Shoreline Monitoring in Tory Channel and Queen Charlotte Sound

FINAL REPORT

April 2000 – April 2002

Report prepared for the Marlborough District Council

by

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in association with
Auckland UniServices Ltd

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1. Introduction

In an agreement between Marlborough District Council and Auckland UniServices Limited, dated 25 January 1997, Auckland Uniservices Ltd, was engaged to establish and report on a shoreline monitoring programme in Tory Channel and Queen Charlotte Sound. Initially, the programme was for three years, involving six sets of surveys. Progress reports were provided every six months (following a survey of shoreline profiles), concluding with a final report in December 1999. The programme was then extended through to April 2002 with a further five surveys. This is the final report for the period beginning with the survey of April 2000 and is accompanied by the fifth progress report, detailing the final survey in April 2002.

Ayson and Partners, Surveyors, of Blenheim, have undertaken the surveys.

2. Purpose of the monitoring programme

Following the introduction of fast ferry services between Wellington and Picton in late 1994 there was considerable debate as to the effects of the fast ferry operation on the shorelines and the biota of Tory Channel and Queen Charlotte Sound. One particular area of concern was beach change, particularly erosion of beaches. Considerable data were produced, and interpretations made by a range of experts at a Planning Tribunal hearing in March and April 1995, culminating in a decision (Decision W 40/95) dated May 1995.

Over the summer of 1995/96, Auckland UniServices Ltd was contracted by the Marlborough District Council and the Department of Conservation to measure and report on wake characteristics, establish and report on a series of beach profiles, and undertake some basic sediment tracing experiments. The results were reported by Parnell, “Monitoring effects of ferry wash in Tory Channel and Queen Charlotte Sound”, in April 1996. The study included the monitoring of 13 profiles over the period 8 November 1995 to 29 February 1996.

The present monitoring programme began in April 1997. Surveys were scheduled to follow the end of the fast ferry operating season at Easter, and to precede the summer operating season in December. Since that time, the different summer and winter operating schedules have been abandoned, with more consistent operating regimes. However, the surveys have continued to be planned in April and November, although some surveys have been outside this time frame (notably June 2001).

Apart from the issues related to vessel wakes, there is poor understanding of how beaches in the Marlborough Sounds behave. Therefore, beaches of a range of types have been included in this study.

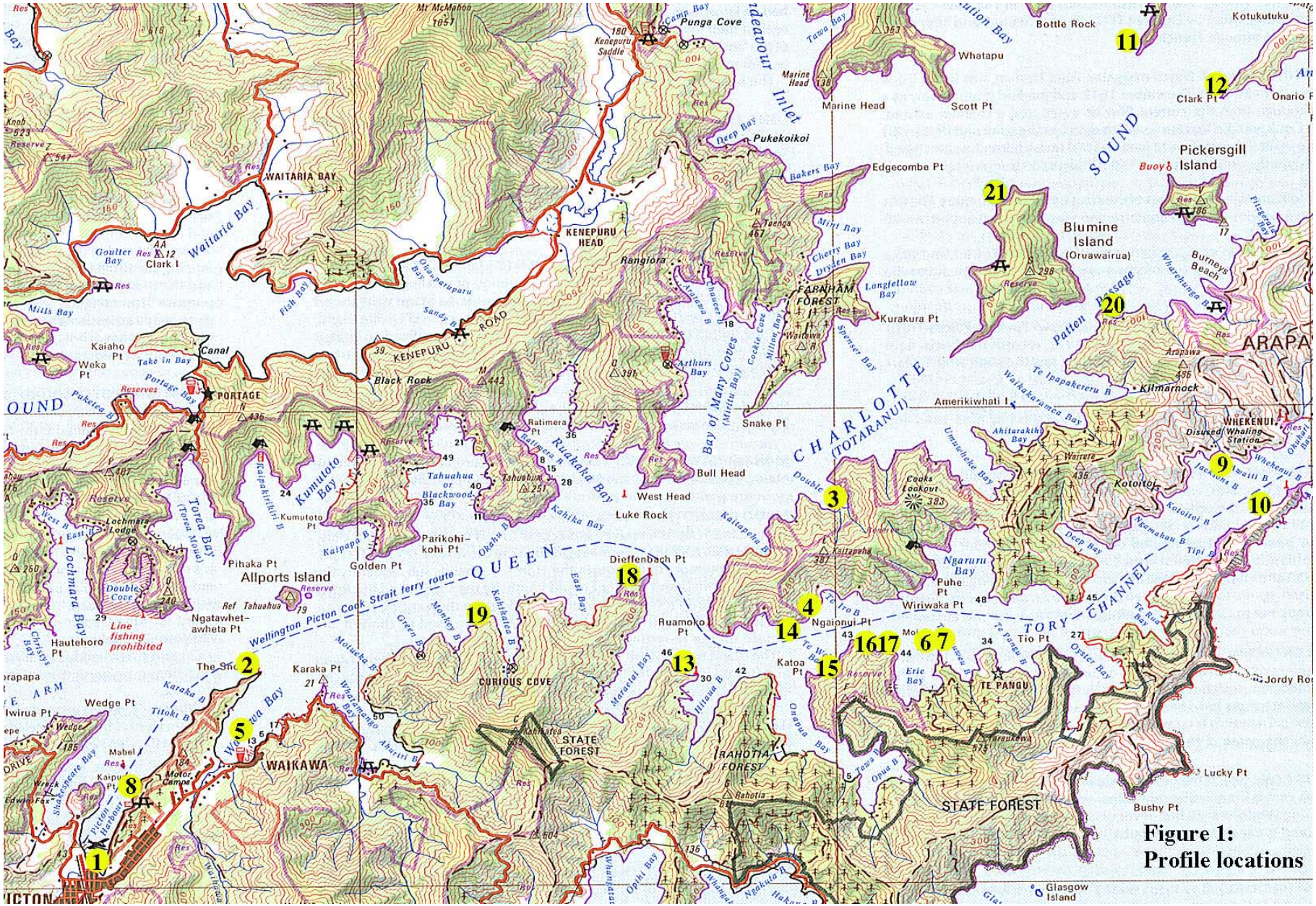
3. Profile locations and methods

Details of the selection of survey sites, establishment of profiles, benchmarks and datums, and survey methodology are in the final report of the first contract period. Profile descriptions are also in that report. The location of the 21 profiles is shown in Figure 1. Details of the locations of the profiles are in Table 1. Positions are in terms of the GPS ellipsoid (WGS84). A list of current datum levels is in Appendix 1. A visual impression of the profiles can be obtained from the photographs in Section 5 and in Appendix 2.

Table 1: Profile Locations

Pr	Name	Lat °	Lat '	Lat "	Long°	Long '	Long "
1	Picton Foreshore	41	17	17.6	174	0	25.1
2	The Snout at Picton Point	41	15	46.5	174	2	10.9
3	Double Bay	41	13	10.3	174	11	36.7
4	Ngaionui Bay (C Thomas)	41	14	16.5	174	11	8.5
5	Blackmore's at Waikawa	41	15	50	174	2	58.2
6	Moioio Island 2	41	14	39.4	174	12	56.9
7	Moioio Island 1	41	14	39.6	174	12	56.3
8	Bob's Bay	41	16	31.3	174	1	1
9	Te Awaiti	41	12	28.8	174	17	16
10	Tipi Bay	41	13	40.2	174	17	12.8
11	Long Island	41	7	22.3	174	16	12.6
12	Clark Point	41	8	12.6	174	17	30.7
13	Slip Beach	41	15	0	174	9	8.3
14	Ngaionui Point	41	14	27.6	174	10	46.2
15	Te Weka Bay	41	14	58.3	174	11	34

16 McMillan's Bay	41	14	45.5	174	12	11.4
17 McMillan's Side	41	14	43.5	174	12	9.6
18 Dieffenbach West	41	14	13.4	174	8	9.4
19 Curious Monkey	41	14	28.8	174	6	14.4
20 Patten's Passage	41	10	56.9	174	15	47.4
21 Blumine Island	41	9	37	174	14	4.4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21
WAITARIA BAY
KENEPURU HEAD
Punga Cove
Pukekoikoi
Edgecombe Pt
Whatapu
Marine Head
Scott Pt
Bottle Rock
Kotukutuku
Clark Pt
Pickersgill Island
Blumine Island (Oruawairua)
Burneys Beach
ARAPAWA
Kilmarnock
Kurakura Pt
FARNHAM FOREST
Rangiora
Black Rock
PORTAGE
Kaiaho Pt
Weka Pt
Canal
Amerikiwhati I
Snake Pt
Bay of Many Coves (Miritu Bay)
CHARLOTTE (TOTARANUI)
QUEEN
Wellington Picton Cook Strait ferry route
TORY CHANNEL
SOUND
Bull Head
West Head
Luke Rock
Ratimera Pt
Kumutoto Pt
Parikohi-kohi Pt
Golden Pt
Pihaka Pt
Allports Island
Ngatawhet-awheta Pt
Hautehoro Pt
Lochmara Bay
Torea Bay
Lochmara Lodge
Line fishing prohibited
Dieffenbach Pt
Ruamoko Pt
Ngaionui Pt
Puhe Pt
Wiriwaka Pt
Tio Pt
TE PANGU
Jordy Rock
Lucky Pt
Bushy Pt
STATE FOREST
RAHOTIA FOREST
CURIOUS COVE
Karaka Pt
Wedge Pt
WAIKAWA
Picton Harbour
Motor Camp
Mabel I
Glasgow Island
Figure 1:
Profile locations

4. Vessel operations affecting the profile sites

The Tory Channel and Queen Charlotte Sound route, carrying passengers and freight between Wellington and Picton, has been used for many years. In late 1994, two fast vessel operations (Condor 10 and Albayzin) started using the route complementing the conventional ferries (Arahunga, Aratika and Arahura). Over subsequent summers the Condor 10 operated the route between approximately the first week of December through to Easter. For the rest of the year the route was operated by conventional ferries only. A number of significant changes occurred in 1999. In February 1999 a new 'conventional' ferry (Aratere) began operation. On 4 May 1999 a new fast service operated by an INCAT design vessel (TopCat) commenced operation. The Condor 10 continued operation past its traditional service completion at Easter through to 12 July 1999. On 8 December 1999 (after the last survey of this report), the Condor Vitesse commenced operation replacing the Condor 10. Late in 2000 the TopCat service ceased, a larger vessel (InCat 057) replaced the Condor Vitesse, and one of the three conventional ferries (the Aratika) was withdrawn from service. In December 2000 the Marlborough District Council enacted a bylaw that had the effect of slowing fast ferries to 18 knots while in he Marlborough Sounds. The Bylaw did not apply to conventional vessels. Numerous other vessels of a variety of vessel types use the Tory Channel and Queen Charlotte Sound route.

5. Profile analyses

In this section data are presented for each profile and an interpretation of the changes that have occurred is presented. Each profile analysis is accompanied by figures which comprise three or four pages of figures. The first page has photographs of the profile site taken from about 20 meters each side looking back towards the profile line at the top, and at the bottom a diagram of profile lines at the start of the first contract (April 1997), the end of the first contract (November 1999) and the end of the current contract period (April 2002). The second page comprises a 'spaghetti' diagram showing the eleven surveys of the profiles (April 1997, November 1997, April 1998, November 1998, April 1999, November 1999, April/May 2000, November 2000, June

2001, November 2001 and April 2002) in the upper section, and in the lower section, a different view of the same data commonly known as an 'Excursion Distance Analysis'. For those profiles for which a longer term data set is available (those monitored by Kirk and Single, or by Parnell (1996)), a second set of figures showing the combined record is presented. The final page shows beach volume data (m^3 per linear meter of beach) presented as a graph and a table. The limits for the calculations are determined as shown in Figure 2 and Table 2. The upper beach limit was a point on the upper beach landward of any profile change (if possible) or at the upper limit of the profile measurement. Because changes at the lower beach can indicate erosion, a measurement based on elevation is appropriate. This was taken at profile closure depth if this was evident, or at a point which was reached by most profiles. Where a profile did not reach the chosen lower limit, a value was estimated based on linear extrapolation or on values measured before and after a missing data point.

Table 2: Volume calculation limits

Pr	Name	Upper beach limit (m)	Lower beach limit (m)
1	Picton Foreshore	6.9	-0.5
2	The Snout at Picton Point	0.0	2.7
3	Double Bay	-1.5	-1.0
4	Ngaionui Bay (C Thomas)	-2.0	-0.3
5	Blackmore's at Waikawa	2.3	-0.8
6	Moioio Island 2	-2.0	-1.5
7	Moioio Island 1	0.0	-1.5
8	Bob's Bay	0.0	-1.0
9	Te Awaiti	0.3	-1.5
10	Tipi Bay	0.0	-1.3
11	Long Island	0.0	-0.8
12	Clark Point	0.0	-0.3
13	Slip Beach	-1.0	-1.3
14	Ngaionui Point	-2.0	-0.8
15	Te Weka Bay	2.0	-1.5
16	McMillan's Bay	0.0	-0.8
17	McMillan's Side	-2.0	-0.8
18	Dieffenbach West	0.0	-0.5
19	Curious Monkey	0.0	-0.5

20	Patten's Passage	0.0	-0.5
21	Blumine Island	0.0	-0.5

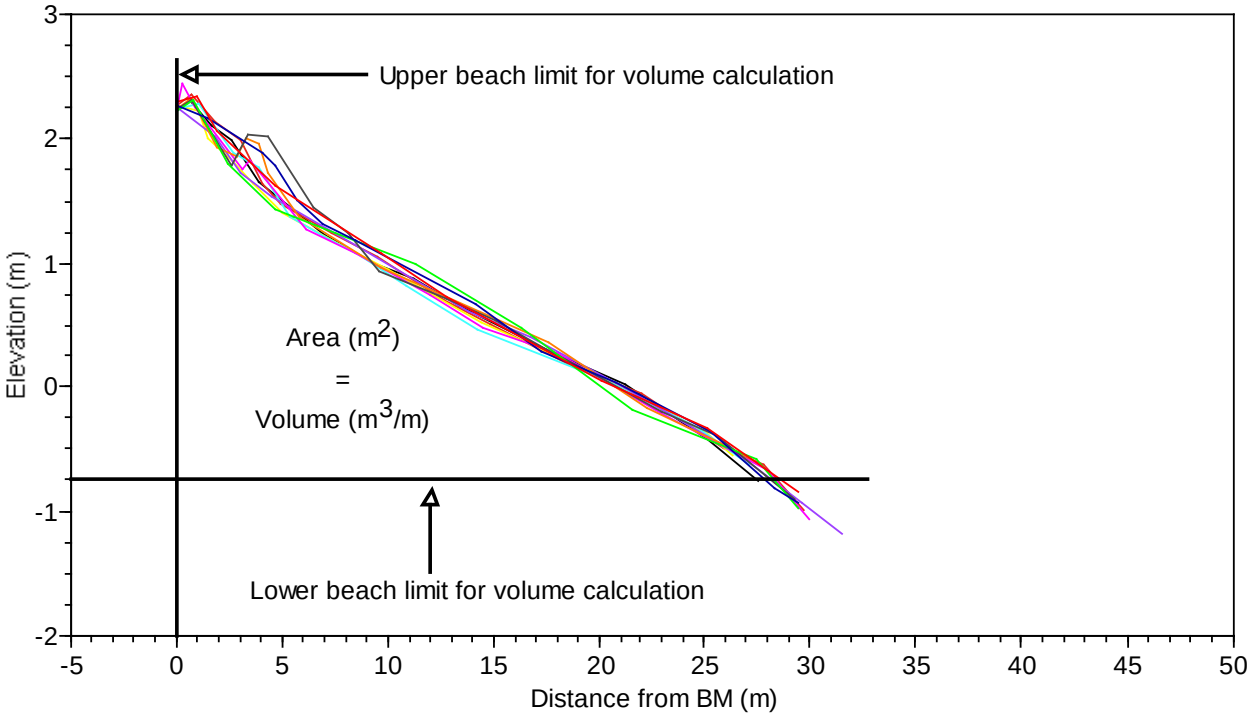


Figure 2: Volume calculation methodology

The 'spaghetti' plots of profiles are useful for establishing envelopes of change of the beach shape, but interpretations of changes which have occurred are difficult, due to the clutter of lines which are present. As the data set grows, any useful interpretation based on these plots becomes almost impossible. Excursion distance plots use exactly the same data plotted as a time series, and makes interpretation of beach changes easier. Excursion distance analysis is a method by which a three dimensional data set (distance, height and time) can be illustrated as two dimensional plots. It can be undertaken with either distance or height on the vertical axis, although having distance on the vertical axis is more useful for most purposes. Excursion distances are calculated by determining a set of height values for which calculations will be made. These values are normally equally spaced and for the following figures, are shown in the box on the right hand side of the graph. These numbers are in units of metres above or below the datum (in this case approximate MSL). Using linear interpolation the horizontal distance from the datum is calculated for each of the height values, and these are plotted as a time series with time on the horizontal axis. For each survey this provides a "point contour map" of the profile, and when plotted as a time series, an

indication of how levels change through time. The graphs provide a lot of information. If two lines converge, the beach is getting steeper at those contour heights. If two lines diverge, the beach is getting flatter. If the lines trend seaward (increasing values on the distance axis), the beach is accreting. If the lines trend landward, the beach is eroding. Figure 3 attempts to show the methodology of Excursion Distance Analysis.

