HCL
Hume Consulting Ltd

Memo

From	**Dr Terry Hume, Managing Director, Hume Consulting Ltd**
To	Owen Burn, Green Group Ltd
CC	Andrew Johnson, Johnson Brothers Ltd
Date	1 May 2024
Subject	**Rangaunu sand extraction**
File path *(right click to update)*	*C:\Users\Terry\OneDrive\Documents\All files - master list - VALUABLE\Hume Consulting Ltd\Rangaunu sand extraction\HCL memo Rangaunu sand extraction v5.docx*

Summary

From a coastal physical processes (not ecological) perspective, and on the limited information available, the outer edge of the Rangaunu ebb tidal delta has desirable characteristics and is potentially a good site for sand extraction for aggregate because:

- There is a large volume of sand at the site (49,200,000 m^3) compared with the proposed one-off sand take of 60,000 m^3 per year (which equates to 0.12% of the total volume and a layer 7 cm thick over the proposed extraction site).
- Depending on the further analyses the sand is likely to be of suitable size grade and clean.
- Given the thin layer of extraction (maximum cut depth 300 mm) the effects on adjacent shores are expected to be minimal and short term. Wave and tidal action at the site will quickly infill any of the dredge cuts and minimise alteration in the patterns of waves and longshore wave energy gradients at the shoreline and therefore patterns of erosion and accretion along the shore.

Important matters requiring further assessment are:

- Matching the particle size of the sediment dredged from the extraction area with that of the nourishment site to meet requirements for aggregate.
- Determining the rate of replenishment of sand from natural processes such as longshore transport.
- Giving consideration to a monitoring scheme.

Introduction

Johnson Brothers Ltd are exploring the possibility of extracting sand from the seabed surface of the ebb tidal delta outside the entrance to Rangaunu Harbour, Northland for the purpose of construction aggregate. Hume Consulting Ltd (HCL) was approached by Owen Burn of Green Group Limited to provide an initial consideration of coastal physical processes (not ecological) aspects of the proposed project.

This memo provides a preliminary desktop assessment based on technical information sourced from technical reports, science papers and charts and the writer's involvement in offshore sand extraction projects in the Pakiri-Mangawhai nearshore, Kaipara Harbour entrance and South Taranaki Bight. It identifies several matters where further assessment is required.

The writer is familiar with the extraction site having walked the beaches adjacent to the inlet and travelled out over the bar (while fishing). He visited the Paihia nourishment site in January 2020 as part of coastal hazard mapping assessment by Tonkin & Taylor.

Physical setting and ebb delta processes

The Rangaunu ebb tidal delta is a large shoal of sand at the tidal inlet of the Rangaunu Harbour on the east coast of Northland (Figure 1). Tidal inlet processes and sand storage at tidal inlets are well understood from a conceptual viewpoint, both internationally and for New Zealand situations (Hume and Herdendorf 1988, 1992 and 1993; Hume 2003 and Hicks and Hume 1996). The sedimentology and tidal processes for Rangaunu inlet have been described by Pickrill (1985).

