EASTLAND PORT MAINTENANCE DREDGING AND DISPOSAL PROJECT

Morphological response of the shoreline to maintenance dredging and disposal of sediments

Report prepared for Eastland Port, Gisborne

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MetOcean SOLUTIONS

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1. Introduction

Eastland Port Ltd are seeking to renew their maintenance dredging and disposal consents at the Port of Gisborne.

Currently, dredged sediment is disposed at an offshore disposal site situated in approximately 18 – 20 m water depth (Figure 1.1), with an average annual rate of approximately 73,000 m^3 based on estimates obtained between 2002 and 2019 by Eastland Port.

Maintenance dredging is expected to occur using the Trailing Suction Hopper Dredge (TSHD) “Pukunui” although, if there are significant inflows of sediment due to large storm events, a higher productivity Trailing Suction Hopper Dredge (TSHD) may be required to ensure the required port and channel depths can be maintained. It is likely that some maintenance dredging may also be undertaken using a Backhoe Dredger (BHD) or Cutter Suction Dredger (CSD).

MetOcean Solutions (MOS) has been contracted to provide coastal oceanographic expertise to investigate both physical and morphological effects and associated sediment transport patterns resulting from the dredging and disposal of maintenance dredging material at the current disposal site. For this purpose, the process-based model Delft3D has been used to hindcast the sediment dynamics over northern Poverty Bay and Eastland Port. This included the use of combined reduction techniques and morphological acceleration factors (MORFACs) as well as storm-induced morphological reconstructions. Qualitative and quantitative calibration has been achieved through the comparison of morphological model outputs against measurements.

The numerical model outputs from simulations of the maintenance dredging and disposal were used to assess the likely response of the shoreline to the proposed activities. Details of the assessment approach are provided in MetOcean Solutions (2018, 2019).

The report is structured as follows: Section 2 provides an overview of previous assessments of the historical evolution of the Poverty Bay shoreline, while Section 3 presents the methodology applied in this study. In Section 4 the effects of the maintenance dredging and disposal are discussed in terms of wave height and sediment dynamics, followed by a brief summary in Section 5. The references cited in this document are listed in Section 6.

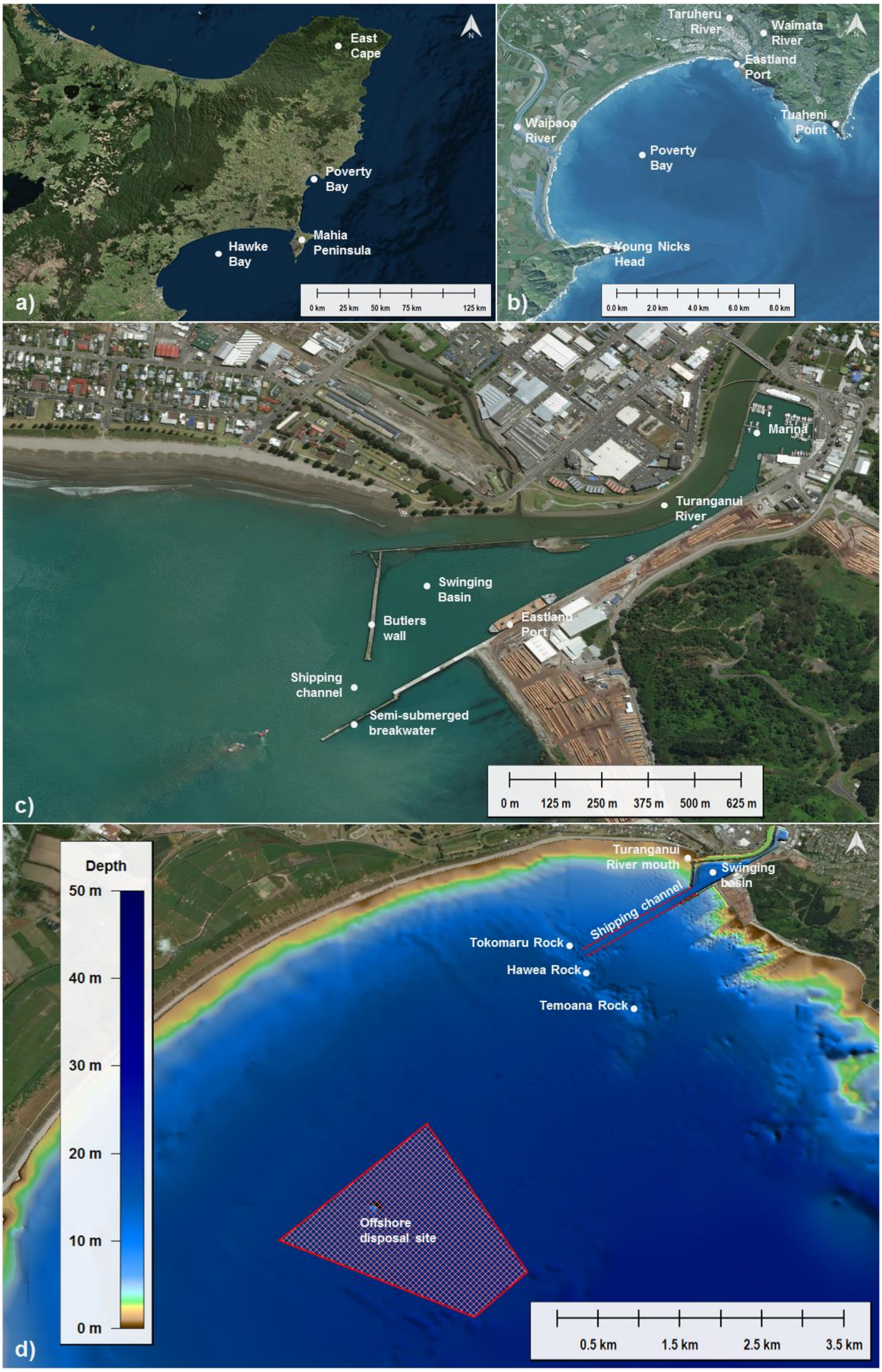

Figure 1.1 Maps showing the location of Poverty Bay (a, b), and Eastland Port (c) with the locations used in the present study. Both offshore disposal and shipping channel are indicated on top of the bathymetry in (d).

