Coastal Geomorphology

Rapid shoreline building on a stormy coast

Darren King, Terry Hume, *and* ***Scott Nichol*** *answer some questions about the origins and formation of Piha Beach.*

Along Auckland's stormy west coast, waves and winds have carried ashore large amounts of sand to fill small embayments like Piha Beach. Over the last century a rapid influx of sand has added a substantial area of new land to Piha. Understanding the dynamics of this process is important for managing our coastal environments, particularly in relation to how we make decisions about coastal hazards and how close to the sea we can safely build.

So where does the sand come from at Piha? How much is stored within the system? Has the rate of sand delivered to Piha varied through time, and what are the implications for building by the sea? Research at NIWA and the University of Auckland looks for the answers to these questions through a variety of means.

Sources of the sand

Analysis of the sand and other geological evidence shows that the black sands of Piha came originally from the andesitic volcanic rocks of Mt Taranaki (some 300 km south along the coast) and also from the Taupo Volcanic Zone (via the Waikato River), as well as from local streams and cliff erosion. Sand is transported from these sources north along the coast by the longshore currents that are generated by the large and persistent swell originating in the Southern Ocean.

Scale of the system

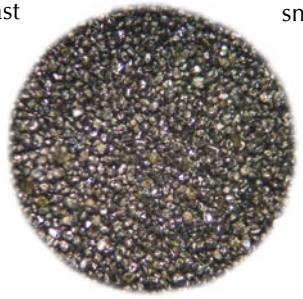
Sand has been coming ashore at Piha for thousands of years. Wave-cut caves behind the dunes at Piha suggest that when sea level rose to its present position some 6500 years ago, waves were washing against the rocky cliffs of the Waitakere Ranges. Since this time, sand driven ashore by waves and wind has filled the 2-km-long bay and built the beach and the dunes, and sandbanks in the shallow water offshore. There are also extensive sheets of sand piled against the hills (on the sides of the rising Waitakere Ranges) and now covered with bush. A topographic survey revealed that some 12.7 million m³ of sand has accumulated above mean sea level at Piha Beach.

But the sand accumulation at Piha has not been regular. Ground-penetrating radar (GPR) surveys across the sand dunes indicate variable rates of sand accumulation and styles of shoreline building. Sand has accumulated as seaward-advancing (prograding) dunes and also as landward-advancing (transgressive) sands blown inland by winds to smother the landscape, infill valleys, and pile up against the flanks of the hills. These different styles of coastal evolution are a consequence of fluctuations in meteorological conditions, wave climate, and sand supply.

However, not all the sand arriving at Piha stays in the bay. The waves at Piha Beach are very energetic and typically reach 1.5 to 2.5 m in height (up to 6.5 m in storms),

Facts about Piha Beach

- Sand sources include Mt Taranaki and the Taupo Volcanic Zone
- It has 12 700 000 m³ of sand above mean sea level
- From 1940 to 2000 the beach grew seawards by 0.4–1.0 m/yr



Piha sand under the microscope. The black grains are titanomagnetite, a mineral that derives from the breakdown of Mt Taranaki volcanics, and the mineral that gives west coast iron sands their characteristic colour.
Photo: Scott Nichol

Piha Beach on Auckland's west coast.
In the foreground is Lion Rock.

Photo: Carey Staunton

Photo: Greta Jansen

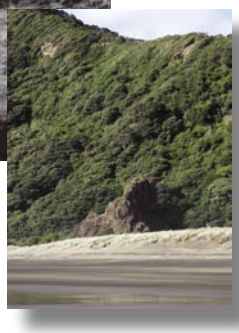
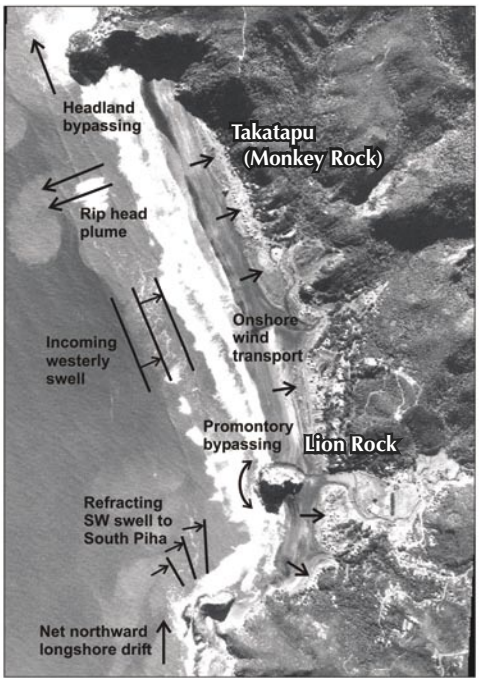
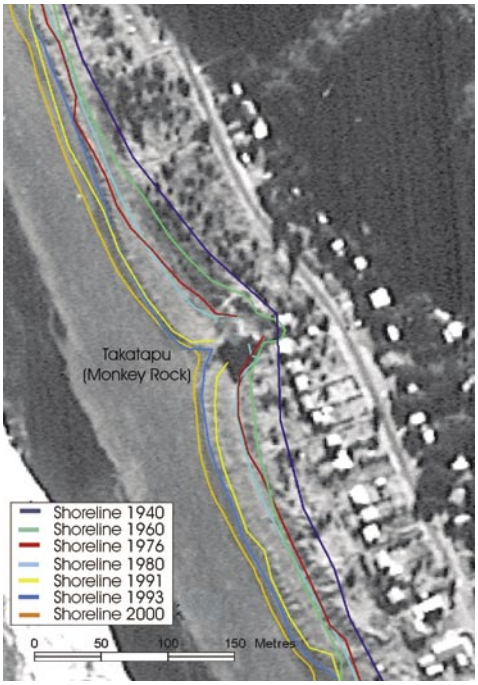


