Morphological and Sedimentological Impacts of Hurricane Michael along the North-West Florida Coast

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Introduction

In October 2018 Michael, an energetic category 5 hurricane, made landfall in Mexico Beach, North-West Florida. It is the third most intense Atlantic hurricane to make landfall in the United States in terms of center pressure and the strongest storm in terms of maximum sustained wind speed since Hurricane Andrew in 1992. The hurricane generated a storm surge of up to 5 m which is nearly 15 times the average tidal range in this area, which is 0.34m, and thus provided an opportunity to study the response of a variety of coastal environments to an extreme storm.

Morphology changes induced by Hurricane Michael along the Barrier Islands were quantified through analysis of pre & post storm LiDAR surveys, as well as aerial and ground photos. Sedimentological characteristics of storm deposits around the barrier islands, within Apalachicola Bay and surrounding coastal marsh were examined with 116 sediment cores and 40 sediment samples. This poster will present 1) the morphological characteristics and spatial variation of dune scarping and beach erosion; and 2) the sedimentological characteristics of storm deposits in various environments including: ocean facing and bay facing barrier beach, within the Apalachicola Bay, and the coastal marsh along the Bay.

Study Area and Hurricane Michael

Hurricane Michael made landfall at Mexico Beach, Florida:

1) The storm was moving at ~20 km/hr at landfall (Fig. 1).
2) Maximum storm surge of ~ 5 m was measured at Mexico Beach (Fig. 2). Significantly elevated water level lasted at least 16 hours.
3) Maximum wave height reached 9 m (WWIII) ~30 km offshore the headland, or 60 km offshore Mexico Beach (Fig. 4). Energetic conditions (H_s > 3 m) lasted 33 hours.
4) Study site encompasses significant shoreline orientation variation (Figs. 1 & 5).

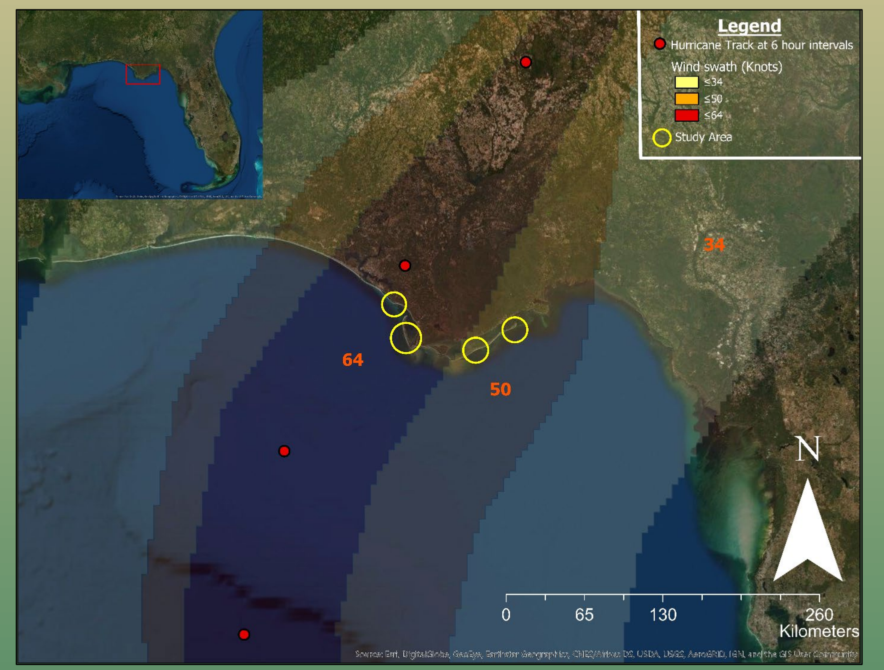


Fig. 1. Track, speed, and wind field of Hurricane Michael. Our field sites are located to the right side of the track with onshore forcing.

