Morphology change at the Avon-Heathcote Estuary mouth: A 2019 update

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The Canterbury Earthquake Sequence (CES) altered the morphology of the Avon-Heathcote Estuary (AHE). Much of the tidal lagoon uplifted by 0 - 0.4 m, reducing the tidal prism by ~12%-18% (Measures et al., 2011). The abrupt CES changes follow a theorized 400-year period of gradual subsidence and tidal prism increase. Questions remain regarding whether estuary morphology has reached a post-quake equilibrium. Inlet-area relationships would suggest a reduction in inlet cross-sectional area as a possible response. The question of whether the estuary will tend to infill or erode has great relevance to the surrounding suburbs' resilience to sea level rise (Hughes et al., 2015).

As the most recent survey was in 2014, a group of University of Canterbury Geography students was encouraged by Dr Deirdre Hart to update our knowledge of the estuary and inlet. A field programme, including beach profiles, Real-Time Kinematic (RTK) surveys, single-beam echosounder data, drone photography and photogrammetry was undertaken in April and May of 2019 in the AHE inlet region.

Our fieldwork returned useful data that was analysed against historical sections and Digital Elevation Models (DEMs) (see Figure 1). We observed a fluctuating shoreline on the New Brighton spit; a cyclic north-south meander of the channel; the main channel deepening; a secondary flood channel scouring out; and the erosion of multiple sand bars. A vegetation-line analysis indicated shoreline accretion on the seaward side of New Brighton Spit between 2004 and 2019, and erosion within the estuary. This is further supported by the beach profile survey results, which also show erosion along the mudflats on the northeast side of the estuary.

Friedrichs (2011) notes that 'the morphological response of most tidal flats is rapid relative to the decade-plus timescales of engineering works, climatic fluctuations, and sea-level rise.'

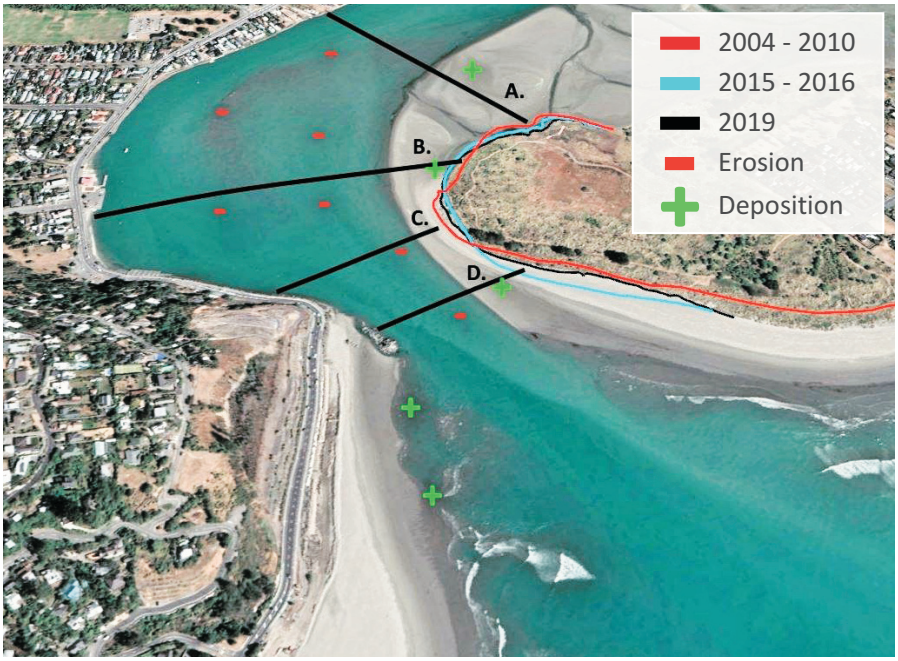

Figure 1: Avon-Heathcote Estuary mouth, showing erosion and deposition since 2011-13 interpreted from 2019 data; changing vegetation extent on New Brighton Spit digitised from aerial photos; and Transects A, B, C and D interpolated from bathymetric surveys.

The ratios of inlet volume to estuary volume, and the hypsometry of the estuary itself, can cause the tide to rise and fall at different rates – this is tidal asymmetry. This leads to an asymmetry of velocity, and thus sediment transport. Wind waves within the estuary can also contribute to sediment transport asymmetry (Hunt, 2016).

We hypothesized that the uplift and sediment supply associated with the CES could be analysed relative to asymmetry relationships, tide observations, and recent surveys to understand the timescales of estuary morphological response and look for any 'tipping points' towards infill-favouring morphology or hydraulics.

Tidal height data and DEM analysis within the AHE, corroborated by model results from Richard Measures at NIWA, indicate an estuary that is flood-dominant except for the deep channels, which are ebb-dominant. Most bulk asymmetry ratios indicate flood dominance, and a small reduction in flood dominance was found using a 2011 DEM as compared to pre-CES data.

