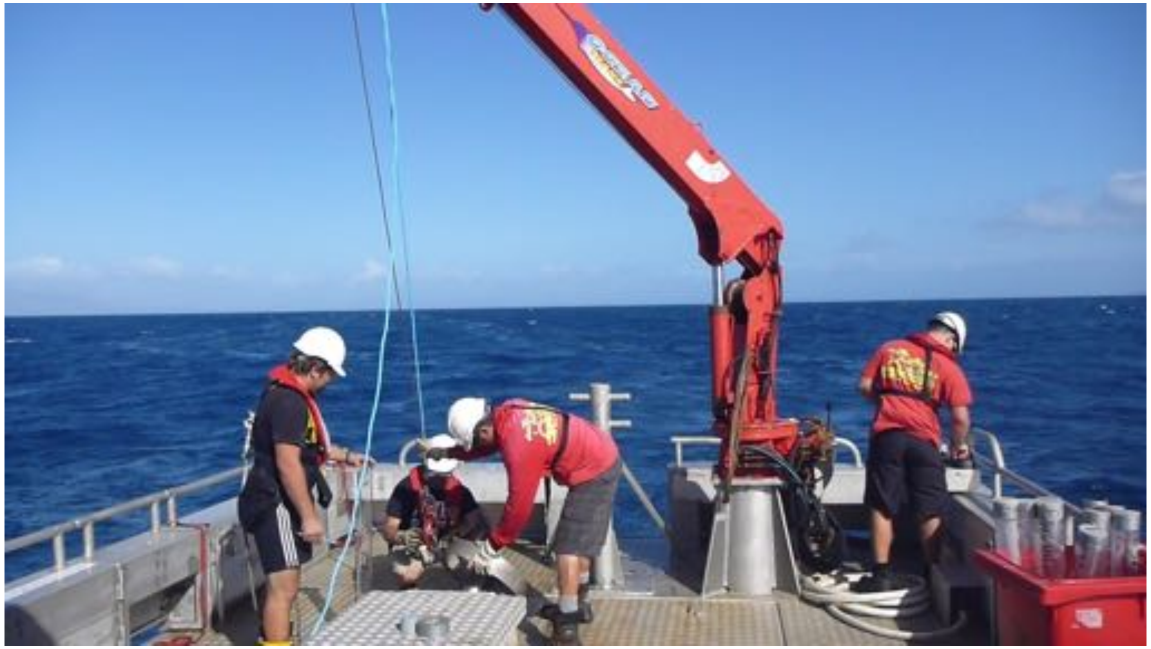
Hauraki Gulf sedimentation



UNINTENDED CONSEQUENCES OF FLOOD PROTECTION

WILLEM DE LANGE

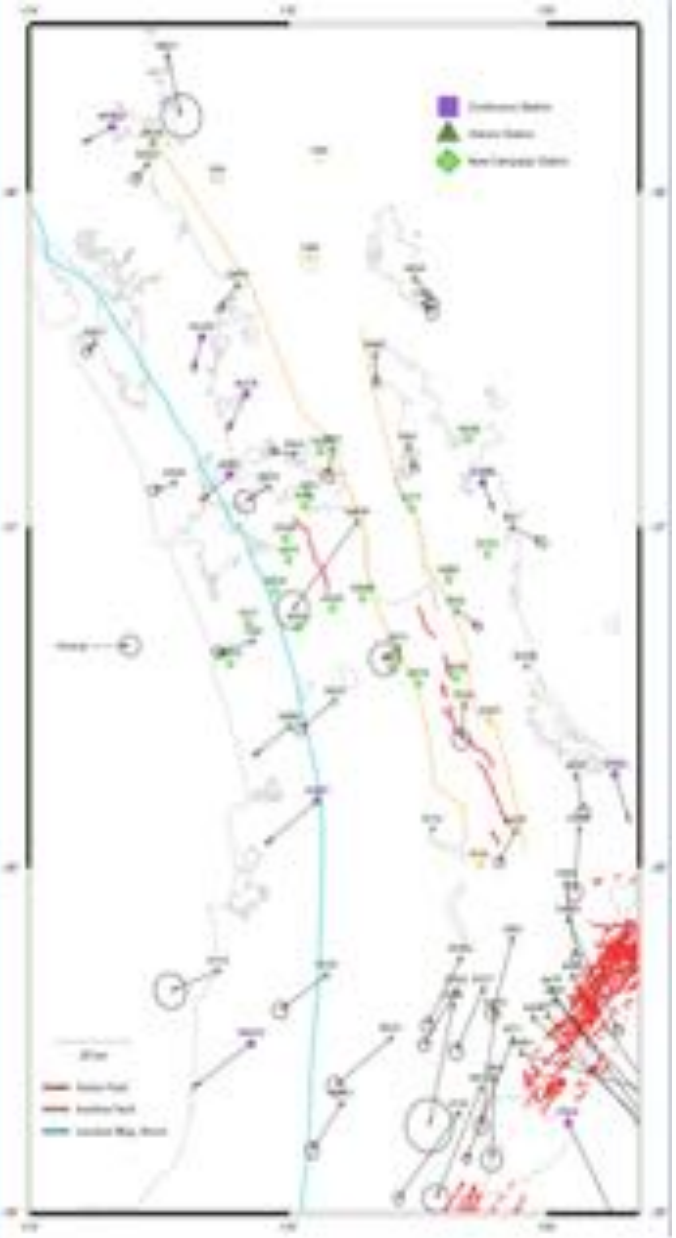
Introduction

Hauraki Gulf identified as having anthropic sedimentation problem

- *"Historic forest clearance and mining during the late 1800s to early 1900s generated vast amounts of sediment."*
  - State of our Gulf 2017

Occupies active rift

- Western & eastern boundaries rotating eastwards at different velocities
- Widening by 0.9 mm.y^{-1}
- Dextral shear of 0.1 mm.y^{-1}
- Associated with 2-10 mm.y^{-1} subsidence within rift



R. Pickle presentation, University of Auckland, November 2016

Holocene shoreline changes

Due to a high sediment supply associated with volcanic eruptions & breakout floods, the shoreline has advanced seaward during Holocene

- Initially Waihou & Piako Rivers occupied western basin
- Waihou River migrated eastwards as shoreline advanced
- Rate of shoreline advance decreased over time

Piako River – 2017 Flood

Waihou River

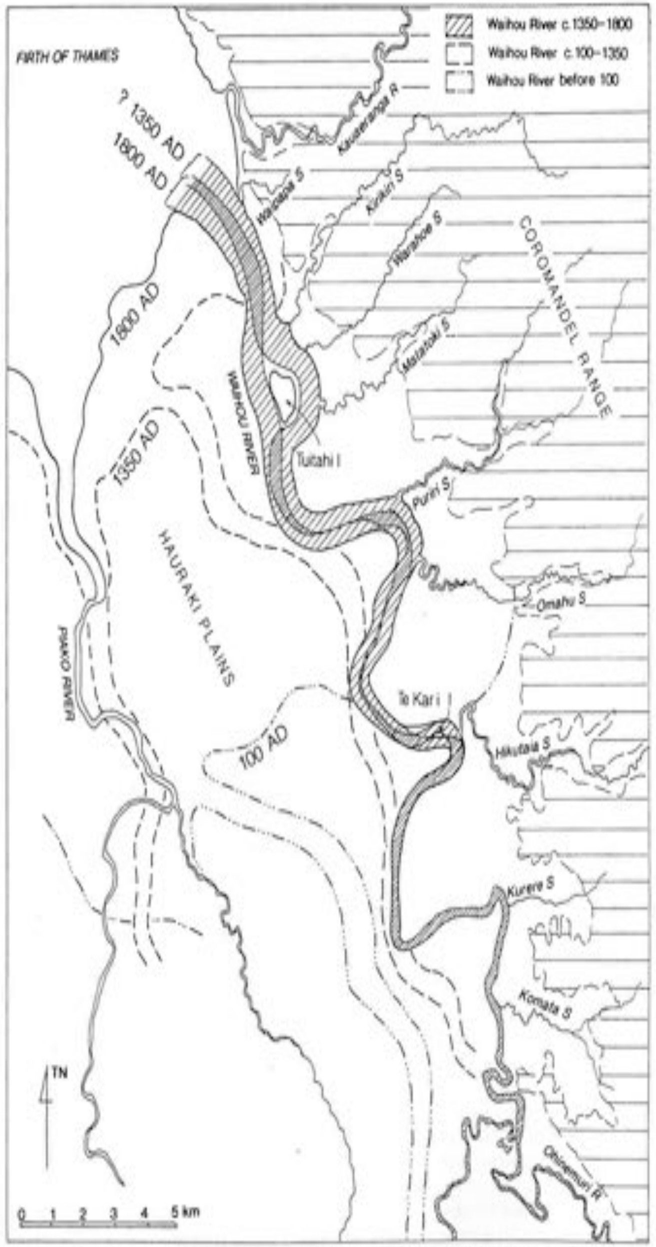


Fig 2.8 Movements of the Waihou River over the last 2,000 years (based on McLeod pers. comm. 1991; N.Z. Aerial Mapping 1980–1985).

