Shoreline changes for southeastern Matakana Island (Panepane Point) following capital dredging (2015-16)

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By Willem de Lange, Vicki Moon

Environmental Research Institute

Faculty of Science and Engineering

The University of Waikato, Private Bag 3105

Hamilton, New Zealand

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Reviewed by:

Associate Professor Karin Bryan
School of Science
University of Waikato

Approved for release by:

Dr John Tyrrell, Business Manager
Environmental Research Institute
University of Waikato

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Executive summary

Surveys of the mean high water mark before and after the capital dredging of 2015/16 indicate minor shoreline fluctuations on the open coast of Matakana Island that are consistent with normal variations. The largest change has occurred at the Panepane Point spit tip, which eroded by ~20 m between August 2015 and October 2016. This is most likely due to the changed alignment of the channels approaching the narrowest section of the tidal inlet, and is consistent with the predicted impacts in the Assessment of Environmental Impacts. Panepane Point is not expected to continue to erode further with the current channel alignment.

The patterns of erosion and accretion observed for the ebb tidal delta (Matakana Banks) since the dredging are consistent with those reported before dredging, and are associated with the migration of swash bars over the swash platform of the delta in response to normal variations in wave and tidal currents. These is some evidence to suggest that the ebb tidal delta is starting to extend further offshore. The observed changes do not indicate that the ebb tidal delta is undergoing collapse following dredging.

The patterns of erosion and accretion observed in the Lower Western Channel are consistent with channel migrations observed in the past, superimposed on continuing shoaling of the ebb shield of the flood tidal delta (Centre Bank). The contribution of dredging to this behaviour is currently being investigated.

Introduction

During the Environment Court Appeal against the resource consents issued to the Port of Tauranga Ltd for proposed capital dredging, concerns were raised that deepening and widening of the channels around the entrance to the Tauranga Harbour would result in severe erosion of the shoreline of Matakana Island and particularly of Panepane Point. This erosion could threaten areas of cultural significance that lie landward of the previous 1922 shoreline.

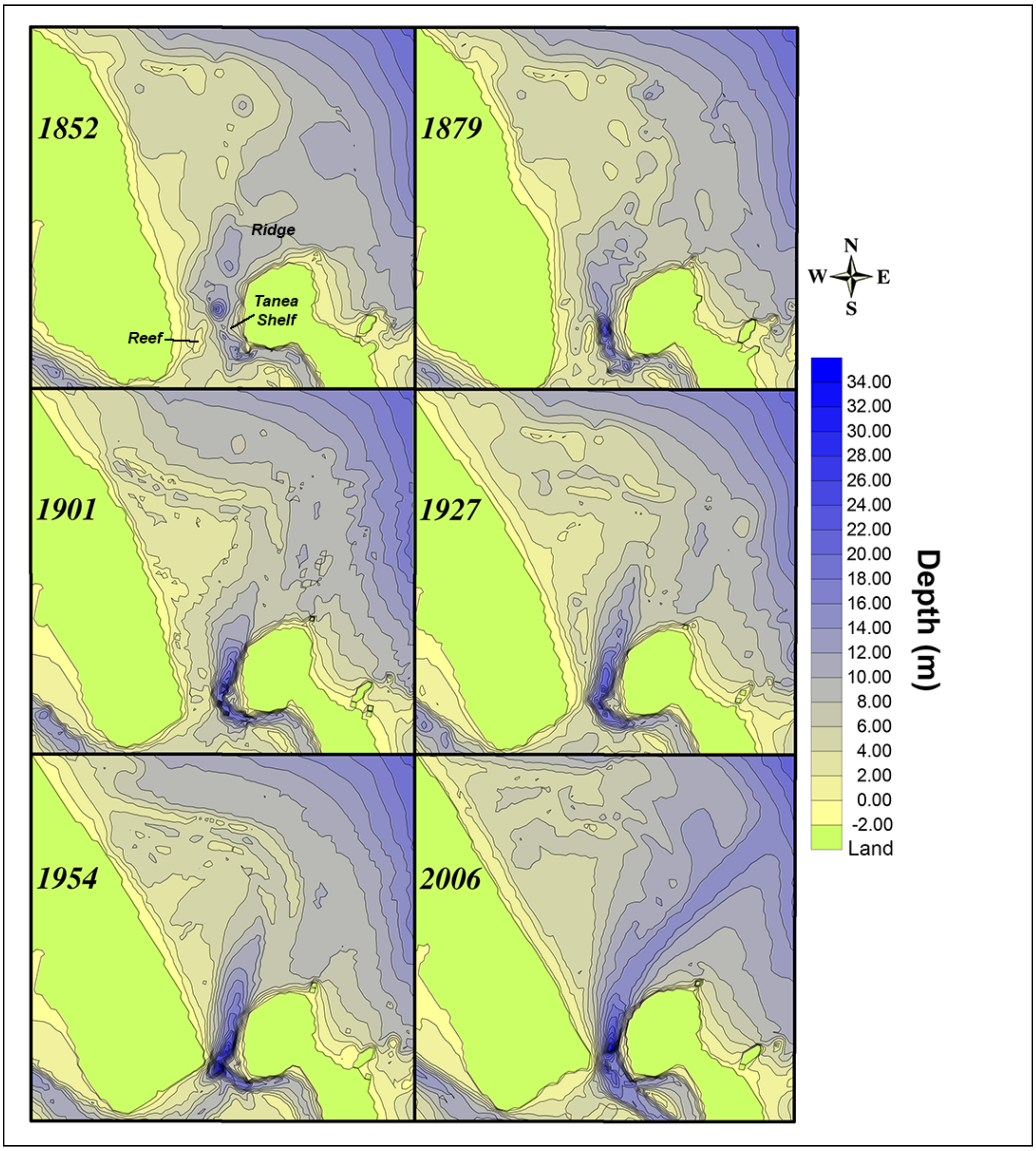

Figure 1. Bathymetry of the ebb tidal delta and tidal inlet compiled from historical survey data by Brannigan (2009) The data show the progressive narrowing and deepening of the tidal inlet associated with the progradation of Panepane Point, and the changing morphology of the ebb tidal delta between 1852 and 1954. The final compilation for 2006 includes any additional effects of the dredged shipping channels and their potential impacts on the ebb tidal delta morphology. The locations of resistant Pleistocene materials that underlie the present-day Panepane Point are indicated on the 1852 bathymetry.

