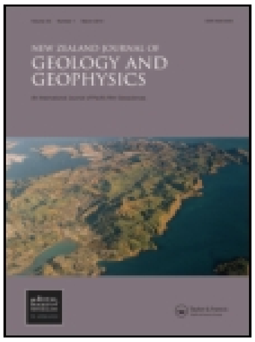

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P. B. Riley , I. S. Monro & J. C. Schofield

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Late Holocene sedimentation in Omaha Bay, North Island, New Zealand

P. B. RILEY
Beca, Carter, Hollings and Ferner Ltd
132 Vincent St
Auckland, New Zealand*

I. S. MONRO
Murray, North and Monro
9 Gore St
Auckland, New Zealand

J. C. SCHOFIELD
New Zealand Geological Survey
Department of Scientific and Industrial Research
P.O. Box 61 012
Otara, New Zealand†

Abstract Short-term changes in sea level at Omaha Bay, North Island, New Zealand, not only promote erosion of the beach during sea-level rise and the beach's progradation during sea-level fall, but may promote parallel changes on at least the upper portion of the offshore coarse belt. Long-term changes in sea level promote a different response from the sea floor; sea-level fall causes erosion over much of the upper and lower portions of the shoreface and forms coarse shell lag deposits which, in the past, possibly covered much of the shoreface.

A hole formed by dredging of sand from off the ebb-tide delta was filled within a few years after dredging ceased.

Keywords coastal environment; sedimentation; shorelines; changes of level; erosion; dynamics; C-14; Holocene; dredging

INTRODUCTION

Omaha Bay lies in the moderately protected outer limits of the Hauraki Gulf, along the east coast 60 km north of Auckland, New Zealand. An inner, more protected portion of the bay is known as Little Omaha Bay (Fig. 1) which lies between the rock-bound headlands of Ti Point and Karamuroa Pt and is separated from the Whangateau Harbour by Mangatawhiri Spit. The latter consists of a parallel series of slightly dune covered beach ridges in the south, rising to foredunes in the north which are postglacial in age (Schofield 1973). Detailed mineralogical studies of this coastal area and the larger region of Northland (Schofield 1967, 1970) show that almost all of the sand deposited in Mangatawhiri Spit is marine in origin.

Quantitative assessments (Schofield 1975a) suggest that the movement of sand from the sea floor onto the coasts has resulted from the local, overall, first-order fall in sea level of 2.1 m in the last 4000 years or so. Furthermore, each separate phase of progradation is a quantitative function of the net fall in sea level between two successive, second-order, sea-level fluctuations (Schofield 1975b). However, the effects of sea-level change on the sea floor, and indeed the degree and nature of sedimentary transport on the sea floor, is little understood. Although the evidence presented here has resulted from a number of virtually unrelated investigations, it indicates that offshore sediments are far more mobile than is generally thought.

There has been a long-held view, still prevalent, that modern sea-floor sediment decreases in size away from the shore and that any coarser sediment at deeper levels is most likely relic from some previous low sea level. However, as Swift (1976) described, the decrease in grain size away from the shore is restricted to the upper shoreface which lies immediately seaward of the breaker zone, whereas grain size on the deeper but still active lower shoreface and adjacent shelf floor may be "far more variable and generally markedly coarser". To explain this situation, Swift visualised the coastal transport system "as two coast-parallel pipes, corresponding to the wave-driven littoral drift near the beach and the intermittent storm- or tide-driven sand flux that occurs on the shoreface and inner shelf seaward of the breaker zone. These two pipes are connected by valves, corresponding to the onshore-offshore cycle of sand exchange." ..."We do not have the measurement of onshore-offshore sand transport that would allow us to document the manner in which this system actually works".

The purpose of this report is to record evidence that supports the supposition that the coarse offshore belt found on the lower shoreface in Omaha Bay is a lag deposit, and is part of the modern hydraulic regime, and not a relic feature. This evidence is based on a number of radiocarbon dates and eight periods of sea-floor levelling surveys.

*Present address: Riley Consultants, P.O. Box 35163, Auckland 10.
†Present address: 43 Whakarite Rd, Ostend, Waiheke Island, New Zealand.

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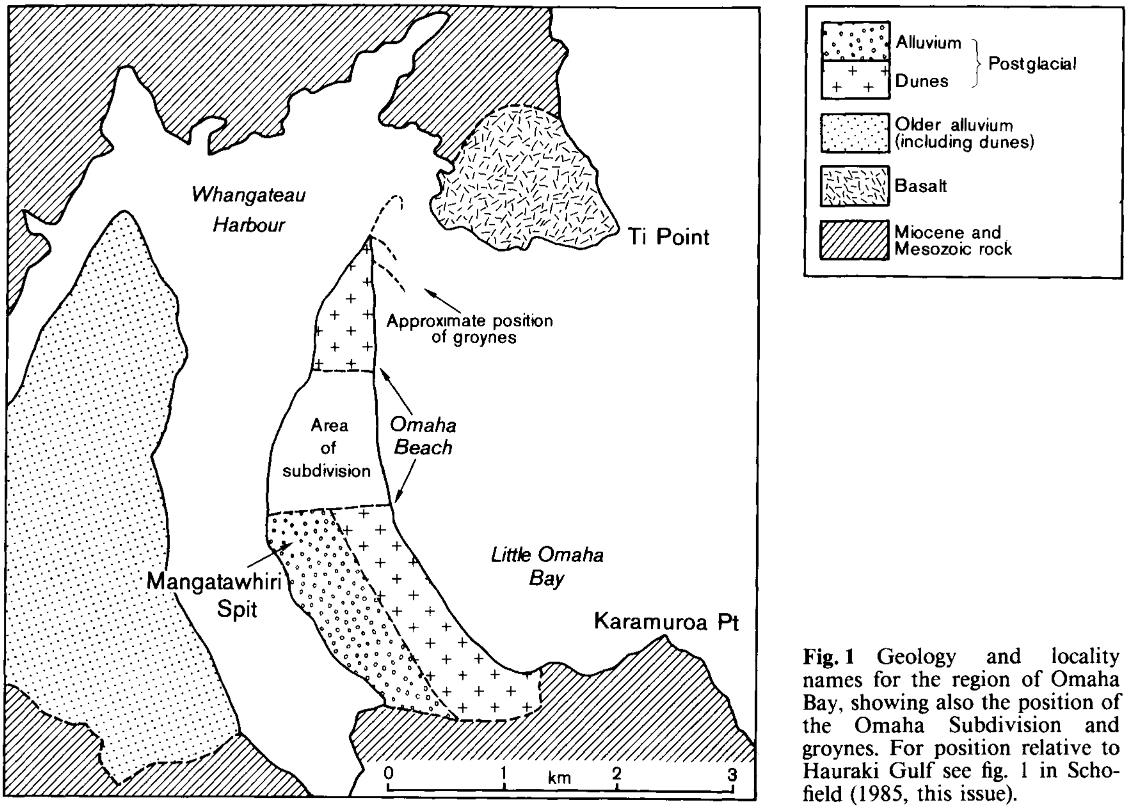


Fig. 1 Geology and locality names for the region of Omaha Bay, showing also the position of the Omaha Subdivision and groynes. For position relative to Hauraki Gulf see fig. 1 in Schofield (1985, this issue).