Phillips,2000. *Waihou Journeys*

Land-use changes

No evidence for anthropic land-use impacts before Kaharoa Eruption ~AD 1350

Earliest evidence of permanent Maori settlement ~ AD 1520

Extensive Maori settlement by AD 1700 –forest clearance of alluvial fans along base of ranges

Captain Cook's expedition surveyed Waihou River – November 1769

Infrequent visits to obtain timber until European settlement started ~ AD 1820

"European" sedimentation mostly at Piako River mouth

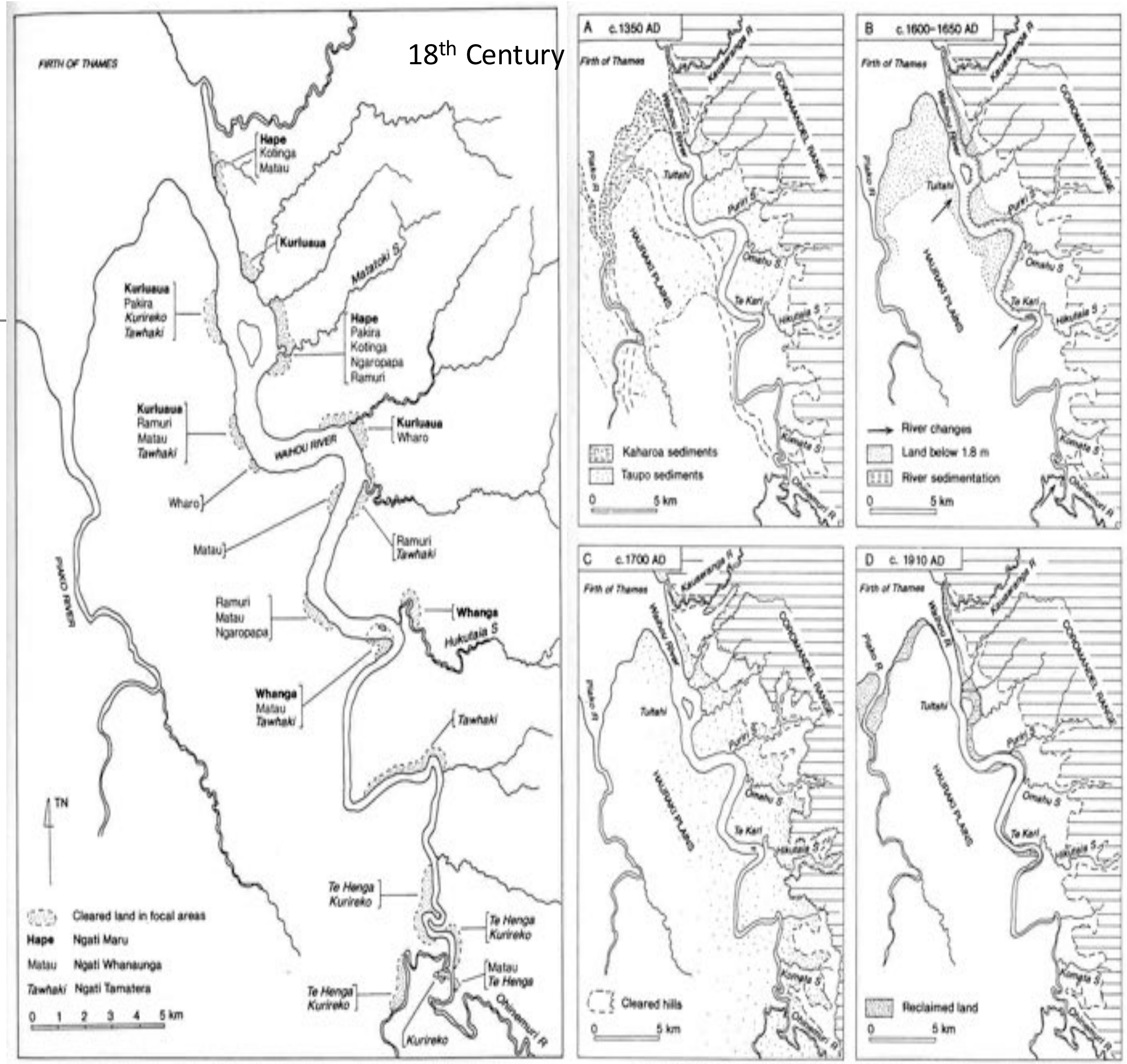


FIG 4.7 Focal areas along the lower Waihou River attributed to the principal ancestors who lived c.1700.

FIG 2.13 The changing environment along the lower Waihou River from around 1350 until 1910 AD.

Phillips,2000. *Waihou Journeys*

Ohinemuri & Waihou Rivers

Waihou & Ohinemuri Rivers have shoaled since European settlement

- Predominantly upstream of Paeroa, but also downstream to Hikutaia Stream
- Often attributed to discharge of mine waste into Ohinemuri River
    - Averaged 250 kt.y^{-1} from 1875-1955 (cf. estimated 820 kt.y^{-1} from all rivers at present)

1769

1820

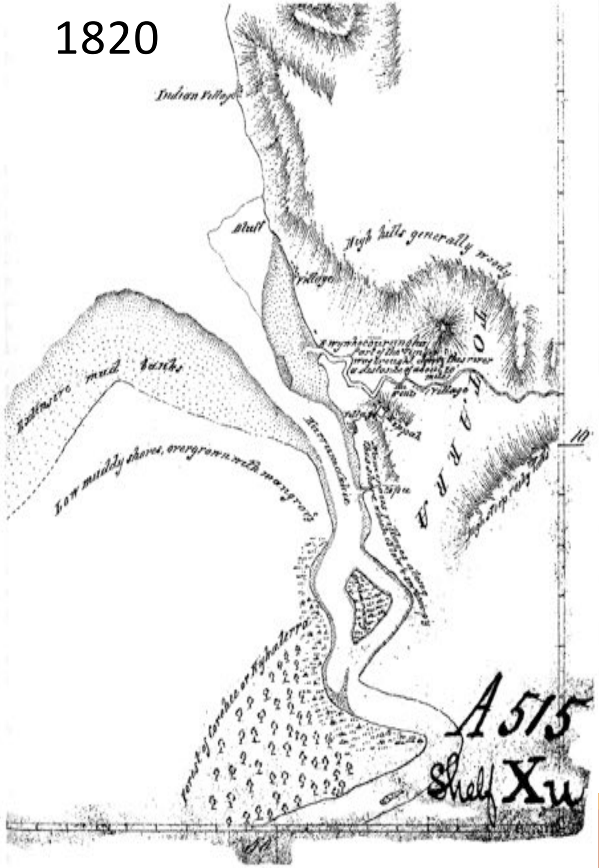


Fig 5.5 Captain Downie's map (1820), of the lower Waihou River. ALEXANDER TURNBULL LIBRARY, MAPCOLL 832.15A1/1820/ACC.1159