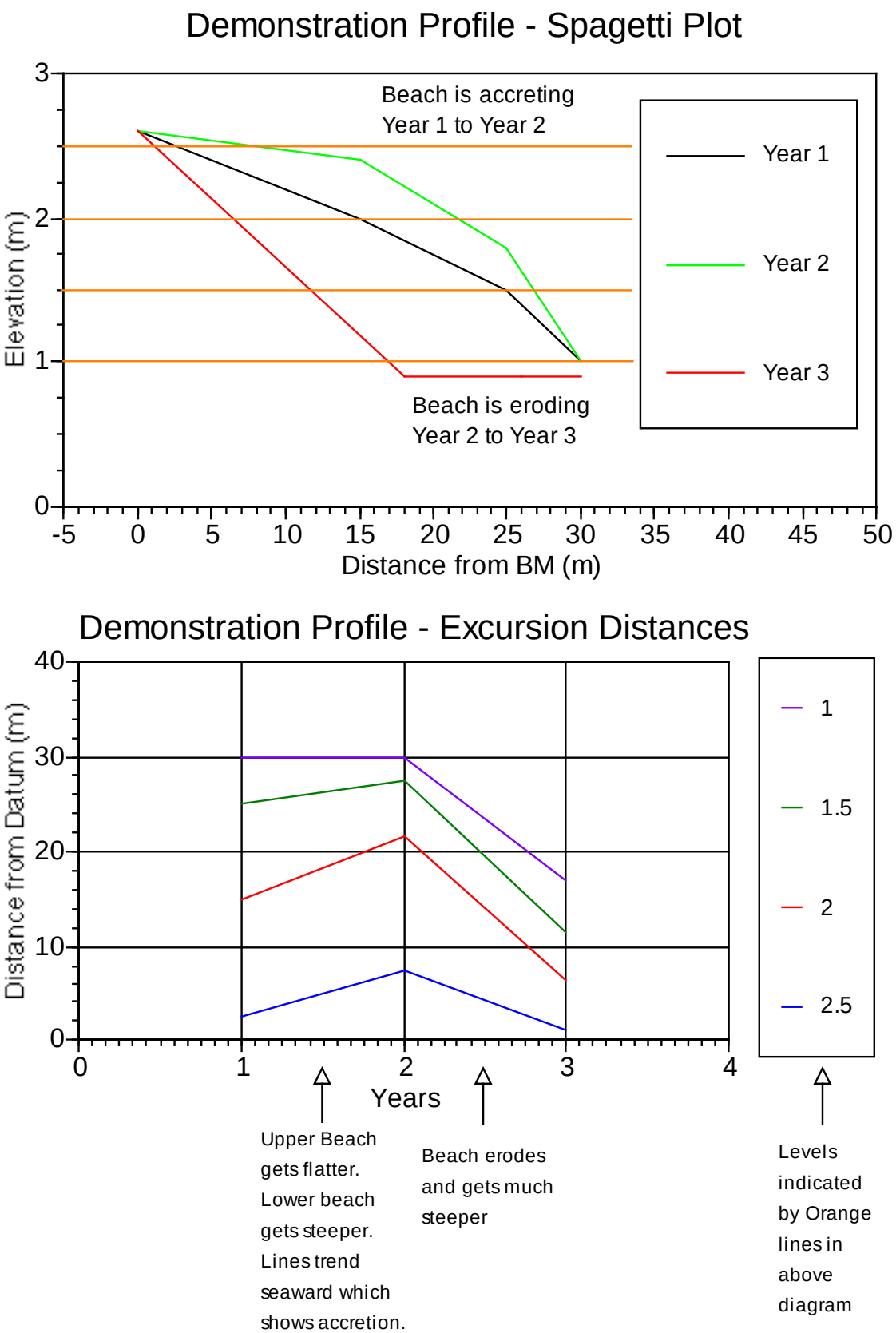
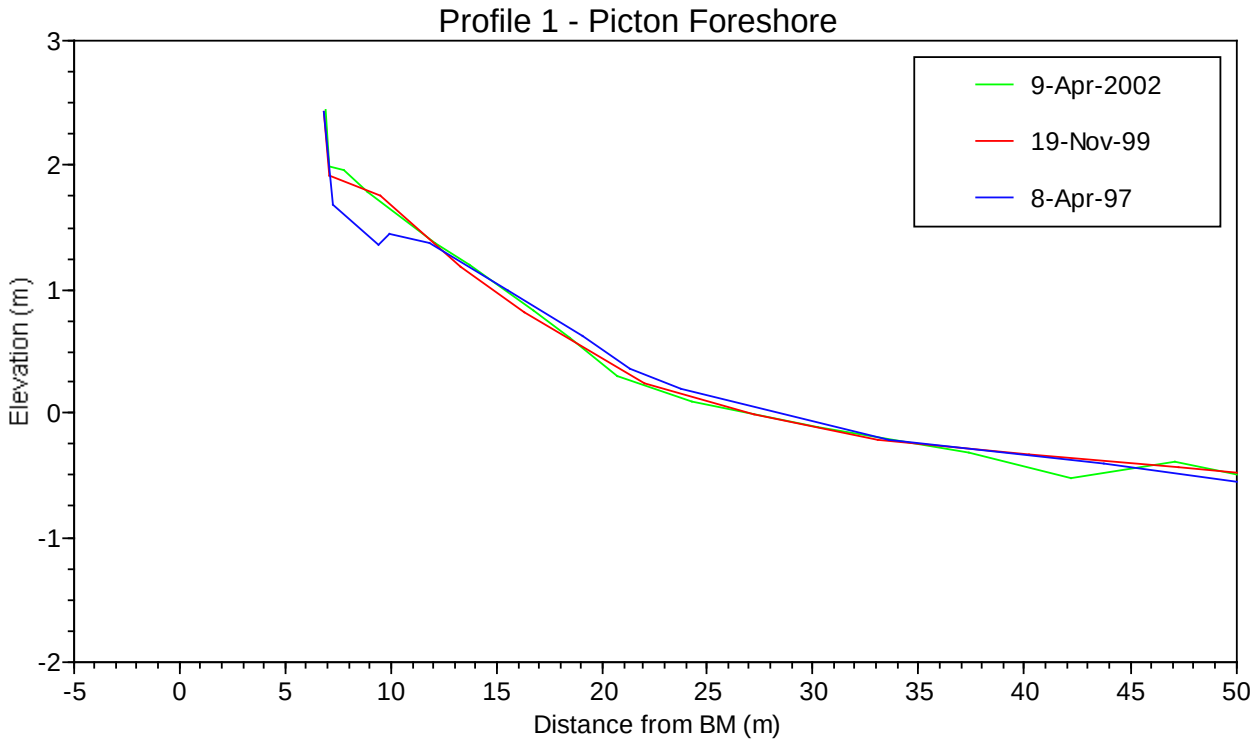


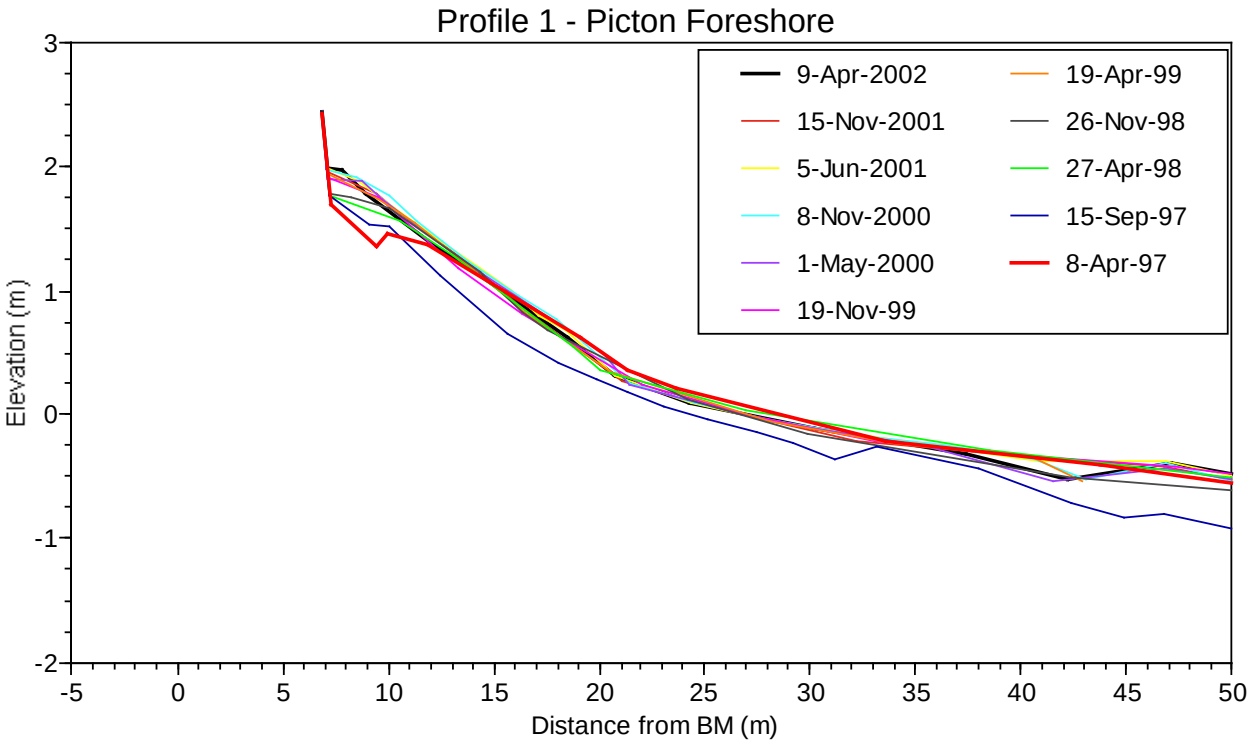
Figure 3 : Excursion Distance Analysis Demonstration

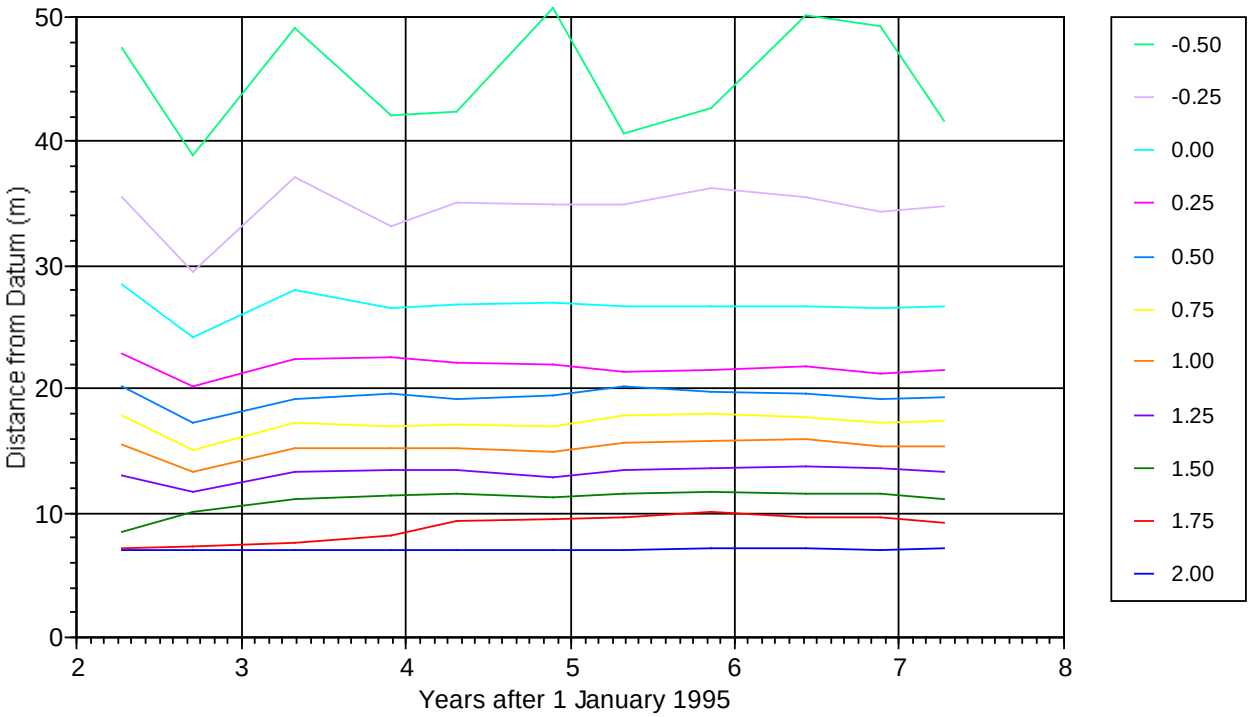
Profile 1 – Picton Foreshore

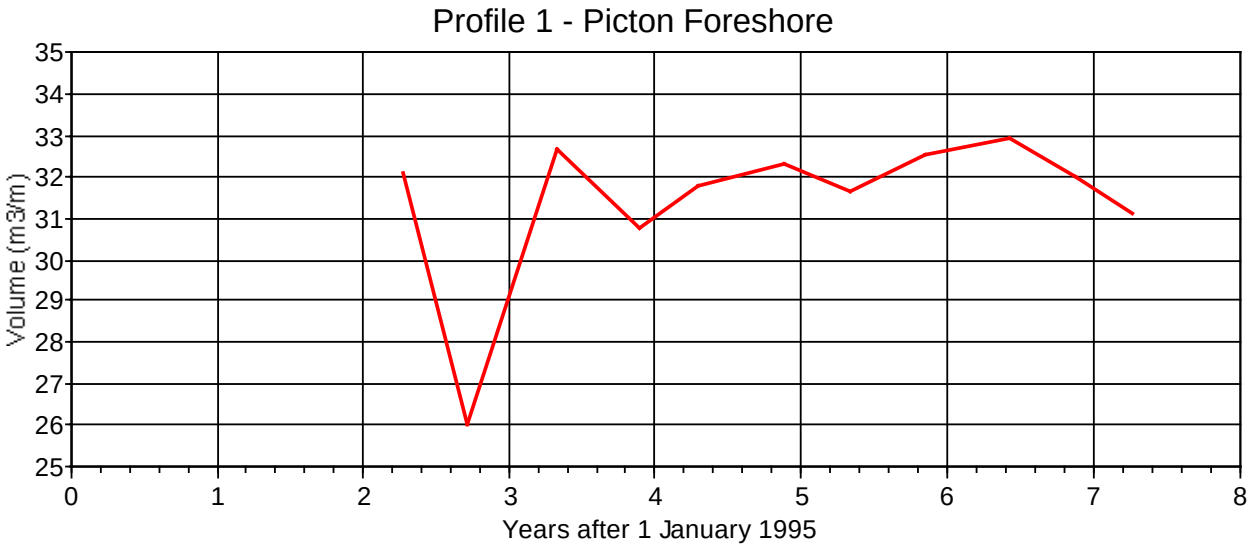
The Picton Foreshore underwent extensive modification with the improvement of the landward side of the retaining wall in late 1997. Sediments on the beach comprise both natural marine sediments and river sand deposited in a beach nourishment programme.

I do not know if further nourishment has taken place since late 1997 or early 1998. If further nourishment has taken place, then the rate of nourishment is clearly appropriate. If there has been no renourishment then the beach has been very stable since that time. Beach volume has maintained a relatively narrow range since April 1998, between 30.8 m^3/m and 32.9 m^3/m. There has been no apparent change in sediment characteristics. There is no indication that the seawall has had an adverse effect on beach stability. There is no indication that waves caused by vessel wash in the inner harbour are having an adverse effect on the Picton foreshore beach.