2. Background

Gisborne District Council (GDC) have supported, undertaken or commissioned extensive assessments of coastal hazard zones along Poverty Bay by examining the historical evolution of the Poverty Bay shoreline (Smith 1988; Beamsley 2003; and Gibb 2014[1]). As part of this process, the beach areas adjacent to Eastland Port have been regularly surveyed to investigate the natural evolution of the nearshore and, as such, indirectly the impact of the port maintenance dredging on the environs sediment dynamics. Coastal studies carried out through the analysis of *in situ* measurements and numerical model outputs have considerably improved the understanding of the physical processes controlling the evolution of the shoreface along Poverty Bay and the effect of previous dredging operations, and the ongoing maintenance dredging.

The present section provides an overview of the main outcomes of these previous studies that have been used to support the impact assessment of the proposed disposal programs.

2.1.1 Waikanae Beach region

Between 1910 and 1993, Waikanae Beach located to the West of the Turanganui River Mouth has been characterised by a progradation of its shoreline. However, this progradation has been historically variable. The construction of the river diversion wall in the 1930's and the significant capital dredging and wharf construction in the later 1960's modified positively and negatively the sediment budget along Waikanae Beach, respectively. Since 2000, the stretch of coastline between Midway Beach to Waikanae Beach has been relatively stable. This stability results from the balance between the physical processes and sediment supply from diabathic, parabathic and fluvial sources. Given the sediment sources, the inter-annual variability in catchment sediment run-off and the northward alongshore sediment transport within Poverty Bay plays an important role in the evolution and stability of the shoreline.

During storm events, sediment within the littoral area offshore Waikanae Beach is expected to migrate offshore due to suspended-load transport where the deepened navigation channel acts as a sediment-trap. Due to increasing water depths and decreasing bed shear stresses, the eroded sediments settle in the lee of the channel where the mixture of sand and mud particles forms a consolidated surficial layer (Smith 1988; Beamsley 2003; and Gibb 2014).

2.1.2 Kaiti Beach region

Based on aerial photographs and surveys, Smith (1988) estimated approximately 2000 m^3 of sediment annually is deposited onto Poverty Bay beaches from both the cliffs east of Kaiti

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[1] https://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&uact=8&ved=0ahUKEwjE6s-KjdXTAhXFnJQKHTVFAaAQFgg1MAM&url=http%3A%2F%2Fwww.gdc.govt.nz%2Fassets%2FUploads%2FAppendix-J-Coastal-Assessment.pdf&usg=AFQjCNHoNDy7IGpIk3qOUMtxhvI6R8mr-Q&sig2=PZtiPqS8OGr7MMb6DQ3iGQ

Beach and the cliffs of Young Nick's Head. These sediments, along with parabathic alongshore and diabathic offshore sediment transport associated with incident waves coming from the south/south-eastern quadrant control the relative stability of Kaiti Beach. The western section of Kaiti Beach near the main breakwater has not shown any significant trend changes since 2000 while the eastern section of the beach has been eroded. It is likely that the construction of the main breakwater in the early 1900's and the capital dredging in the 1960's significantly reduced the nourishment of Kaiti Beach via eastward directed parabathic sediment transport and fluvial inputs. However, the breakwater also likely interrupts the westward alongshore sand transport making the deposition of material possible and leading to a relatively stable shoreface (Smith 1988; Beamsley 2003; and Gibb 2014).

2.1.3 Waipaoa River Mouth

To the North of the Waipaoa River mouth, the large discharges of fluvial sediments and the northward alongshore parabathic sediment transport acts to positively nourish the foreshore. The dissipation of waves by friction throughout the bay contributes to limit the erosion of sediments during storm events. As such, this region of Poverty Bay has been continuously subjected to progradation over the last century. By contrast, the beach area to the south of the Waipaoa River mouth near Te Wherowhero Lagoon has been somewhat eroded since 2000; likely due to the effect of incoming waves from the eastern quadrant. In absence of southward alongshore drift, the nourishment of the southern beach areas by fluvial sediments is limited (Smith 1988; Beamsley 2003; and Gibb 2014).

3. Method

The shoreline morphological response to the Eastland Port maintenance dredging program has been investigated using numerical model results provided in MetOcean Solutions (2018, 2019). Given that maintenance dredging of the shipping channel has been undertaken at it's existing level for more than 30 years and consents the offshore disposal ground have been in place since 1998, the background provided in Section 2 allowed us to contextualise the predicted change within the nearshore environs. The present section briefly summarises the methodology applied in the numerical modelling. Further details about the numerical modelling strategy are provided in MetOcean Solutions (2018).

3.1 Channel modelling

The open-source Delft3D system was used to run 3-dimensional high-resolution process based morphodynamic simulations within northern Poverty Bay and the Eastland Port environs. The numerical modelling involved fully-coupled wave, current and morphological interactions. Input reduction techniques and morphological acceleration factors were applied within the Delft3D modelling framework. The morphological model results were successfully calibrated and validated against measurements, with details of the calibration and validation presented in MetOcean Solutions (2018).

Simulations for two 1-year periods with contrasting ambient forcing regimes of La Niña and El Niño (June 1998-June 1999, and June 2002-June 2003, respectively) were carried out to assess the morphological response of the system to the maintenance dredging (i.e. the dredging of 75,000 and 120,000 m^3, for La Niña and El Niño, respectively, considering both the channel and swinging basin). Simulations including the existing channel profile were performed to assess the effect of the channel on the nearshore wave climate.

3.2 Disposal modelling

The morphological modelling of the disposal mound associated with the estimated one-year maintenance dredging volume for both La Niña and El Niño climatic conditions (i.e. 75,000 m^3 and 120,000 m^3, respectively) were simulated. The model domain was extended to include the entire Poverty Bay in order to fully capture the physical processes around the disposal site. To isolate the effect of dredged sediment discharged at the disposal ground, the initial model conditions assumed sediment available only within the disposal ground, which is then progressively dispersed throughout the sequence of representative events. Wave modelling considering both the pre- and the post-disposal environments was also carried out in order to examine the potential effect of the disposal mound on the nearshore wave climate.

4. Results

The effect of the maintenance dredging and potential disposal mound on the inshore wave climate and morphological response of the shoreline has been assessed by examining the predicted inshore significant wave height, transport fields and predicted depth changes. We compared results of the proposed offshore disposal with those expected for the existing bathymetry.

