Appendix E
Cat Island Borrow Area Analysis

Cat Island Borrow Area Analysis

Multiple borrow area configurations were considered for Cat Island restoration. Borrow area CI1 is located northeast of Cat Island in an ambient water depth of 3.6 meters. Borrow area CI3 spans an area 5590 meters long by 215 meters wide offshore of Cat Island in an ambient water depth of 3.6 meters. Borrow area CI4 is located offshore of Cat Island in an ambient water depth of 4 meters. The proposed borrow sites are located in relatively shallow water, creating potential adverse affects on the shoreline of Cat Island due to the wave refraction over the excavated pit. This chapter details an analysis conducted to quantify the potential impacts of the borrow area excavation (for beach nourishment) on sediment transport and shoreline change at Cat Island.

Model Setup

Shoreline and littoral transport impacts induced by the excavation of proposed borrow areas are examined with the spectral nearshore wave transformation model STWAVE (Smith et al. 1999) and the shoreline change model GENESIS (Hanson and Kraus 1989). The conditions simulated represent the pre- and post-dredging bathymetry for each proposed borrow area. The location of the proposed borrow areas relative to Cat Island are shown in Figure 1.
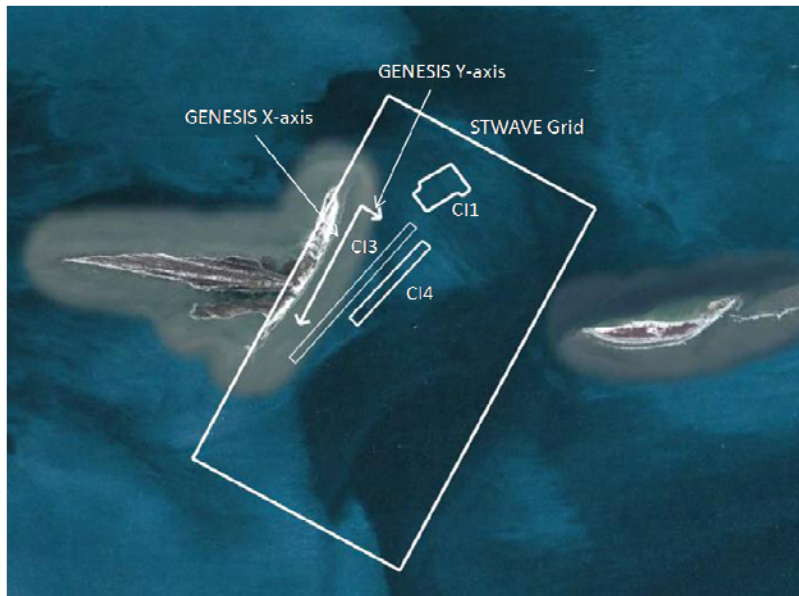
Figure 1. Location of Proposed Borrow Areas

Analysis involved simulating the transformation of offshore wave conditions derived from WIS Station 144 from the 15-m contour to the 7-m contour with the WISPH III transformation technique. Waves emanating from the northeast are primarily fetch driven waves from the Mississippi Sound. These fetch driven waves are of shorter period and smaller wave height compared with Gulf of Mexico waves. Two WIS transformations were performed; the first involved sheltering to account for the effect of Ship Island on waves from the Gulf of Mexico, and the second did not involve sheltering. The final offshore wave time series corresponding to the 7-m water depth at the offshore STWAVE boundary was compiled by replacing calm events in the sheltered wave time series with corresponding short period(less than 6 sec) wave events in the unsheltered time series. . In this way, the generated Cat Island offshore wave time series accounted for the sheltering effect of Gulf of Mexico waves but also included appropriate representation of locally generated waves within Mississippi Sound. The transformed wave information corresponds to the offshore boundary of the STWAVE grid with the X-axis directed onshore, and the Y-axis parallel with the Cat Island shoreline. The resolution of the STWAVE grid is 25 m in both the x and the y directions. Nearshore wave conditions generated by STWAVE along the nominal 3-meter contour for both the existing and dredged conditions provided necessary input to

GENESIS, which estimates longshore sand transport rates and shoreline change along the shoreline of Cat Island.

The GENESIS x-axis runs parallel to the Eastern shoreline of Cat Island from the northeast to the southwest and is comprised of 170 shoreline cells at 25 m intervals. Because detailed calibration data are not available for this study, the calibration coefficients were assigned typical values of K_1=0.10 and K_2=0.05 which, result in a reasonable longshore sand transport regime compatible with developed sediment budgets in the region (Byrnes et al. 2011). These calibration values are typical of those applied in previous studies that employed WIS hindcast wave information as input, for example the Northern Gulf of Mexico Regional Sediment Management demonstration project. (Lillycrop and Parson 2000) Because this study is a relative analysis between with and without an excavated borrow area, aimed at estimating the potential shoreline impacts of proposed dredging of the near shore borrow area, the importance of a detailed calibration is diminished. Existing bathymetry is shown in Figure 2 and bathymetry change between with and without the borrow areas is plotted in Figures 3 to 5 to highlight proposed borrow area configuration. The nearshore wave reference line (where the STWAVE information is stored and transferred to the GENESIS model) is represented by a thick black line in all figures and is located at the 5-meter contour.
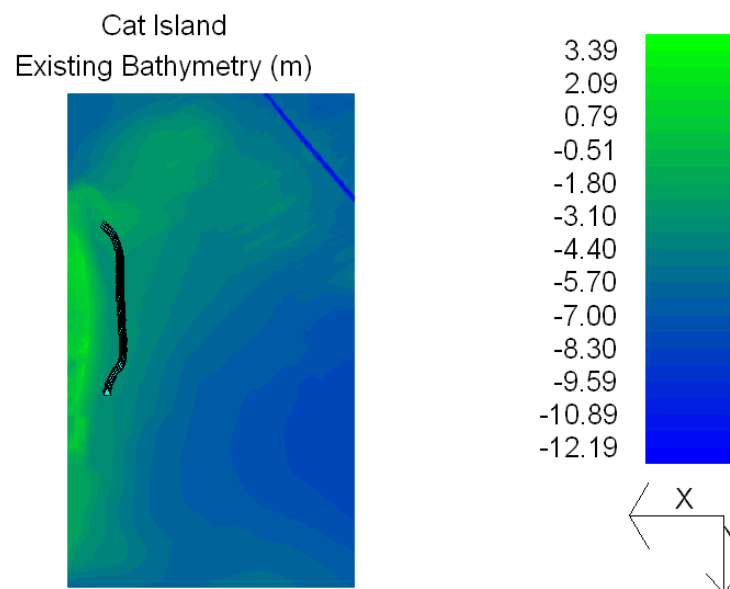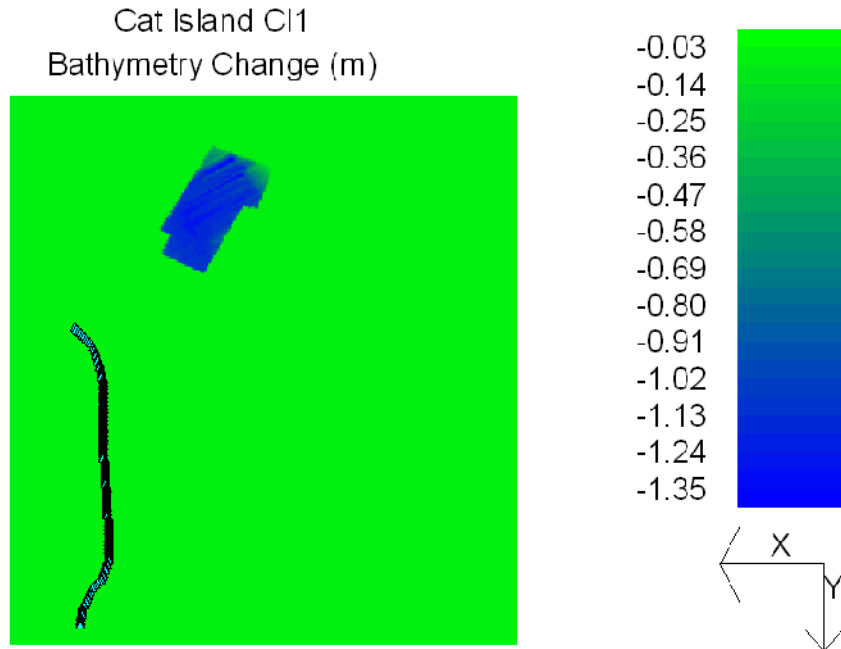

