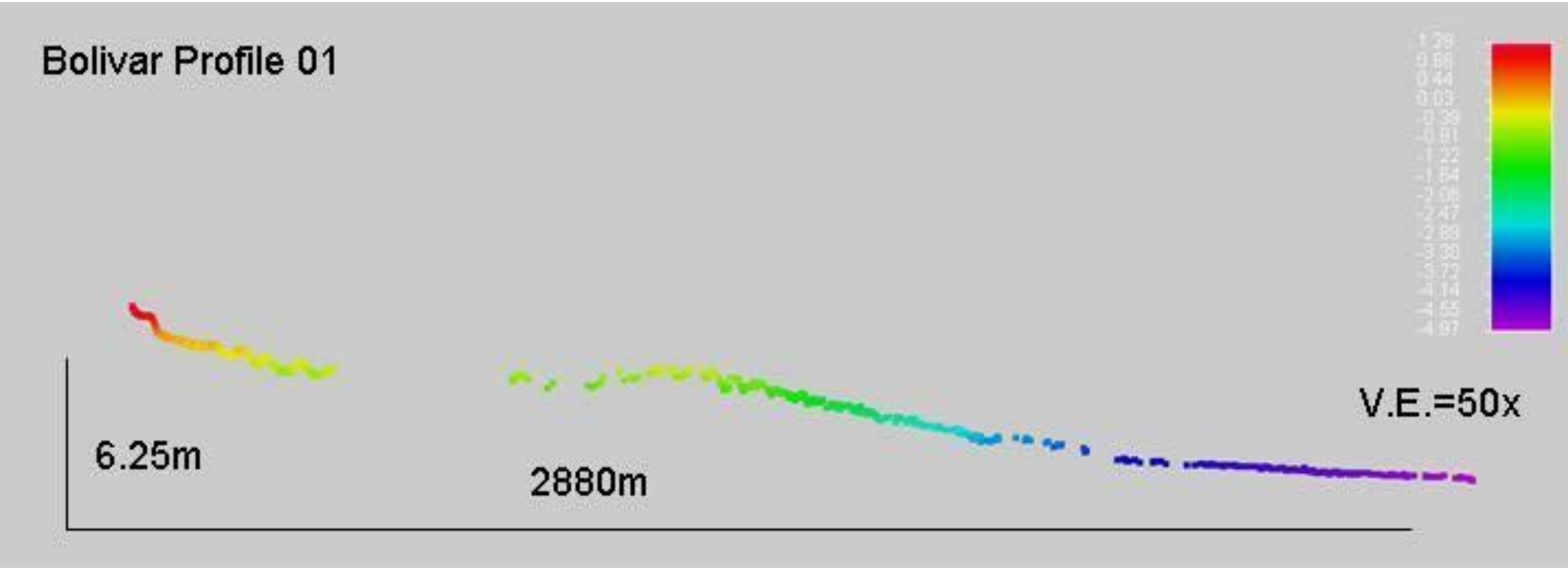

10
Dumping Gr
(discontinued
14
1.4
17
Masts
11
1
Obstn
at MLLW)14
17
16
16
66960
Legend
Elevation (m)
-8.762000 - -7.641200
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
0.3 0.15 0 0.3 0.6 0.9 1.2
Kilometers

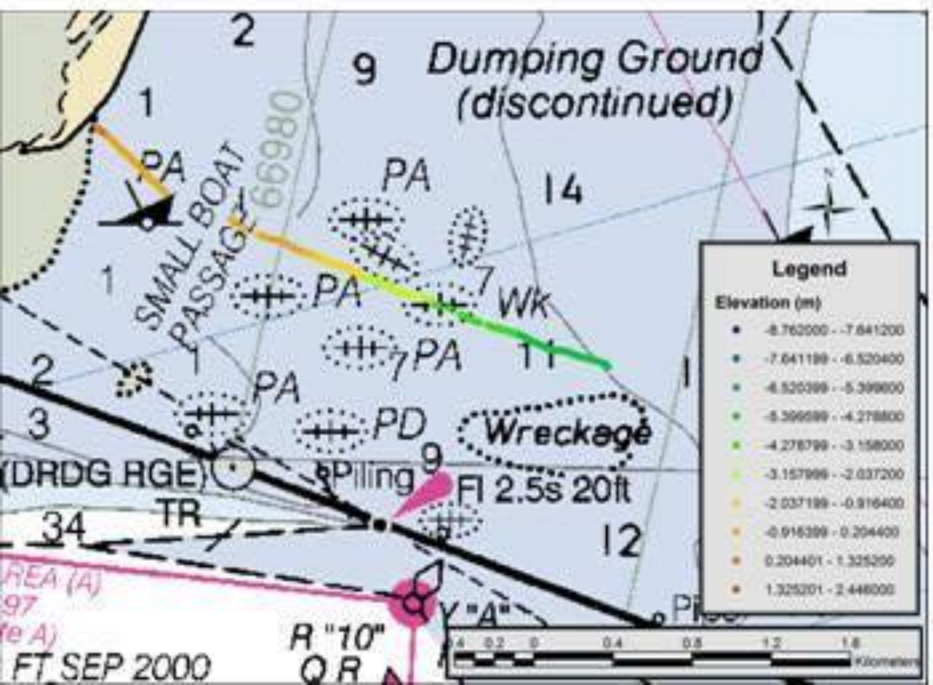

Bolivar Profile 05
N
Legend
Elevation (m)
-8.762000 - -7.641200
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
3 1.5 0 3 6 9 12
Kilometers

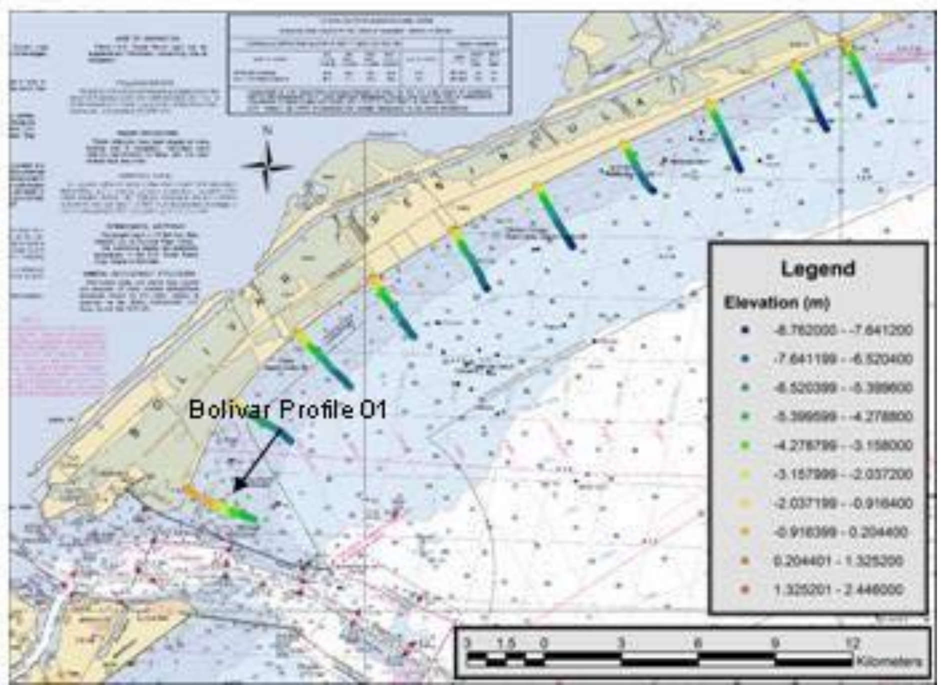

Bolivar Profile 03
V.E.=50x
8.95m
2792m


Legend
Elevation (m)
-8.762000 - -7.641200
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
0.3 0.15 0 0.3 0.6 0.9 1.2
Kilometers
Wreck

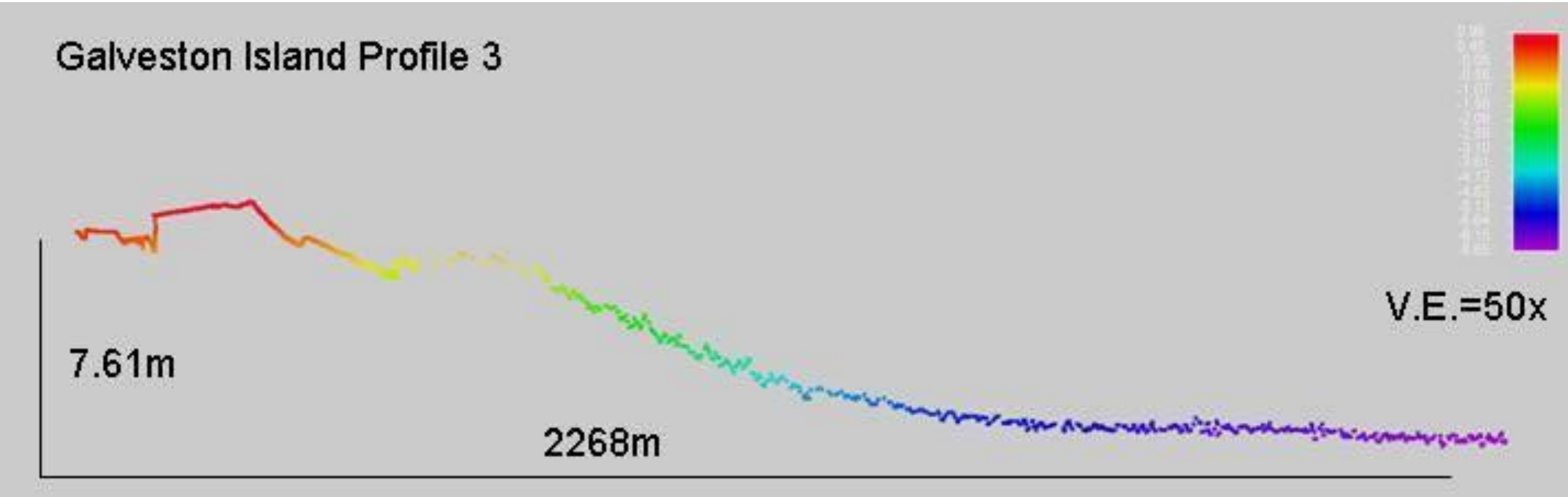

Bolivar Profile 03
Legend
Elevation (m)
-8.762000 - -7.641200
-7.641199 - -6.520400
-6.520399 - -5.399600
-5.399599 - -4.278800
-4.278799 - -3.158000
-3.157999 - -2.037200
-2.037199 - -0.916400
-0.916399 - 0.204400
0.204401 - 1.325200
1.325201 - 2.446000
3 1.5 0 3 6 9 12
Kilometers

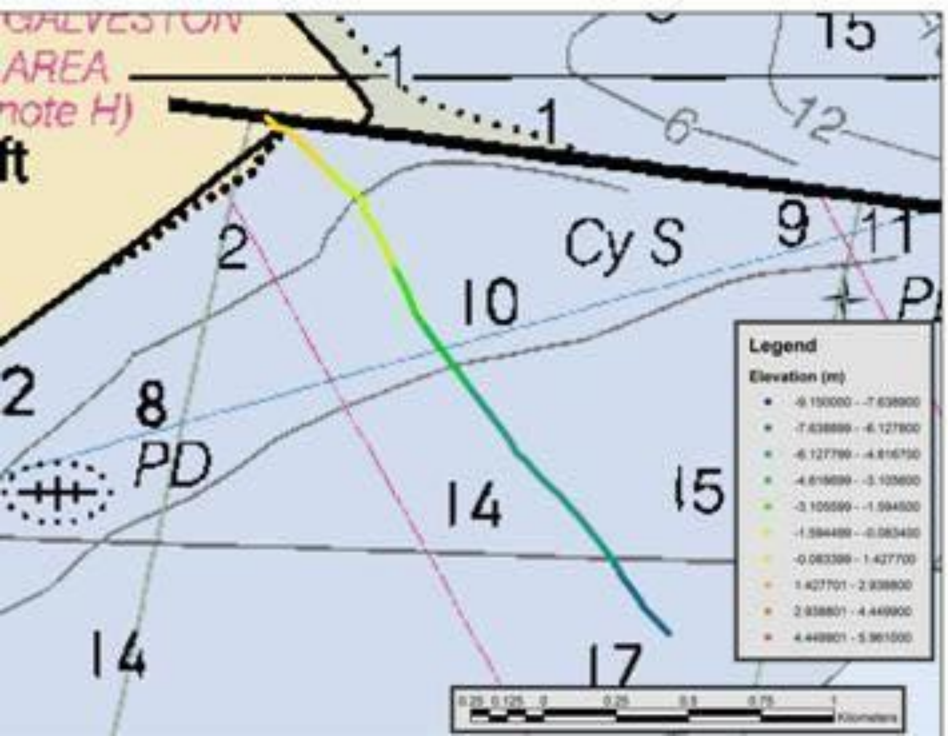

Bolivar Profile 01
6.25m
2880m
V.E.=50x

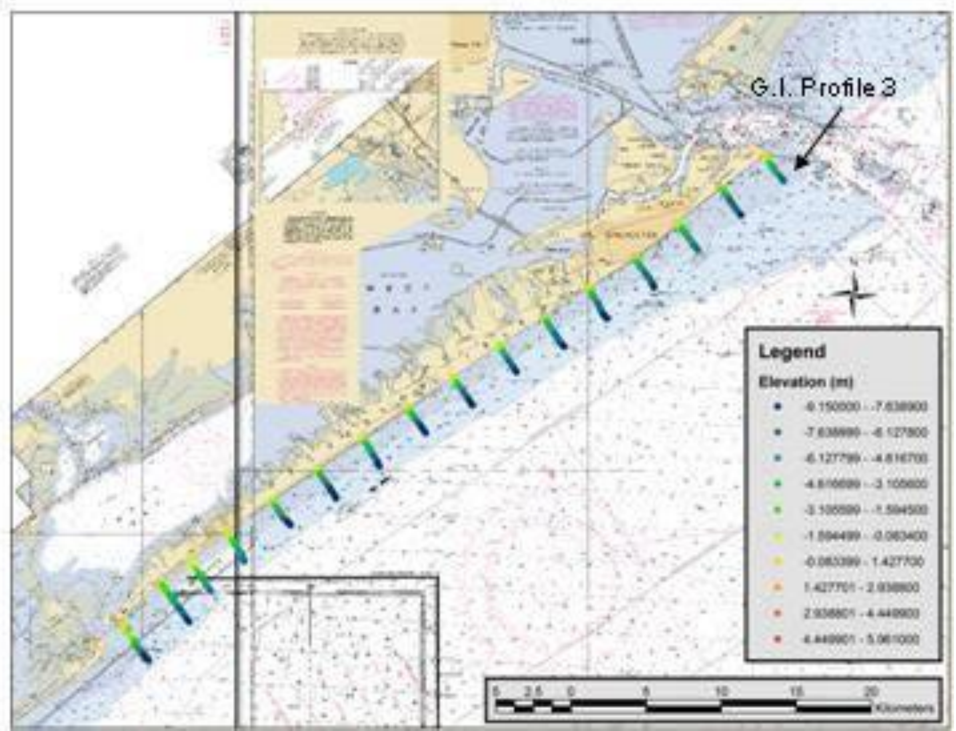

Dumping Ground
(discontinued)
SMALL BOAT PASSAGE
Wreckage
Fl 2.5s 20ft
Legend
Elevation (m)

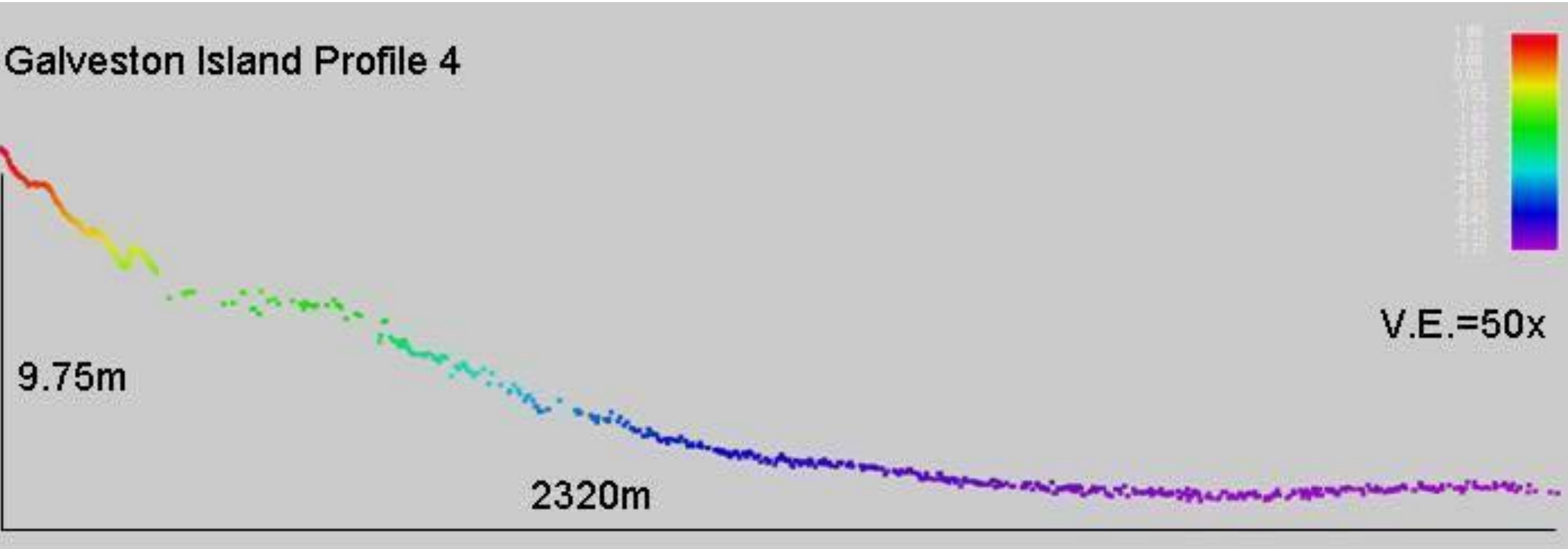

Bolivar Profile 01
Legend
Elevation (m)

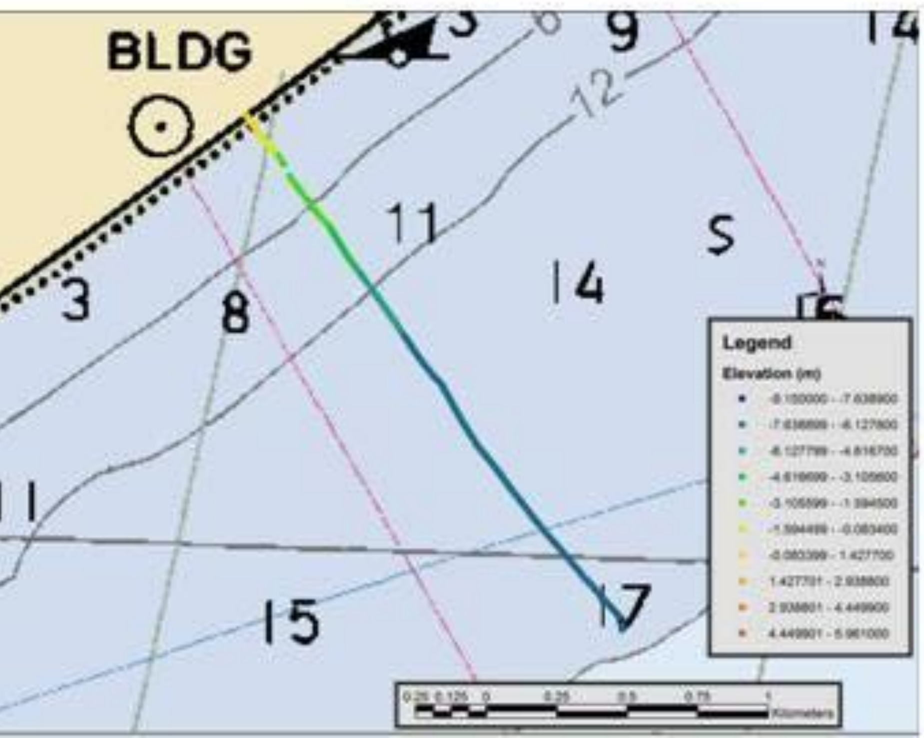
Appendix B **Galveston Island Profiles**

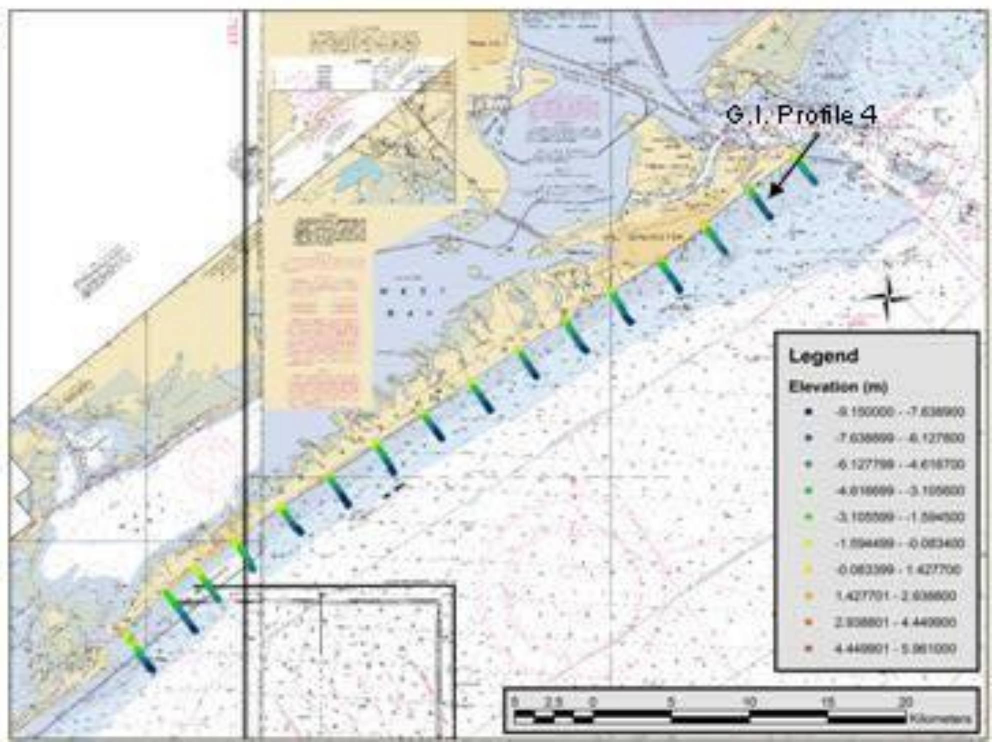

Galveston Island Profile 3
V.E.=50x
7.61m
2268m

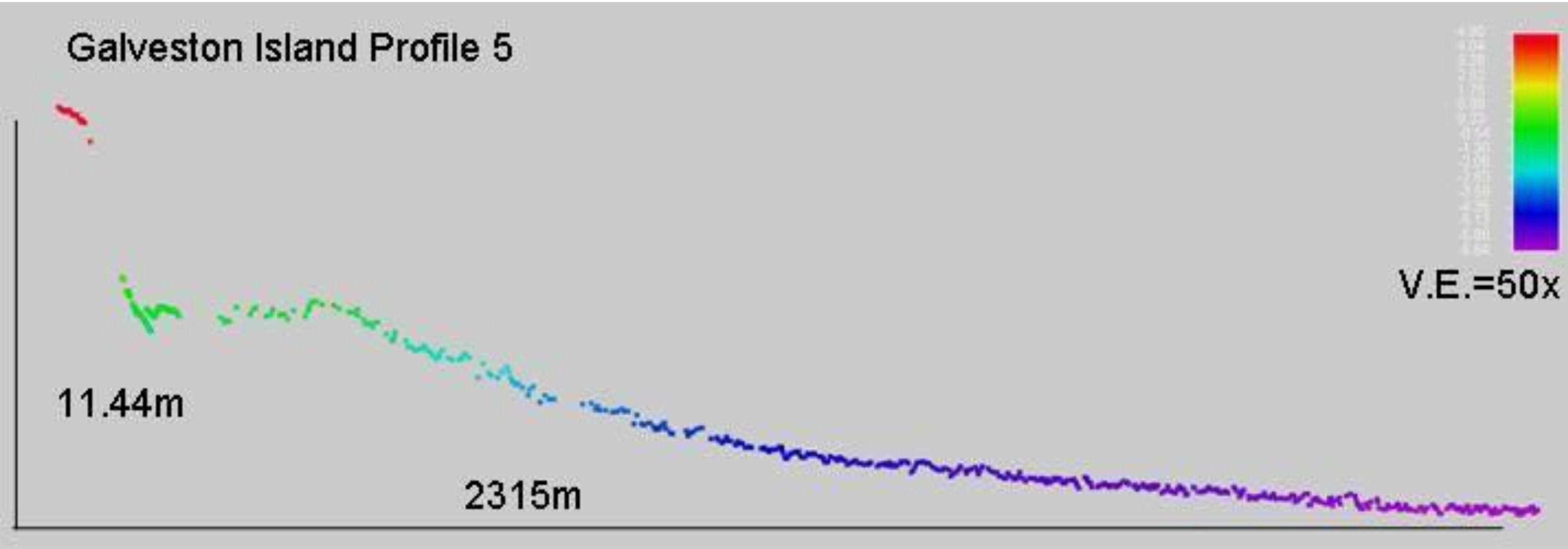

Legend
Elevation (m)