Previous studies summarised in de Lange *et al*. (2015) have recognised that there have been long term changes in the shoreline of southeastern Matakana Island, including the location of Panepane Point (Figure 1), which have been associated with a narrowing and deepening of the tidal inlet between Panepane Point and the rhyolite dome of Mauao. These changes make it difficult to correlate specific shoreline movements with dredging activities (de Lange *et al.*, 2015), although Ramli (2016) identified a change in sediment circulation from bar-bypassing to inlet-bypassing following the initial dredging of the Entrance Channel in 1968. This was likely associated with an increased longshore sediment flux towards the harbour entrance for the south-eastern 1-2 km of Matakana Island.

Subsequent capital dredging in 1992 and biannual maintenance dredging was not found to have any measurable effect on sedimentation patterns for the ebb tidal delta (Matakana Banks) or the stability of Matakana Island shoreline or Panepane Point (Ramli, 2016). However, Ramli (2016) did identify that shoal bars on the swash platform migrated in response to spring-neap and possibly longer tidal cycles, and variations in dominant weather patterns (eg. ENSO extremes of La Niña and El Niño). The variations in bathymetry over the ebb tidal delta associated with the migrating shoal bars will affect wave shoaling and breaking patterns, and potentially influence longshore sediment transport along the Matakana Island shoreline. This is being investigated as part of a current PhD project at the University of Waikato.

The same processes may also contribute to observed short and medium term variability of the location and shape of Panepane Point (Figures 2 and 3). However, it is also evident that the maximum southeastern extent of the spit at Panepane Point is constrained by the location of the shipping channel, and arguably the capital dredging in 1992 resulted in a southwards migration of the spit tip as shown in Figures 2 and 3.

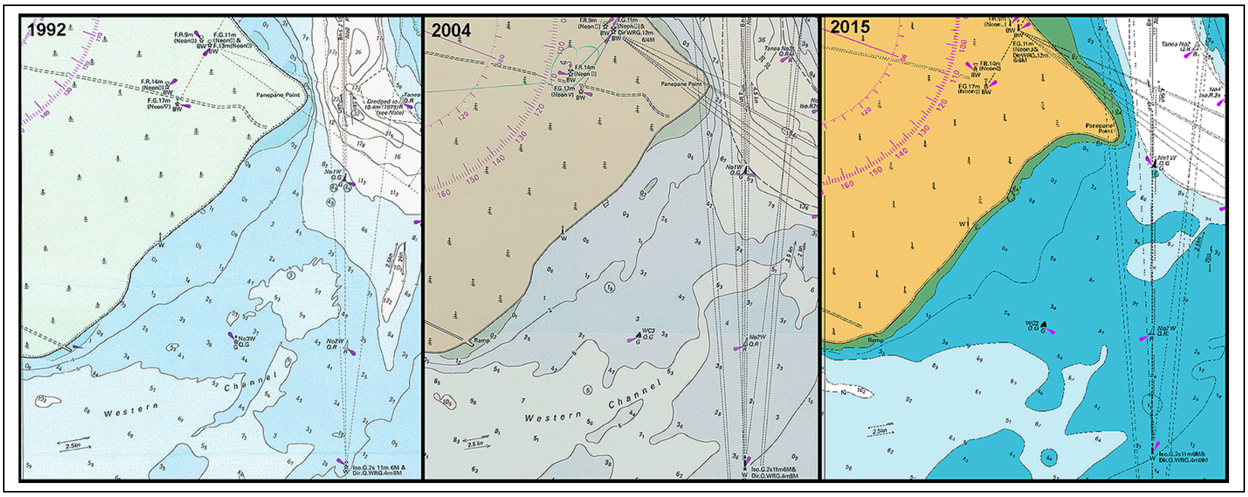

Figure 2. Sections of LINZ hydrographic chart NZ 5412 – Port of Tauranga – highlighting Panepane Point and the Lower Western Channel shoreline of Matakana Island. The charts show the south-eastward extension of Panepane Point associated with erosion to the south forming a more prominent spit, and shoaling of the Lower Western Channel.

Current meter observations indicate the presence of a relatively strong flood tide eddy in the lee (south) of Panepane Point. This eddy likely is contributing to the erosion of the southeastern shoreline of Matakana Island that has displaced the shoreline landward of the 1922 shoreline (Figure 3). The eroded sediment is likely to have contributed to the accretion on the immediate southern side of Panepane Point (Figures 2 and 3).

Observations of the shoreline of Panepane Point during fieldwork by University of Waikato staff and students indicate that the shoreline is quite mobile and may change location by several metres during a tidal cycle. Therefore, the time series of shoreline surveys is likely to incorporate an uncertainty due to short and medium term fluctuations associated with tidal and weather processes.