4.1 Effects of the proposed continuation of the maintenance dredging

A previous report on the shoreline changes along Midway and Waikanae beaches (Gibb, 2014) indicates that within Poverty Bay there is a pattern of historic accretion (spanning the last 7500 years, and in more detail over the last 70-113 years and specifically between 2000-2014). A foredune complex is visible along the coast, except between Grey Street and the Turanganui River mouth. This part of the coast, although highly modified by human activity, is relatively stable, according to Gibb (2014).

The shelf currents greatly influence the alongshore component of the sediment transport toward Eastland Port. Sediment is mostly supplied from the Waipaoa River, at about 0.15 Mt/year (Gibb, 2014), and transported along Midway and Waikanae beaches with a large portion of the drifted material deposited at the month of the Turanganui River, forming a bank. The deposited sediment is likely reworked and transported to the port navigation channel during ebb tides and peak flows (Gibb, 2014), together with fluvial material from the Turanganui river (Beamsley, 2003). Smith (1988), Foster and Carter (1997), Hicks et al. (2000), Kniskern (2007), and Moriarty et al. (2015) also showed that the Waipaoa River discharges significant amounts of sediment into Poverty Bay and over the adjacent continental shelf margin. The resultant influx of fluvial material results in a progradation of the beaches into the bay.

Wave classes 4 to 6 (MetOcean Solutions, 2019) represent dominant wave energy events impacting Midway and Waikanae Beaches, with the incident direction being from the southerly quarter. The shipping channel has little impact on the incident wave directions at Midway and Waikanae Beaches due to the incident wave direction being approximately perpendicular to the orientation of the shipping channel. Similarly, incident wave height is not expected to be significantly modified by the shipping channel, as no focusing or diffusion of the incident wave energy is expected (again due to the orientation of the shipping channel relative to the dominant incident wave direction). As such, the impact of maintaining the existing shipping channel on the shoreline stability and littoral processes are expected to be minor, and a continuation of the existing observed shoreline morphological evolution is expected (see Gibb, 2014)

The significant wave height and direction for two contrasting wave classes are given in Figure 4.1 and Figure 4.2 (Class 1: H_s = 2.16 m T_p = 10 s, *Dir* = 100 and Class 6: H_s = 5.7, T_p = 12 s, *Dir* = 230), while Figure 4.3 shows the mean total transport during “La Niña” for wave conditions of Class 6 for the existing configuration.

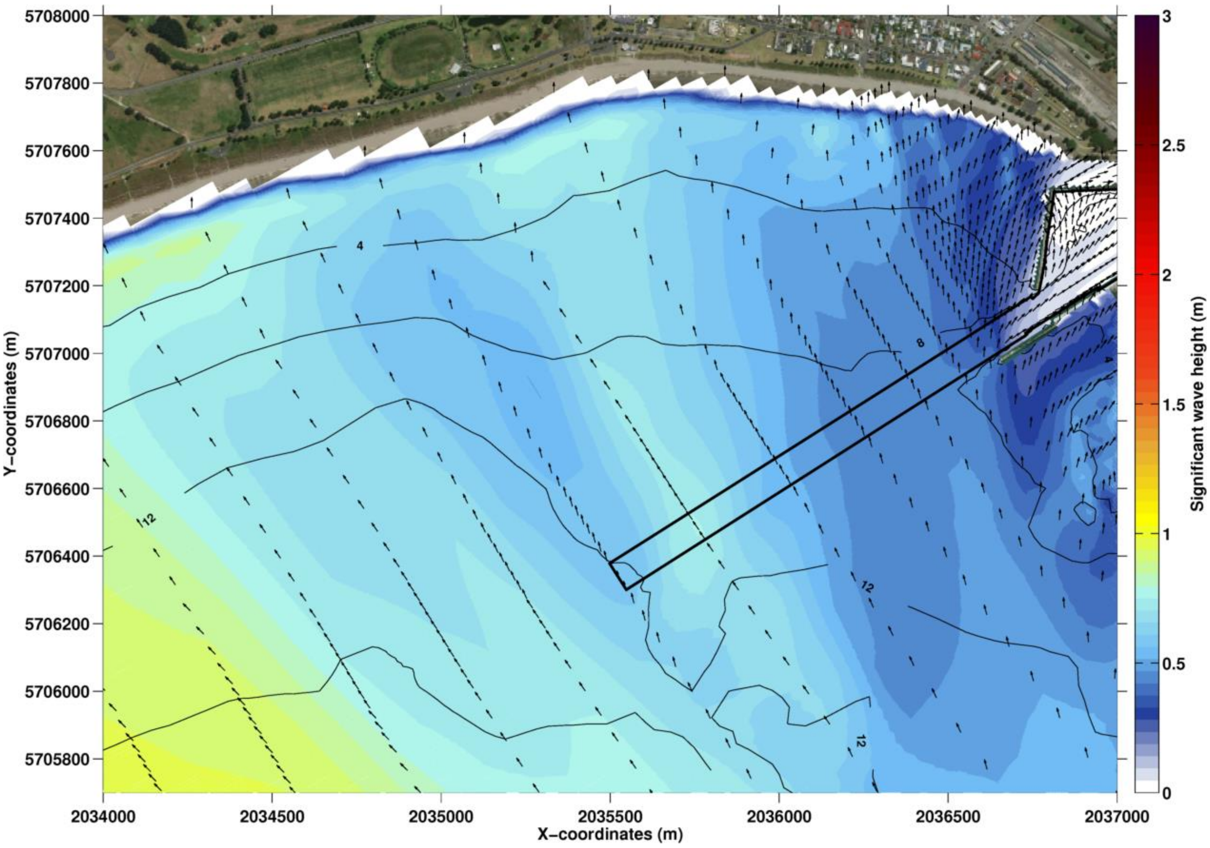


Figure 4.1 Significant wave height for existing configuration (Class 1 Hs=2.16, Dir=100.4°, Tp=10s) in the vicinity of the navigation channel and along the adjacent beaches to Eastland Port. The black polygon indicates the navigation channel.

