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ABSTRACT

At the request of, and in conjunction with, the Taranaki Harbours Board and Water and Soil Directorate of the Ministry of Works and Development, a survey was undertaken in June 1984 to map the distribution and determine the quantity of sand in and adjacent to Port Taranaki.

A thick wedge of sand was found to lie against and seaward of the main breakwater, with most of the surveyed area being an exposed lahar surface with shallow depressions infilled with a thin veneer of sand.

Keywords: sediments, Port Taranaki, side-scan sonar, seafloor survey

INTRODUCTION

Port Taranaki has been sited in a natural embayment in the North Taranaki Bight coastline around which the settlement of New Plymouth developed. Prior to the development of the port in the early 1880s, longshore drift moved sediment freely along the coast in a northeasterly direction, providing nourishment to beaches adjacent to New Plymouth (Gibb 1983). Construction of the port's main breakwater began in 1881, interrupting coastal sediment transport and trapping sand. Dredging consequently began and has continued unabated. Trap efficiency of the port increased with subsequent lengthening of the main breakwater to its present 1256 m (Fig. 1) and with the construction of the 730-m lee breakwater in 1968. Gibb (1983) estimated that between 128,000 m^3 and 173,000 m^3 of sand are trapped by Port Taranaki every year and that the cooling-water sand-trap of the New Plymouth Thermal Power Station has trapped another 14,000 $m^3.y^{-1}$ since commissioning in 1974. The bulk of this sand (142,000 – 187,000 $m^3.y^{-1}$) is dredged and dumped 2 km offshore. A proportion of this sand is probably transported back towards New Plymouth's beaches during northwesterly storms (Gibb 1983).

Port construction has starved the downdrift coast of sand and, consequently, the shoreline northeast of the port is eroding rapidly (Gibb 1983). A sand bypass programme has been proposed as a possible method of erosional control. The programme will involve moving the trapped sand northeastwards to points where it can re-enter the natural system and renourish the depleted beaches.

The present survey was undertaken to assess the nearshore sand resource in the vicinity of the port and beaches.

SURVEY METHODS

The survey was undertaken using a side-scan sonar and sub-bottom profiler over a 7-km length of coastline from Moturoa Island, west of New Plymouth, to Fitzroy beach near the Waiwakaiho River mouth in the northeast (Fig. 1). It extended seawards to the 20-m contour up to 2.5 km offshore. Survey lines were laid out at 200-m spacing covering a total area of 14 km^2. The survey was carried out from the 6-m NZOI survey vessel *Taraiti* in two stages.

Surface sediments were firstly mapped using a Klein 400 side-scan sonar system. Underwater transducers (one each side of a tow-fish) scanned 300 m of seafloor with high-frequency sound along 60 km of survey track (Fig. 2), providing complete coverage of the area with a 100-m overlap between tracks.

Sand thickness was then determined in areas where the side-scan showed sand to be present, using an EG & G 230 "Uniboom" sub-bottom profiling system, which resulted in 25 km of high-resolution seismic track (Fig. 3).

Navigation throughout the survey was by Del Norte Trisponder operated by the Hydrographic Surveyor of the Taranaki Harbours Board Engineer's Department. Plotting of tracks was carried out by the Taranaki Harbours Board on a 1:5,000 metric grid.

SEDIMENTS AND SEDIMENT DISTRIBUTION

Side-scan sonographs were interpreted to produce a mosaic (Fig. 4) of sediment distribution in the survey area. From this mosaic, it was possible to identify four different but merging areas of seafloor (Fig. 1). *Area*

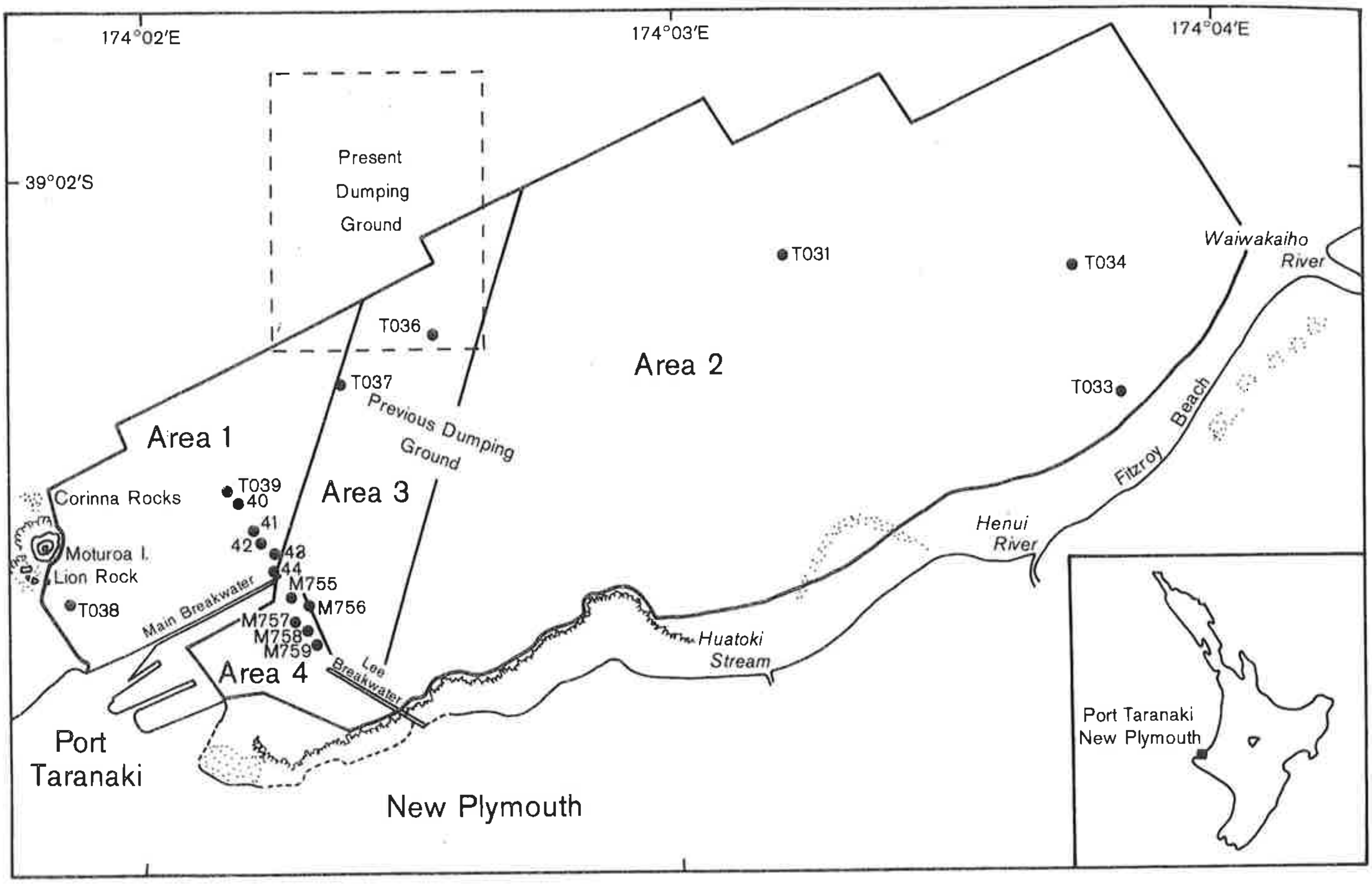


Fig. 1. Locality map showing the side-scan sonar areas and station positions, Port Taranaki to Waiwakaiho River.

