

SUPPLEMENTARY FIGURES

Reviewing the far-reaching ecological impacts of human-induced terrigenous sedimentation on shallow marine ecosystems in a northern-New Zealand embayment

John D. Booth

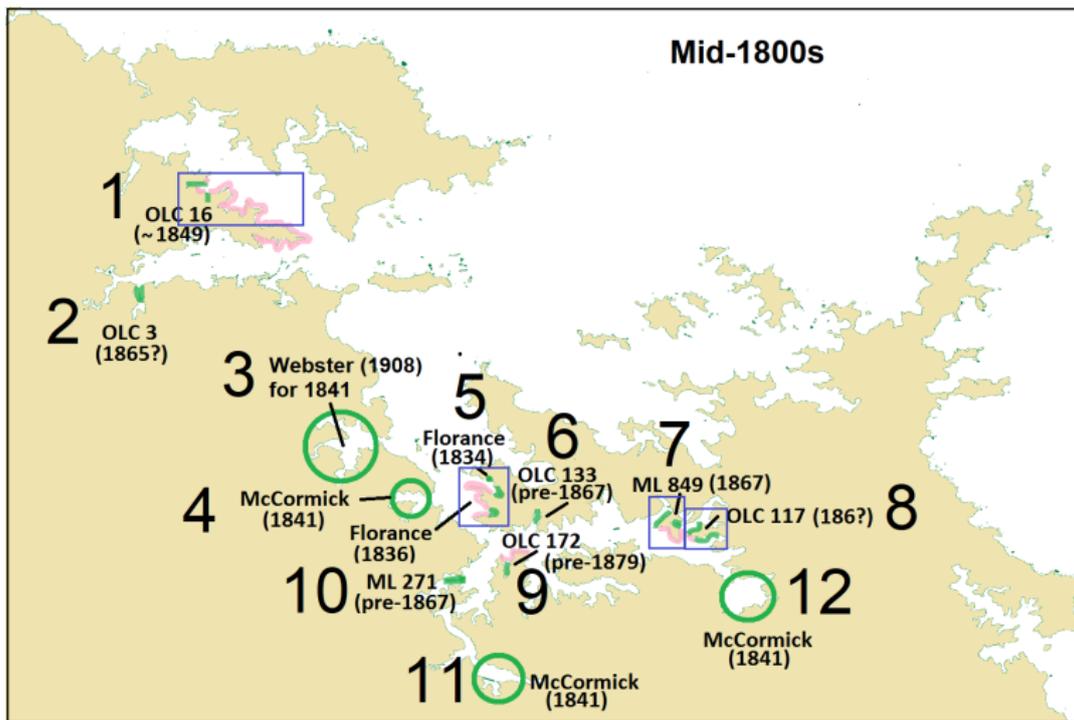


Figure S1. Old land claims (OLC) and Māori land surveys (ML), and written accounts from the mid-1800s, indicate where mangroves existed (green shading) or were referred to (green circles); pink indicates shorelines where, on the one plan explicitly showing mangroves, no mangrove cover was indicated. Shores without shading may or may not have supported mangroves. Whereas some localities have shown little change in areal cover since the mid-1800s (blue boxes) (1 and 5 [6 and 8 were already at full-extent]), others have expanded (2, 7 and 9).

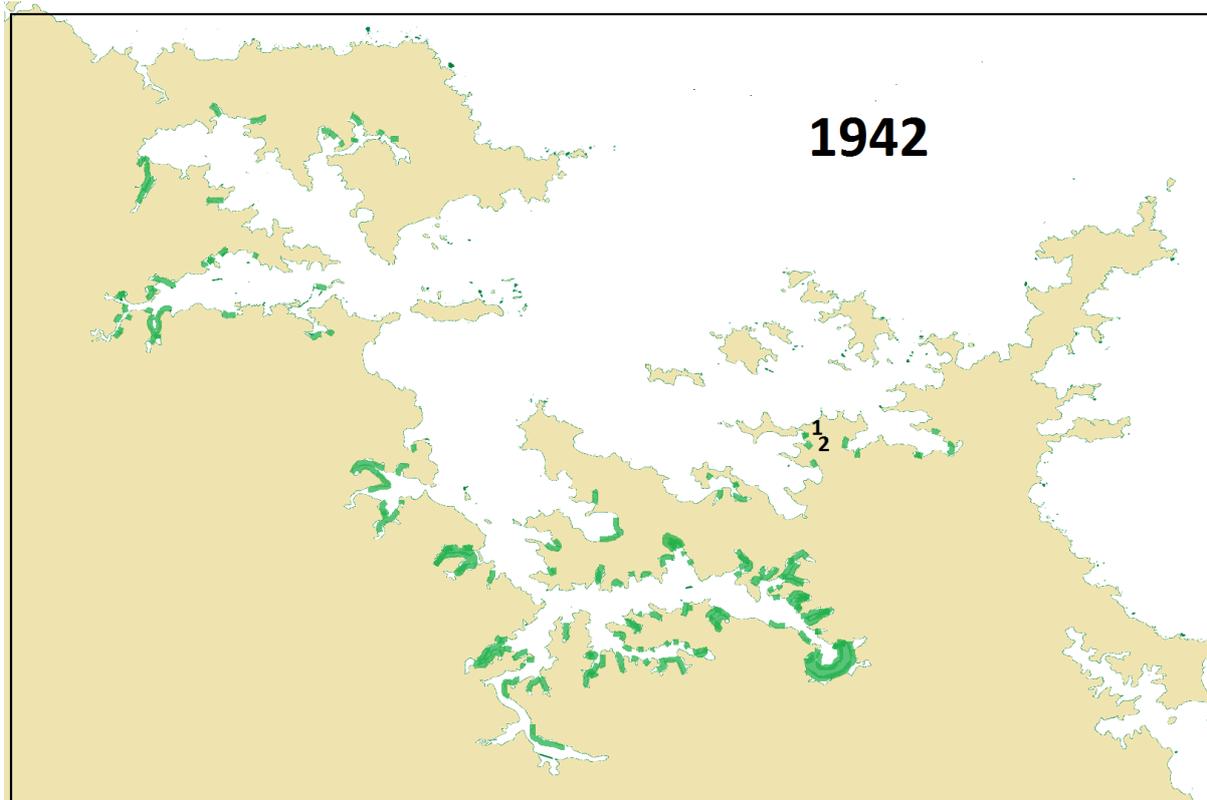
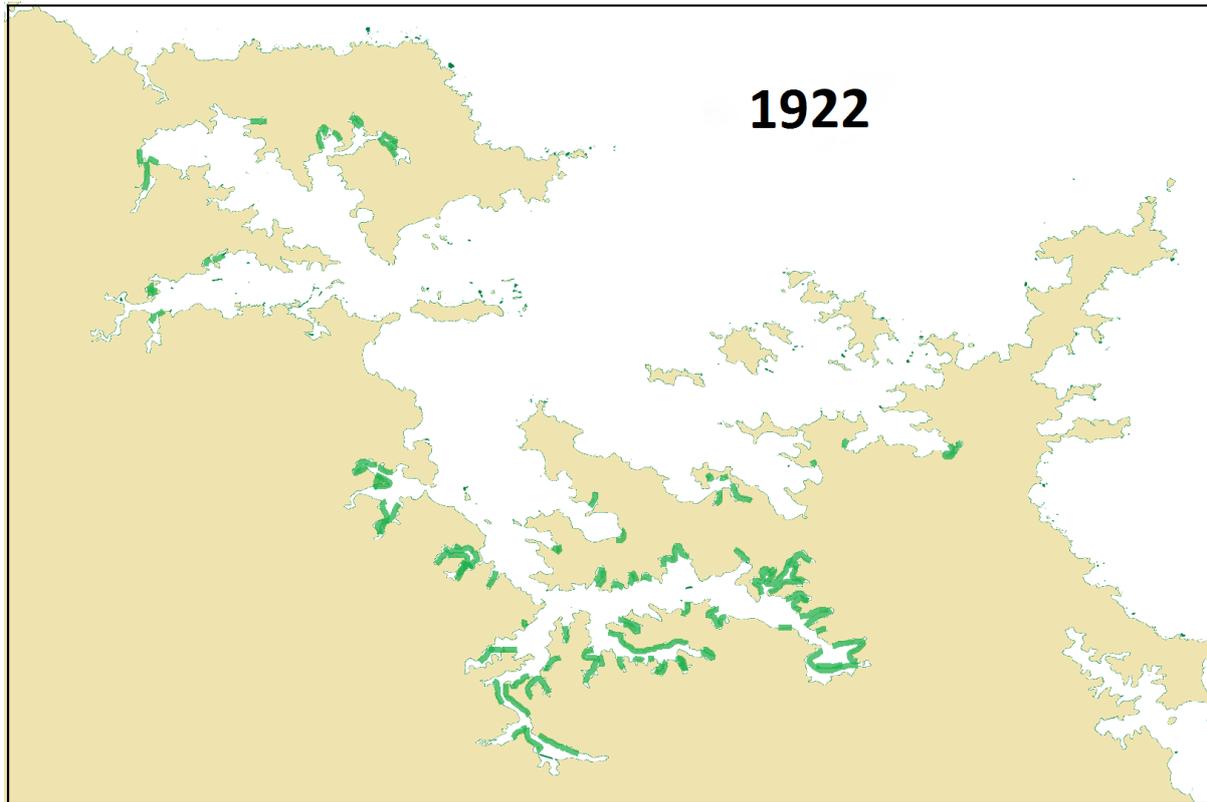


Figure S2. Presence of mangroves (green) in the Bay of Islands in the early-1900s (Ferrar and Cropp 1922) (upper) and in 1942 (Department of Lands and Survey topographical maps) (lower; omission of mangroves at sites 1 and 2 is almost certainly oversight).