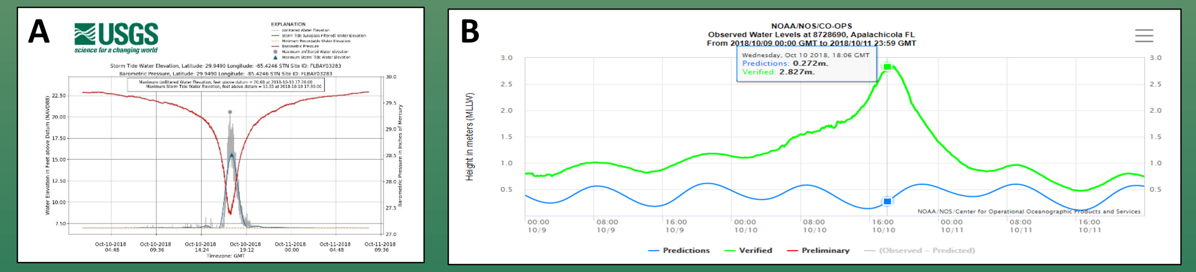
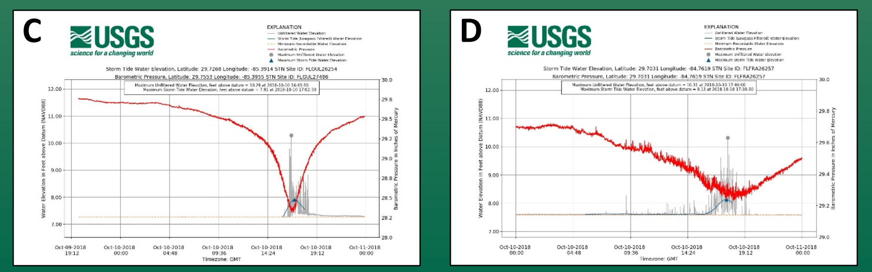



Fig. 2. Measured storm surge at various sites: A) Mexico Beach, B) Apalachicola Bay, C) Cape San Blas, D) St. George Island.

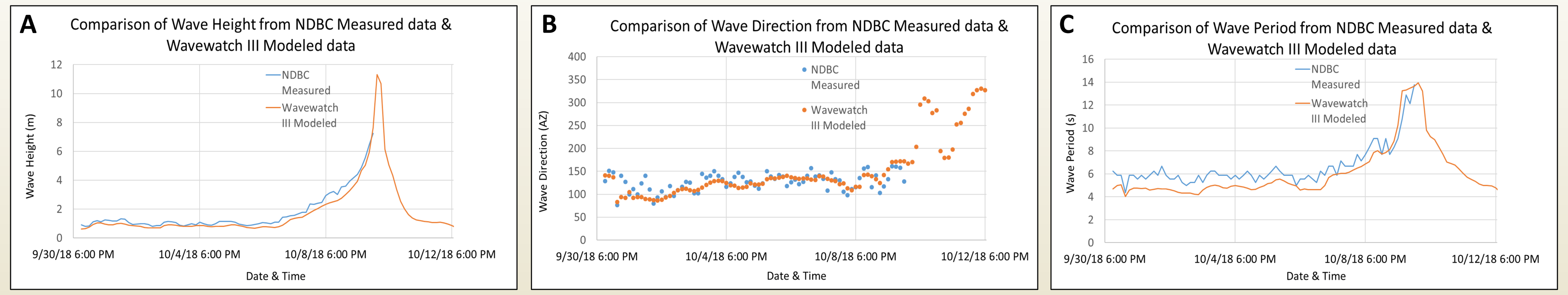


Fig. 3. Comparison of WAVEWATCH III data and measured data at NDBC Station 42039 (115NM SSE of Pensacola at 270 m of water). WWIII data matched the measured values well.