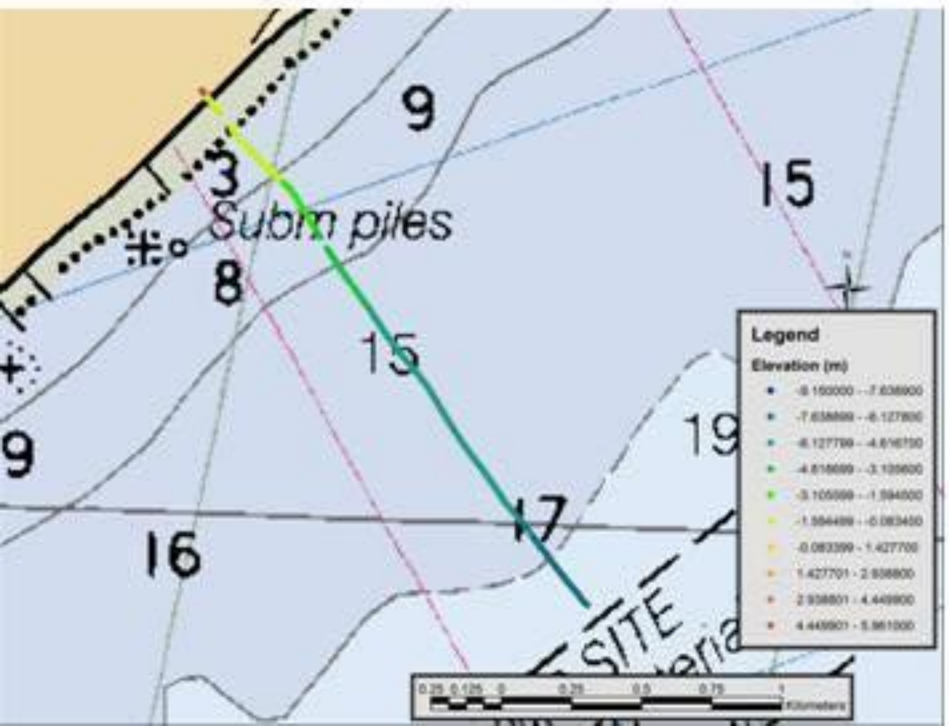

G.I. Profile 3
Legend
Elevation (m)

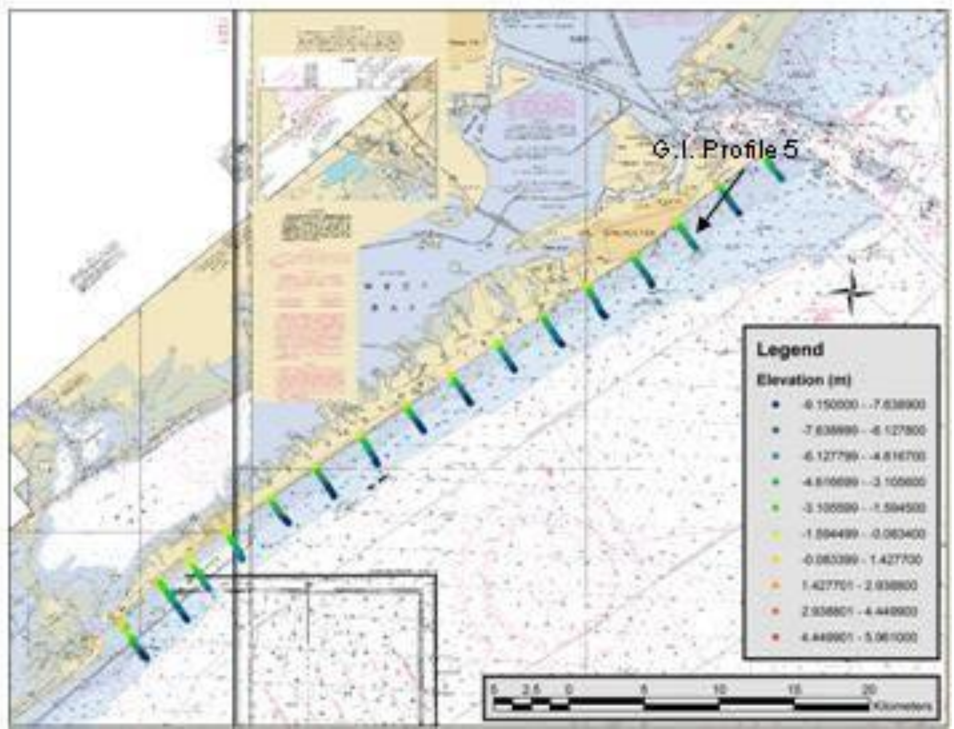

Galveston Island Profile 4
9.75m
2320m
V.E.=50x

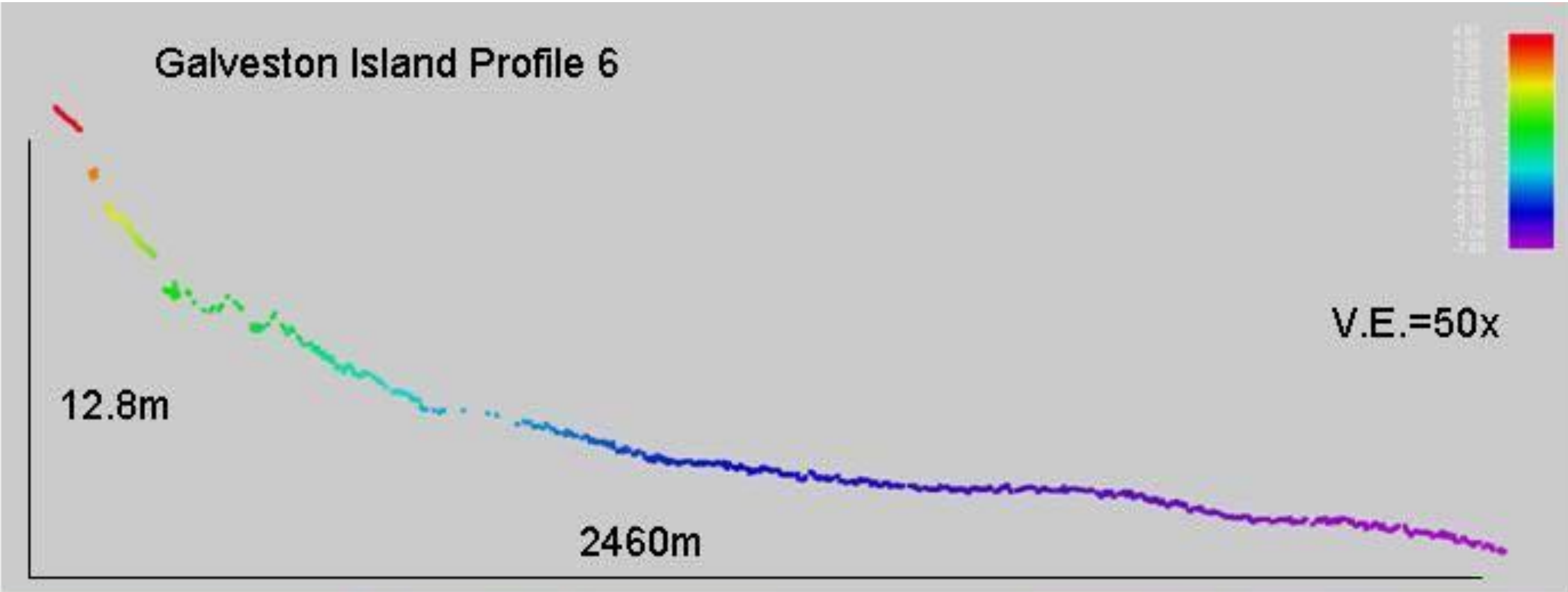

BLDG
Legend
Elevation (m)

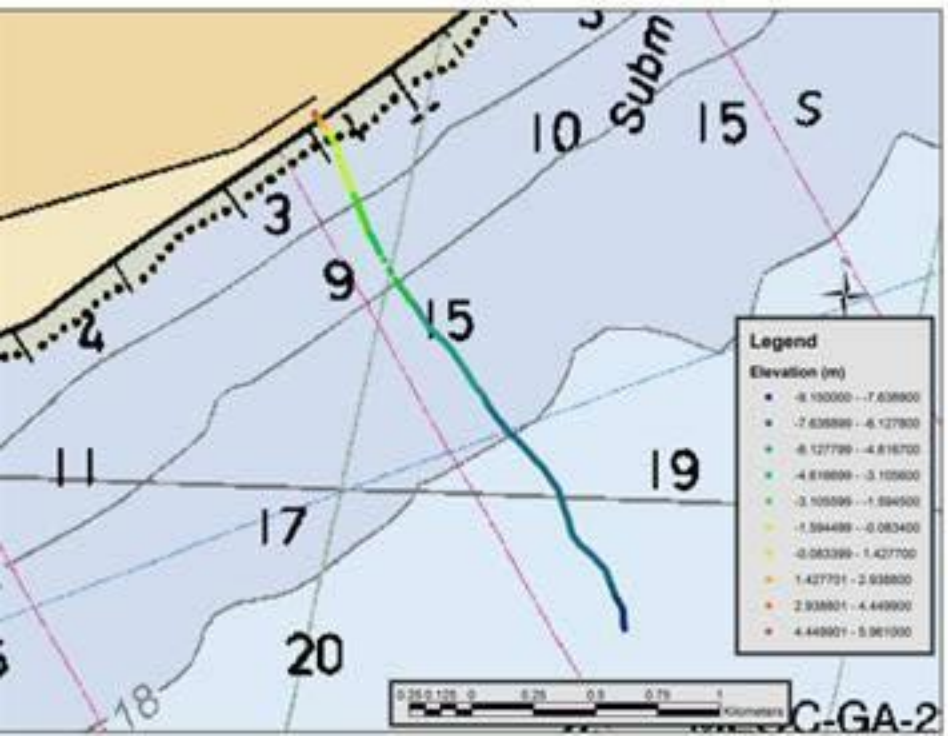

G.I. Profile 4
Legend
Elevation (m)

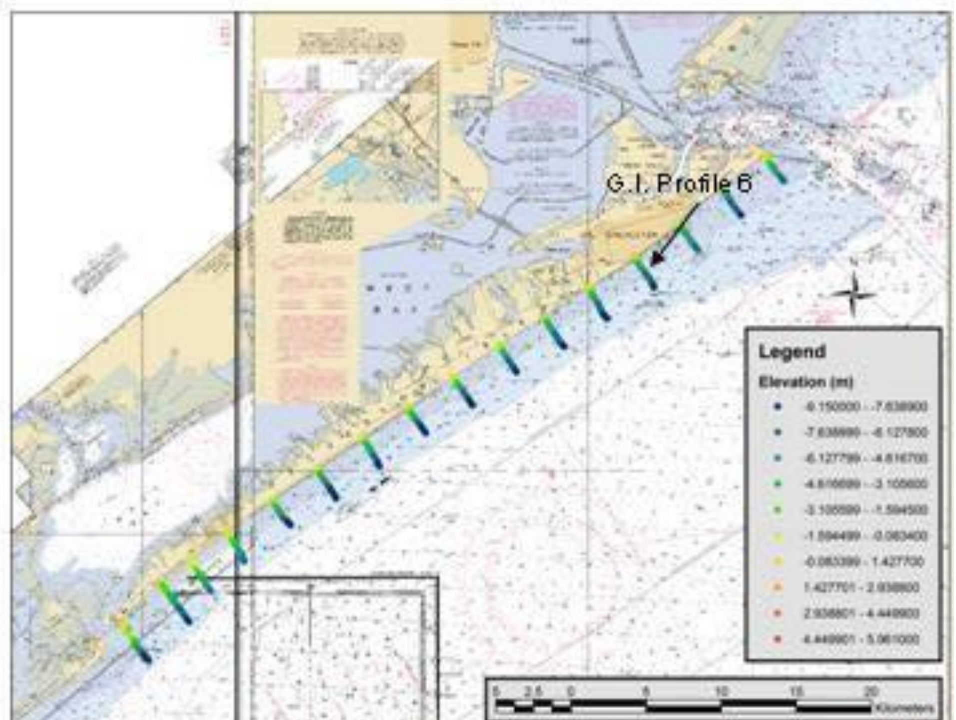

Galveston Island Profile 5
V.E.=50x
11.44m
2315m

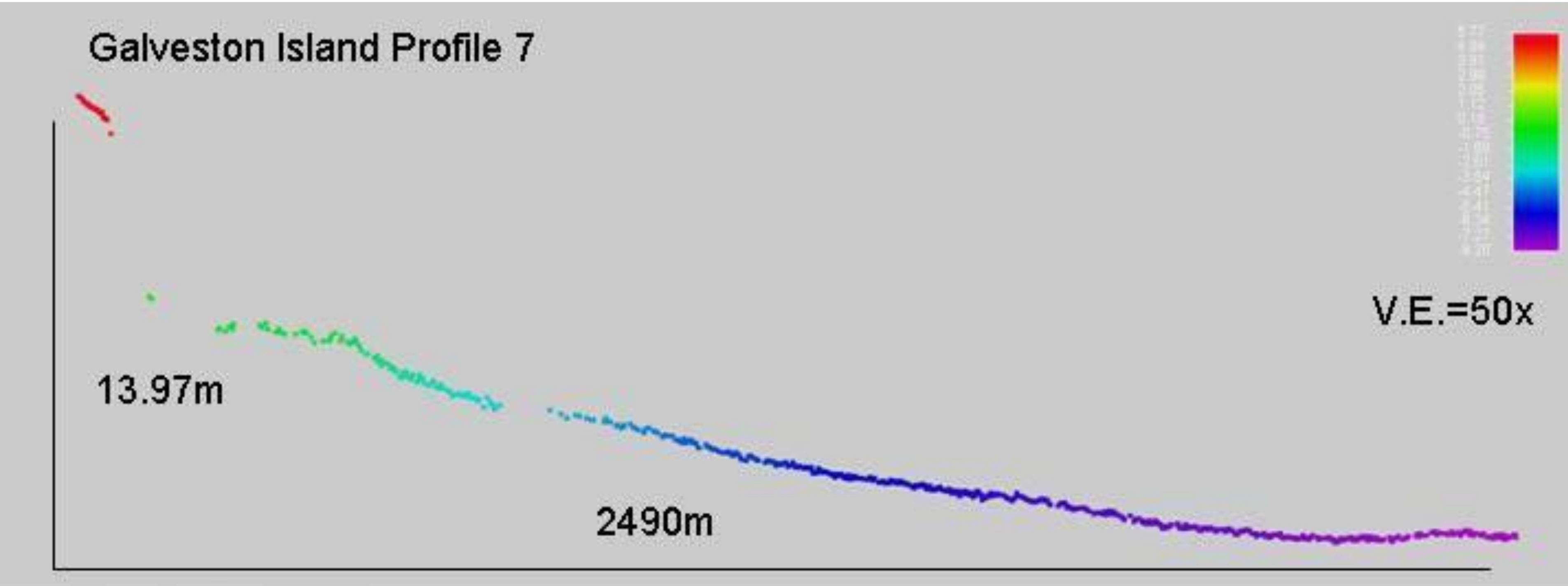

9
3
Subm piles
8
15
15
19
17
16
9
Legend
Elevation (m)

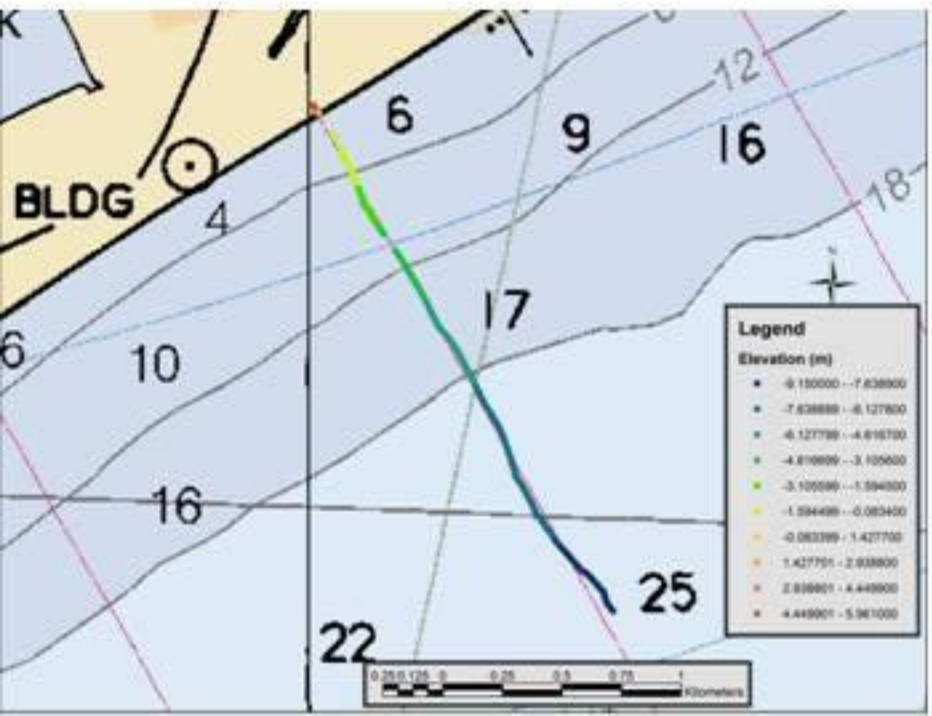

G.I. Profile 5
Legend
Elevation (m)