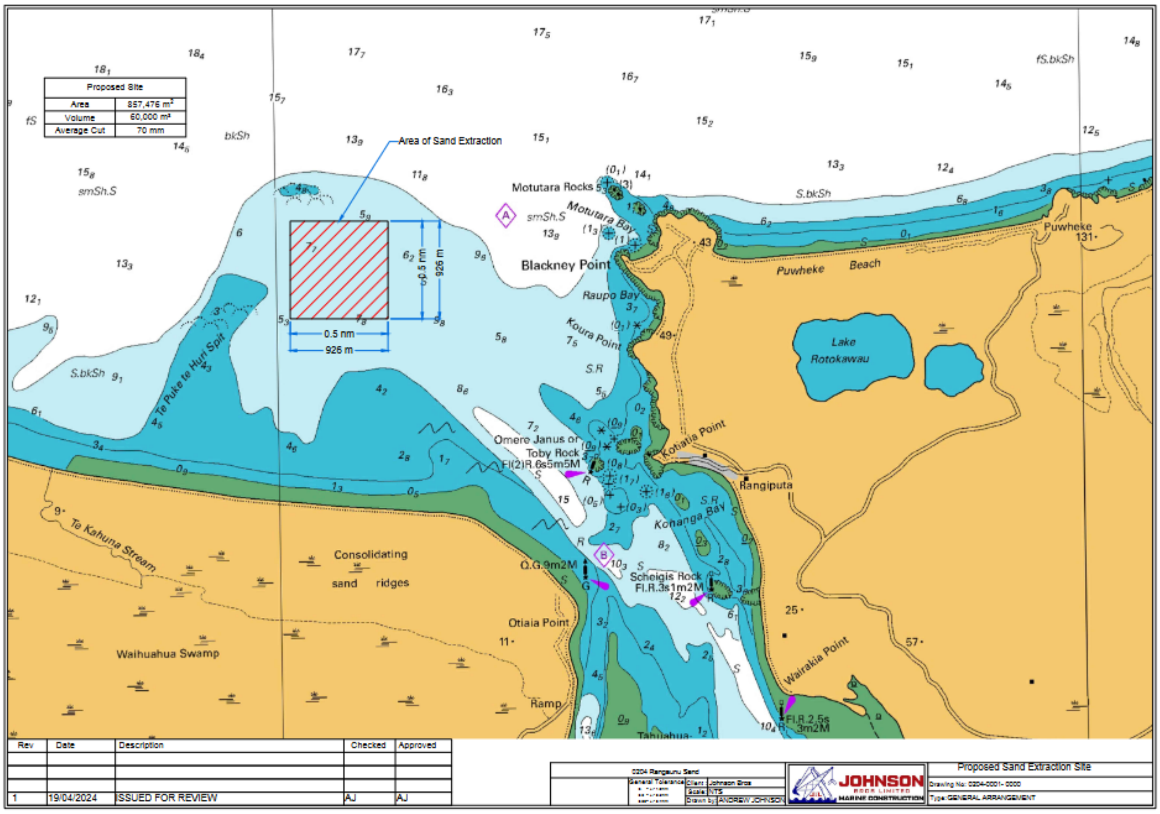

Figure 1. Entrance to Rangaunu Harbour showing the proposed area of sand extraction (hatched box) on the seaward edge of the ebb tidal delta (Chart NZ 5113 Rangaunu Bay and Awanui River Approaches).

<u>Conceptual model of a tidal inlet</u>

Tidal inlets are situated at the entrances to estuaries on sandy shores. There are three main components to a tidal inlet: 1) the throat which is a narrow deep channel between the shores where strong currents flow back and forth, 2) the flood tidal delta which forms a sand shoal inside the inlet and 3) the ebb tidal delta formed by sandy shoals in the bay outside the entrance. The cross-sectional area of the throat is directly related to the tidal prism (the amount of water flowing in and out of the tide) (Hume and Herdendorf 1992 and 1993).

In general terms the major driving force of sand transfers in inlet systems is tidal currents with waves playing a lesser role. Sand movements are connected throughout the tidal inlet in the following manner. Sand is fed to the delta mostly by longshore transport. During storms waves entrain sand on the seabed of the ebb delta and adjacent beaches and the incoming (flood) tide carries it into the inlet where is deposited on the flood tide delta just inside the entrance.

On the outgoing (ebb) tide sand exits the throat and is redeposited on the ebb delta. The important point here is that in this system of circulating sand transfers between the inlet shoals and adjacent shores activity such as sand extraction operations in one part of the tidal inlet may affect sand transfers in another part of the system (including adjacent beaches), depending on the relative scale of extraction operations.

