Why does Tauranga Harbour exist?

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Image courtesy Peter Clark, Western Bay of Plenty District Council

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Introduction

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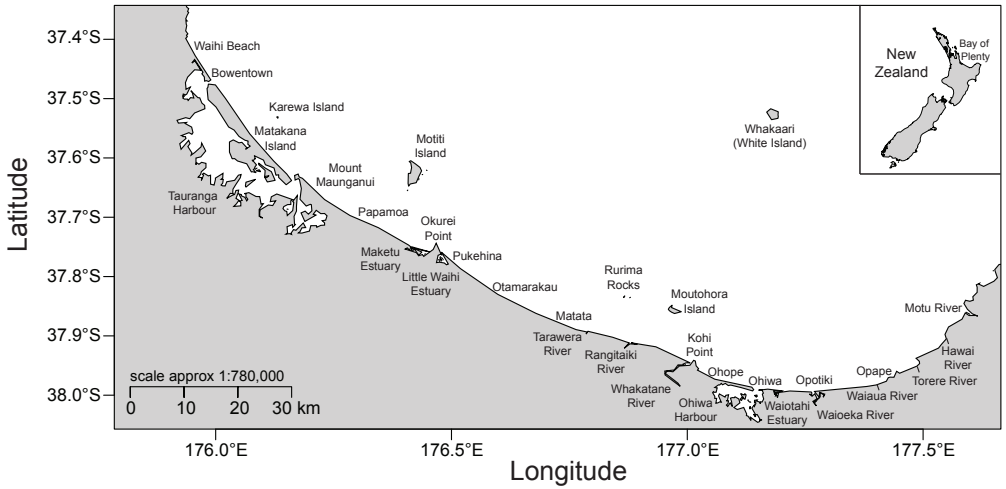
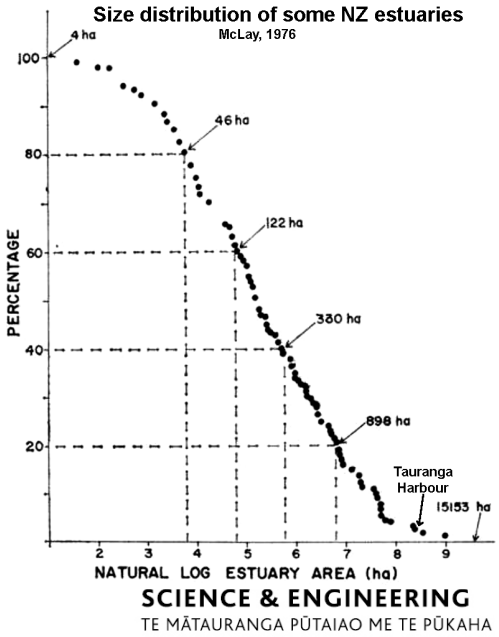
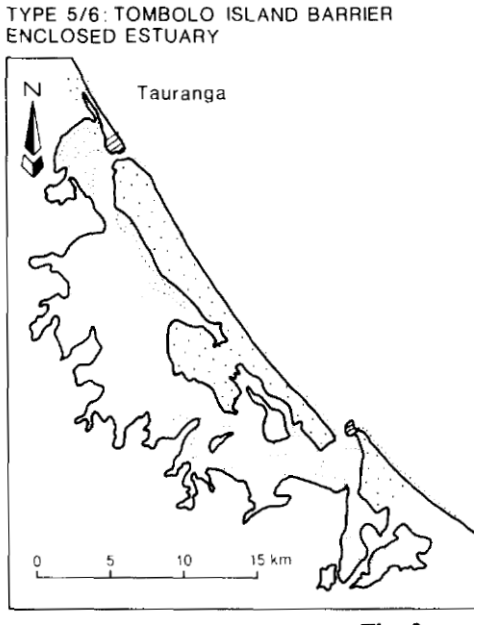
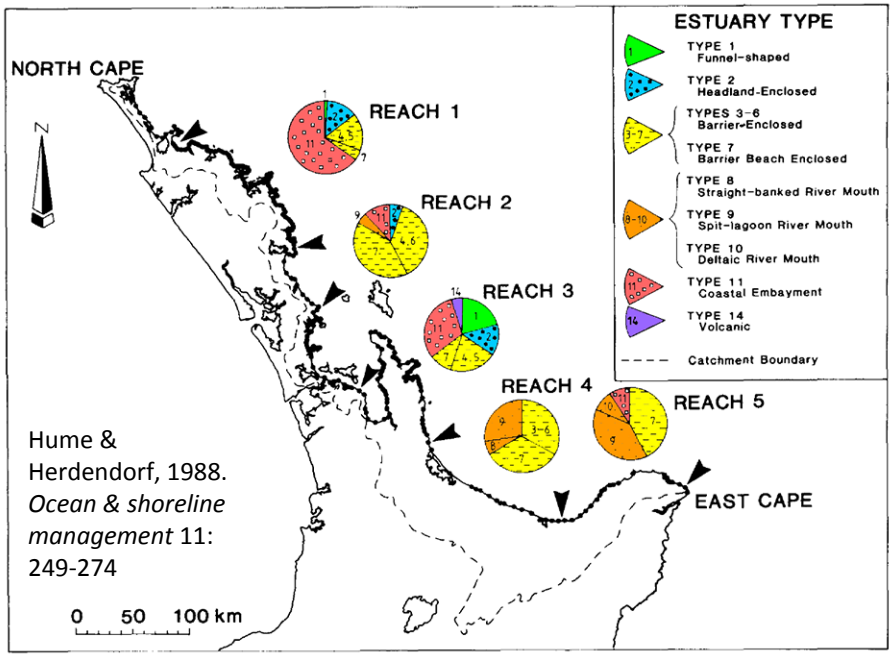
- Tauranga Harbour is unusual
  - Two entrances
  - Enclosed by a barrier island & two tombolos
  - Extensive areas of intertidal flats & sub-tidal channels (218 km^2)
  - Immature compared to most east coast estuaries