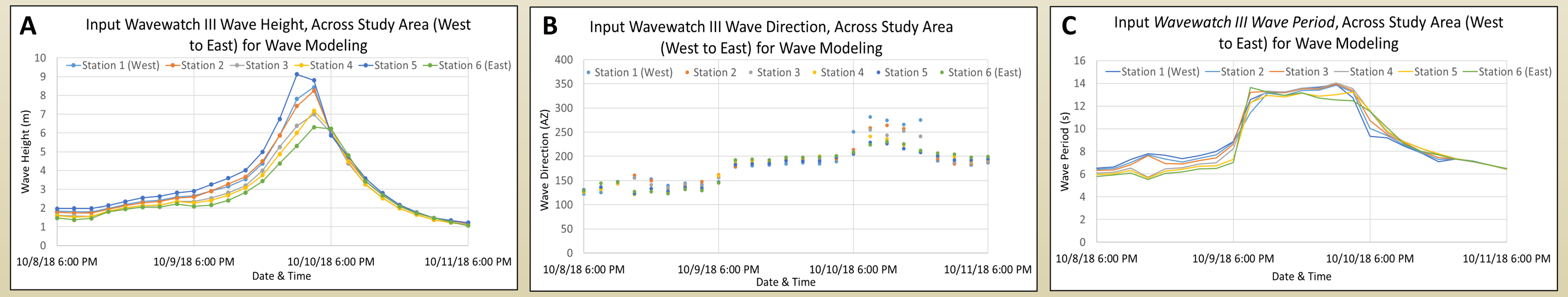


Fig. 4. WWIII conditions at the offshore boundary of the CMS-Wave model domain (~30 km offshore the headland)

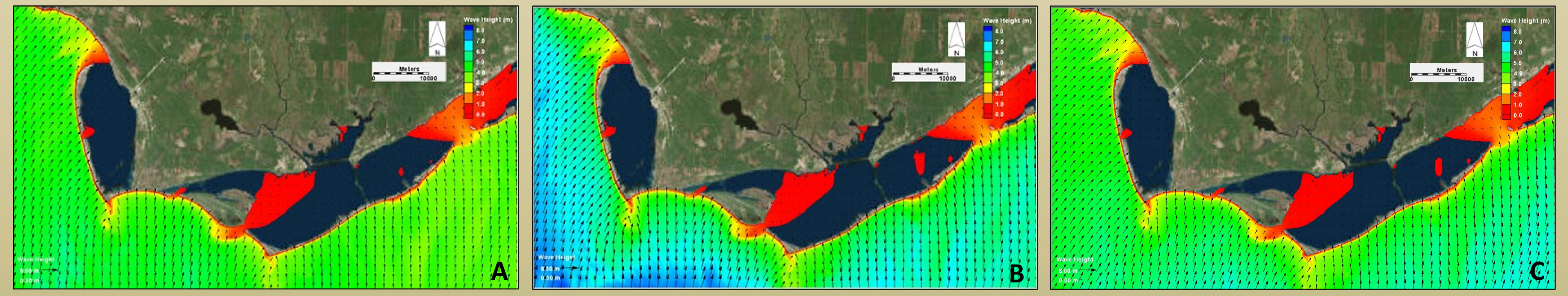


Fig. 5. CMS-Wave modeled wave field: A) 6 hours before peak wave height, B) peak wave height, and C) 6 hours after peak wave height. The highest wave occurred in the middle of St. Joseph Island where a breach occurred.

Dune-Beach Changes Induced by Hurricane Michael

1) Multiple beach ridges were eroded at Mexico Beach with minimal shoreline change, the beach gained sand near the inlet, small dunes were eroded with minimal shoreline change at the developed coast but with tremendous structure damage landward (photo inset) (Fig. 6).
2) At St. Joseph Island, beach ridges were eroded at the northern section, a breach occurred in the middle where the highest wave was modeled, and beach/dune erosion along the southern section, with severe structural damage (photo inset) (Fig. 7).
3) Overall, shoreline position at most locations remained relatively un-changed.