1, north and west of the main breakwater, is characterised by sonographs of low reflectivity. *Area 2*, north and east of the lee breakwater, is characterised by sonographs of high reflectivity. *Area 3*, between *areas 1* and *2*, appears to be a transitional area with sonographs showing patches of both high and low reflectivity. *Area 4* consists of the harbour, main shipping channel, and the area around the breakwaters. It has predominantly low-reflectivity sonographs which show man-made features associated with the running of the port.

Area 1. West of the Harbour Entrance

The low reflective signal in this area is indicative of a sandy substrate as reported by Carter *et al.* (1981) and Gibb (1983). The sonographs show a featureless sandy bottom with no indication of large-scale bedforms (megaripples, sand waves). However, bedforms with a wavelength of < 1 m are below the resolution of the side-scan and divers have reported the presence of ripples, up to 0.1 m wavelength (Kirk 1980; Gibb, pers. comm. 1985), over much of the sandy area. Textural analysis of samples collected from this area (MWD Stns T038–T044, Fig. 1) by the Ministry of Works and Development show the sediment to be well-sorted fine sand (Table 1).

Around the breakwater, Moturoa Island, and Lion and Corinna Rocks, the sonographs show the presence of gravel and rock. There is a sharp boundary with the sand and, in places, a scarp of around 1 m at the gravel/rock outcrop. The sonographs also show the occurrence of a few isolated elevated targets and small patches of high reflectivity, casting shadows. From previous surveys (Carter *et al.* 1981) and diver observations, these have been determined to be volcanic boulders and raised gravel beds similar in nature to those found along the foreshore. The boulders stand up to 2 m high while the gravel beds are elevated above the sandy floor by up to 1 m.

Area 2. East of the Harbour Entrance

The high-reflectivity signal in this area is indicative of a hard surface. From the geology of the area and coastal exposures it is known that this area consists of a "lahar-deposited, volcanic agglomerate with a patchy veneer of gravel" (Carter *et al.* 1981). The sonographs show two types of high-energy reflector: (1)

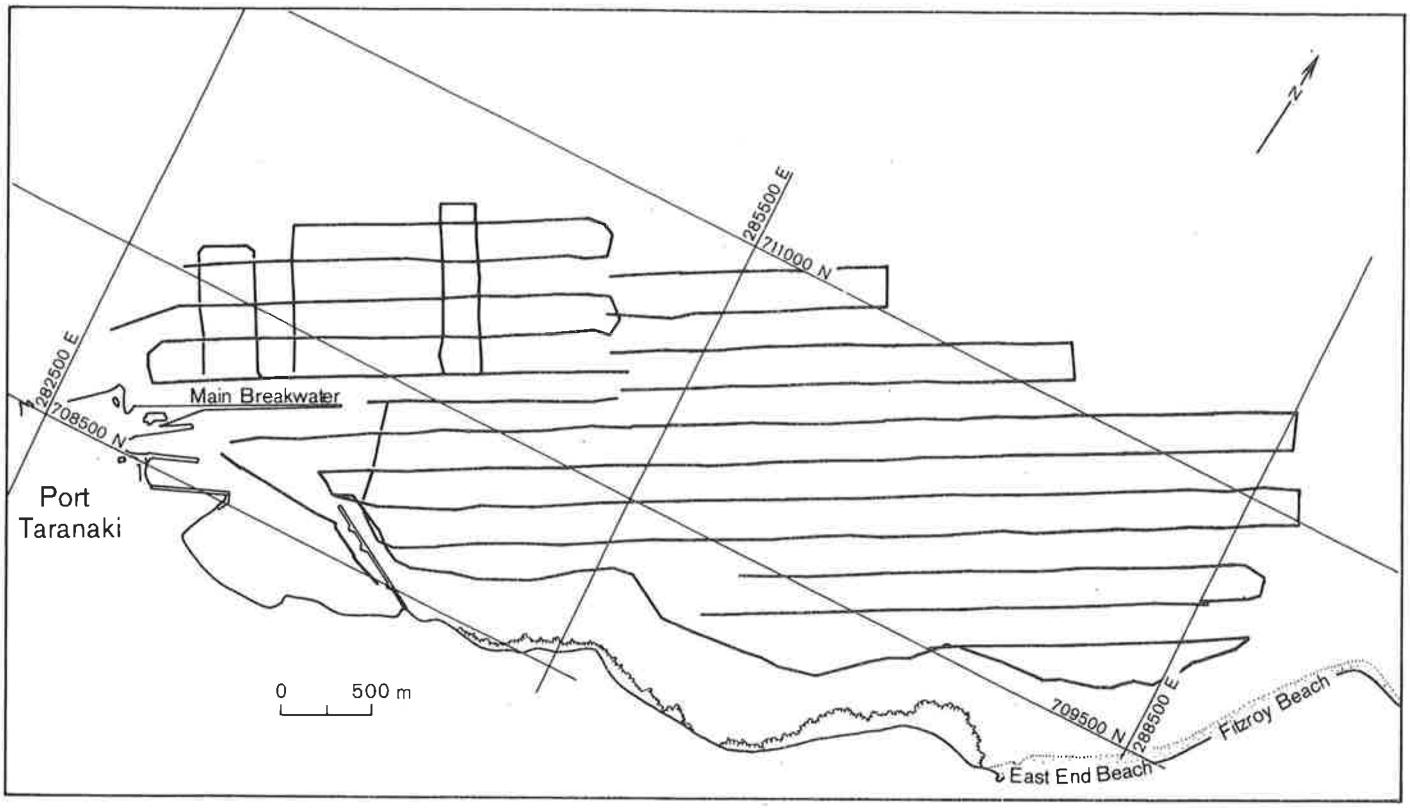


Fig. 2. Side-scan sonar tracks, Port Taranaki to Waiwakaiho River.