Hume & Herdendorf, 1988. *Ocean & shoreline management* 11: 249-274

Hypsometry

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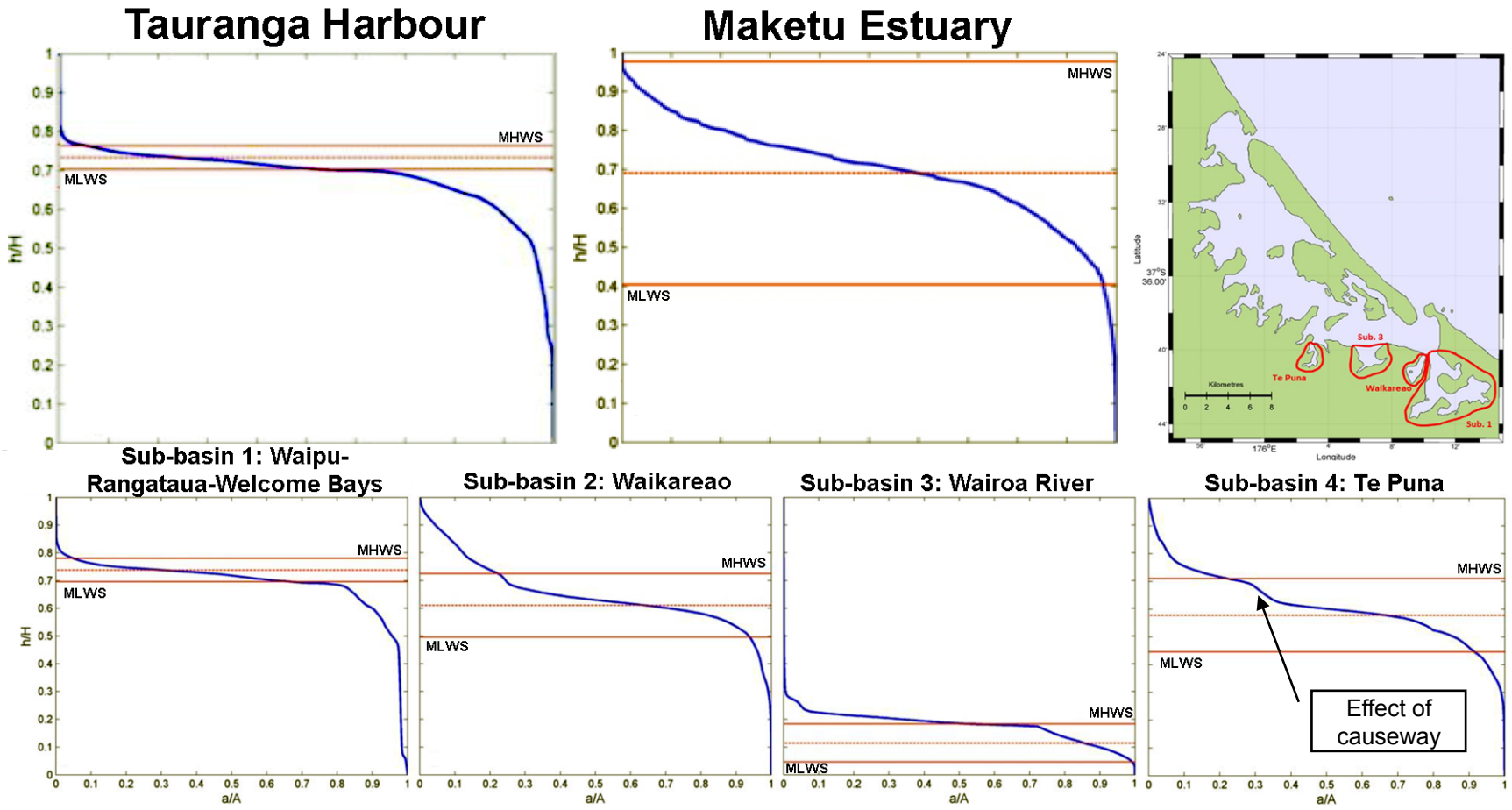
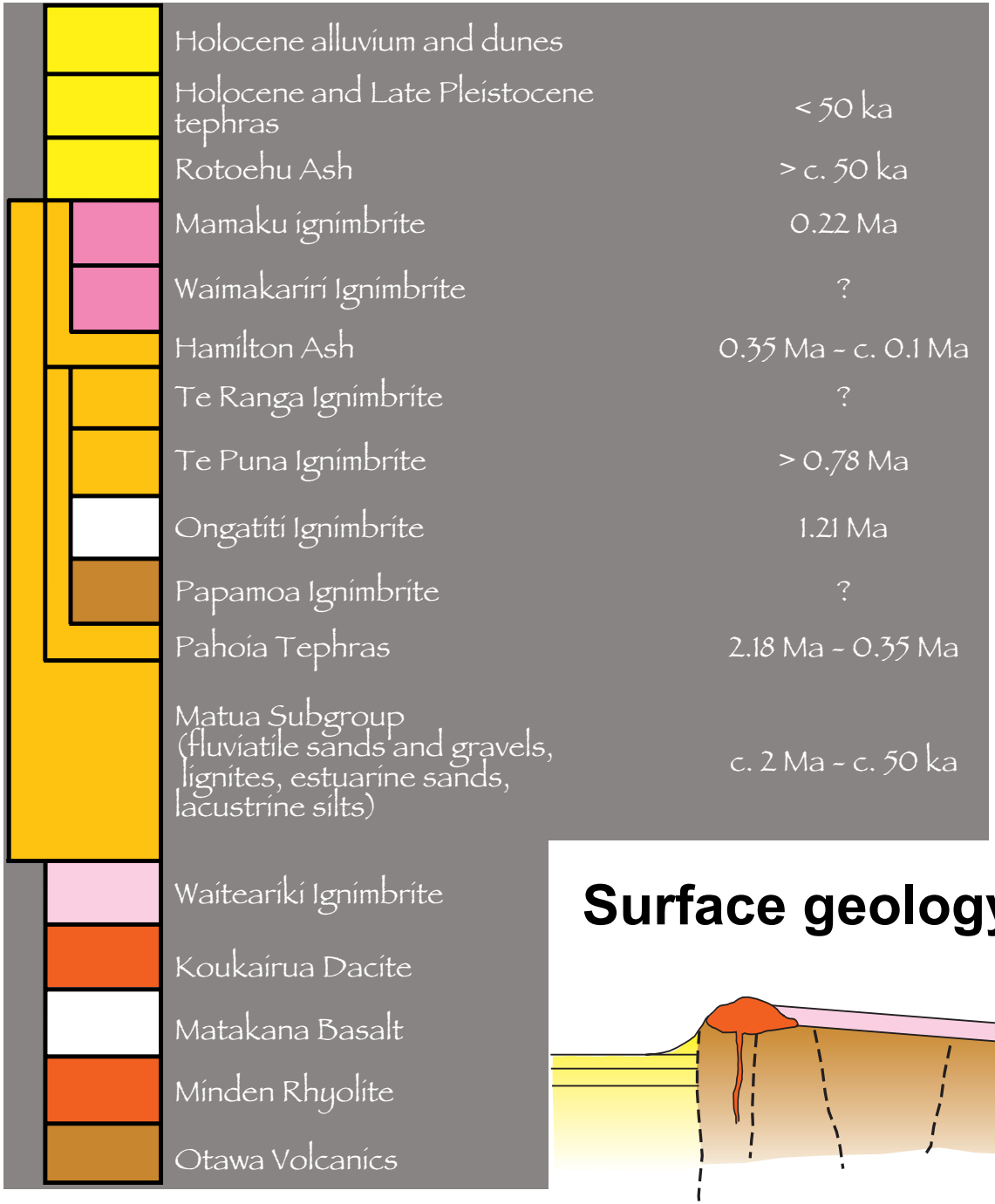
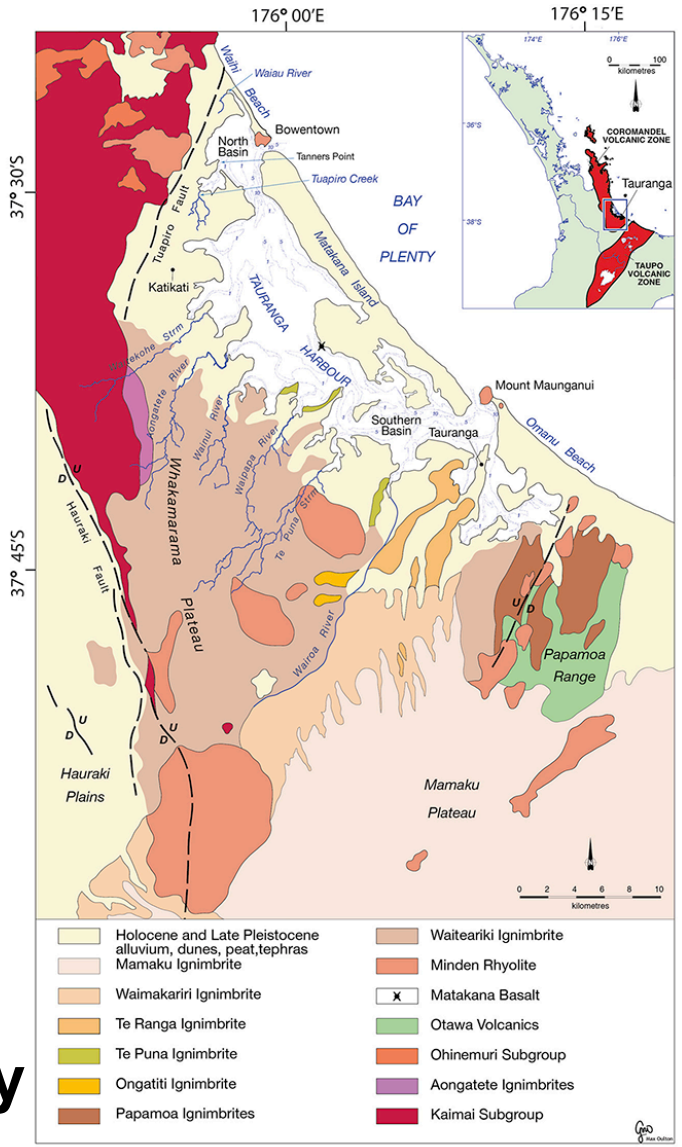
Overall, Tauranga Harbour is less mature than other estuaries