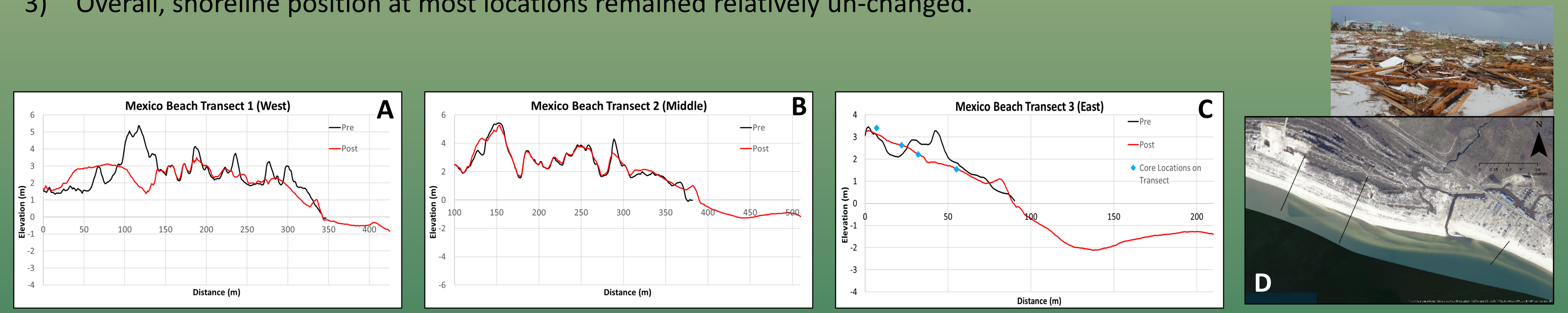


Fig. 6. Dune-beach changes at Mexico Beach, profiles extracted from LIDAR surveys : A) natural coast with multiple beach/dune ridges, B) natural coast near a small tidal inlet, C) developed coast, and D) locations of the profiles.

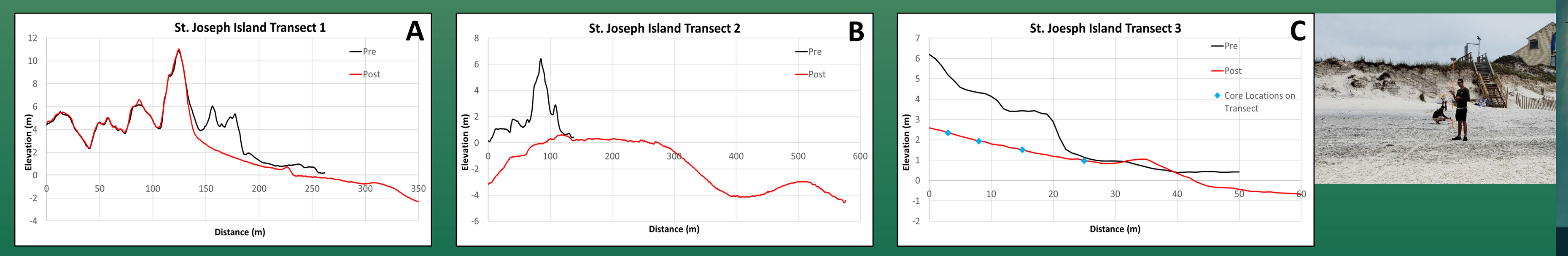
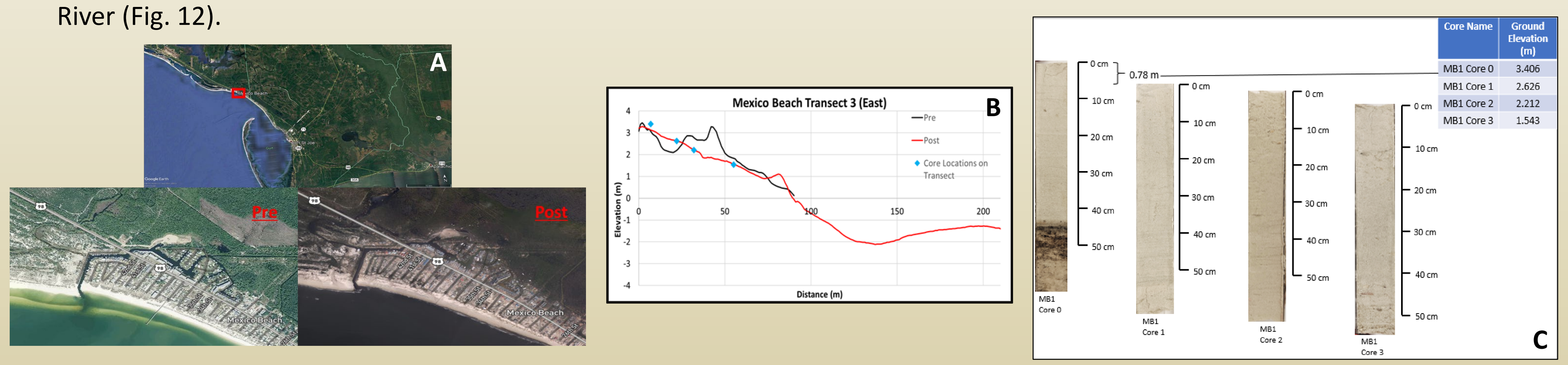


Fig. 7. Dune-beach changes at St. Joseph Island, profiles extracted from LIDAR surveys: A) natural coast with multiple beach/dune ridges, B) natural coast that was preached, C) developed coast, and D) locations of the profiles.