OFFSHORE OBSERVATIONS

Sea-floor surficial sediments

A cross section normal to Mangatawhiri Spit through the centre of Little Omaha Bay, and across the offshore coarse belt (Fig. 2, 3), shows that the sea floor consists of Swift's (1976) three major components—an upper shoreface, a lower shoreface, and an inner shelf. The upper shoreface tends to be concave and extends to a depth of about 10 m (about the same approx. limiting depth given by Swift (1976)). Its surficial sediment decreases in grain size away from the coast. It merges into the lower shoreface without any abrupt change in slope or grain size. Nevertheless, the lower shoreface differs, in that it is convex in its general outline, and the grain size increases towards its offshore flank away from its upper and lower limits.

Within the lower shoreface, the coarse offshore belt coarsens from medium sand to coarse sand off Tokatu and Ti Points. Its extension to deep levels off Tokatu Point could be analogous to the offshore gravel belt of eastern Otago, which lies at its deepest levels where the offshore currents are most restricted (Schofield 1976). There is a relatively abrupt change in slope where the lower shoreface meets the inner shelf. The latter is far less steep and is underlain by less well sorted silty fine sand.

Sea-floor subsurface sediments

During investigations by Beca, Carter, Hollings and Ferner in 1976, four shallow boreholes and a very shallow excavation (point A) were placed along a central profile in Omaha Bay (Fig. 2, 3). The holes were rotary drilled using a small drill stationed on the sea floor and a power-pack held in a boat above. Samples were collected, to almost 4 m below the present sea floor, by two methods — either rotating a "plug barrel" into the sediment, 0.2–0.5 m at a time, for bulk samples, or by pushing in a steel tube, 0.2–0.3 m at a time, in which the sample was held. At no time was casing used; the drillers were confident that the circulation of bentonite being pumped through a rotating fishtail bit in the hole, when it was not being deepened during sampling, was sufficient to stabilise the sides of the hole.

Description

Sample descriptions including shell content, median grain size, colour, and radiocarbon ages are sum-

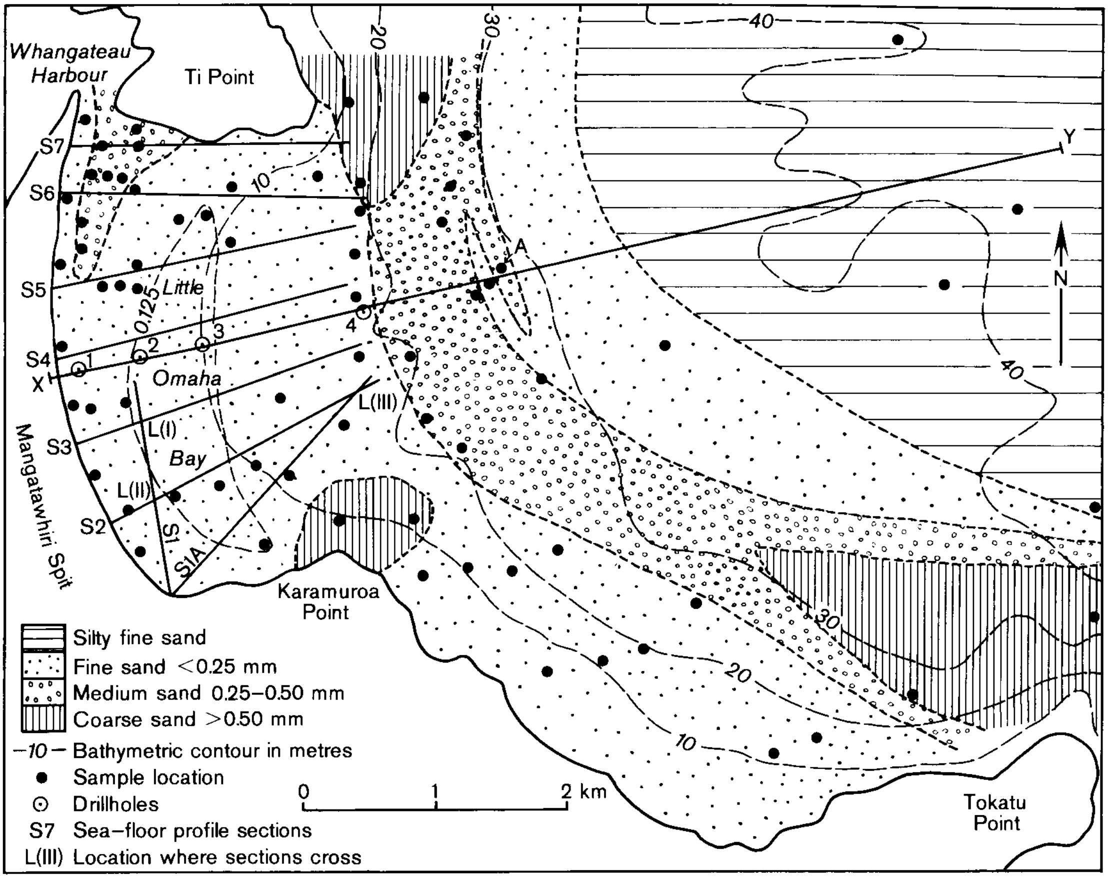


Fig. 2 Location of offshore sea-floor profile sections S1–S7, and cross section X–Y shown in Fig. 3. Region of finest sand within Little Omaha Bay is circumscribed by isomedian 0.125 mm. Offshore grain size distribution is based on samples collected during 1963 before enlargement of ebb-tide delta at entrance to Whangateau Harbour.

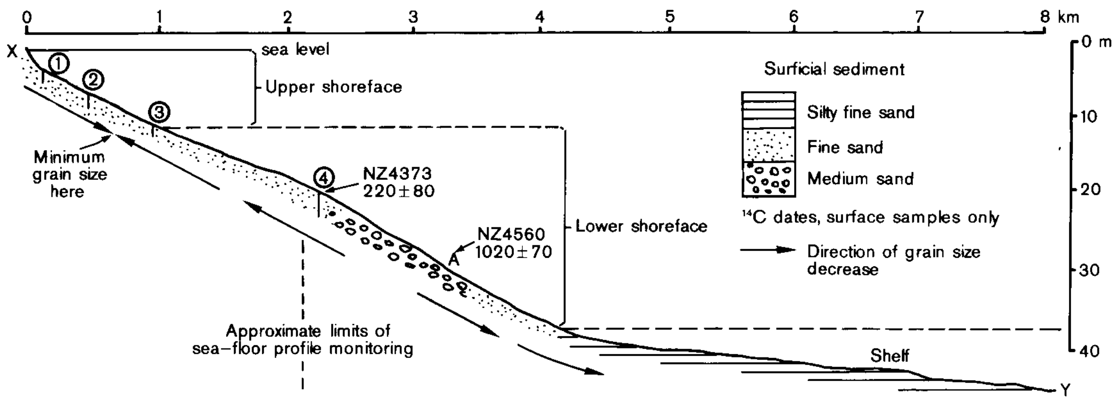


Fig. 3 Cross section X–Y across centre of Little Omaha Bay (see Fig. 2).