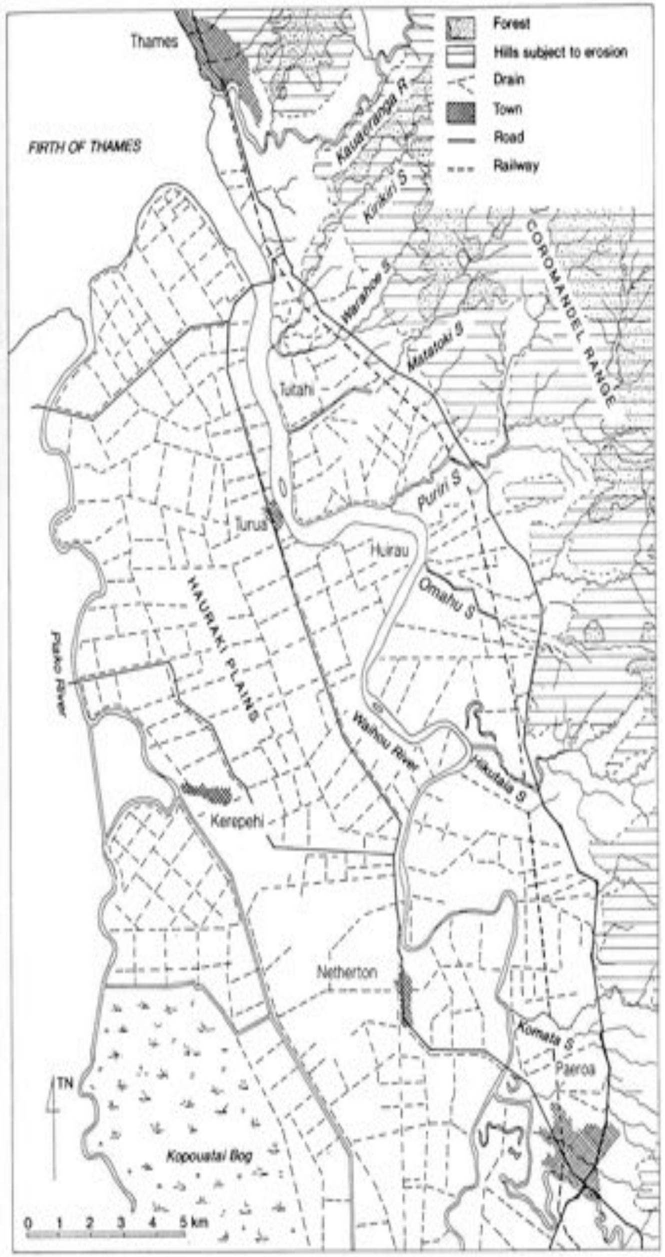


Fig 2.11 Modern vegetation and landform in the eastern Hauraki Plains (based on D.O.S.L.I. 1980, 1981; Trustrum & Crippen 1986a, 1986b).

Phillips,2000. *Waihou Journeys*

Hauraki Gulf - Sediments

Modern sediment input into Gulf is low

- Mostly fine sand & mud
- Estimated 820 $kt.y^{-1}$

Poor quality seismic data were used to estimate sediment thickness above a "strong reflector"

- Assumed to be last glacial ground surface
- Noted that it may also represent rock basement

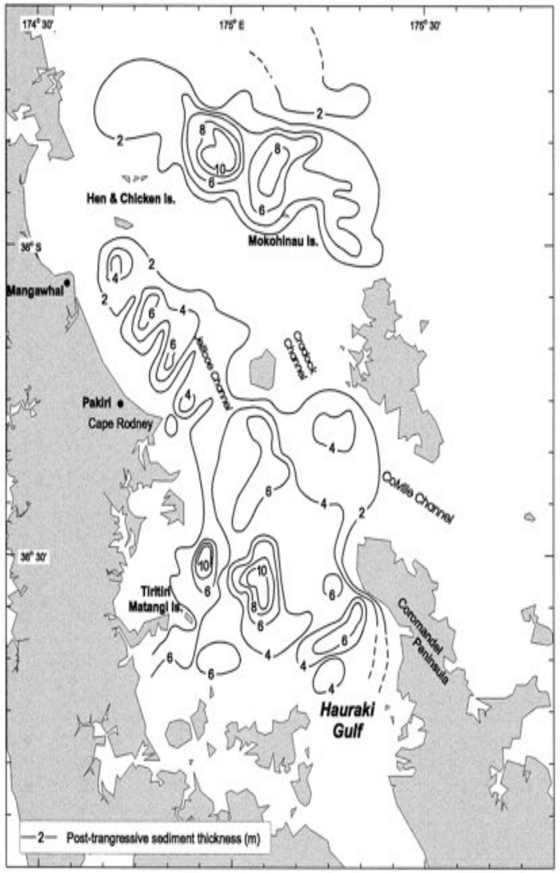


Fig. 5. Sediment accumulation in the Hauraki Gulf area. The main depocentres are indicated by isopachs denoting thickness (m) above the uppermost unconformable surface identified in seismic profiles. B. Manighetti, L. Carter / Marine Geology 160 (1999) 271–300

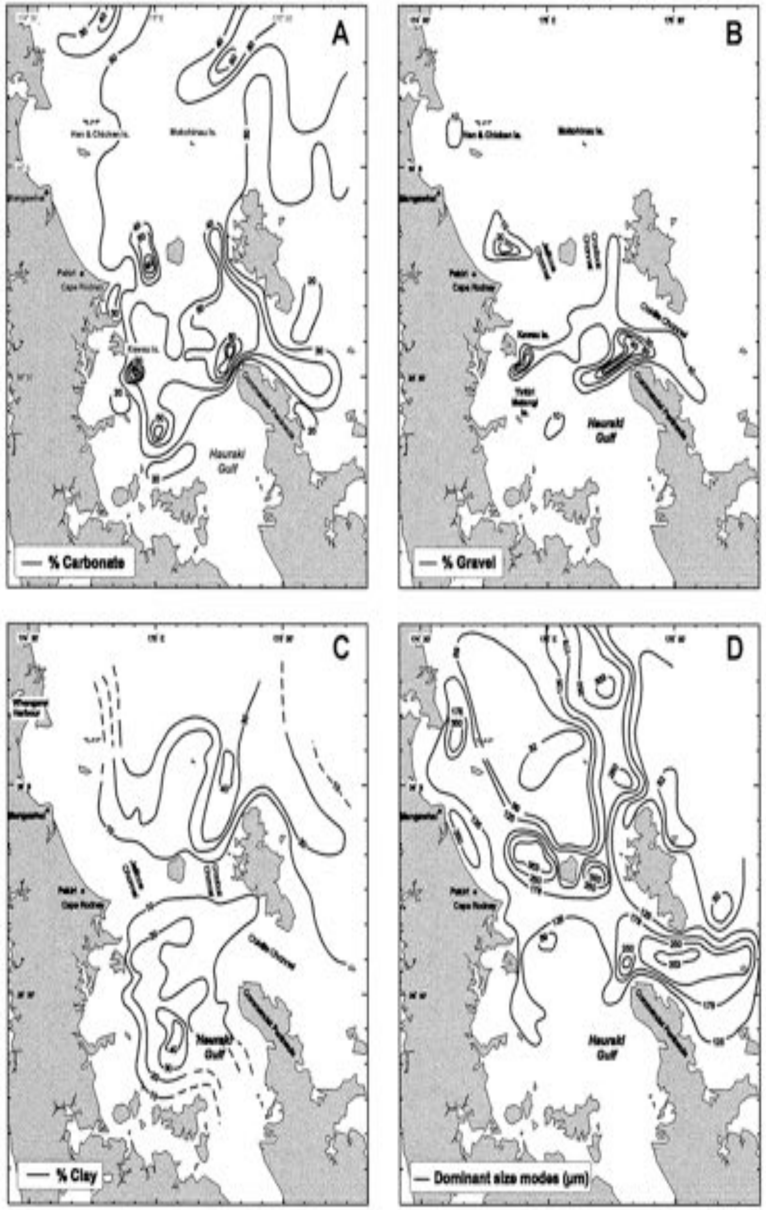


Fig. 3. Contour maps of the study area showing (a) weight percentage of calcium carbonate; (b) weight percentage of gravel; (c) weight percentage of clay; and (d) the dominant size modes in microns, for Hauraki samples indicated in Fig. 1.