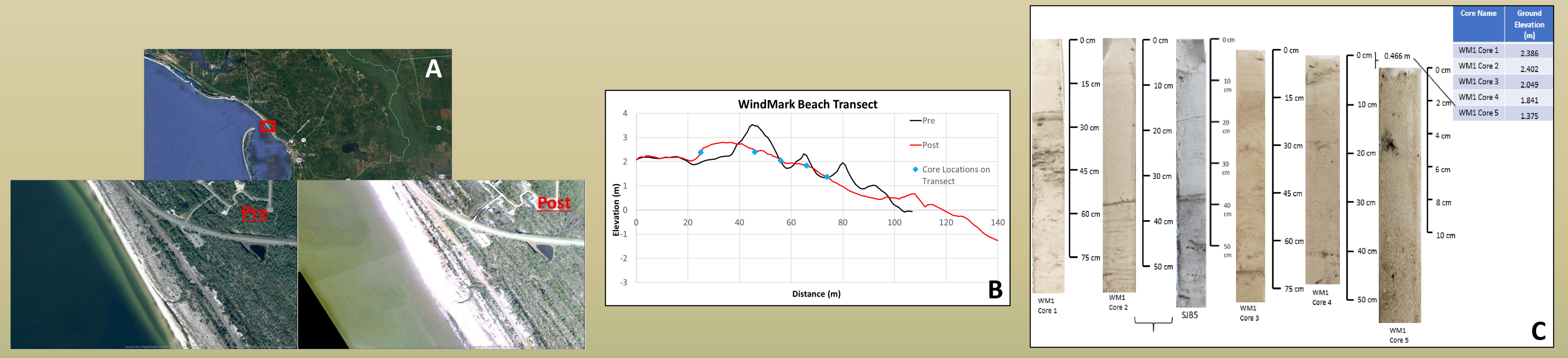
Storm Deposits Induced by Hurricane Michael

1) Storm deposits over eroded dunes can be identified by planner beach bedding over dune sand with decayed plant material (Fig. 8).
2) Storm deposits over eroded beach are difficult to distinguish due to similar sedimentologic characteristics (Figs. 8 & 9).
3) Overwash deposits into back-barrier marsh environment can be identified by the sharp contact between beach sand and organic rich marsh sediment. The landward penetration at Cape San Blas is slightly over 100 m (Fig. 10).
4) Overwash deposit into marsh environment at a protruding marsh island along the landward shoreline be identified by the sharp contact between beach sand and organic rich marsh sediment. The landward penetration is less than 30 m (Fig. 11).
5) No sandy overwash deposits can be identified in the broad marsh environments associated with Apalachicola River and Carrabelle River (Fig. 12).



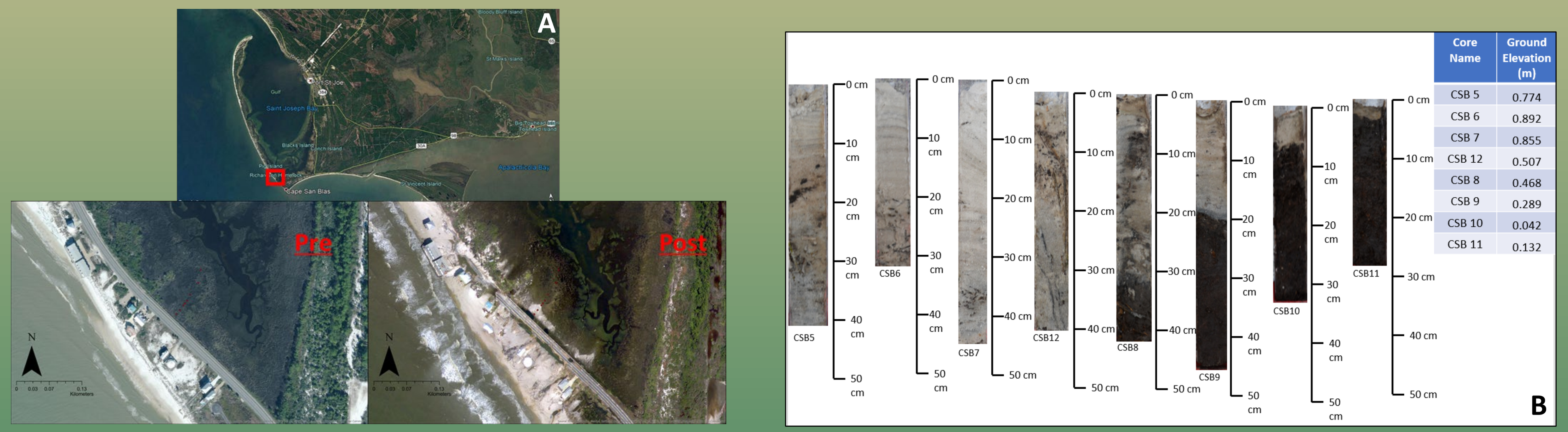
Core Name	Ground Elevation (m)
MB1 Core 0	3.406
MB1 Core 1	2.626
MB1 Core 2	2.212
MB1 Core 3	1.543