Sediments

Pickrill (1985) described sediments on the Rangaunu ebb delta as follows. The ebb channel is armoured with a lag deposit of comminuted shell gravel (70%) set in a matrix of poorly sorted, medium-coarse sand. The inner delta platform is covered with fine sand (fine sand range 0.125 to 0.25mm) and devoid of large-scale bedforms but small (<30 cm wavelength) symmetrical straight-crested ripples oriented to the swell direction from the north. Beyond the 4 m isobath, the delta platform has a complex sediment and bedform distribution. It comprises fine sand with megarippled linear furrows, 10-30 m wide, up to 800 m long, tending perpendicular to the shore, and lined with coarser sediments than the surrounding platform. Seawards of the delta front, the sea floor slopes gently seaward and is mantled with well-sorted shelly sand free of large-scale bedforms. Schofield (1970, Table 5) reported the physical characteristics of sands on the beaches and foredunes at the heads of Rangaunu Harbour as being of grain size averaging 0.21 mm (cf. fine sand range 0.125 to 0.25 mm) and comprising mostly quartz (86.9%) with some feldspar (12.1%) and traces of mafics (dark) minerals (0.45%) and residue (0.35%).

Flow and sediment transport patterns

Pickrill (1985) described most sediment transport on the ebb delta as being confined to channel-margin megaripple fields moving sand seaward onto the seaward margin terminal lobe of the delta. Wave and tidal forces interact to direct sediment landward from the lobe in anticlockwise gyres, generating recurved bars and furrows on the delta platform and feeding sediment to Te Puke te Huri (subtidal) Spit around the outer face of the delta. Flood tides and shoaling waves return this sediment to the shoreface and back to the harbour mouth. Flood flow is concentrated in a marginal channel on the eastern side of the delta; wave reinforced flood flows transport sediment landward in sand ribbons from the floor of Rangaunu Bay into the harbour.

Sand storage

Tidal deltas are major sinks of sand along the coast of New Zealand's North Island. Hicks and Hume (1996) described the sand volumes and morphologies of 17 ebb tidal deltas off natural inlets on the New Zealand North Island coast identifying four basic ebb-delta forms. Rangaunu was identified as a ‘Type II Constricted’ ebb delta, being longshore-elongated, of reasonably symmetrical 'batwing'-shape, but with the eastern rocky headland constraining growth of the eastern arm of the delta thereby preventing development of a 'free' form. The primary factors appearing to control the shape (morphology) of ebb deltas are volume of tidal outflow, shoreline configuration, and to a lesser extent wave energy. At Rangaunu the relatively low wave energy on the coast allows the ebb delta to grow seawards (rather than being flattened against the shoreline). The bedrock on the eastern headland shore at Rangaunu influences both the location of the inlet (many New Zealand inlets lie against rocky headlands) and the configuration of the adjacent sandy shoreline and to a degree the orientation of the main ebb channel. Hicks and Hume (1996) found that the major controls on ebb delta sand volume are primarily the volume of the tidal prism (134 X 10^6 m^3 at Rangaunu) and secondarily the angle of inlet outflow with respect to the shoreline (42 degrees relative to adjacent shore for Rangaunu). Delta volume also appears to increase with decreasing wave energy. The volume of sand contained in the Rangaunu ebb delta was estimated as being 49.2 x 10^6 m^3 (Hicks and Hume 1996 Table 1).

Sand replenishment

Comparing sounding records Pickrill (1985) calculated that the average annual rate of sediment accumulation on the ebb delta between 1958 and 1979 was 404,000 m^3/year. However, Pickrill had

strong reservations about the accuracy and large size of this number given that the sediment inputs from the Awanui River are very small (and muddy) and that East Beach has formed at the head of Rangaunu Bay, and net littoral drift is probably negligible, a conclusion supported by the maintenance of geographically separate coastal sand facies on the east coast of the Northland peninsula (Schofield 1970). Hicks and Hume (1996) estimated the littoral drift to be of the order of 20,000 m^3/year.