Figure 2. Existing condition bathymetry

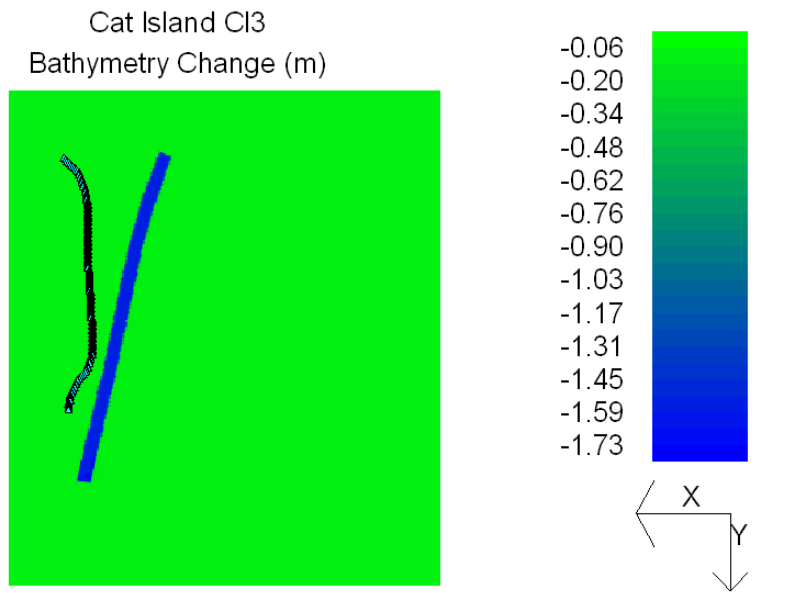**Figure 3. Existing condition bathymetry minus CI1 dredged condition bathymetry**

Figure 4. Existing condition bathymetry minus CI3 dredged condition bathymetry
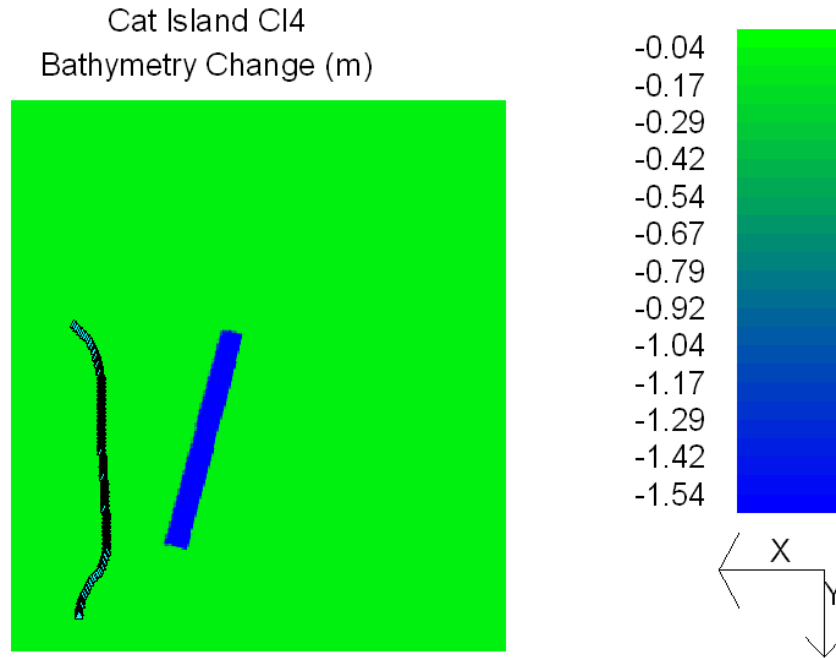
Figure 8-3.

Cat Island CI4
Bathymetry Change (m)

Figure 5. Existing condition bathymetry minus CI4 dredged condition bathymetry

Wave Transformation Analysis

Nearshore wave transformation simulations were performed for 188 representative wave conditions identified through analysis of WIS hindcast station GOM 144 located in 15 m water depth offshore of Cat Island (Figure 1). Figure 6 shows the distribution of representative wave conditions by incident wave angle and period. The incident wave angle is measured clockwise from shore normal. The value in each block represents the number of occurrences for a specific wave condition in the 20-year WIS hindcast spanning the interval 1980 through 1999. For each representative wave condition, an idealized TMA wave spectrum was generated and applied as input to STWAVE.
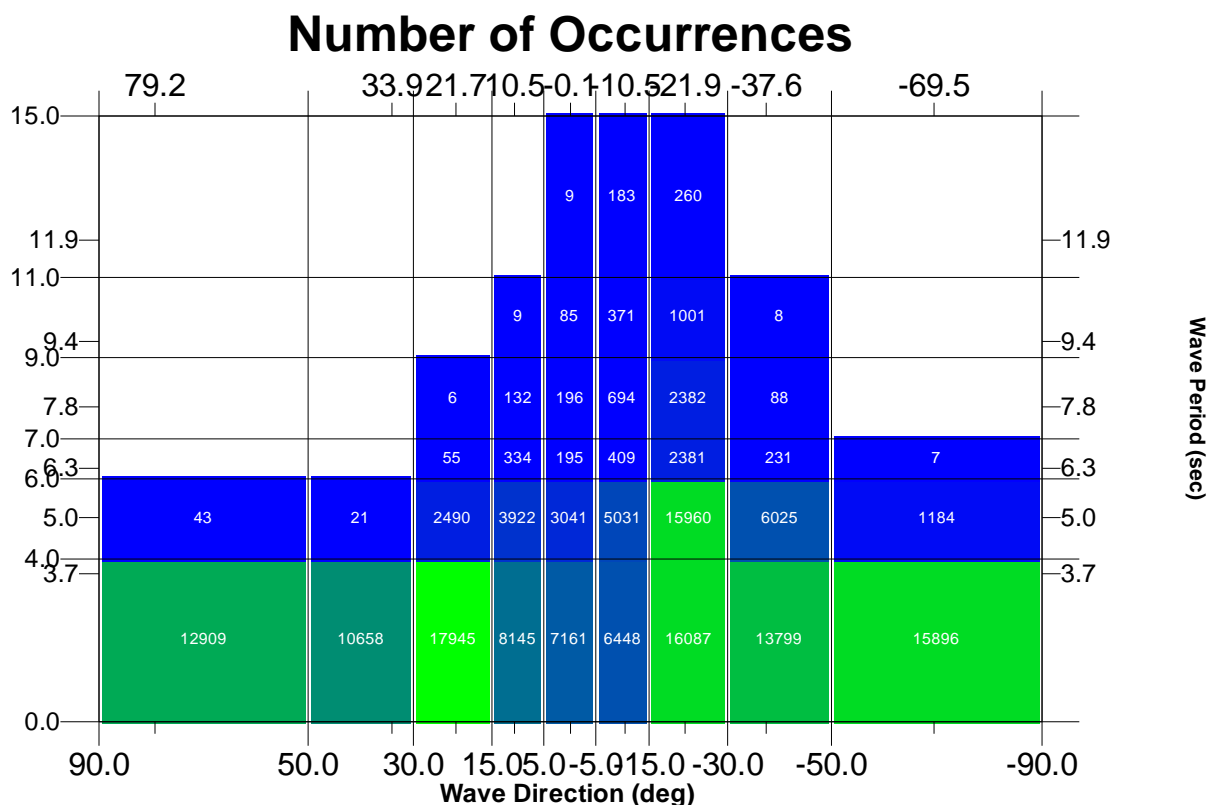
Number of Occurrences