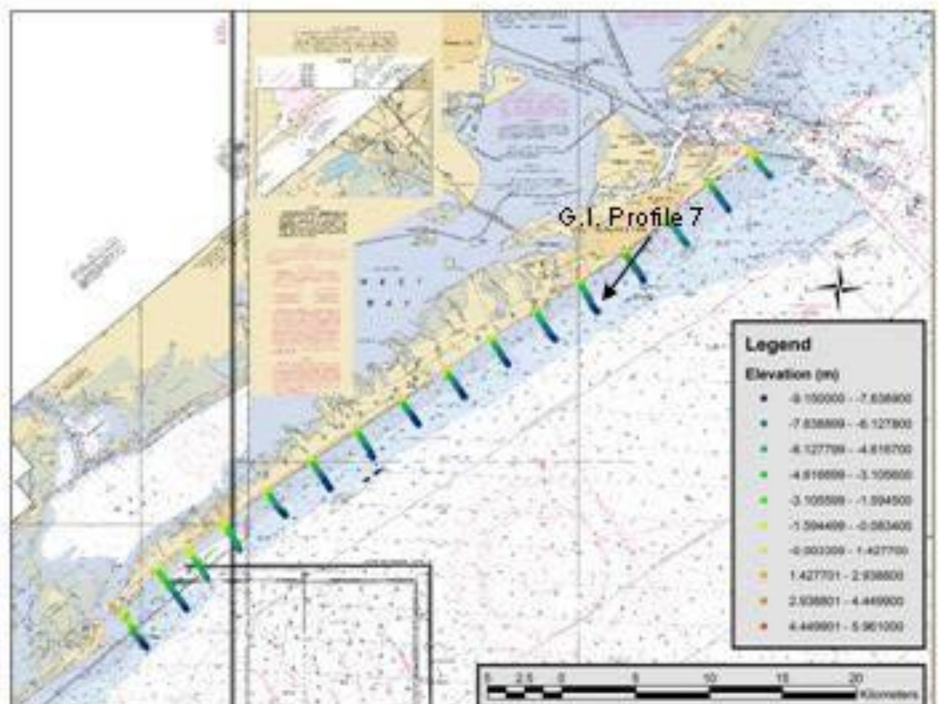

Galveston Island Profile 6
V.E.=50x
12.8m
2460m

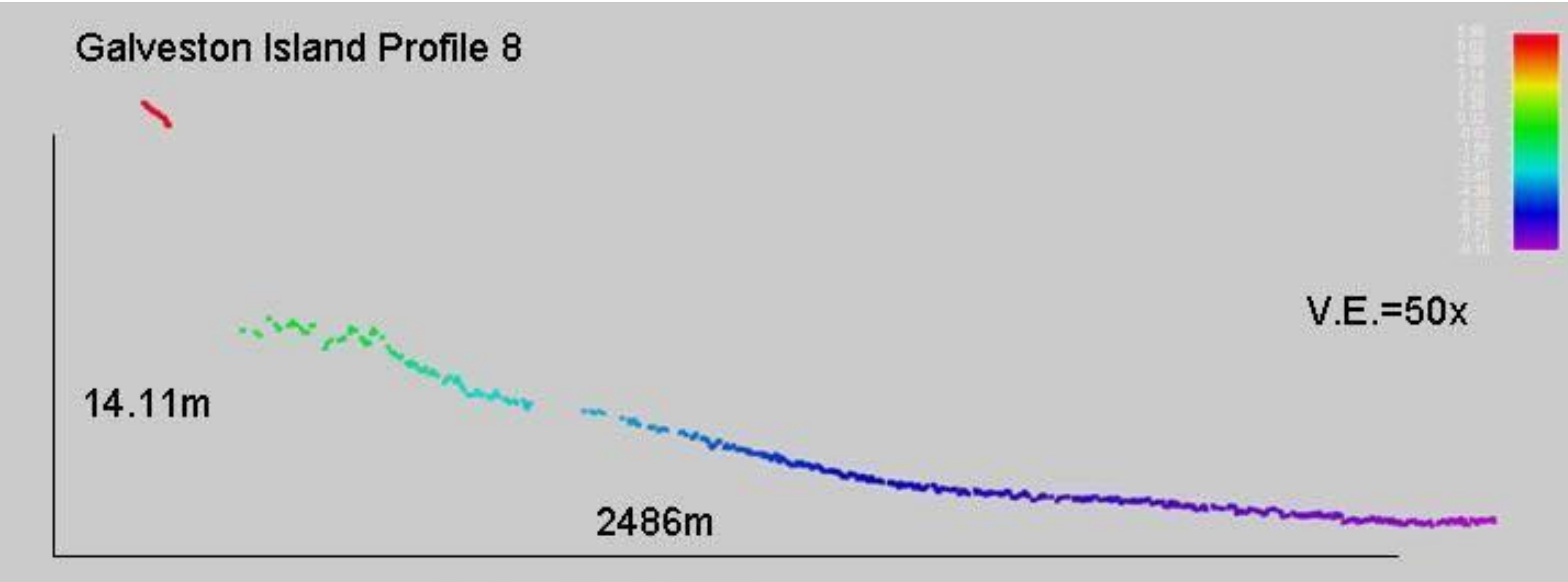

Legend
Elevation (m)
Kilometers

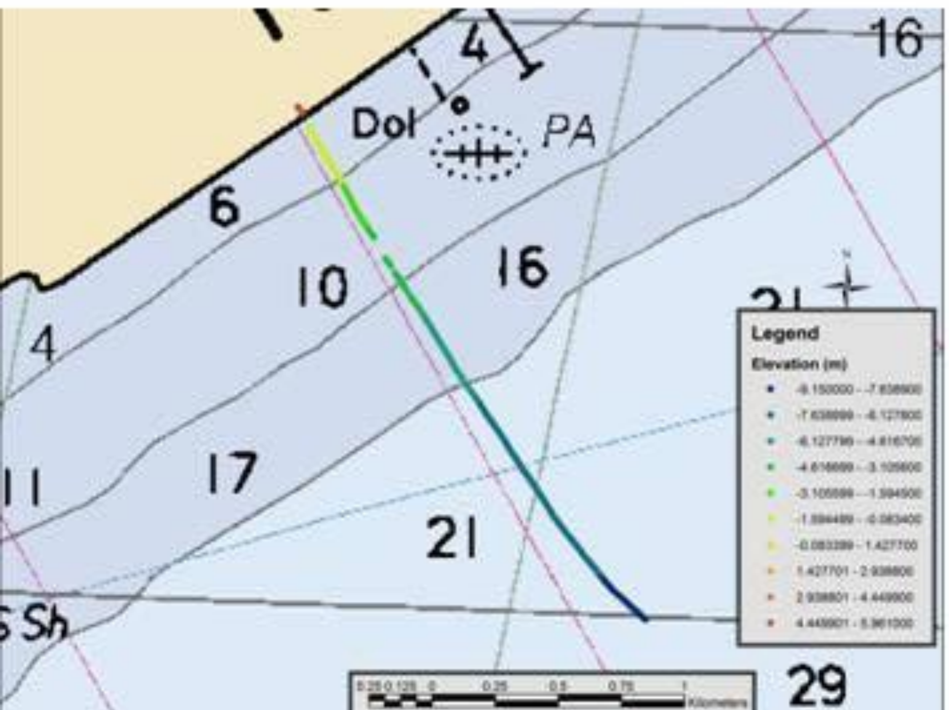

G.I. Profile 6
Legend
Elevation (m)
Kilometers

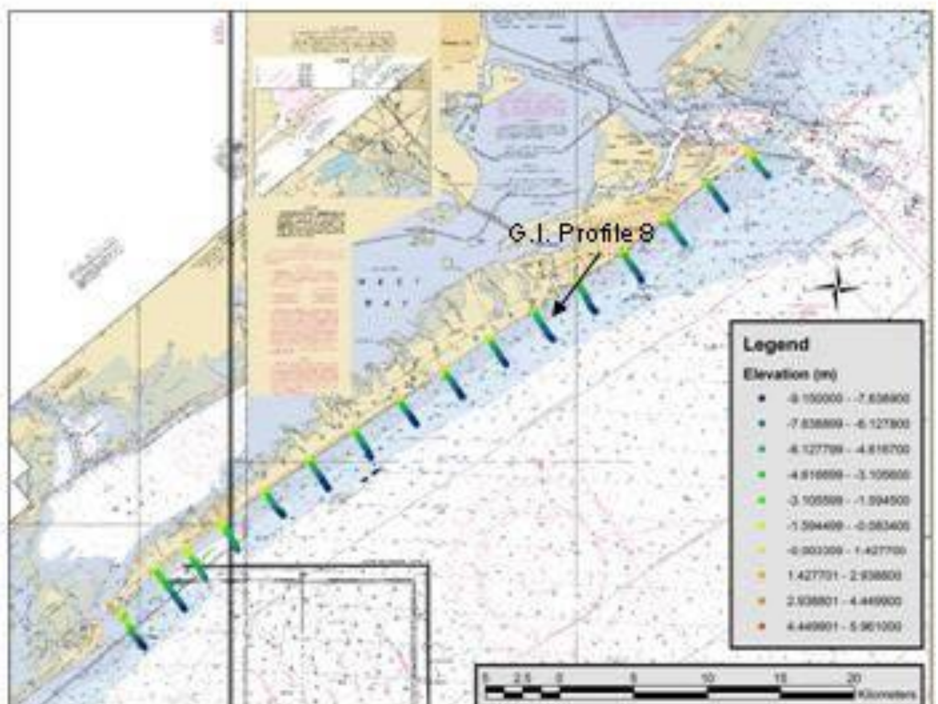

Galveston Island Profile 7
13.97m
2490m
V.E.=50x

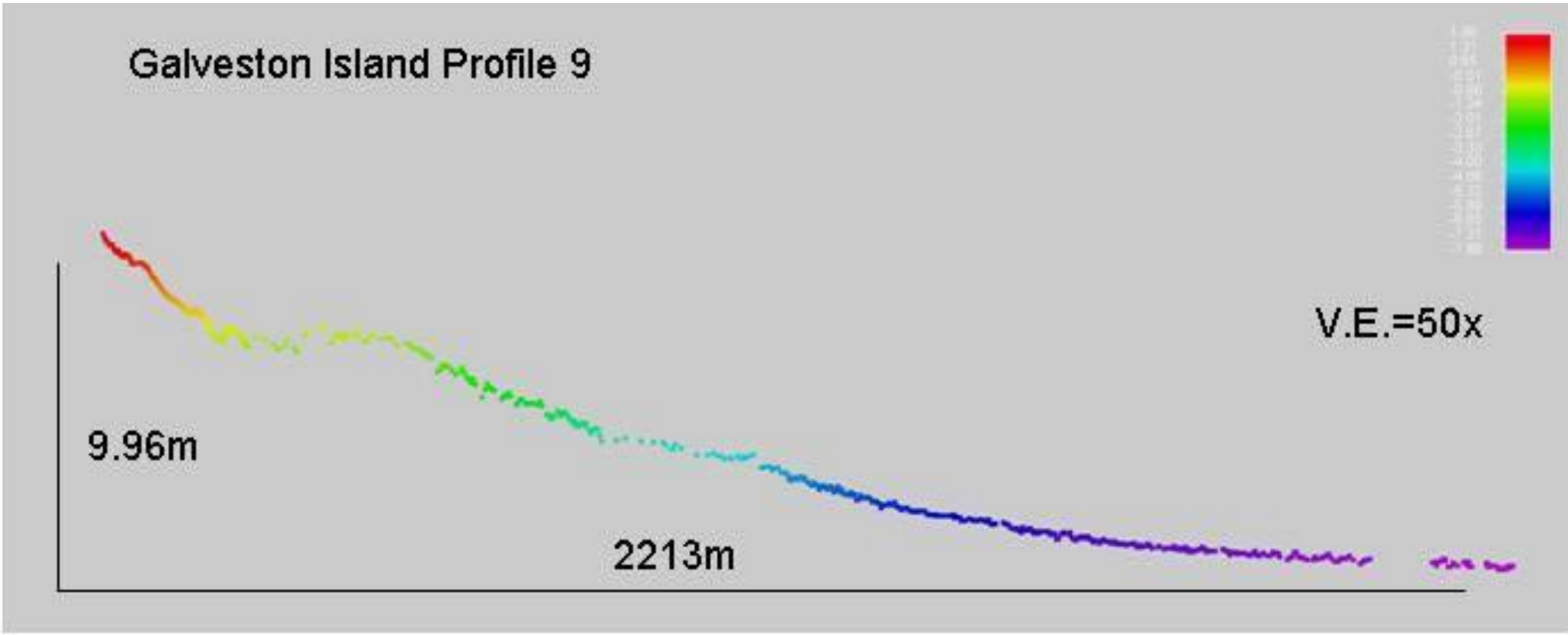

6
9
16
12
18
BLDG
4
17
10
16
25
22
Legend
Elevation (m)

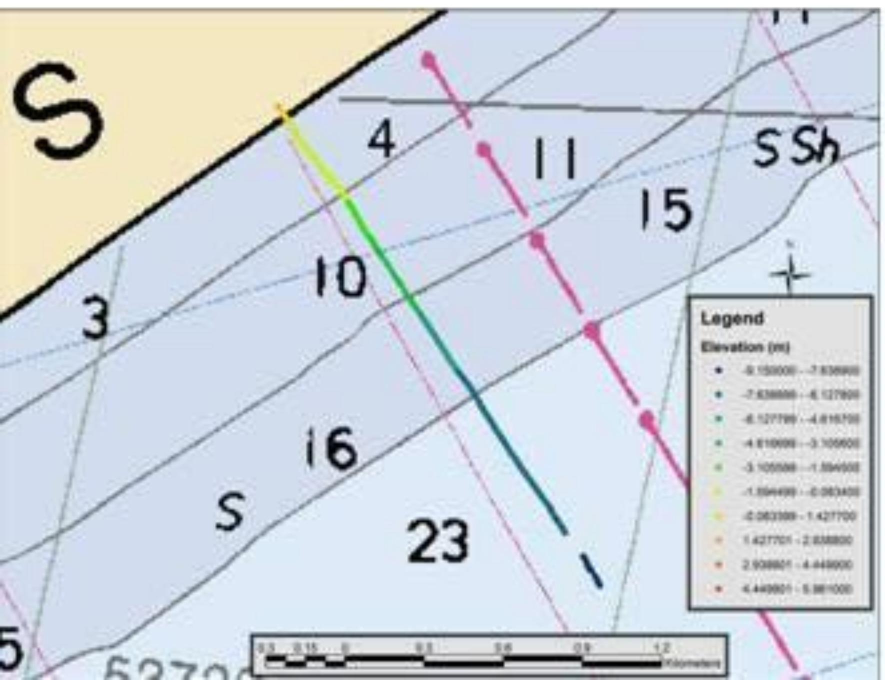

G.I. Profile 7
Legend
Elevation (m)

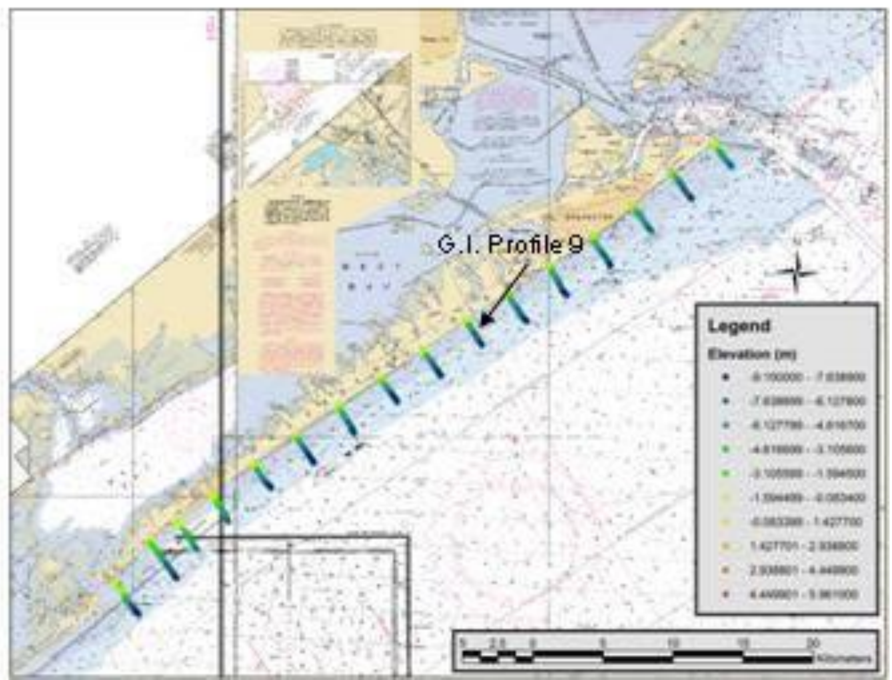

Galveston Island Profile 8
V.E.=50x
14.11m
2486m

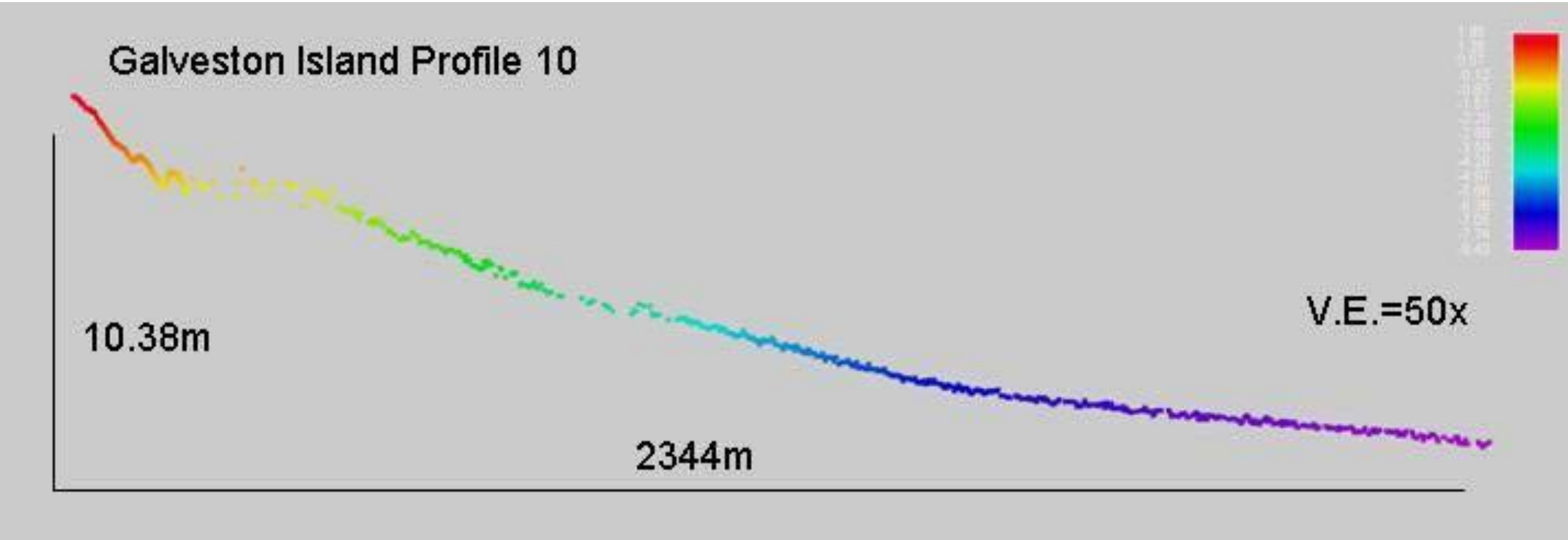

16
4
Dol
PA
6
10
16
4
17
21
11
Sh
29
Legend
Elevation (m)
-9.150000 - -7.638900
-7.638899 - -6.127800
-6.127799 - -4.616700
-4.616699 - -3.105600
-3.105599 - -1.594500
-1.594499 - -0.083400
-0.083399 - 1.427700
1.427701 - 2.938800
2.938801 - 4.449900
4.449901 - 5.961000
Kilometers

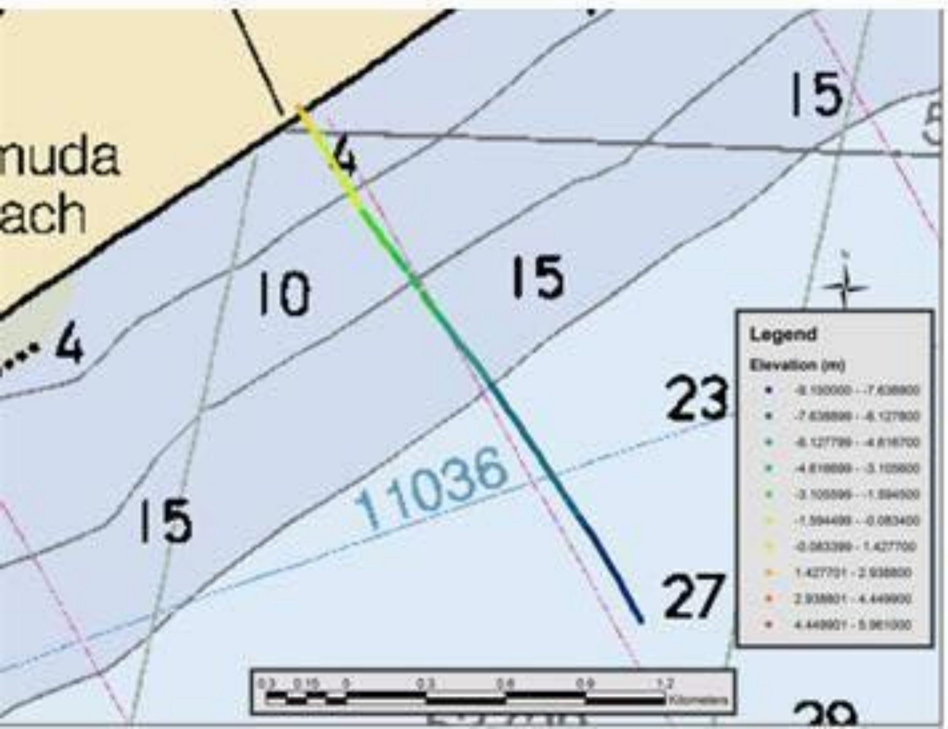

G.I. Profile 8
Legend
Elevation (m)
-9.150000 - -7.638900
-7.638899 - -6.127800
-6.127799 - -4.616700
-4.616699 - -3.105600
-3.105599 - -1.594500
-1.594499 - -0.083400
-0.083399 - 1.427700
1.427701 - 2.938800
2.938801 - 4.449900
4.449901 - 5.961000
0
5
10
15
20
Kilometers

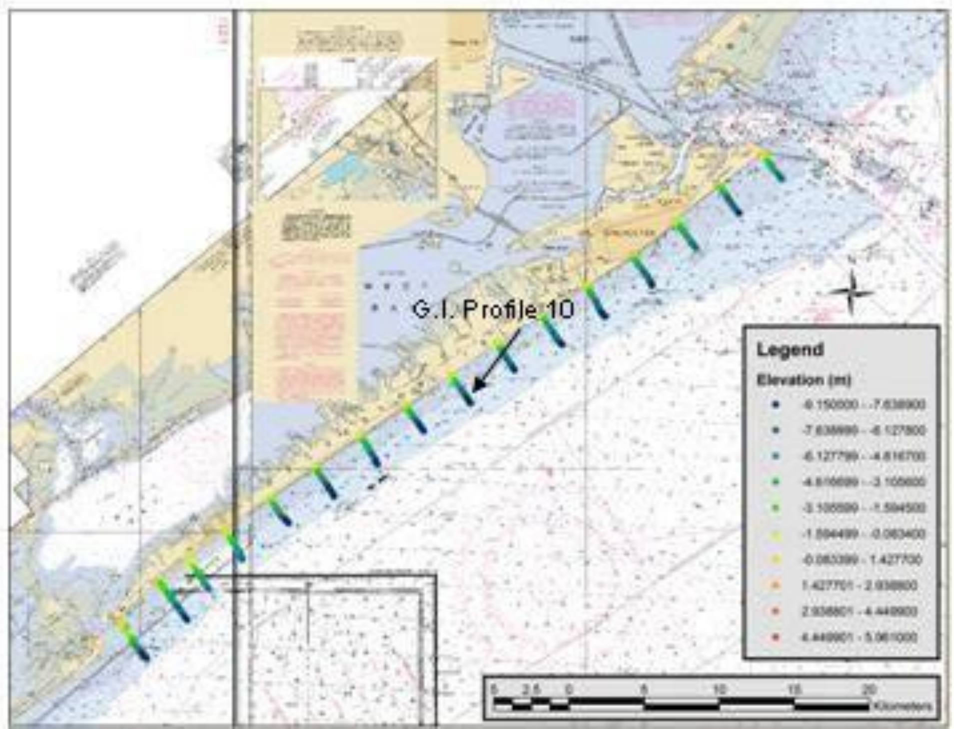

Galveston Island Profile 9
V.E.=50x
9.96m
2213m

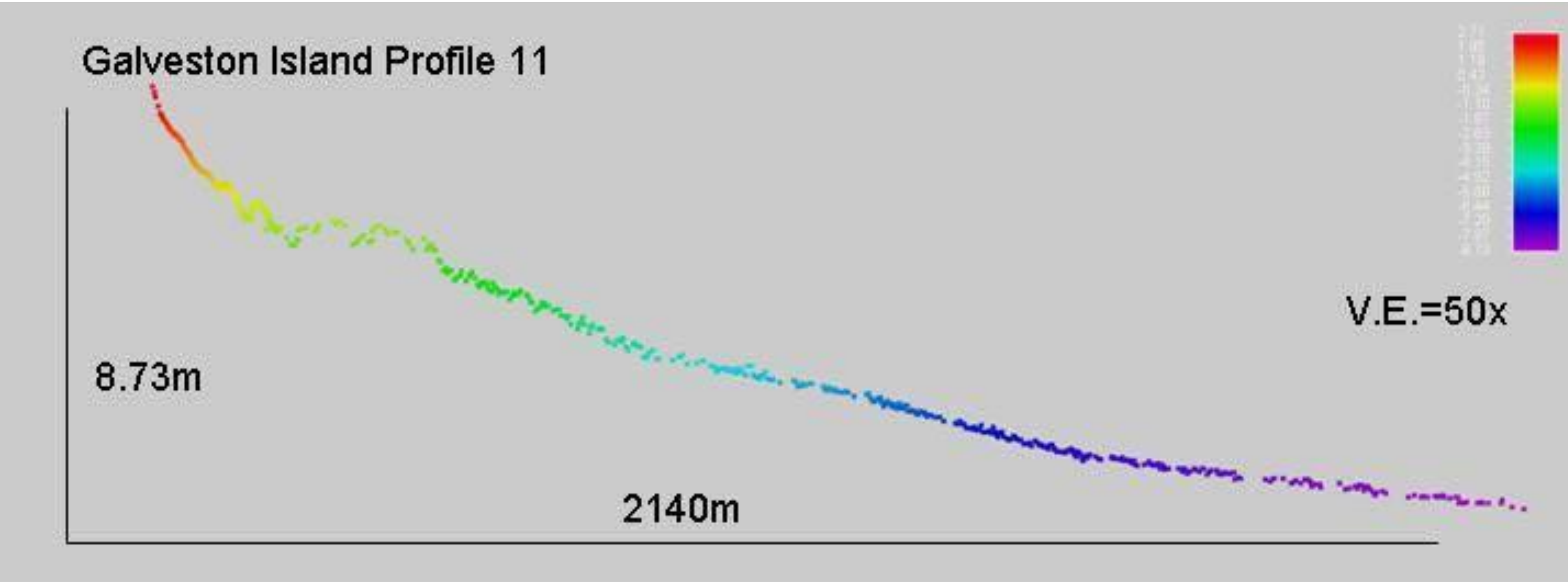

S
4
11
SSh
15
10
3
16
S
23
Legend
Elevation (m)