Profile 1 - Picton Foreshore
9-Apr-2002
19-Nov-99
8-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 1 - Picton Foreshore
9-Apr-2002
15-Nov-2001
5-Jun-2001
8-Nov-2000
1-May-2000
19-Nov-99
19-Apr-99
26-Nov-98
27-Apr-98
15-Sep-97
8-Apr-97
Elevation (m)
Distance from BM (m)

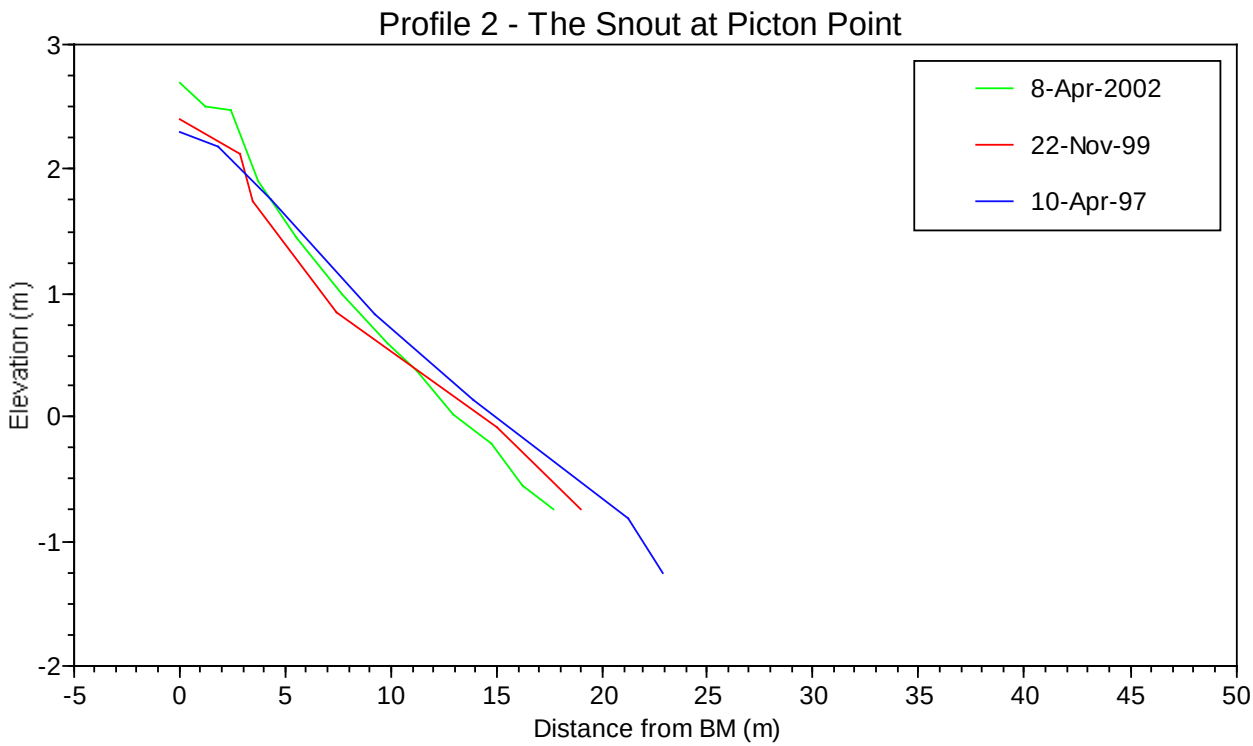

-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Distance from Datum (m)
Years after 1 January 1995



Date	Years since 1/1/95	Volume (m^3/m)
8-Apr-97	2.27	32.1
15-Sep-97	2.71	26.0
27-Apr-98	3.32	32.7
26-Nov-98	3.90	30.8
19-Apr-99	4.30	31.8
19-Nov-99	4.88	32.3
1-May-00	5.33	31.7
8-Nov-00	5.85	32.5
5-Jun-01	6.43	32.9
15-Nov-01	6.87	32.0
9-Apr-02	7.27	31.1

Profile 2 – The Snout at Picton Point

It was concluded at the time of the last major report in December 1999 that Profile 2 had been stable over the survey period. It is now clear that there has been a distinct trend of erosion of the lower beach and accretion of the upper beach, leading to a substantial steepening of the beach profile. This is most clearly illustrated by the EDA plots. The beach profile lines show that the measured beach profile does not reach closure depth, which indicates that the deep water channel is migrating shoreward. There has, however, been some recovery of the lower beach since November 2000 when it was at its most landward position. It is likely that sediment accumulating on the upper beach has come from further down the profile. There has, however, been an overall loss of sediment from 36.4 m^3/m in April 1997, to 33.6 m^3/m in April 2002. The lowest volume recorded, however, was 31.8 m^3/m in November 2000. It may or may not be coincidental that recovery started immediately after the fast ferries were slowed to 18 knots. However, recordings at this site in 1995/6 indicated a very large wave, possibly associated with the fast ferry passing through critical velocity adjacent to this site. There have been no apparent changes in sediment composition over the survey period.


Profile 2 - The Snout at Picton Point
8-Apr-2002
22-Nov-99
10-Apr-97
Elevation (m)
Distance from BM (m)
3
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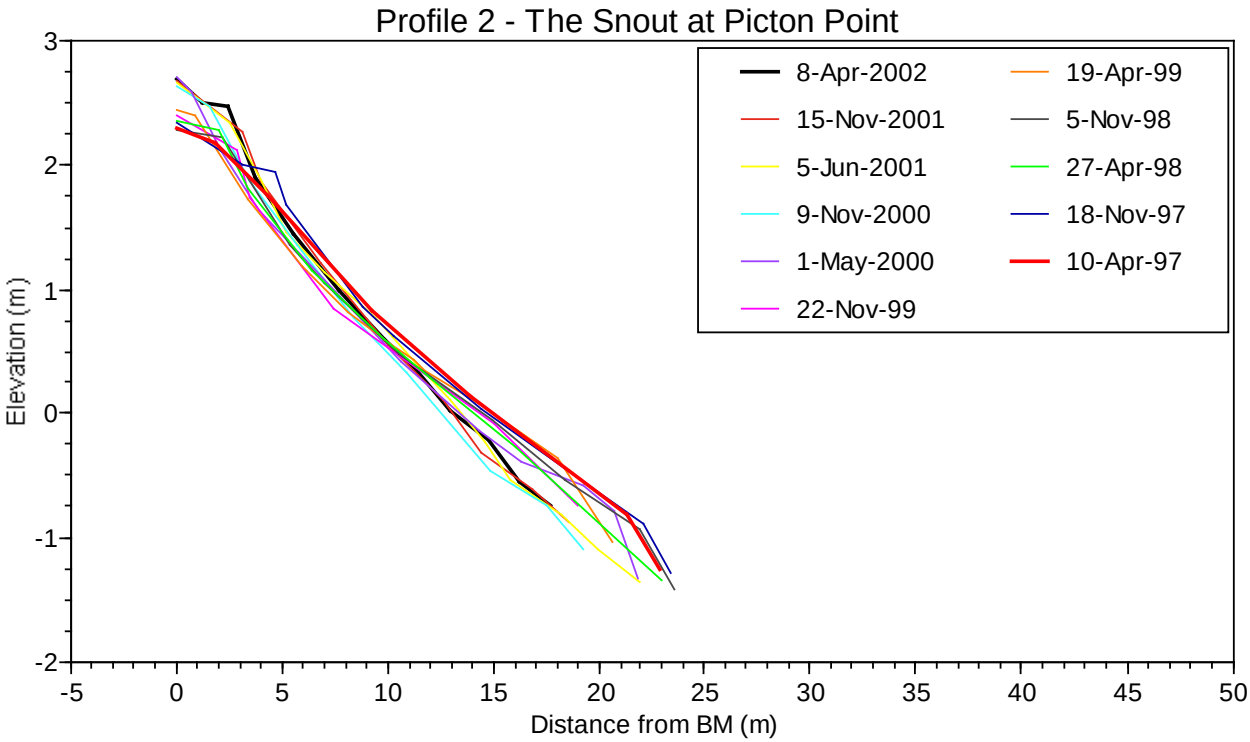
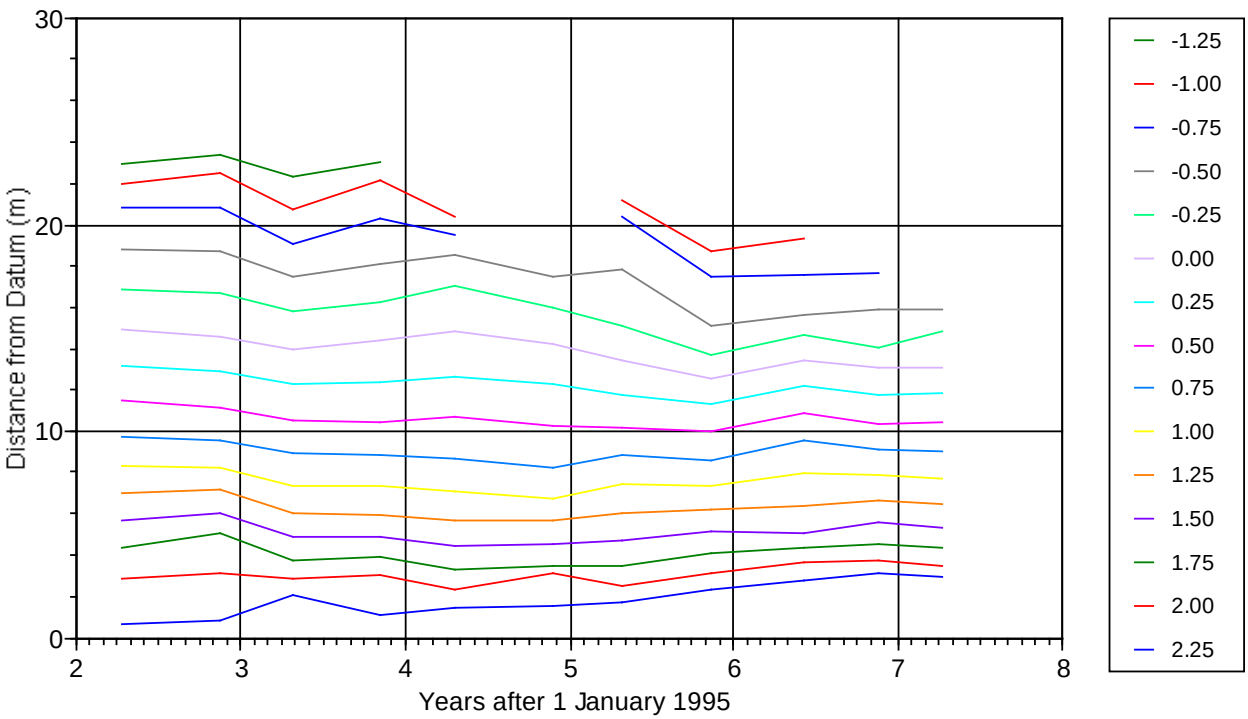
35
40
45
50


Profile 2 - The Snout at Picton Point
8-Apr-2002
15-Nov-2001
5-Jun-2001
9-Nov-2000
1-May-2000
22-Nov-99
19-Apr-99
5-Nov-98
27-Apr-98
18-Nov-97
10-Apr-97
Elevation (m)
Distance from BM (m)


Distance from Datum (m)
Years after 1 January 1995
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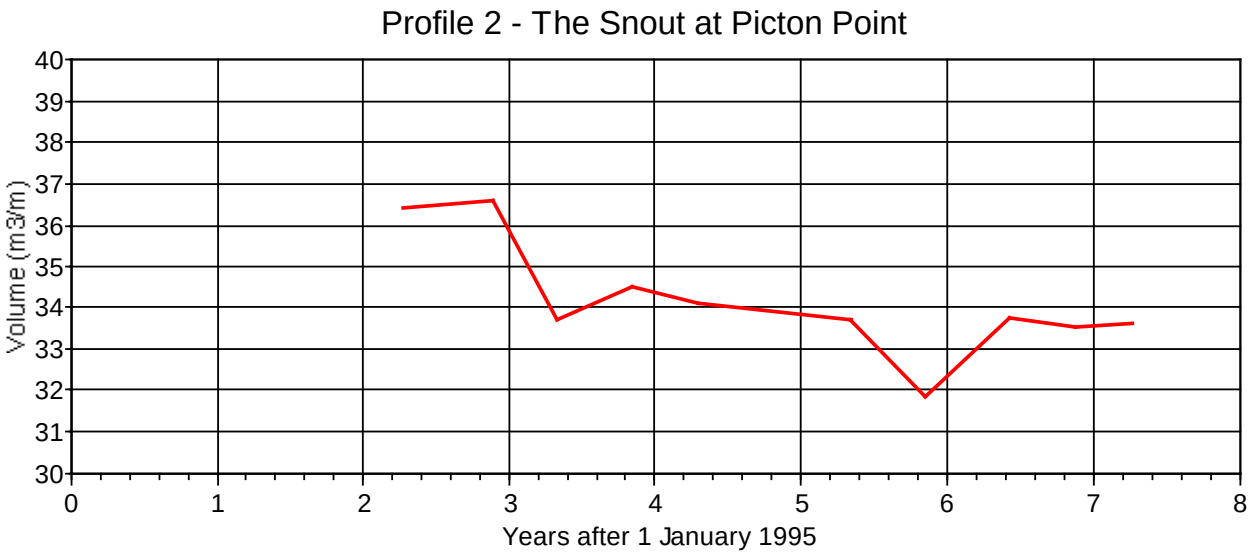
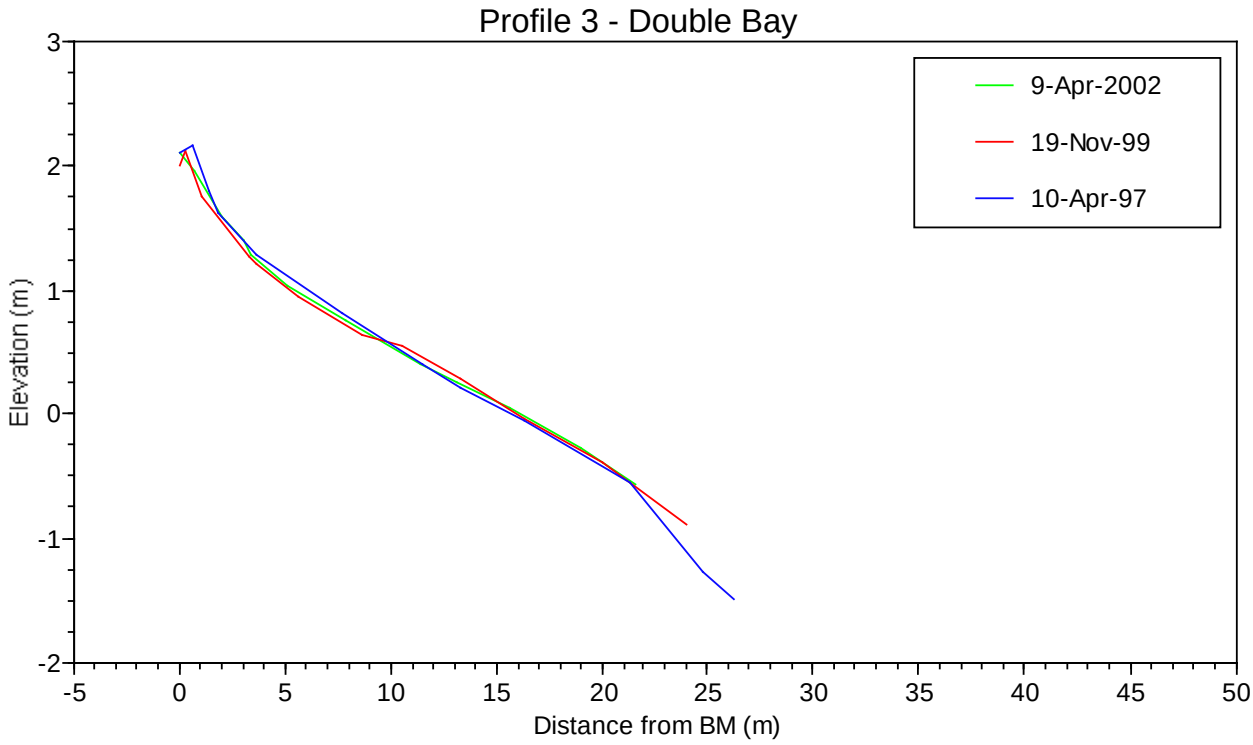
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25



Date	Years after 1/1/95	Volume (m^3/m)
10-Apr-97	2.28	36.4
18-Nov-97	2.88	36.6
27-Apr-98	3.32	33.7
5-Nov-98	3.84	34.5
19-Apr-99	4.30	34.1
1-May-00	5.33	33.7
9-Nov-00	5.86	31.8
5-Jun-01	6.43	33.7
15-Nov-01	6.87	33.5
8-Apr-02	7.27	33.6

Profile 3 – Double Bay

The upper beach and berm have accreted over the survey period, but the changes in beach level have only been in the order of 20cm. The berm, however, virtually disappeared for a short period in early 2000. There has been a corresponding loss of sediment on the middle beach, in the order of 20cm, leading to a small steepening of the beach face. The profiles clearly reach closure depth. Sediment composition has been stable although bands of sand are either deposited or exposed on the surface on some occasions. Volume data indicate relative stability but with significant fluctuations. There is no indication of a seasonal pattern to the changes.