Figure 6. Distribution of the representative wave conditions by incident wave angle and period

STWAVE simulations were performed to compute wave transformation across irregular offshore bathymetry from approximately the 7-m contour to the 3-m contour. STWAVE simulations were performed to estimate near shore wave conditions for existing and each dredged condition. Changes in significant wave height and direction resulting from excavation of the proposed borrow areas were determined by subtracting existing condition STWAVE results from dredged condition STWAVE results. Figure 7 is a plot of wave heights over the STWAVE computational domain for existing bathymetry and an event with a period of 5 s and an approach angle of 63.48 degrees. Figures 8 through 22 illustrate estimated significant wave height changes induced by excavation of the respective proposed borrow areas offshore of Cat Island for select characteristic wave conditions. The wave conditions shown were chosen to illustrate frequently occurring events on Cat Island. Figures 7 through 13 correspond to typical 5 second waves approaching Cat Island from the northeast and from the southeast, respectively. Figures 14 through 19 correspond to 6.25 second waves approaching Cat Island from the east-northeast sector and the southeast, respectively. Figures 20 through 22

show a 3.01 meter wave with a 6.25 second period passing over the borrow area. For both borrow area configurations, wave height decreases in the lee of the borrow area. Wave heights tend to increase along the sides of borrow areas in the down-wave direction for the smaller wave events. For larger events, breaking occurs before the waves reach the borrow area.
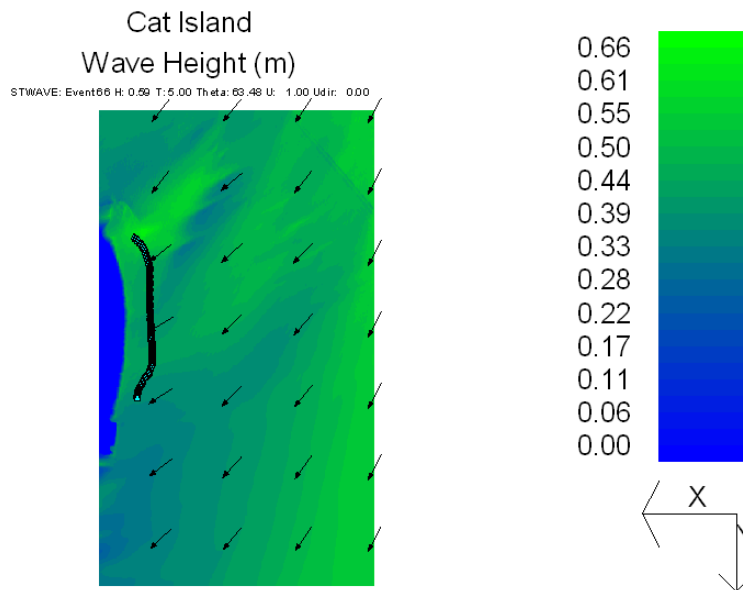

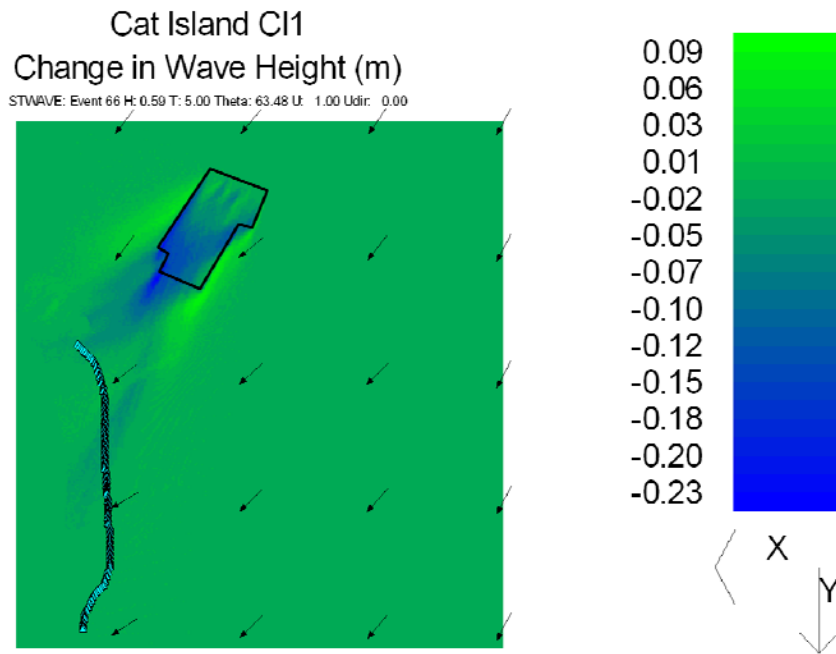**Figure 7. Existing Condition wave heights for incident wave of H= 0.59 m, T =5 s and Theta = 63.48 deg**