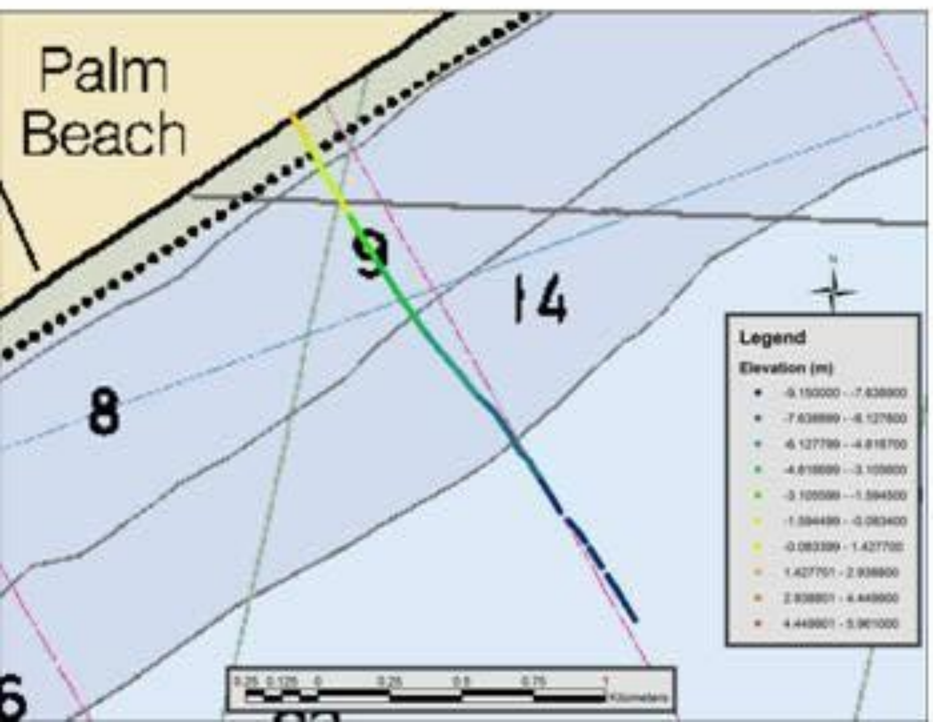

G.I. Profile 9
Legend
Elevation (m)

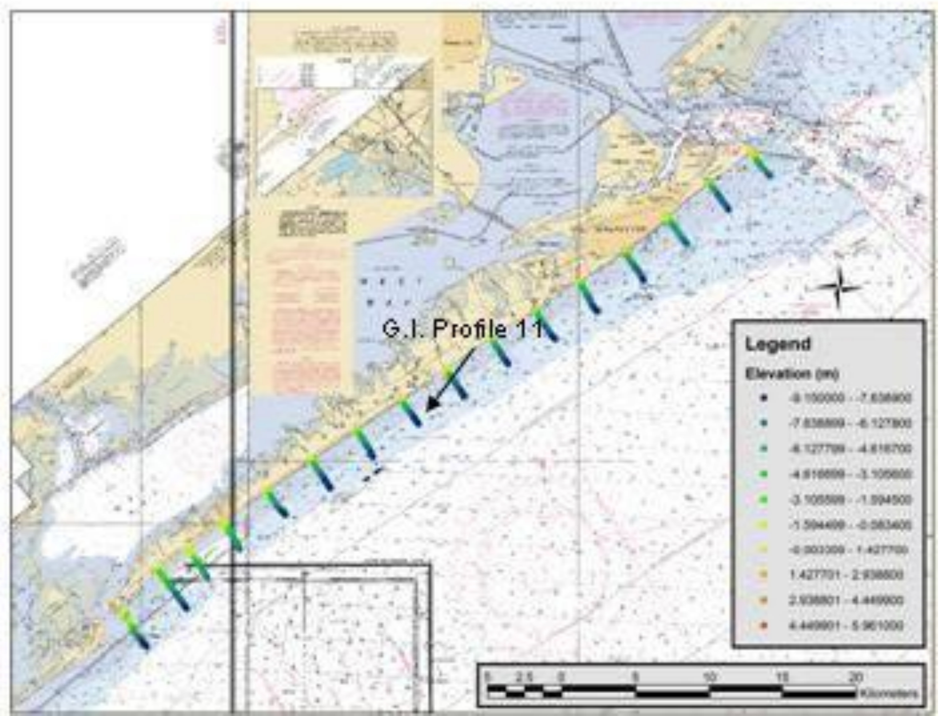

Galveston Island Profile 10
10.38m
2344m
V.E.=50x

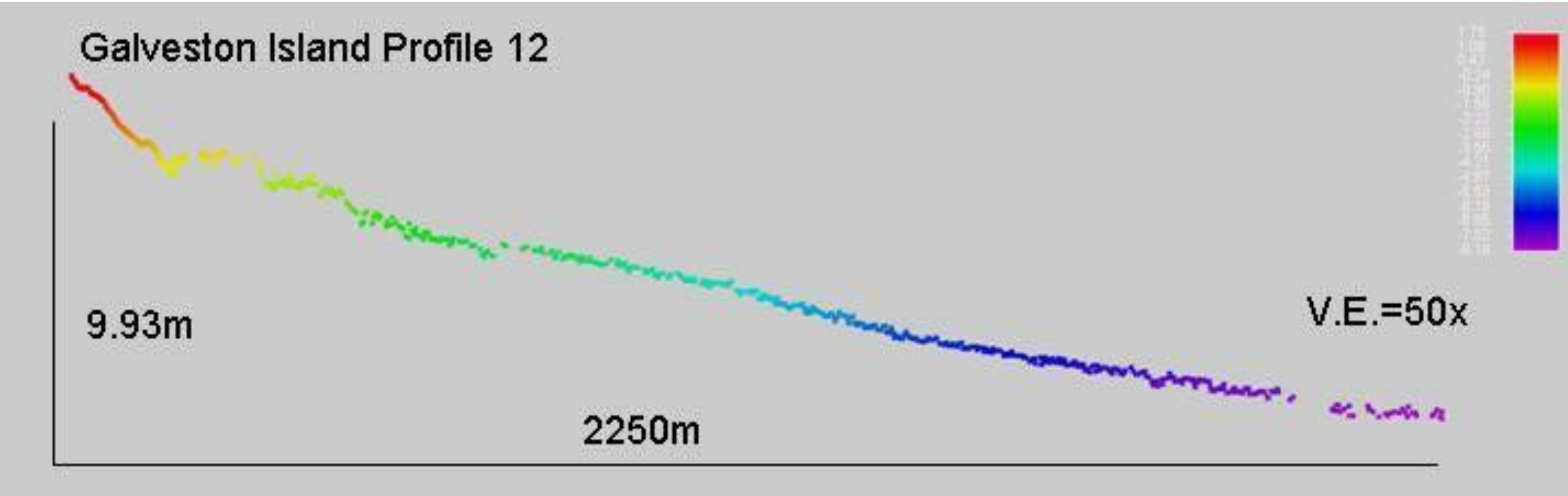

nuda
ach
4
10
15
15
15
4
23
27
11036
Legend
Elevation (m)

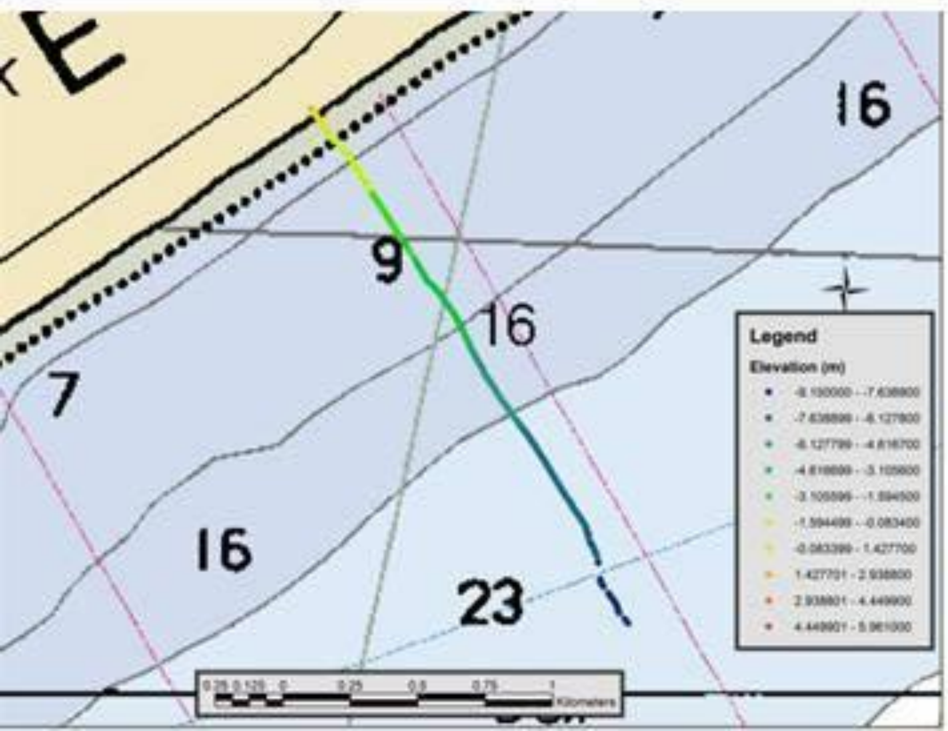

G.I. Profile 10
Legend
Elevation (m)

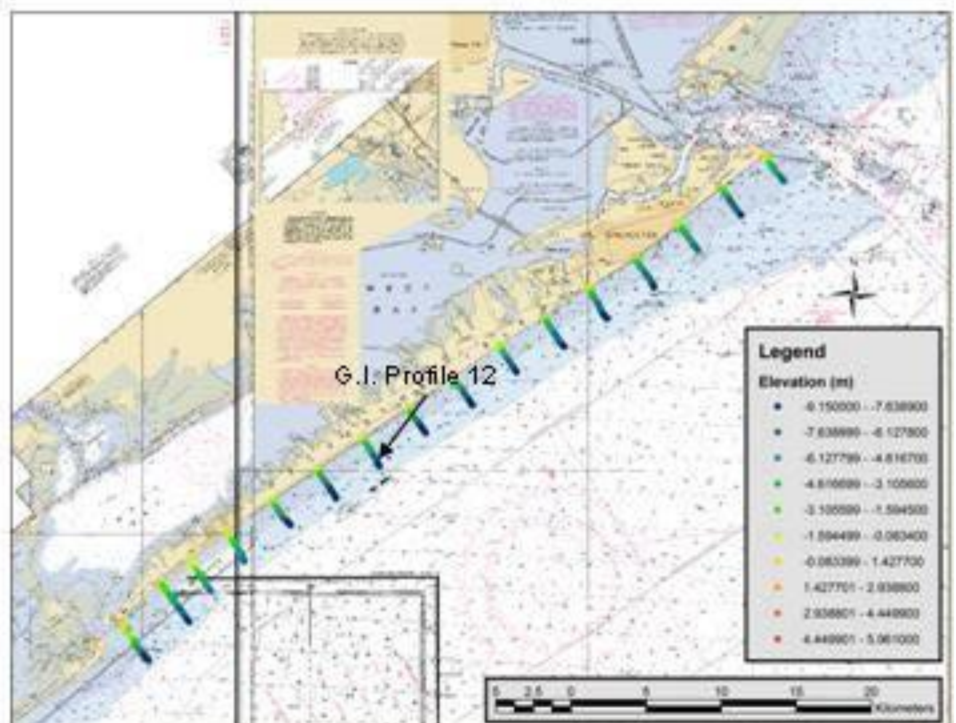

Galveston Island Profile 11
V.E.=50x
8.73m
2140m

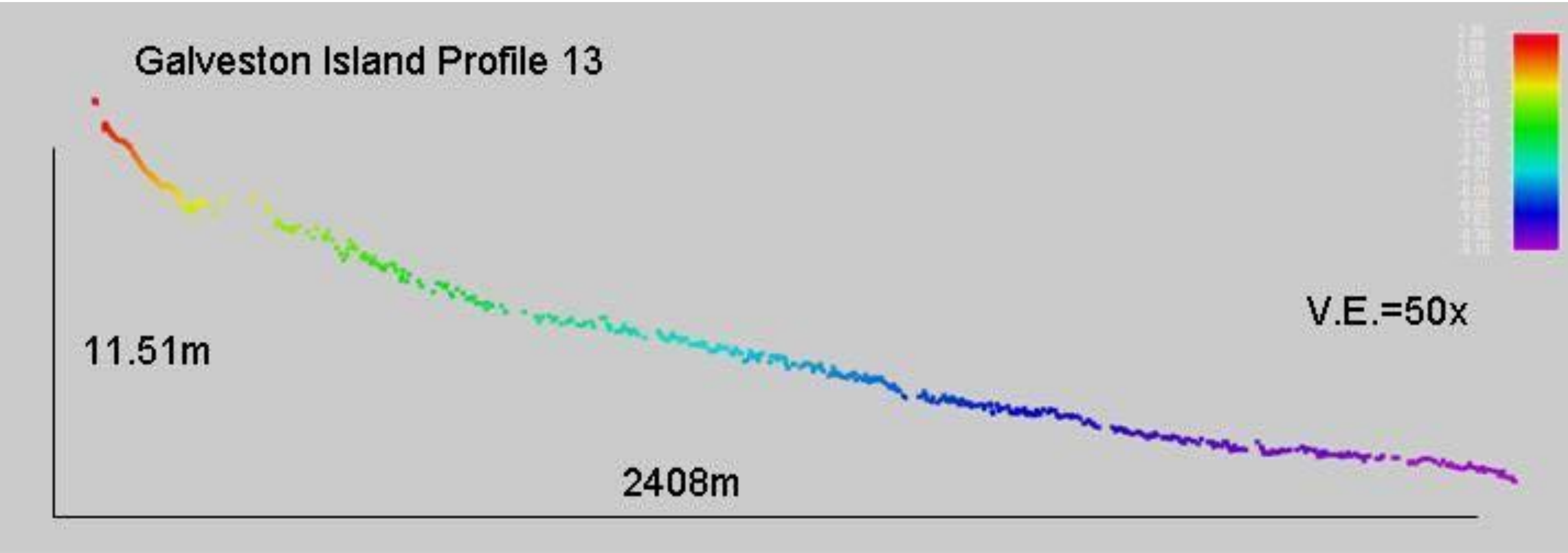

Palm Beach
9
14
8
Legend
Elevation (m)

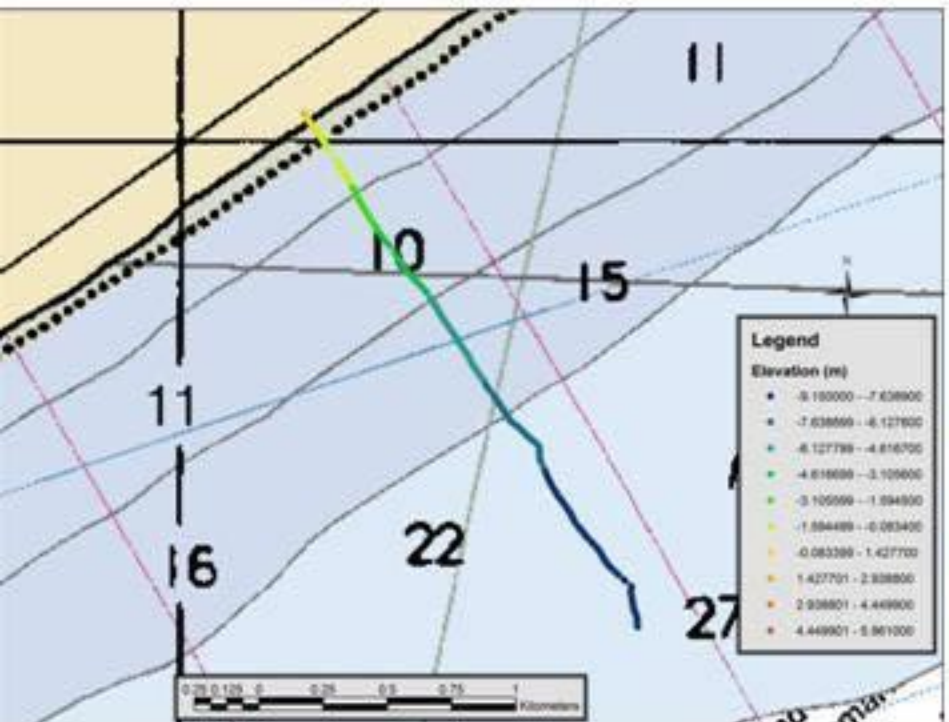

G.I. Profile 11
Legend
Elevation (m)