Figure S3. Present distribution of mangroves in the Bay of Islands (upper, <https://www.seasketch.org/#projecthomepage/5357cfa467a68a303e1bb87a>) and changes in the main categories of mangrove cover between the early-1950s (lower, based on aerial images in Table S1) and 2009 (<https://marinedata.niwa.co.nz/bay-of-islands-coastal-survey-project/>). Dark green represents the distribution of large trees in the early-1950s (believed to essentially reflect the distribution of mangroves at first European contact – and probably much earlier); light green represents the presence of small trees in the early-1950s; pink indicates the *landward* expansion that has taken place between the early-1950s and 2009; and red is significant *alongshore* expansion between the early-1950s and 2009. Blue is appropriated ('reclaimed') mangrove habitat; black is mangrove habitat now a pond. '

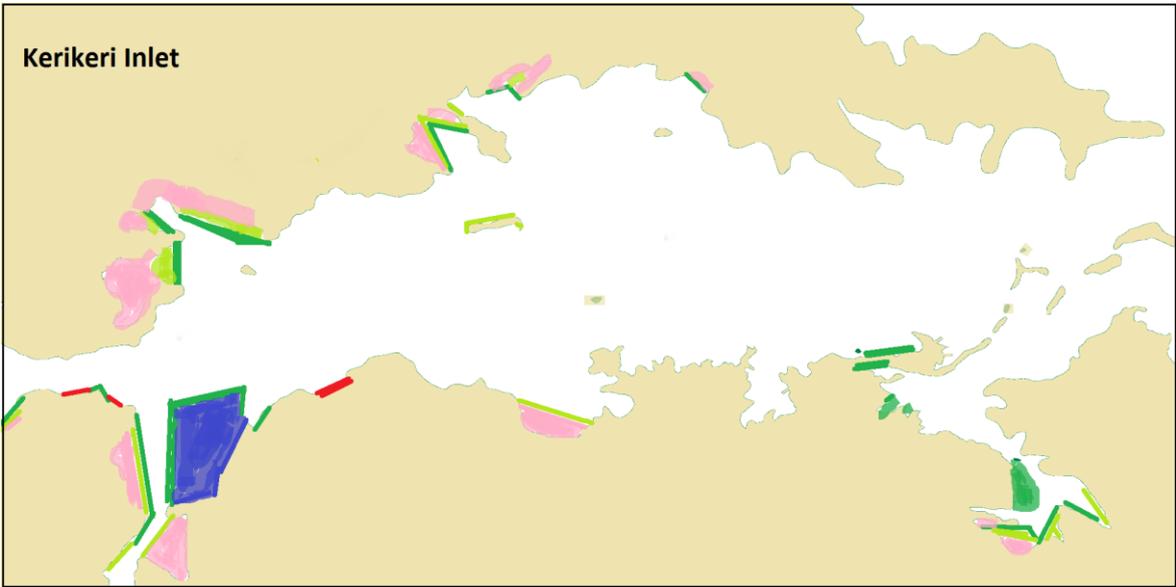
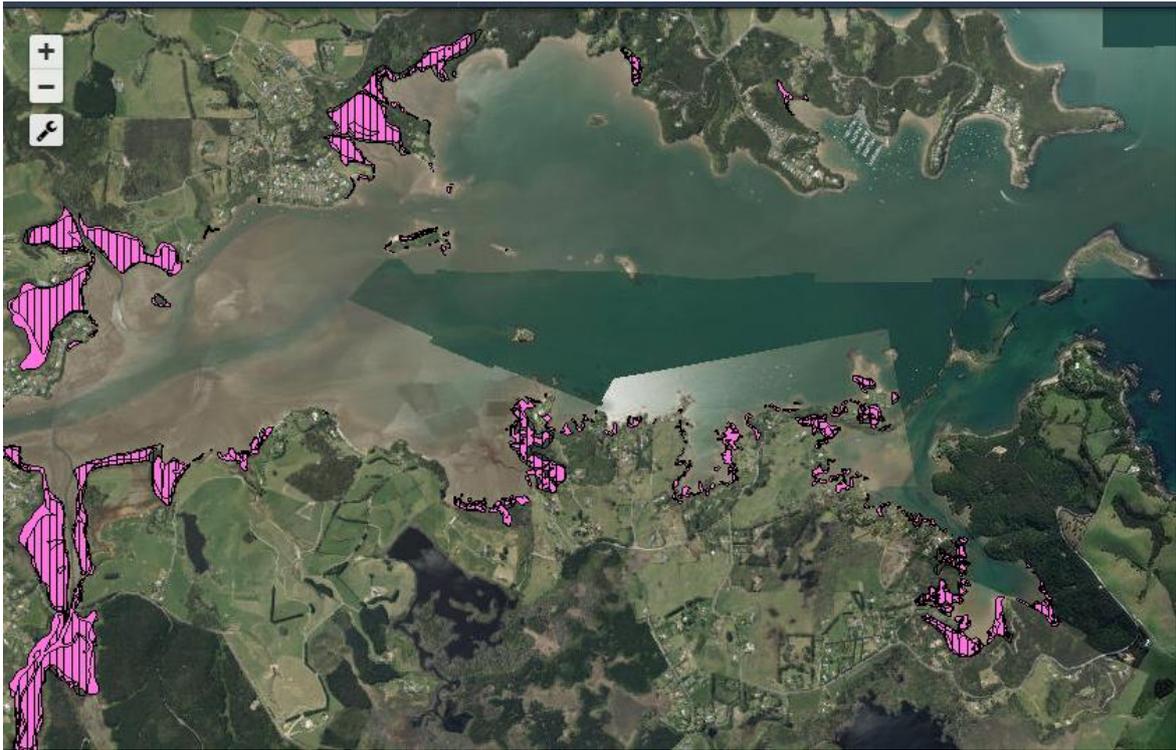