B. Manighetti, L. Carter / Marine Geology 160 (1999) 271–300

Hauraki Gulf - Sediments

Combining sedimentological data, sidescan, seismic & numerical models, Manighetti & Carter (1999) proposed a conceptual model of sediment transport for the Hauraki Gulf

- Indicates thick modern depocentre in central Hauraki Gulf capturing fine sediment input from rivers discharging into the Gulf
- Basis for marine spatial planning

We evaluated this model by assessing sedimentation within

1. Modern depocentre
2. Coromandel Harbour
3. Firth of Thames

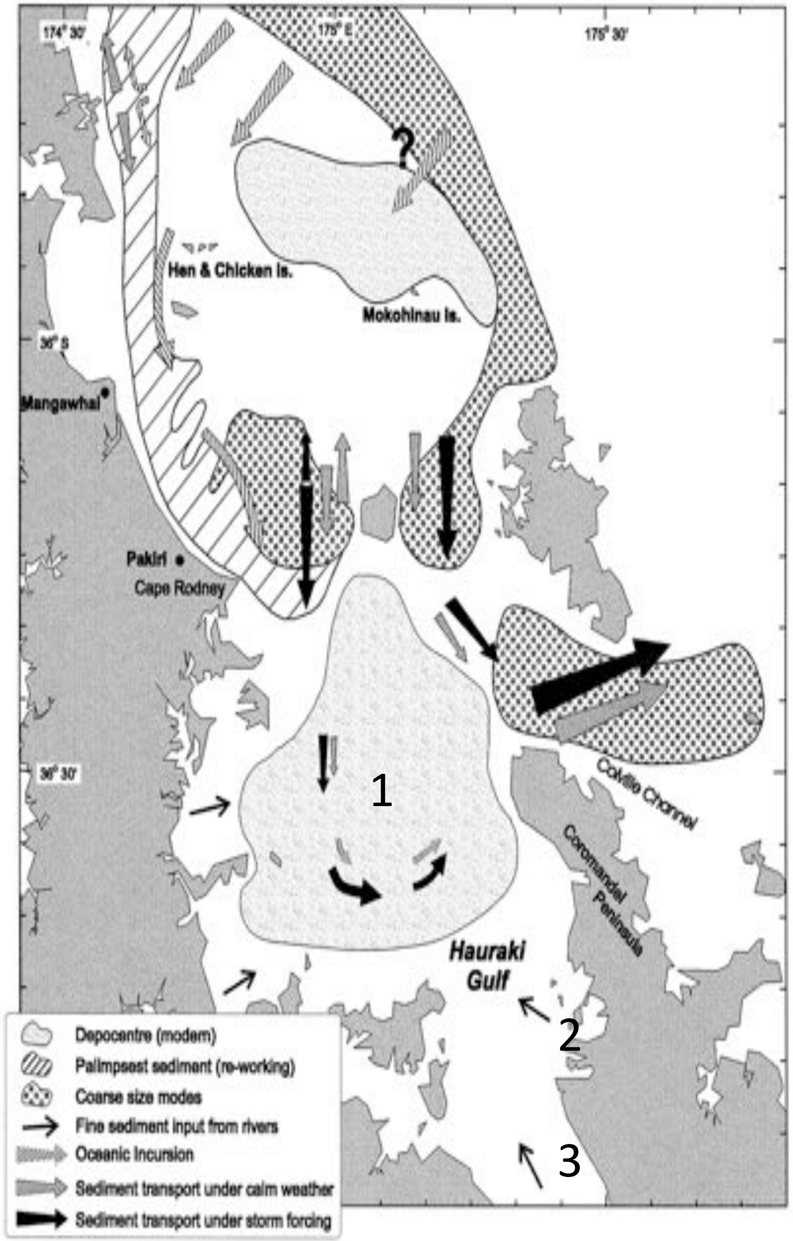


Fig. 9. Sediment transport and deposition under calm weather and during storms, with relative magnitude of transport expressed by size of arrows. The main depocentres, zones of reworking and areas of coarse surficial sediment are indicated schematically.

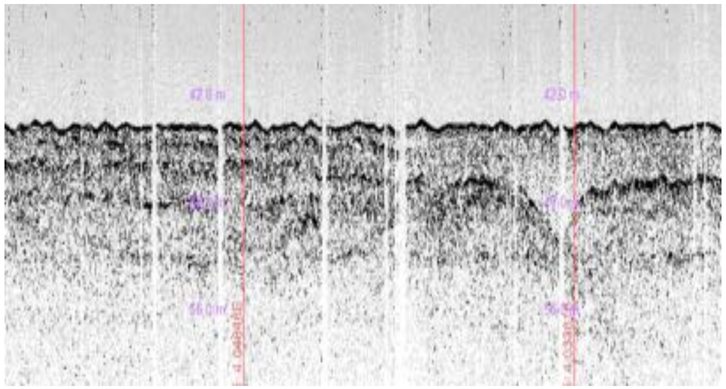
B. Manighetti, L. Carter / Marine Geology 160 (1999) 271–300

Central Hauraki Gulf

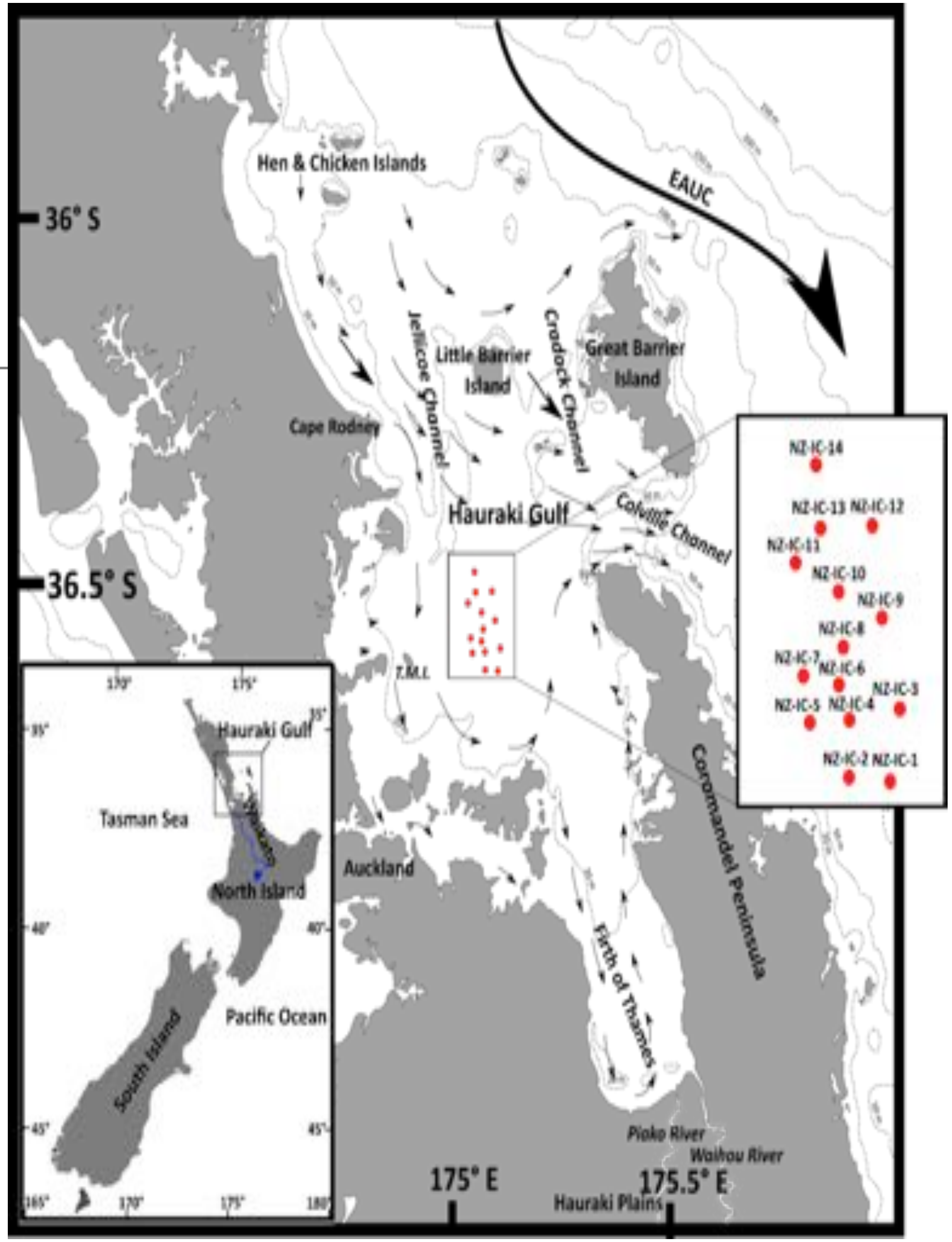
High resolution CHIRP seismic survey undertaken within Hauraki Gulf depocentre