Profile 3 - Double Bay
9-Apr-2002
19-Nov-99
10-Apr-97
Elevation (m)
Distance from BM (m)
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-1
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-5
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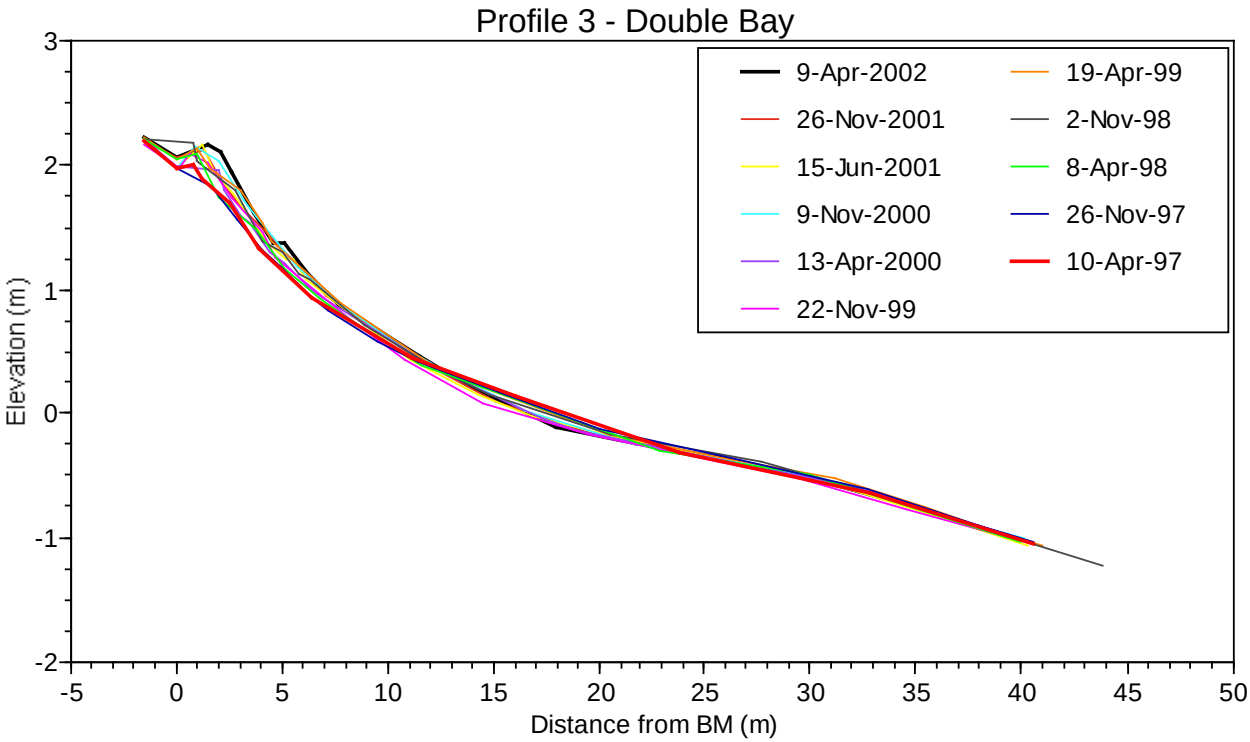
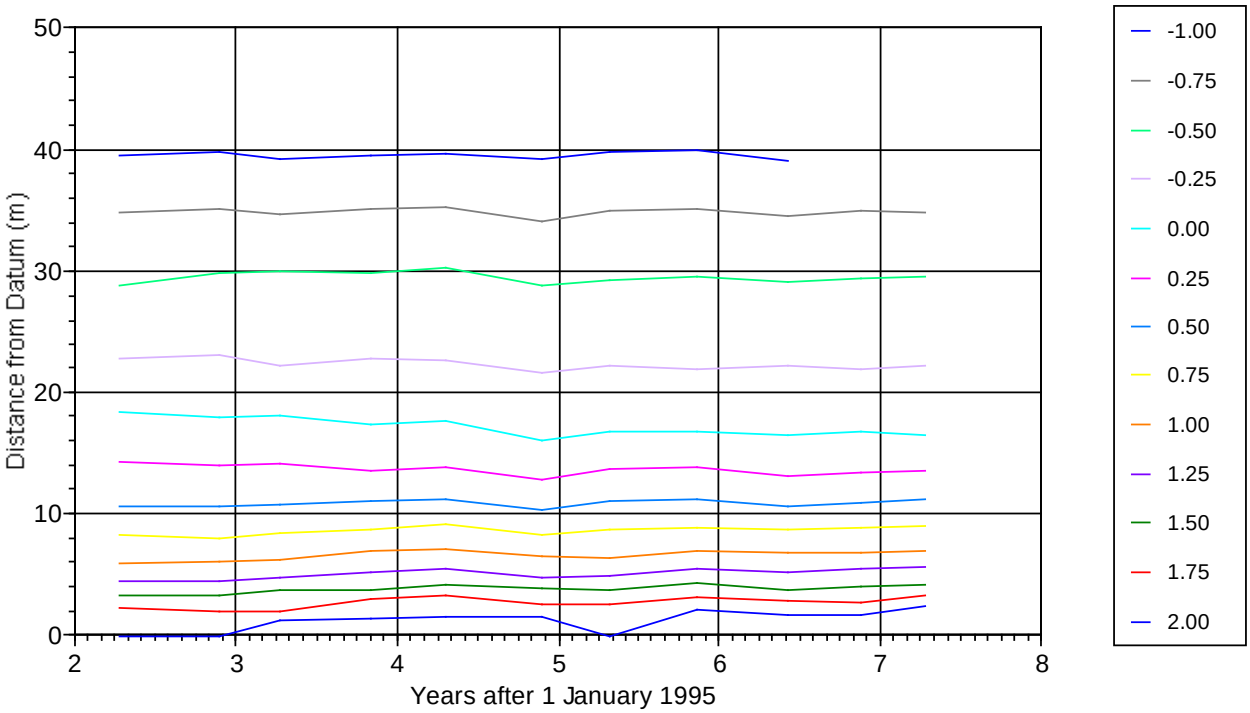
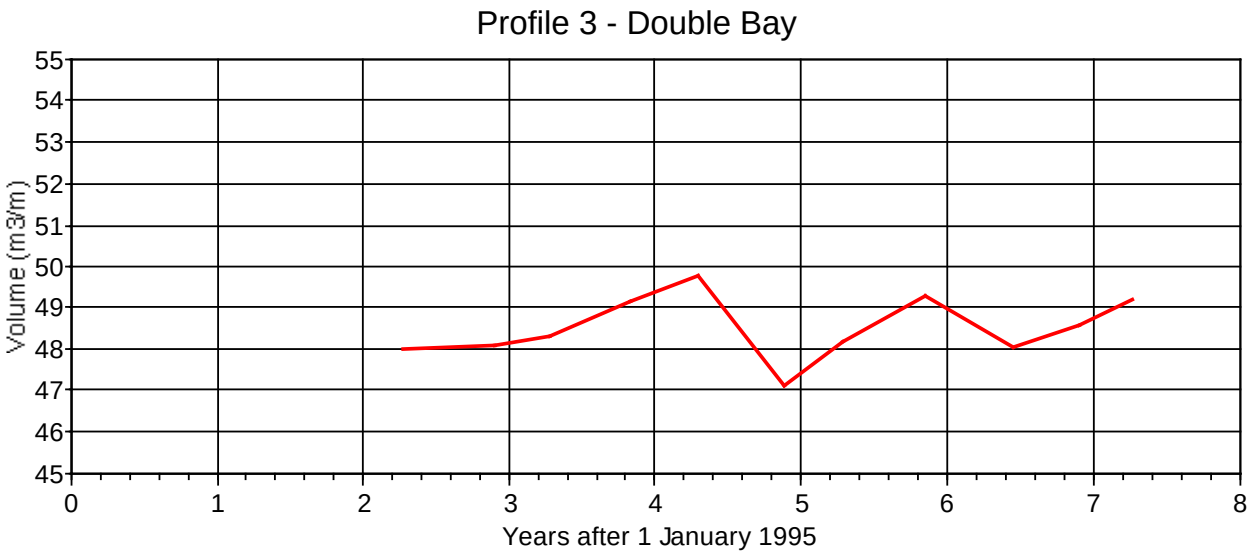

Profile 3 - Double Bay
9-Apr-2002
26-Nov-2001
15-Jun-2001
9-Nov-2000
13-Apr-2000
22-Nov-99
19-Apr-99
2-Nov-98
8-Apr-98
26-Nov-97
10-Apr-97
Elevation (m)
Distance from BM (m)


Distance from Datum (m)
Years after 1 January 1995
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

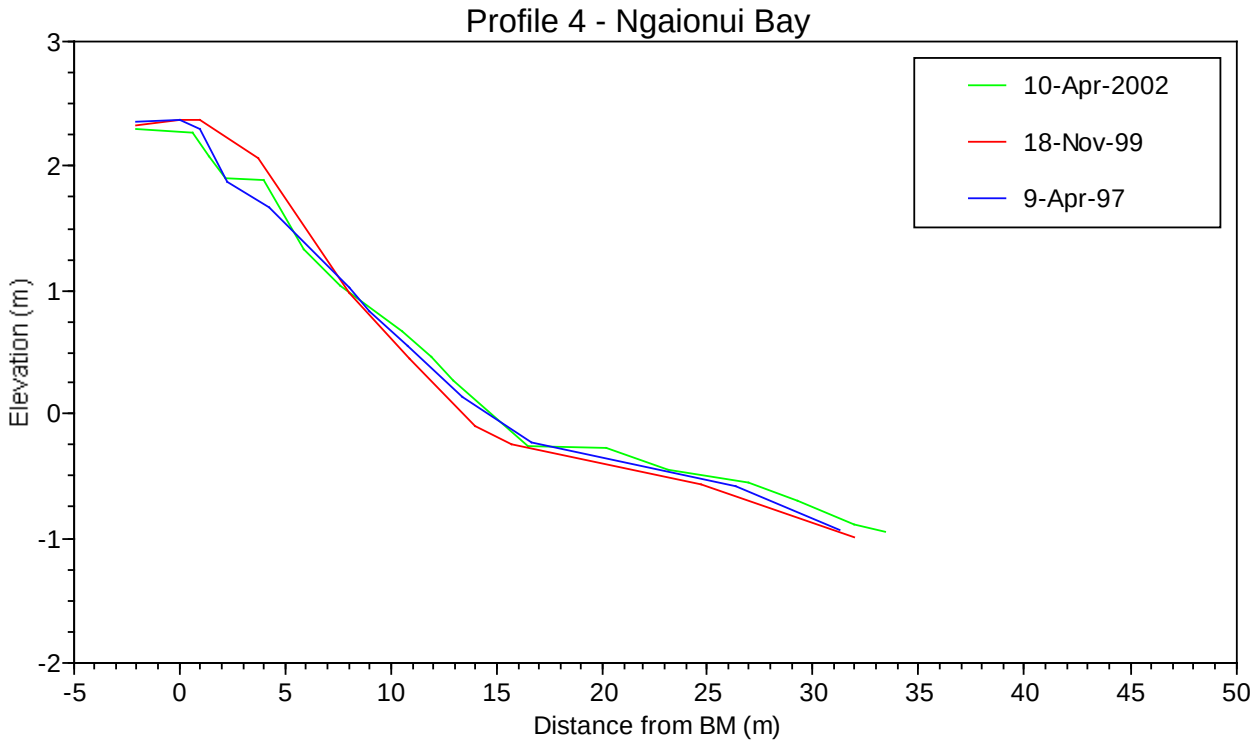


Date	Years after 1/1/95	Volume (m^3/m)
10-Apr-97	2.28	48.0
26-Nov-97	2.90	48.1
8-Apr-98	3.27	48.3
2-Nov-98	3.84	49.1
19-Apr-99	4.30	49.8
22-Nov-99	4.89	47.1
13-Apr-00	5.28	48.1
9-Nov-00	5.86	49.3
15-Jun-01	6.46	48.0
26-Nov-01	6.90	48.6
9-Apr-02	7.27	49.2

Profile 4 – Ngaionui Bay

Between April 1999 and April 2000 a very substantial berm built at the top of the beach. The upper beach prograded substantially and the middle beach retreated a little. The berm was still in place in November 2000. Between that time and the following survey, substantial beach works took place, removing the berm and much of the sediment on the upper beach. This is clearly evident in the data and in the profile photographs. It is unfortunate that these beach works coincided with the slowing of the fast ferries in December 2000, as this makes interpretation of the changes difficult. The build up of the berm had previously been interpreted as possibly relating to the continuation of the fast ferry service through the winter months, or to the wake characteristics of the ferries operating at that time. There has been an apparent recovery of the upper beach (and consequently the beach volume) since the beach works took place, evident in the last two surveys.

This location has a very distinct change in slope at approximately –0.25m, indicating probable closure depth for this profile.