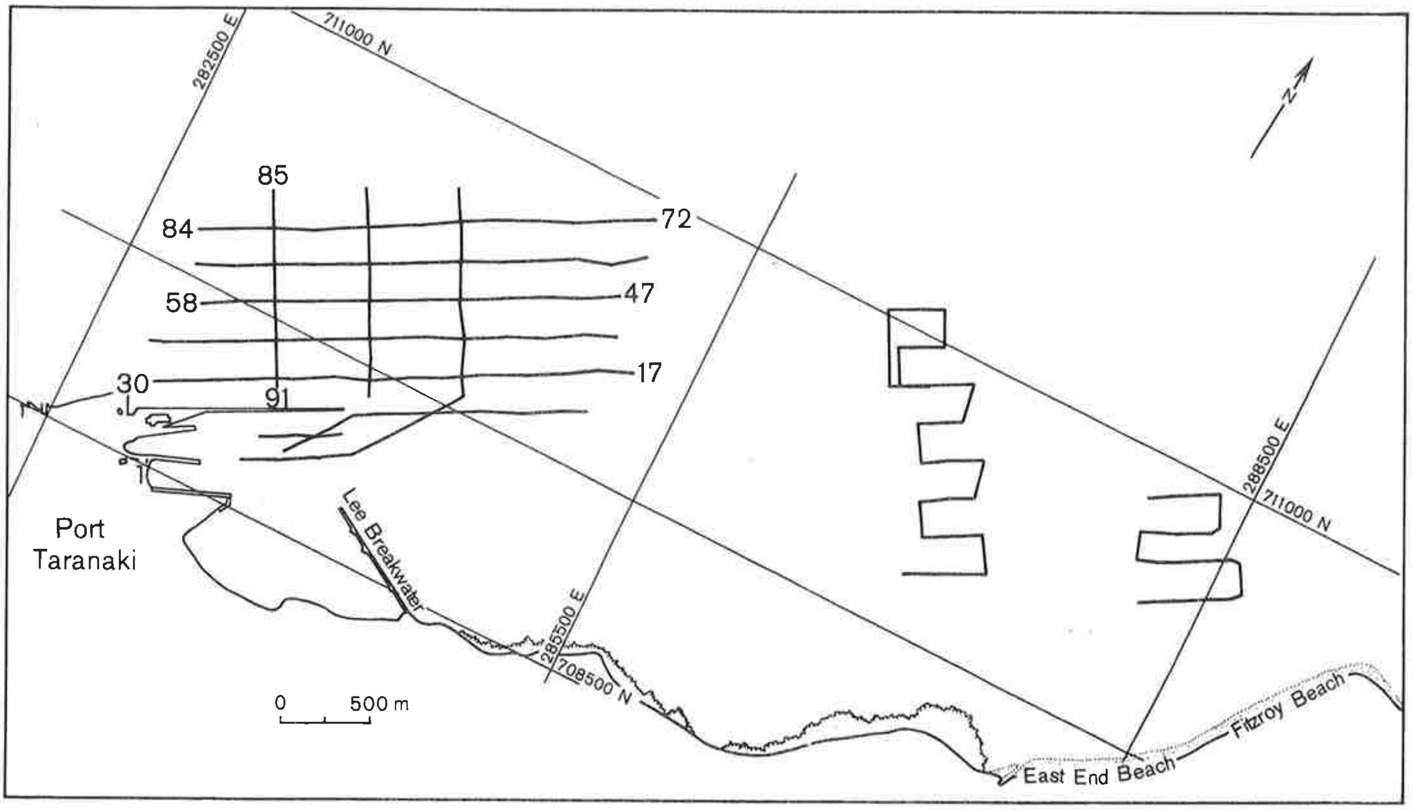


Fig. 3. Uniboom seismic tracks, Port Taranaki to Waiwakaiho River.

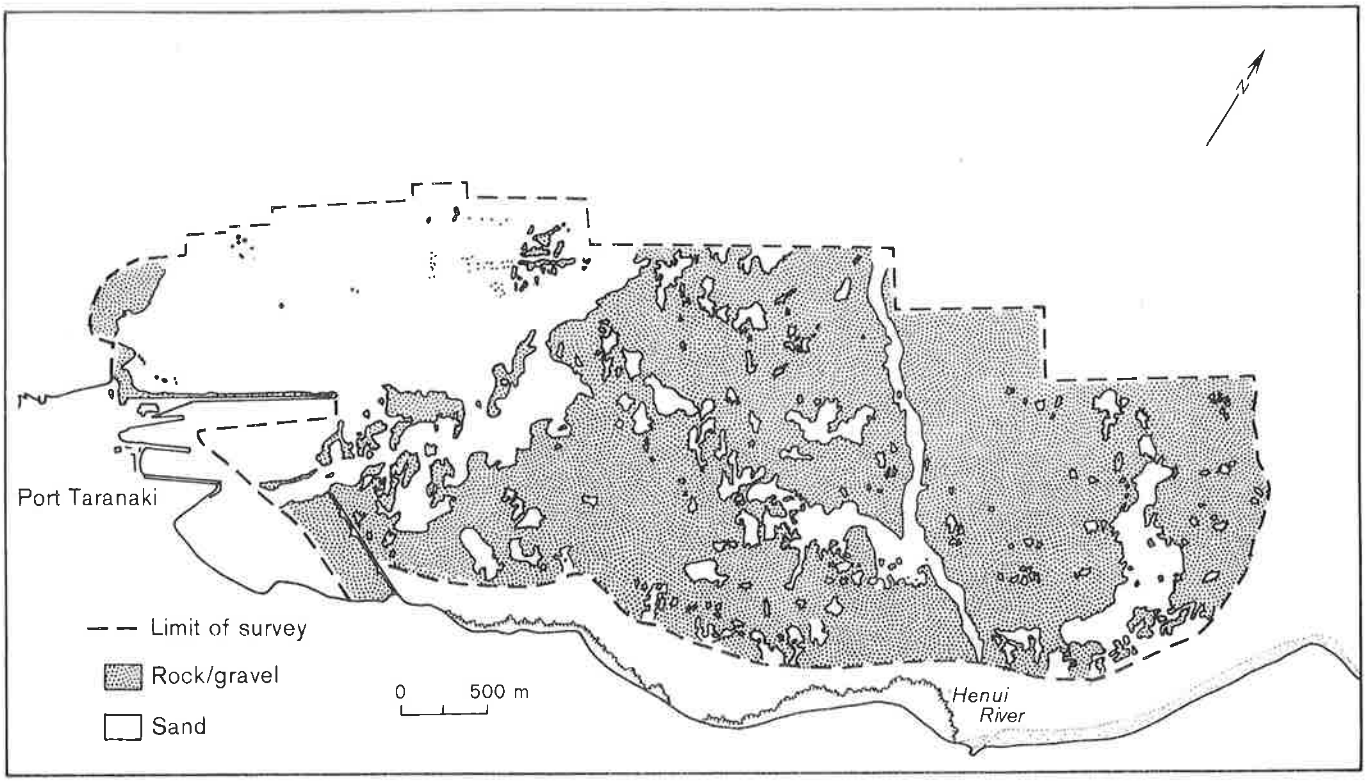


Fig. 4. A mosaic of seabed substrates, Port Taranaki to Waiwakaiho River, from the side-scan sonar images.

dark records with little or no variation; (2) dark records with shadows which are often parallel. Type (1) is interpreted to be gravel veneer, while type (2) is considered to be the solid lahar deposits, with relief up to a metre, or lag deposits of large boulders. There is no obvious pattern or trend to the distribution of these two reflector types and they generally merge into each other.