Figure 8. Wave height change (dredged − existing) for incident wave of H=0.59m, T =5 s and Theta = 63.48 deg for CI1
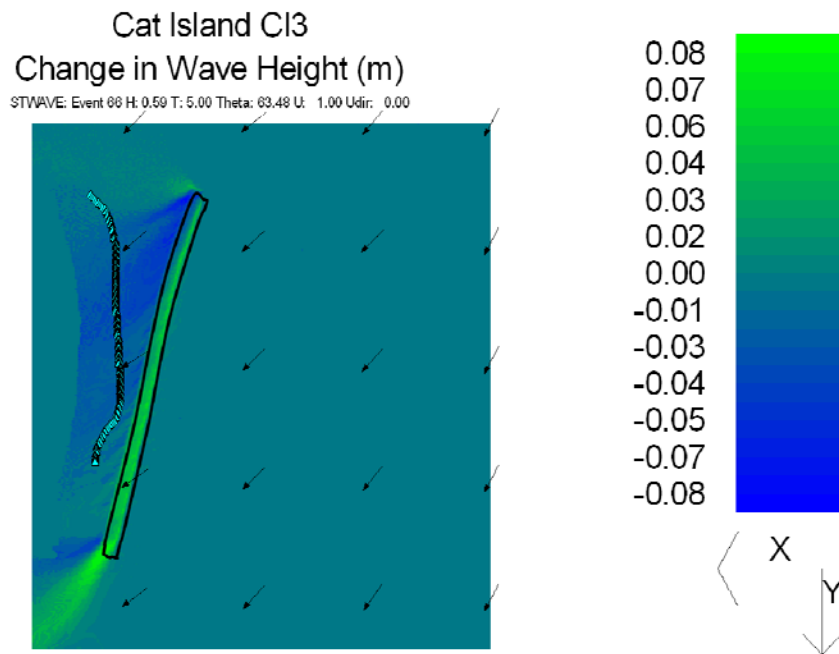
Figure 9. Wave height change (dredged − existing) for incident wave of H=0.59m, T =5 s and Theta = 63.48 deg for CI3
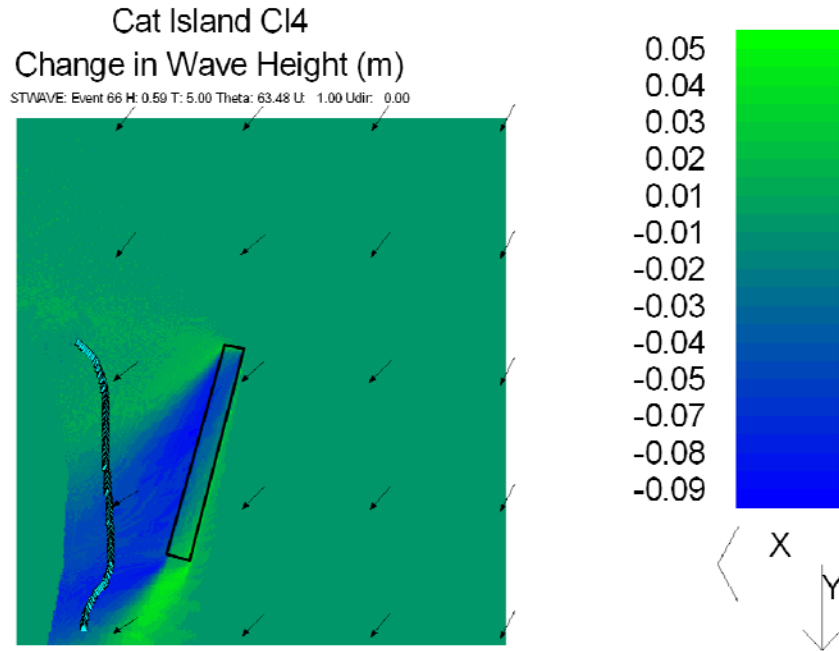
Figure 10. Wave height change (dredged − existing) for incident wave of H=0.59m, T =5 s and Theta = 63.48 deg for CI4
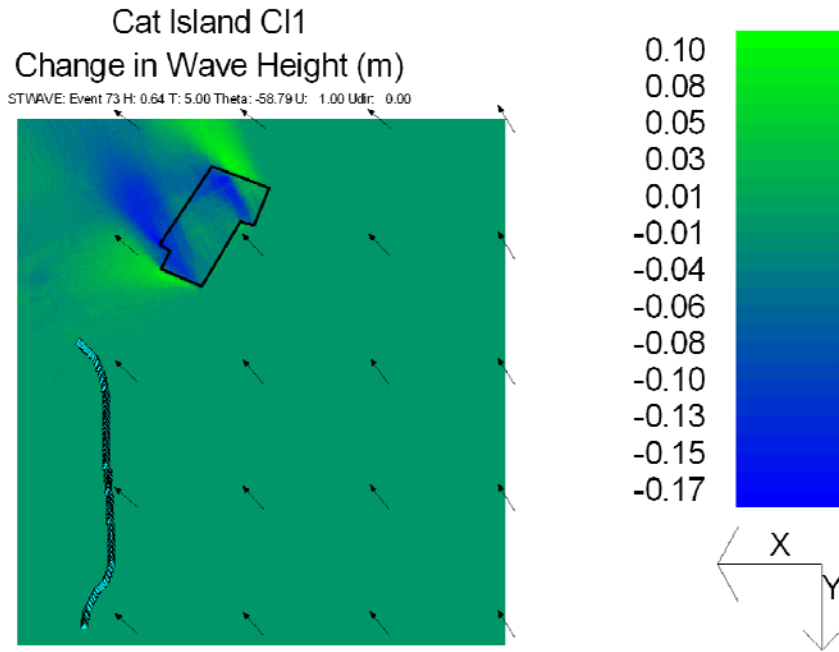

Figure 11. Wave height change (dredged − existing) for incident wave of H=0.64m, T =5 s and Theta =-58.79 deg for CI1
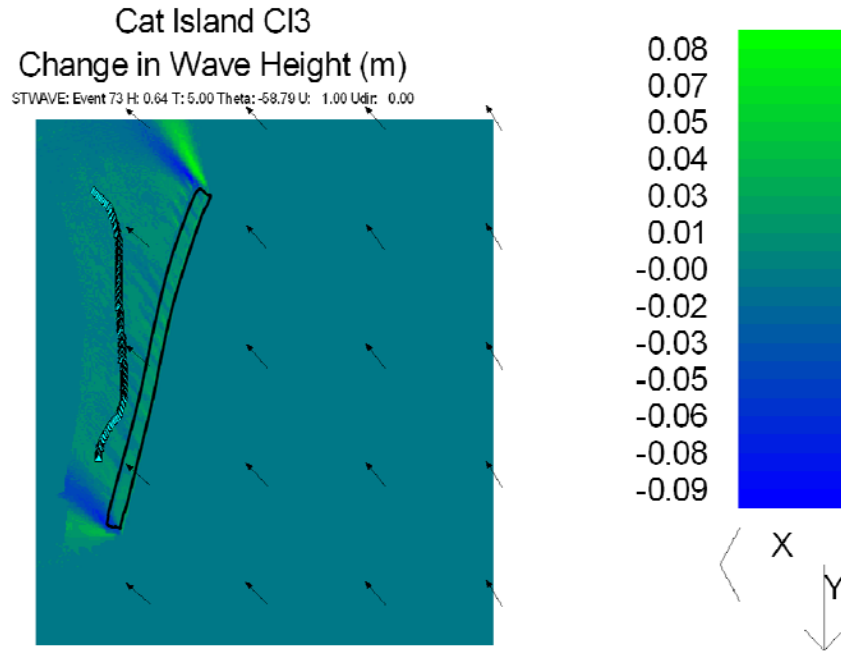
Figure 12. Wave height change (dredged – existing) for incident wave of H=0.64m, T =5 s and Theta =-58.79 deg for CI3
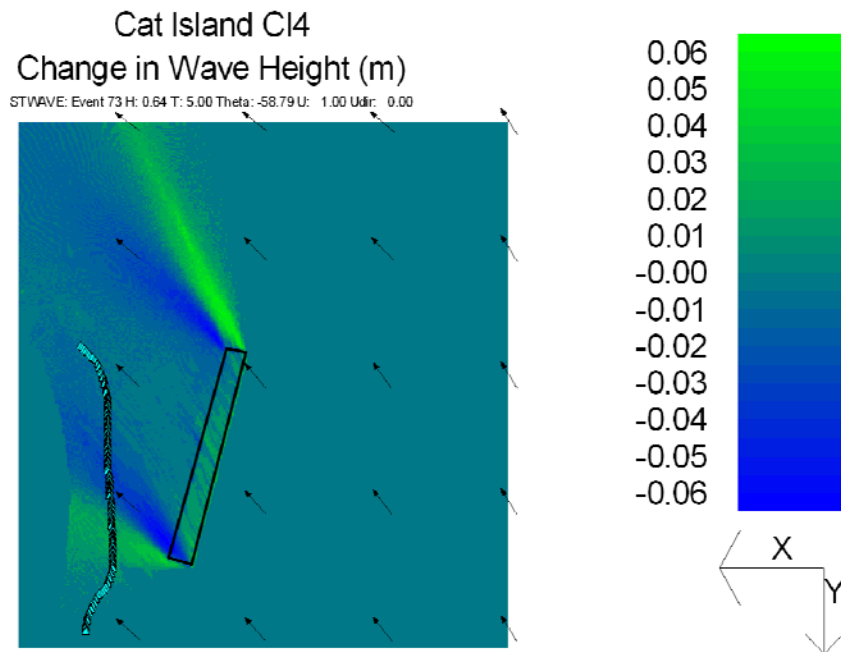