Fig. 8. Storm deposits along developed section of Mexico Beach: A) pre- and post-storm aerial photos, B) Pre- and post-storm beach profiles, extracted from LIDAR surveys, and C) sediment cores.



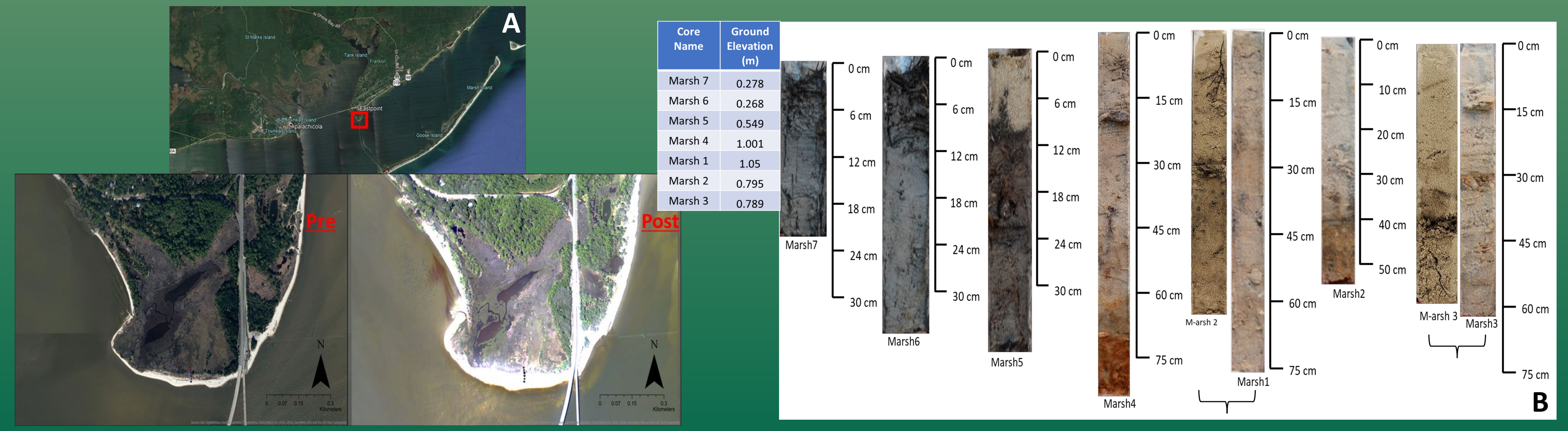
Core Name	Ground Elevation (m)
WM1 Core 1	2.386
WM1 Core 2	2.402
WM1 Core 3	2.049
WM1 Core 4	1.841
WM1 Core 5	1.375

Fig. 9. Storm deposits along natural beach with multiple beach ridges: A) pre- and post-storm aerial photos, B) Pre- and post-storm beach profiles, extracted from LIDAR surveys, and C) sediment cores.



Core Name	Ground Elevation (m)
CSB 5	0.774
CSB 6	0.892
CSB 7	0.855
CSB 12	0.507
CSB 8	0.468
CSB 9	0.289
CSB 10	0.042
CSB 11	0.132

Fig. 10. Storm overwash at Cape San Blas: A) pre- and post-storm aerial photos, and B) sediment cores.