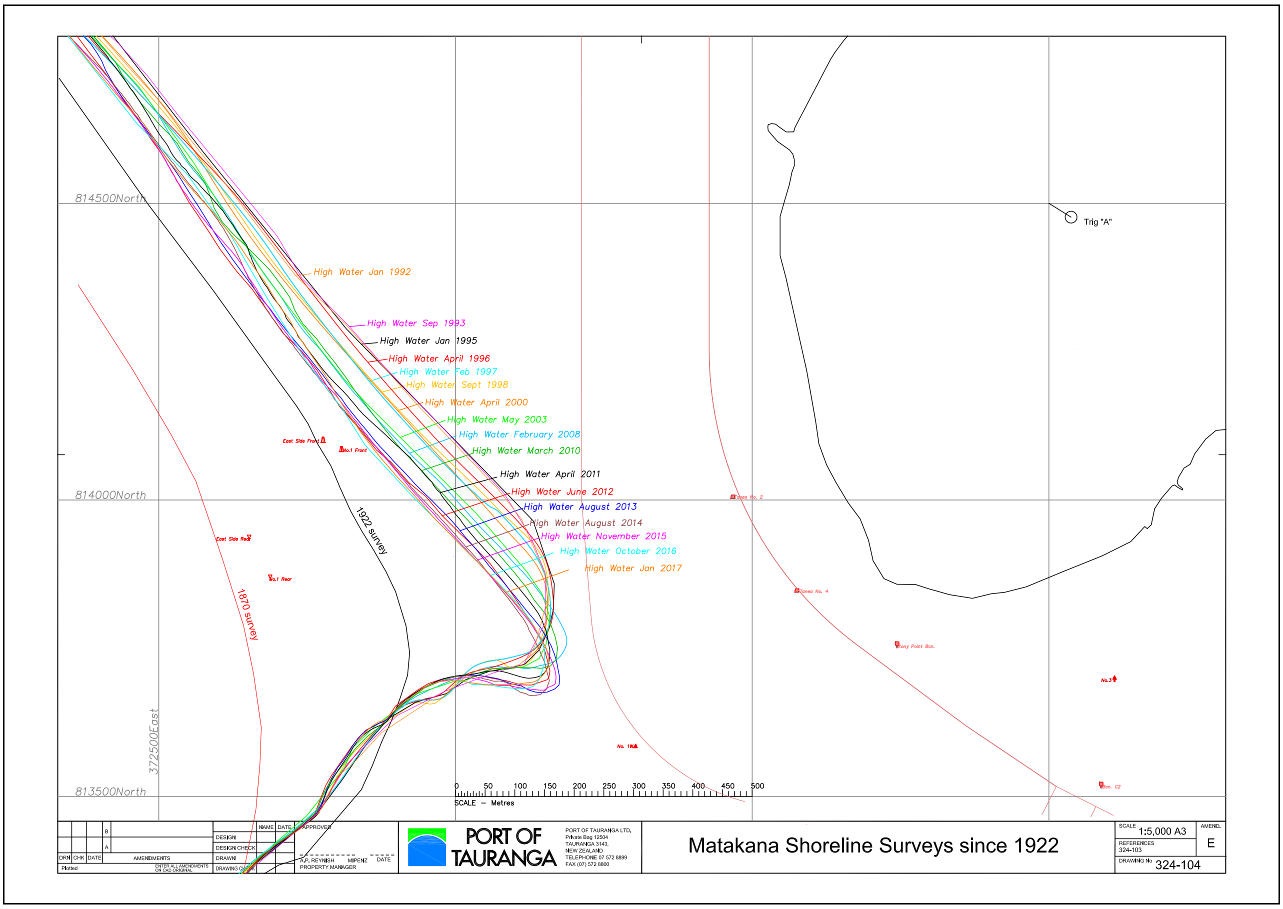

Figure 3. Summary of mean high water mark (MHW) surveys of southeastern Matakana Island conducted by the Port of Tauranga since 1992 compared to the 1922 reference shoreline. (Port of Tauranga drawing No 324-104)

Predicted impacts of capital dredging

Tidal inlets confine the flow, resulting in increased flow velocities (Vennell, 2006). ADCP surveys of the Tauranga Harbour entrance demonstrate this effect (Figure 4). The eastern side of the harbour entrance is the flank of Muauo, a rhylolite dome, and consists of rock slopes covered in boulders, which is resistant to erosion and is associated with lower depth averaged velocities. The western flank consists of mobile sand bedforms in shallow depths, overlying shell lags at depth, and higher depth averaged velocities close to shore (Figure 4). Despite the differences evident in the depth averaged velocity, analysis of the momentum balance from the ADCP data indicates that, despite the lower roughness, the western flank of the channel exerts more frictional control on the flow through the tidal inlet than the eastern flank. Further, at peak flows, horizontal advection dominates over bottom friction, suggesting that the orientation of the flow entering the tidal inlet may control the flow behaviour within the inlet (Vennell, 2006).

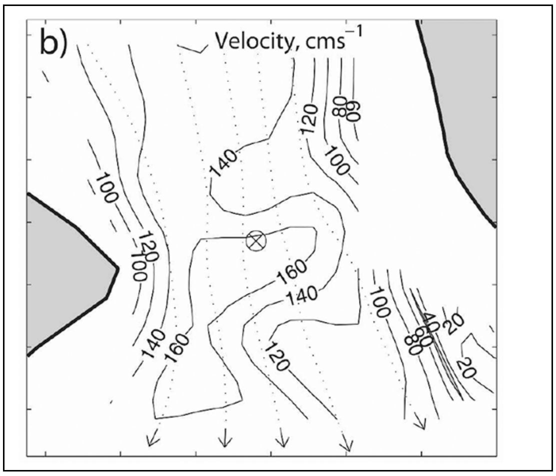

Figure 4. Peak flood depth-averaged velocity in the Tauranga Harbour entrance measured by a boat mounted ADCP in January 1993 (Figure 4b, Vennell, 2006).