Figure 13. Wave height change (dredged – existing) for incident wave of H=0.64m, T =5 s and Theta =-58.79 deg for CI4
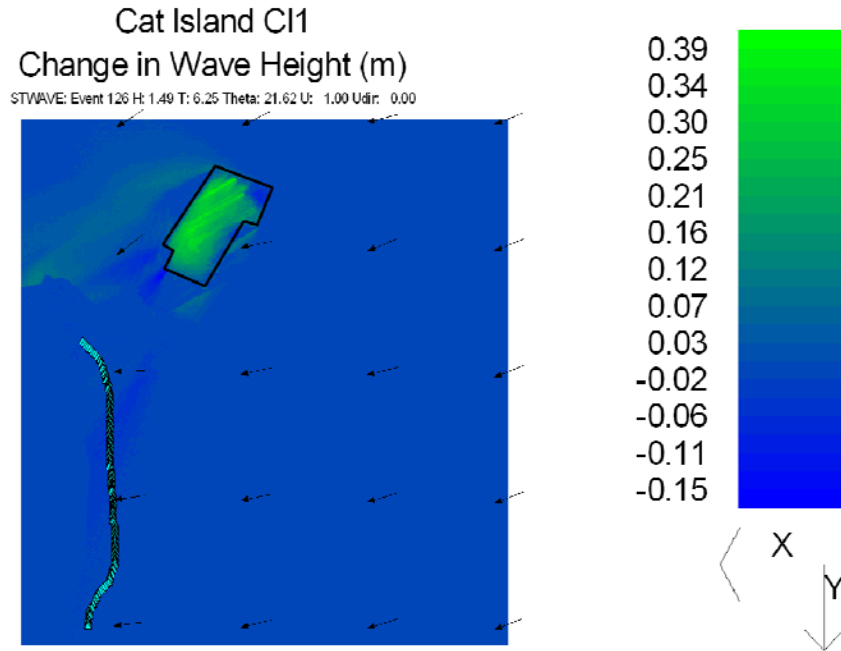
Figure 14. Wave height change (dredged – existing) for incident wave of H=1.49 m, T =6.25 s and Theta = 21.62 deg for CI1
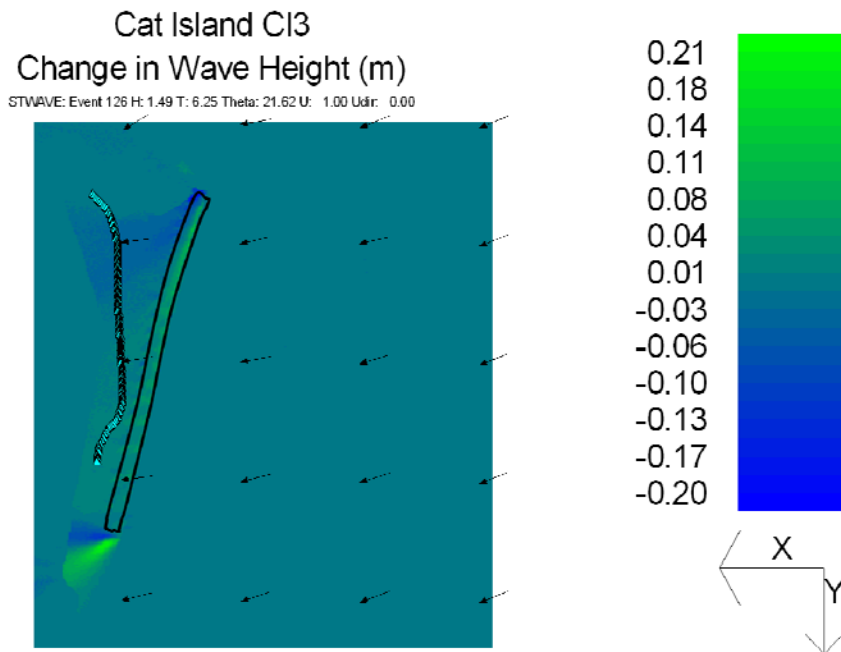

Figure 15. Wave height change (dredged – existing) for incident wave of H=1.49 m, T =6.25 s and Theta = 21.62 deg for CI3
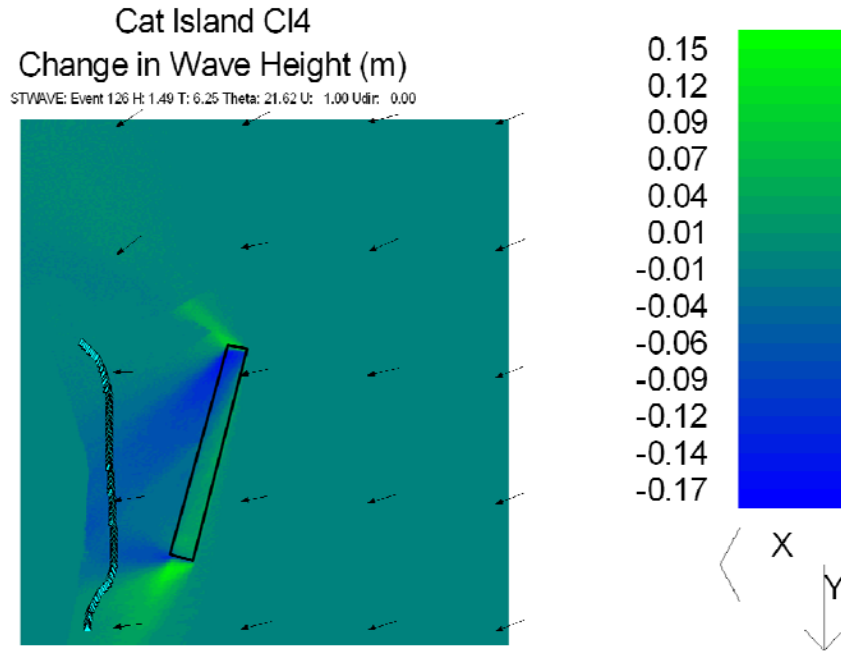
Figure 16. Wave height change (dredged − existing) for incident wave of H=1.49 m, T =6.25 s and Theta = 21.62 deg for CI4
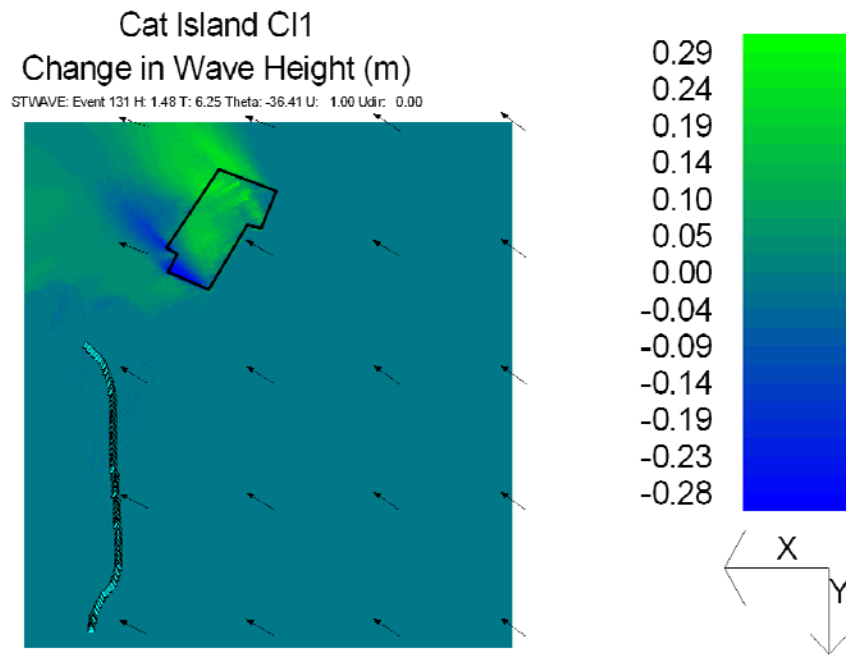