The form of the tide within the estuary gave interesting clues to the post-CES adjustment period. Harmonic analyses of records from tide gauges on the lower Avon and Heathcote Rivers showed small changes to in-estuary tidal constituents, indicating an increased frictional effect after the CES. This signal in the M2 and M4 tidal constituents reverted to pre-CES magnitude at the two tide gauges after a period of 3-4 years, indicating that a hydraulic equilibrium was reached around 2014. Survey results indicated that the inlet channel and some flood tidal delta regions have been eroding back to pre-CES elevations (see Figure 2). The CES does not appear to have shifted asymmetry relationships, with our 2019 survey showing estuary channels deepening towards their pre-CES cross-sectional area, rather than continuing to infill.

The long-term trend of in-estuary tidal prism increase, while interrupted by uplift and deposition, appears to have resumed. The

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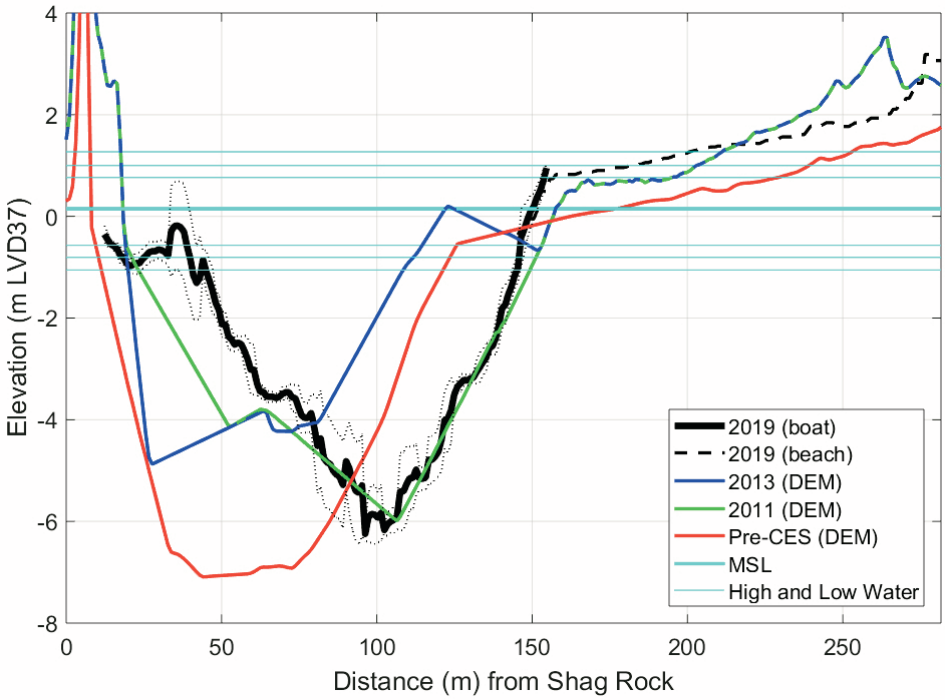

Figure 2: Beach and bathymetric surveys were compared with historical DEMs at Transect D. The inlet channel changes are interpreted as follows: Pre-CES – Deep (7m) channel, south side; 2011 – Shallower (6m) channel, north side, beach accretion; 2013 – Shallow (5m) channel, south side. Bar offshore of New Brighton Spit; 2019 – Channel back to 2011 depth (6m), north side. Beach higher below HW, lower landward.

potential 'respite' from sea level rise provided by uplift appears to be short-lived due to the energetic environment within the estuary and the likely fine-grained infill.

Up-to-date surveys and interpretation relative to the physical processes shaping the form of New Zealand's coastal waterbodies, including potential tectonic changes, must be emphasized when managing coastal hazards.

References

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The 2020 NZCS Conference will be held on Waiheke Island, from 17-20 November. Further details and updates will be made available on the NZCS website (www.coastalsociety.org.nz/conferences/nzcs-2020) and in the July issue of *Coastal News.*

This year's theme of Small Islands, Big Oceans reflects both the challenges and opportunities faced by the islands in the Hauraki Gulf and is reflective of New Zealand as a group of small islands in the Pacific. Waiheke Island and the Hauraki Gulf reflect challenges faced in many coastal and island locations. They are places where the growing demand for coastal use, transport, infrastructure, tourism and changing culture are balanced with unique opportunities to support land conservation and the need to understand and preserve a unique marine environment in a changing world.

The conference theme provides the opportunity for cross disciplinary exploration of the sustainable management of our islands and our oceans, the changing governance, uses and expectations, and the potential to both lead the world and learn from and be inspired by case studies from other small islands within big oceans.