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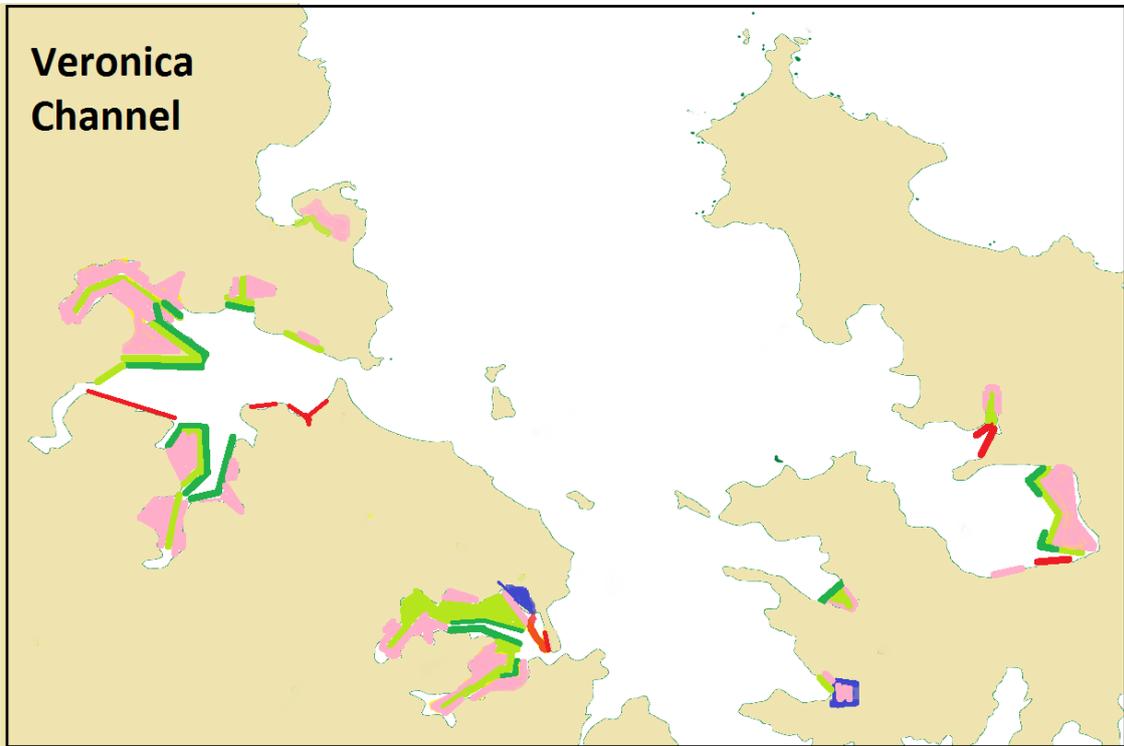
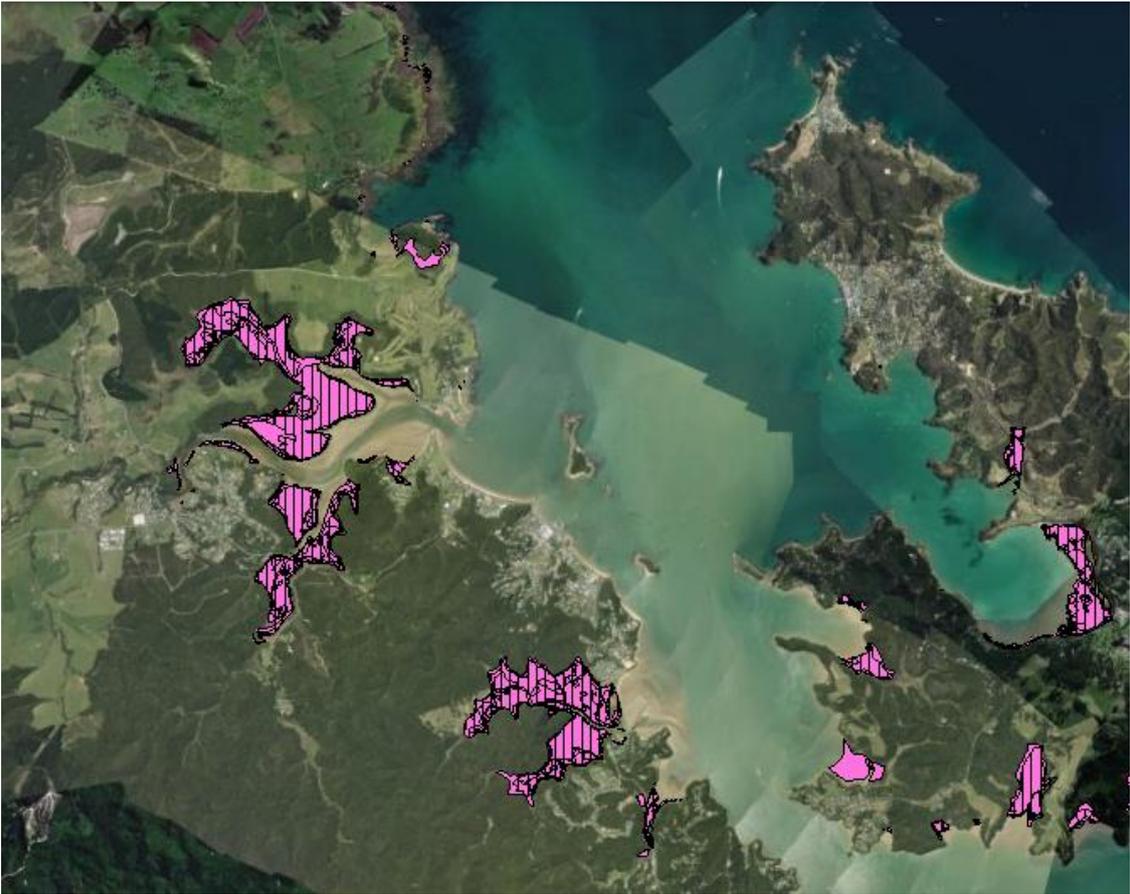


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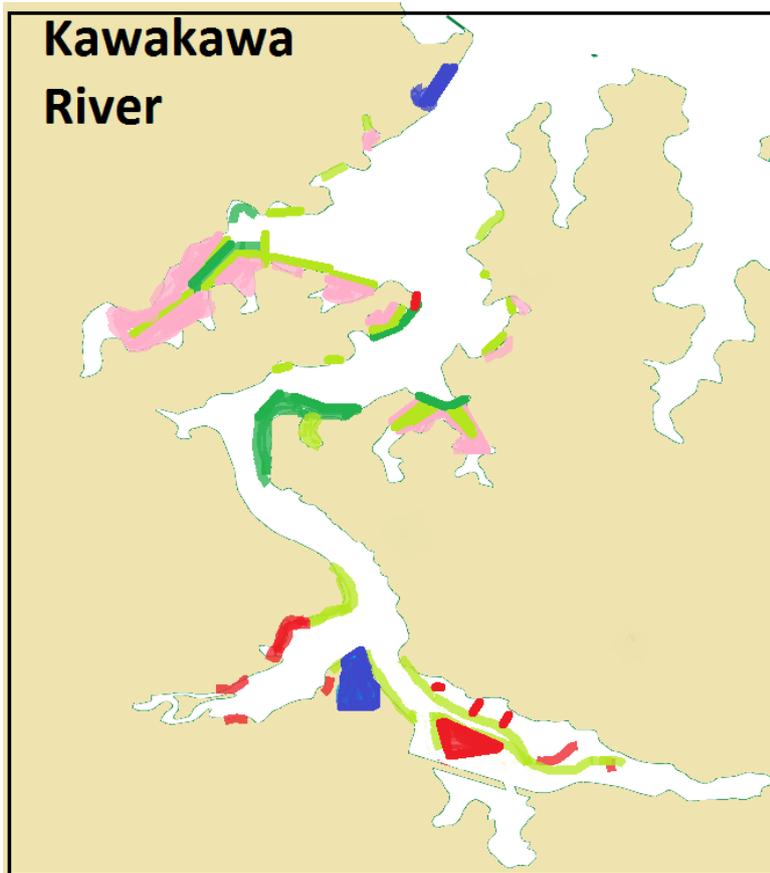
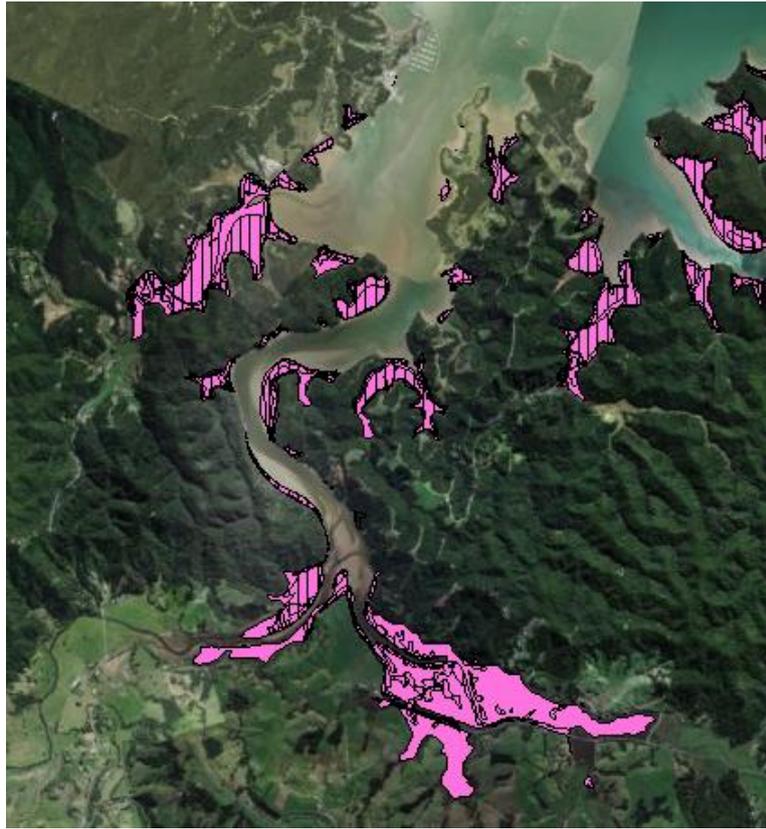