Scattered over this hard surface are patches of fine sand. Diver observations (W. Bayfield, Taranaki Catchment Commission, pers. comm.) suggest that these sand patches are mobile and moving along the coast in a northeasterly direction and are probably only temporarily trapped in bathymetric depressions. The best example of this entrapment is the northwest-aligned sand ribbon (Fig. 5A) off the mouth of the Henui River, cutting across the direction of longshore drift. This sand has been trapped in a depression in the seafloor and can be traced for several kilometres seaward on the mosaic. This is probably a relict river bed of the Henui River, cut into the lahar deposits during a period of lower sea level. A similar infilled depression further eastward is probably a relict channel of either the Henui or Waiwakaiho Rivers.

Samples from this area (Fig. 1, MWD Stns T031, T033, T034) show the sand to be very similar to that found in *Area 1* but slightly coarser and not so well sorted (Table 1).

TABLE 1. Statistical parameters of grain size (ϕ diameter), using the method of Folk and Ward (1957).

	Station no.	Mean	Standard deviation	Skewness
Area 1	T038	2.15	0.44	+0.44
	T039	3.18	0.49	−0.15
	T040	3.03	0.52	−0.09
	T041	2.95	0.53	−0.04
	T042	2.73	0.51	+0.06
	T043	2.36	0.44	−0.02
	T044	2.27	0.46	−0.05
Area 2	T031	2.77	0.58	+0.04
	T033	2.72	0.54	+0.10
	T034	2.75	0.59	+0.05
Area 3	T036	2.50	0.67	+0.10
	T037	2.29	0.49	0.00
Area 4	M755	2.48	0.58	+0.03
	M756	2.62	0.70	+0.13
	M757	2.22	0.54	−0.15
	M758	2.41	0.53	−0.04
	M759	2.39	0.54	−0.22

Area 3. **Transitional Central Area**

The sonographs have both high and low reflectivity (Fig. 5B) in this area. The western side is predominantly sand with patches of rock/gravel which change into predominantly rock with patches of sand on the eastern side. With longshore drift to the northeast, this area can be seen as a transitional zone between the sandy *area 1* and the rock/gravel *area 2*. The sonographs for this area show no resolvable megaripples or other large bed-forms but, again, ripples have been reported by divers on earlier surveys (Kirk 1980).

The textural parameters of sand in this area (Fig. 1, MWD Stns T036, T037) show little variation from samples from *areas 1* and *2* (Table 1).

Area 4. **Inner Harbour, Harbour Entrance, and Surrounding Area**

This area is predominantly sandy with patches of gravel/rock (Fig. 5C) around the harbour entrance and lee breakwater, and with out-cropping along the foreshore. The most conspicuous features in the harbour are man-made. Numerous patches of sub-parallel grooves occur in the area of the wharves and along the main shipping channel (Fig. 5D). These grooves, previously reported by Carter *et al.* (1981) in their 1980 survey, are a result of dredging operations in the harbour by the suction dredge *Ngamotu* and ship's-anchor drag-marks near the wharves. The sand at the entrance to the port (Fig. 1, NZOI Stns M755–M759) shows very similar properties to that sampled in the other three areas (Table 1).

The 1980 sonograph mosaic of this area produced by Carter *et al.* (1981) is remarkably similar to that of the present survey (Fig. 6). The overall sediment distribution does not seem to have varied greatly in the four years between surveys. The sand transported around the harbour entrance conforms to a set pattern with the same areas of gravel remaining uncovered. Sand fills the depressions in the underlying lahar surface while the high points remain exposed on the seabed.

DEPTH OF SAND COVER

Marginal sea conditions experienced during the latter part of the survey, in combination with a signal-processing fault in the Uniboom recording system, resulted in records having poor resolution and high noise content. This made interpretation difficult and decreased resolution so that layers thinner than 1.5 m could not be readily distinguished. However, a strong reflector is clearly evident beneath the sand of *area 1* (Fig. 7). The reflector outcrops near the sand/gravel interface on side-scan sonographs and is considered to represent the planed surface of lahar and gravel deposits.

From the Uniboom records and by using the side-scan mosaic to determine the edge of the sand, an isopach map depicting sand thickness was drawn (Fig. 8). This map shows a sand deposit which is thickest (13 m) in *area 1* in the west of the study area. The volume of sand within the mapped area is calculated to be 14.7 million m^3.

A cross section (Section "A", Fig. 9) through this deposit between fix positions 91 and 85, perpendicular to the main breakwater (Fig. 3), shows a fairly uniform sand depth of 10–12 m. Internal reflectors within the sand show only minor onlap, suggesting that the sand has acted as one body from 7 to 20 m water depth; there is no evidence to suggest it has built seawards from a nearshore sand prism.

Three cross sections (sections "B", "C", "D", Fig. 9) parallel to the main breakwater (Fig. 3) show that the 10–12-metre-thick sand deposit thins rapidly northeastwards, pinching out against the lahar at a line seawards from the end of the breakwater. Internal reflectors show northeastward downlap, confirming predictions that the sand body developed from southwest to northeast. Cross section "B", between fixes 72 and 84, is furthest offshore, at a water depth of about 20 m. It shows prograding fill in a 5-m depression covered by about 6 m of sand which terminates against a gravel outcrop in the northeast. Cross section "C", between fixes 47 and 58, is 200 m inshore from "B" at a depth of about 15 m. It shows similar northeastward-prograding infill in a depression which may be a trough perpendicular to the coast. The sand overlaps the edge of the trough as a 1–2-m-thick veneer on what is probably a gravel/lahar substrate. Cross section "D", between fixes 17 and 30, 150 m off the main breakwater, shows sand prograding northeastwards on an irregular surface to a point level with the end of the breakwater.

The depression in the lahar seen on these cross sections may be a relict drainage channel, running perpendicular to the coast between Moturoa Island and the rise in the lahar basement to the east. The radial pattern of drainage from Mount Egmont means there are numerous rivers and streams running to the coast in close proximity as well as many old dry channels. During lower stands of sea level, these river channels extended well past today's shoreline. Subsequent sea-level rise has flooded these channels and infilled some of them with sand, as seen off the Henui and Waiwakaiho Rivers, and in the channel described off the main breakwater.