14 sites were selected & cored

Cores were processed at Universities of Waikato & Bremen



Section of seismic profile 5 showing sediment layers overlying a series of small ridges & valleys



Location of study area in Hauraki Gulf. Left inset map shows study area in the North Island of New Zealand. Red dots in the main map mark the core locations (NZ-IC-1 to NZ-IC-14; right inset map). Black arrows indicate the prevailing surface currents in and outside the Gulf according to Black et al (2000) (T.M.I. – Tiritiri Matangi Island; EAUC – East Auckland Current).

Results

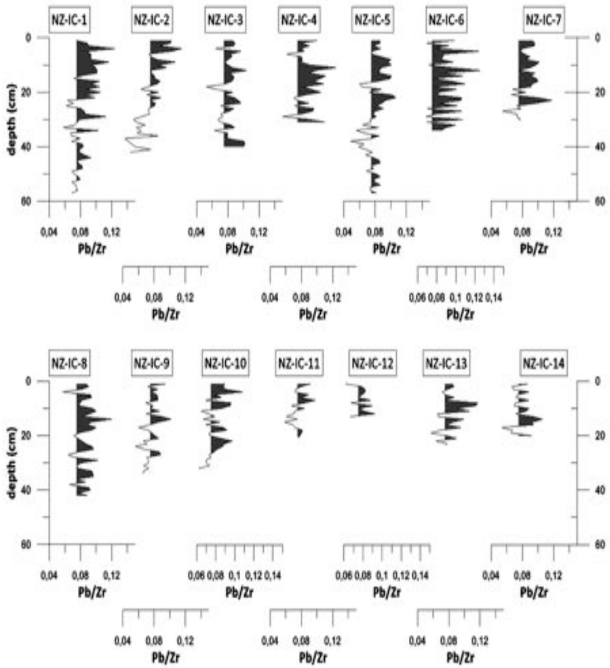
No heavy metal anthropic signature was found in the cores

Cores with Ca/Ti ratios indicating terrigenous input show no clear anthropic sediment influx

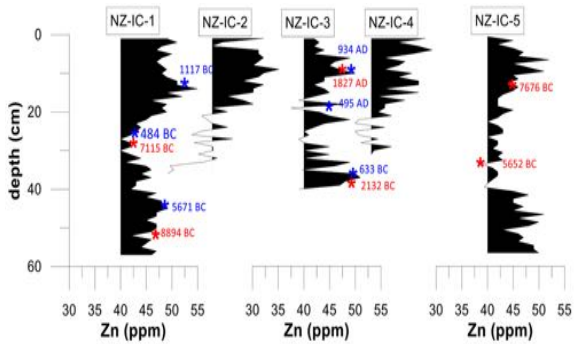
- ^{14}C ages all too old
- ^{210}Pb data suggest recent sediment limited to uppermost 5 cm

Modern central Hauraki Gulf depocentre doesn't really exist

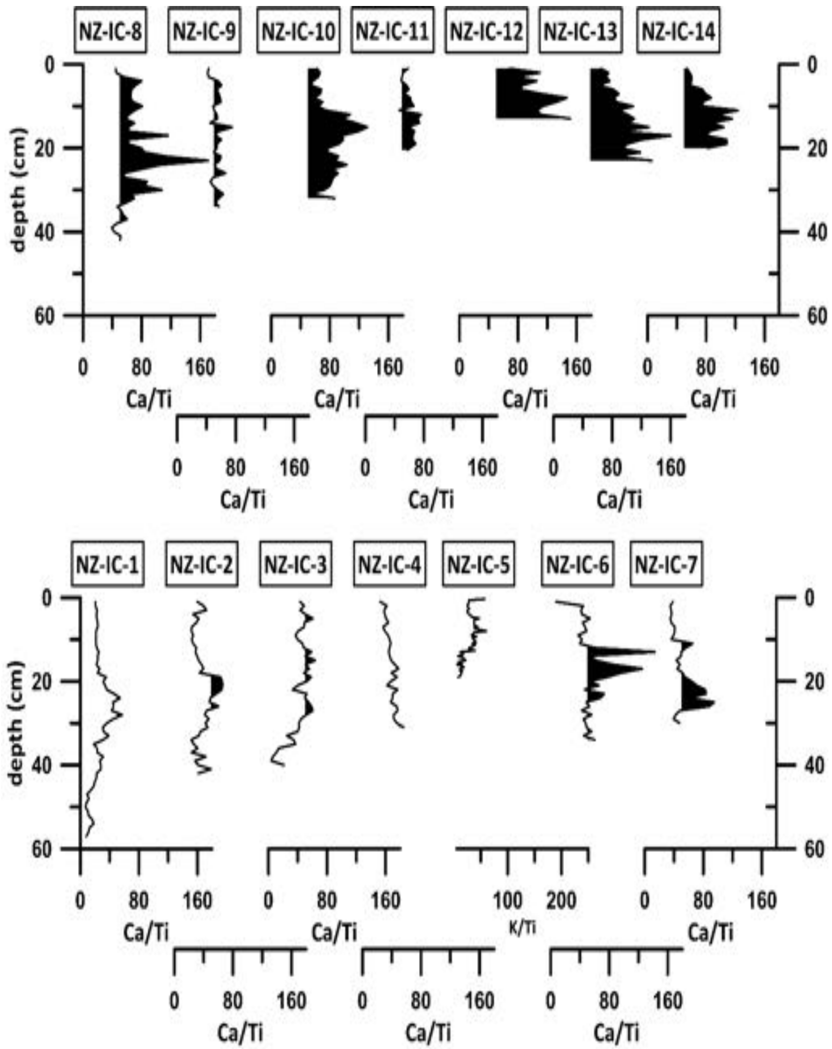
- Palimpsest?



Pb/Zr ratio of sediments (Zr normalised to reduce influence of marine versus terrestrial sources).



Radiocarbon ages for cores with terrigenous input (red = molluscs, blue = forams)

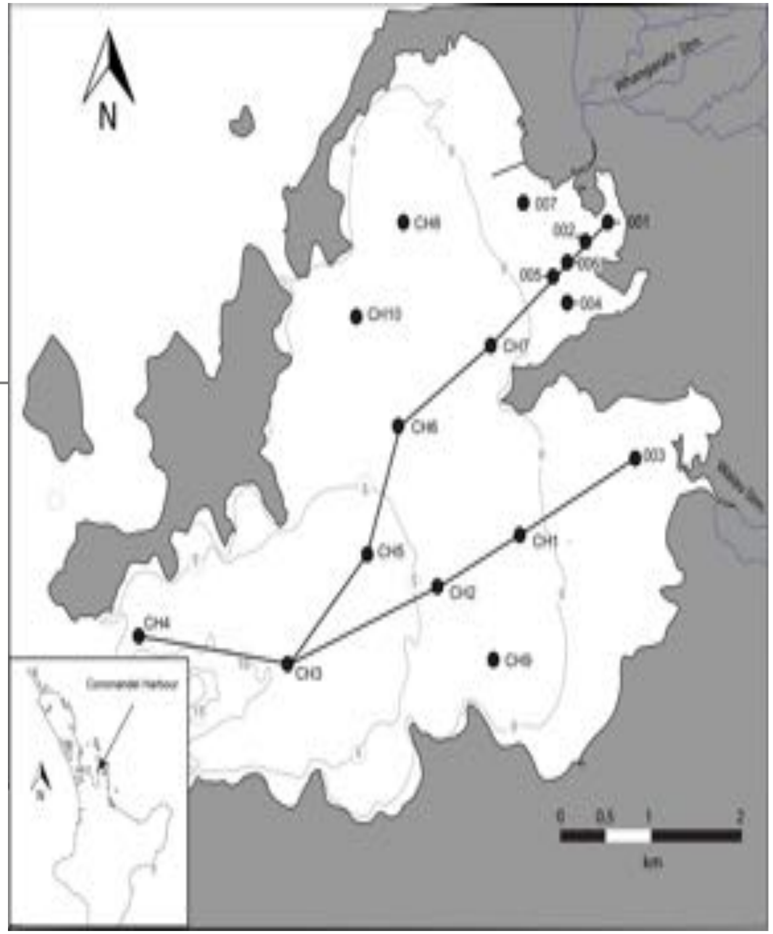


Ca/Ti ratio of the sediments, indicating higher ratios in the northern cores. Black shading of the curves indicates Ca/Ti ratios over 50 (reduced terrigenous input).