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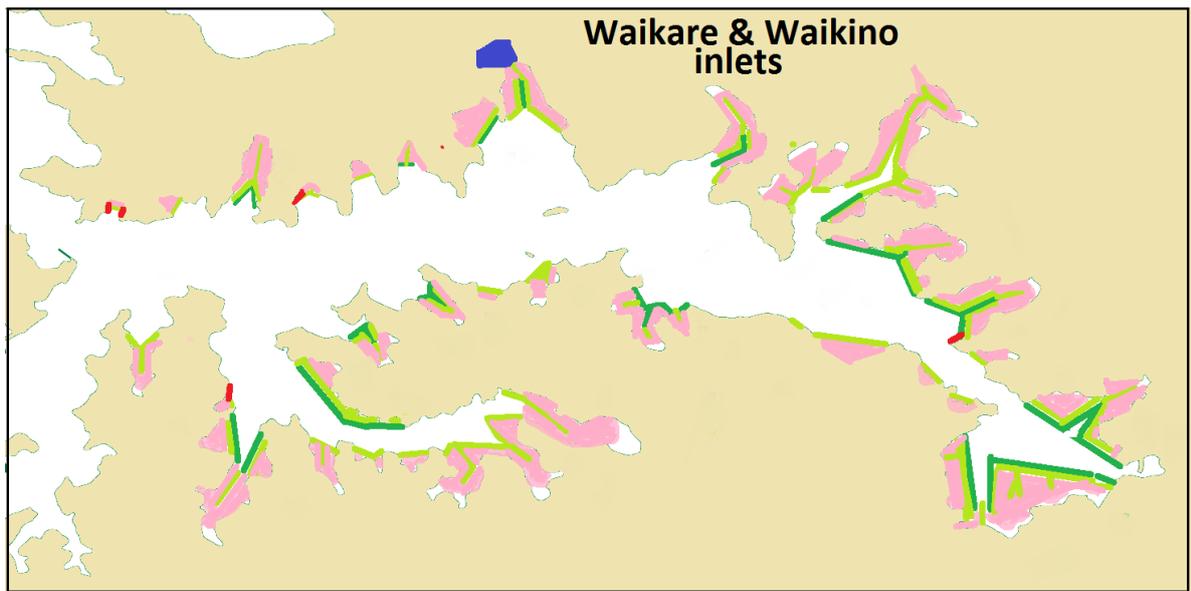
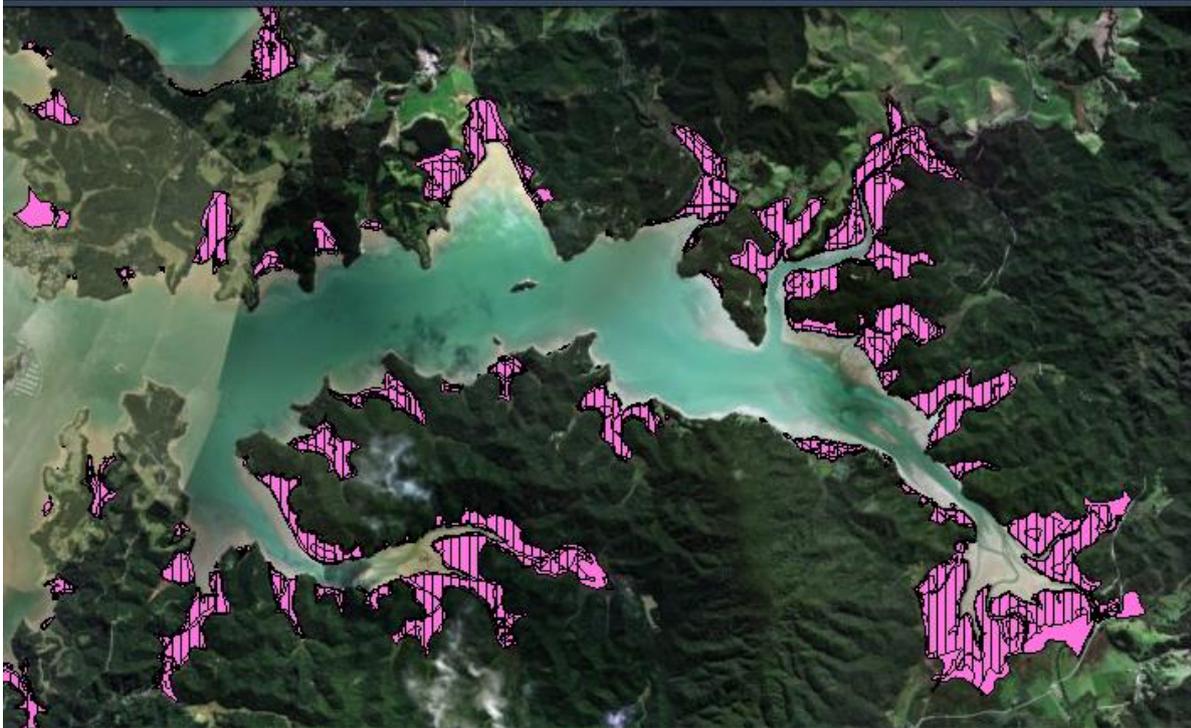


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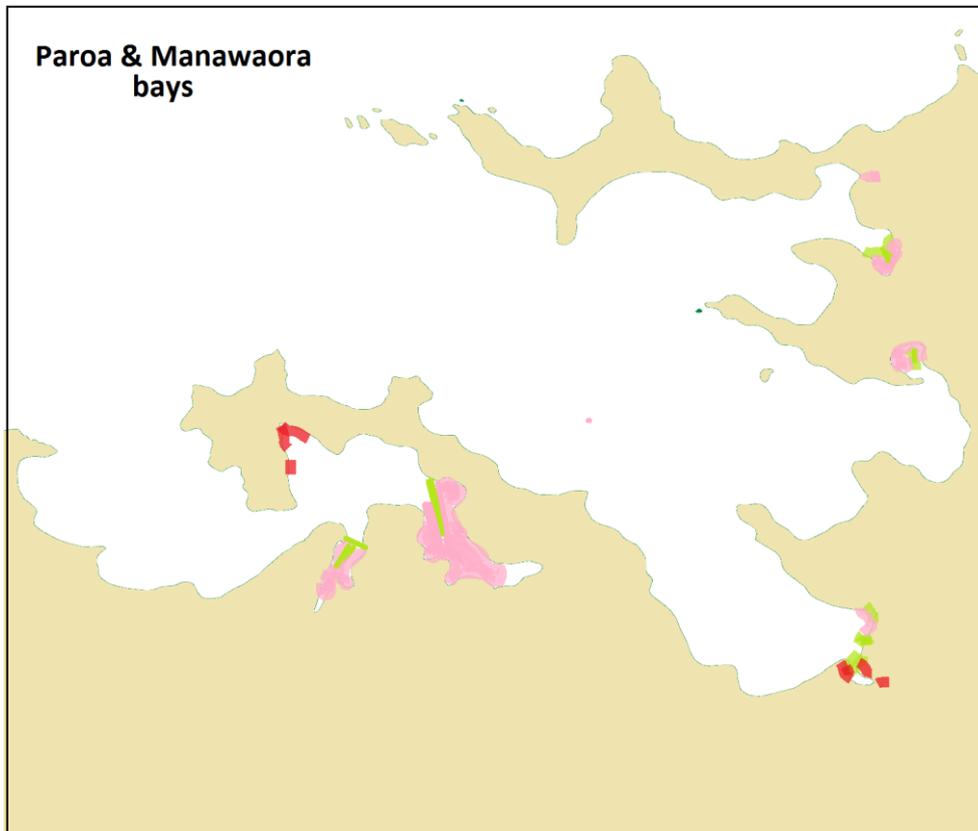