The port's existing dumping ground is bisected by both cross sections "B" and "C". Dumping may

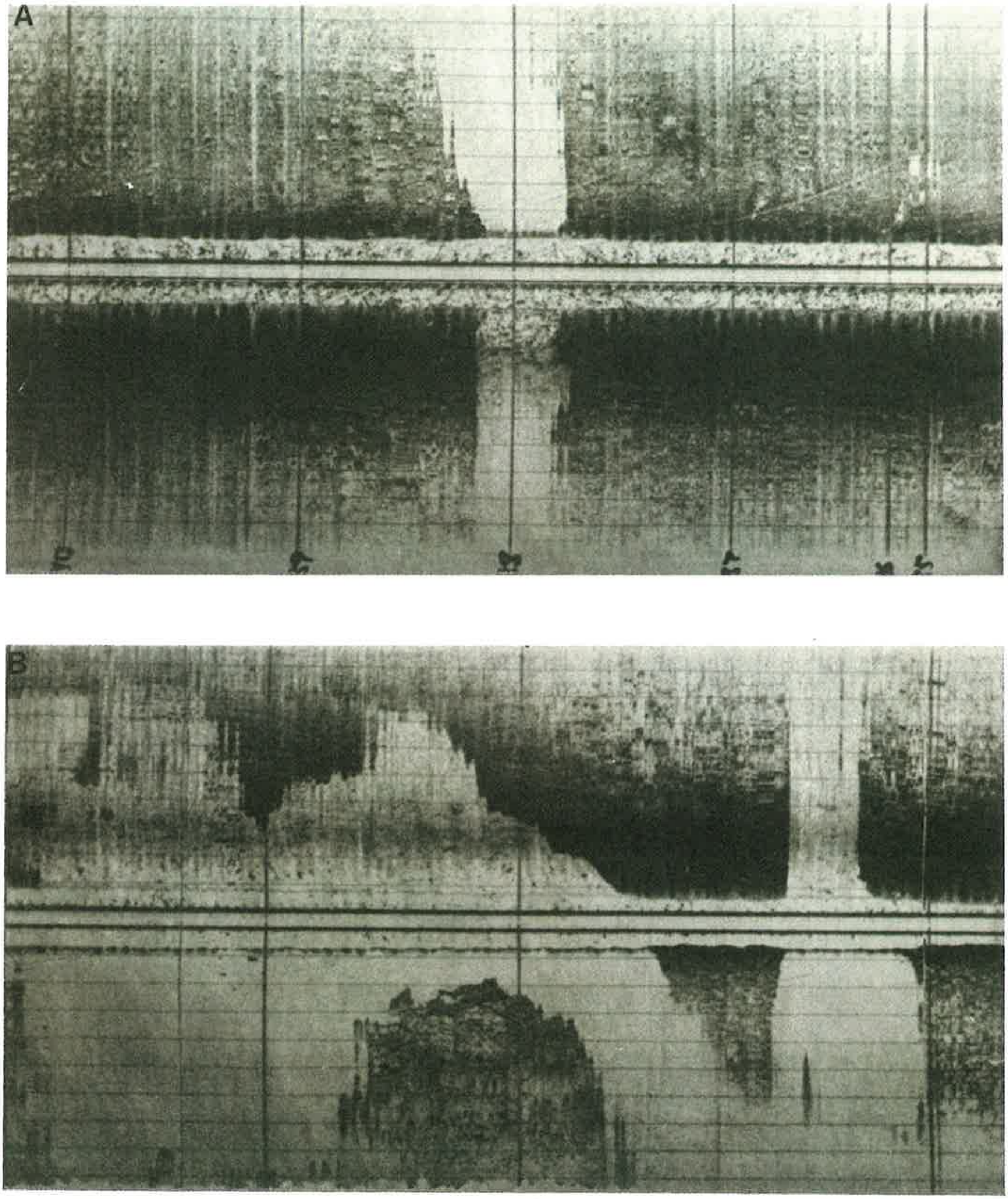
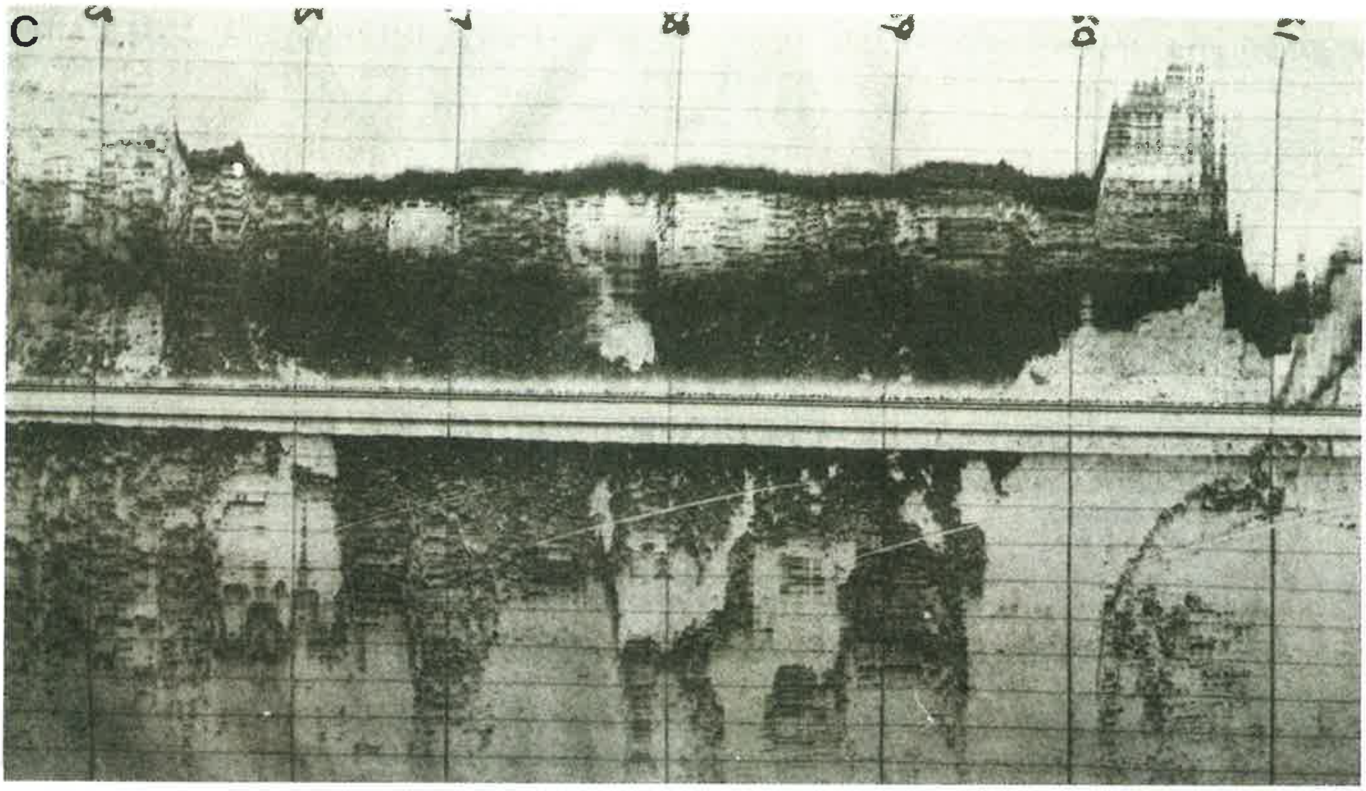
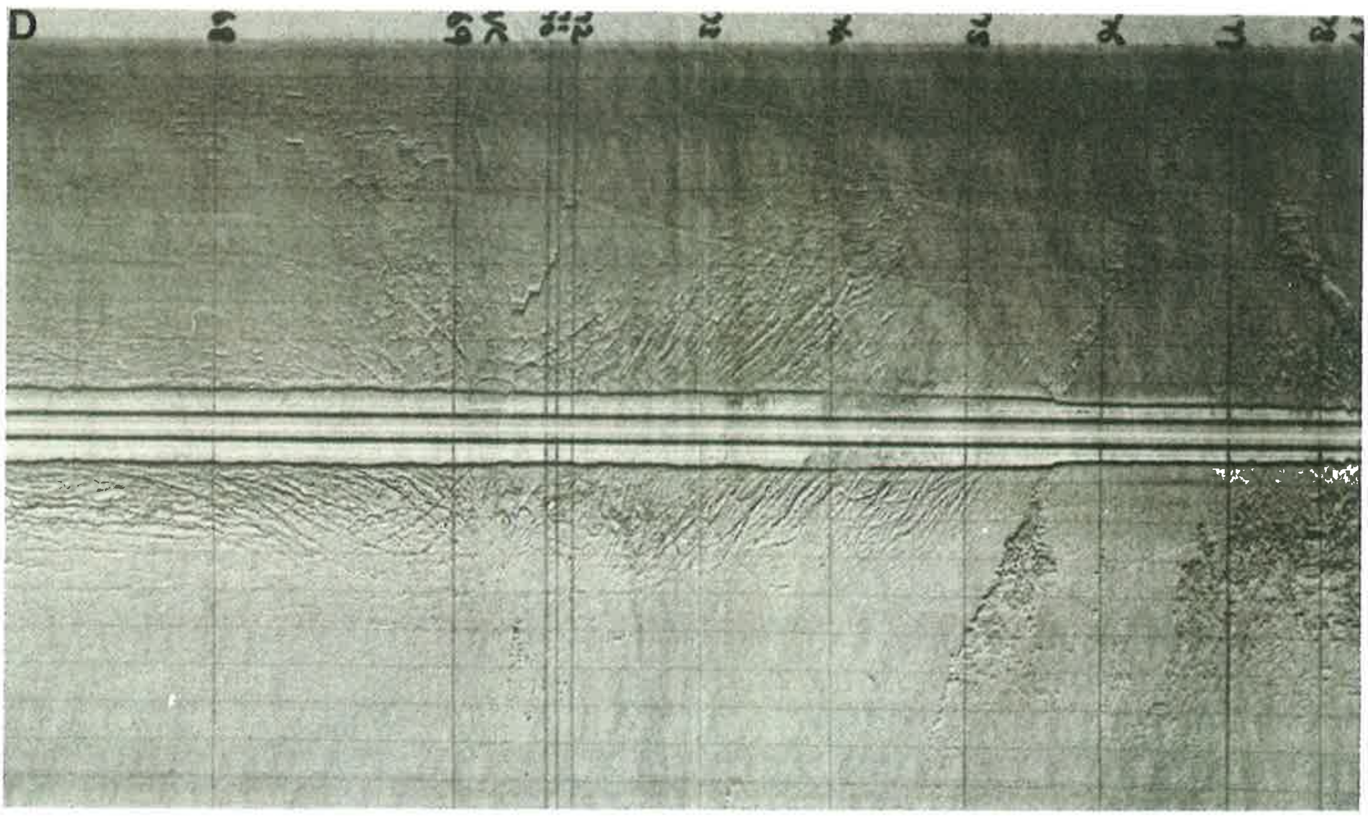