Table 1 Sediment sample descriptions from drillholes made across Little Omaha Bay. Drillhole locations are shown on Fig. 2.

Depth below sea bed (m)	Shell content: % > 1.6 mm	Shell content: Shape > 1.6 mm*	Shell content: Predominant species†	Shell content: *Tawera* size (mm)	Gravel: Content‡	Gravel: Max size (mm)	Median grain size (mm)	Colour of sediment§	^{14}C age B.P.
Drillhole 1 (−3.9 m)‖									
0	3.5	W	Z+T	27	O	–	0.13	G	
1.0	3.5	50/50	Z+T	27	O	–	0.14	G	
1.2¶	7.5	W	Z+T	24	R△	7.5	0.13	G	
1.7	30.0	F	Z+T	24	R△	5.0	0.16	G	2430±100
1.9	13.0	F	T+Z	26	O	–	0.13	G	(NZ4371)
2.2	35.0	F	T+Z	25	O	–	0.15	G	5390±60
2.4¶	1.0	50/50	T+Z	10	O	–	0.12	G	(NZ4562)
2.6	0	–	–	–	–	–	0.13	G	
3.1	2.0	F	T+Z	10	–	–	0.15	G	
3.7	4.5	F	Z	23	R	5.0	0.14	G	
Drillhole 2 (−8.02 m)‖									
0.3	< 1.0	W	T	20	O	–	0.11	G	
0.6	40.0	F	T	23	R	10.0	0.11	G	370±70
0.9	20.0	F	T	25	R	5.0	> 2.0	G	(NZ4372)
1.2	30.0	F	T	23	R	10.0	> 2.0	G	
1.4	44.0	F	T	23	R	10.0	1.1	B1	
1.7	30.0	F	T	23	O	–	0.14	B1	480±60
									(NZ4563)
2.2¶	14.0	F	T	23	R⊙	10.0	0.18	B2	120±70
2.7	9.0	F	T	22	R⊙	10.0	0.17	B1	(NZ4564)
3.1	6.0	F	T	24	O	–	0.15	B1	
3.4¶	5.5	50/50	T	25	R	5.0	0.15	B1	
3.7	9.5	F	T	25	R	5.0	0.14	B1	200±90
									(NZ4565)
Drillhole 3 (−11.4 m)‖									
0.1	0	–	–	–	–	–	0.12	G	
0.4	29.0	F	T	26	R	13.0	0.23	G	850±120
0.6	30.0	F	T	23	O	–	0.13	G	(WK88)
0.8	24.0	F	T	25	C⊙	20.0	0.48	G	2510±120
0.9¶	6.5	F	T	7	R	3.0	0.16	G	(WK89)
1.1	< 1.0	F	–	–	R	7.5	0.16	G	
Drillhole 4 (−19 m)‖									
0.0	4.5	W	T	24	R⊙	10.0	0.23	B1	220±80
0.6¶	17.0	W	T	29	R⊙	7.5	0.25	B2	(NZ4373)
0.9	8.0	W	T	24	O	–	0.18	B2	
1.2¶	7.5	50/50	T	25	C⊙	10.0	0.21	B2	300±30
1.7	3.5	F	T	24	C	10.0	0.18	B1	(NZ4374)
2.4	11.0	50/50	T	25	C⊙	20.0	0.15	G	250±60
									(NZ4561)
Excavation A (−27.5 m)‖									
0.0	–	–	–	–	–	–	–	–	1020±70
									(NZ4560)
0.15	4.5	W	T	24	R⊙	10.0	0.34	B1	960±120
									(WK90)

*W = predominantly whole; F = predominantly fragmental; 50/50 = 50% W, 50% F.
†Z = *Zethalia zelandica*, T = *Tawera spissa*.
‡O = nil; R = rare; C = moderately common; △ = angular; ⊙ = very rounded.
§G = light grey; B1 = light creamy grey; B2 = light brown grey.
‖Depth of water with respect to Omaha Datum.
¶Clay content examined by X-ray diffraction analysis.

marised in Table 1. These show significant differences in the colour, age, and sorting of the sediment sampled from bores (1) and (3) and from bores (2) and (4) respectively. The youthfulness and slightly less well sorted nature of the sand samples from bores (2) and (4) suggest that they could be contaminated by the collapsing-in of sand from near the top of the holes. Further evidence for contamination of the bulk of the sand in bores (2) and (4) is shown by the creamy-brown tints of sediment confined to these holes, which, for the most part, is the same colour as the bentonite ("Rheogel-D") employed by the drillers. X-ray diffraction analyses of (a) "Rheogel-D", (b) marine-mud fraction from a sand in Omaha Bay, (c) clay fractions from bores (1) and (3), and (d) clay fractions from the creamy-brown tinted sediment in bores (2) and (4) confirm the presence of "Rheogel-D in (d) and its absence in (c). Thus, all the radiocarbon dates from bores (2) and (4), except for those at or near the surface, have been ignored in the following discussion.

Shellbeds from depths of 0.4 m and 0.8 m in bore (3) together with the lower sample in excavation (A) (Table 1) were examined by Dr M. Larcomb (Bioresearches Ltd.); and those from 1.7 m bore (1), 0.6 m bore (2), and from near the surface in bore (4) were examined by Dr A. Beu (New Zealand Geological Survey). Their faunas are consistent with an environment the same as that from which the samples were collected (i.e., a shallow-water, moderately exposed, sandy–gravelly, offshore sea floor).

Colour retention in shells ranges from 5 to 20% in the older shellbeds (those with dates of 2430, 2510, and 5390 years B.P.), to 30% in the 850 year old shellbed, to 95% in the 200 and 370 year old shells. However, 90% colour retention in the shell within the 1000 year old near-surface sediments of excavation (A) suggests that it may be related to the oxidation-reduction environment rather than to age.

Interpretation

Apart from the offshore coarse belt, the modern sediments on the floor of Omaha Bay contain only a few percent of coarse shell. The high percentages of coarse shell, as shellbeds interbedded with more normal sands in bores (1) and (3), and near the top of bore (2), could represent lag deposits in which fines have been winnowed during periods of low sedimentary supply.

Changes in sedimentary supply could arise from a number of environmental changes which, for the Omaha region, must be restricted to changes in the coastal marine regime — the size and mineralogical nature of the local hinterland precludes it from being the source of all but a minor portion of the coastal sediment (Schofield 1975a). Changes within the marine regime, of importance to local sedimentary supplies, are in turn restricted to longshore drift and sea-level change. The mineralogy of coastal sands throughout North Auckland (Schofield 1970) shows that longshore drift has been minimal along the east coast, including Omaha, and that there has been a resultant development of a number of localised, coastal, mineralogical sand facies. Hence, although there is still room for changing net directions of longshore drift that could have had important local effects, it is possible that the main control of sedimentary supply, on and off the sea floor, has been changes in sea level.