Coromandel Harbour

Sediment cores obtained within Coromandel harbour to assess anthropic impacts

- Intertidal flats (OO series)
- Subtidal (CH series)



Coring sites within Coromandel Harbour. CH sites = 6 m tower vibracorer, OO sites = portable 3 m vibracorer

Coromandel Harbour

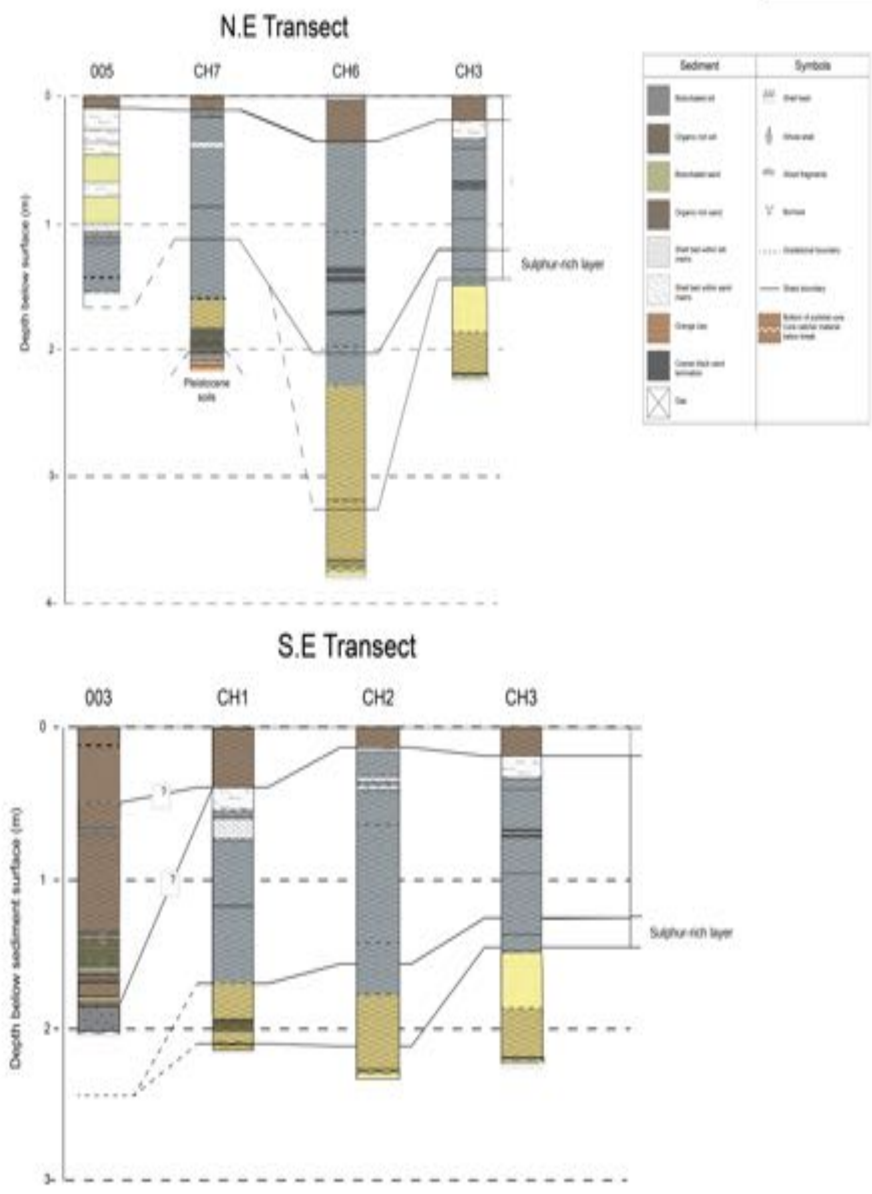
Variable thickness Holocene deposits found

Thickest anthropic deposits occurred in mouth of Waiau Stream in SE Coromandel Harbour

Metal contamination levels were low and mostly confined to intertidal flats

Palynological indicators of settlement located deeper in core than other indicators
- Clearest anthropic signal associated with pine forestation since 1975?

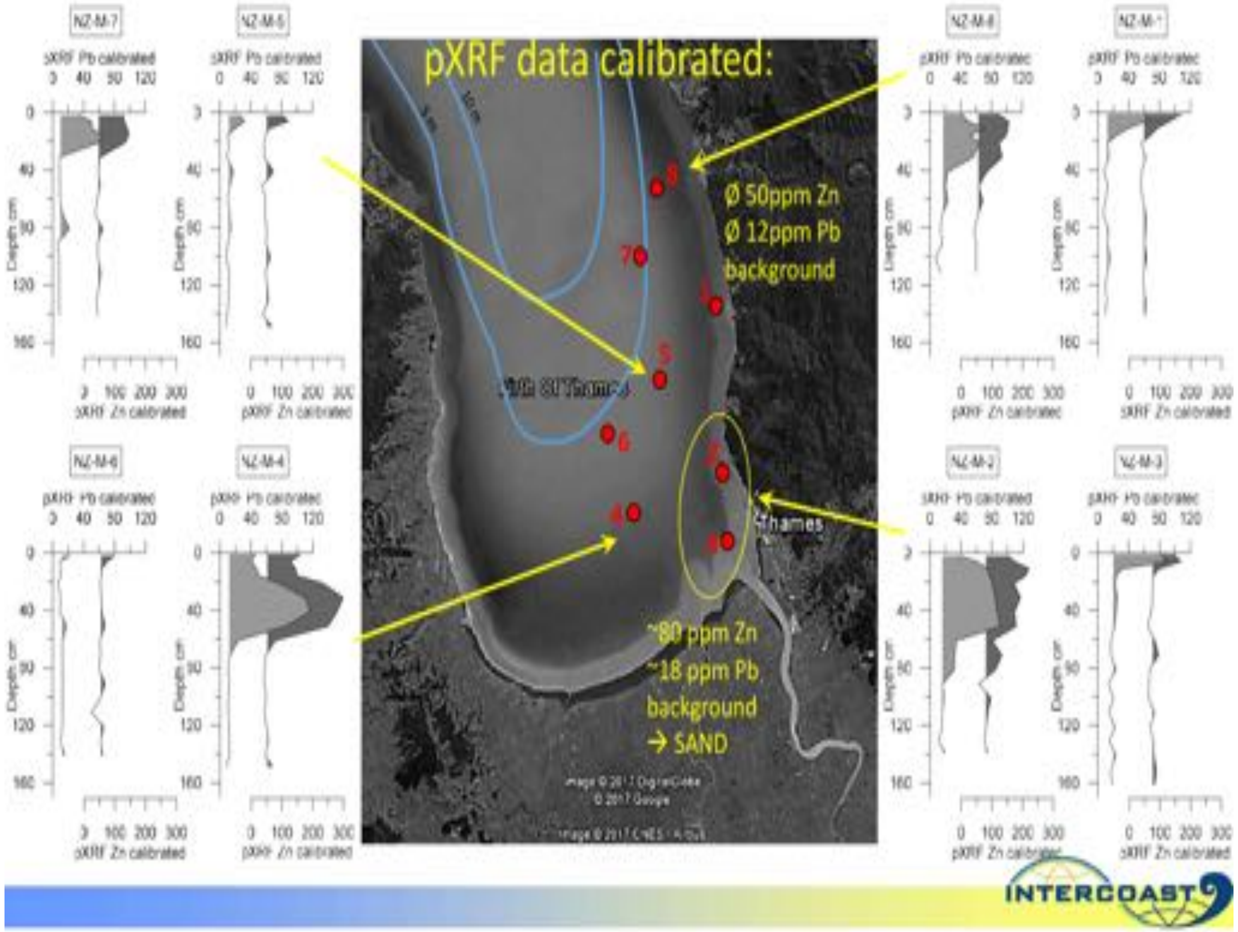
Sedimentation rates highest in early Holocene & decreasing to present?