Fig. 5. Side-scan sonar records —
A. A sand-filled ribbon off the mouth of the Henui River.
B. With the system on manual tuning — the light record is of sand, the dark is rock and gravel.





C. At the top is the breakwater. The seabed near the breakwater is rock and gravel, with sand beyond.
D. With the system on automatic tuning. The record shows mainly sand, with suction-dredge trails and a few patches of gravel.

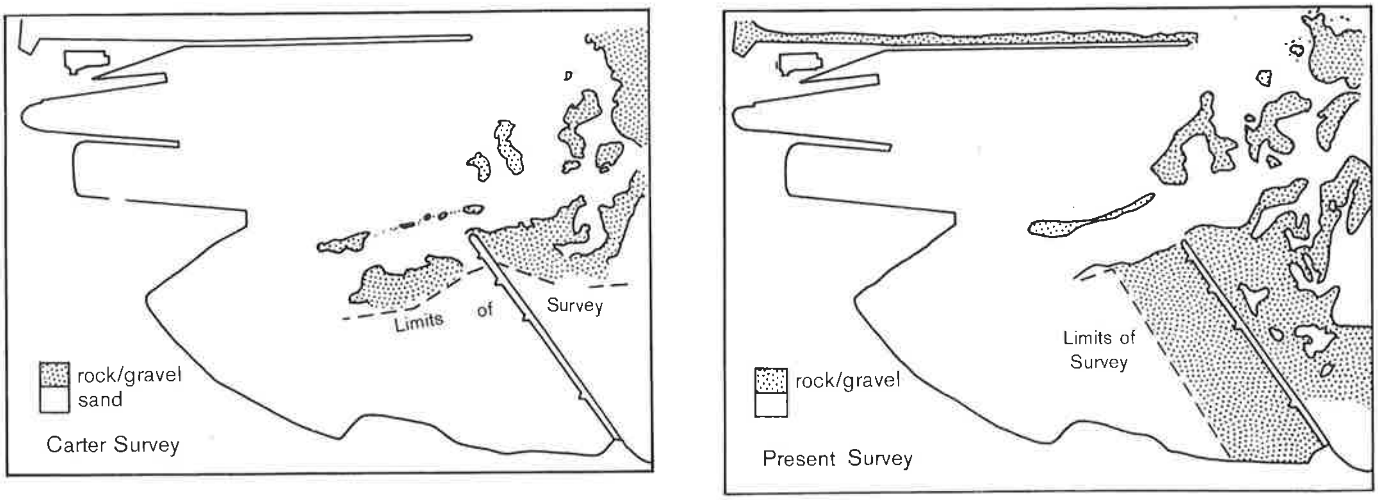


Fig. 6. Sonograph mosaics of the Carter *et al.* (1981) survey and the present survey.