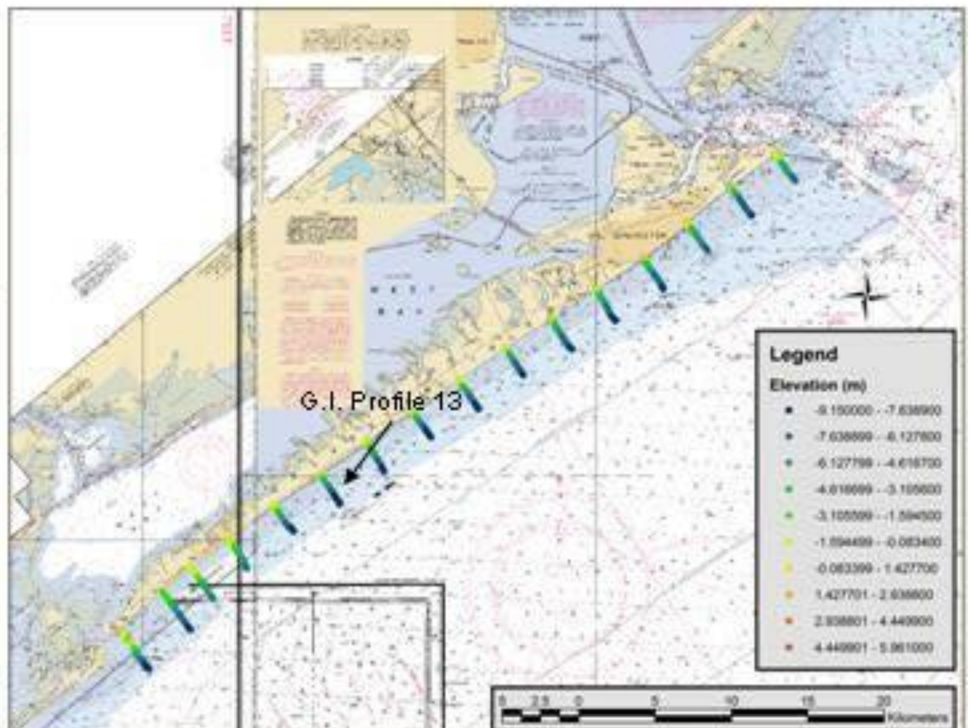

Galveston Island Profile 12
9.93m
2250m
V.E.=50x

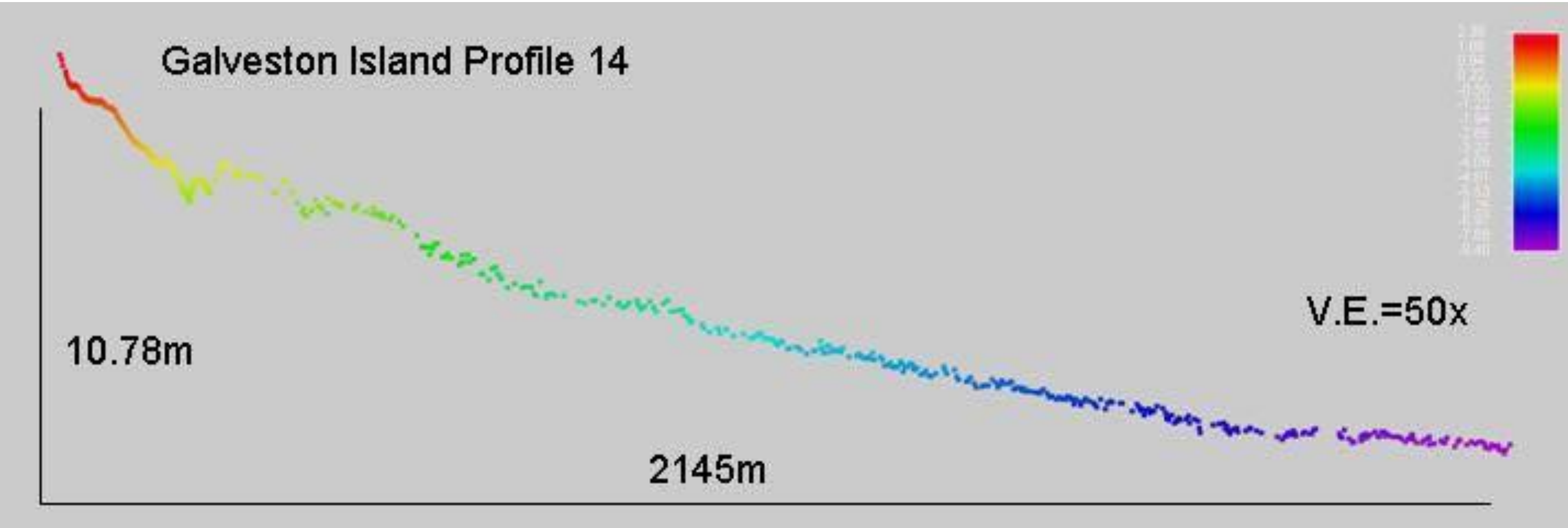

9
16
16
7
16
23
Legend
Elevation (m)
Kilometers

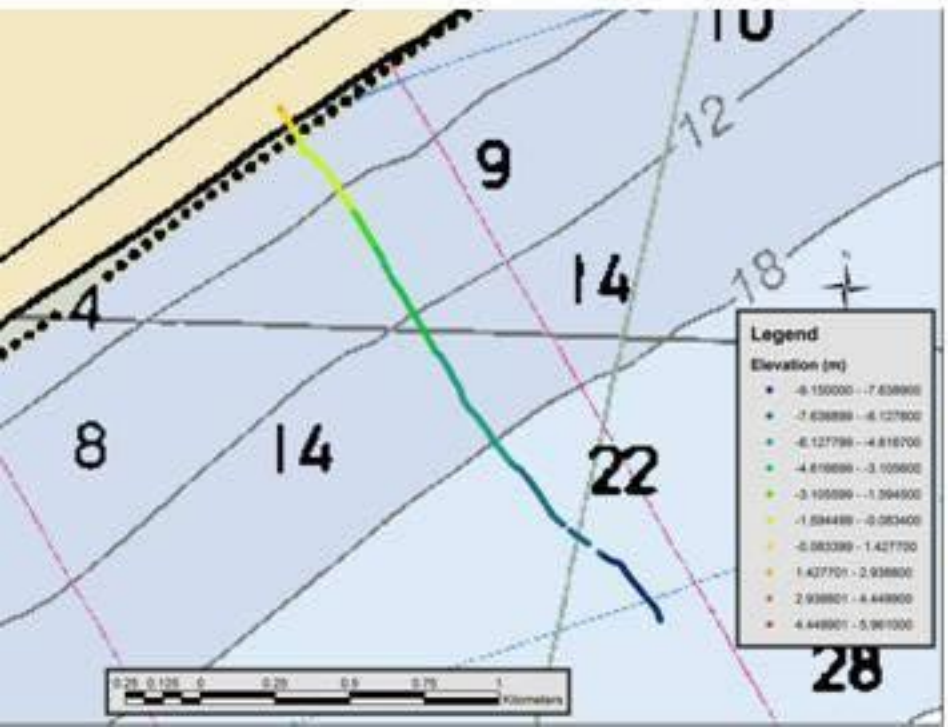

G.I. Profile 12
Legend
Elevation (m)
Kilometers

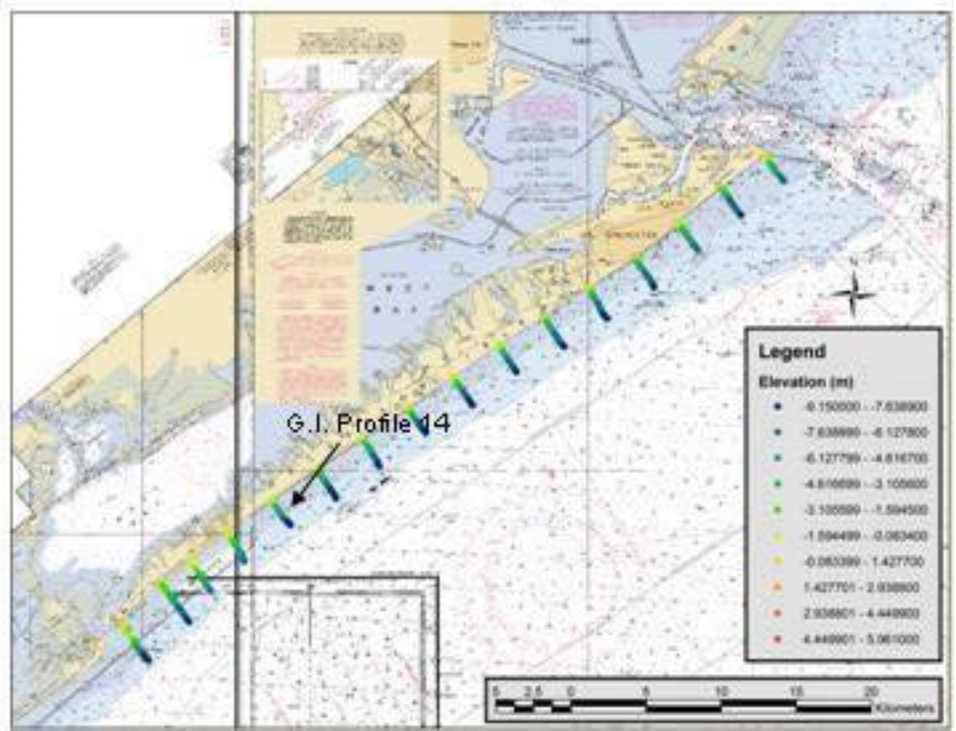

Galveston Island Profile 13
11.51m
2408m
V.E.=50x

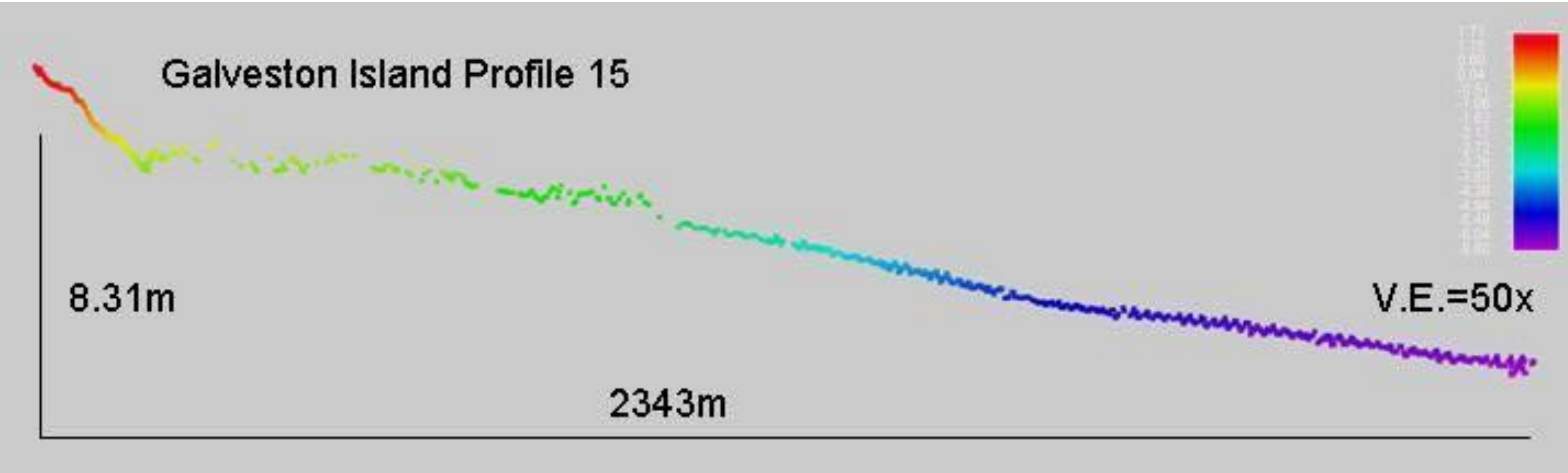

10
15
11
11
16
22
27
Legend
Elevation (m)
-9.150000 - -7.638900
-7.638899 - -6.127800
-6.127799 - -4.616700
-4.616699 - -3.105600
-3.105599 - -1.594500
-1.594499 - -0.083400
-0.083399 - 1.427700
1.427701 - 2.938800
2.938801 - 4.449900
4.449901 - 5.961000
Kilometers