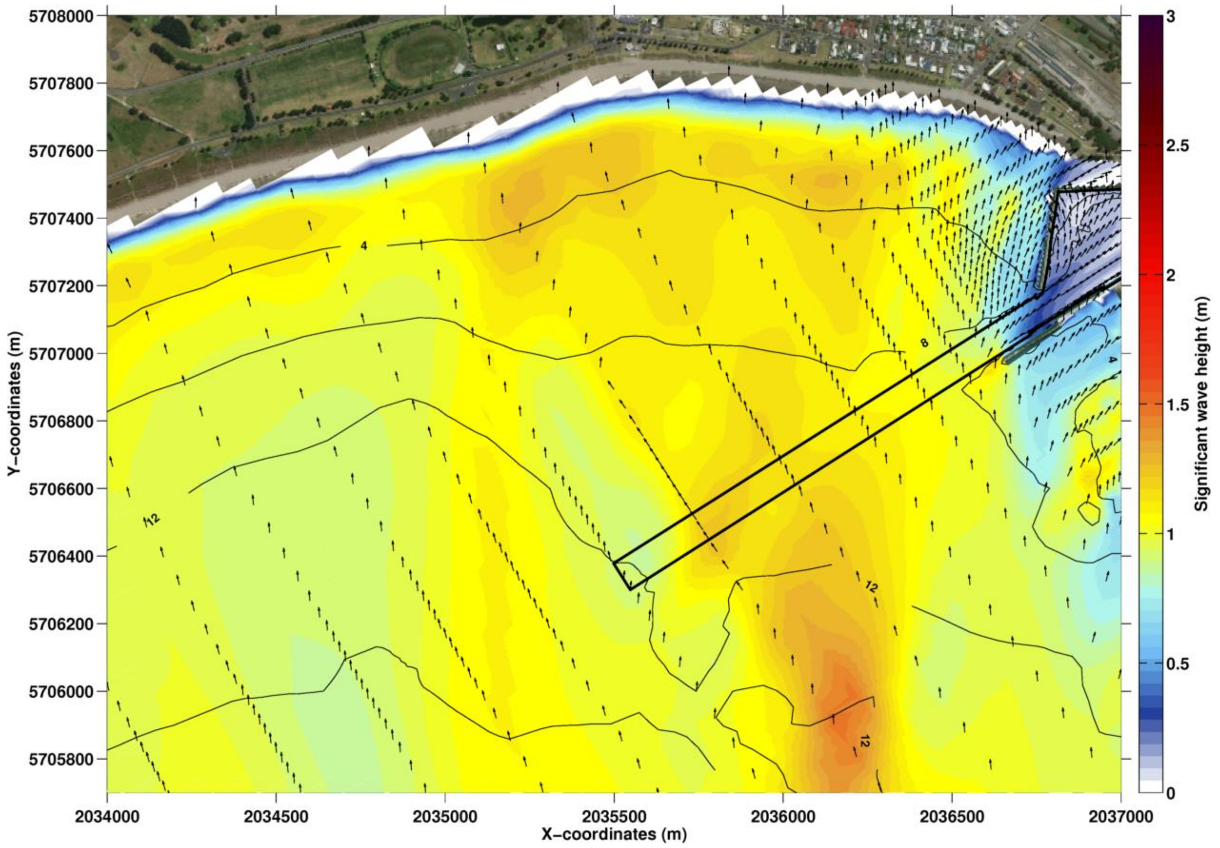


Figure 4.2 Significant wave height for existing configuration (Class 6 Hs=5.72, Dir=232°, Tp=12s) in the vicinity of the navigation channel and along the adjacent beaches to Eastland Port. The black polygon indicates the navigation channel.