Evidence that sea-level changes could have been an important influence on long-term changes of the sea floor is found in the dates of the three shellbeds in bores (1) and (3) (Table 1) — namely, 850 $\pm$ 120, 2430 $\pm$ 100 to 2510 $\pm$ 120 (a mean of 2460), and 5390 $\pm$ 60 years B.P. (all dates in terms of $T\frac{1}{2}$ = 5730 years) — and the near-surface shellbed of 370 $\pm$ 70 years B.P. in bore (2). These four periods are more closely related to periods of regression than they are to marine transgression during the late Holocene, second-order, sea-level fluctuations (Fig. 4) and are thus evidence that the dated shellbeds could be lag deposits formed at times of low sea level (i.e., as sea level fell, the tendency would be for a winnowing action of the sea-floor sediments, with a consequent removal of the finer fraction).

The modern-day lag equivalent is restricted to the offshore coarse belt from which three radiocarbon dates have been obtained — namely, near-surface samples from excavation (A) on the downslope side of the offshore coarse belt at a depth of 25 m (Fig. 3) which gave ages close to 1000 years B.P. (Table 1), and a surface sample from bore (4) on the upslope side of the offshore coarse belt that gave a date of 220 years B.P. (Table 1). As Northland has been stable in at least the last 4000 years (Schofield 1973), there is no way in which the offshore coarse belt could be a 1000 year old beach submerged to a depth of 25 m or more. The offshore coarse belt is thus interpreted as a lag that is currently developing within the late Holocene hydraulic regime, and that could become more widespread if sea-level began to fall rather than continue its present rise. In fact, the offshore coarse belt has probably had a complex history of development related to a first-order fall in sea level as well as to second-order changes that may have given rise to the 370, 850, 2460, and 5390 year old shellbeds. Thus, the older portions of the present-day offshore coarse belt have probably been under continuous development since the beginning of the first-order fall in sea level — as distinct from the shorter periods of time in which the second-order

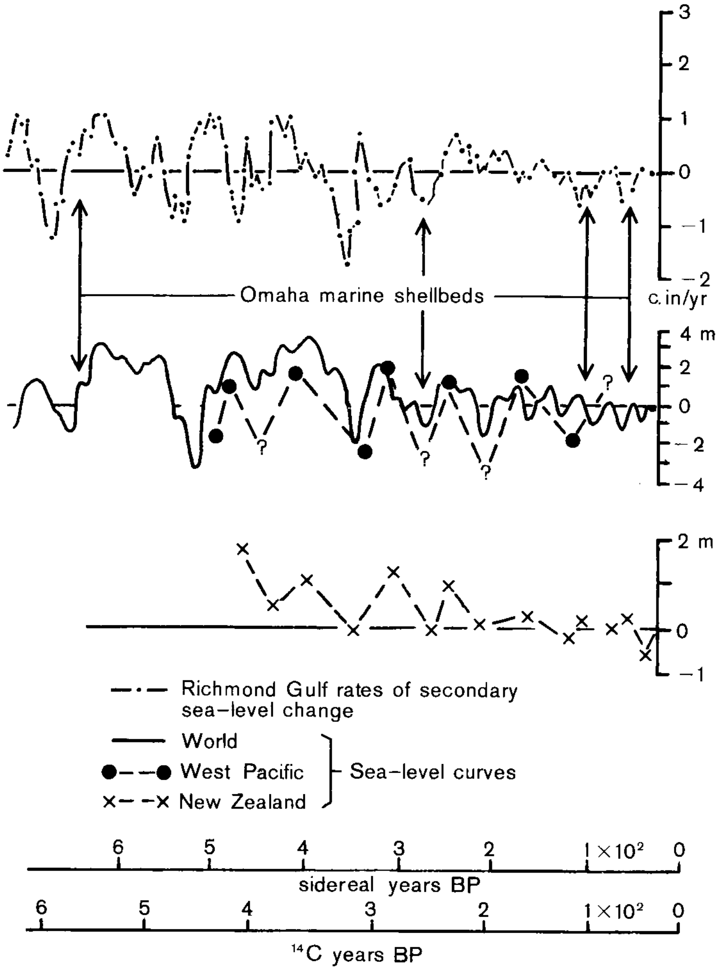


Fig. 4 Relation of the Omaha shell dates to local and world sea-level fluctuations. The world sea-level curve and the Richmond Gulf rates of secondary sea-level change are after Hillaire-Marcel & Fairbridge (1978): the West Pacific and New Zealand curves are from Schofield (1980).

sea-level falls gave rise to the buried shellbeds on the upper parts of the shoreface — and the 1000 year dates for parts of the present-day offshore coarse belt could represent an average of several thousand years of development. For further discussion see Schofield (1985, this issue).

Offshore surveys, 1980

Except for profile section 1A, the offshore surveys (Fig. 2) form continuations of the concurrently surveyed beach sections. The beach sections are at right angles to the coast, but profile section 1 lies at the hooked southern end of the beach, and its offshore continuation more or less parallels the main trend of the beach (Fig. 2). Hence, profile section 1A (Fig. 2) acts as a replacement. The offshore profile sections were surveyed by Murray, North and Monro out to the limits of Little Omaha Bay beyond which there is less shelter and it is more difficult to obtain accurate depth recording and keep on the line of section. However, all sections consistently crossed the central zone of fine sand which lies between the two coarser belts of sand — one lying inshore, close to and parallel to the beach, and the other offshore, extending across the mouth of Little Omaha Bay.

Survey control for the offshore profile sections was made by three theodolites, one providing guidance along the line and two intersecting the transducer position in the boat. A Raytheon DE719B survey echo sounder was calibrated by bar check to 20 m before and after each set of profiles. Calibration was held and checked by frequency meter. For tidal reduction, a Foxboro automatic tide gauge was set up at Ti Point. An allowance for tidal slope between Ti Point and the bay was derived by measurements over both spring and neap tides.

Accuracy

One possible source of error could arise from changing sea-surface slope related to changing tides. Figure 5 illustrates the difference in tidal level between tide gauges established at the Ti Point wharf, just inside the entrance to the Whangateau Harbour (datum) and the landward end of profile section 6 not far outside this same entrance. Between these two gauges there is a maximum difference of 0.3 m during a high mid spring tide. Another tide gauge set up at the southern end of the beach showed little difference between it and the profile section 6 gauge. This means that the greatest differences occurred where they would be expected, in the restricted entrance to the harbour. Except for the early surveys of February and March, this possible source of error was minimised by having the surveys conducted as closely as possible to high tide. From April onwards, corrections made for this tidal slope were seldom more than 0.05 m and never greater than 0.12 m. Internal checks for accuracy have been provided by the crossing of profile sections during the January, February, and March surveys (Fig. 2 and Table 2) and a check survey line that cut across profile sections 2, 3, 4, 5, 6 and 7 in September (Table 3). These 10 checks show a difference of less than 0.05 m, except for an 0.10 m difference in January. Further checks were provided at times when the onshore beach and offshore sections joined at low tide, and also by consistency in patterns of progradations or erosion shown by all sections both spatially and temporally. These latter checks show an unexplained error of 0.2 m in the March profile sections 1A, 2 and 3. When not taken into account, this error causes the southern half of the bay to appear to be substantially more prograded during the February–March interval than the northern half of the bay; also, as a result of the same error, the southern half of the bay during March–April appears to be

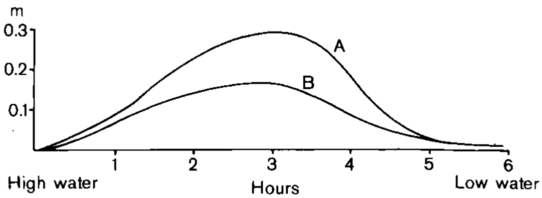


Fig. 5 Differences in tidal levels between gauges at Ti Point wharf and at the beach end of profile section 6 during (A), a high spring tide of 7 April 1981, and (B), a moderately high spring tide of 11 November 1980.