Firth of Thames

Sediment cores show evidence of anthropic impacts

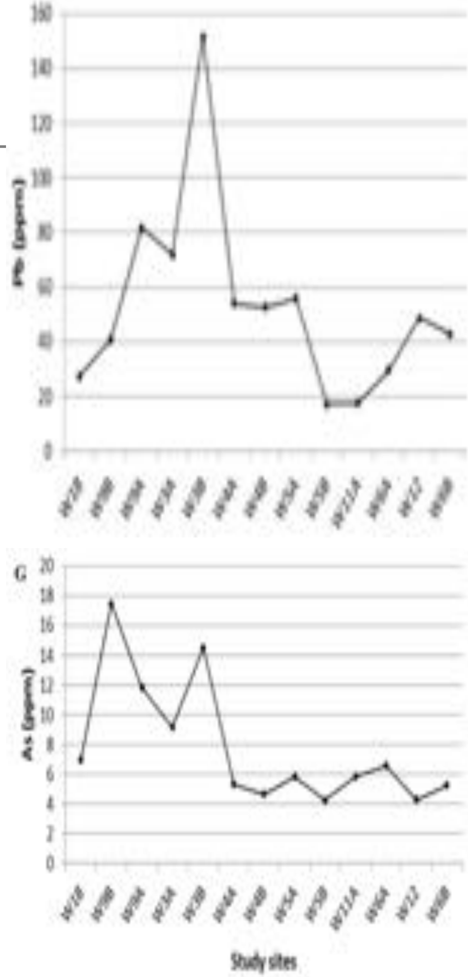
- <1 m thick
- Mostly close to mining areas along Thames coast, particularly closest to site where tailings were discharged into the Firth (NZ-M-2 & NZ-M-8)
- No clear evidence for discharge of anthropic sediment from Waihou River (NZ-M-3)
- Sediment being resuspended by storms (NZ-M-4)?



Ohinemuri & Waihou Rivers

Webster (1995), Upiap (2016), Clement et al (2017) & Tofeeq (in prep) found mining contamination occurs between Waikino & Hikutaia

- Highest concentrations upstream of Paeroa, especially within flood deposits
- Increases in some metals near mouth of Waihou River (Kopu Bridge) linked to Thames mine waste disposal & possibly A&G Price foundry

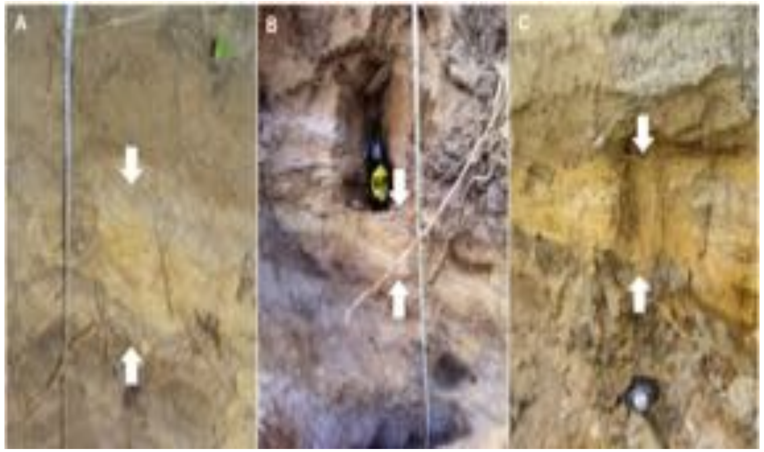


XRF metal concentrations determined for sites along Ohinemuri & Waihou RIvers

1907 Flood

Ohinemuri River overtopped banks & flowing overland into the Waihou River

- Left a widespread yellow silt deposit between Mackaytown & Paeroa
  - High metal concentrations
- Resulted in Government Commission of Enquiry



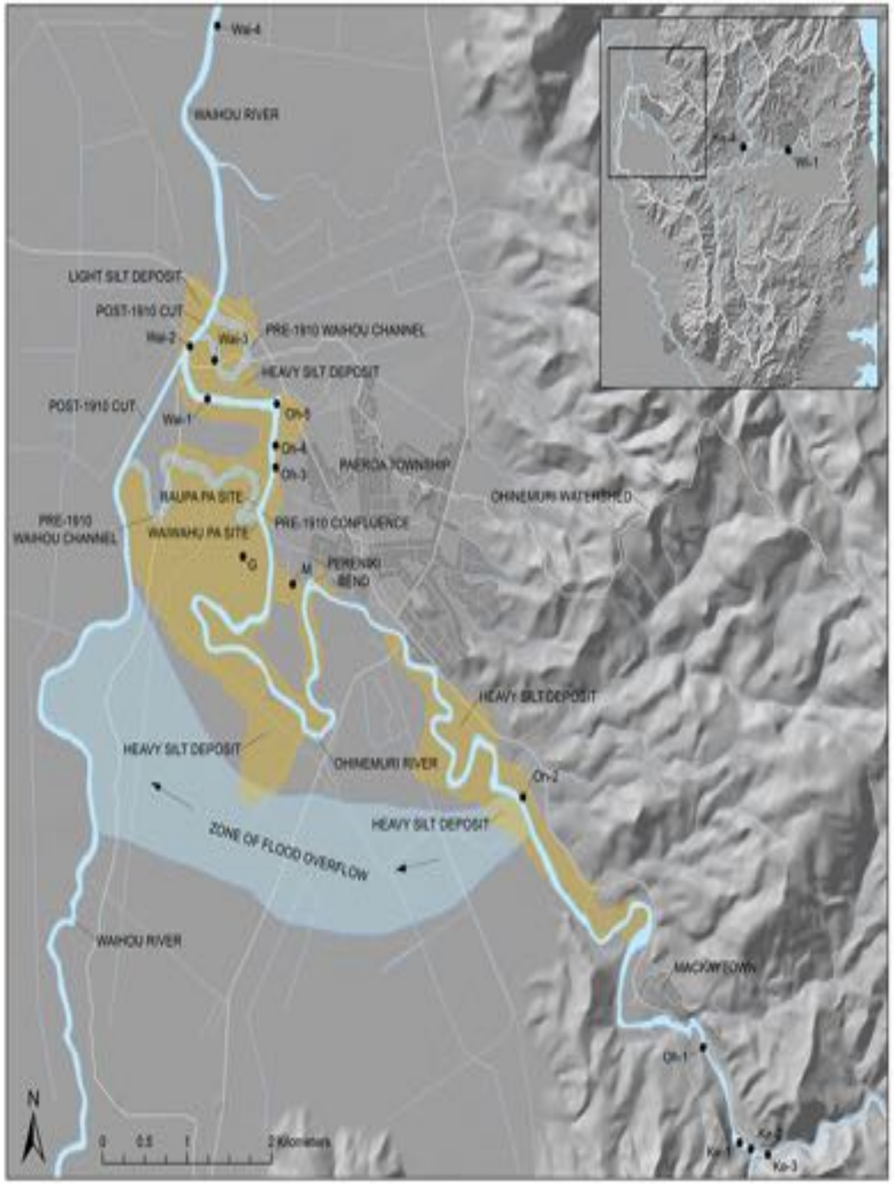


Fig. 4. Map of the study area around the township of Paeroa and the Ohinemuri-Waihou confluence. Shown are the locations of cores G and M, floodplain sections Oh-1 to Oh-5 and Wai-1 to Wai-4, and bulk sediment samples recovered from the Ohinemuri River channel (Ke-1 to Ke-3; see inset map for location of Ke-4) and the Ohinemuri River bank (Wi-1, see inset map for location). The documented passage of the 1907 flood is indicated (the 'zone of overflow', marked as such in maps in AJHR 1910), as is the thickness of post-flood silt deposits mapped as part of the 1910 inquiry (AJHR, 1910). Post-1910 cuts to the Waihou channel and the realignment of the Ohinemuri channel are also shown. Flow of both the Waihou and Ohinemuri rivers is from south to north.