Proposed extraction and site suitability

The project proposes a take of 60,000 m^3 per year of sand to be dredged from the seabed in about 6 to 8 m water depth (below chart datum) at the seaward edge of the ebb tidal delta. Dredging would be undertaken by a 'cutter suction type' process with a maximum cut depth of 300 mm over an area of 857,476 m^2 (926 m x 926 m).

Considerations to determine if a site is suitable for extraction from a coastal physical processes point of view include:

- Suitability of sand characteristics for construction aggregate.
- Volume of sand at the extraction site.
- Rate of replenishment of sand from natural processes (river inputs, littoral drift).
- Effects on adjacent shores.

Sand volumes and sustainability

Ebb tidal deltas represent a potentially huge reservoir of sand for industry and beach renourishment providing environmental and sustainability considerations can be met. In the absence of detail site specific coastal processes information an estimate of the amount of sand in storage at an ebb delta is probably the best indicator of the amount of sand that can be extracted safely from it before the stability of the adjacent shoreline is compromised by interrupted sand by-passing and diminished wave shelter.

At Rangaunu there is a large volume of sand at the site (49,200,000 m^3) compared with the proposed take of 60,000 m^3 per year which equates to 0.12% of the total sand volume and effectively evens out at a layer 7 cm thick over the proposed extraction site.

Potential effects on adjacent shores

Depressions in the seabed, such as those caused by pits dug in the seabed by sand extraction, can potentially affect incoming waves by refraction (bending the wave path) and diffraction (lateral dispersion of wave energy) and locally by shoaling (changing the wave height) them as they pass over the modified seabed. Any such changes in the wave field at the extraction site will be propagated shoreward, leading to changes in wave conditions nearshore and at the beach. Extracting sand from the seabed can also alter the patterns of sand transport across the inner shelf seabed and potentially reduce the supply of sand to the nearshore and beaches. Changes to the nearshore wave climate and sand supplies can potentially cause changes in shoreline processes (erosion and accretion) inshore of the operations affecting natural landforms and geomorphic character and public access to the marine environment.

The magnitude of the changes will depend on the scale of the operations. The plan at Rangaunu is to extract sand to only a shallow depth (maximum cut depth would be 300 mm). This is probably similar in height to some of the naturally occurring bedforms, depressions and bumps on the delta surface. As a consequence, the effect of the dredge cuts on the waves and currents will be minimal. Furthermore, it is anticipated that because sand transport at the site is very energetic, that any pits will be rapidly infilled (in weeks to months depending on wave events) and effects on the shore minimised.

Some uncertainties

A piece of key information about which there is some uncertainty is the rate of natural replenishment of sand to the delta by longshore and transport from the offshore.

A complicating factor is that rising sea level (SLR) associated with climate change could see an increase in ebb delta sand volume. Hicks and Hume (1996) have shown that for estuaries with extensive intertidal areas and/or a low-lying hinterland (such as Rangaunu) SLR will cause an increase in the tidal prism. As a consequence, and according to the Bruun Rule (Bruun 1962) the level of the seabed offshore will need to be lifted in order to accommodate SLR and the ebb delta could be expected to grow in volume until a new equilibrium is established with the larger tidal prism due to SLR. Given that the major source of sand for the beaches and delta has been the offshore seabed and that longshore transport and river inputs likely small, then the sand demand by the delta is likely to be offset by sand being eroded off adjacent beaches while these ebb delta adjustments were occurring.

That is to say that some of the longshore transport of sand that could have offset the effects of sand extraction could be 'soaked up' to offset delta build up due to sea level rise.