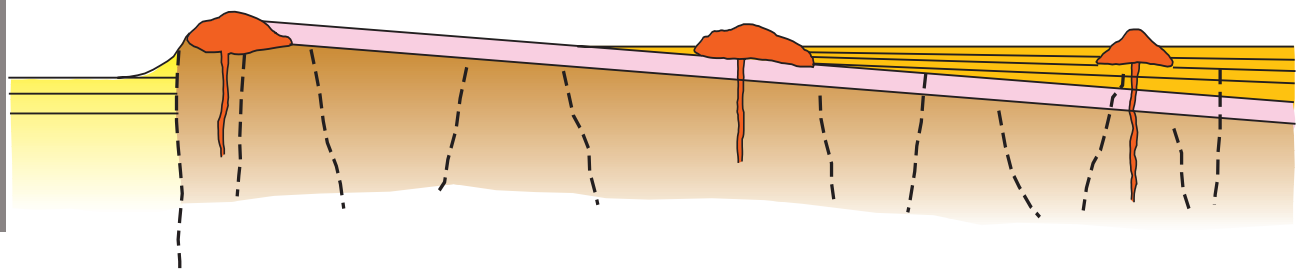


Some sub-basins are more mature



Surface geology

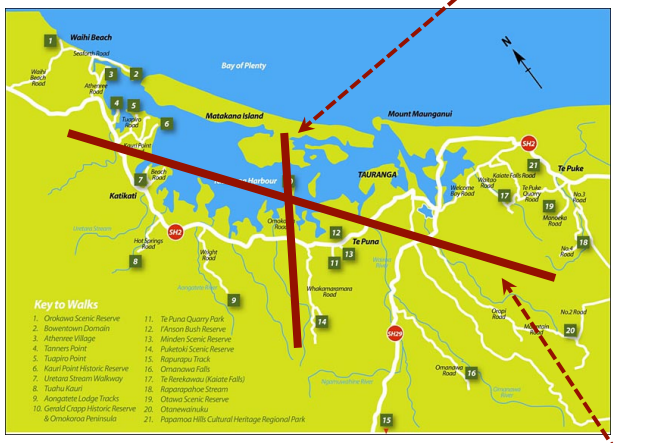


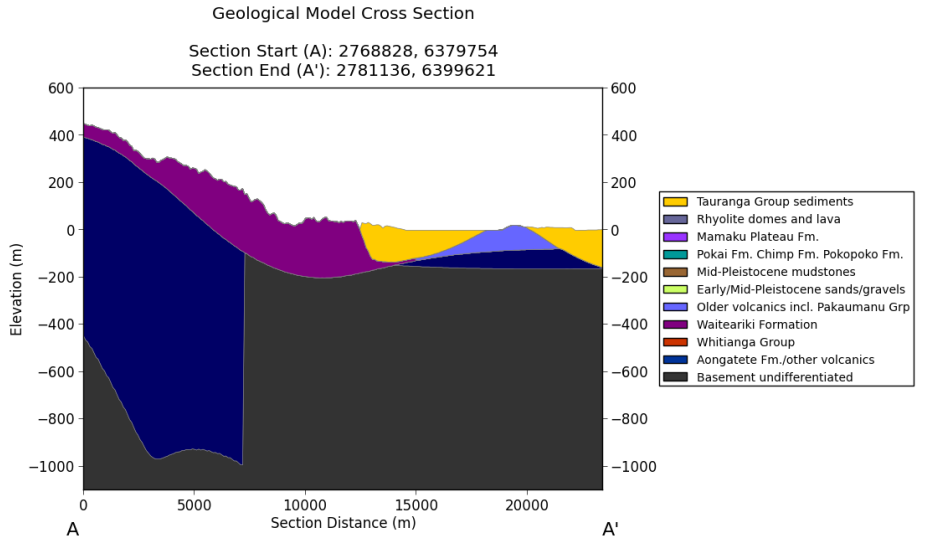


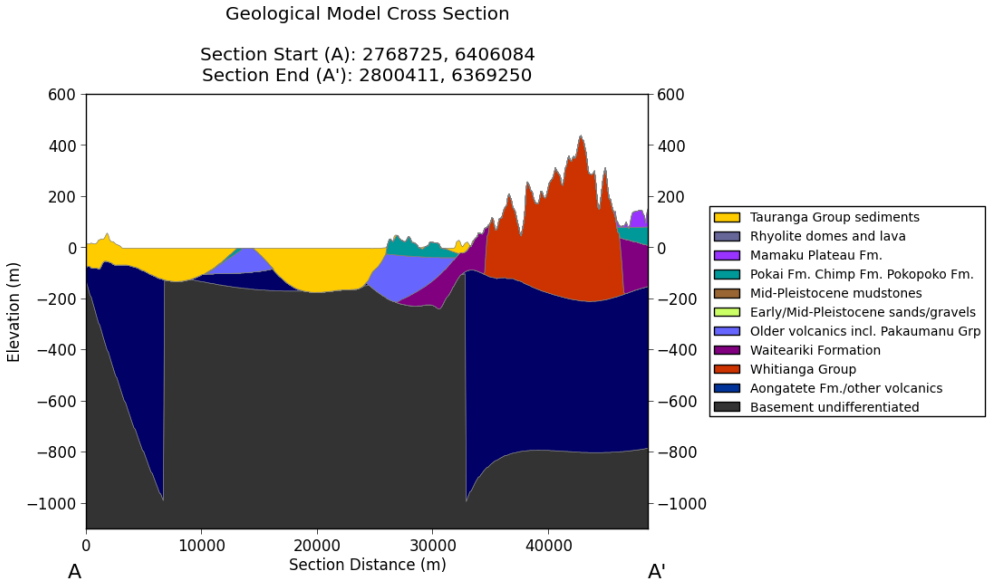
Badesab *et al* 2017 *Estuarine, Coastal and Shelf Science* 194:240-251

Subsurface geology

- Not well mapped
  - Evidence for multiple faults crossing harbour
  - Two basins subsiding with central ridge uplifting?