Disrupting the shell lag, which armours the sea floor and resists erosion, potentially would result in increased sediment transport and possibly erosion. However, diver observations and seismic reflection data indicate that the shell lag layer is metres thick, and should rapidly re-establish an imbricated surface resistant to further erosion. The shallow area of mobile sand bedforms represents the area most likely to change, and its immediate proximity to Panepane Point, suggests that there is a close relationship between the sand movement in this zone and the location of the spit tip.

Figure 5 summarises the changes to the channel alignments associated with the capital dredging during 2015-16. It is clear that channel widening in the narrowest section of the tidal inlet involved the eastern flank and avoided disturbance of the sand and shell material on the western flank. However, the changes in the channel cross-sectional areas and their orientations in the approaches to the narrowest section potentially would affect the flows through the tidal inlet.

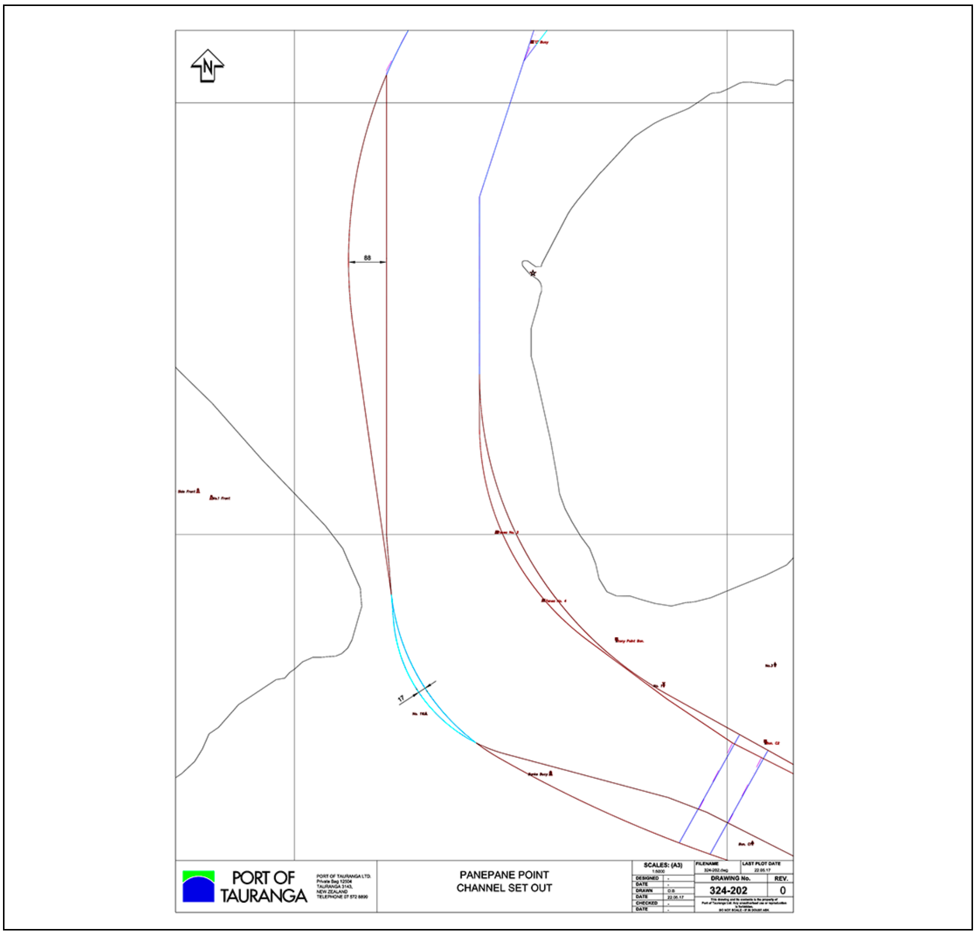

Figure 5. Summary of the changes to the channel alignments through the tidal inlet of Tauranga Harbour. (Port of Tauranga drawing No 324-202)

Assuming the entire proposed capital dredging occurred in one campaign, numerical modelling predicted changes in current velocities (Figure 6) and potential sediment transport in terms of residual transport vectors (Figure 7). Some of largest increases in velocity were predicted to occur in the lee of Panepane Point at peak flood tide. Consequently, over a full tidal cycle, the numerical model results suggested the potential for scouring of the channel margin adjacent to Panepane Point. It was suggested that this scour could lead to erosion of Panepane Point, although it was expected that this would be minor and not result in erosion back to the 1922 shoreline.

To address concerns about potential erosion, periodic shoreline surveys are being undertaken to identify changes and assess if mitigation measures are necessary. The results of the first 3 surveys are summarised below.