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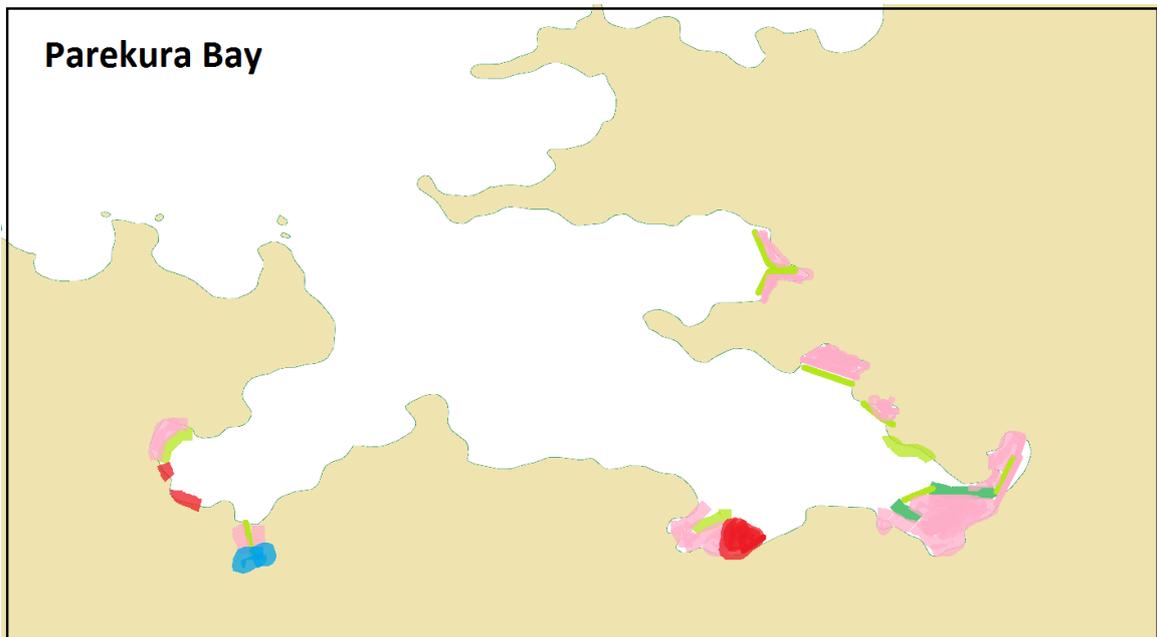


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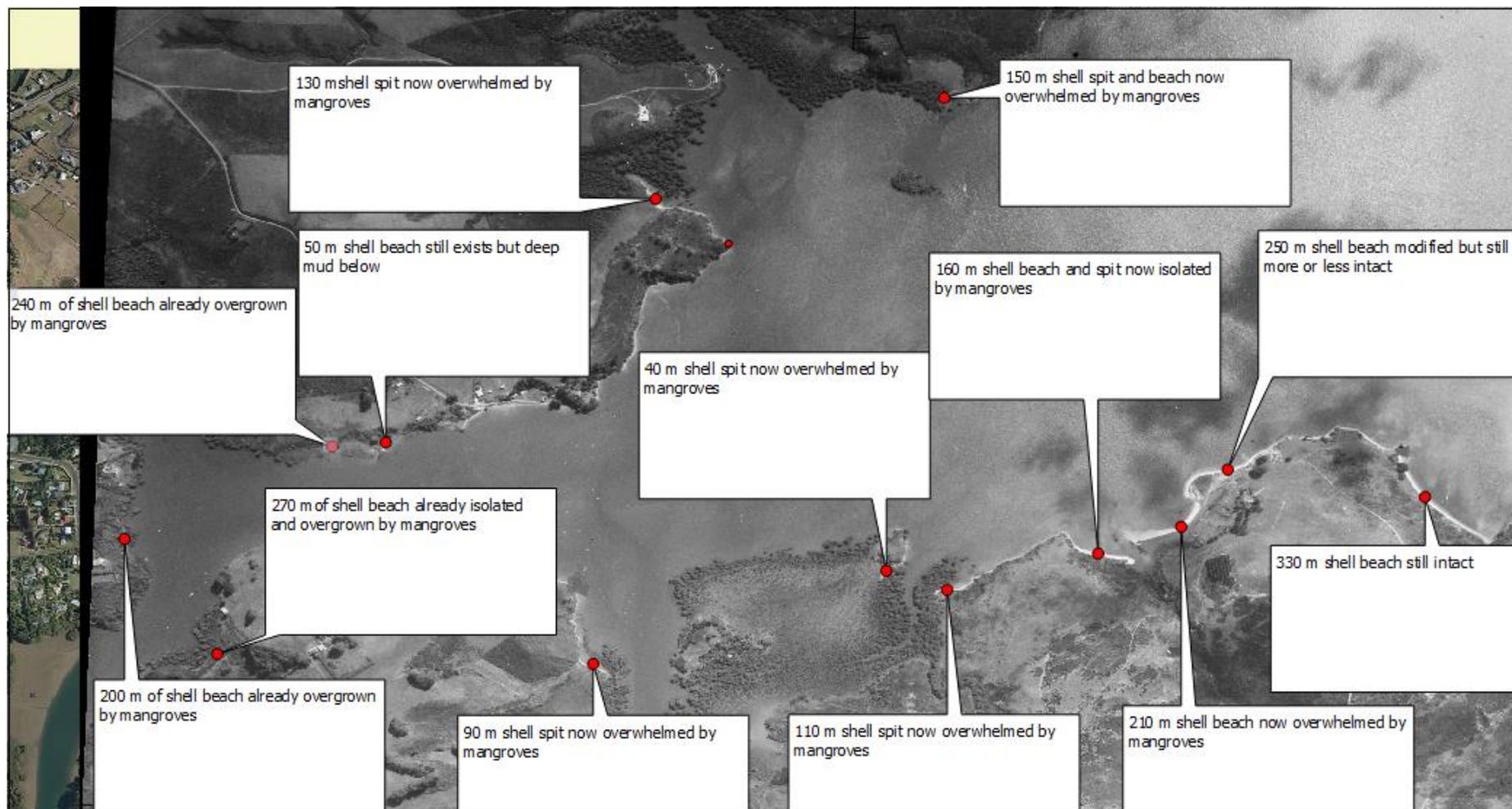


Figure S4. Many of the uppershore sand/coarse-shell beaches and spits that had, at least until the early-1900s, comprised the shores of much of the sheltered soft margins of the Bay of Islands, had by 2009 been overrun by mangroves, this 1951 example being the upper mid-Kerikeri Inlet (upper; NZ Aerial Mapping Ltd image 542-2, orthorectified over the Oceans 20/20 image [<http://www.os2020.org.nz/>]) and the lower northern mid-Kerikeri Inlet (lower; NZ Aerial Mapping Ltd orthorectified image 541-63).