Table 2 Locations levelled on more than one offshore section.

Location (see Fig. 2)	Level below Omaha datum on section (1)	(1A)	(2)	(3)	Dates
L(i)	8.5	—	—	8.55	29 Feb 1980
L(ii)	6.25	—	6.15	—	23 Jan 1980
L(ii)	6.40	—	6.40	—	29 Feb 1980
L(iii)	—	17.9	17.9*	—	21 Mar 1980

*Projected 154 m along curve of sea-floor profile section.

Table 3 Omaha Beach check survey line results, 18 September 1980.

Profile section no.	Depth at intersection with check survey line*	Time (1)	Depth at intersection with check survey line*	Time (2)	Difference (m)
2	6.15	HW+1h 05min	6.20	HW+1h 50min	+0.05
3	8.35	HW+45min	8.40	HW+1h 53min	+0.05
4	8.10	HW	8.05	HW+1h 56min	−0.05
5	7.50	HW−35min	7.45	HW+2h 00min	−0.05
6	4.90	HW−1h 05min	4.90	HW+2h 05min	0.0
7	1.50	HW−1h 25min	1.45	HW+2h 09min	−0.05

*In each case, the same line formed the northern continuation of beach profile 1.

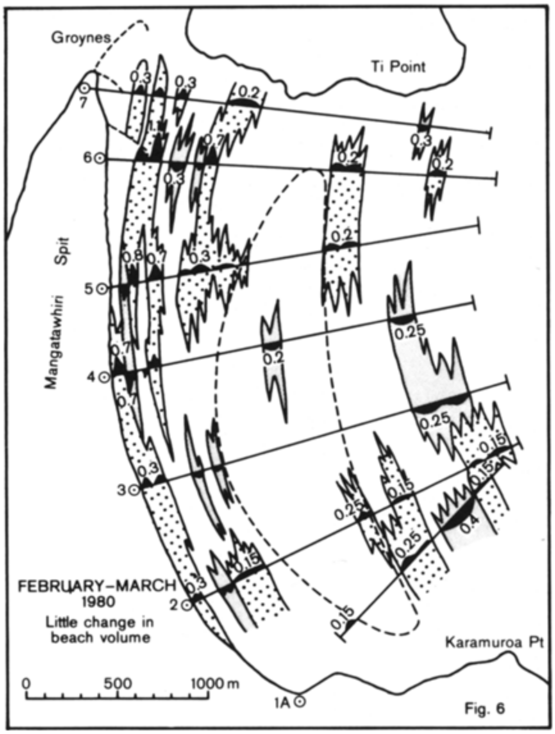


Fig. 6

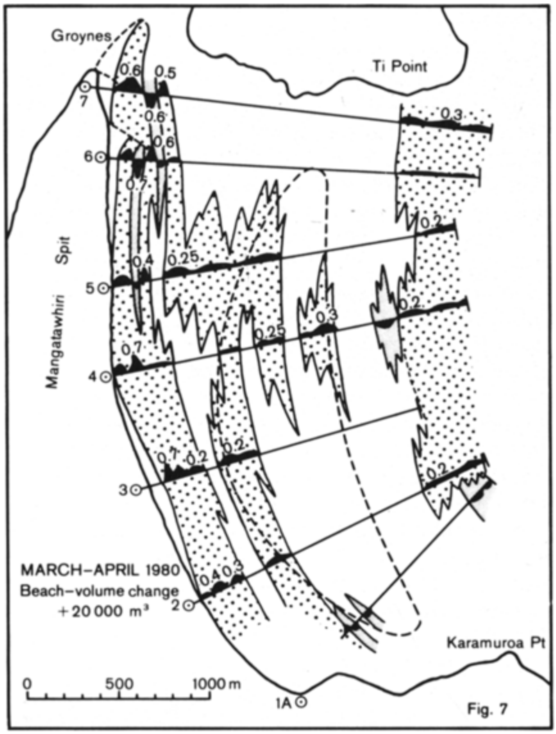


Fig. 7

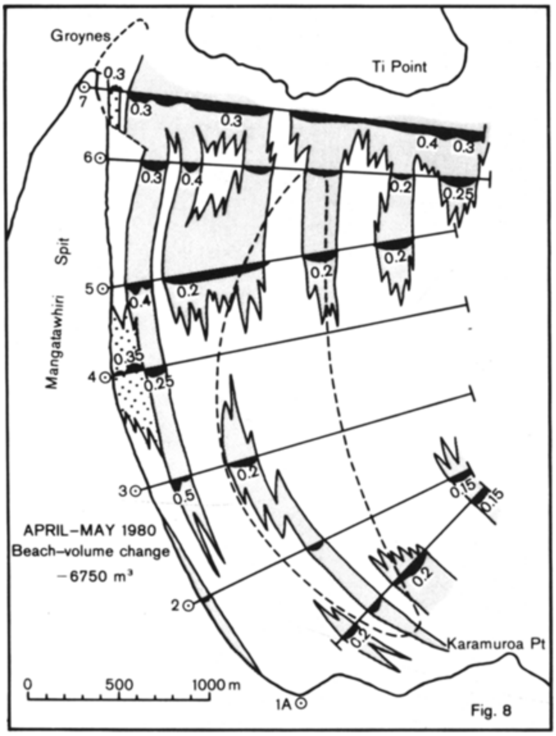


Fig. 8

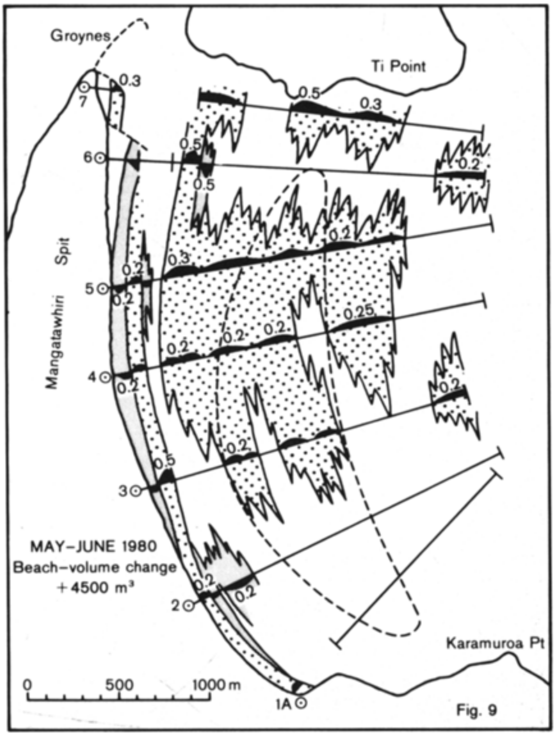
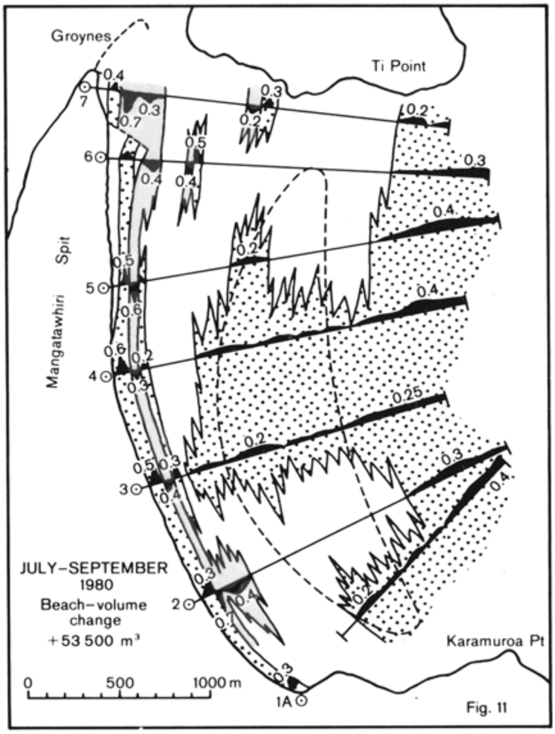
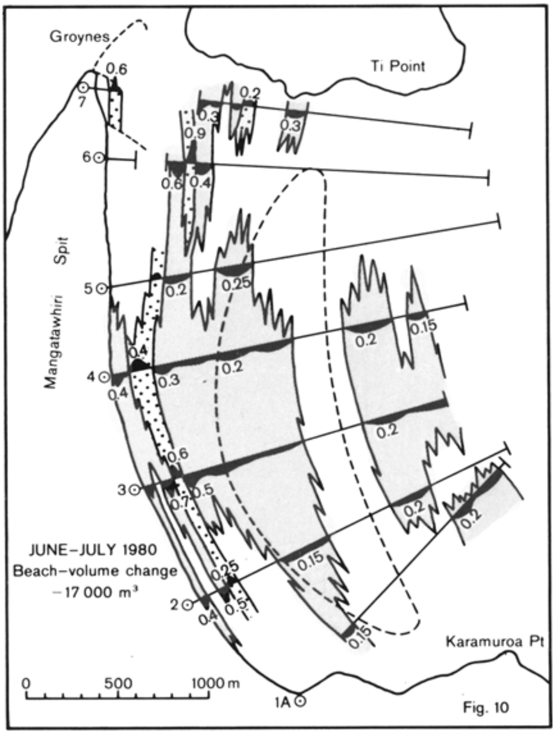


Fig. 9





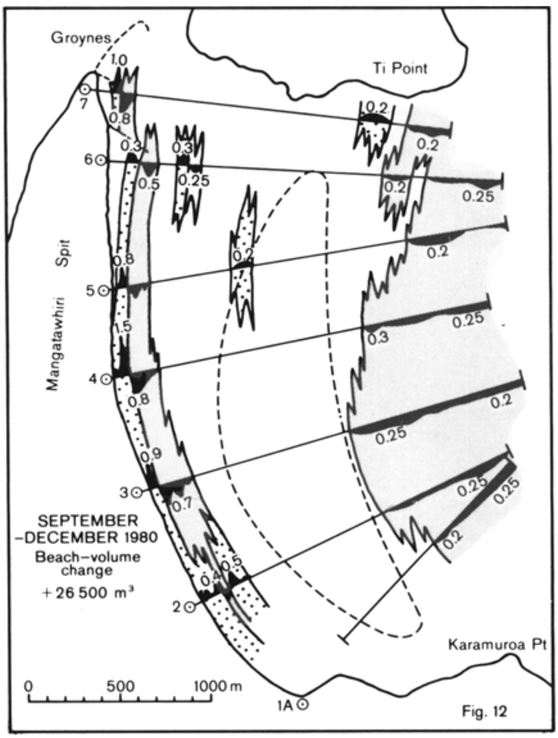


Fig. 6–12 *(this and opposite page)* Approximate changes along beach and offshore sea-floor profile sections. Degree of buildup in metres is shown above each sea-floor profile whereas erosion is shown below; approximate areas of progradation are dotted, those for erosion are shaded. The finest sea-floor sand lies within the dashed line in the central portions of Little Omaha Bay and separates the inshore from the offshore coarse belts (see Fig. 2).