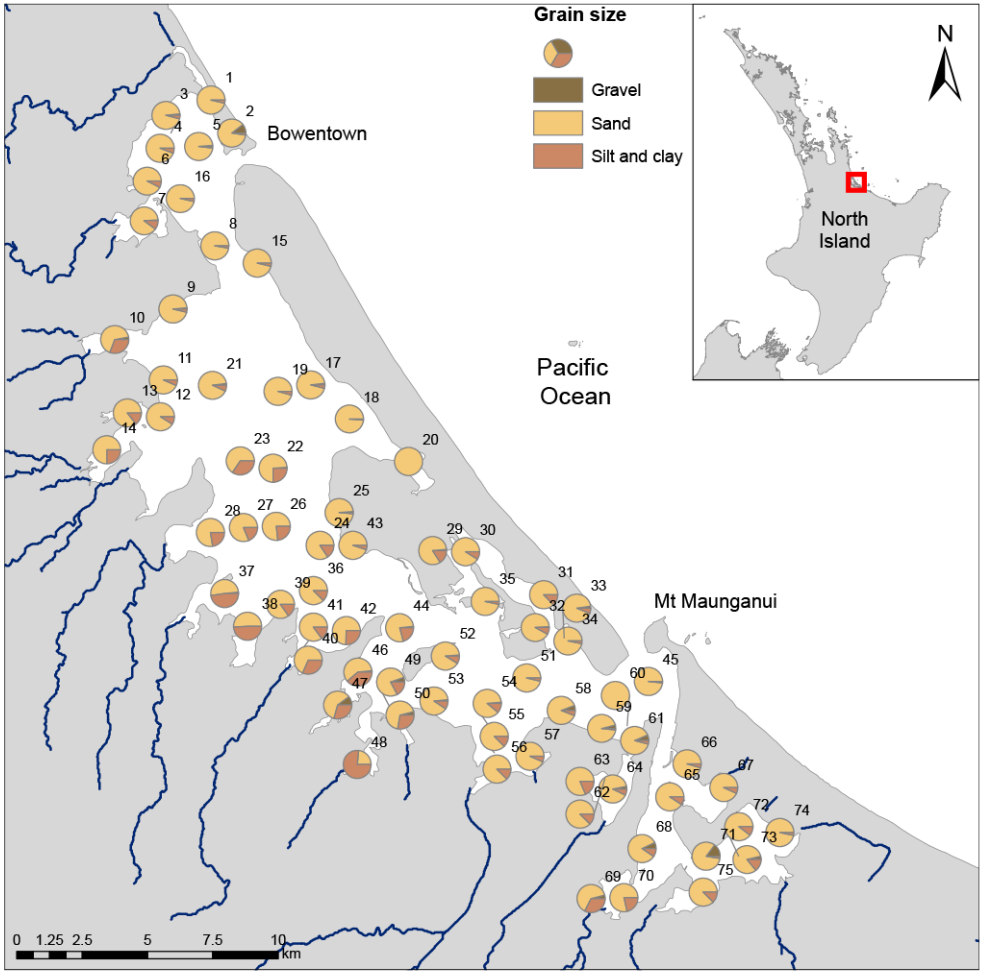






Surficial sediments

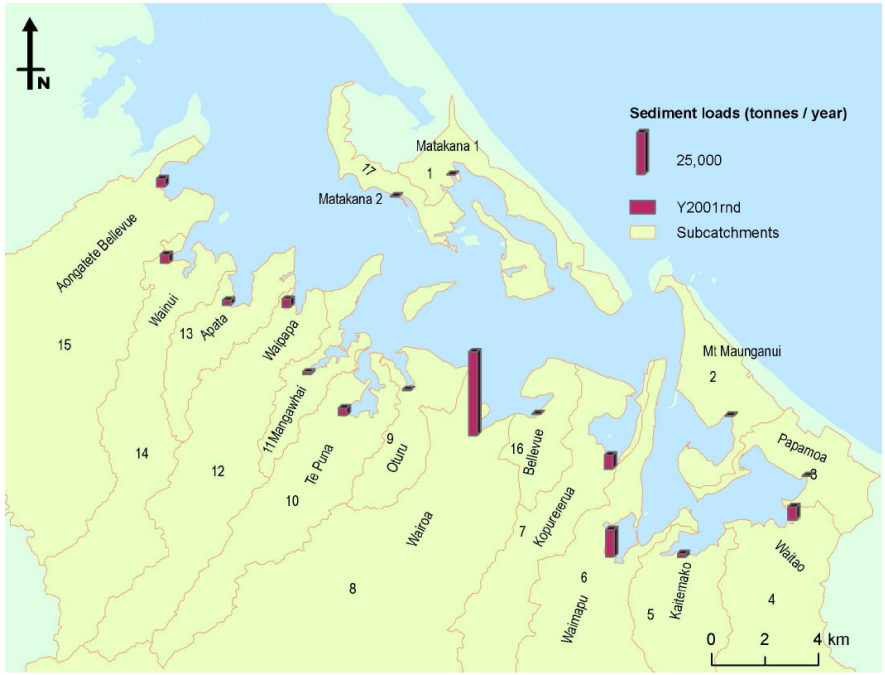
- Harbour sediments are predominantly sandy, except for areas of restricted wave activity
  - Upper Te Puna Estuary (site 48)
  - Apata/Wainui (sites 37 & 38)
- Fine content & associated contaminants decrease with distance from freshwater inputs
  - Organic content is low, except for Upper Te Puna Estuary
  - Contaminant & nutrient levels are low

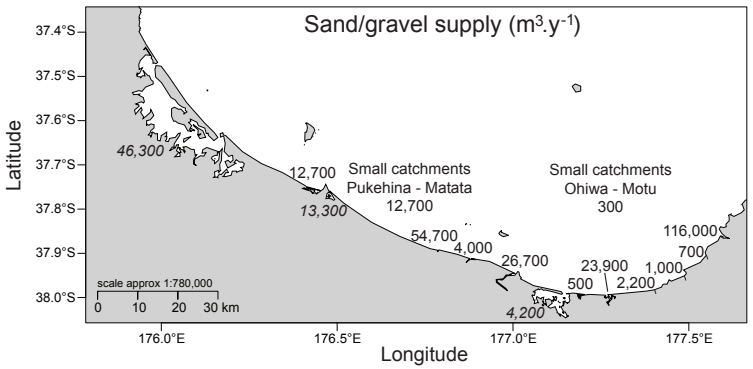


Ellis *et al*, 2017. *Ecological survey of Tauranga Harbour* (revised)

Sediment supply

- Sediment input from catchments is mostly fine suspended load
- Fluvial coarse sediment input is low & largely trapped in sub-estuaries
  - Especially by causeways
- Input from cliff erosion not well defined
  - Multiple sources following Cyclone Debbie – April 2017
- Biogenic inputs not known





Tahunamanu Island

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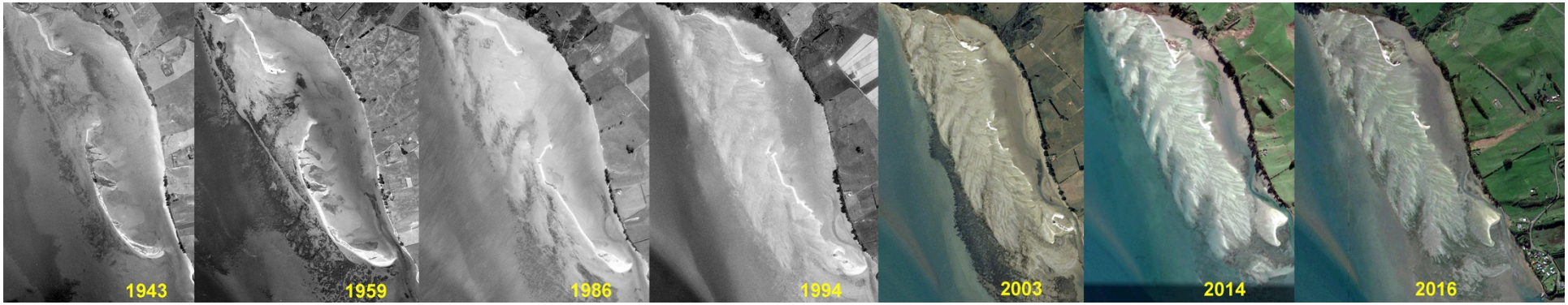
- Input of sediment is episodic
- Tahunamanu Island accreted substantially after influx of sediment from Matakana Island in 1940s
- Progessively eroded resulting in siltation of Opureroa Channel and extension of spit (now eroding)



Ruahihi Canal failure

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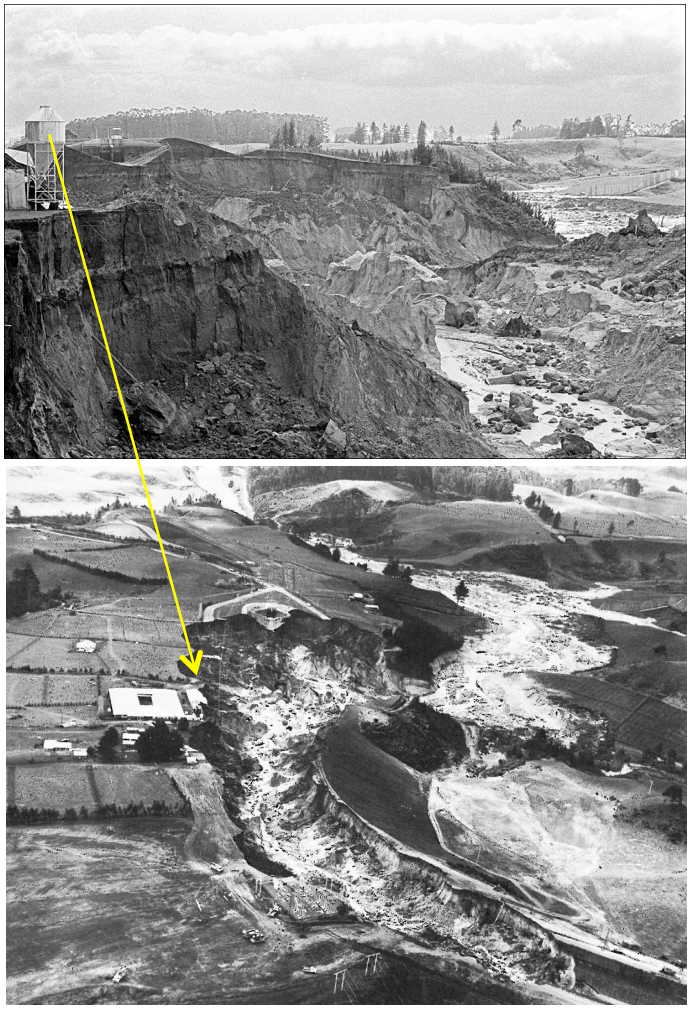
- 2pm Sunday 20th September 1981
- Eastern bank of canal connecting Lake McLaren to Ruahihi power station failed
- >1 Mm^3 of sediment + water flowed down Ivy Creek into Wairoa River
- Perano (2000) obtained 12 cores at mouth of Wairoa
  - No evidence of material deposited from Ruahihi Canal failure
  - Observed that deposits associated with storms during her study were reworked & exported from river mouth within days
  - Concluded that sedimentation rates within the Wairoa subestuary were very low despite large episodic influxes of sediment