Figure 17. Wave height change (dredged − existing) for incident wave of H=1.48 m, T =6.25 s and Theta =-36.41 deg for CI1
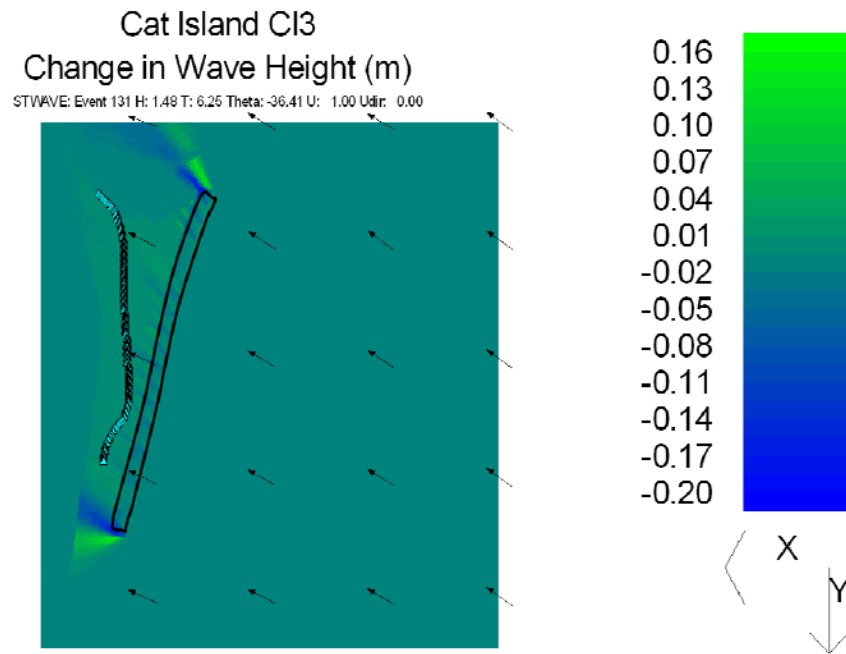
Figure 18. Wave height change (dredged – existing) for incident wave of H=1.48 m, T =6.25 s and Theta = -36.41 deg for CI3
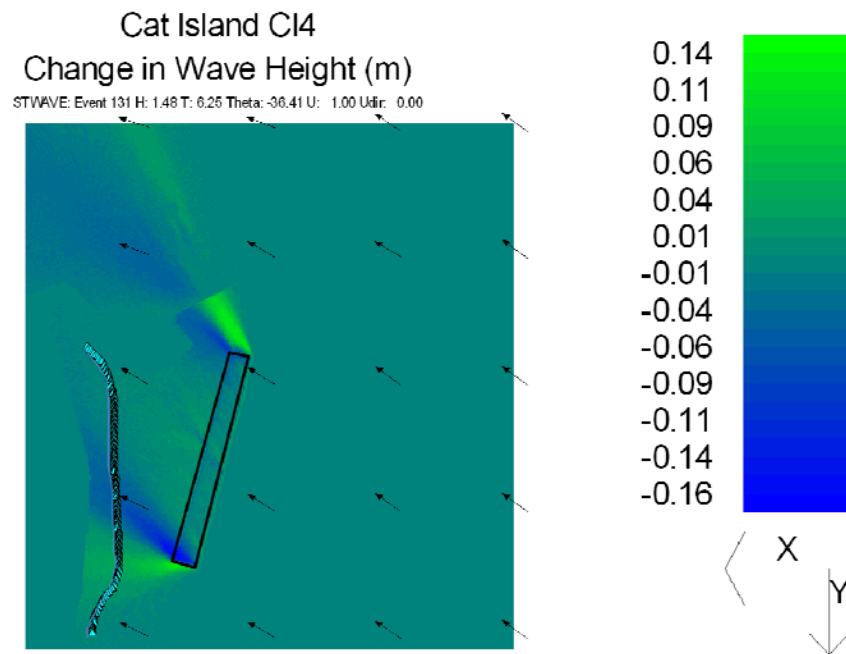

Figure 19. Wave height change (dredged – existing) for incident wave of H=1.48 m, T =6.25 s and Theta = -36.41 deg for CI4
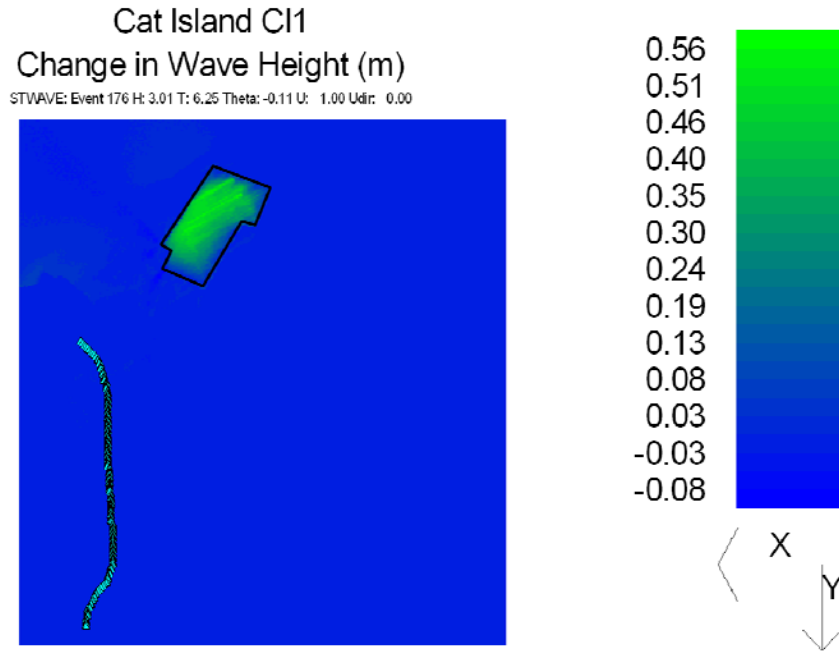
Figure 20. Wave height change (dredged – existing) for incident wave of H=3.01 m, T =6.25 s and Theta = -0.11 deg for CI1
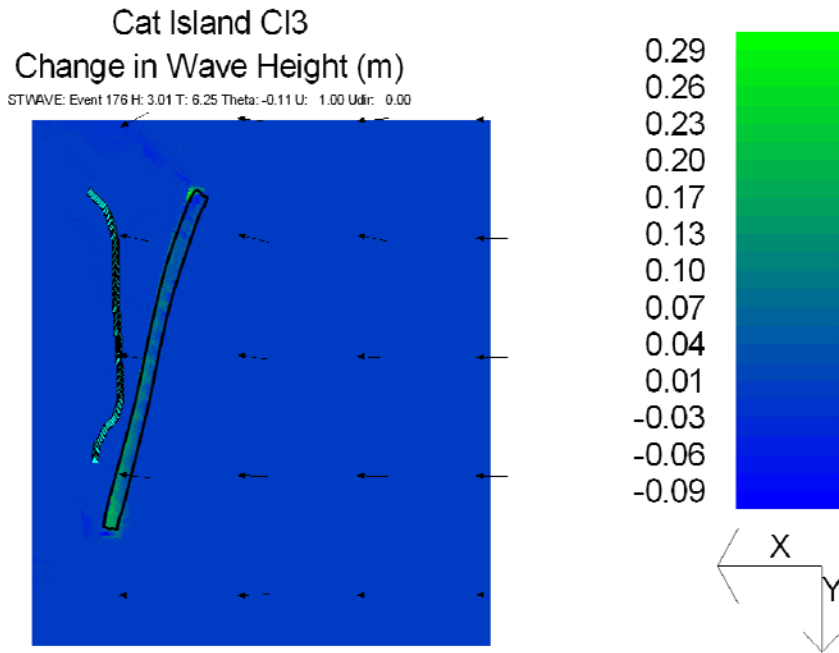