eroded in contrast to the progradation of the northern half. Corrections by −0.2 m for the March profile sections 1A, 2 and 3, corrects both these inconsistencies and at the same time further corrects the low-tide overlap of the onshore and offshore profile sections. (This latter amounted to a discrepancy of 0.45 m; 0.26 m being due to tidal slope and 0.2 m being due to this unexplained cause. These discrepancies occurred close to a mid spring tide and the unexplained 0.2 m difference could have a tidal origin. Further research is required with tide gauges set along the more exposed portions of the beach as well as at both ends).

Offshore changes, 1980

In comparing one period of offshore survey with another, the total error could be twice 0.1 m (i.e., 0.2 m). Thus, in the sea-floor change sketches in Fig. 6–12, only changes that are 0.2 m or greater

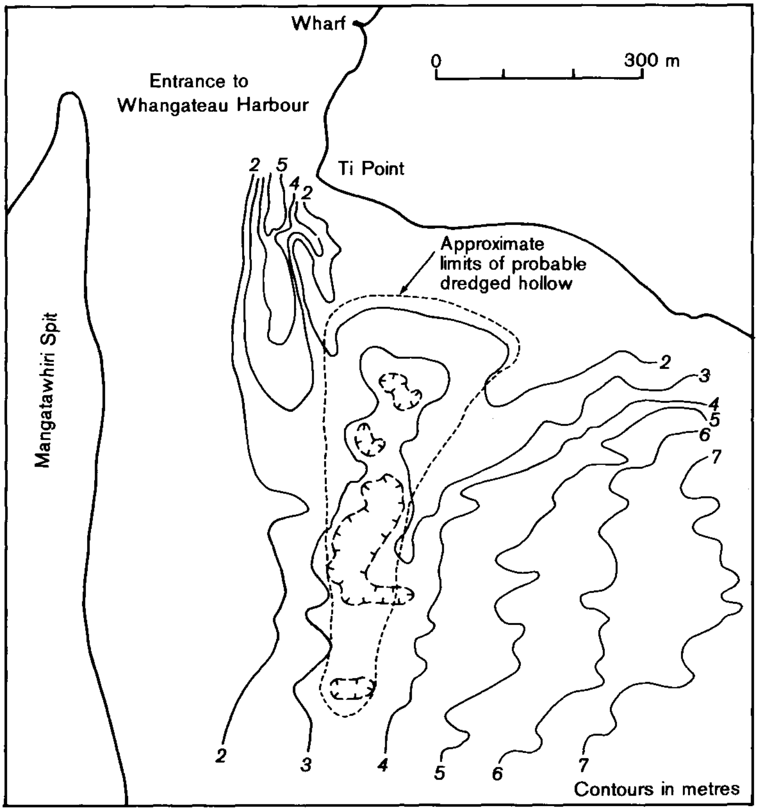


Fig. 13 Figure of ebb-tide delta based on a Royal New Zealand Navy chart for which the soundings, below approximate low tide level, were done in January 1963. The soundings, given to the nearest feet, are not shown but were closely spaced throughout most of the area shown in this figure. Dashed contours enclose regions slightly deeper than 3.5 m and lie within the probable dredged hollow.