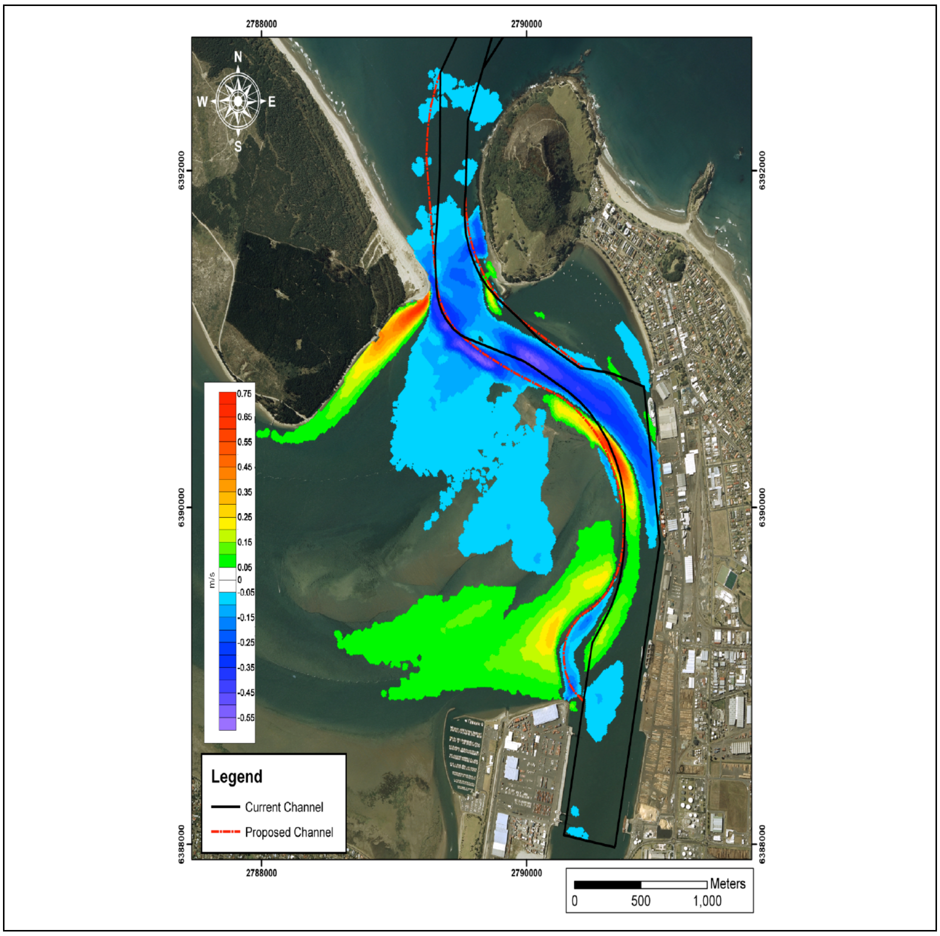

Figure 6. Predicted change in peak spring flood tide velocities following completion of all proposed dredging (Figure 9.61 – Healy Evidence): positive values indicate an increase in velocity after dredging.

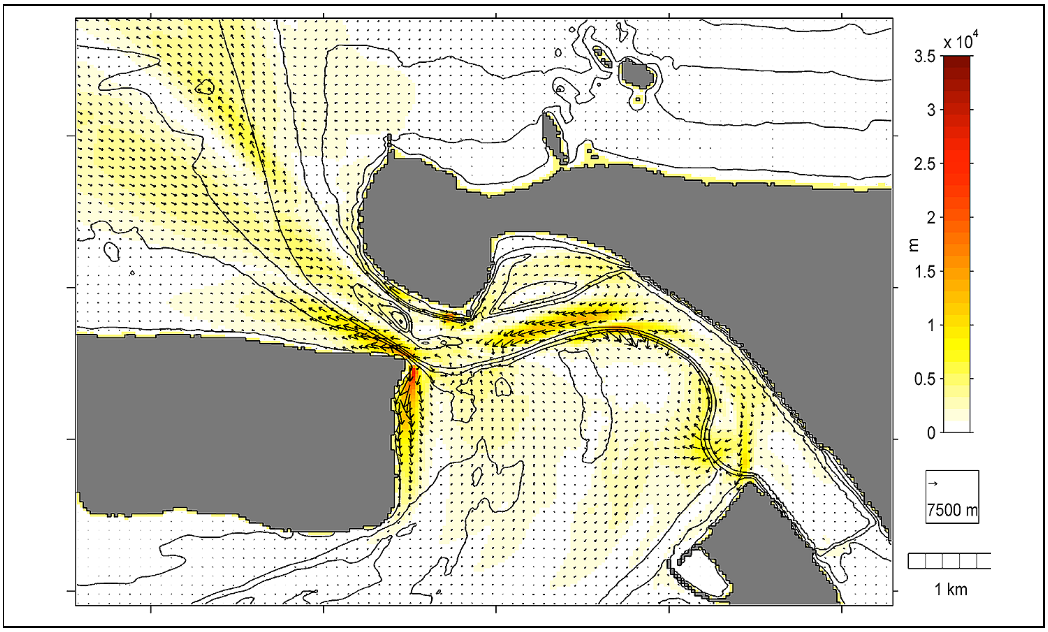

Figure 7. Full spring tide residual differences between pre and post-dredging model results. The arrows indicate the magnitude and direction of sediment transport, and the colour contours also indicate the magnitude of transport. (Figure 9.70 Healy Evidence)

Effects of 2015-16 capital dredging on Matakana Island

The Port of Tauranga undertook surveys of the mean high water mark before dredging occurred (18 August 2015), and after the completion of the capital dredging (19 October 2016 and 18 January 2017). Apart from some minor shoreline fluctuations on the open coast of Matakana Island (Figure 8A), the main change evident between the surveys is ˜20 m of erosion from the spit tip at Panepane Point (Figure 8B).