Profile 4 - Ngaionui Bay
10-Apr-2002
18-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
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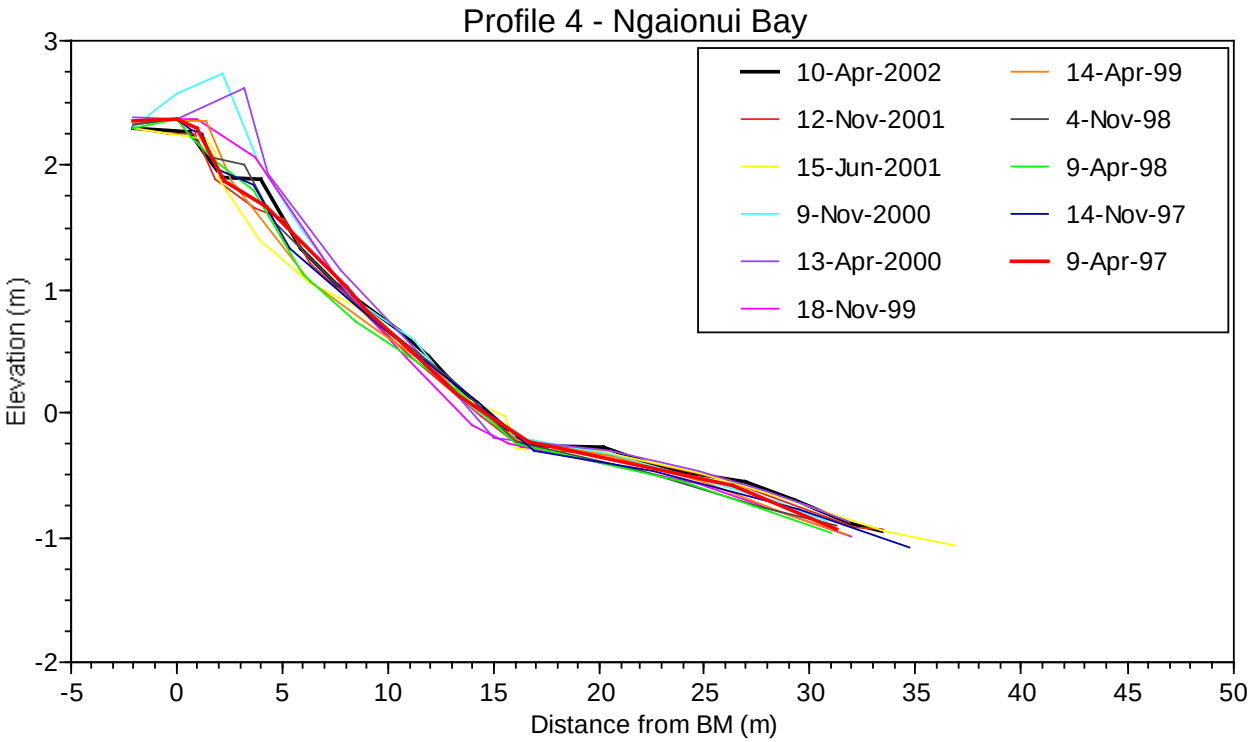
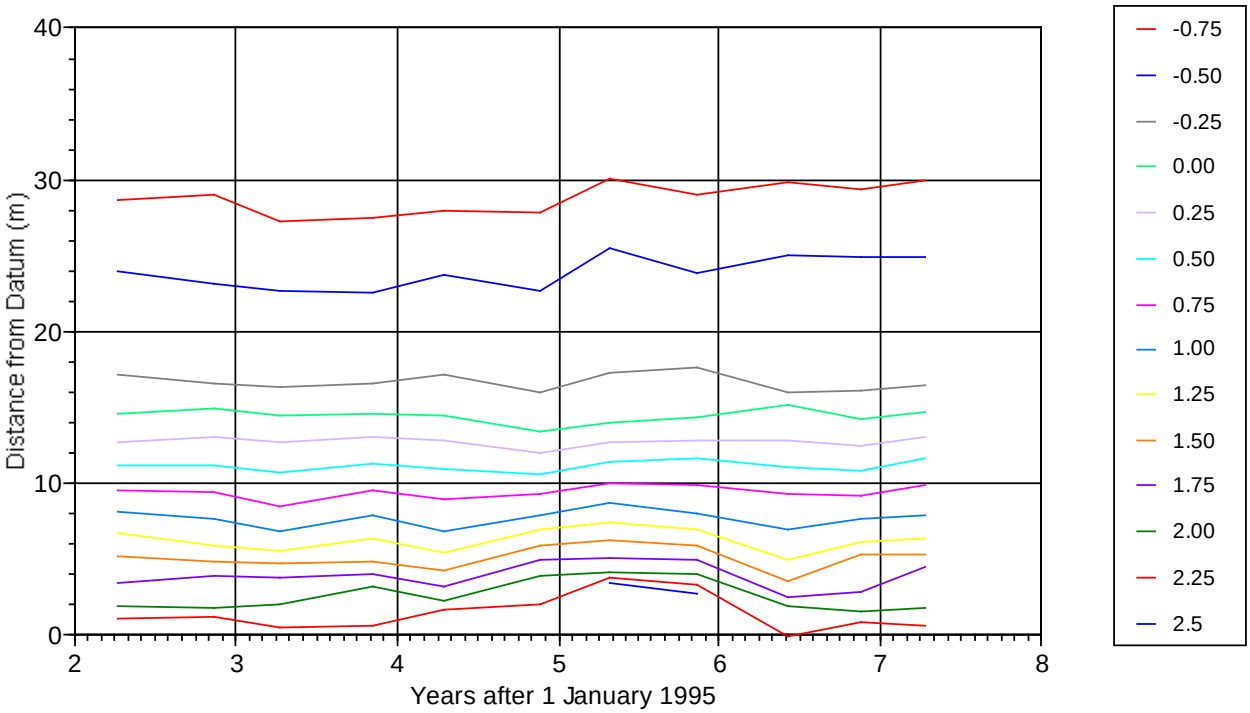
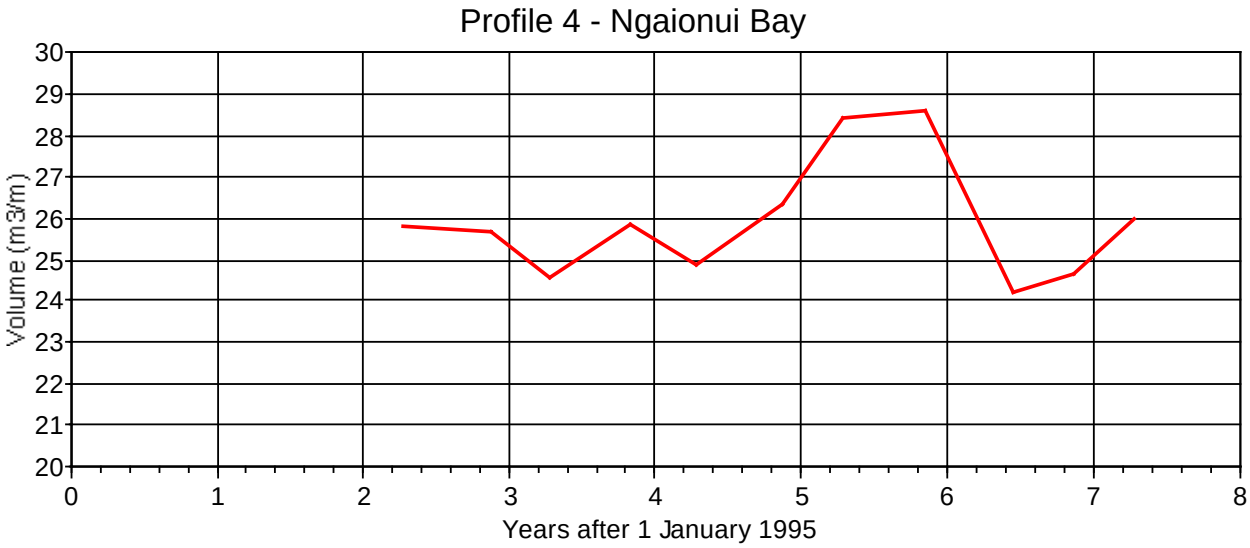
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 4 - Ngaionui Bay
10-Apr-2002
12-Nov-2001
15-Jun-2001
9-Nov-2000
13-Apr-2000
18-Nov-99
14-Apr-99
4-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)

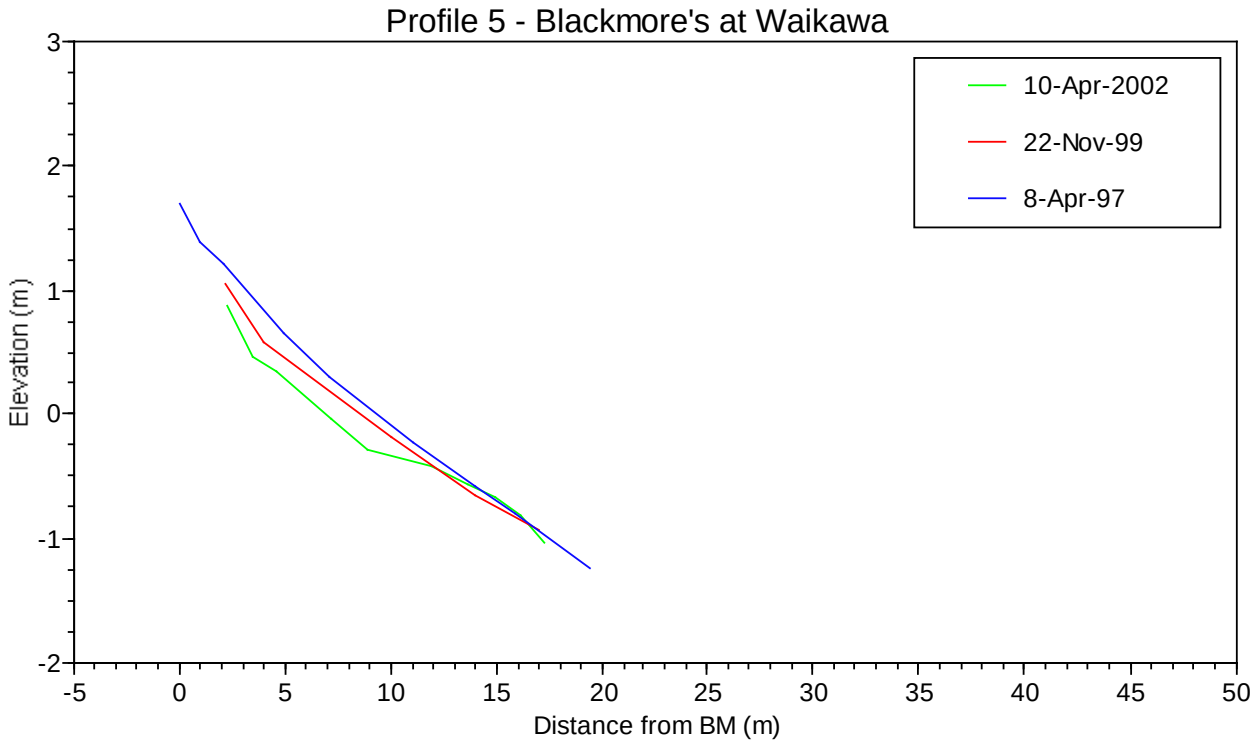

-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.5
Distance from Datum (m)
Years after 1 January 1995

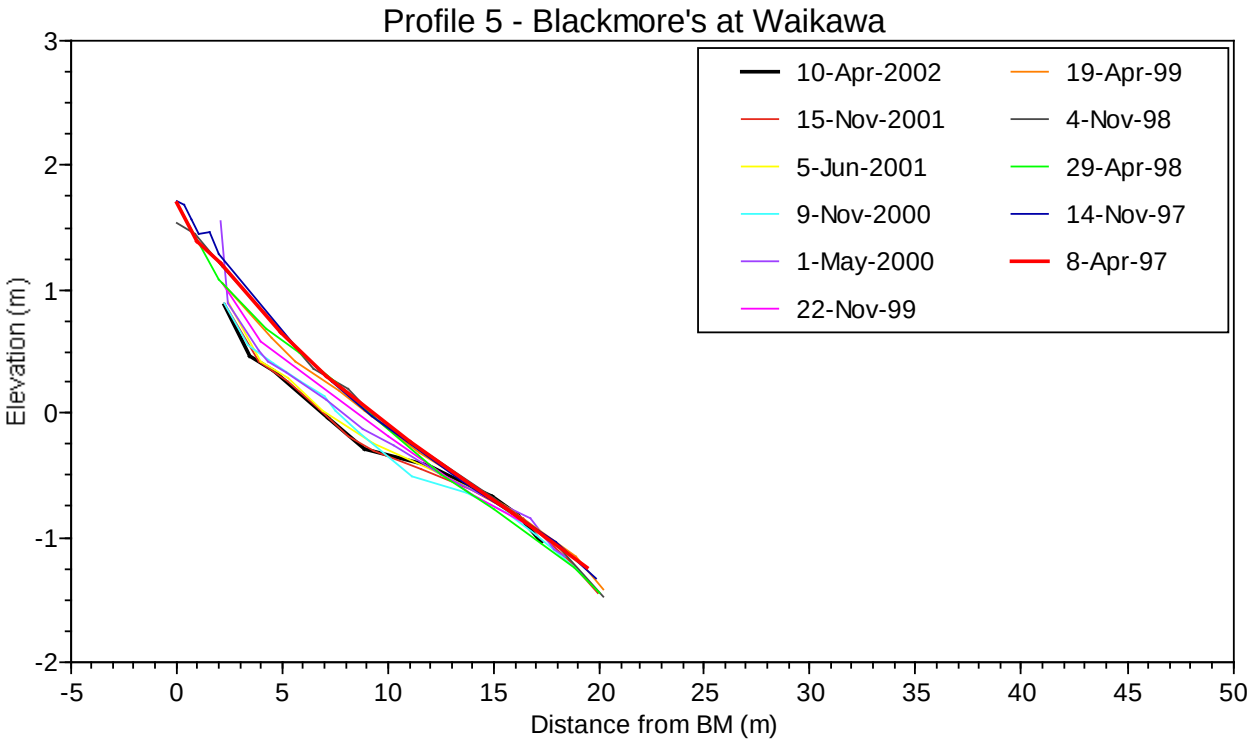


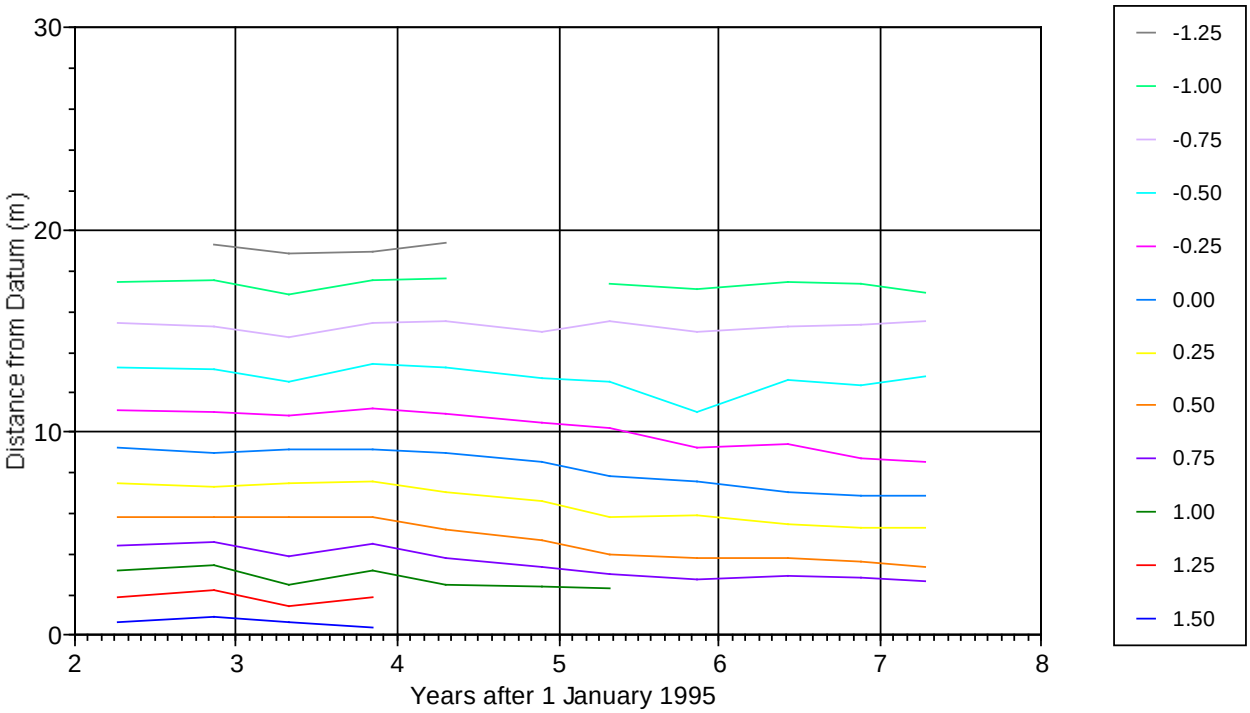
Date	Years after 1/1/95	Volume (m^3/m)
9-Apr-97	2.27	25.8
14-Nov-97	2.87	25.7
9-Apr-98	3.27	24.6
4-Nov-98	3.84	25.9
14-Apr-99	4.29	24.9
18-Nov-99	4.88	26.3
13-Apr-00	5.28	28.4
9-Nov-00	5.86	28.6
15-Jun-01	6.46	24.2
12-Nov-01	6.86	24.7
10-Apr-02	7.28	26.0

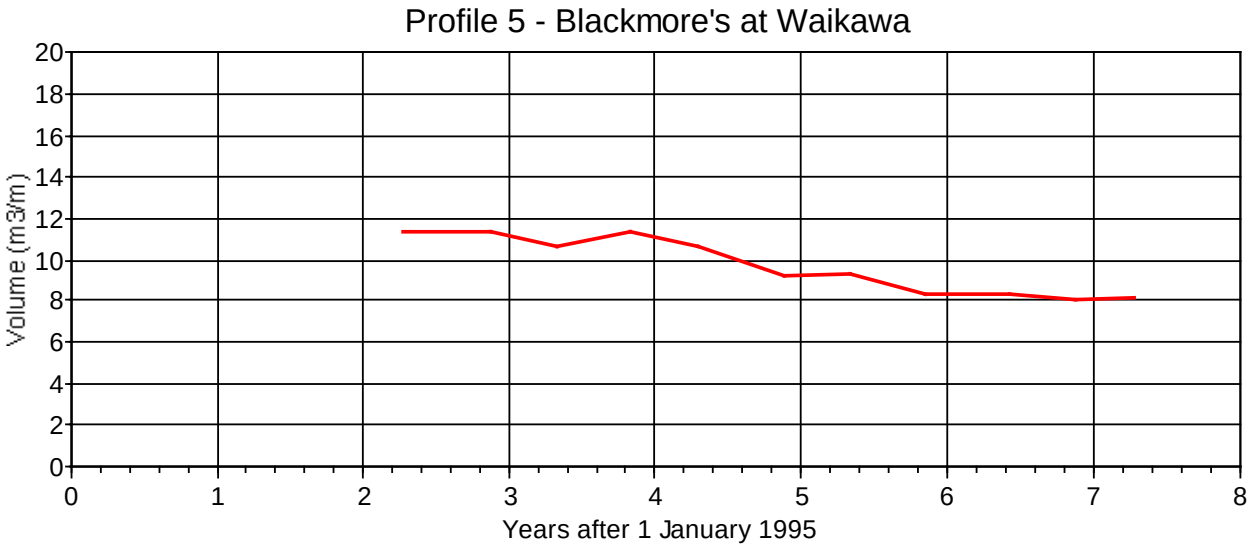
Profile 5 – Blackmores's at Waikawa

There has been a gradual retreat on this profile since surveys began in April 1997. There has at various times been building work in the vicinity of this profile line, and it may be that these events have contributed to the change. At present, the profile appears to be stripped to bedrock, and further loss of sediment is therefore unlikely. There has been no recovery since the fast ferries slowed down in December 2000.