Table 4 Storm events at Omaha Bay during 1980.

Date (1980)	Max. wind gust (A)*	Max. wind gust (B)*	Direction at (A)	Wind run at (B) in kilometres	Days of easterly conditions	Tide height at (A) in metres
14 Dec	45	43	ENE	1183	5	3.65
15 Mar	57	41	E	821	2	3.38
6 Apr	31	?	E	550	2	3.10
30 Jun	50	42	NE	785	2	3.30
5 Oct	41	42	ESE	844	3	2.95

*(A) = Auckland 50 km south of Omaha; (B) = Leigh 10 km north of Omaha.

are taken into account. Apart from some substantial close-inshore changes down to depths of approximately 3 m below low tide, the offshore changes are rarely greater than 0.2 m, and thus may not be significant. An exception occurred during the July–September period when there appeared to have been a consistent progradation of 0.3–0.4 m at depths of 15 m and more across the entrance to Little Omaha Bay (Fig. 11). This progradation diminished to 0.2 m or less as it crossed the centre of the bay, the main movement being towards the south of centre of the beach. It coincided with the most sustained period of coastal progradation during the 1980 period of beach observation and with a lack of easterly storms (see Table 4). It is also comparable to the June 1963 period of progradation which, from other evidence (Schofield 1967), also appeared to have penetrated across the bay, the primary movement being similarly towards south of centre of the beach.

This suggested buildup of 0.3–0.4 m on the sea floor shorewards of the coarsest part of the offshore coarse belt (see position of latter relative to limit of offshore sections, Fig. 3), and at depths of 15

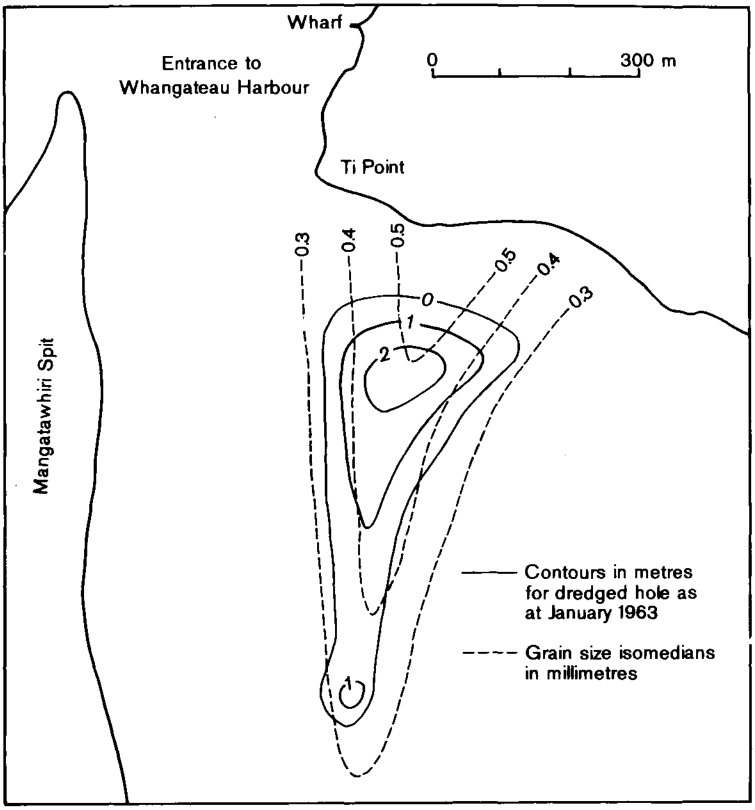


Fig. 14 Dredged hole within ebb-tide delta as at January 1963, based on data given in Fig. 13, shown in relation to grain size isomedians.

m+, agrees with the visual observations recorded for sea-floor changes off the coast of Whangarei which lies along the east coast of Northland not far north of Omaha. The coast of Whangarei is more exposed than that at Omaha, and offshore sedimentary transport is likely to occur at deeper levels. Iron rods that Gillie (1979) set at 18 m depths on the seabed of the open coast off Whangarei showed a sea-floor change of up to 0.14 m during the first 4 months of 1977. From this and other considerations, Gillie concluded that gravels on the sea floor at 30–50 m depths are "at least palimpsest and may be more correctly termed modern, because of the degree to which contemporary inner shelf processes are determining sediment characteristics".

EBB TIDE CHANGES 1963–78 AND EFFECT OF DREDGING

Sand for building uses should preferably have a median grain size above 0.3 mm (Schofield & Woolhouse 1969). The only area in which sand of this coarseness lies at shallow depths within Little Omaha Bay occurs as a bar outside the entrance to Whangateau Harbour where dredging is recorded (Beca, Carter, Hollings & Ferner Ltd 1976). Contours at metre intervals on a 1963 New Zealand Navy Sounding chart (Fig. 13) show a hollow of about 1–2 m depth, roughly 3 m below low tide or 5–6 m below high tide, which is the depth recorded at which dredging took place.

By making use of the contour trends shown in the 1963 survey (Fig. 13), it is possible to draw theoretical contours that would most likely have existed if there had been no dredging, and hence construct the probable nature and size of the dredging hole (Fig. 14) and determine the volume of missing sand. This amounts to about 60 000 m^3 or the volume of sand recorded as being dredged from Omaha during the 3–4 years prior to January 1963, the date when soundings were taken.

A repeat sounding survey in 1978 shows that, between 1963 and 1978, this dredged hole had been naturally infilled, and there followed the growth of the ebb-tide delta on the seaward side of the northern end of the spit and on the ocean side of the entrance to Whangateau Harbour. Differences in