Scarp near intake structure



Failed section of canal looking north towards SH29

Sediment export

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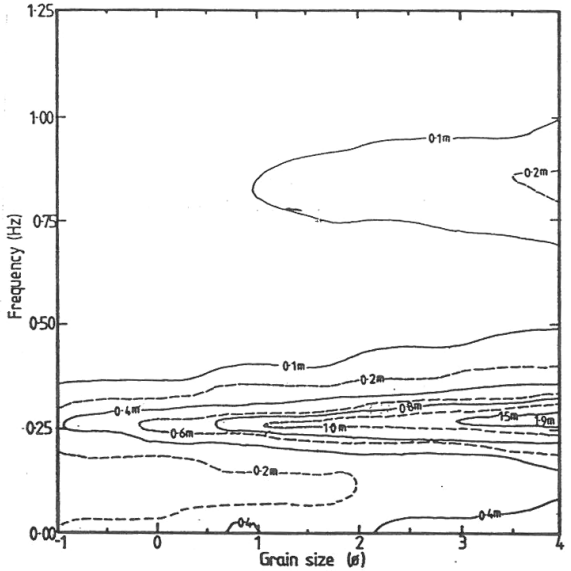
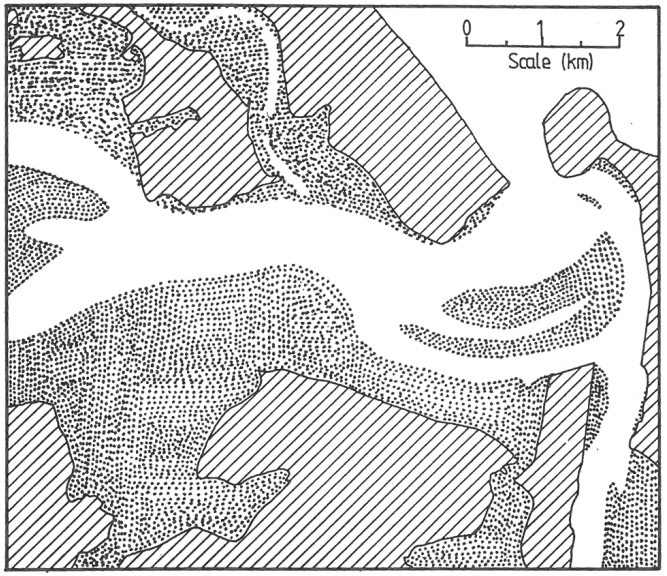
- Sedimentation on Tauranga Harbour intertidal flats is influenced by wave agitation of sediments combined with tidal currents
- Results in export of finer sediments (silts + clays) out of the harbour
- Subtidal channels generally have sufficiently fast flow to prevent settling of fine sediments
- Accumulation of fine sediment requires a reduction in available wave energy
  - Causeways
  - Vegetation





Magnetic tracers

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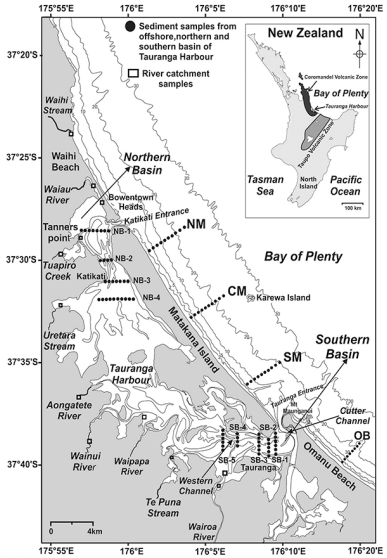
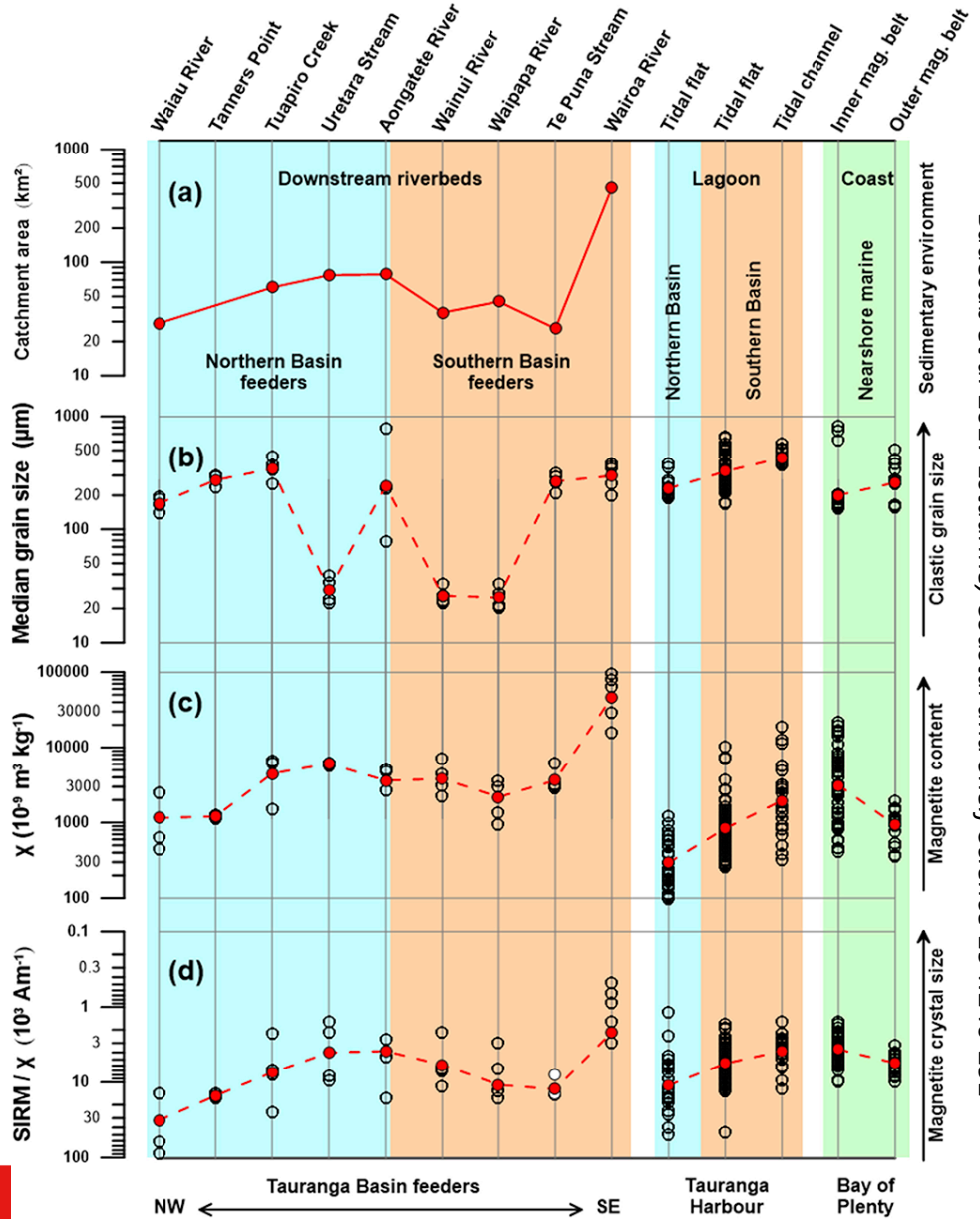
- Magnetic minerals indicate that fine sediments are exported, and fluvial inputs of coarser sediments do not travel far from source
- Suggests marine inputs may dominate
  - Doesn't discriminate age of the deposits