Further assessments

Further assessments that need to be undertaken to confirm some of the assumptions in this memo, and most likely needed in order to obtain a resource consent include:

- The rate of replenishment of sand from natural processes will be an important determinant as to whether extraction is sustainable. Replenishment could be checked by: 1) Undertaking a hydrographic surveys of the ebb tidal delta bathymetry to check for sand build up or erosion since 1979 (and the Pickrill analysis of 1958-1979) and 2) Undertaking numerical modelling to confirm the rate of sediment transport and inputs from offshore or alongshore. It is now possible to generate long term hindcast record (59 year 1958-2016) of waves for this purpose from the JRA55 global wave hindcast and local winds and using tools such as tools such as the SWAN numerical nearshore wave model was used to refract and shoal waves from the ocean into the Rangaunu Bay nearshore.
- There is a need to locate any historical records of shoreline erosion and accretion for the beaches adjacent to Rangaunu inlet that may have been assessed from shoreline survey data, aerial photographs and LiDAR. These may be available from a project mapping the long term shoreline changes in around the New Zealand coast by Auckland University/NIWA ('New Zealand's Changing Coastline' project a National Science Challenge funded project).
- Consideration needs to be given to monitoring. Topographic surveys of adjacent beaches should be undertaken to determine shoreline movements and potential effects of sand extraction, Beach surveys are a common condition of consent associated with sand extraction. This exercise is more to provide factual information on shoreline erosion and accretion (that can be used to counter observations/assumptions that extraction and erosion are linked). In the case of Rangaunu I suspect that the effects of extraction will be undetectable within the noise of natural sediment processes on the delta and beaches. Topographic surveys can be made from LiDAR, aerial imagery (plane or drone) or beach profiles.

References

Bruun, P. 1962. Sea level rise as a cause of shore erosion. Journal of Waterway, Port, Coastal and Ocean Engineering, 88: 117-130.

Hicks D.M. and Hume, T.M. 1996. Morphology and size of ebb tidal deltas at natural inlets on open-sea and pocket-bay coasts, North Island, New Zealand. Journal of Coastal Research 12 (1) 47-63. Fort Lauderdale (Florida), ISSN0749-0208.

Hume, T.M., Herdendorf, C.E. 1988. A geomorphic classification of estuaries and its application to coastal resource management-A New Zealand example. Journal of Ocean and Shoreline Management, 11, 249-274.

Hume, T.M., Herdendorf, C.E. 1993. On the use of empirical stability relationships for characterising inlets. *Journal of Coastal Research,* 9: 413–422.

Hume, T M., Herdendorf, C.E. 1992. Factors controlling tidal inlet characteristics on low drift coasts. *Journal of Coastal Research,* 8(2): 355–375.

Hume, T.M. 2003. Estuaries and tidal inlets. Chapter 9: 191–213. In: Goff, J.; Nichol, S. and Rouse, H.L. (eds). *The New Zealand Coast. Te Tai Aotearoa.* Dunmore Press, New Zealand: 312.

Pickrill, R.A. 1985. Sedimentation in an ebb-tidal delta, Rangaunu Harbour, Northland, New Zealand, New Zealand Journal of Geology and Geophysics, 28:3, 531-542, DOI: 10.1080/00288306.1985.10421205

Schofield, J.C. 1970. Coastal sands of Northland and Auckland, New Zealand Journal of Geology and Geophysics, 13:3, 767-824, DOI: 10.1080/00288306.1970.10431354

HCL
Hume Consulting Ltd

Memo

From	**Dr Terry Hume, Managing Director, Hume Consulting Ltd**
To	Owen Burn, Green Group Ltd
CC	Andrew Johnson, Johnson Brothers Ltd
Date	1 May 2024
Subject	**Hokianga Harbour sand extraction**
File path *(right click to update)*	*C:\Users\Terry\OneDrive\Documents\All files - master list - VALUABLE\Hume Consulting Ltd\Hokianga Harbour sand extraction\HCL memo Hokianga sand extraction.docx*

HCL were requested to provide an opinion as to whether proposed Hokianga sand extraction sites are potentially viable. My understanding is that Johnson Brothers Ltd are exploring the possibility of extracting sand from the Hokianga Harbour for general construction purposes. The proposal is to extract 30,000 m^3 per year of sand from each of two shoals inside the harbour entrance north and south (Middle Bank) of Kawehitiki Point. Sand would be extracted from each site using a 'cutter suction type' dredging process with a maximum cut depth of 300 mm over an area of 428,738 m^2.