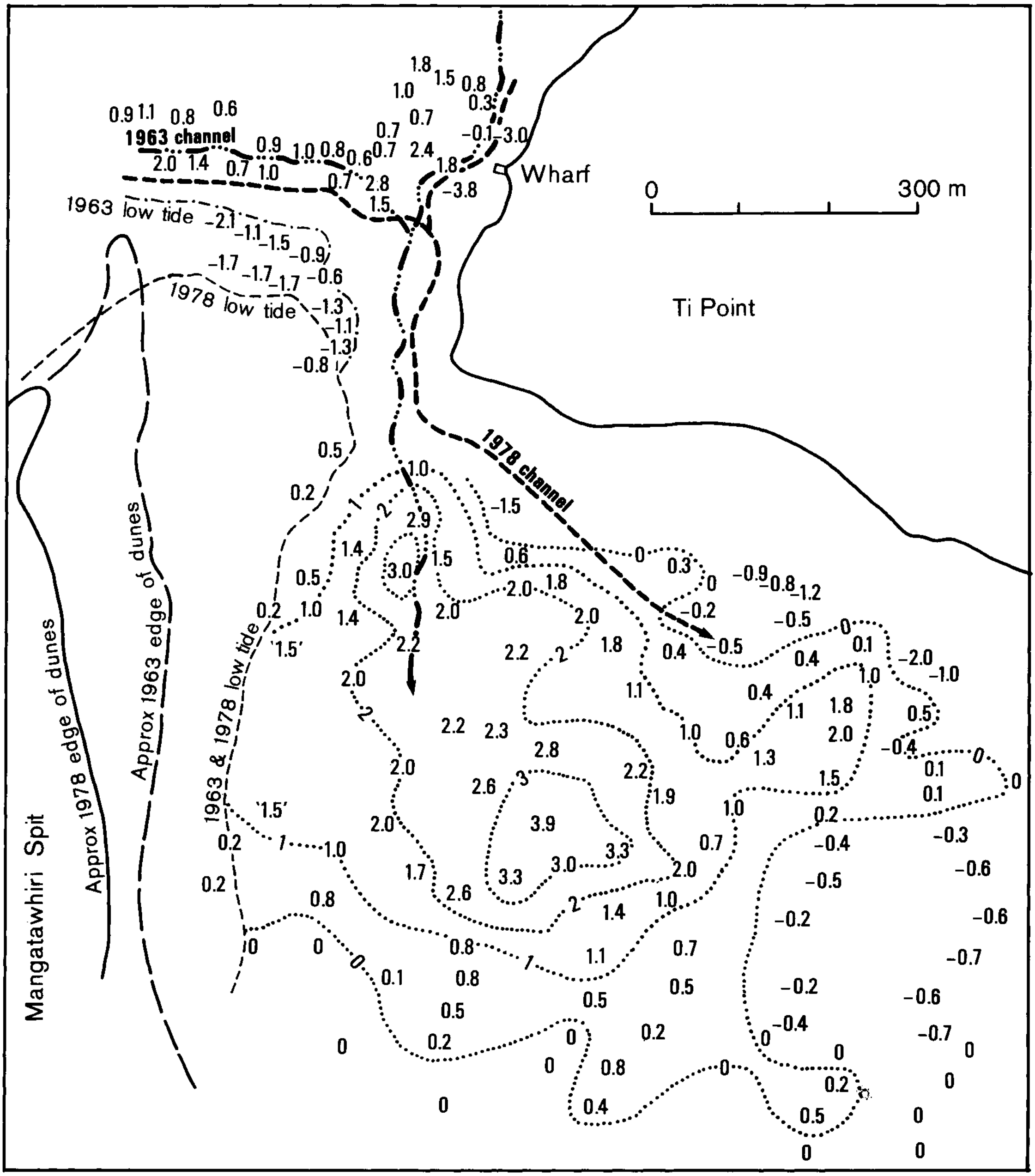


Fig. 15 Isopachs in metres on ebb-tide delta as developed between 1963 and 1978.

the 1963 and 1978 sounding charts enable an isopach map to be produced for the thicknesses of the sand added to this ebb-tide delta sometime between 1963 and 1978 (Fig. 15). These thickness isopachs show that the added volume of sand during this period was 450 000 m³ ± 80 000 m³ (80 000 m³ being the volume represented by a plus or minus change in sea-floor level of 0.2 m — the average change in sea-floor level measured by the 1980 offshore surveys over the ebb-tide delta (see above)).

CONCLUSIONS

Effect of dredging

The hole formed by dredging of sand from the sea floor, and as measured in January 1963 towards the end of 21 years of dredging, represented only about 3 years of dredging. Thus, this hole was completely infilled within a few years after dredging ceased, since when it probably had little or no direct effect on the local sand system.

Offshore coarse belt

Along at least parts of the western and eastern coasts of the Auckland–Northland region, and the eastern Otago coast (Schofield 1975a, 1976), an offshore coarse belt appears at different depths ranging from a few metres to 100 m depending on coastal wind and wave exposure. That there is more or less consistent movement of sediment within the offshore belt seems clear from the above evidence and from supportive evidence at other localities (Schofield 1976; Gillie 1979; Willoughby 1981). That it is probably a lag deposit and not a relic beach is supported by the 1000 year old shell samples from the downslope portion of the offshore coarse belt within Omaha Bay (Fig. 3); this age is probably a mean of shells concentrated over a period of time greater than 1000 years.

Local coastal changes relative to sea-level change have been described in a number of publications including the 1980 beach-volume changes (see fig. 7 in Schofield 1985, this issue). Sea-floor behaviour, as shown by the sea-floor profile surveys, suggests that the offshore coarse belt reacts similarly to the inner coarse belt and associated beach. This is most clearly shown during the major period of coastal progradation leading to the coastal addition of 53 500 m^3 between July and September 1980 (Fig. 11), a quiescent period for easterly storms (Table 4). At this time there was the expected dry beach buildup, together with marked sea-floor erosion immediately off the beach. Also at this time, there was a marked sea-floor buildup of 0.3–0.4 m across the mouth of Omaha Bay (Fig. 11) (i.e., upslope of the central coarsest portion of the offshore coarse belt). This appears to be analogous to the beach buildup further up the slope. A concomitant loss at depths below the central portion of the offshore coarse belt would be expected but the offshore profile sections did not extend to these depths. Sea-floor changes between other periods of sea-floor surveys show similar trends for the inshore and offshore coarse belts. Thus, in the March–April and May–June intervals (Fig. 7 and 11), when there were additions to the beach of 20 000 and 4500 m^3 respectively, the sea floor is prograded except for a narrow belt close to the beach; and during the April–May and June–July intervals (Fig. 8 and 10), when the beach was eroded by 6750 and 17 000 m^3, there is erosion of the sea floor, except for a narrow strip close to the beach, particularly well developed during the period of greater coastal erosion (Fig. 10).

The February–March 1980 interval (Fig. 6) was a period of coastal stability and, at this time, the offshore changes show no definite pattern. The only period of apparent anomalous sea-floor change occurs between September and December (Fig. 12). This was a period of continued coastal accretion following on from the July–September accretion, and the sea-floor surveys clearly show the expected narrow inshore belt of erosion at this time as the low-water bar lost sand to the beach. However, they also show that the upslope portion of the offshore coarse belt was being eroded instead of being built up. This apparent anomaly may be explicable in relation to sea-level change, as follows.

Figure 7 in Schofield (1985, this issue) shows that with sea-level rise during 1980 there is coastal erosion, whereas with sea-level fall during 1980 the coast is prograded. However, the relationship is not a direct one but is the sum effect of sea-level change over a period of time. Thus, this same figure shows that the best correlation of coastal change is with either a running four-monthly mean for sea-level change, or the cumulative departure from the sea-level monthly average, both of which represent an averaging out of past sea-level events. This lag between cause and effect may be less for the offshore coarse belt than it is for the inshore beach, and the lag in beach changes could be a result of this. Thus, although the four-monthly running mean shows a continuation of sea-level fall from September to December when there was coastal progradation, in actuality, sea level had risen in this time (fig. 7 in Schofield 1985). This actual rise many have had a more immediate effect on the offshore coarse belt, causing erosion on its upslope side, with some of this eroded sediment being moved inshore to promote continued coastal progradation.

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