Profile 5 - Blackmore's at Waikawa
10-Apr-2002
22-Nov-99
8-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 5 - Blackmore's at Waikawa
10-Apr-2002
15-Nov-2001
5-Jun-2001
9-Nov-2000
1-May-2000
22-Nov-99
19-Apr-99
4-Nov-98
29-Apr-98
14-Nov-97
8-Apr-97
Elevation (m)
Distance from BM (m)


Distance from Datum (m)
Years after 1 January 1995
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50



Date	Years after 1/1/95	Volume (m^3/m)
8-Apr-97	2.27	11.4
14-Nov-97	2.87	11.4
29-Apr-98	3.33	10.7
4-Nov-98	3.84	11.4
19-Apr-99	4.30	10.7
22-Nov-99	4.89	9.1
1-May-00	5.33	9.4
9-Nov-00	5.86	8.3
5-Jun-01	6.43	8.3
15-Nov-01	6.87	8.0
10-Apr-02	7.28	8.1

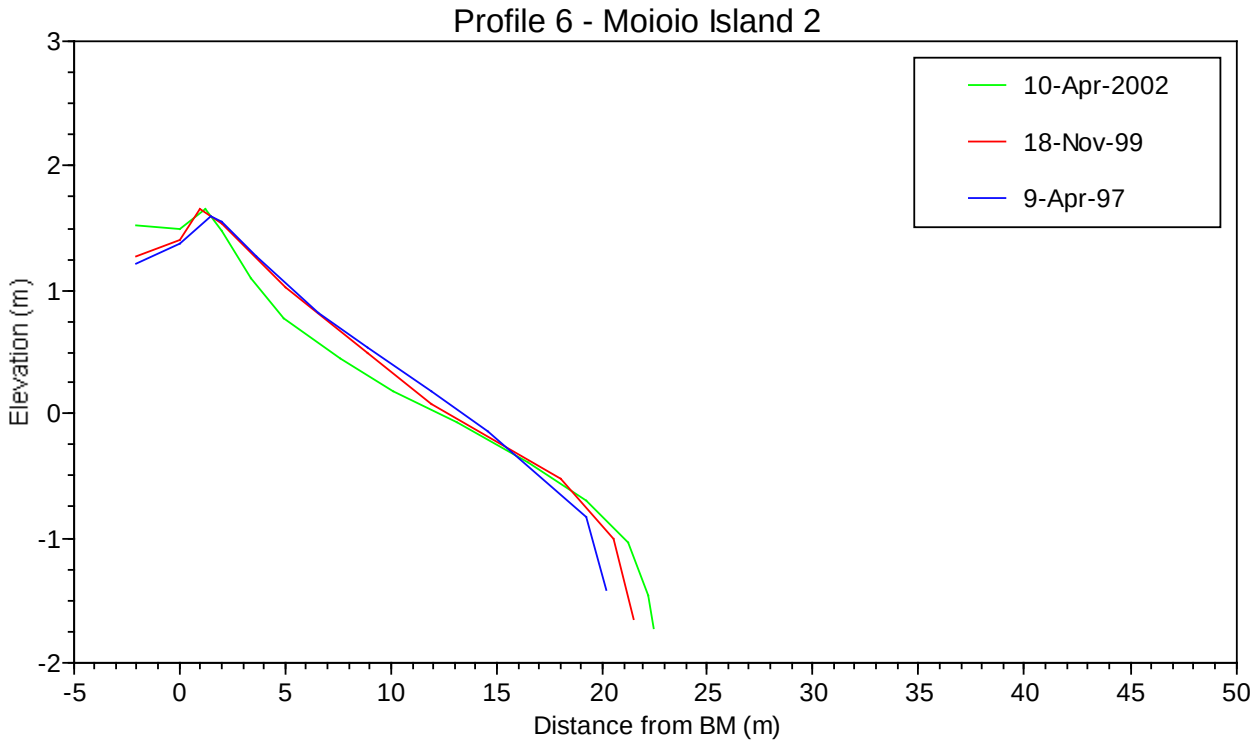
Profile 6 – Moioio Island 2

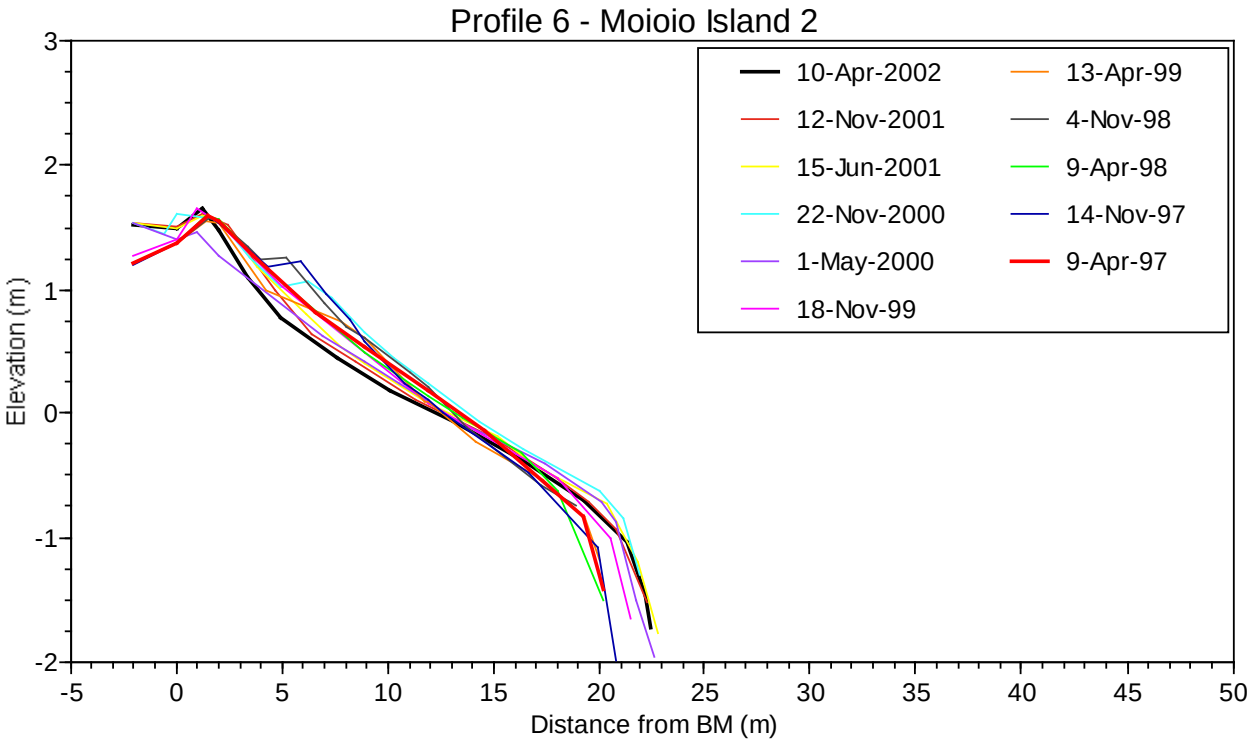
Moioio Island 2 is at the eastern end of the beach on the island, near the slip that has been of considerable concern to Te Ati Awa. For the first few years the beach profile demonstrated seasonality, with a build up of a berm on the upper beach over the winter months, and its removal over the summer months. The berm did not return during the winter of 1999, and by May 2000, the berm at the very top of the beach was removed. It is possible that the cause of the non-return is the continued operation of fast ferries over this period. However, there was recovery by November 2000, with the upper beach berm and the berm at the very top of the beach both returning. Since November 2000, the upper beach berm has removed, and the beach level at the position of the upper beach berm has fallen to its lowest recorded level.

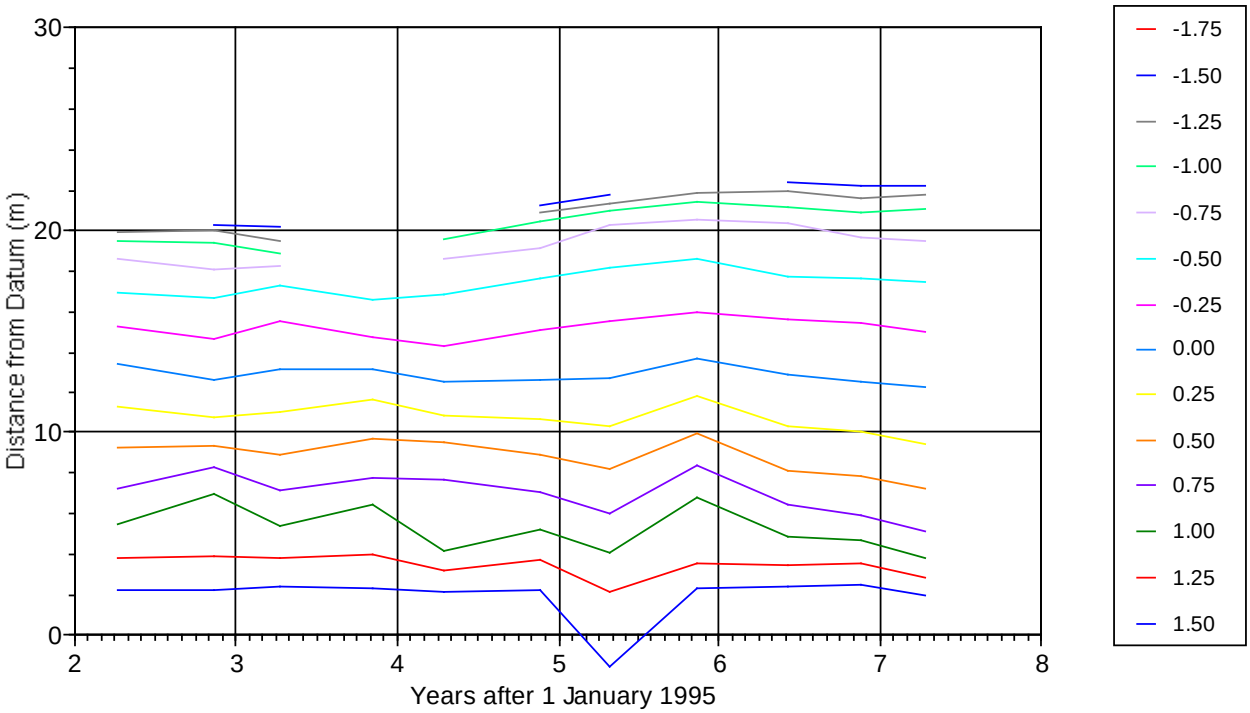
The lower beach, sloping into the channel has been building out over the entire survey period, possibly being supplemented by material coming from the slip at the end of the island.

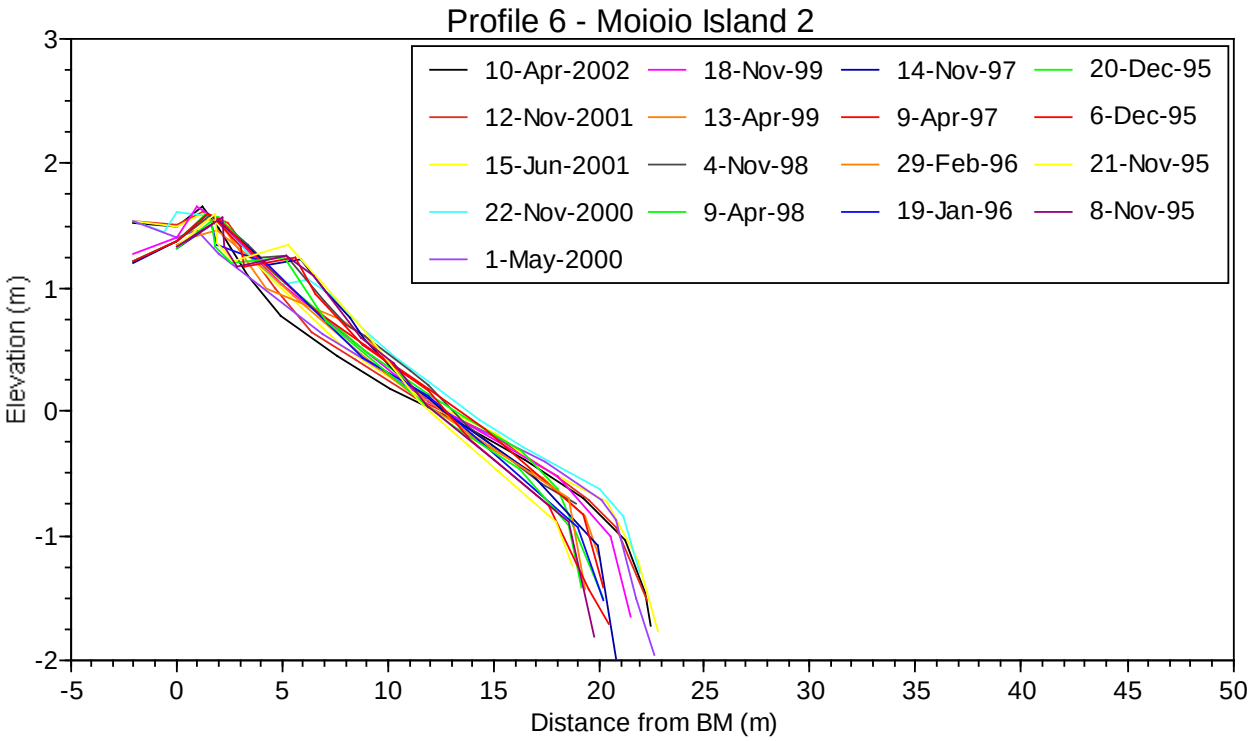
Profile 6 shows significant changes through time, and there is some difficulty in interpretation due to apparent contradictions. The pattern during the period of seasonal operation of the fast ferry seemed clear. The upper beach berm built up over the winter, when the fast ferries were not operating, and then was lost during the summer. When the fast ferries ran continuously, the berm did not return. However, the entire upper beach grew significantly during the second half of 2000, contrary to expectations. Since the ferries slowed in December 2000, the level of the upper and middle beach has fallen significantly, along with beach volumes.

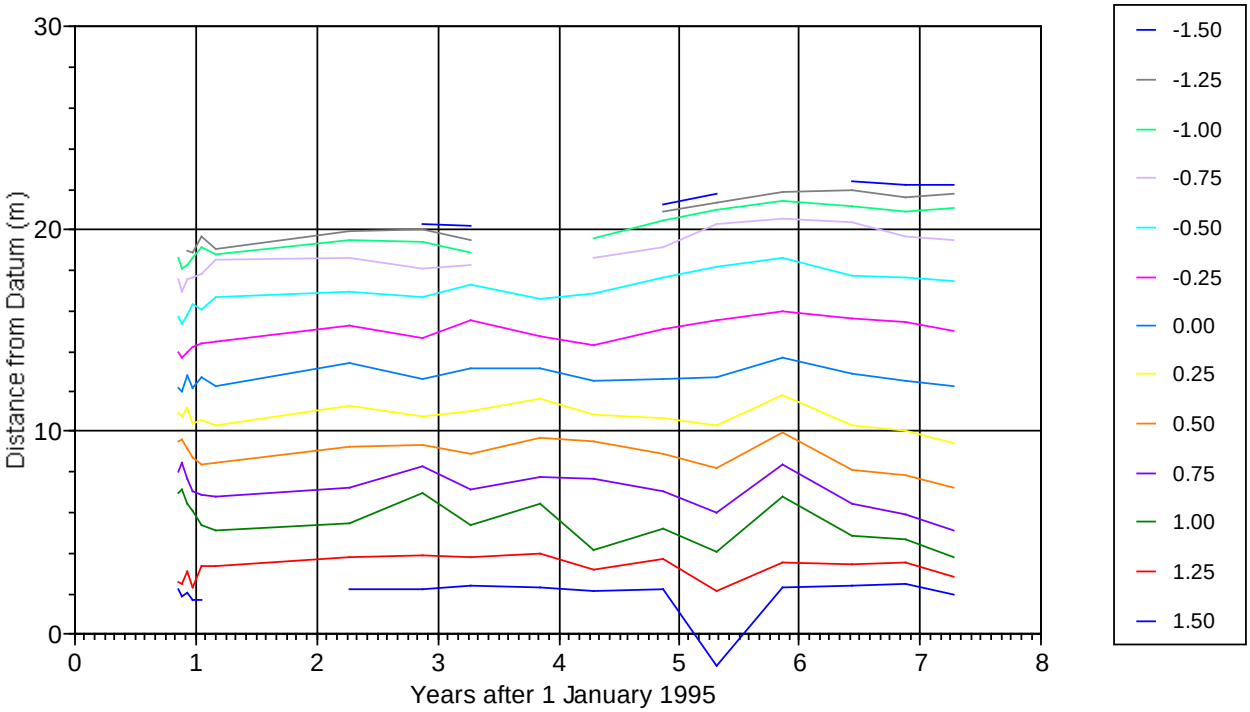
It remains likely that this site reacts to changes in ferry operation. However, it is also likely that it reacts to changes in sediment supply from the adjacent slip. Determining the relative effects of the two sets of events is difficult.