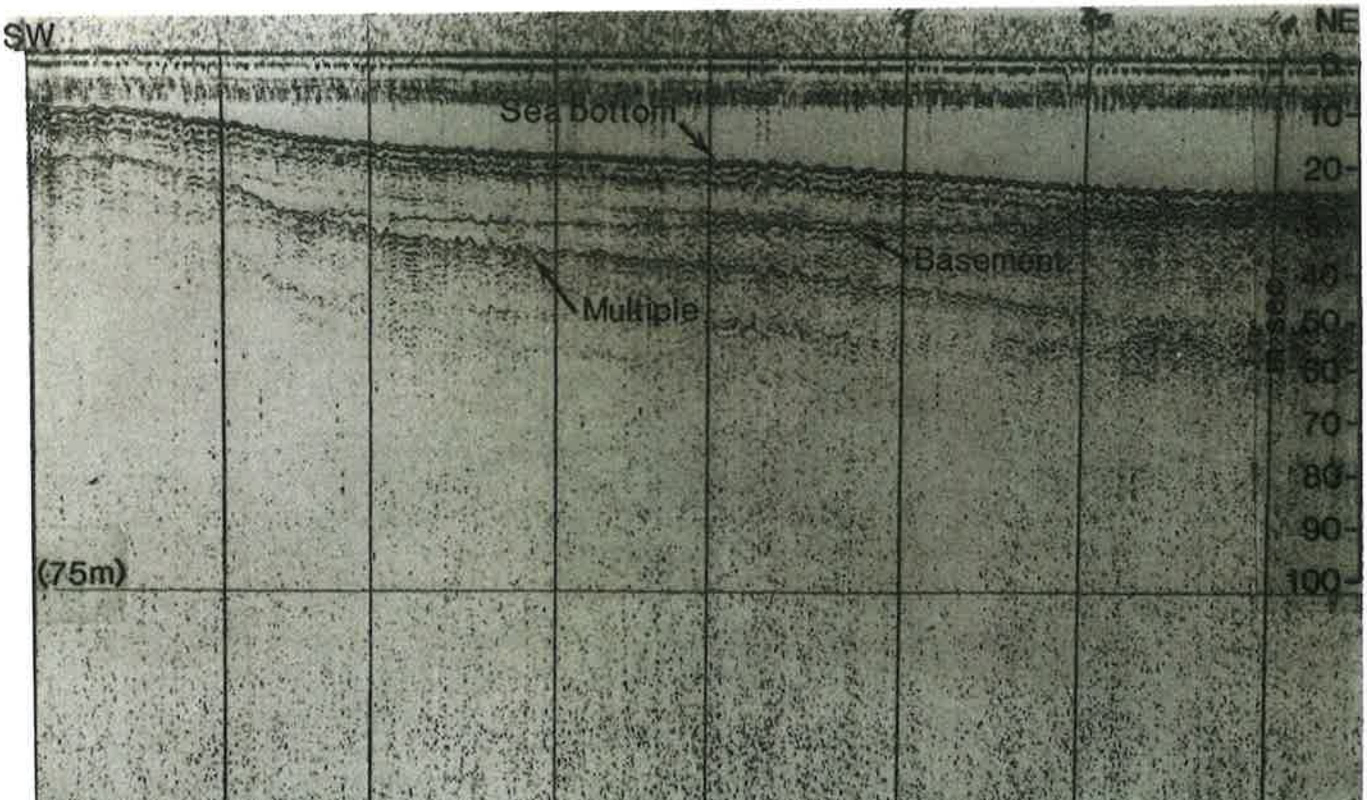


Fig. 7. Uniboom seismic profile showing the northeasterly thinning sand deposit.

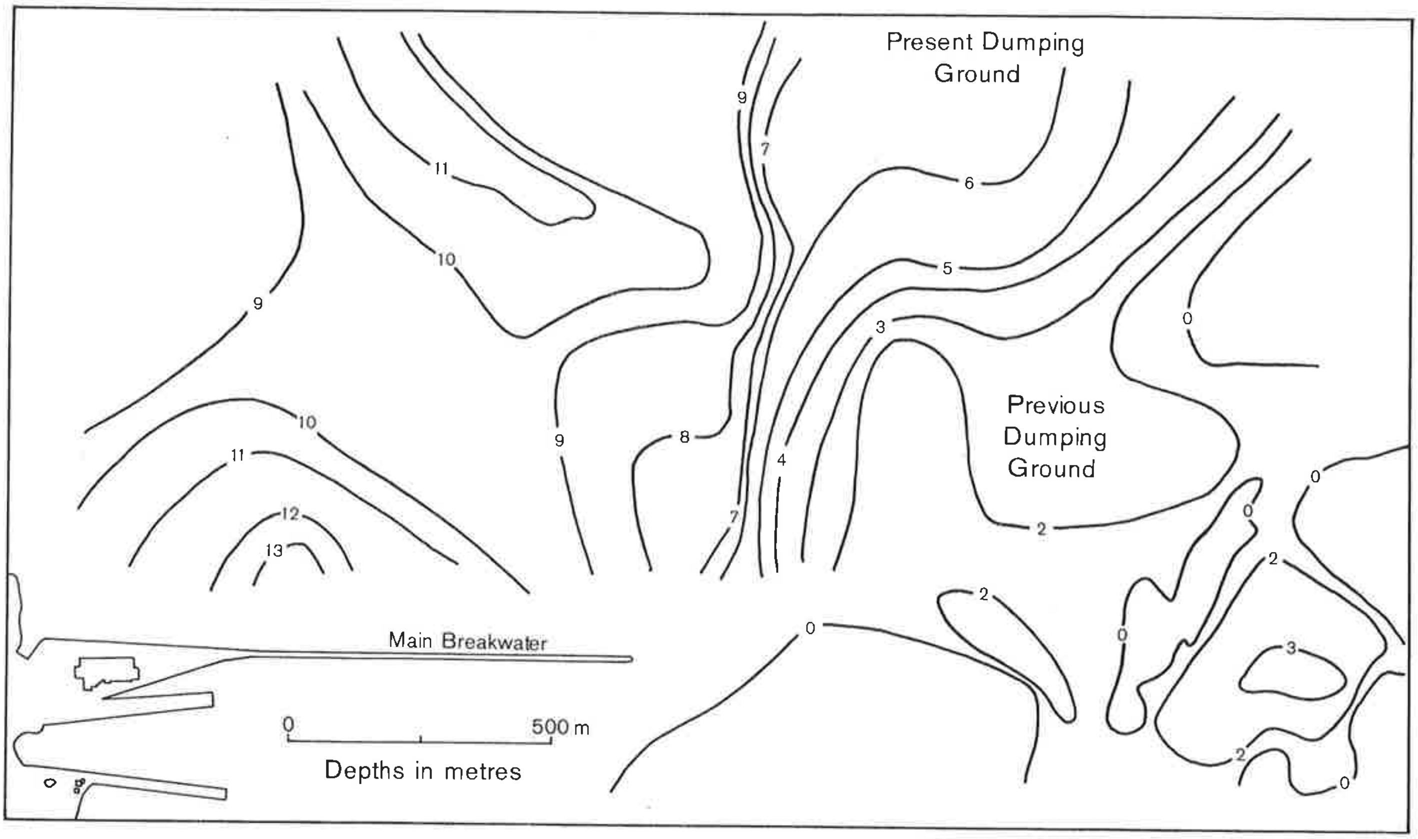


Fig. 8. Isopach map showing sediment thickness.

account for the gentle rise in the seafloor shown near the northeastern end of these sections.