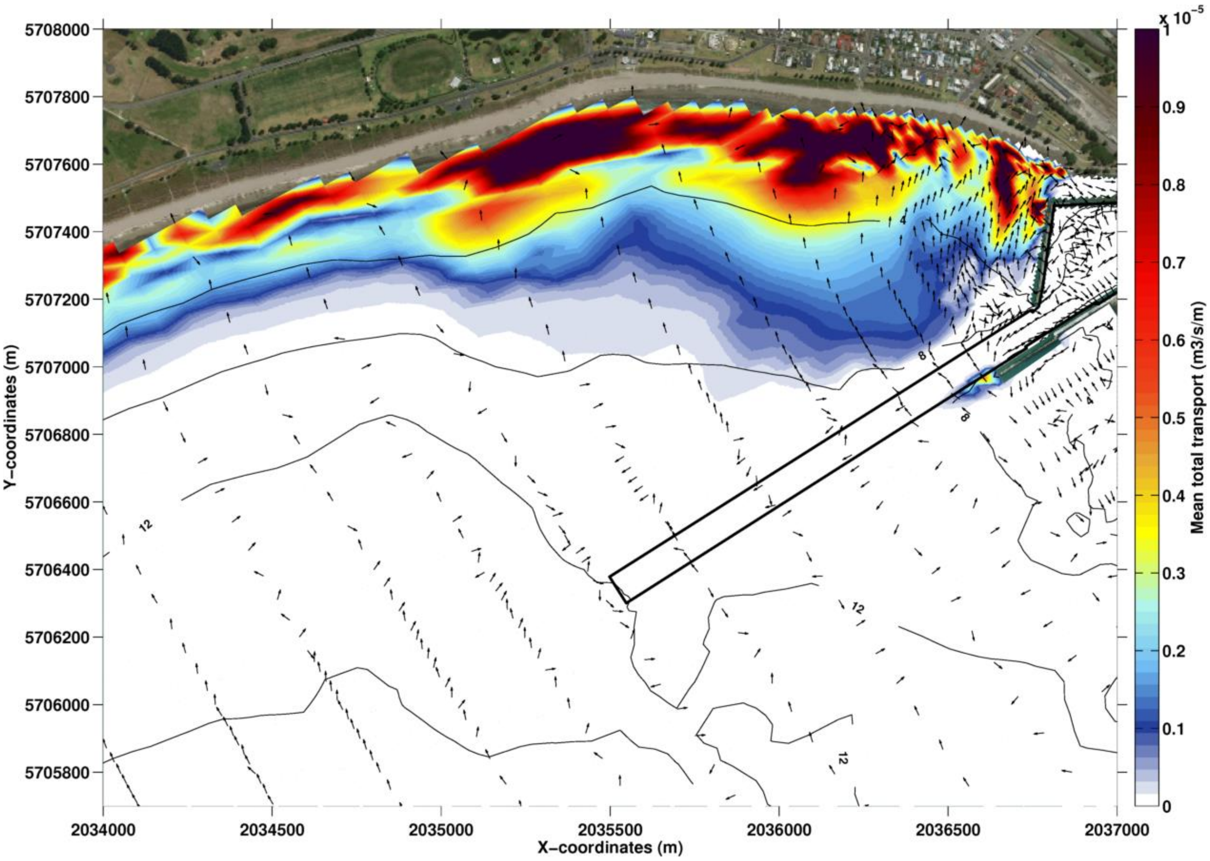


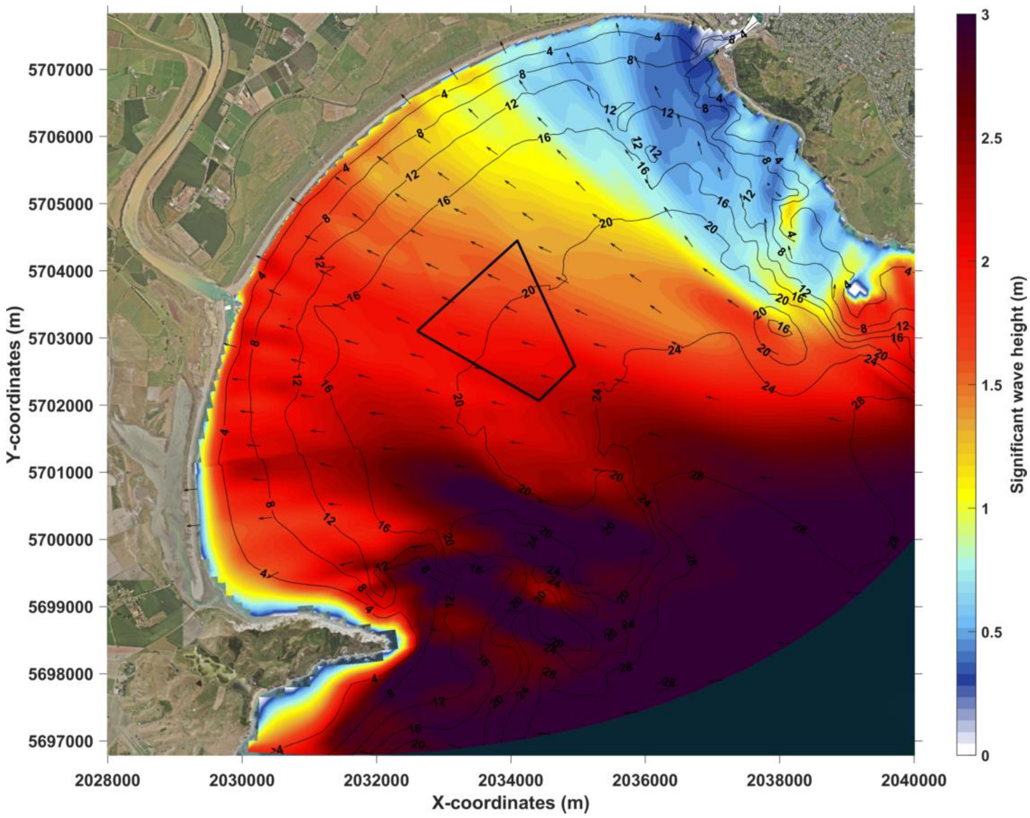
Figure 4.3 Mean total transport ("La Niña", Wave conditions Class 6) for the existing configuration in the vicinity of the navigation channel and along the adjacent beaches to Eastland Port. The black polygon indicates the navigation channel.

4.2 Effect of the proposed offshore disposal

The proposed disposal site is exposed to incident waves from the E-SE quadrants, which refract and propagate into Poverty Bay. The proposed one-year maintenance disposal mound is expected to slightly modify the incident wave refraction patterns inshore of the disposal mound, with expected significant wave height modifications of the order $\pm$0.2% possible (i.e ~0.01 m under energetic conditions) and some very localised changes in wave direction. Immediately in the lee of the disposal ground wave heights are expected to be reinforced, while refraction along the disposal ground edges results in areas of wave height reduction on either side of the disposal ground. The location of these alternating areas of increased/decreased wave height are dependent on the incident wave directions (Figure 4.4 and Figure 4.5). A comparison of wave direction at the 10-m isobath across the area where changes in wave height are expected is shown in Figure 4.6.

The relative changes to the incident wave climate are not expected to affect the shoreline sediment dynamics. Likewise, the morphological response of the disposal mound is not expected to result in any noticeable deposition of sediment over the inshore beach areas as shown in Figure 4.7 and Figure 4.8. The extent of movement of mud is predicted to be mostly constrained to 4 m to 20 m-deep waters under wave action. Further, the morphological model suggests a south and south-westward migration of fine sand particles. The medium-grained sand particles (%15 of the dredged material) are expected to slowly migrate outside the disposal area and its margin over extended periods.

The input of sediments from maintenance disposal activities is negligible in terms of beach morphodynamics compared to the fluvial sediment inputs of the Waipaoa River.