Core Name	Ground Elevation (m)
Marsh 7	0.278
Marsh 6	0.268
Marsh 5	0.549
Marsh 4	1.001
Marsh 1	1.05
Marsh 2	0.795
Marsh 3	0.789

Fig. 11. Storm overwash at Cat Point marsh along the landward side of Apalachicola Bay: A) pre- and post-storm aerial photos, and B) sediment cores.

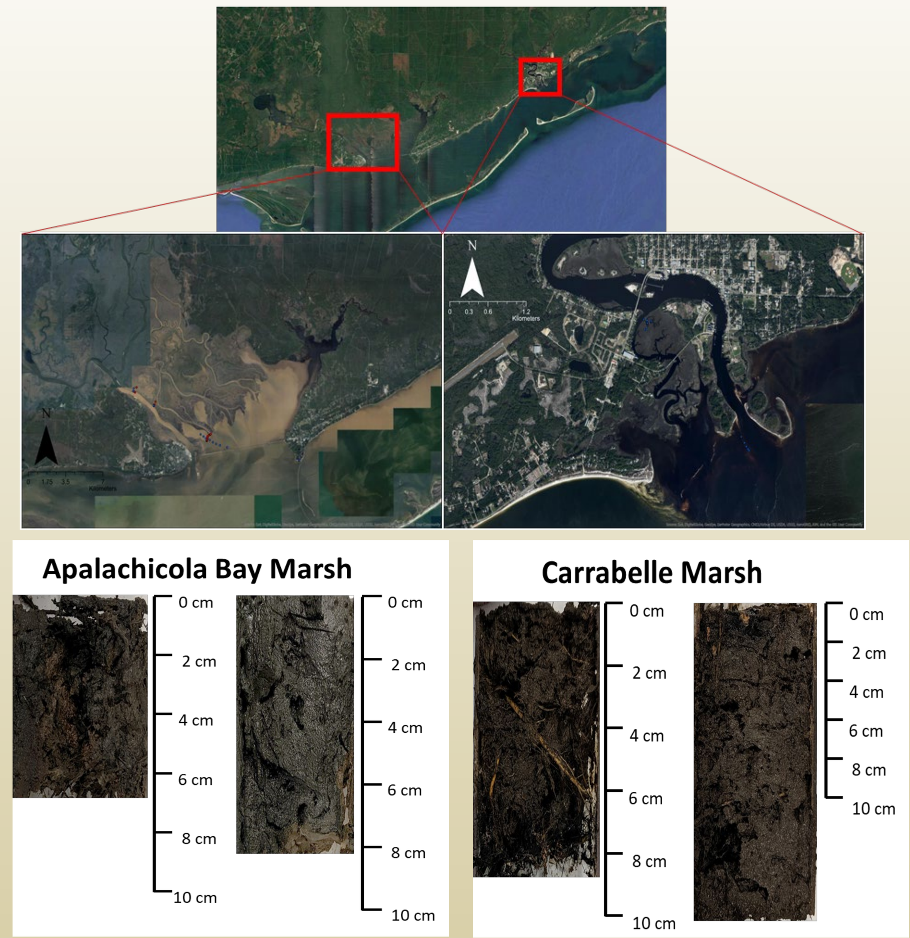


Fig. 12. No storm deposits can be identified from the sediment cores in the mainland marsh areas.

Summary and Conclusions

- The headland and associated shoreline orientation and bathymetry variations had significant influence on the morphologic responses.
- Mexico Beach endured the highest storm surge and strongest wind, resulting in catastrophic structure damage and dune/beach erosion, with small shoreline change.
- St. Joseph Island experienced the highest waves, resulting in more severe dune/beach erosion than Mexico Beach and a breach coinciding with the highest nearshore wave.
- Storm deposits over eroded dunes can be easily identified.
- Penetrations of storm overwash into the marsh/bay environment along the landward side of the barrier islands are limited to ~150 m.
- Penetration of storm overwash into a protruding mainland marsh is limited to less than 30 m.
- No sandy overwash deposits can be identified in the broad marsh environments associated with Apalachicola River and Carrabelle River.
- No visually indefinable sandy storm deposits were found in the greater Apalachicola Bay.

Acknowledgements

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