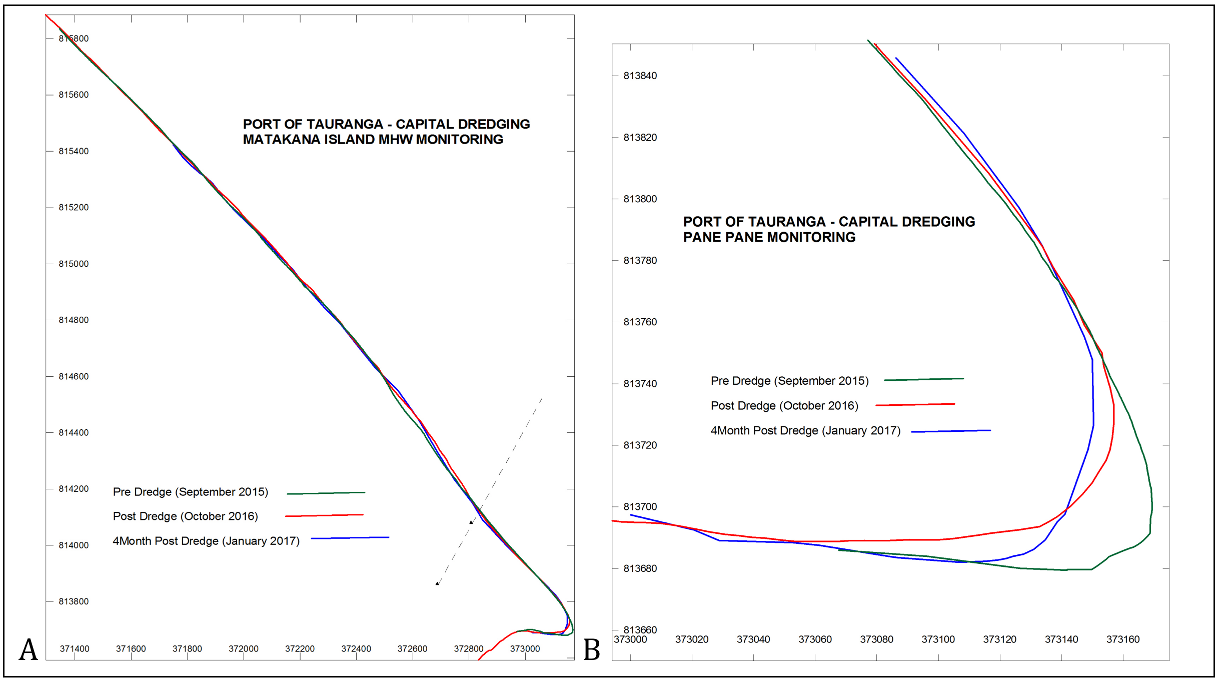

Figure 8. Summary of mean high water mark (MHW) surveys of southeastern Matakana Island conducted by the Port of Tauranga before and after the 2015-16 capital dredging (A), including an enlargement of the Panepane Point section (B). Note the September 2015 survey on the diagrams was undertaken in August 2015. (Drawings provided by DML)

As noted above, the location of the spit tip at Panepane Point is constrained by the location of the western margin of the main channel, which determines the location of strong tidal flows (Figure 5). The numerical simulations predicting the impacts of the capital dredging indicated that some erosion of the spit tip was likely to occur due to the realignment channels approaching the narrowest section of the tidal inlet.

Vennell (2017) compared spring and neap tidal currents measured by a boat-mounted ADCP in 2016, with similar surveys undertaken in 2007. The comparison for the tidal inlet (Figure 9) indicated little difference between the peak flood and ebb current magnitudes, given the cited uncertainty of ±0.2 knots (Vennell, 2017). However, the data do indicate small changes in the flow direction (Figure 9), which are most obvious for the whole tidal inlet during the ebb tide. The changes in direction are consistent with the residual vector distance plot based on numerical model predictions (Figure 7), but the observed magnitude changes are much smaller than predicted. Thomas Sailour's PhD project is extending the area covered post-dredging observations to include areas measured by research projects before dredging commenced, which will determine if the ADCP data reflect the changes in the wider southern basin of Tauranga Harbour.

In relation to the observed changes in Figure 8, particularly at Panepane Point (Figure 8B), the minor erosion of the spit tip is consistent with the minor changes in flow direction along the western margin of the tidal inlet. The observed changes are small compared with the variations evident in the longer time series of shoreline locations (Figure 3), which suggests that the background natural forcing is likely to dominate over the impacts of the dredging in the long-term. At present the observations do not indicate that there is likely to an adverse impact from the capital dredging on the Matakana Island shoreline that requires mitigation. However, scheduled monitoring should continue in order to allow for any potential lagged responses.