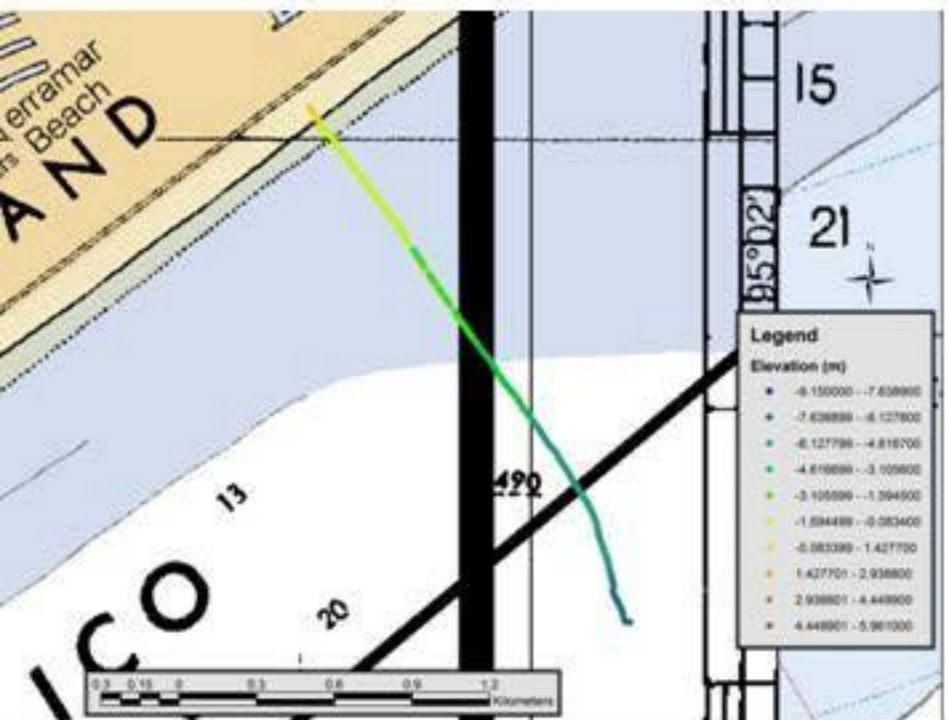

G.I. Profile 13
Legend
Elevation (m)
Kilometers

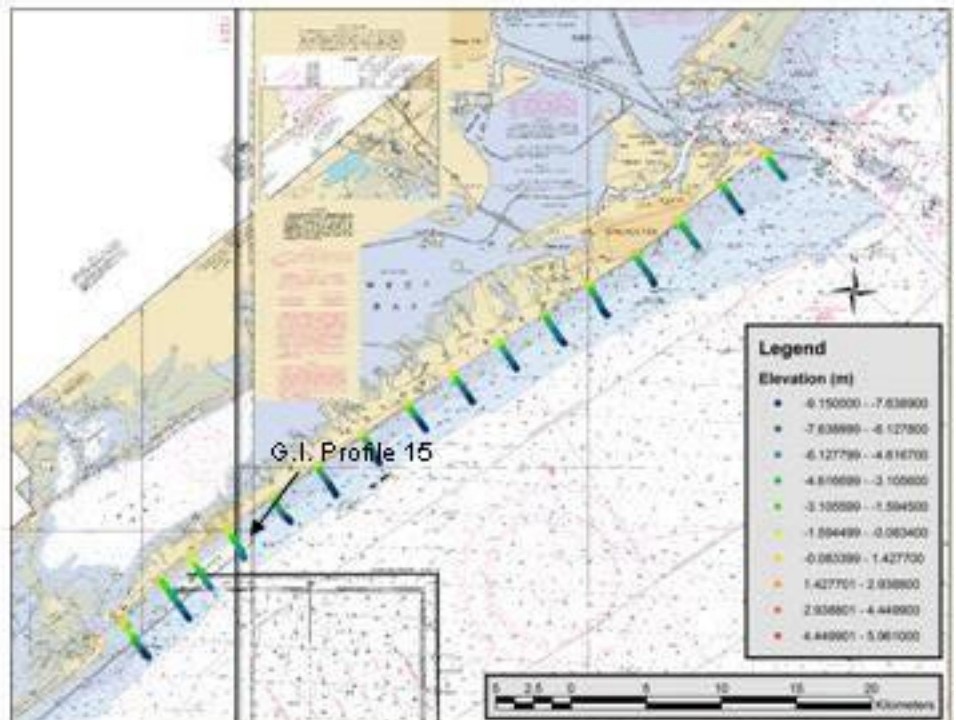

Galveston Island Profile 14
10.78m
2145m
V.E.=50x

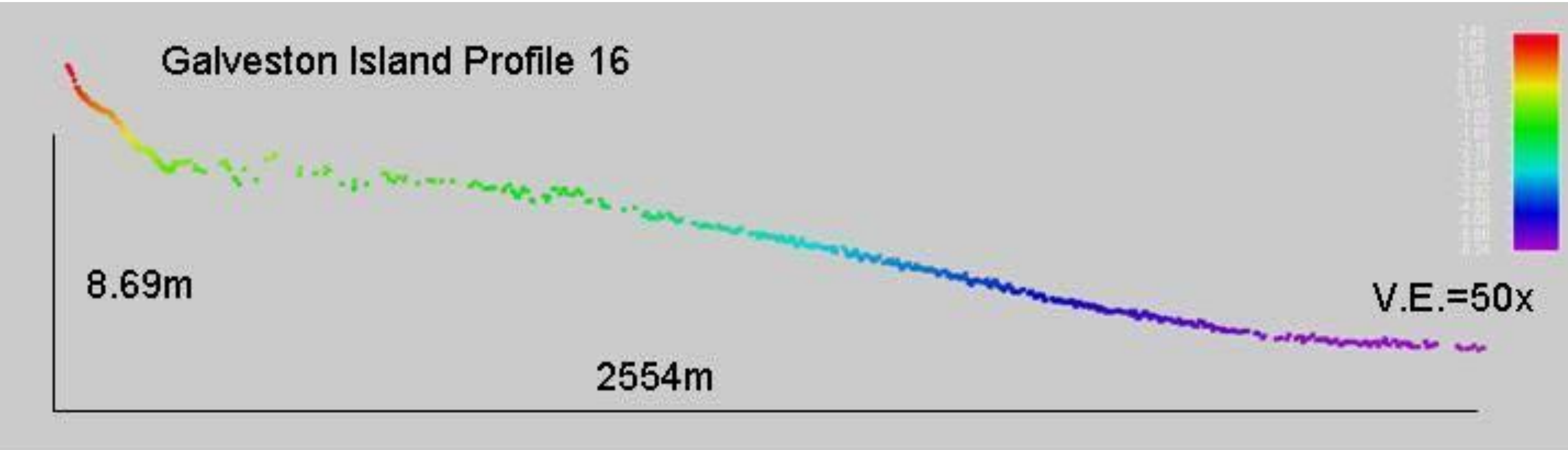

Legend
Elevation (m)
Kilometers

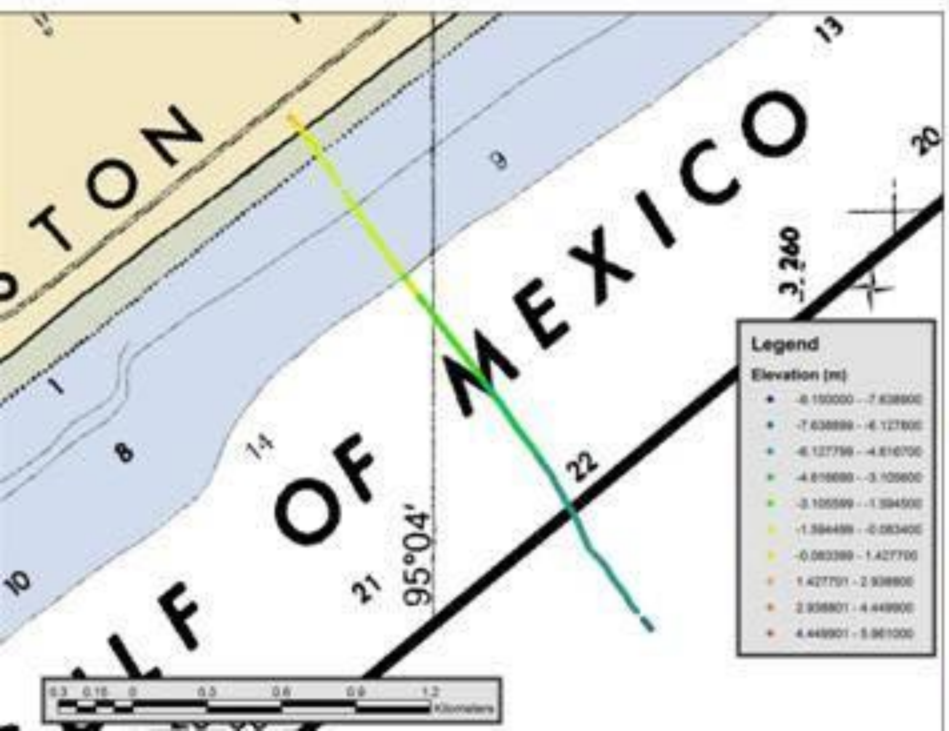

G.I. Profile 14
Legend
Elevation (m)
Kilometers

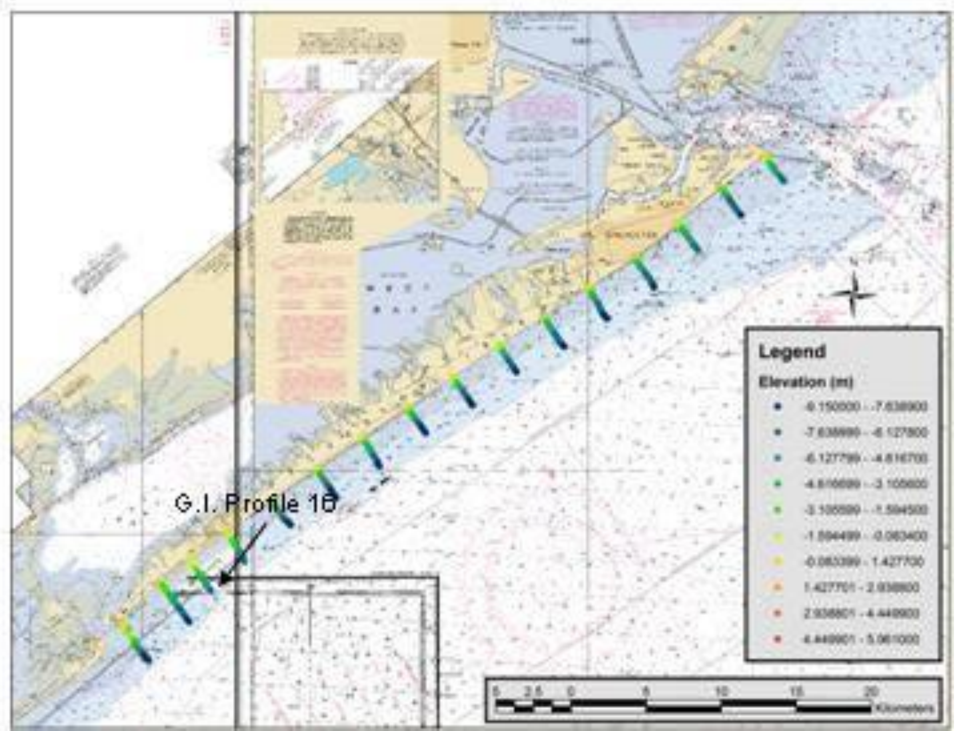

Galveston Island Profile 15
8.31m
V.E.=50x
2343m

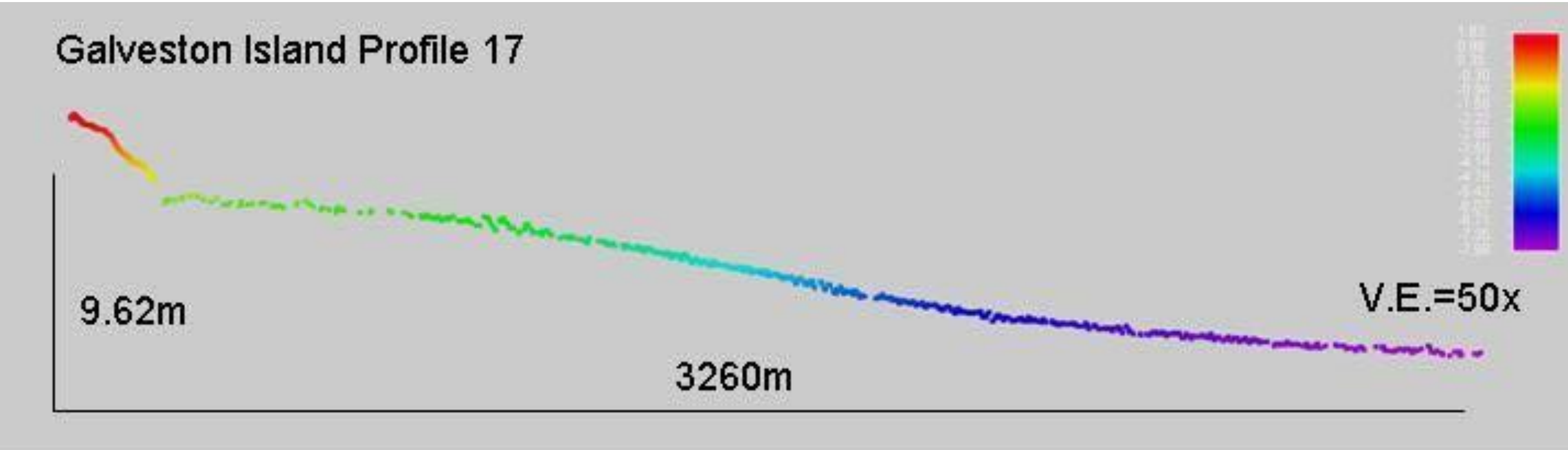

Beach
15
21
95°02'
Legend
Elevation (m)
13
20


G.I. Profile 15
Legend
Elevation (m)
Kilometers

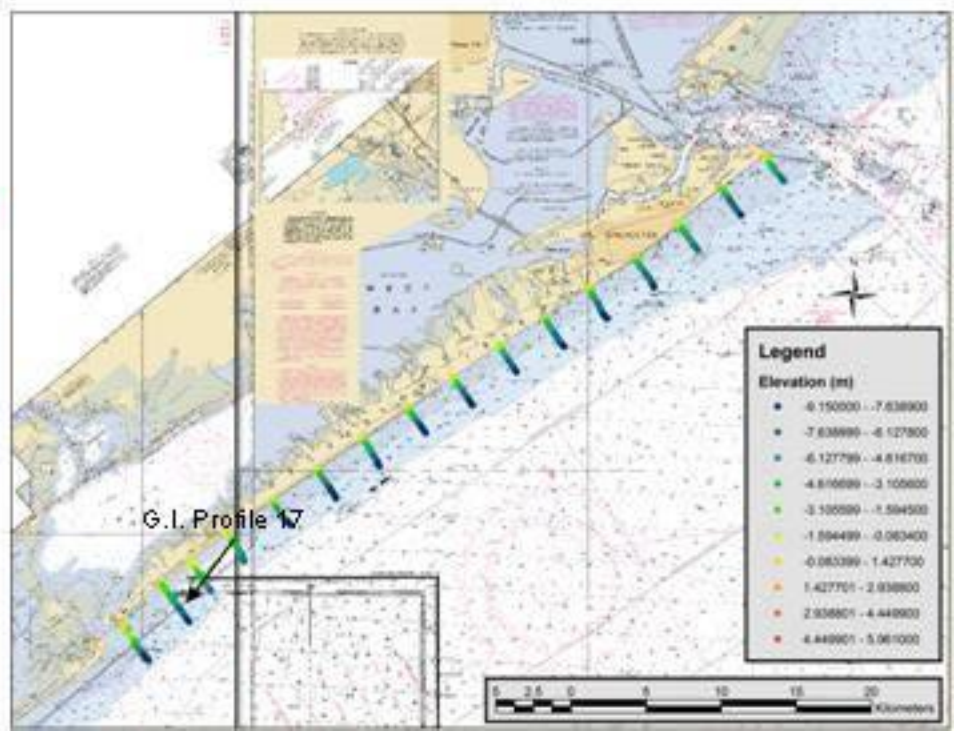

Galveston Island Profile 16
8.69m
2554m
V.E.=50x

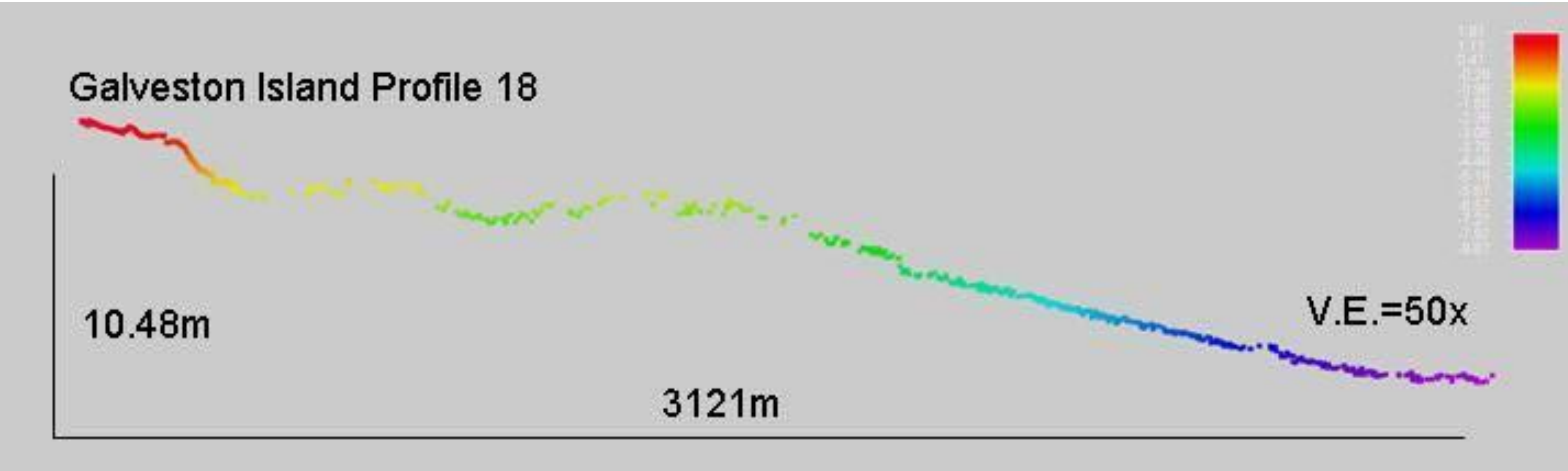

GALVESTON
GULF OF MEXICO
95°04'
Legend
Elevation (m)
-9.150000 - -7.638900
-7.638899 - -6.127800
-6.127799 - -4.616700
-4.616699 - -3.105600
-3.105599 - -1.594500
-1.594499 - -0.083400
-0.083399 - 1.427700
1.427701 - 2.938800
2.938801 - 4.449900
4.449901 - 5.961000
Kilometers

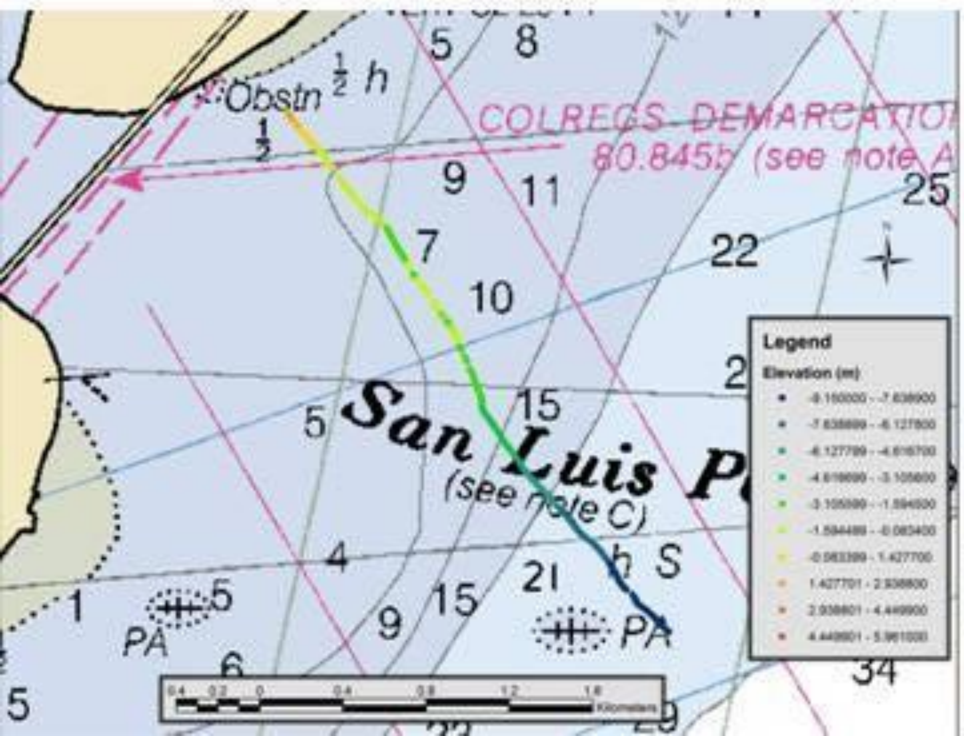

G.I. Profile 16
Legend
Elevation (m)
-9.150000 - -7.638900
-7.638899 - -6.127800
-6.127799 - -4.616700
-4.616699 - -3.105600
-3.105599 - -1.594500
-1.594499 - -0.083400
-0.083399 - 1.427700
1.427701 - 2.938800
2.938801 - 4.449900
4.449901 - 5.961000
Kilometers

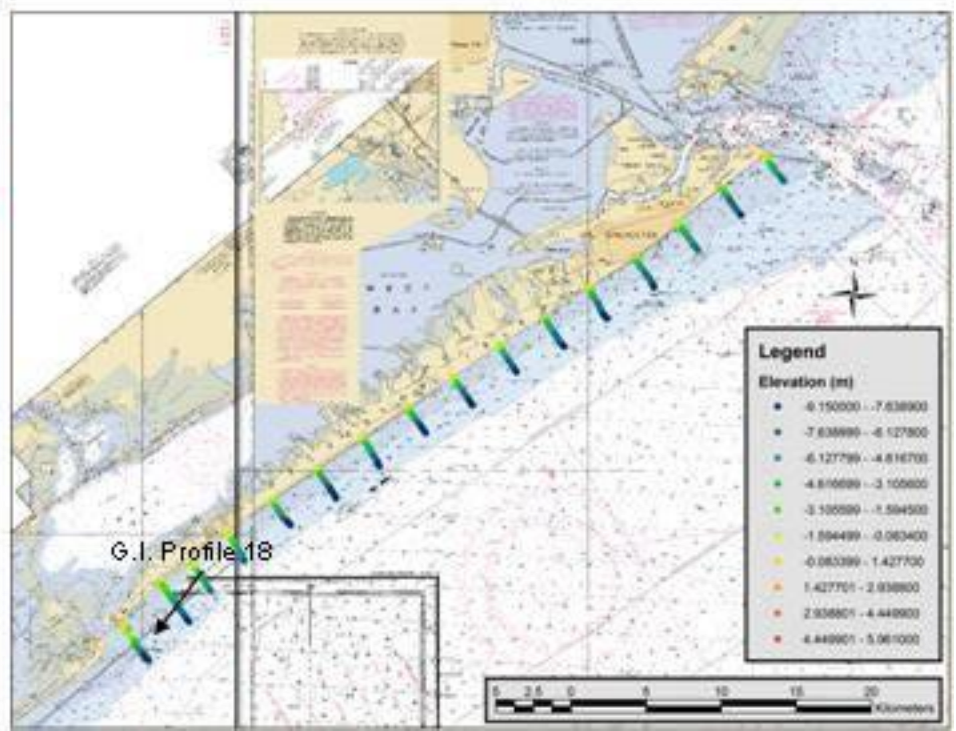

Galveston Island Profile 17
9.62m
3260m
V.E.=50x


GALV
GULF OF
95°04'
SEWAY
S-DEMARCATION LINE
Legend
Elevation (m)
14
25
26
29
34

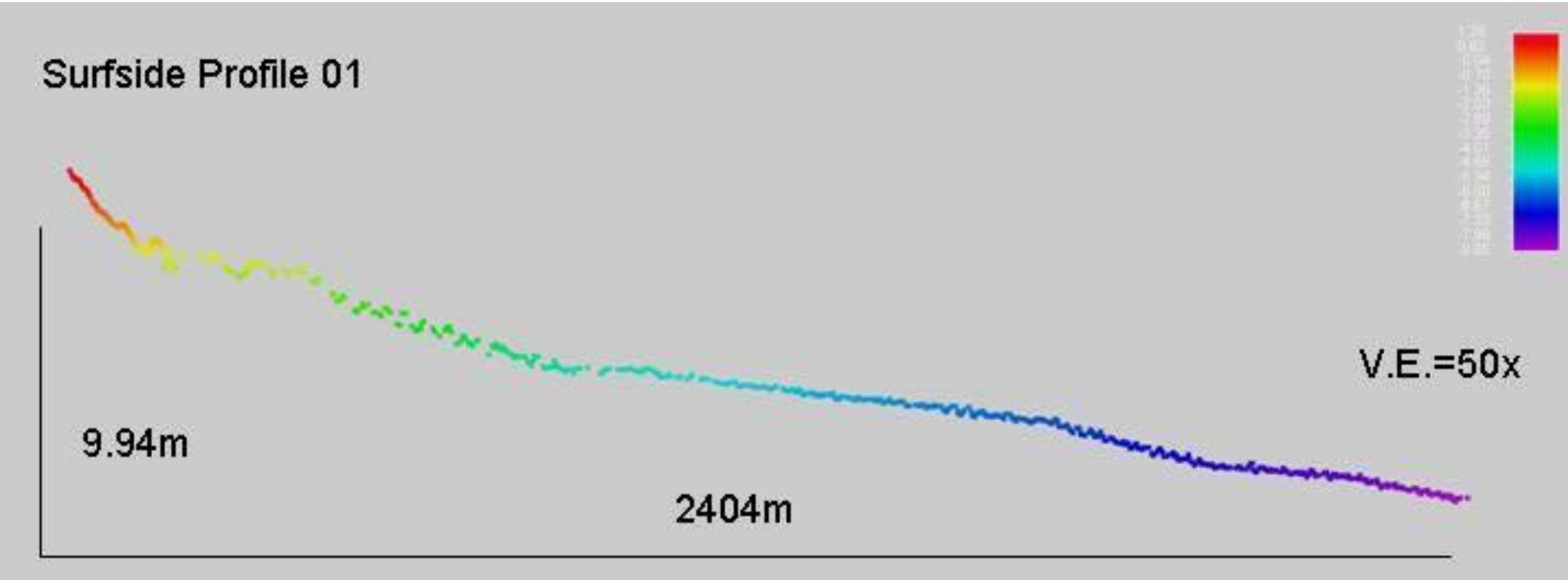

G.I. Profile 17
Legend
Elevation (m)

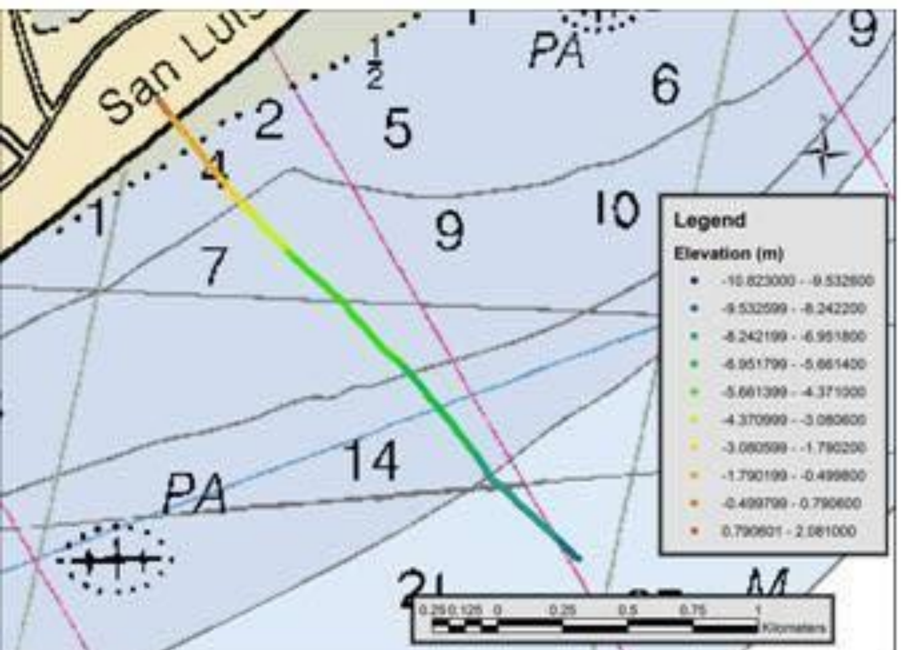

Galveston Island Profile 18
10.48m
3121m
V.E.=50x

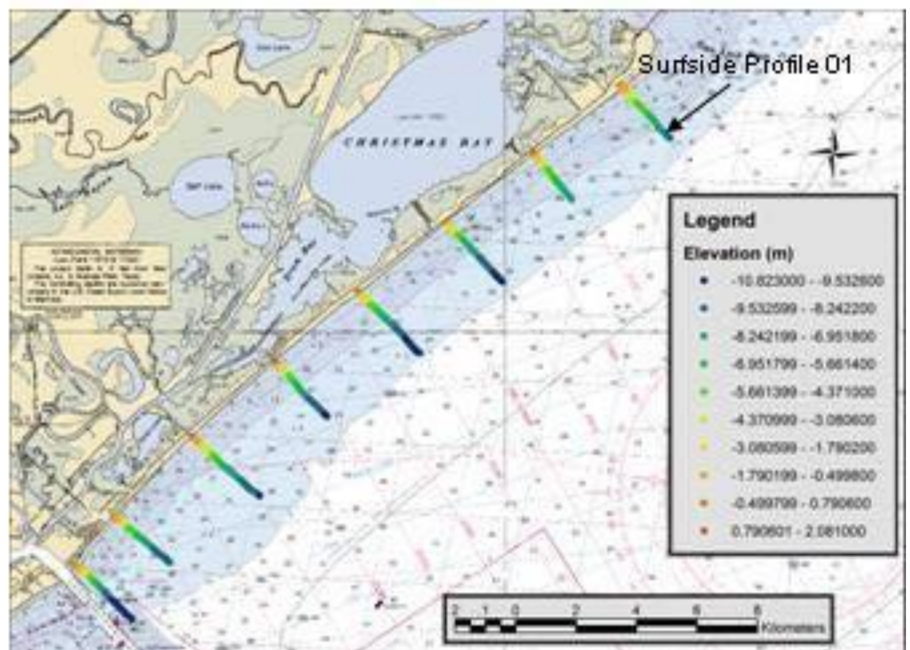

COLREGS DEMARCATION
80.845b (see note A
San Luis
(see note C)
Legend
Elevation (m)

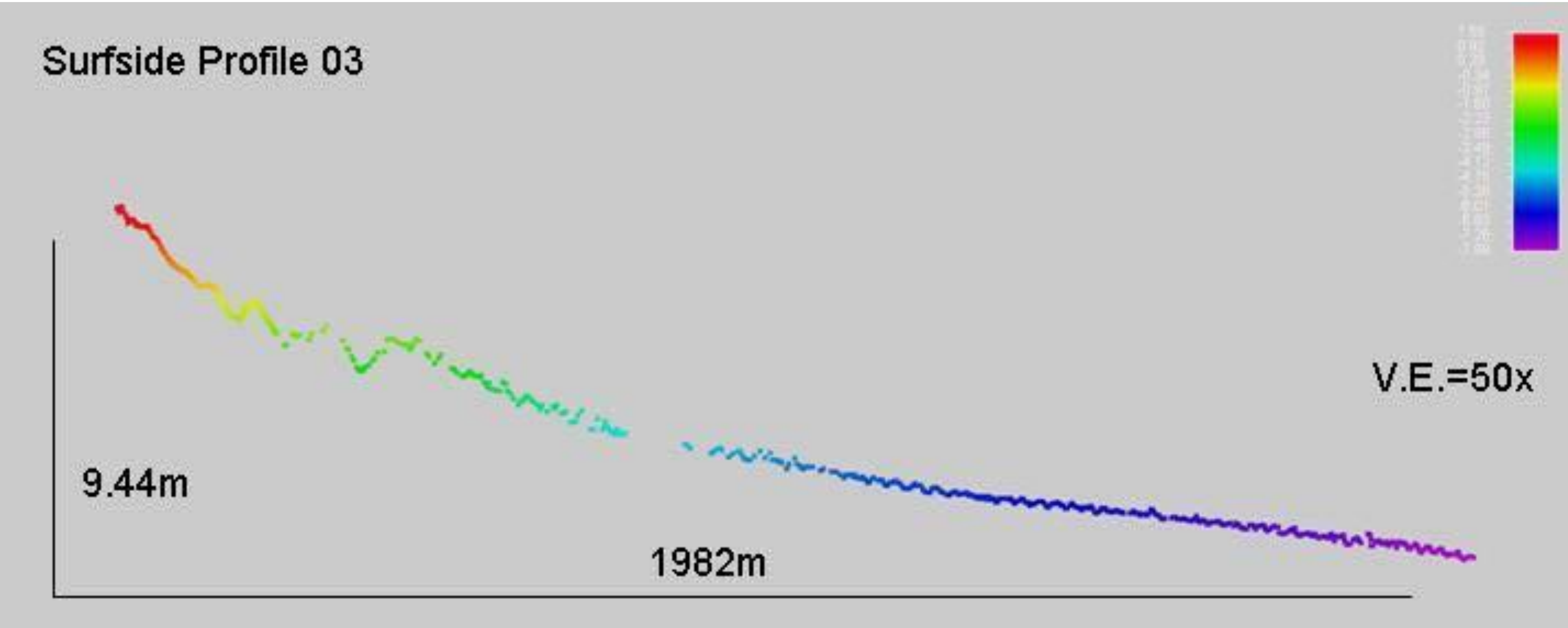

G.I. Profile 18
Legend
Elevation (m)

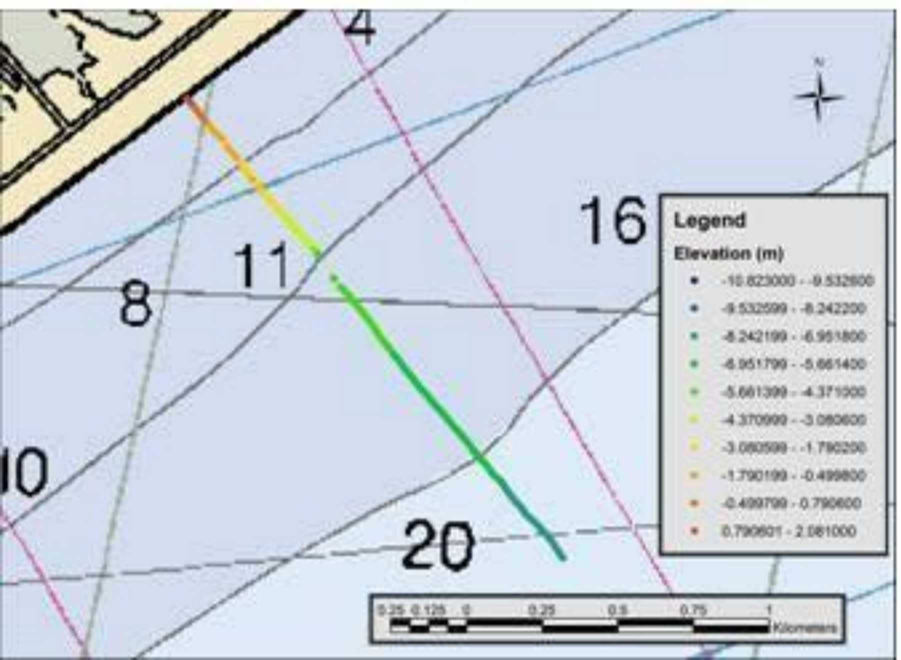
Appendix C **Follett's Island (Surfside Profiles)**