Photo: Carey Staunton

Takatapu (Monkey Rock) at North Piha circa 1900 (above) and today.





Photos: Air Logistics

Mechanisms of sand transport into and out of Piha Beach.

Far right:
Plots of the shoreline positions at North Piha over the period 1940 to 2000. Note how the shoreline in 1940 was at the seaward edge of the houses behind Takatapu (Monkey Rock); the shoreline has advanced well seawards of the rock in the last 60 years.

and during these periods the zone of breaking waves often extends some 500 m offshore. These conditions generate strong longshore currents and rips which transport sand onto and off the beach, and into and out of the Piha embayment, effectively bypassing the headlands at either end. Thus, sand movement and accumulation in the embayment is continually in a state of flux.

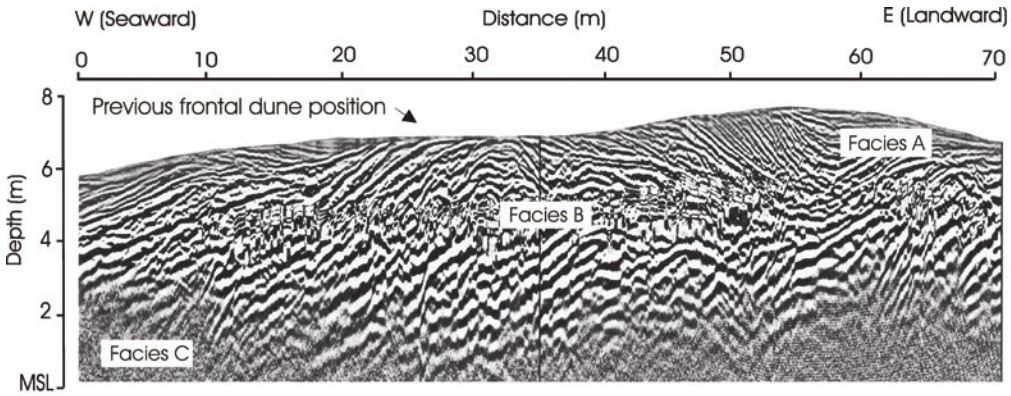
Shape shifting

At North Piha the shoreline and dunes near Takatapu (Monkey Rock) have built out about 150 m seawards of the cliffs, with 70 to 120 m of this change happening during the last century. A photograph of Takatapu taken around 1900 shows the tide lapping at its seaward toe and dunes well landward of the rock. Today, the dunes have built out to the rock and the shoreline is much further out. Mapping these changes from aerial photos shows the shoreline at Piha advanced seawards at a rate of 0.4 to 1.0 m/yr between 1940 and 2000 to gain about 121 000 m^2 of new beach area. This is similar in area to some nine sports fields and the volume of this accumulation is around 700 000 m^3.

What the sea gives, the sea can take away

Shoreline change at Piha reflects continuing adjustment to winds, waves, and sediment supply, upon which human-induced changes over the past century have been superimposed. Coastal managers and the public must recognise that the rapid advancement of the shoreline in the last century and associated increase in 'available' coastal land at Piha may be a temporary situation that nature could well reverse over management time scales. W&A

Darren King, who works at NIWA in Auckland primarily in climate and energy applications, has a long-standing interest in coastal geomorphology and palaeoclimatology. (See his article on reconstructing past climates in W&A 12(2)*: 14–15.) Dr Terry Hume is a coastal geomorphologist based at NIWA, Hamilton, where he is also Assistant Regional Manager. Dr Scott Nichol is a coastal geomorphologist with the School of Geography and Environmental Sciences at the University of Auckland.*



Ground-penetrating radar cross-section through the dunes at North Piha shows the layers of sand inside the dunes. Facies A, B, and C represent phases of development of the dune field.