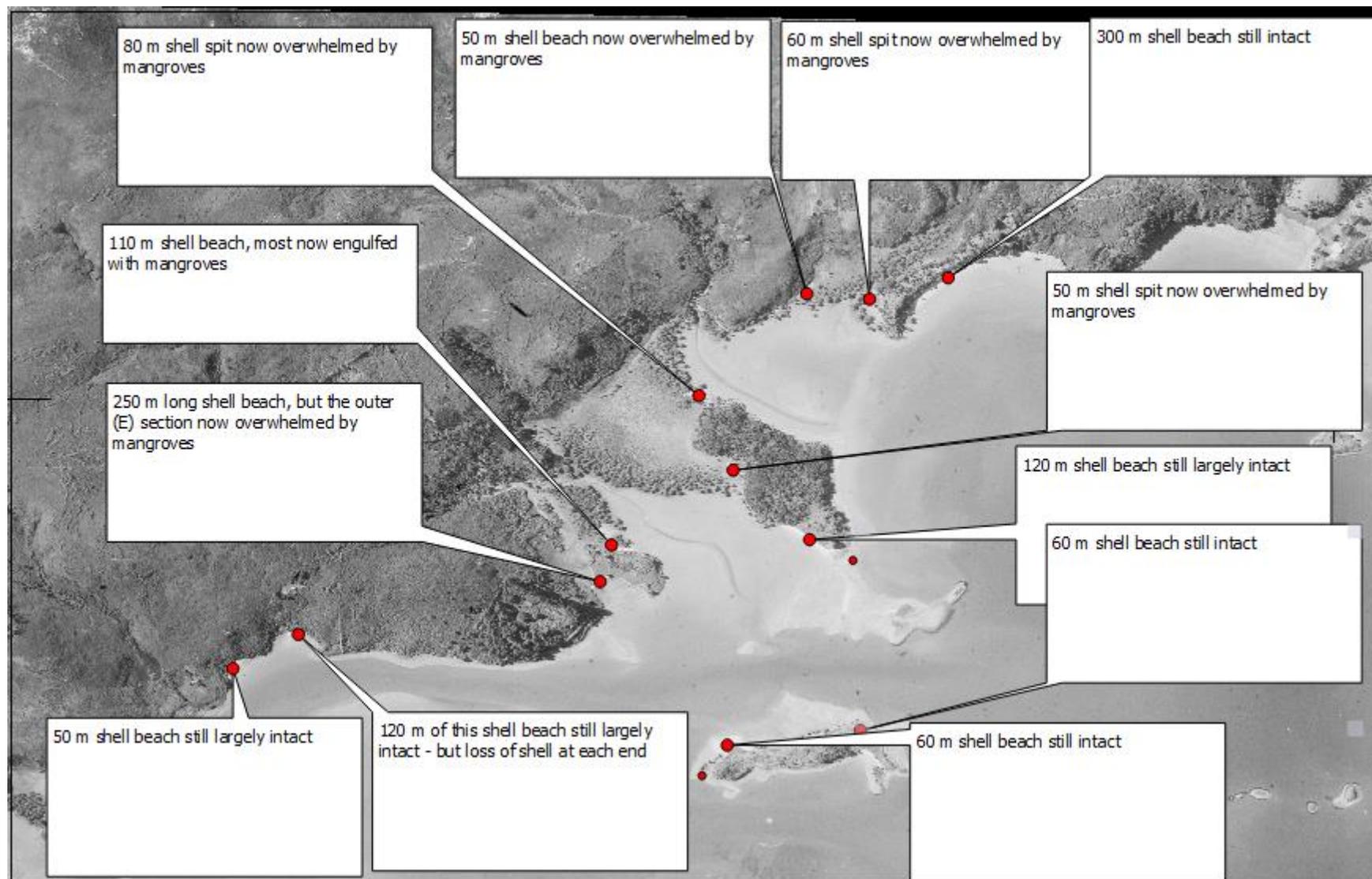


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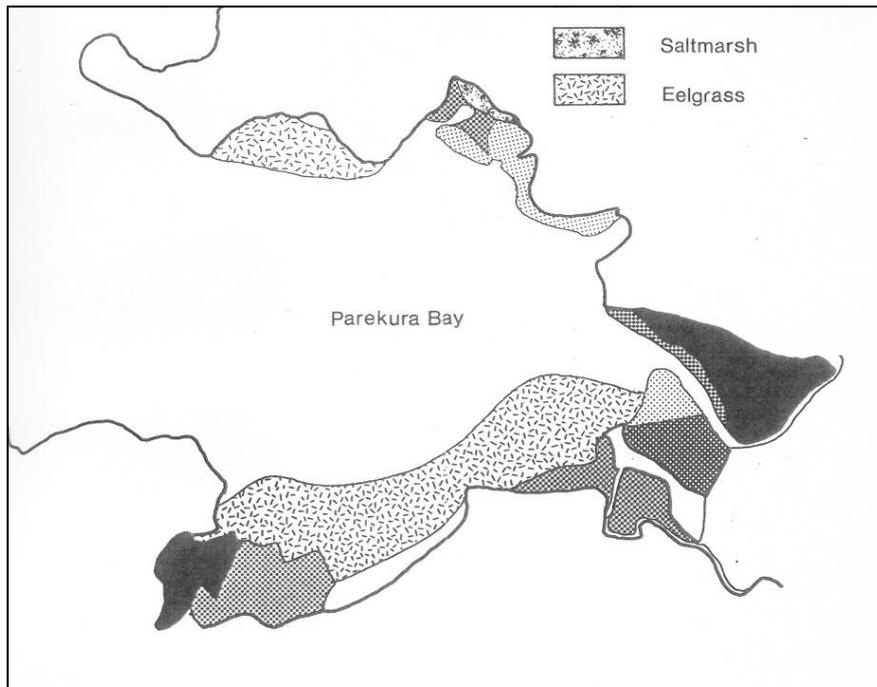


Figure S5. In 1987 these intertidal seagrass beds in Parekura Bay were the largest in the Bay of Islands (labelled eelgrass, and apparently even more extensive in previous times; shading also shows saltmarsh and mangroves) (Walls 1987). Also see <https://www.seasketch.org/#projecthomepage/5357cfa467a68a303e1bb87a>.

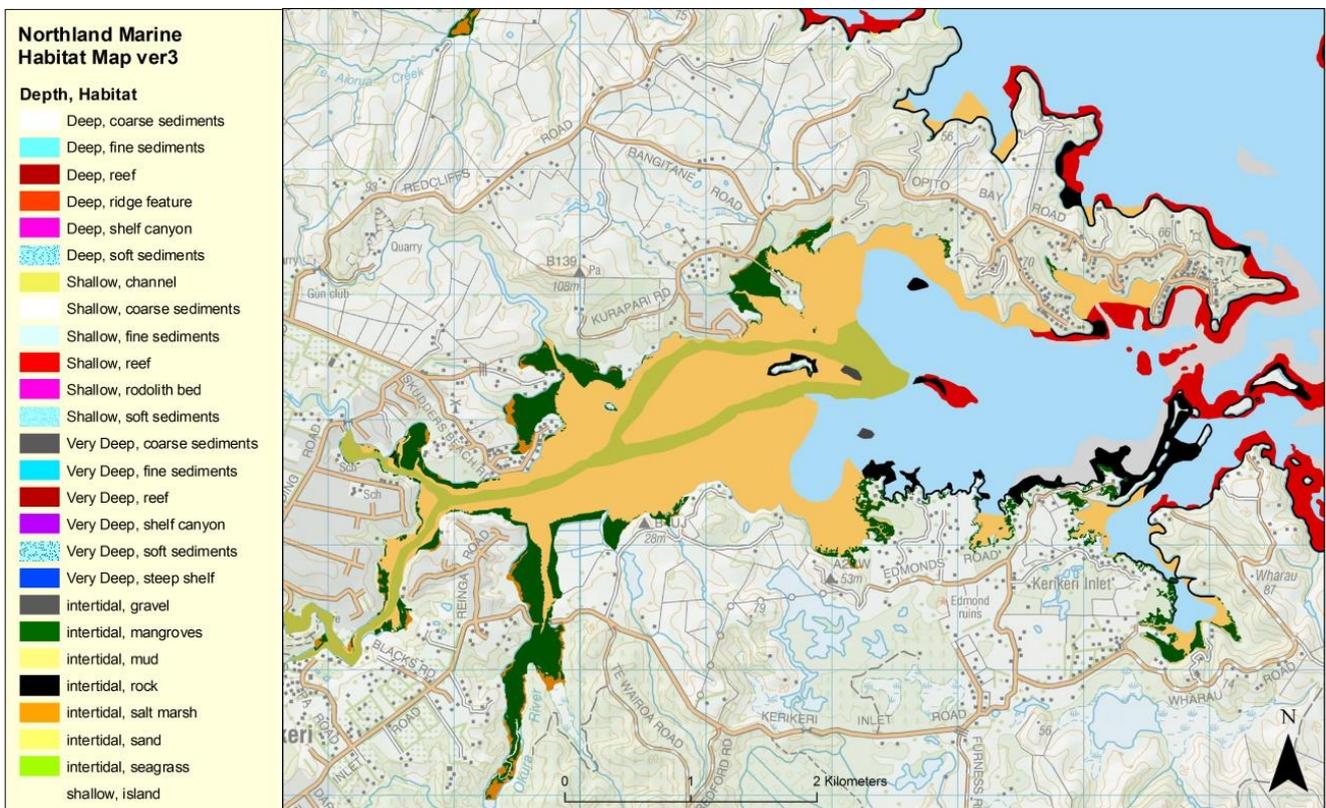


Figure S6. Kerikeri Inlet marine habitats (Vince Kerr, Kerr & Associates, Kamo, pers. comm., 2019).

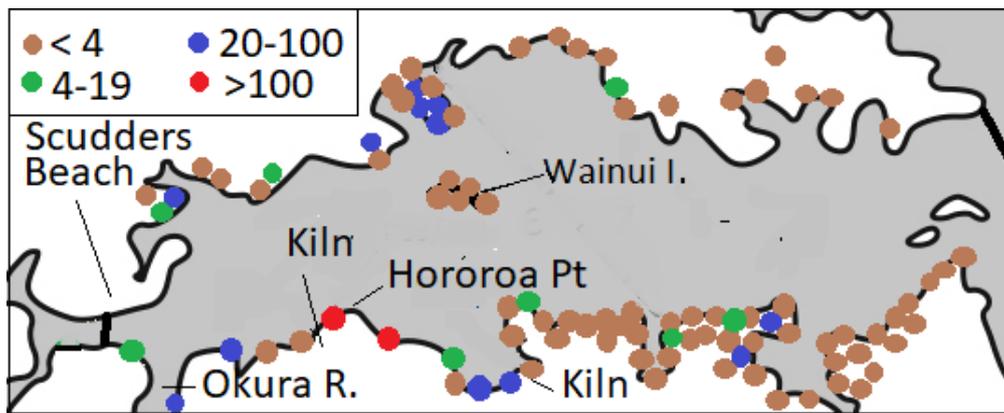


Figure S7. Indicative distribution and volume (minimum m³, assuming 1-m width and 0.2-m depth for each metre-length) of middens in Kerikeri Inlet from archaeological Site Record Forms.