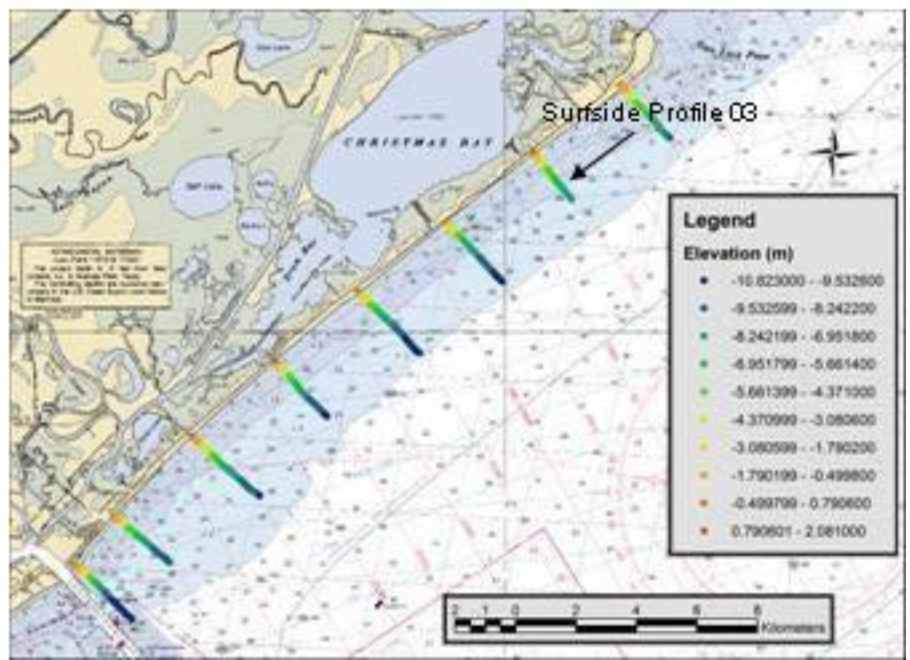

Surfside Profile 01
V.E.=50x
9.94m
2404m

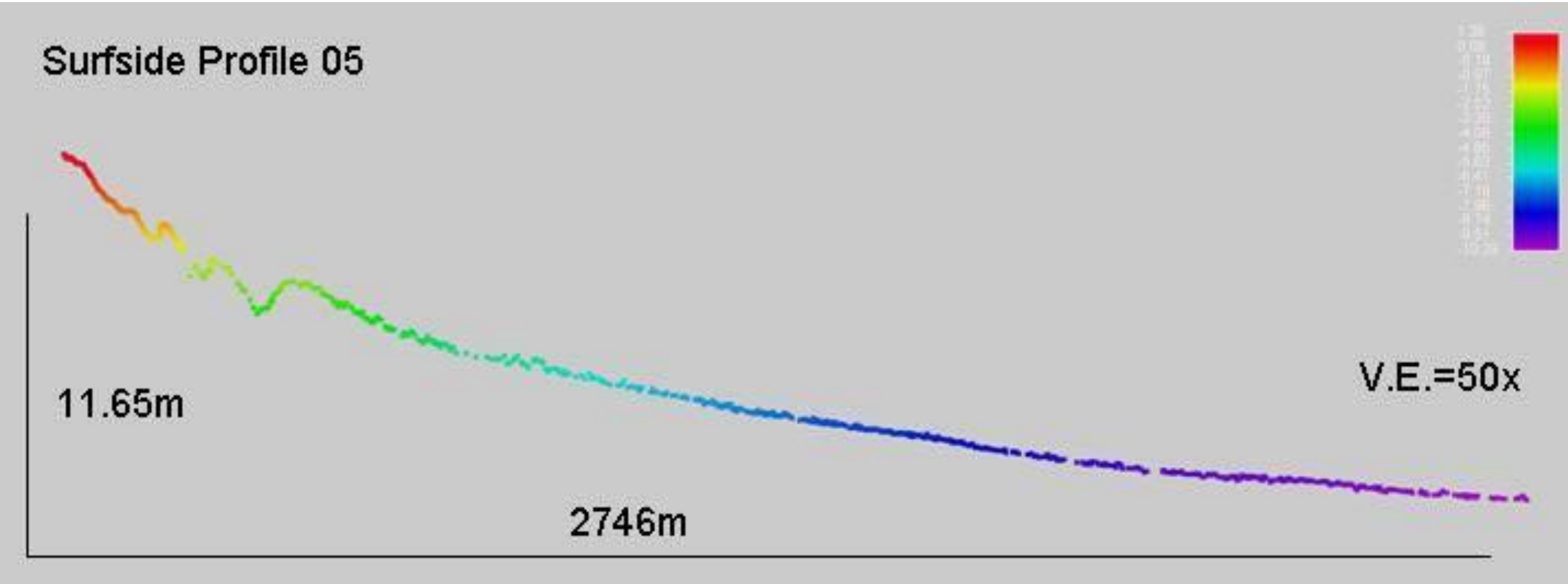

San Luis
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers


Surfside Profile 01
CHRISTMAS BAY
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers

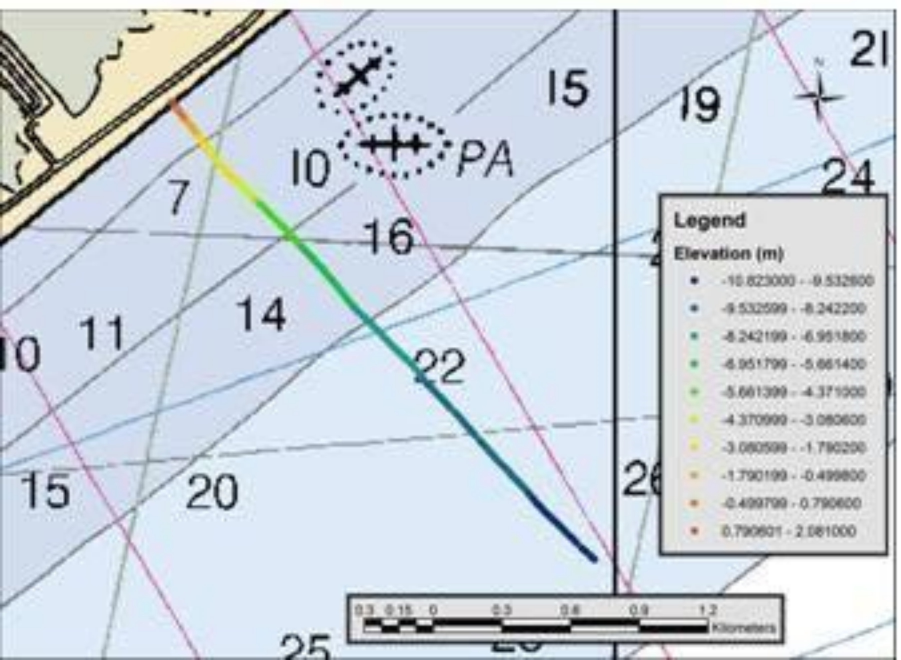

Surfside Profile 03
V.E.=50x
9.44m
1982m


4
16
11
8
20
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers

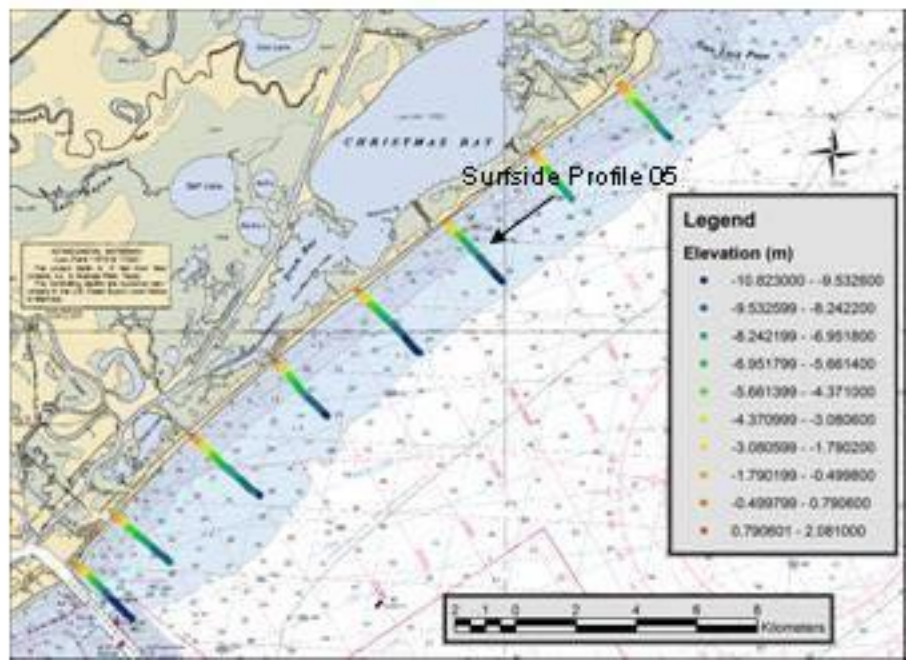

Surfside Profile 03
CHRISTMAS BAY
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers



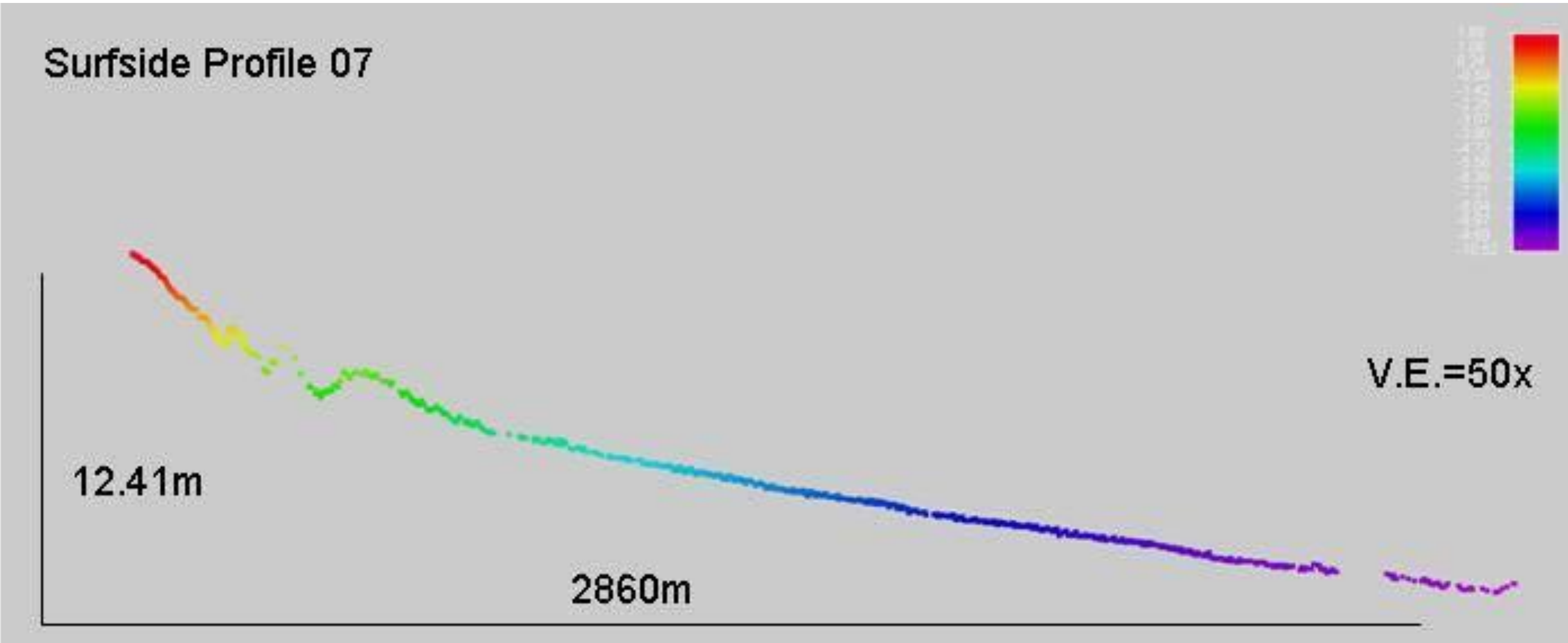
Surfside Profile 05
11.65m
2746m
V.E.=50x

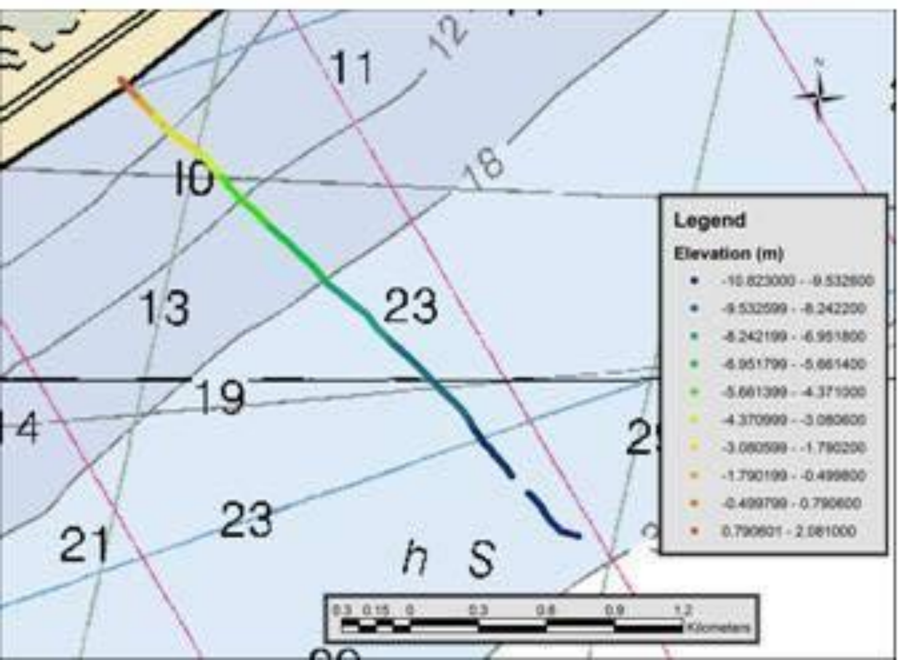


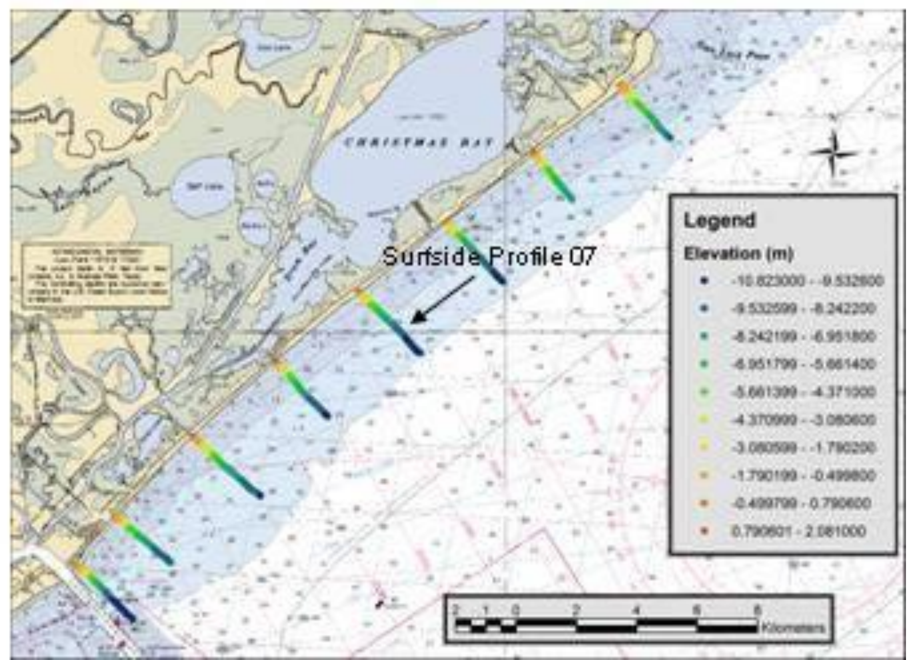
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers

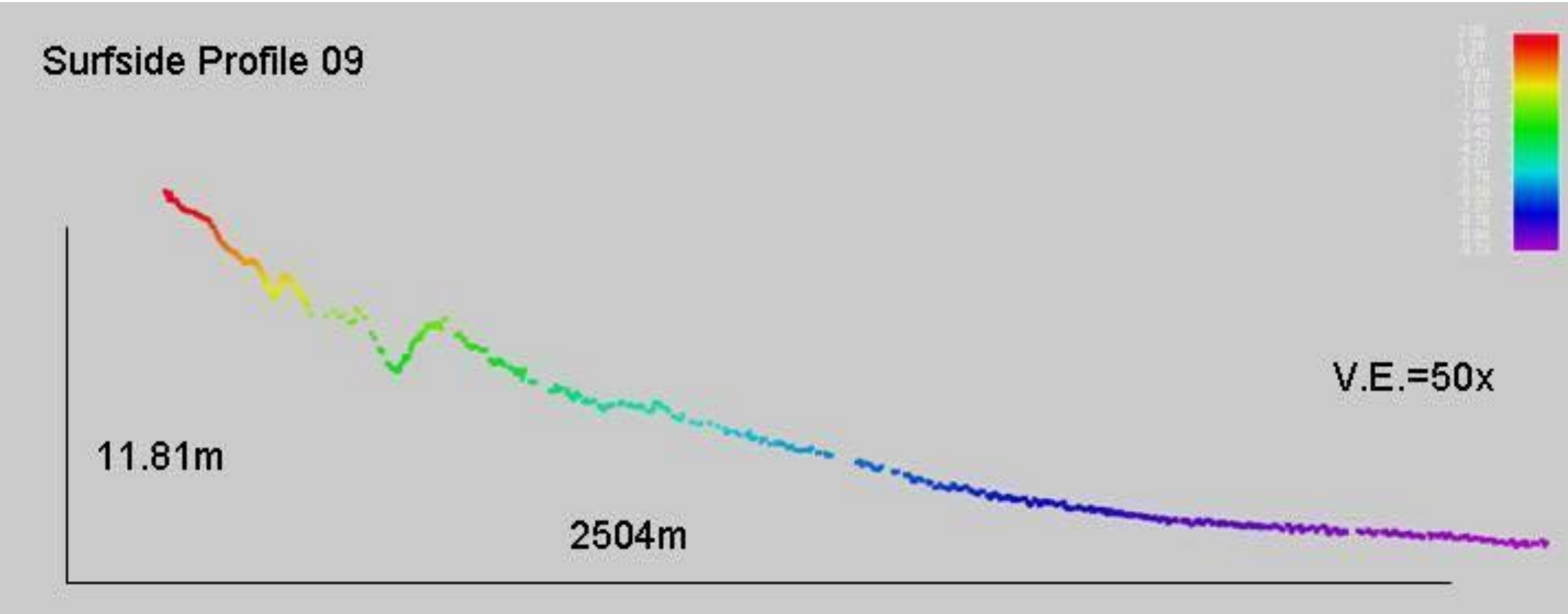


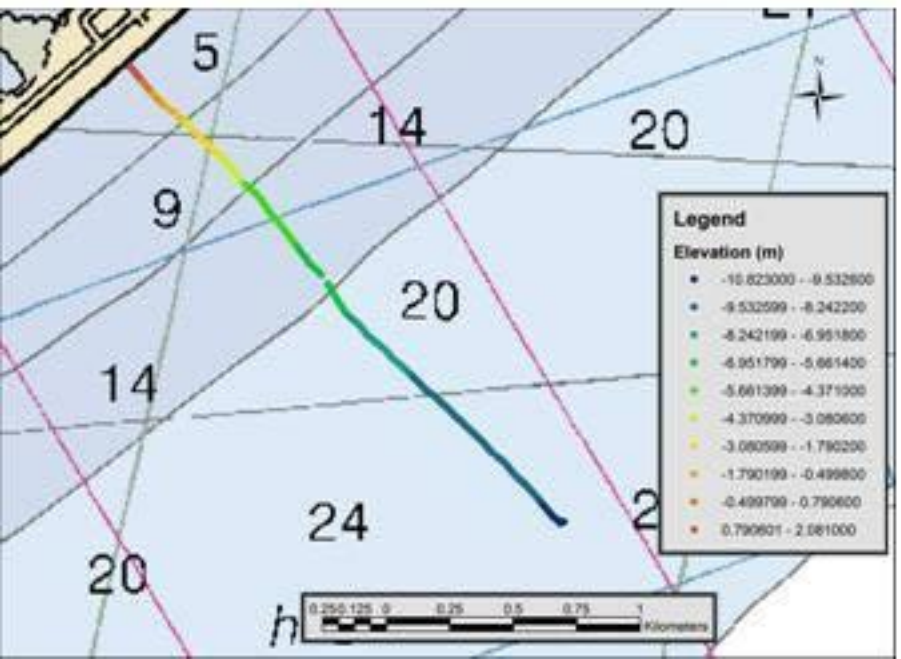
CHRISTMAS BAY
Surfside Profile 05
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers

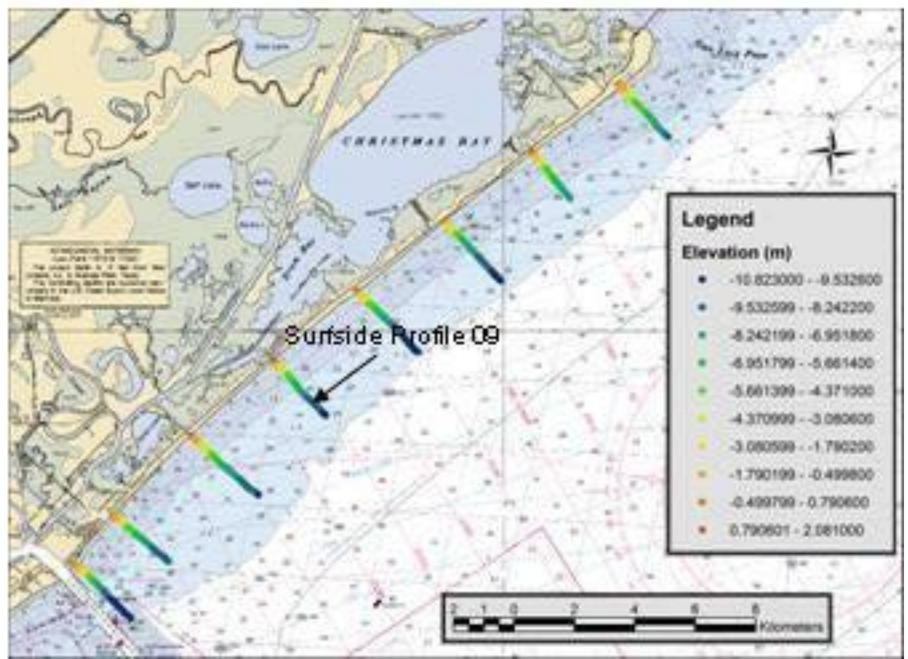

Surfside Profile 07
V.E.=50x
12.41m
2860m

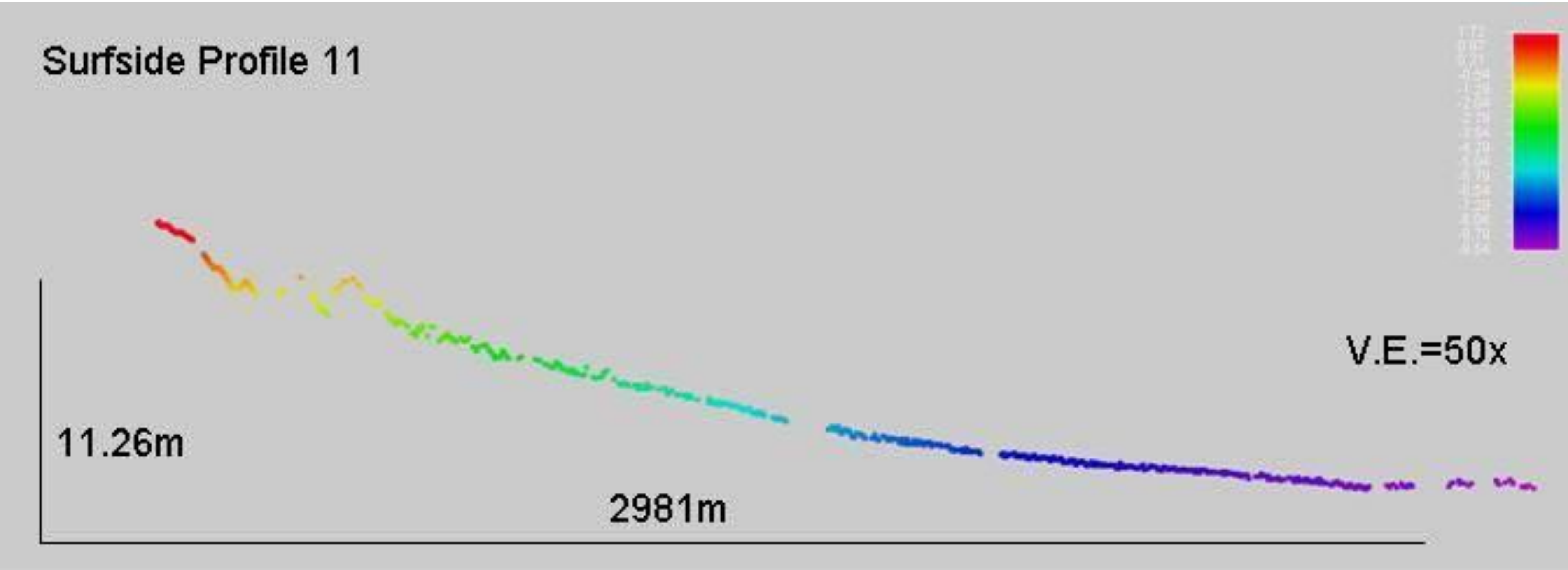

Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers

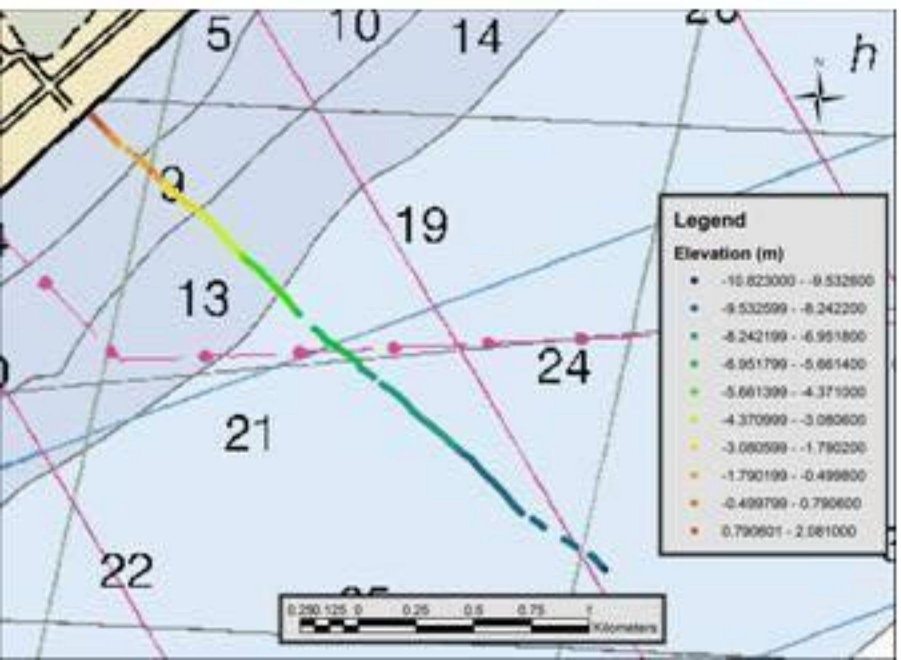

CHRISTMAS BAY
Surfside Profile 07
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers

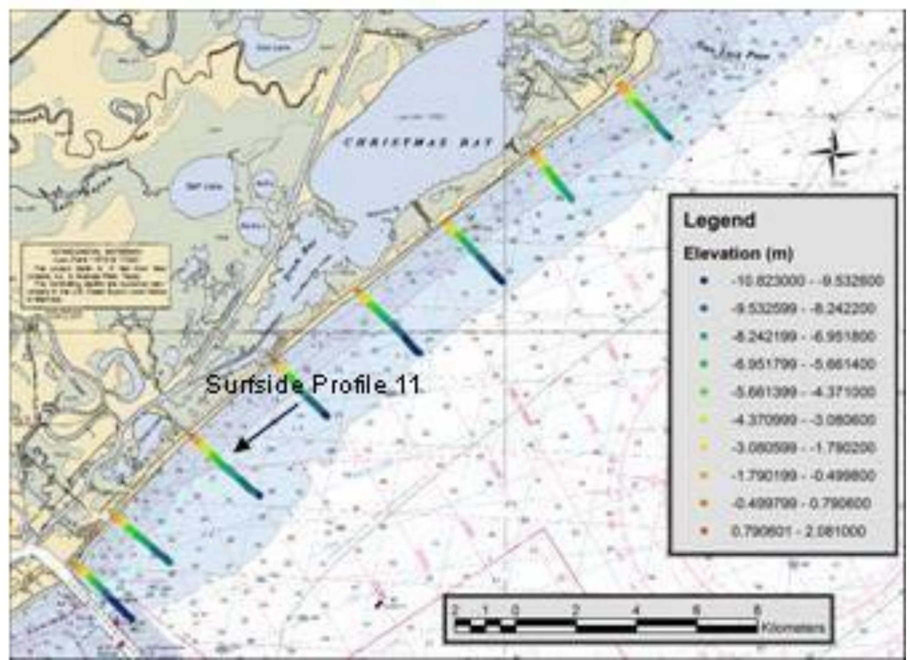

Surfside Profile 09
V.E.=50x
11.81m
2504m

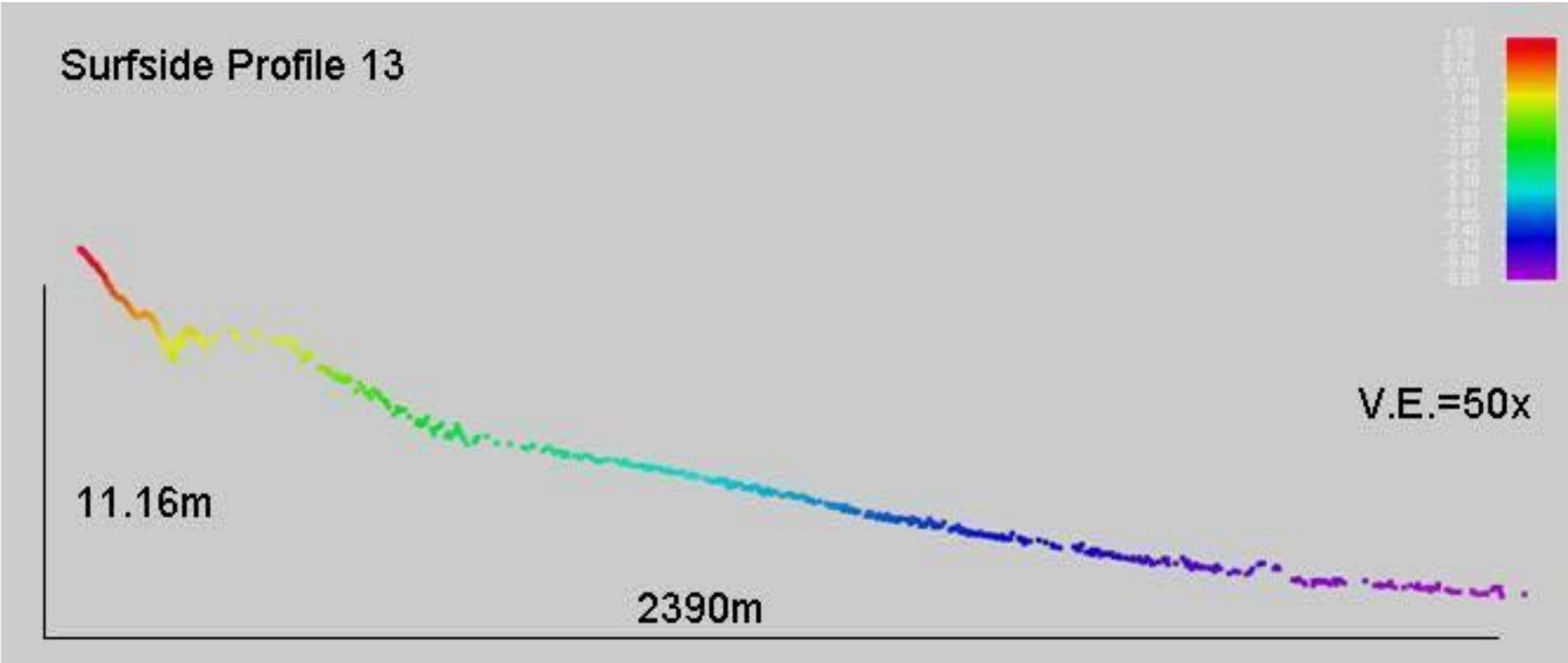

5
14
20
9
20
14
24
20
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers

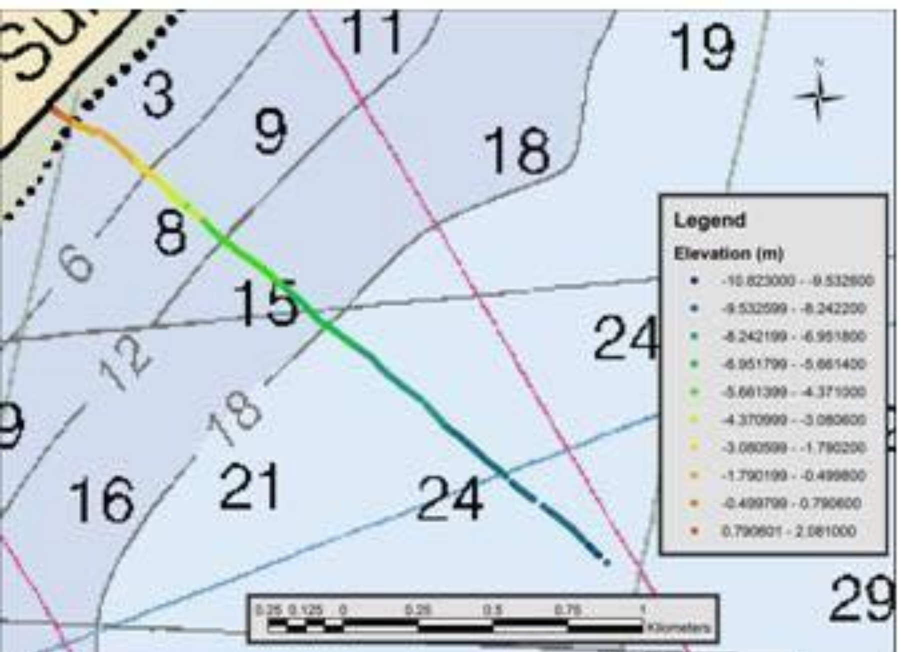

CHRISTMAS BAY
Surfside Profile 09
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers

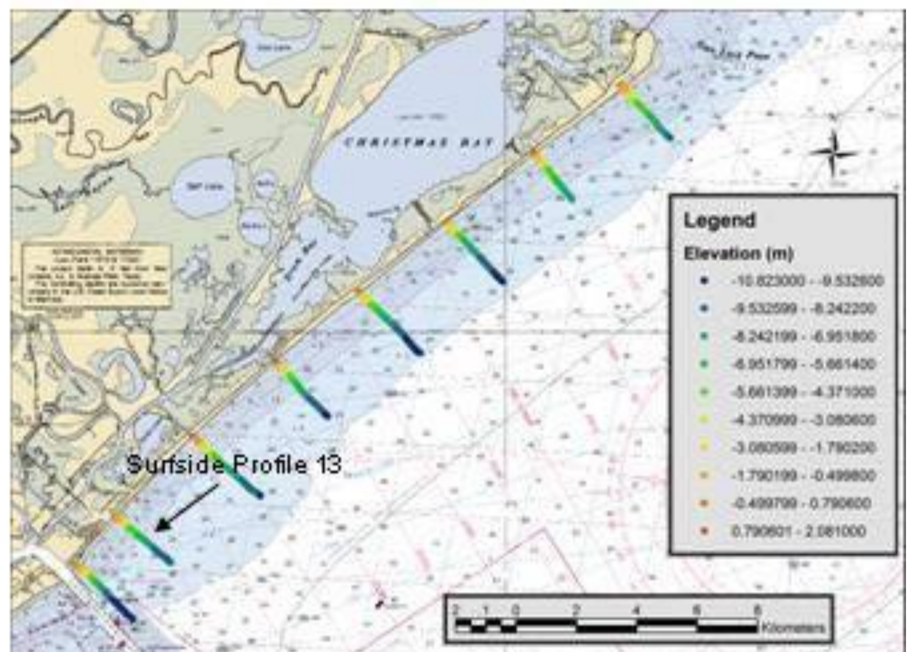

Surfside Profile 11
V.E.=50x
11.26m
2981m

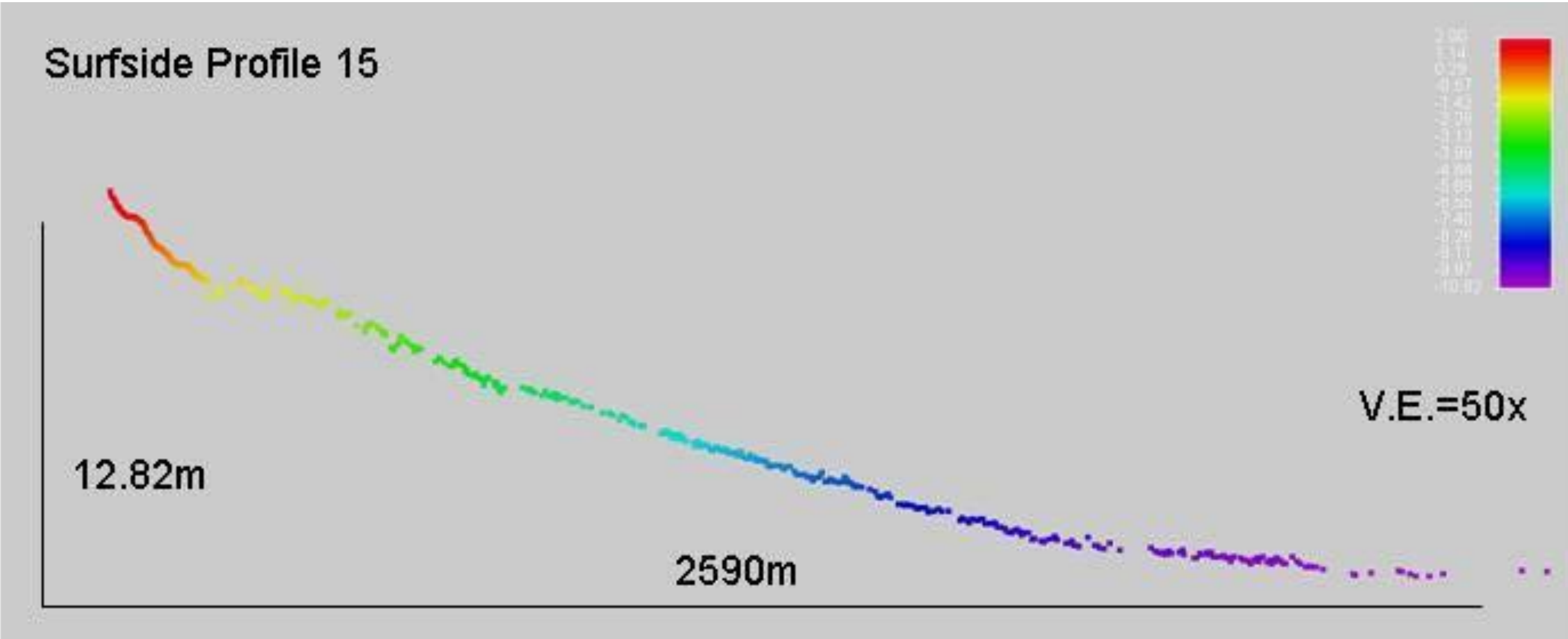

5
10
14
19
13
24
21
22
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers

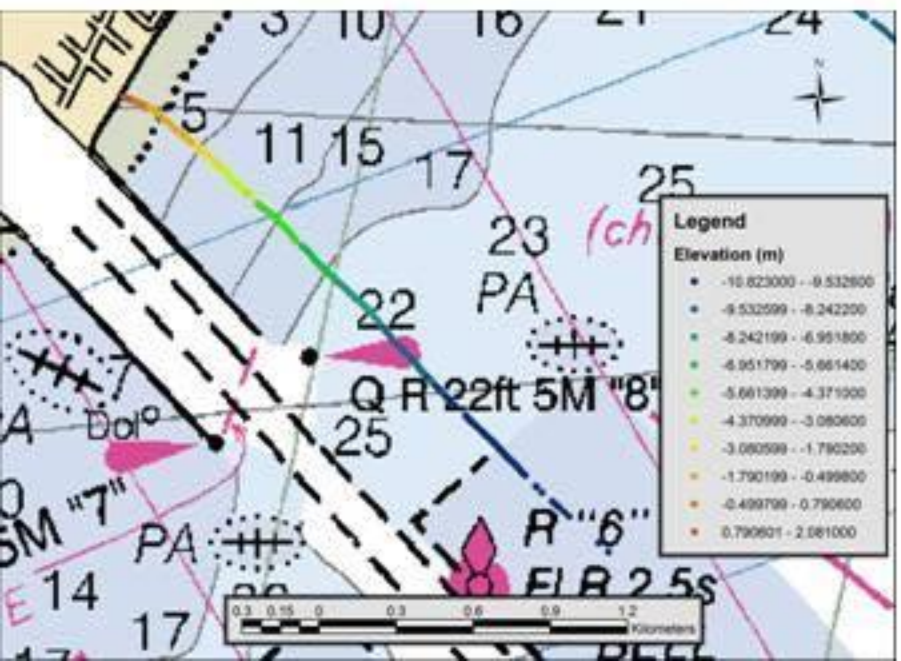

CHRISTMAS BAY
Surfside Profile 11
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers

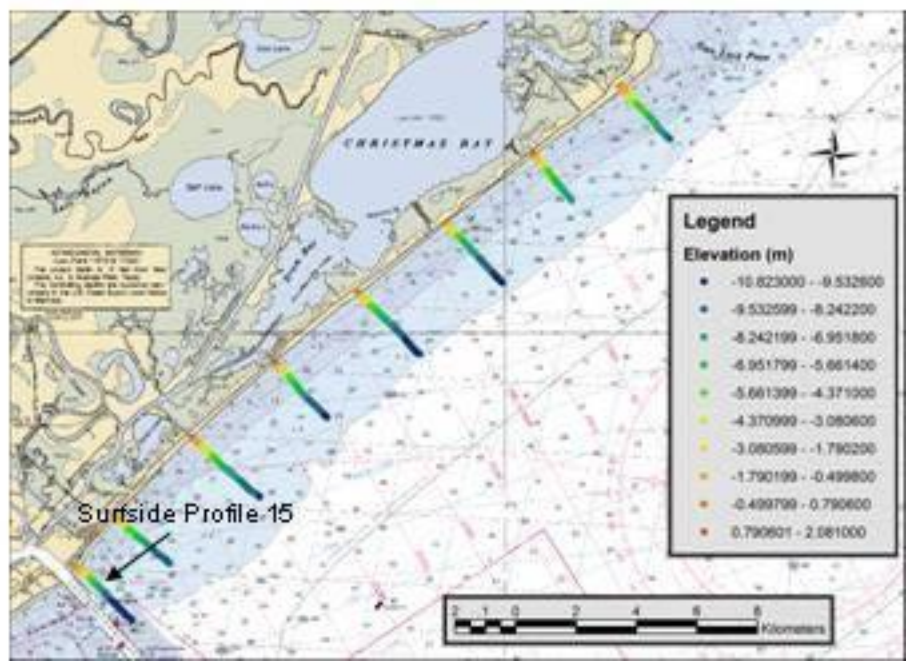

Surfside Profile 13
V.E.=50x
11.16m
2390m


3
9
11
18
19
8
6
15
12
24
18
21
16
24
29
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers


CHRISTMAS BAY
Surfside Profile 13
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers


Surfside Profile 15
12.82m
2590m
V.E.=50x


Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Q R 22ft 5M "8"
FI R 2.5s
Kilometers


CHRISTMAS BAY
Surfside Profile 15
Legend
Elevation (m)
-10.823000 - -9.532600
-9.532599 - -8.242200
-8.242199 - -6.951800
-6.951799 - -5.661400
-5.661399 - -4.371000
-4.370999 - -3.080600
-3.080599 - -1.790200
-1.790199 - -0.499800
-0.499799 - 0.790600
0.790601 - 2.081000
Kilometers

Appendix D **Profile Spread Sheets**

Bolivar Peninsula

On Compact Disc

Galveston Island

On Compact Disc

Follett's Island (Surfside Profiles)

On compact Disc

Appendix E **Survey Dates**

2006 Survey Dates

Permanent Benchmarks

Ground truth 61st benchmark 05/21/06
Ground truth Northeast end seawall benchmark 06/15/06
Ground truth Southwest end seawall benchmark 05/10/06

Temporary Benchmarks

Galveston East Condo 06/02/06
Galveston 61st. Pier 05/24/06
Galveston Indian Beach 05/25/06
Galveston Tampico Way 06/05/06
Galveston Bermuda Beach 05/19/06
Galveston Termini 06/01/06
Surfside Treasure Island 09/10/06
Surfside mid section 09//11/06
Surfside north Jetty 09/11/06
Bolivar North Jetty 09/18/06
Bolivar Mid Section 09/18/06
Bolivar Crystal Beach 09/18/06

Nearshore Profiles

Galveston Profiles (03, 04, 05) 08/30/06
Galveston Profiles (06, 07, 08, 09, 10, 11) 08/31/06

Galveston Profiles (12, 13, 14, 15) 09/08/06
Galveston Profiles (16, 17, 18) 09/12/06

Surfside Profiles (001, 003) 09/12/06
Surfside Profiles (005, 007, 009, 011, 013, 015) 09/13/06

Bolivar Profiles (001, 003, 005, 007, 009, 011, 013, 015, 017, 019) 09/27/06

Beach Profiles

Surfside Profiles (001, 003, 005, 007, 009, 011, 013, 015) 10/01/06

Galveston Profiles (03, 04, 05, 06) 10/04/06
Galveston Profiles (07, 08, 09, 10, 11 12, 15, 16, 17, 18) 10/09/06
Galveston Profiles (13, 14) 10/10/06

Bolivar Profiles (001, 003, 005, 007, 009, 011, 013, 015, 017, 019) 11/02/06

Appendix E **Raw Data**

On Compact Disk

References

Groundspeak Incorporated 2006. Copyright © 2000-2007 Groundspeak Inc. <http://www.geocaching.com/.>

National Geodetic Survey 2006. National Oceanic & Atmospheric Administration (NOAA) <http://www.ngs.noaa.gov/.>