Badesab *et al* 2017 *Estuarine, Coastal and Shelf Science* 194:240-251

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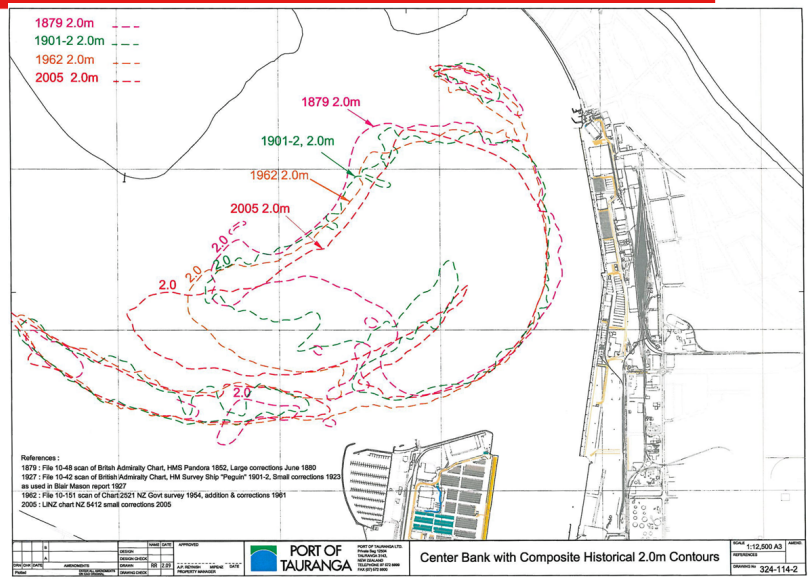
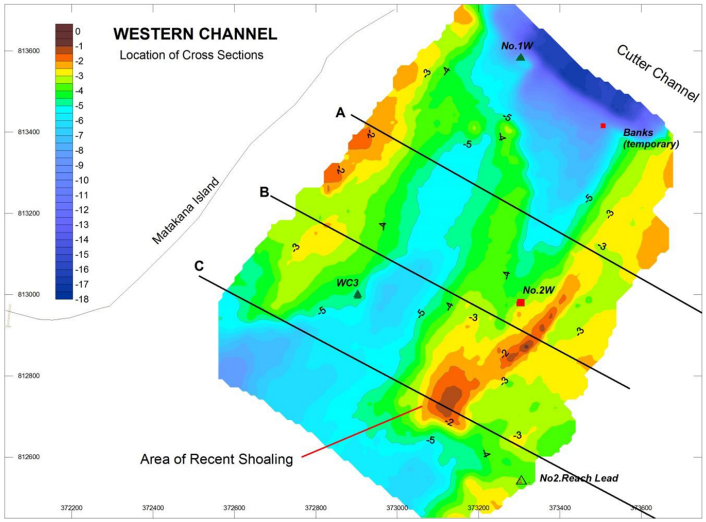
Marine sediment input

- Centre Bank accreted significantly 1879-1962 before dredging commenced
- Has continued to accrete since with expanding area of intertidal flats
- Sediment derived from offshore through tidal bypassing of the inlet – no detectable fluvial input
- Marine input to harbour currently negligible beyond tidal delta system

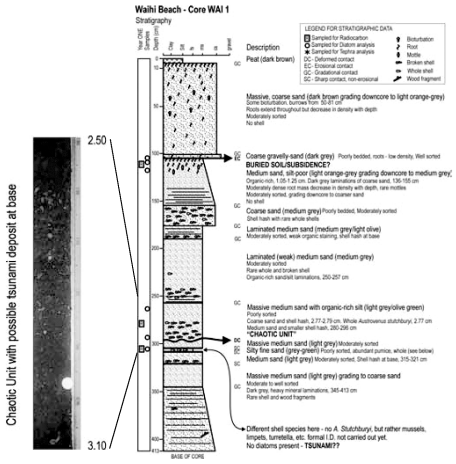


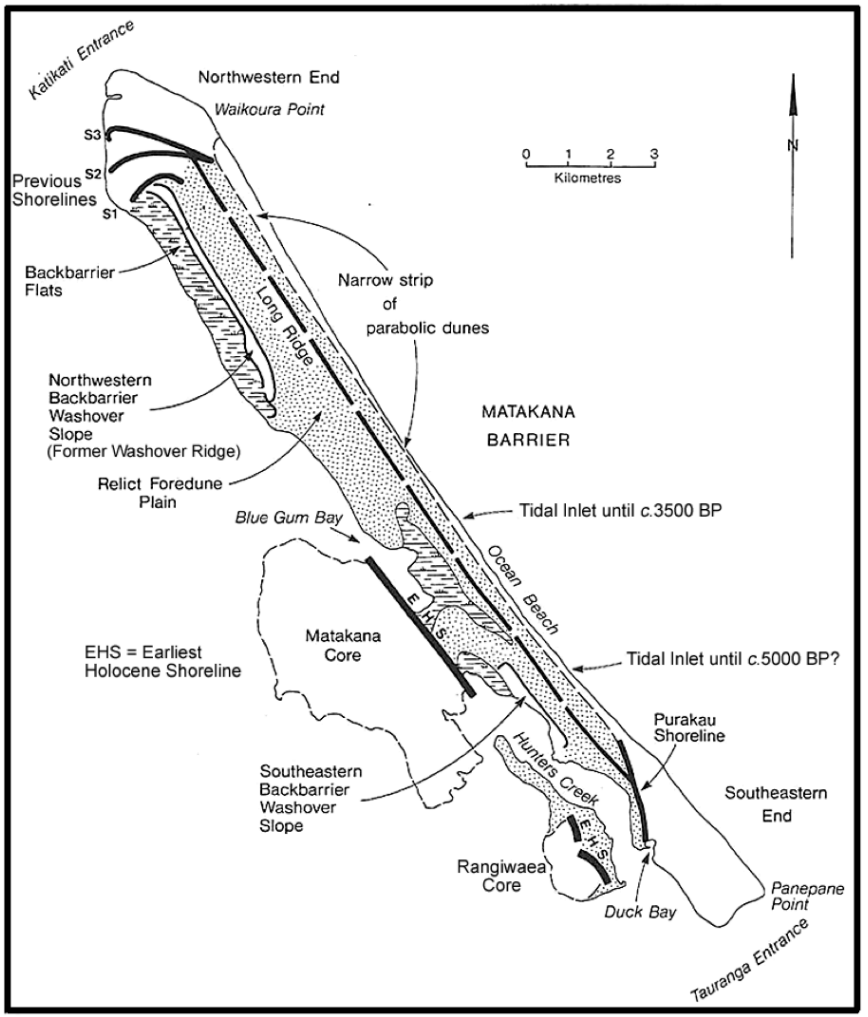


Shoaling since completion of 2015/16 capital dredging

Marine sediment input

- Evolution of Matakana Island indicates marine inputs were greater in the past
  - Multiple tidal inlets (4?)
  - Storm overwash of low-lying barrier islands
  - Large tsunami eroded Matakana Island and deposited sediment within the harbour





Sedimentation rates

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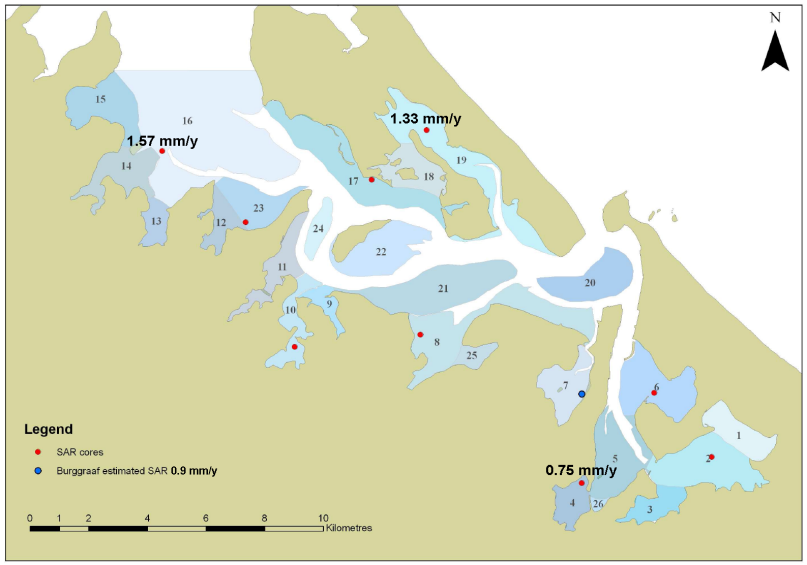
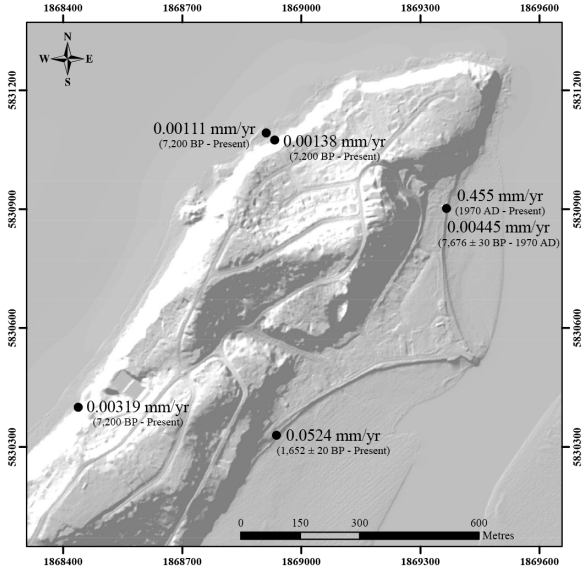
- Limited data available
  - Highest rates for intertidal flats remote from main fluvial inputs
- 40,500 m^3 from Bramley Dr landslide 1979-2014
  - Contributed to accretion at Omokoroa Domain (increased sedimentation rate since 1970)