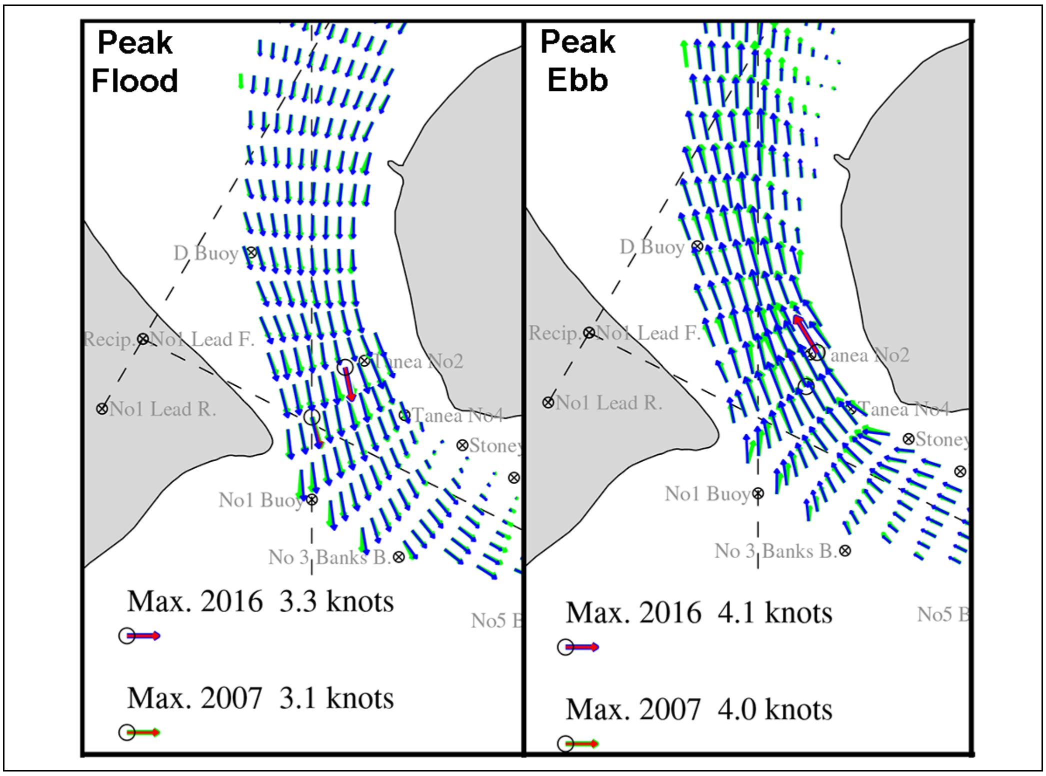

Figure 9. Comparison of spring tide peak flood and ebb flow velocities through the tidal inlet measured by ADCP surveys in 2007 (green) and 2016 (blue). (Taken from pages 4 and 5 of Vennell, 2017).

Impacts on the ebb and flood tidal deltas

Associated with concerns that capital dredging would cause unacceptable erosion of the Matakana Island shoreline, particularly around Panepane Point, it was suggested that the dredging would significantly alter the tidal circulation over the tidal delta systems consisting of a flood tidal delta (Centre Bank) and an ebb tidal delta (Matakana Banks). It was hypothesised that these changes may lead to the collapse of the Matakana Banks system, triggering or exacerbating erosion of Matakana Island.

Ramli (2016) examined the possibility of dredging impacts on Matakana Island leading to collapse and severe erosion. She found that while the initial dredging to create the Entrance Channel in 1968 was associated with a change in the relative influences of wave and tidal currents over the delta, leading to a change from bar-bypassing to tidal bypassing of longshore drift, subsequent dredging did not have any detectable impact. She did observe that the swash bars on the swash platform of the ebb tidal delta were very mobile, changing location in response to the neap-spring tidal cycle and weather patterns. This produced distinctive patterns of parallel erosion and accretion zones in comparisons of multi-beam echo sounder (MBES) survey data (Figure 10).

It was also suggested that the volume changes determined by earlier single beam echo sounder (SBES) surveys were due to the sparse coverage of the survey lines and their positions relative to the swash bars at the time of each survey.

Ramli (2016) did not consider the impact of dredging on the flood tidal delta (Centre Bank). Previous studies (eg. Brannigan, 2009) have noted the shoaling of the flood tidal delta since 1852, which has been associated with shoaling of the lower Western Channel and increased flow through the Otumoetai Channel. These changes have been reinforced to a degree by the deepening of the shipping channels and reclamation of Sulphur Point.

Thomas Saillour is examining the impacts of the recent capital dredging on both tidal delta systems, and has undertaken an initial comparison of the MBES surveys before and after the dredging (Figure 10). The difference between the two surveys indicates that changes have occurred for both the ebb and flood tidal deltas.

Figure 10. Comparison of MBES surveys before and after dredging: red indicates erosion and blue indicates accretion (Thomas Saillour).

The observed patterns for the ebb tidal delta are similar to those observed by Ramli (2016) before the dredging commenced, and are consistent with the migration of the swash bars. In particular the bifurcation in the seaward swash bar on the terminal lobe noted by Ramli (2016) has continued to develop. This suggests that the ebb tidal delta is slowly extending seaward, and does not support the hypothesis of a sudden collapse in response to dredging.

The MBES survey comparison also indicates an area of shoaling on the flank of the flood tidal delta within the Lower Western Channel. This is associated with erosion to the west of the shoaling area, and suggests that this is associated with a westward migration of the channel, rather than an overall decrease in water depth.

Note that the Lower Western Channel effectively consists of a flood channel on the eastern side, and an ebb channel on the western side, separated by a shoal (Figure 11). There appears to be a variation in the relative strength of the flood and ebb flows over time, which results in anti-phased deepening and shallowing of the two channels. Further, the ebb shield of the flood tidal delta has been shallowing over time, which has been associated with progressive shoaling at the landward end of the eastern flood channel.

The Port of Tauranga Ltd has undertaken a series of annual surveys to specifically monitor the shoaling in the Lower Western Channel (Figures 11 and 12). These show the migration of the ebb and flood channels, and the accretion at the landward end of the flood channel. Note that the strong accretion evident in section C and indicated in Figures 10 and 11, began in 2015 before dredging commenced. Although the changes in the Lower Western Channel have been occurring since 1852, it is likely that the deepening of the shipping channels and port reclamation has contributed to the observed changes since 1965. It is difficult to compare the recent changes with those predicted for the Assessment of Environmental Impacts, primarily because the modelling bathymetry involved more dredging changes than were undertaken in 2015-16. The contribution of the actual dredging to the changing flood tidal delta system is currently being investigated by Thomas Saillour for his PhD research.