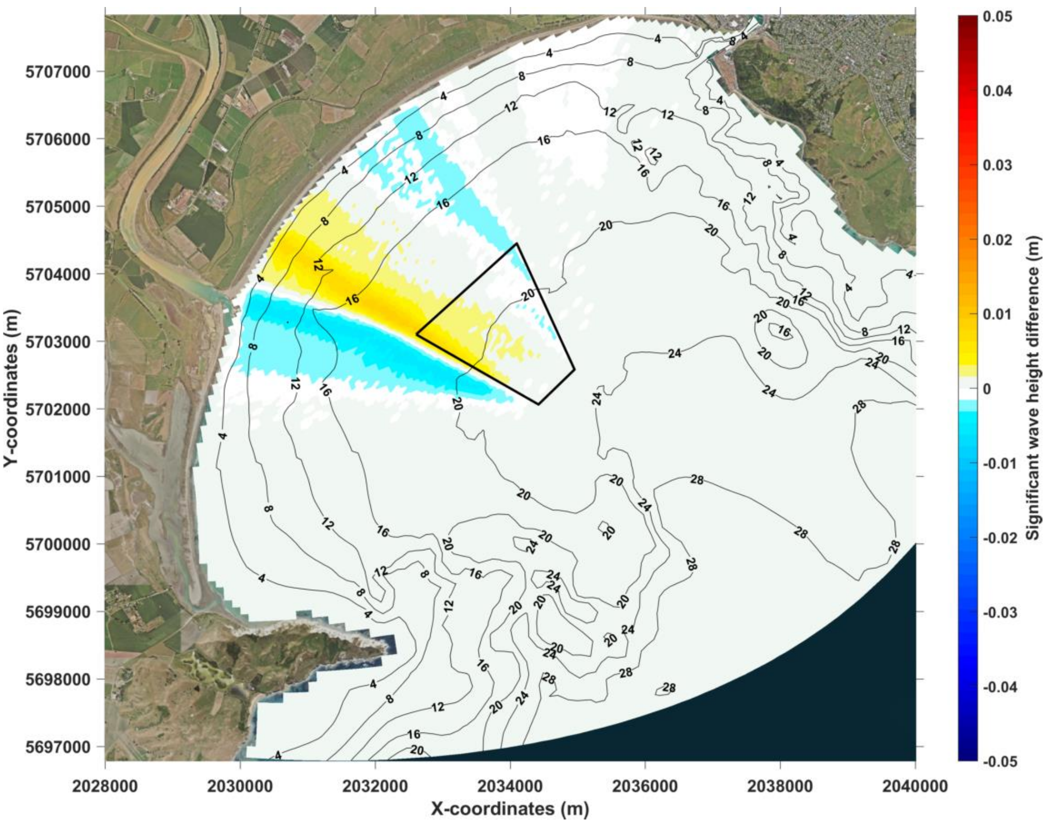
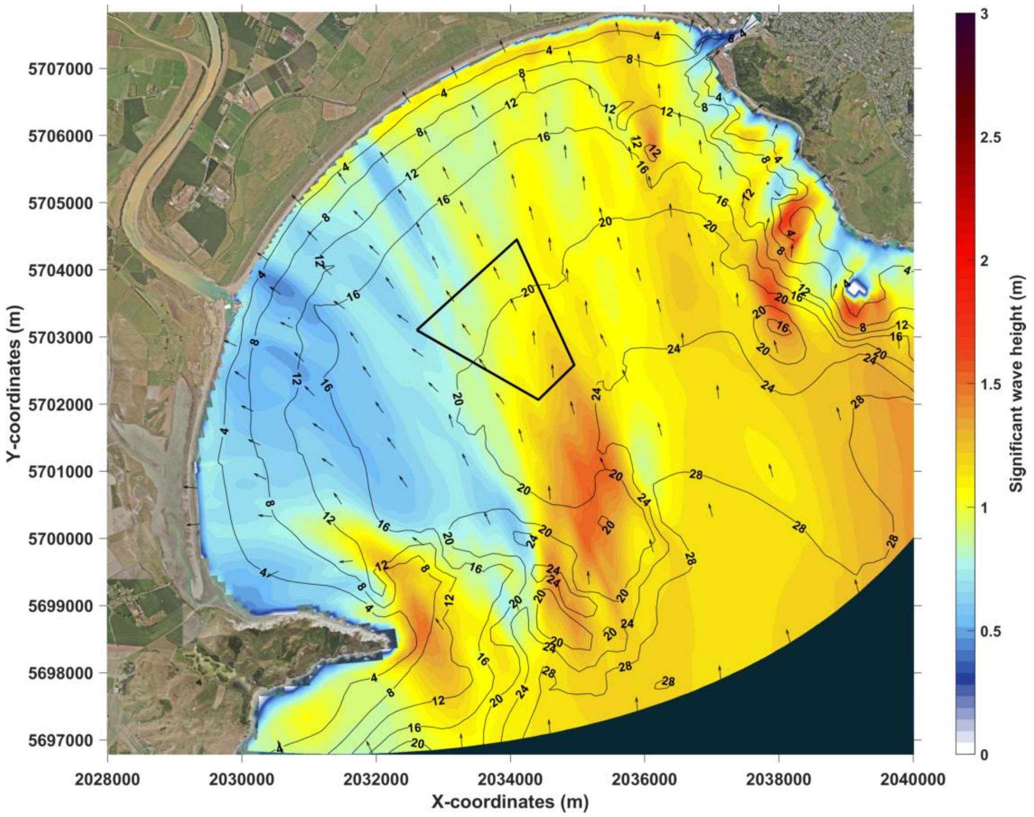


Figure 4.4 Post-disposal significant wave height (top) and difference in significant wave height (bottom) caused by the 4.4 cm disposal mound for the wave class 3 (Hs = 4.75 , Tp = 10.44 , Dir = 73.67).