A.J.H. Clement et al. Geomorphology 295 (2017) 159–175

1910 Enquiry

Recognised mine waste contributed to siltation

- Found most waste (slimes) was deposited on floodplains

However, attributed most of silting due to gully erosion of rolling land in southern Hauraki Plains

- Mixing of sands from gully erosion with slimes from mine waste reduced transport of sediment by river, forming "hard" shoals near Paeroa & Waihou River mouth








Hobbits are the problem, not dwarves?

Flood protection

Involved creation of stopbanks & replanting hillslopes since 1910

Culminated with the Waihou Valley Scheme 1972-1995

- 177 km network of stopbanks along rivers, streams, drains & coast

Progressively reduced frequency of floods depositing sediment on floodplain.

- Floods exceeding design criteria may occur rarely (only 2017 partially exceeded design since Waihou Valley Scheme completed in 1995)
- Sediment transported by rivers now predominantly discharged into Firth of Thames instead of onto floodplains
  - Eg. Swales et al (2008)

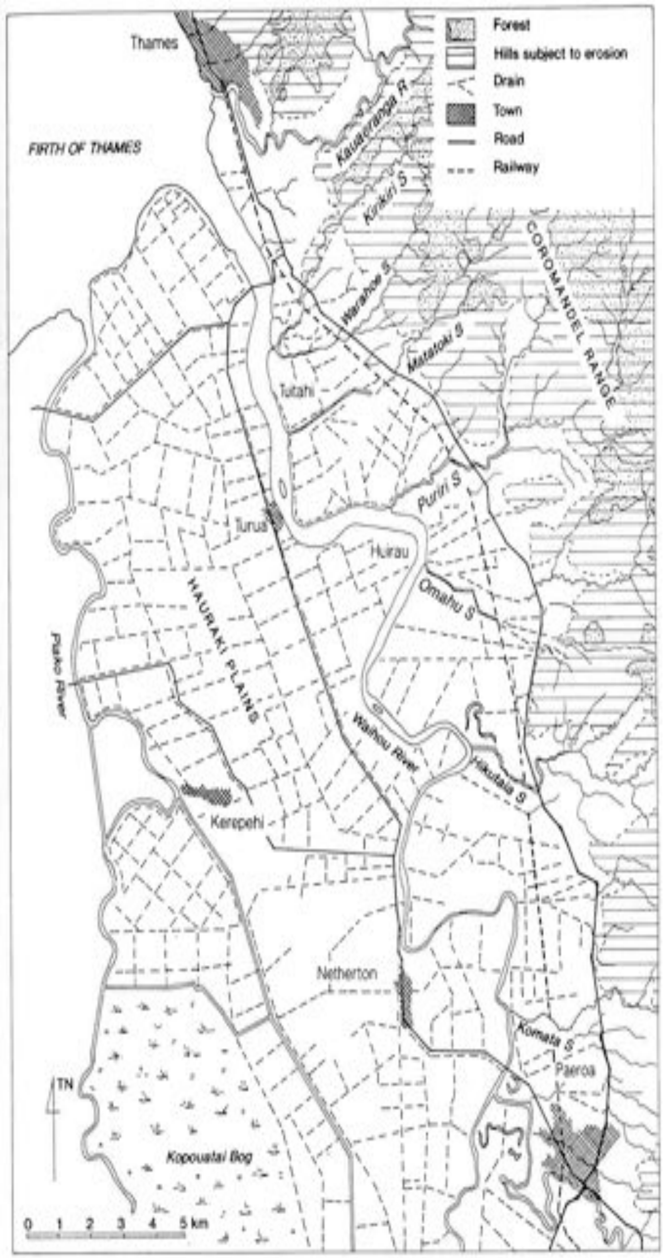


Fig 2.11 Modern vegetation and landform in the eastern Hauraki Plains (based on D.O.S.L.I. 1980, 1981; Trustrum & Crippen 1986a, 1986b).

Phillips,2000. *Waihou Journeys*

Managed realignment

Managed realignment of southern Firth of Thames may be an option to reduce sediment accumulation in Hauraki Gulf

Sacrifice some land between SH25 & coast to provide upper tidal area to trap silt in salt marsh

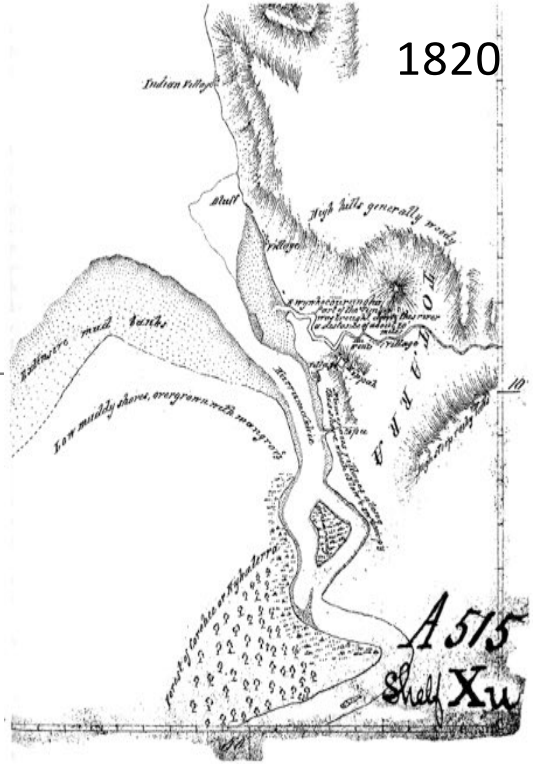
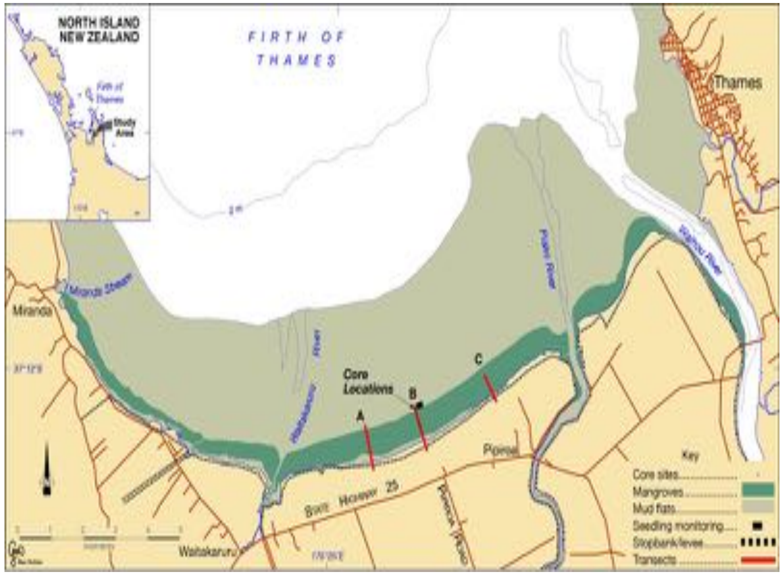


Fig 5.5 Captain Downie's map (1820), of the lower Waihou River. ALEXANDER TURNBULL LIBRARY, MAPCOLL 832.15A1/1820/ACC.1159

Silt traps, Neuharlingerseil, Wadden Sea



Conclusions

Piako River – 2017 Flood

- No modern depocentre in central Hauraki Gulf accumulating anthropic sediment
- Anthropic sediment predominantly deposited on flood plains or within intertidal areas close to source
- Recent marine sedimentation due to stopbanks diverting sediment from floodplains to Firth of Thames
- Could be mitigated by restoring access to some of flood plain during floods, or providing more intertidal salt marsh area