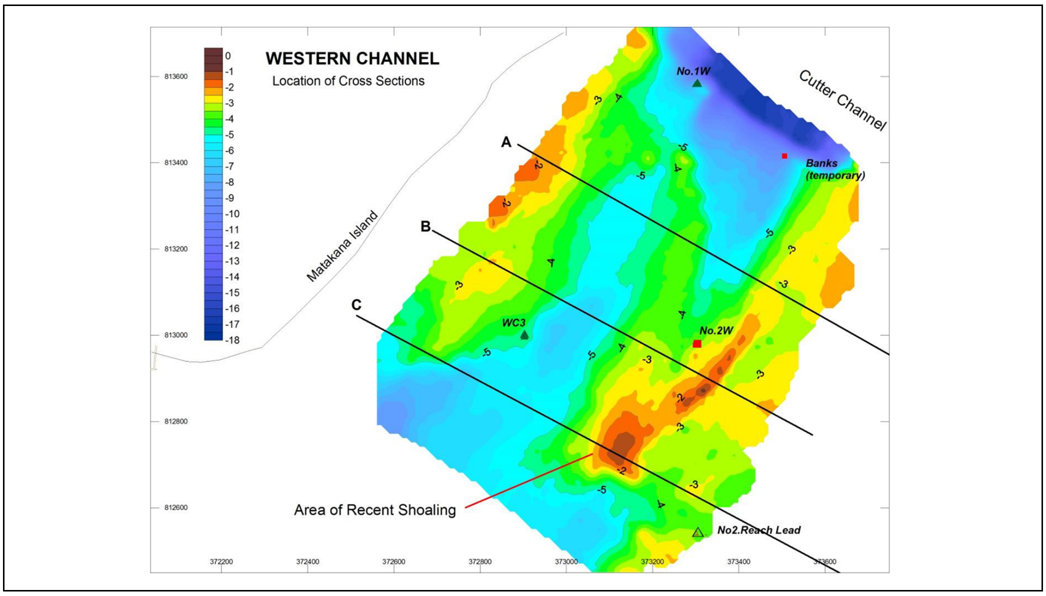

Figure 11. Bathymetry of the Lower Western Channel obtained by the Port of Tauranga in July 2016. The cross-sections marked correspond to those in Figure 12.

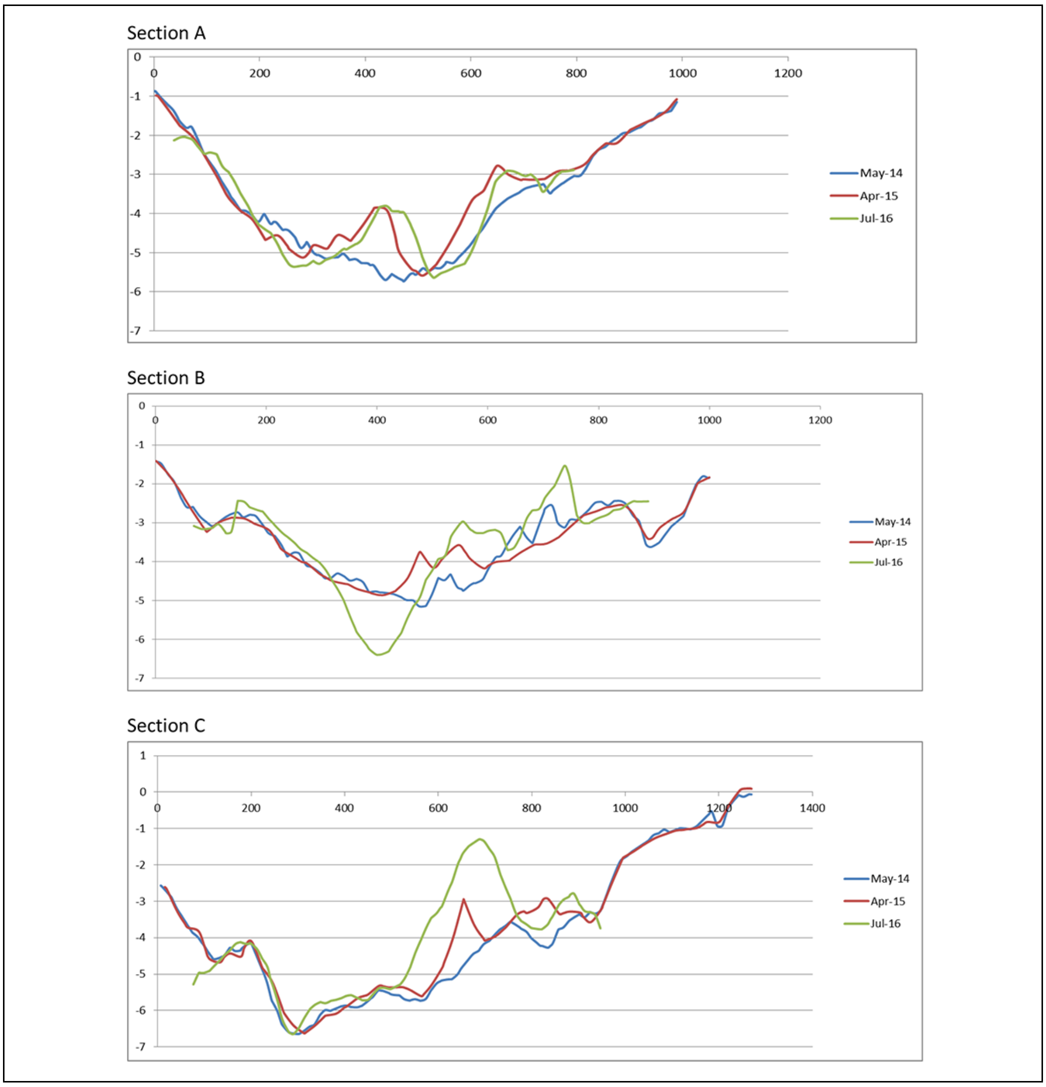

Figure 12. Comparison of cross-sections of the Lower Western Channel 2014-2016.

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