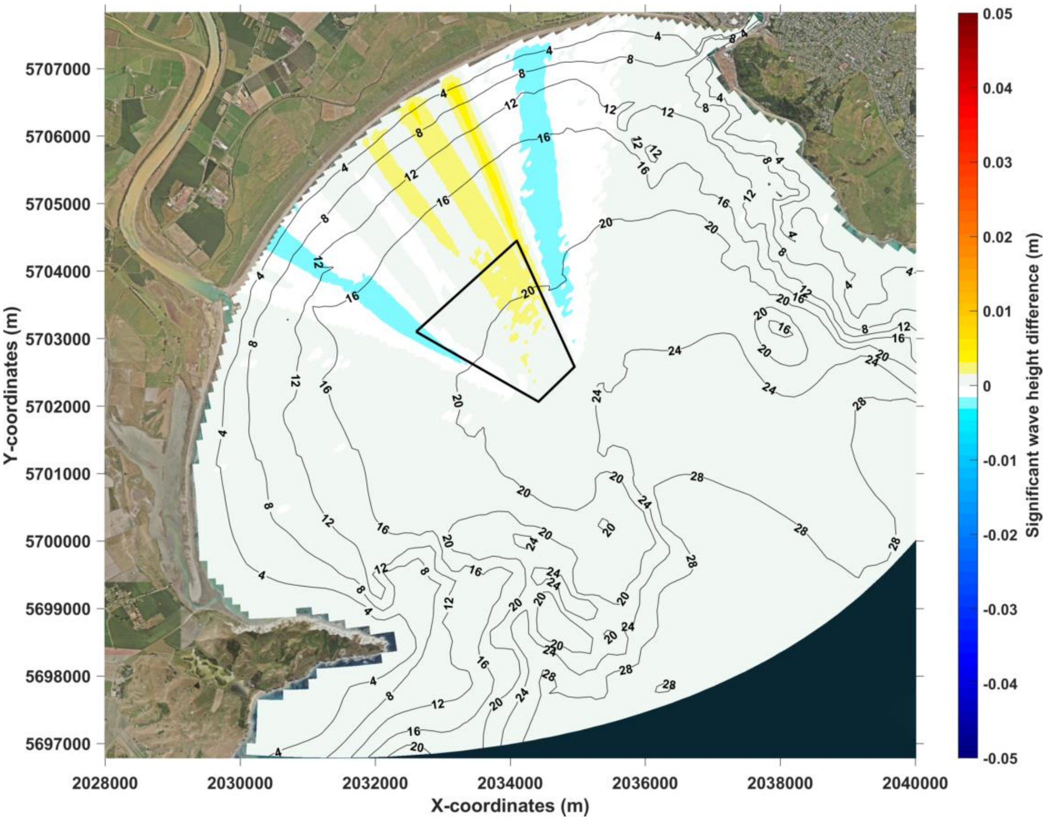


Figure 4.5 Post-disposal significant wave height (top) and difference in significant wave height (bottom) caused by the 4.4 cm disposal mound for the wave class 6 (Hs = 5.72 , Tp = 12.05 , Dir = 232.19).

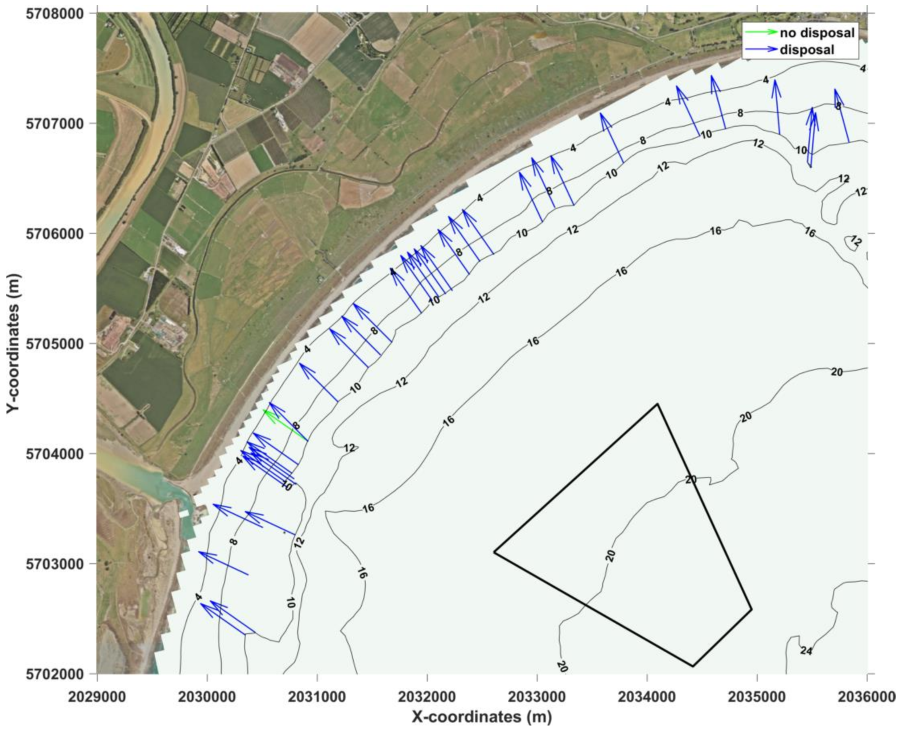


Figure 4.6 Change in wave direction at the 10-m isobath caused by the 4.4 cm disposal mound for the wave class 5 (Hs = 3.53 , Tp = 12.01 , Dir = 219.84).