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Seismic reflection data

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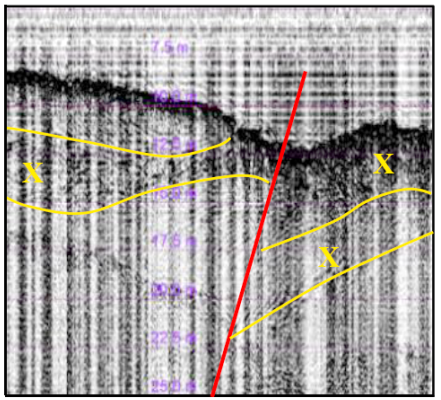
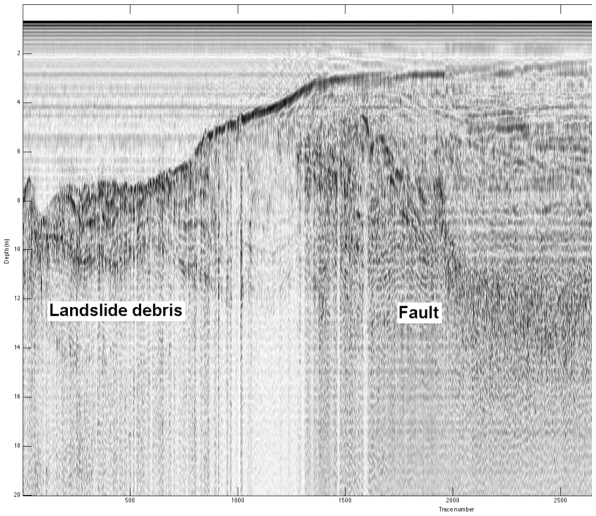
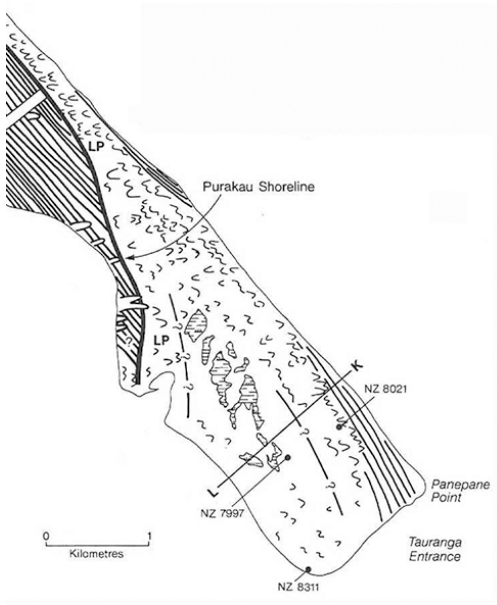
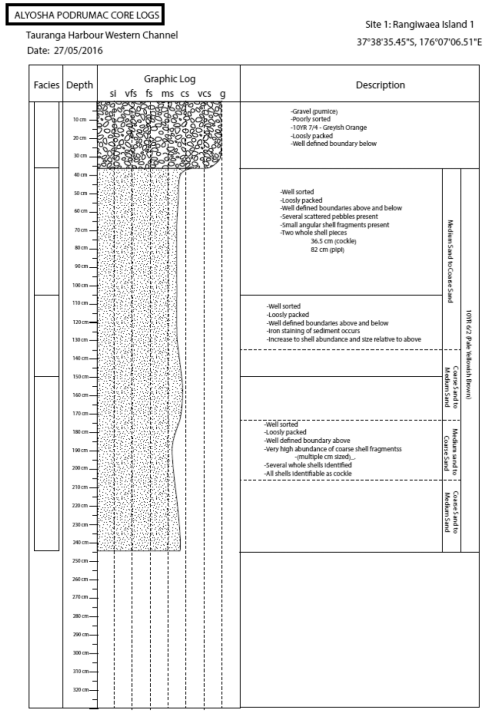
- Faults are evident in sub-surface sediments within the Harbour
- Some appear to displace Holocene deposits
  - 15th Century (?) tsunami depost in Western Channel
- Align with thermal bores, radium hotspots & seismicity (?)









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Seismic reflection data

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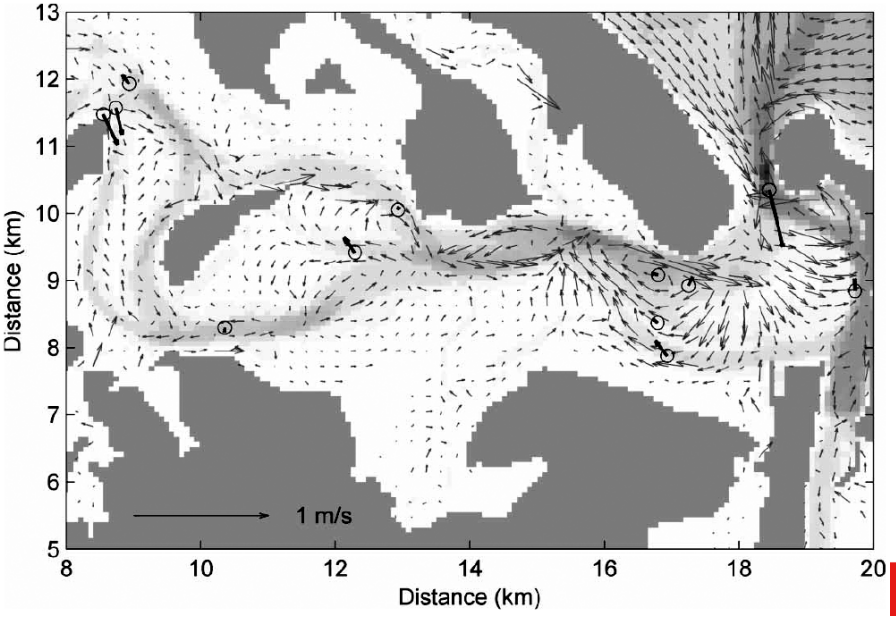
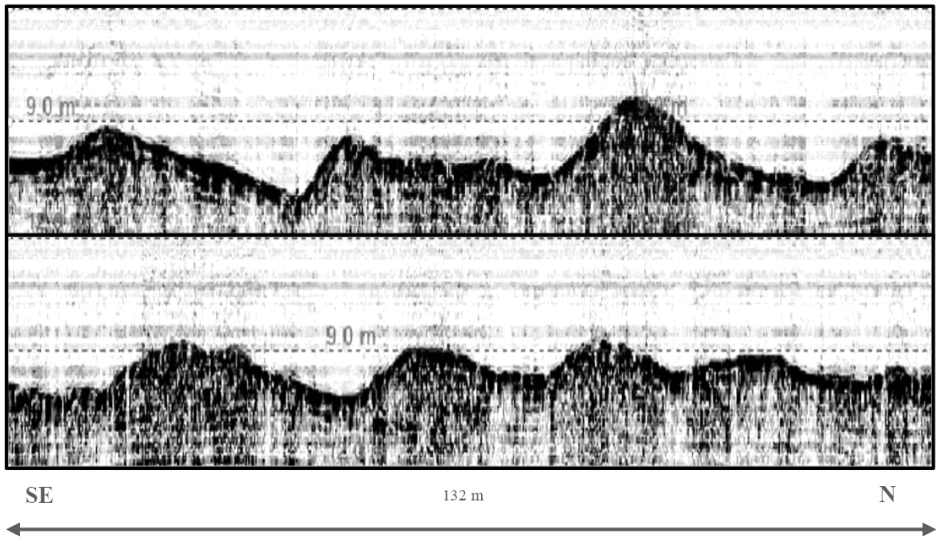
- Sand waves occur in patches in channels with
  - Converging tidal flow with a strong ebb/ flood contrast
  - Proximity to coarse sediment supply (eroding cliffs)
- Unclear if they are linked to tidal delta system (unlike sand waves around Centre Bank)
  - Amount of sediment exchange between patches is unknown