Figure 21. Wave height change (dredged – existing) for incident wave of H=3.01 m, T =6.25 s and Theta = -0.11 deg for CI3
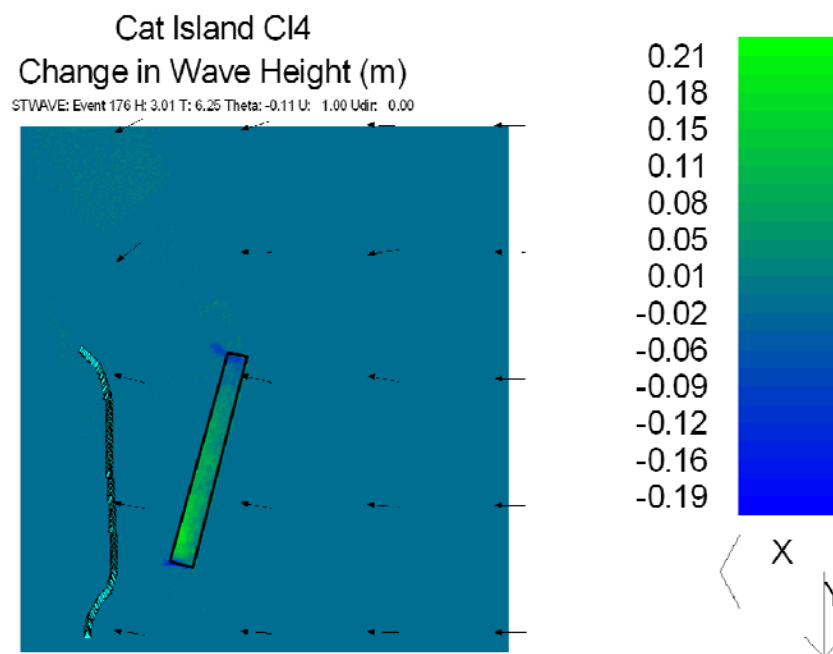
Figure 22. Wave height change (dredged − existing) for incident wave of H=3.01 m, T =6.25 s and Theta = -0.11 deg for CI4

Sediment Transport and Shoreline Change

A GENESIS model domain was generated for examining the influence of borrow areas on shoreline processes along the Cat Island shoreline. The model domain is 4.25 km (2.64 miles) long and the initial shoreline position was developed from existing Gulf shorelines of Cat Island. The origin of the GENESIS axis is at the northeast end of the island.

Wave conditions determined through STWAVE simulations for dredged and existing conditions were applied as input to GENESIS to estimate longshore sand transport rates and shoreline change. GENESIS simulations were run for the 20-year WIS hindcast offshore wave time series (1980-1999). Figure 22 displays estimated final shoreline position for existing and dredged conditions, as well as the initial shoreline position. Dredged conditions show little change in erosion over the 20-year simulation interval as compared with existing conditions. Figure 23 plots shoreline change rate for each condition. Negative values indicate erosion and positive values indicate accretion. Figure 24 plots the difference, or change, in estimated shoreline change rates between existing and dredged conditions for each point on the GENESIS axis. Increased

shoreline recession rates associated with dredged conditions is estimated to approach a maximum of approximately 0.2 m/year for CI1, 0.3 m/year for CI3, and about 0.3 m/year for CI4 in an area that averages around 4 m/year annual erosion.
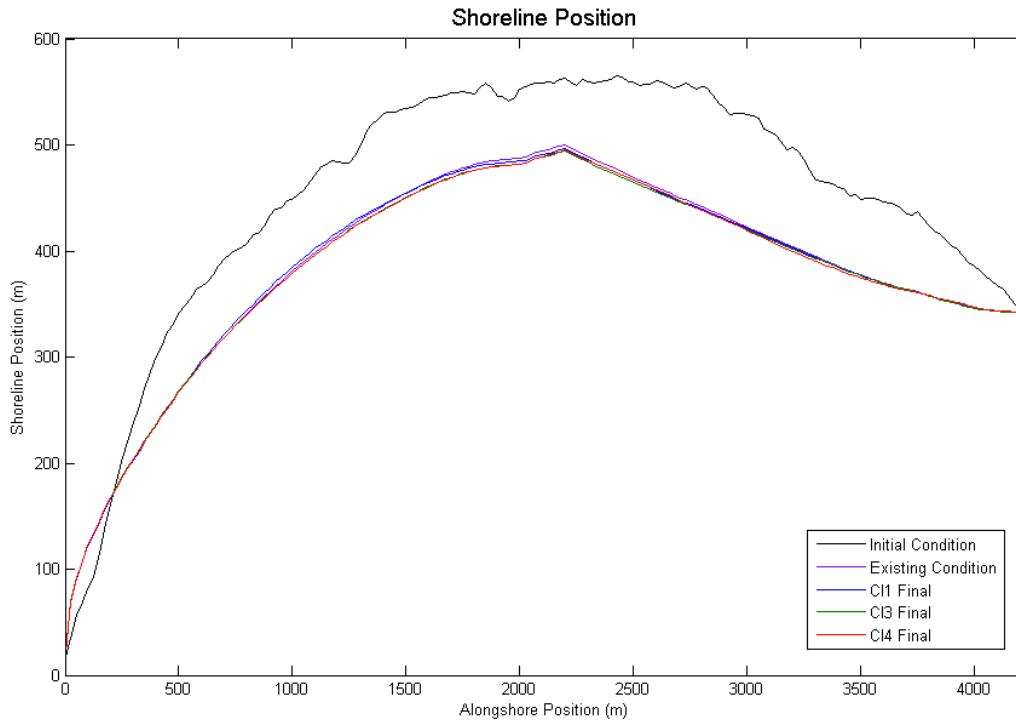