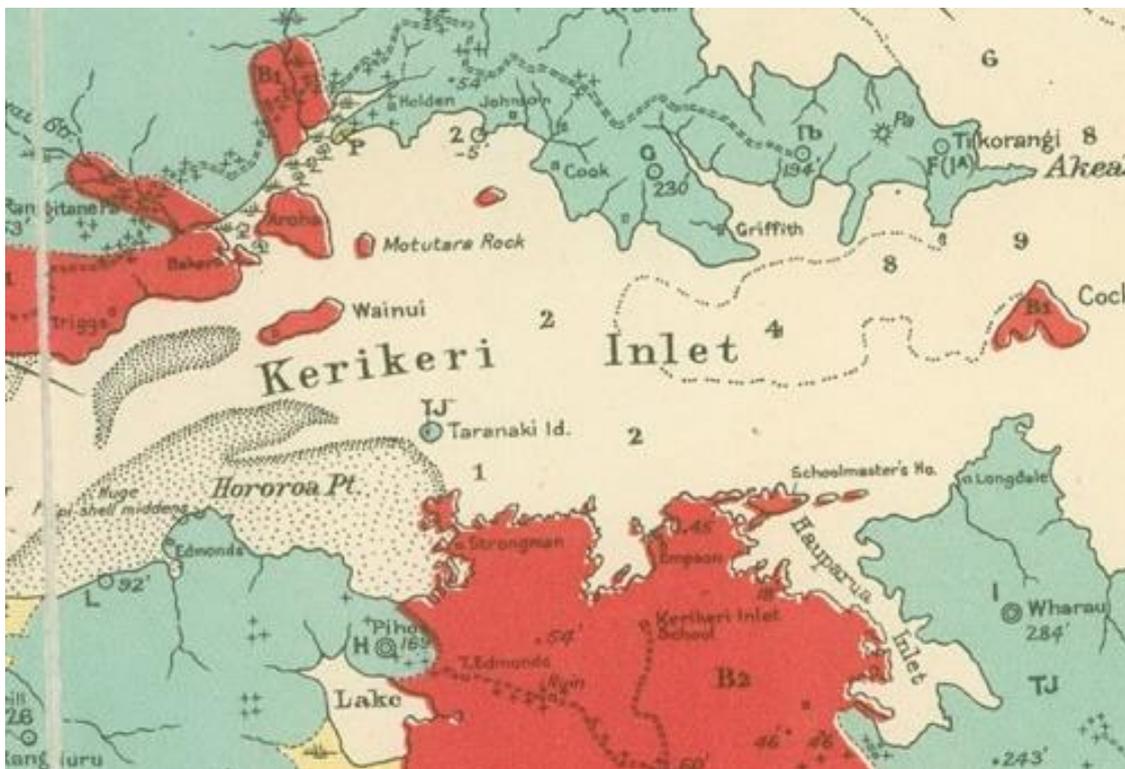


Figure S8. 1922 geological map of mid- and lower-Kerikeri Inlet (Ferrar and Cropp 1922). Note the similar form of the intertidal flats to today, and reference to middens at Hororoa Point; the tree-like symbols represent mangroves.



Figure S9. The exposed face of this remnant of cockle midden P05/464 was at least 6 m high in 2019. The other main shellfish seen was an occasional pipi *Paphies australis*.

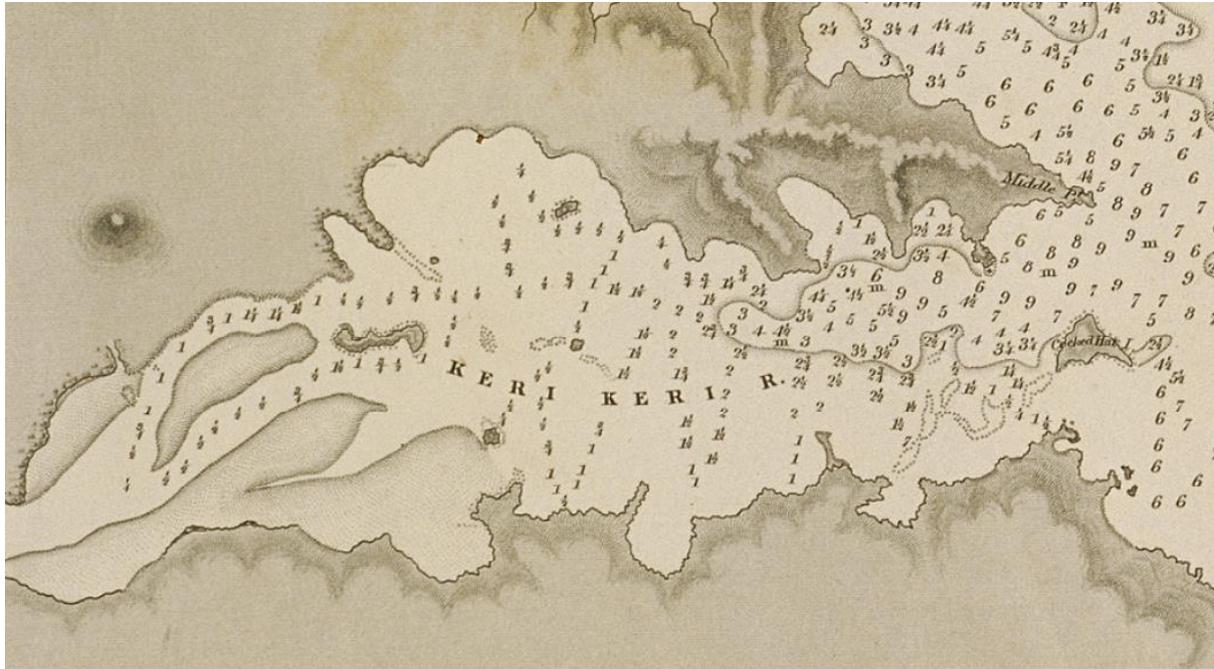


Figure S10. *Acheron's* 1849 chart of Kerikeri Inlet (depths in fathoms) (Stokes 1849) shows a similar geomorphology to today.

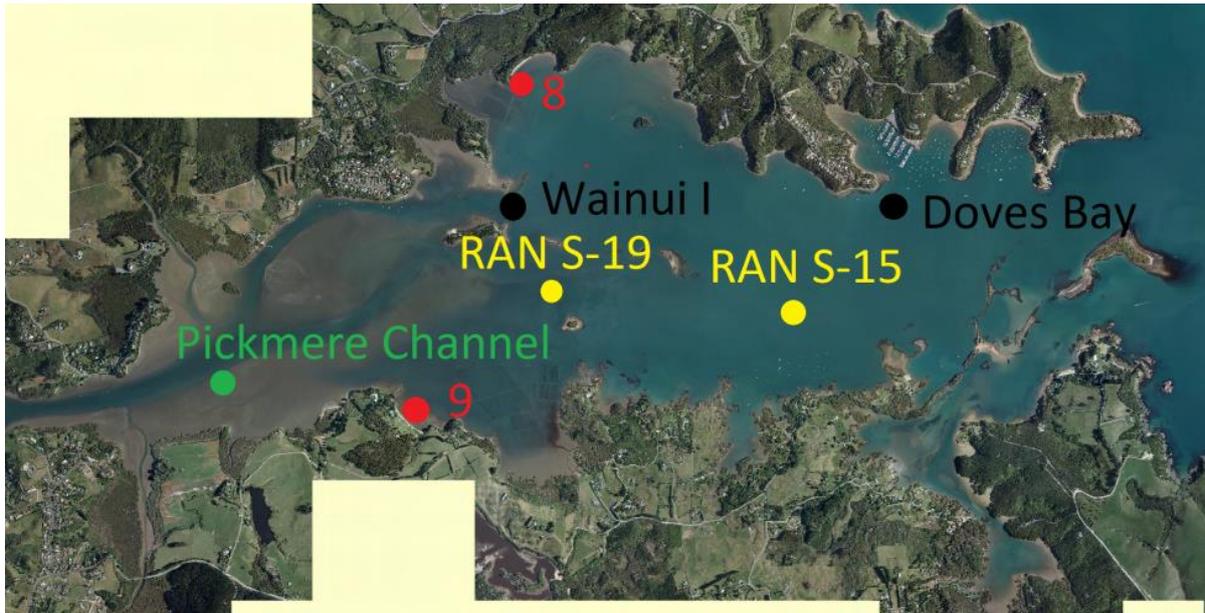


Figure S11. Recent surface benthic grain-size determinations for mid-Kerikeri Inlet. 1) Green dot, Northland Regional Council sampling site 2008–10; (43–46% <math><63\ \mu\text{m}</math>; Griffiths 2011); 2) Yellow dots, Ocean Survey 2020 (2009) RAN S-19 (15.9% mud) and RAN S-15 (48.1% mud) (Swales et al. 2012); 3) Red dots, Ocean Survey 2020 Sites 8 and 9 (Hewitt et al. 2010), with significant proportions of mud and fine sand; and 4) Black dots, Northland Regional Council sampling sites 2012–16 (~75% mud [$<63\ \mu\text{m}</math>], the remainder fine sand; Griffiths 2014; Bamford 2016). Marine chart NZ 5124 indicates widespread fine-mud and fine-sand substrates in this region.$