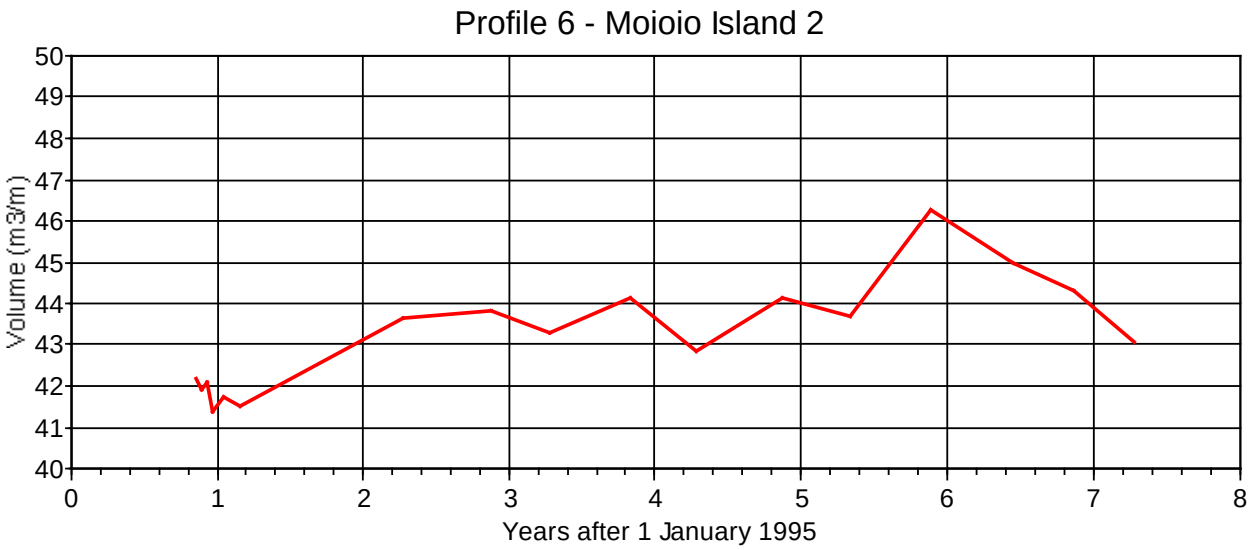

Profile 6 - Moioio Island 2
10-Apr-2002
18-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 6 - Moioio Island 2
10-Apr-2002
12-Nov-2001
15-Jun-2001
22-Nov-2000
1-May-2000
18-Nov-99
13-Apr-99
4-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)


-1.75
-1.50
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Distance from Datum (m)
Years after 1 January 1995


Profile 6 - Moioio Island 2
10-Apr-2002
12-Nov-2001
15-Jun-2001
22-Nov-2000
1-May-2000
18-Nov-99
13-Apr-99
4-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
29-Feb-96
19-Jan-96
20-Dec-95
6-Dec-95
21-Nov-95
8-Nov-95
Elevation (m)
Distance from BM (m)


-1.50
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Distance from Datum (m)
Years after 1 January 1995



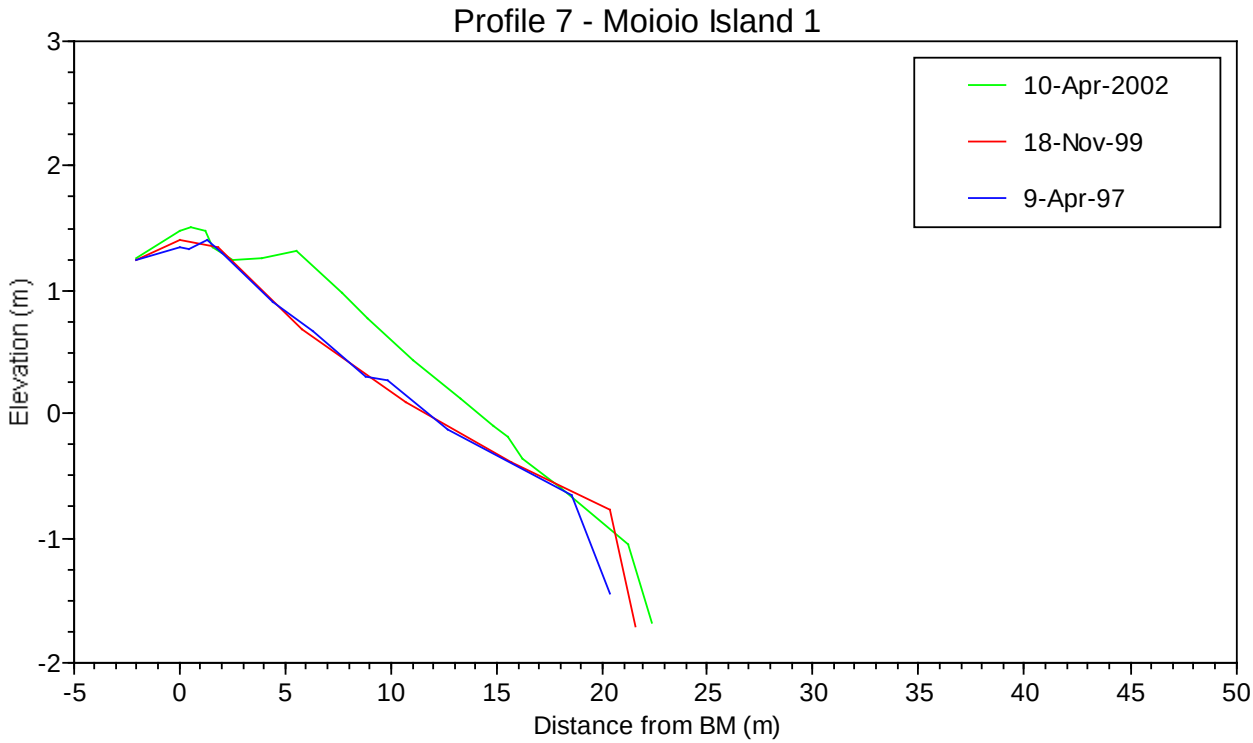
Date	Years after 1/1/95	Volume (m^3/m)
8-Nov-95	0.85	42.17
21-Nov-95	0.89	41.92
6-Dec-95	0.93	42.11
20-Dec-95	0.97	41.40
19-Jan-96	1.05	41.75
29-Feb-96	1.16	41.52
9-Apr-97	2.27	43.65
14-Nov-97	2.87	43.79
9-Apr-98	3.27	43.27
4-Nov-98	3.84	44.12
13-Apr-99	4.28	42.83
18-Nov-99	4.88	44.12
1-May-00	5.33	43.69
22-Nov-00	5.89	46.26
15-Jun-01	6.46	45.01
12-Nov-01	6.86	44.29
10-Apr-02	7.28	43.06

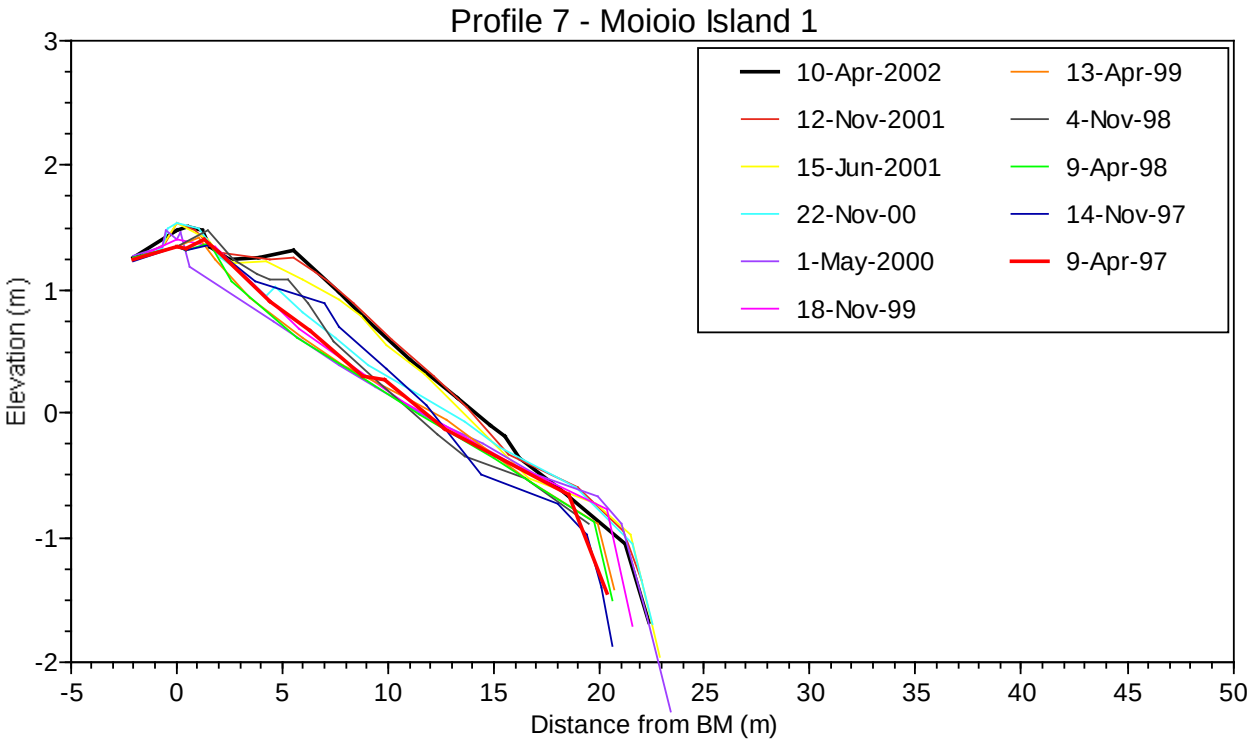
Profile 7 – Moioio Island 1

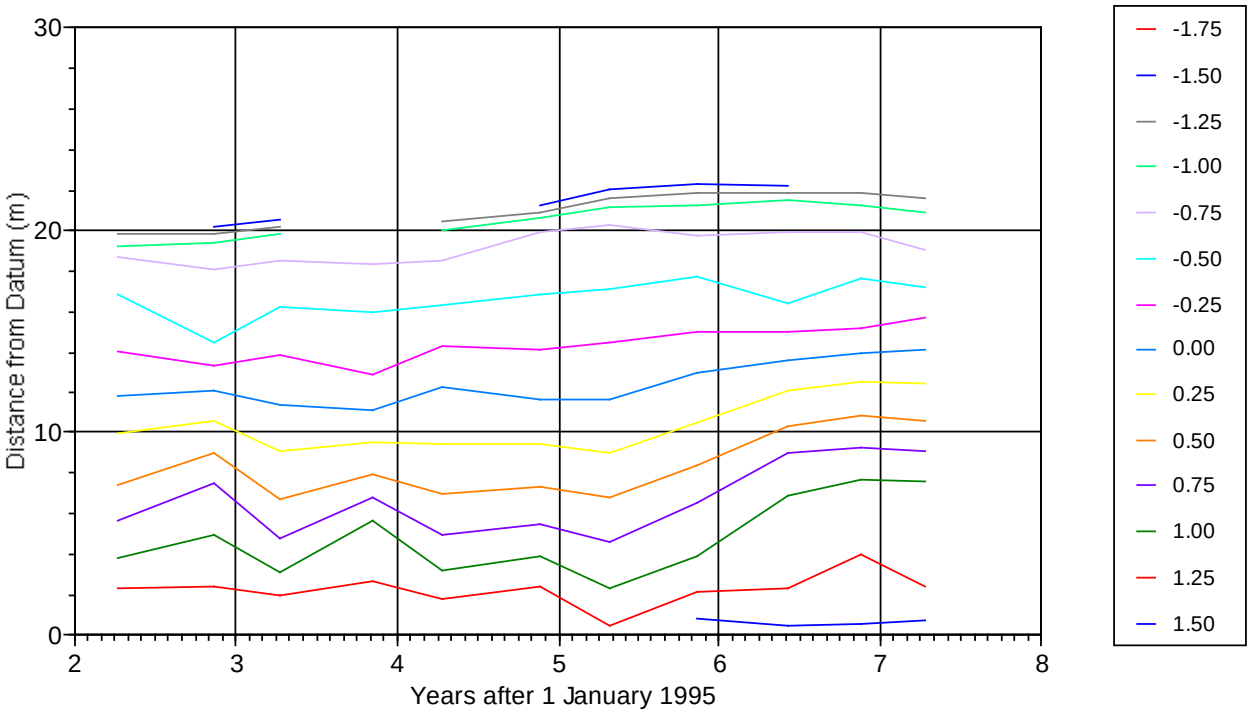
The Moioio Island 1 profile is to the west of Profile 6. There was remarkable seasonality up to the winter of 1999, with the growth of a berm over winter and its loss over summer, but with the growth of the berm not occurring during the winter of 1999. There has been substantial accretion of the upper beach since May 2000, with a major increase in volume, particularly between May 2000 and April 2001. This probably indicates an increase in sediment supply from the slip. Accretion on the middle and lower beach has continued since surveys began in 1995.

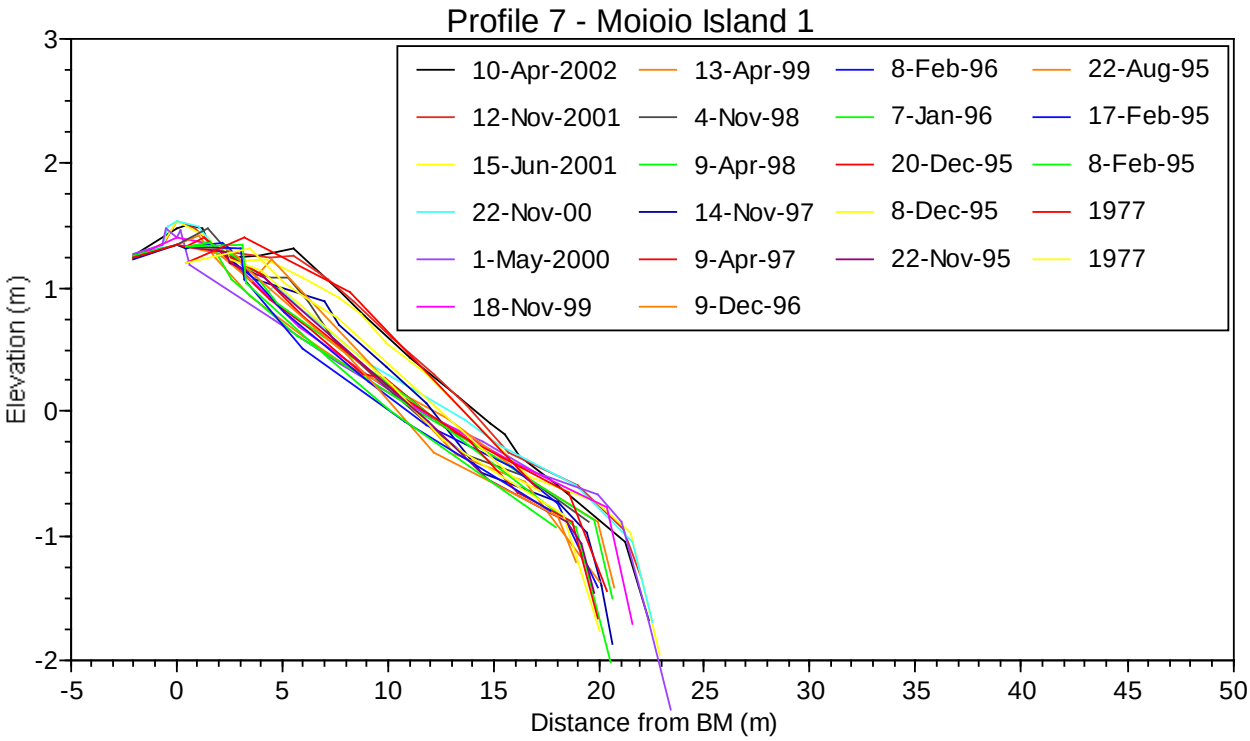
There is little doubt that the beach changes taking place on this profile are caused by the ferry operation regime, but supplemented by changes in sediment supply. In particular, I think it very likely that there was a significant slip event between May and November 2000.