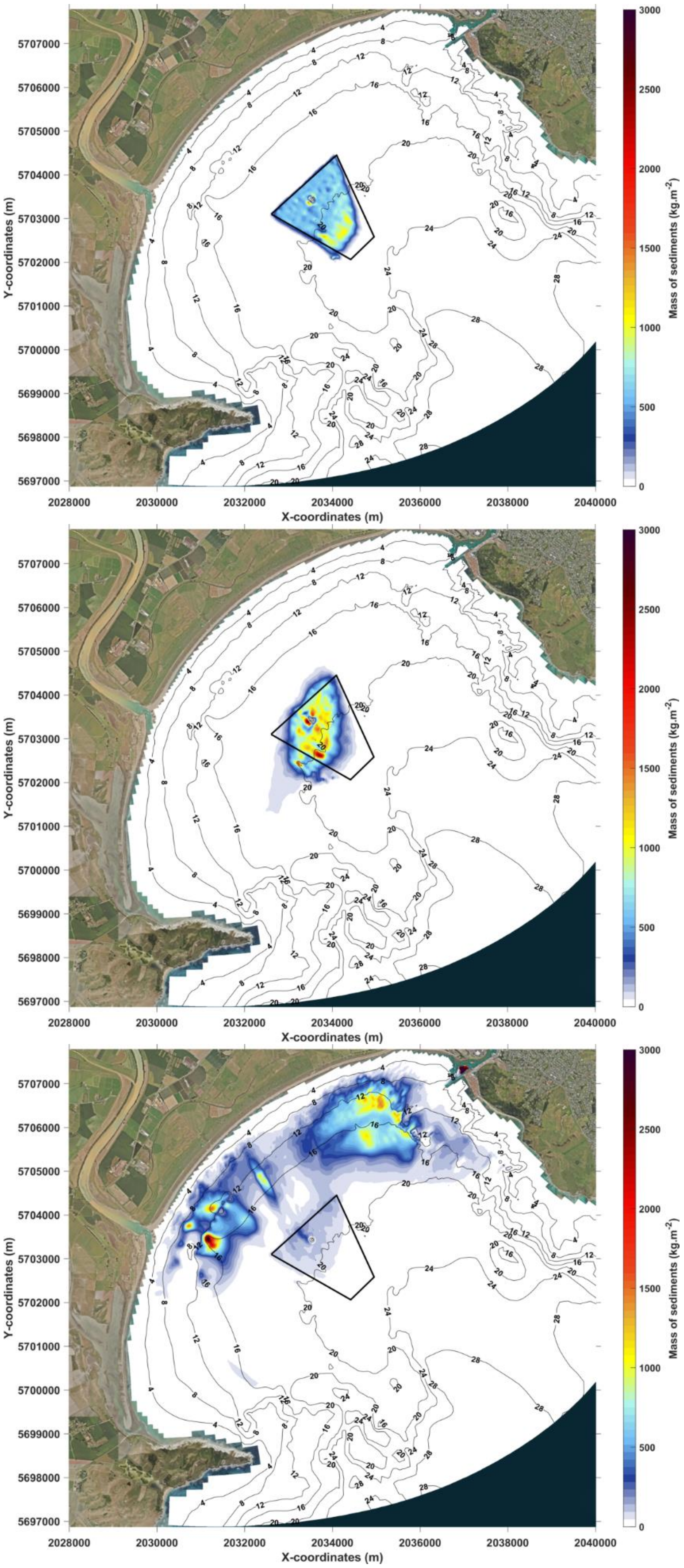


Figure 4.7 Mass of medium sand (top), fine sand (middle) and mud (bottom) after one year characterised by the "La Niña" phase of ENSO.

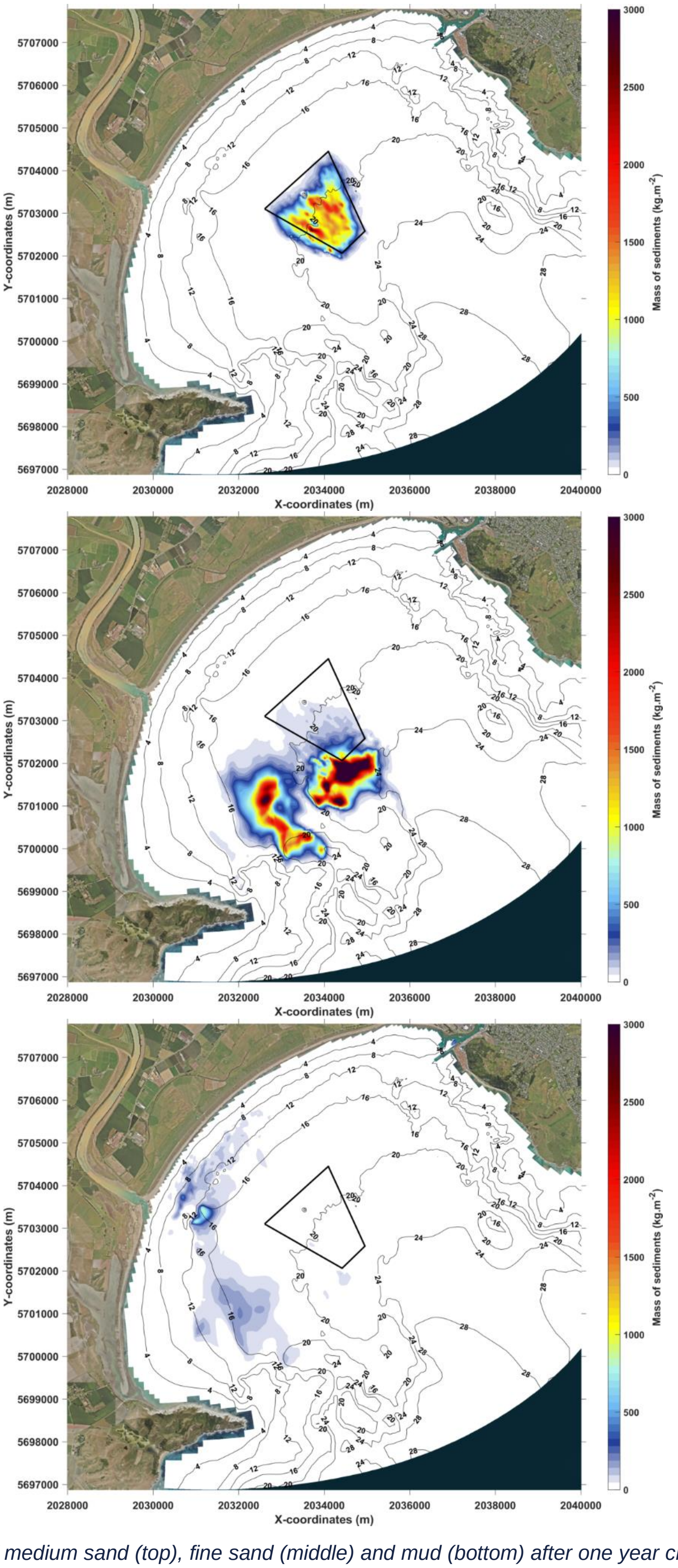


Figure 4.8 Mass of medium sand (top), fine sand (middle) and mud (bottom) after one year characterised by the "El Niño" phase of ENSO.

5. Summary

The likely effects of the continued maintenance dredging and disposal on the shoreline within Poverty Bay has been assessed based on the morphological numerical modelling results provided in MetOcean Solutions (2018, 2019) and by reviewing available literature describing the historic shoreline evolution. With respect to the numerical modelling, particular attention has been given to the expected incident wave conditions and sediment dynamics along Waikanae and Midway Beach resulting from the proposed maintenance dredging and disposal activities.

A summary of the main conclusions are as follows:

- The effect of the existing shipping channel on the inshore incident wave climate and shoreline response will be consistent with what has been observed since the consented dredging began.
- No changes in the alongshore transport is anticipated if existing maintenance dredging depths are maintained.
- The immediate river delta region sedimentary budget is primarily dependent on fluvial regime.
- The proposed one-year maintenance disposal mound is expected to have a negligible effect on the incident wave refraction patterns over and inshore of the disposal mound, with expected significant wave height modifications of the order ±0.2%, and some very localised changes in wave direction which are not expected to modify the overall sediment transport patterns and beach shoreline.
- The relative changes to the incident wave climate are not expected to affect the shoreline sediment dynamics. Likewise, the morphological response of the disposal mound is not expected to result in any noticeable erosion/deposition of sediment over the inshore beach area.
- The input of sediments from maintenance disposal activities is negligible in terms of beach morphodynamics compared to the fluvial sediment inputs provided by the Waipaoa River discharges.

6. References

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