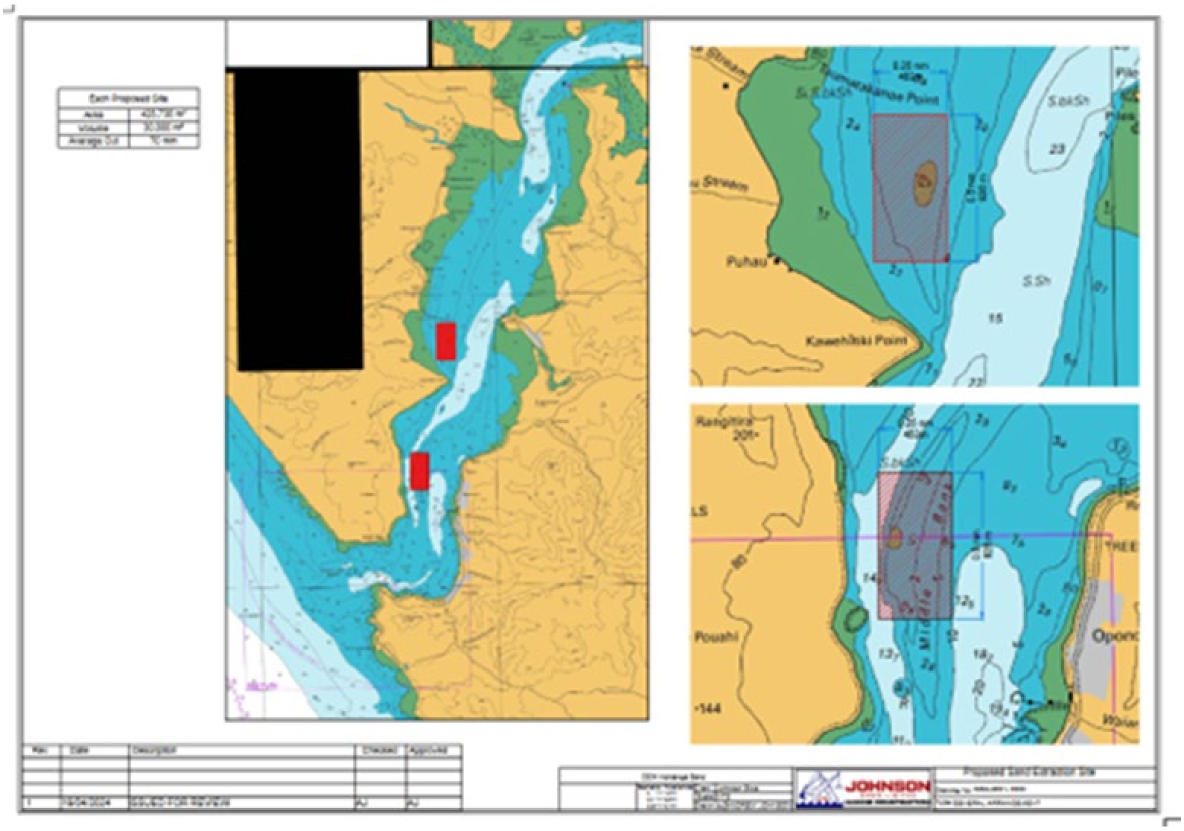

Figure 1. Entrance to Hokianga Harbour showing the proposed area of sand extraction (red and hatched boxes). Source LINZ Chart NZ 4212 Hokianga Harbour)

In my opinion this site is potentially viable subject to considerations described in the following.