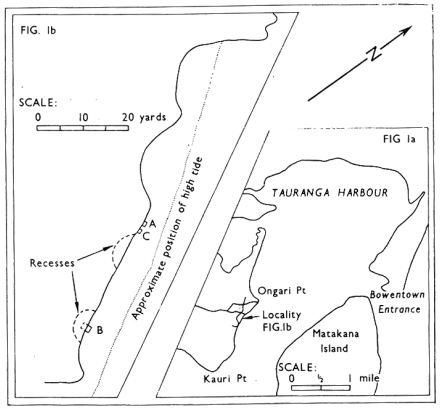


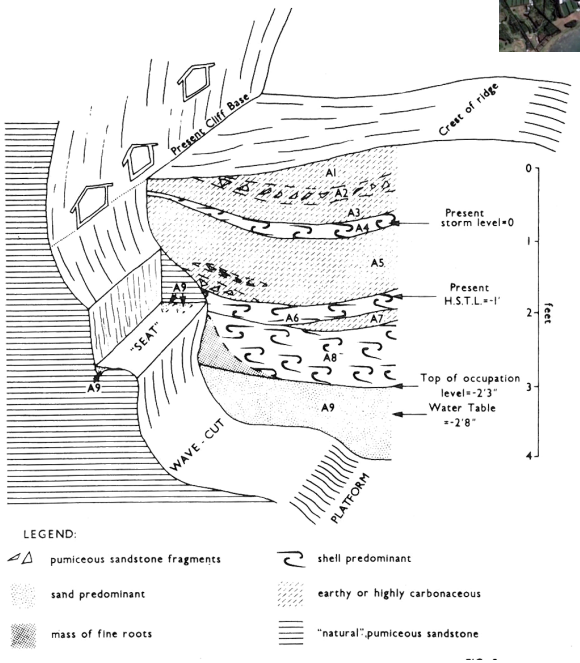
Tay *et al*, 2013. *NZJMFR* 47:2, 249-274

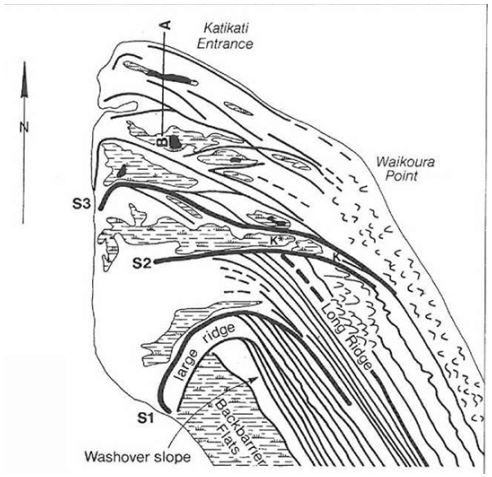


Sea level changes

- Bas-relief “rock” carvings at Ongare Pt dated at ~200 BP
- Indicate > 0.45 m of relative sea level change (~2.3 mm/y)
- Site also impacted by tsunami
  - S1 >3500 BP
  - S2 < 3500 BP
  - S3 ≈ 15th Century







Sea level changes

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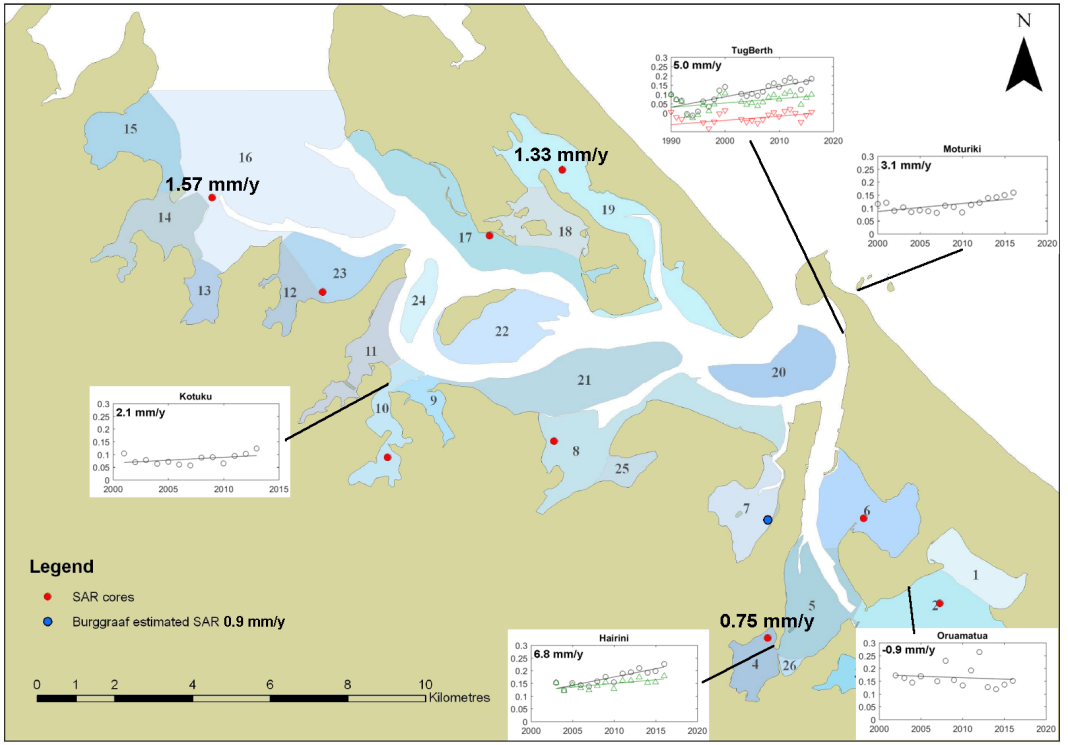
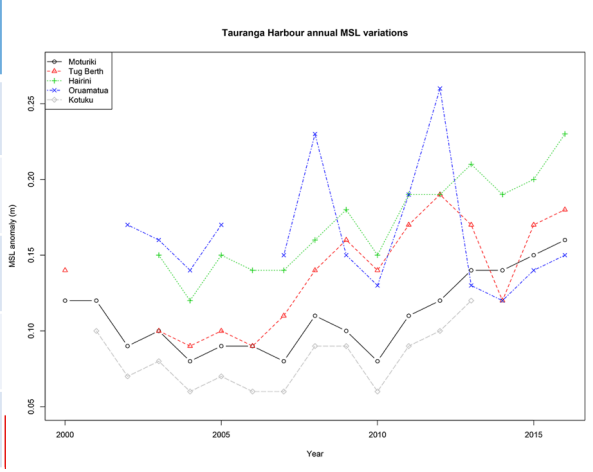
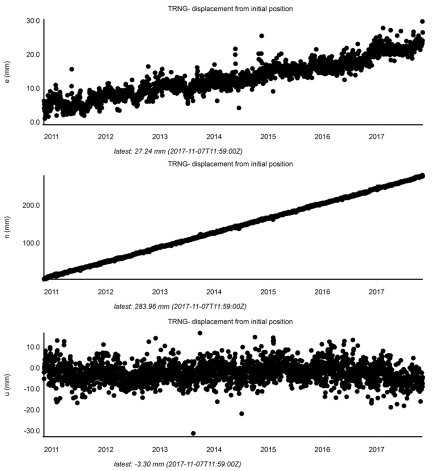
- Water level data within harbour indicate differing rates of relative sea level changes
- Tug Berth gauge structure regularly surveyed to check for settlement
  - None observed within survey error limits (~10 mm)
- GeoNet cGPS data indicated eastern end of harbour rising until 2012, but sinking now?



Location	2000-2016 (17y)	2003-2013 (11y)
Moturiki	3.1 mm/y	3.8 mm/y
Tug Berth	5.0 mm/y	10.1 mm/y
Hairini	6.8 mm/y	6.9 mm/y
Oruamatua	-0.9 mm/y	2.9 mm/y
Kotuku	2.1 mm/y	4.1 mm/y





So why does Tauranga Harbour exist?

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- Sedimentation inputs to harbour are episodic & low overall
  - Fluvial
  - Marine
  - Cliff erosion
  - Biogenic (?)
- Sediment is reworked by waves & tidal currents
  - Fine sediment exported from harbour & minor coarse component retained
- More speculative …
  - Southern & northern basins are subsiding increasing accommodation space
  - Central area & western/ eastern margins are uplifting
    - Results in remobilisation of sediment in rising areas & transfer of coarser sediment to basins (?)

Overall the resulting sedimentation rates are very low