As a result of the shelter given by Moturoa Island, Corinna Rocks, and Lion Rock, a tombolo has formed between the islands and the shoreline. The thick sand cover in *area 1* has been built up on the eastern flank of this tombolo, tapering northeastwards as the wave-shadow effect of the islands is decreased. This is illustrated in the isopach map (Fig. 8) and the cross sections (Fig. 9). Adjacent to the end of the breakwater, cross section "D" shows the sand depth to be 9 m, yet just 250 m past the end of the breakwater away from the shadowing effect of the Sugar Loaf Islands, there is bare gravel and rock. Pinching-out of the prograding sand body near the entrance to the harbour suggests that little of the nearshore transported sand is by-passing the harbour.

East of the harbour entrance, sand patches shown on the side-scan mosaic (Fig. 4), including the channel infills off the Henui and Waiwakaiho Rivers, were not thick enough to be detected on the Uniboom records, showing the sand veneer to be less than 2 m in depth.

CONCLUSIONS

The side-scan mosaic produced from this survey gives a good one-off "aerial photograph"-like picture of the seafloor of the Port Taranaki coastal area. From local diver observations it is known that the boundaries between sand, gravel, and lahar are mobile, changing in response to waves, tides, and currents. *Areas 3* and *4* at the edge of the thick sand body would be expected to show the greatest variation. However, comparison between side-scan surveys of 1980 and 1984 in the area around the harbour entrance shows little change, suggesting that the broad-scale pattern could be fairly stable.

This study and preceding surveys (Kirk 1980; Carter *et al.* 1981) show that sand is moved along the coast in response to predominantly northwesterly waves (Pickrill and Mitchell 1979). The eastward-thinning wedge of sand in *area 1* is being fed fresh sand from the west through longshore drift and is losing sand from its eastern edge. Some of this sand may be migrating along the coast in deep water beyond the influence of the breakwaters but much of the inshore sand is being trapped by the harbour, resulting in the continuous need for dredging.

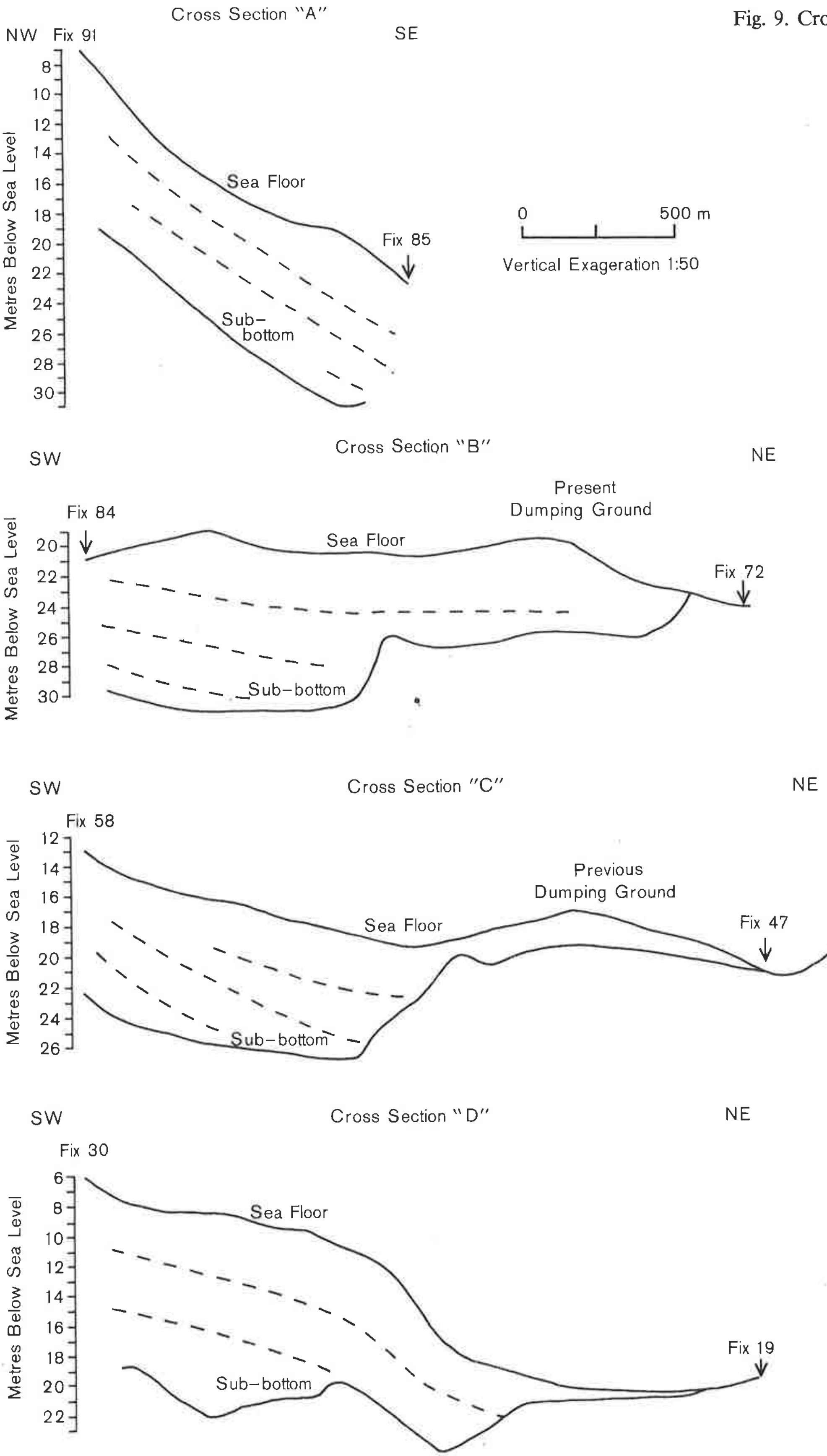


Fig. 9. Cross sections from Uniboom records.

This survey was done during a period of relatively calm weather. Transportation patterns observed during these conditions may change considerably during storms, therefore the mosaic of sand distribution resulting from this survey must be seen as a pattern produced by time-averaged conditions preceding the survey.

ACKNOWLEDGMENTS

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