I make this statement from a coastal physical processes (not ecological) perspective, and on the limited information available. There are no studies of sand transport and storage in the area. Apart from a desk top analysis I made of sand storage in New Zealand tidal deltas I have not undertaken work in the Hokianga Harbour. However, tidal inlet processes and sand storage at tidal inlets are well understood from a conceptual viewpoint, both internationally and for New Zealand situations (Hume and Herdendorf 1988, 1992 and 1993; Hume 2003 and Hicks and Hume 1996).

From my understanding of tidal inlet processes I would surmise that the sand in the proposed extraction areas is part of shoals/sand banks built from sand carried into the harbour by the incoming tide. Hydrodynamic modelling (MetOcean 2020) shows strong flood (incoming) tidal currents against the northern shore of the harbour that have the potential to transport sand through that area. The overall shape of the shoals is then sculpted by the interaction of the flood and ebb tides. The source of the sand is the large ebb tidal delta offshore from the entrance of the harbour. This delta is a large sand body containing about 16.4 million m^3 of sand (Hicks and Hume 1996). The delta in turn is fed by littoral drift – i.e., sand being driven by the dominant south-westerly swell northwards up the west coast of the North Island. The littoral drift is estimated at 175,000 m^3/yr (Hicks and Hume 1996).

In my opinion the site is potentially viable for sand extraction because

- The shoals are being fed by the large volume of sand in the ebb tidal delta which is turn being renourished by longshore transport.
- Given the thin layer of extraction (maximum cut depth of 300 mm) the effects on adjacent shores are expected to be minimal and short term. Wave and tidal action at the site will quickly infill any of the dredge cuts and minimise alteration in the patterns of waves and

longshore wave energy gradients at the shoreline and therefore patterns of erosion and accretion along the shore.

Any consent application would be strengthened by studies that:

- Confirm the feed of sand to the shoals from natural processes, thereby making the extraction sustainable.
- Assess for potential adverse effects on the northern shoreline adjacent to the proposed extraction sites (given issues associated with erosion along the southern shoreline (described in Davis Consultants 2020)
- Gives consideration to monitoring potential effects on the shoreline.

On the basis of the very limited information it's difficult to give an opinion on the sustainable amount of extraction. Extraction from Middle Bank closer to the entrance and the feed of sand from the sea is probably the preferable option of the two extraction sites. If further studies were required to assess sand feed into the harbour shoals, an option would be to make use of the MetOcean hydrodynamic model to assess the capacity for sand to be delivered to the proposed extraction sites. I would also note that the proposed extraction from the Hokianga shoals is from a similar environmental situation to extraction that has taken place from the Lady Franklin shoals inside the mouth of the Kaipara Harbour.

References

Davis Consultants 2020. Ōmāpere Seawall for Clutterbuck & Petrie. Assessment of Environmental Effects and Application for Resource Consents. 92pp + appendices.

Hicks D.M. and Hume, T.M. 1996. Morphology and size of ebb tidal deltas at natural inlets on open-sea and pocket-bay coasts, North Island, New Zealand. Journal of Coastal Research 12 (1) 47-63. Fort Lauderdale (Florida), ISSN0749-0208.

Hume, T.M., Herdendorf, C.E. 1988. A geomorphic classification of estuaries and its application to coastal resource management-A New Zealand example. Journal of Ocean and Shoreline Management, 11, 249-274.

Hume, T.M., Herdendorf, C.E. 1993. On the use of empirical stability relationships for characterising inlets. *Journal of Coastal Research,* 9: 413–422.

Hume, T M., Herdendorf, C.E. 1992. Factors controlling tidal inlet characteristics on low drift coasts. *Journal of Coastal Research,* 8(2): 355–375.

Hume, T.M. 2003. Estuaries and tidal inlets. Chapter 9: 191–213. In: Goff, J.; Nichol, S. and Rouse, H.L. (eds). *The New Zealand Coast. Te Tai Aotearoa.* Dunmore Press, New Zealand: 312.

MetOcean 2020. Hokianga Harbour Hydrodynamic Study. Hydrodynamic Study of WasteWater Discharges. Report prepared for Far North District Council. 85pp + appendices.