Figure 22. Comparison of Existing and Dredged condition estimated final shoreline. Northeast end of the island is to the left.
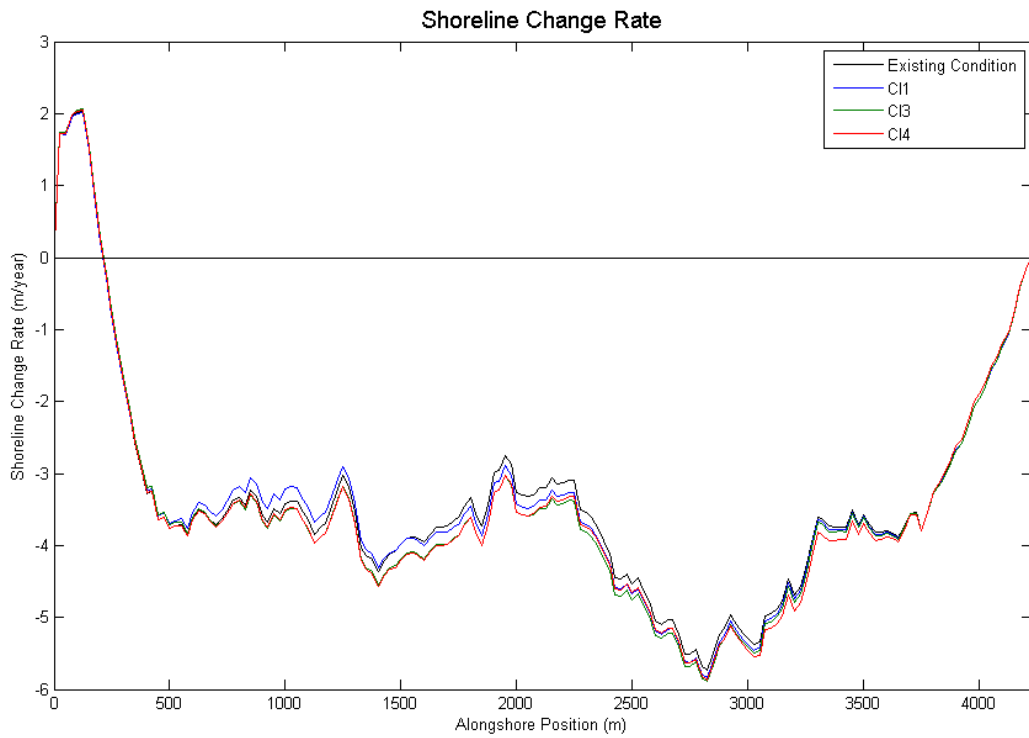
Figure 23. Comparison of Existing and Dredged condition shoreline change rate. Northeast end of the island is to the left.
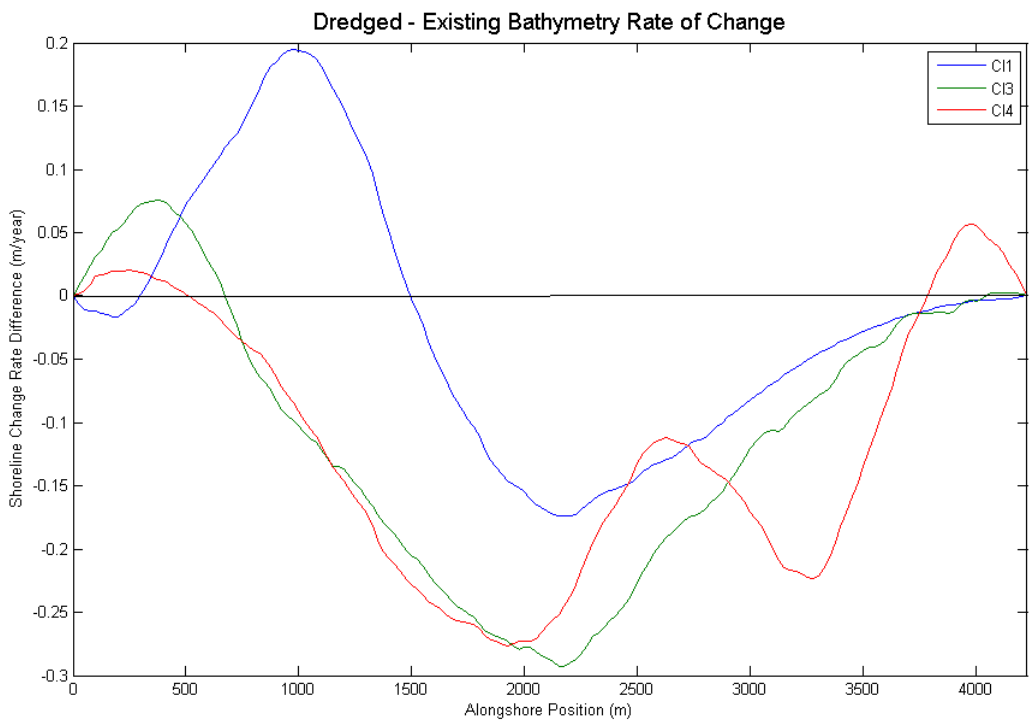

Figure 24. Dredging induced change in shoreline change rate. Northeast end of the island is to the left.

Estimated average annual longshore sand transport rates for existing and proposed borrow area dredged conditions is plotted in Figure 25. Positive values indicate transport to the right on the plot (northeast to southwest transport). This leads to a positive slope in the longshore sand transport rate indicating erosion whereas a negative slope indicates shoreline accretion. The steeper the slope, the higher the predicted shoreline rate of change. A stable shoreline is associated with a constant longshore sand transport rate. Estimated average annual longshore sand transport rates for dredged conditions vary from approximately -60,000 m³/year (north-directed) at the northern tip of Cat Island to nearly 30,000 m³/year (south-directed) at the southern tip of Cat Island for each borrow area.
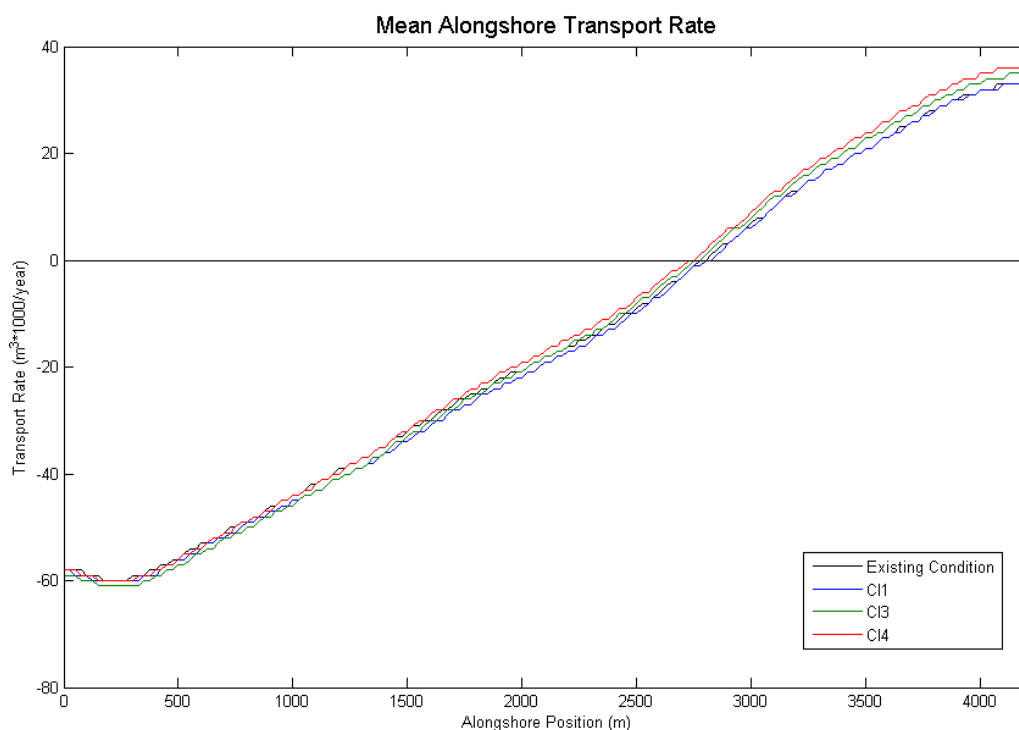
Figure 25. Mean alongshore transport rate. Northeast end of the island is to the left.

Conclusion

The impacts of excavation from near shore borrow areas for the proposed restoration project on Cat Island were assessed with the spectral near shore wave transformation model STWAVE and the shoreline change model GENESIS. Wave conditions from the WIS hindcast database for WIS Station GOM 144 were transformed from the 15 m contour to the 7 m contour to provide wave data for the offshore portion of the STWAVE grid

using a WIS Phase III transformation. STWAVE simulations were performed for existing and proposed borrow area dredged conditions to obtain estimates of nearshore wave conditions landward of borrow areas and to enable a comparative analysis aimed at quantifying borrow area impacts on shoreline processes along Cat Island shoreline. The effects of proposed borrow areas on nearshore wave conditions were quantified by examining change in nearshore wave height and direction landward of the borrow areas. STWAVE results show increases in wave heights surrounding the borrow area with little affect on the GENESIS save stations. STWAVE results were applied as input to GENESIS to quantify the influence of the borrow areas on shoreline processes. An analysis was conducted comparing results for both the existing and dredged (restored) conditions. Longshore sand transport rates were calibrated with typical values for K_1 and K_2 of 0.10 and 0.05 respectively and produced transport rates consistent with sediment budget estimates. The magnitude of increased erosion approaches 0.2 m/yr for the CI1 compared to 0.3 m/yr for CI3 and 0.275 m/yr for CI4 compared to an overall erosion rate of 5.8 m/yr. The northeast end of Cat Island is expected to prograde as a result of borrow area CI1 reaching a maximum increase of approximately 4 m relative to existing conditions over 20 years (0.25 m/yr). Approximately 700m of shoreline is predicted to prograde relative to existing conditions. For borrow area CI3, about 750m of shoreline is predicted to prograde relative to existing conditions with a maximum increase of approximately 1.5 m. CI4 prograde up to 0.4 m for a 500 m section on northeast Cat Island and 1.1 m for a 400 m section on the southwest end of Cat Island due to shorter wave heights behind the borrow area.

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