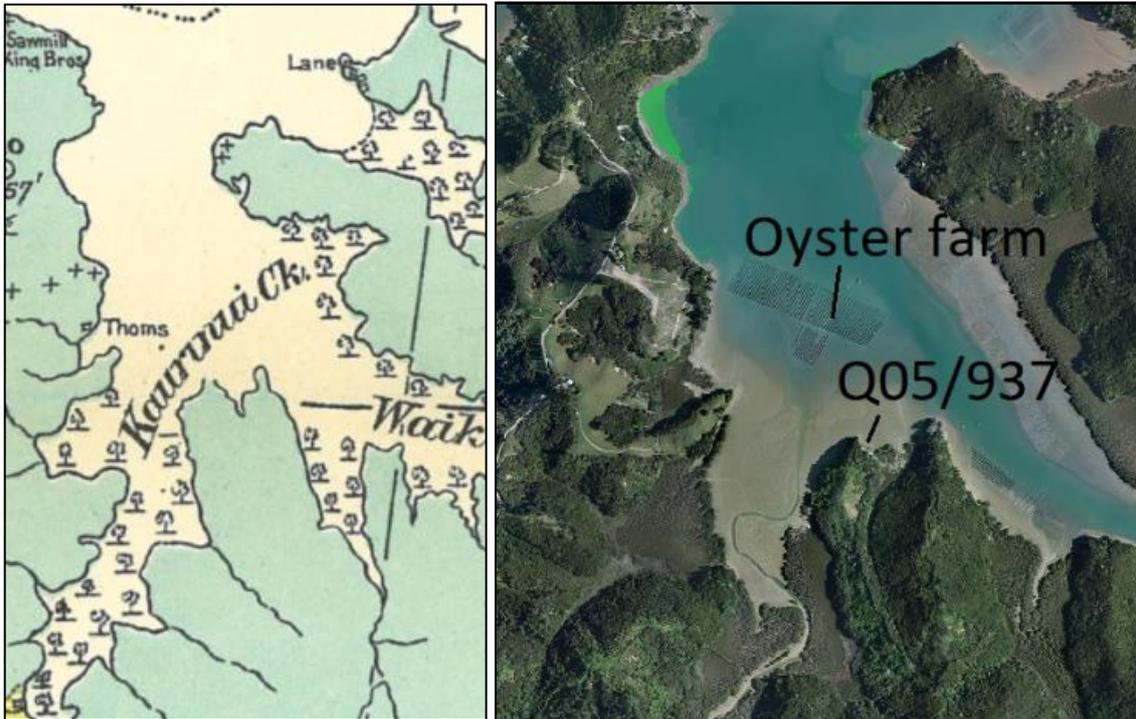


Figure S12. Mangroves were well established in Waikino Creek by 1922 (upper left, Ferrar and Cropp), and have since spread shoreward, most areas having, in turn, becoming heavily sedimented (upper right; current [low-density] cockle beds indicated in green). Waikino cockle midden Q05/937, comprised mainly of large (30–55 mm), opened cockles, was still 3.5-m high in places, after (presumably several) years of mining (Turner 2006) (lower).

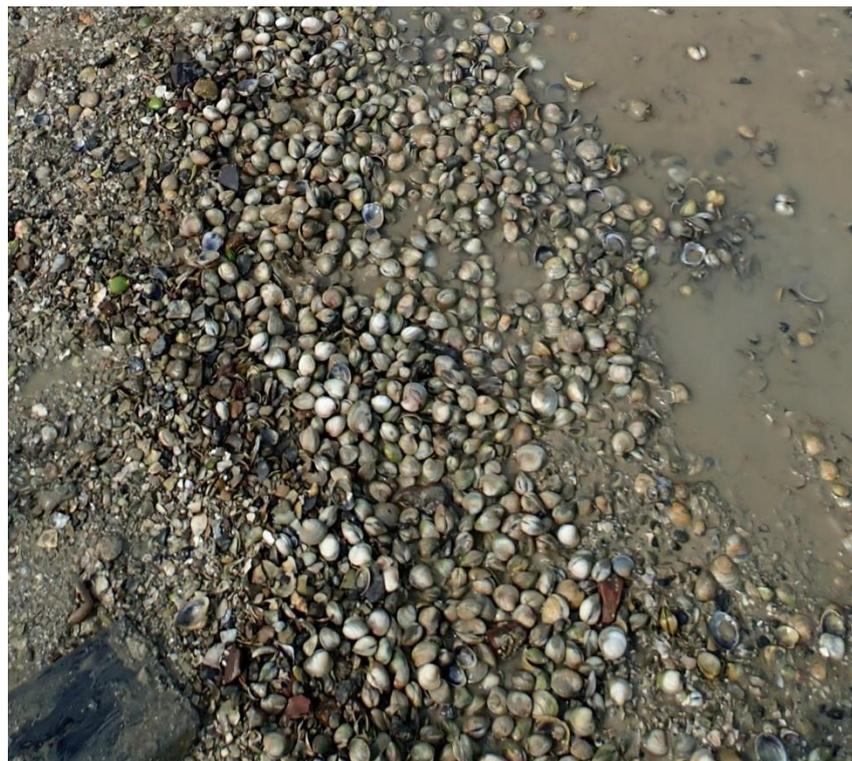
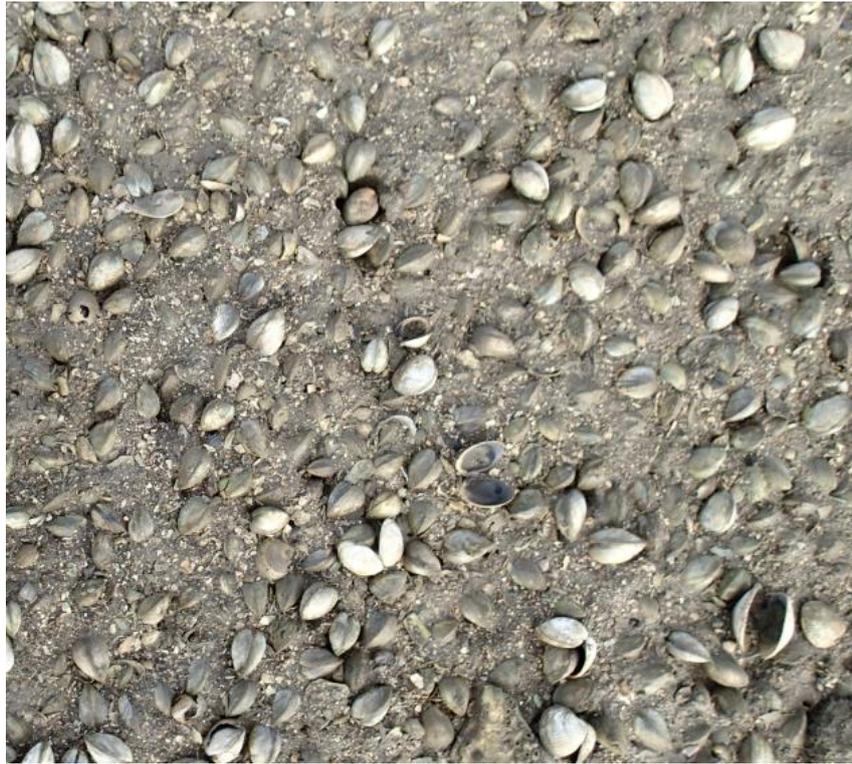


Figure S13. High proportions of Middle Bank (Hororoa) cockles (mainly 25–30 mm), under normal river-flow conditions in 2019, were partly or fully exposed at the surface, rather than completely buried; although those buried are dense, by no means is all space taken (upper). Low ridges of live but unburied cockles, first observed in early December 2019, were still alive – although less numerous - in late-February 2020 on the (apparently unnamed) beach 1 km south of Te Haumi (lower); there had not been any storm or other relevant weather immediately before or during. (Photos: author)



Figure S14. Innumerable recently-dead 30–35-mm cockles on intertidal Whiorau Bay (part of Parekura Bay) in May 2014 produced foul odours for days. (Photo: author)

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