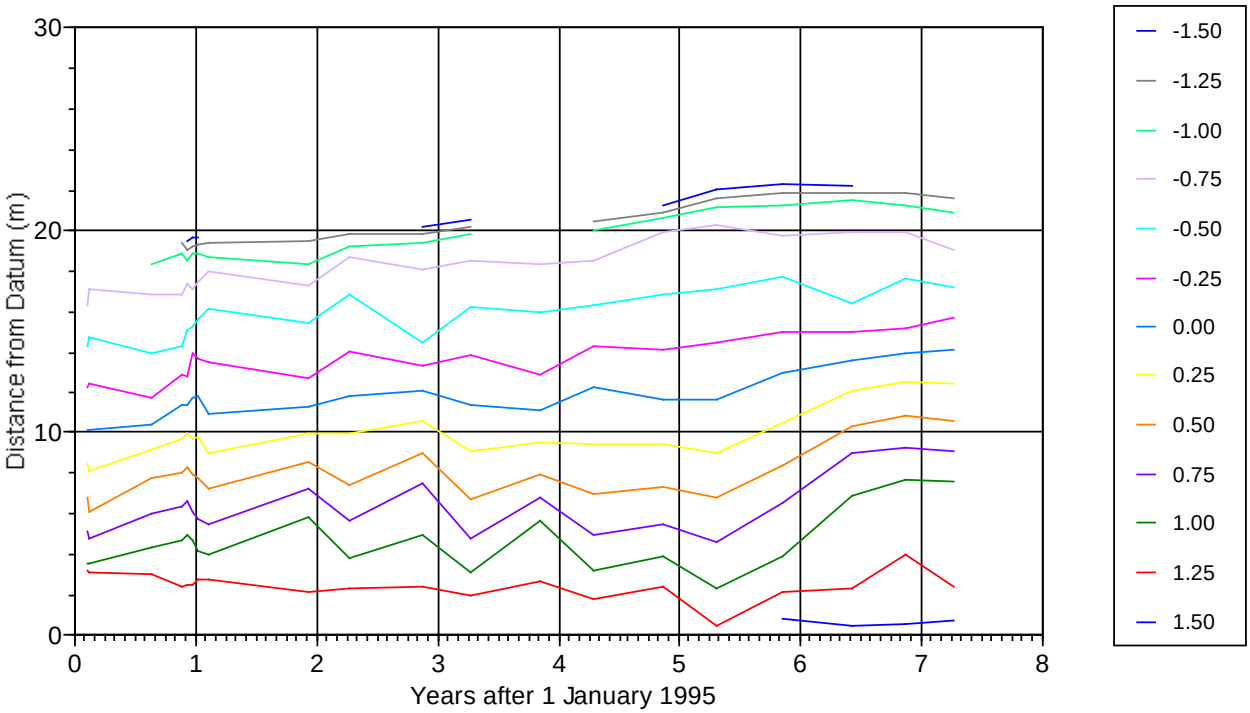
The high level of the beach in 1977 (surveyed by Newton) is interesting, but little significance can be placed on this without further data and assurances regarding data quality.

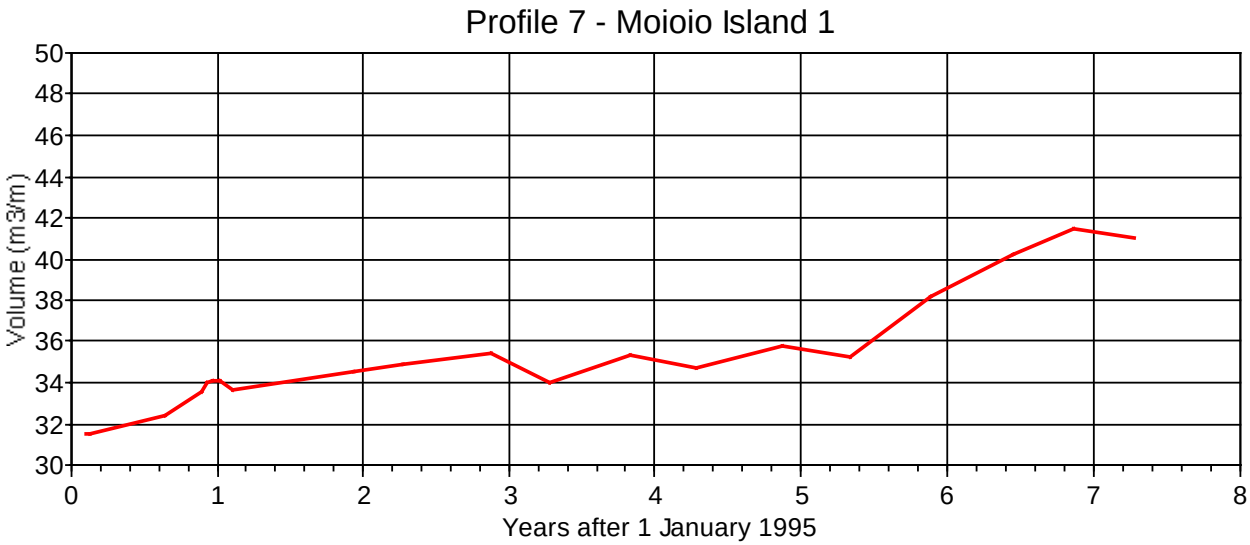

Profile 7 - Moioio Island 1
10-Apr-2002
18-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 7 - Moioio Island 1
10-Apr-2002
12-Nov-2001
15-Jun-2001
22-Nov-00
1-May-2000
18-Nov-99
13-Apr-99
4-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)


-1.75
-1.50
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Distance from Datum (m)
Years after 1 January 1995


Profile 7 - Moioio Island 1
10-Apr-2002
12-Nov-2001
15-Jun-2001
22-Nov-00
1-May-2000
18-Nov-99
13-Apr-99
4-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
9-Dec-96
8-Feb-96
7-Jan-96
20-Dec-95
8-Dec-95
22-Nov-95
22-Aug-95
17-Feb-95
8-Feb-95
1977
1977
Elevation (m)
Distance from BM (m)

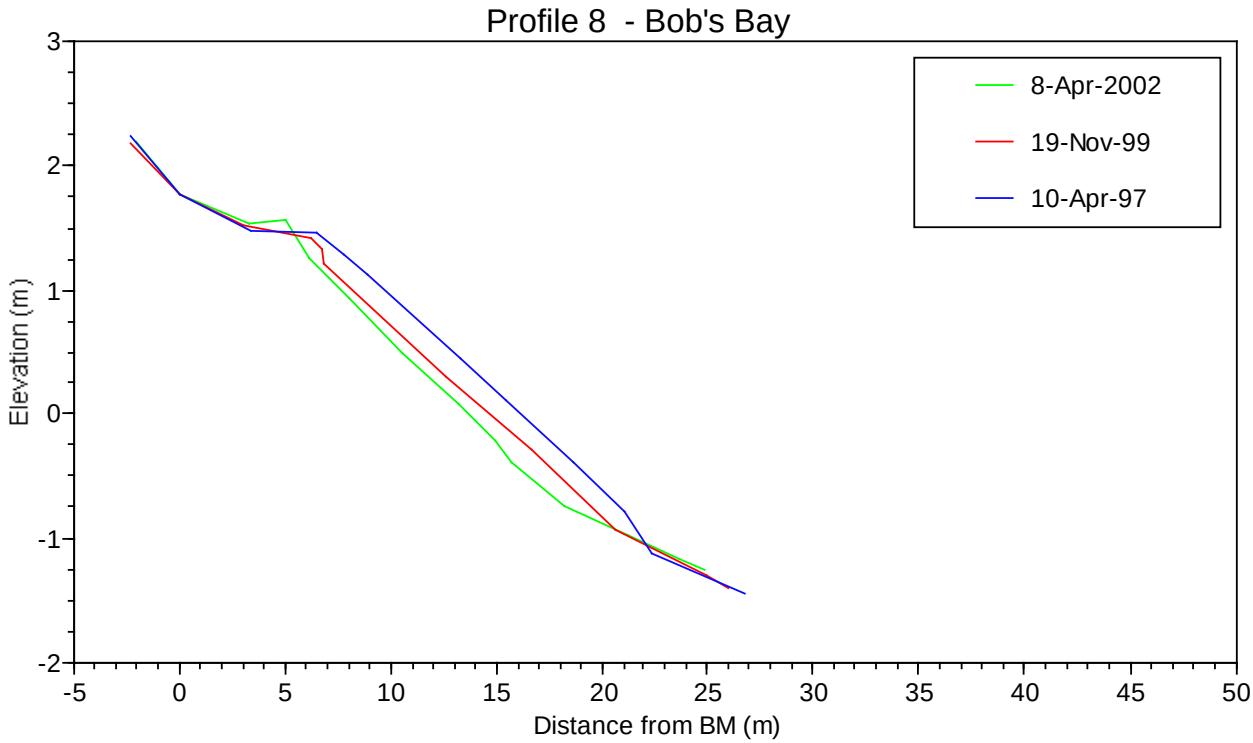

-1.50
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Distance from Datum (m)
Years after 1 January 1995

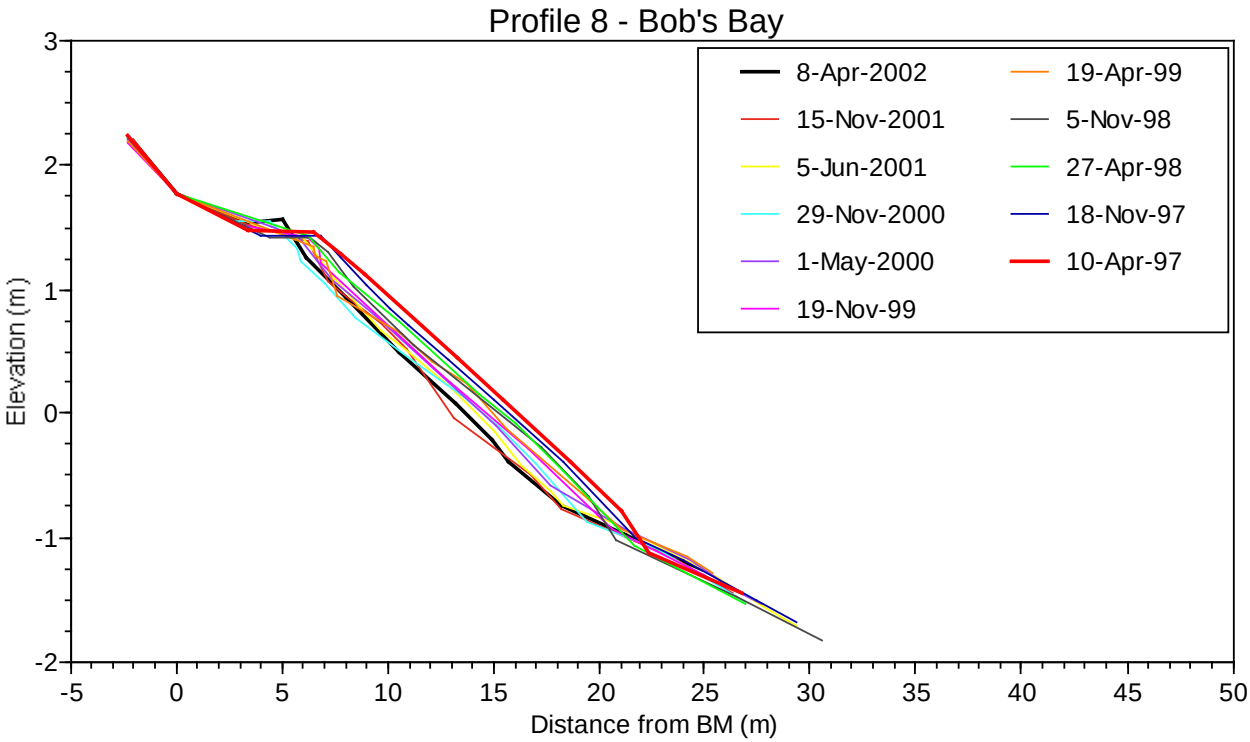


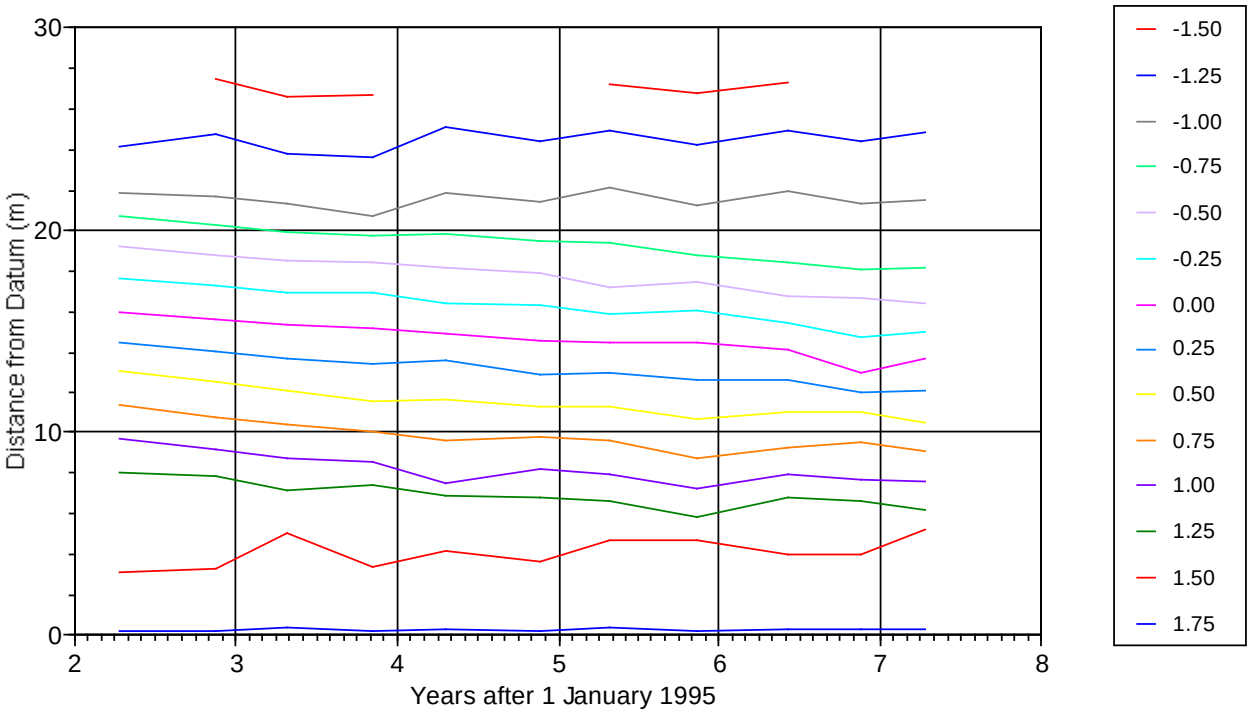
Date	Years after 1/1/95	Volume (m^3/m)
1977	17.50	38.3
8-Feb-95	0.10	31.6
17-Feb-95	0.13	31.6
22-Aug-95	0.64	32.4
22-Nov-95	0.89	33.6
8-Dec-95	0.94	34.0
20-Dec-95	0.97	34.1
7-Jan-96	1.02	34.1
8-Feb-96	1.10	33.7
9-Dec-96	1.94	34.5
9-Apr-97	2.27	34.9
14-Nov-97	2.87	35.4
9-Apr-98	3.27	34.0
4-Nov-98	3.84	35.3
13-Apr-99	4.28	34.7
18-Nov-99	4.88	35.8
1-May-00	5.33	35.2
22-Nov-00	5.89	38.1
15-Jun-01	6.46	40.3
12-Nov-01	6.86	41.5
10-Apr-02	7.28	41.0

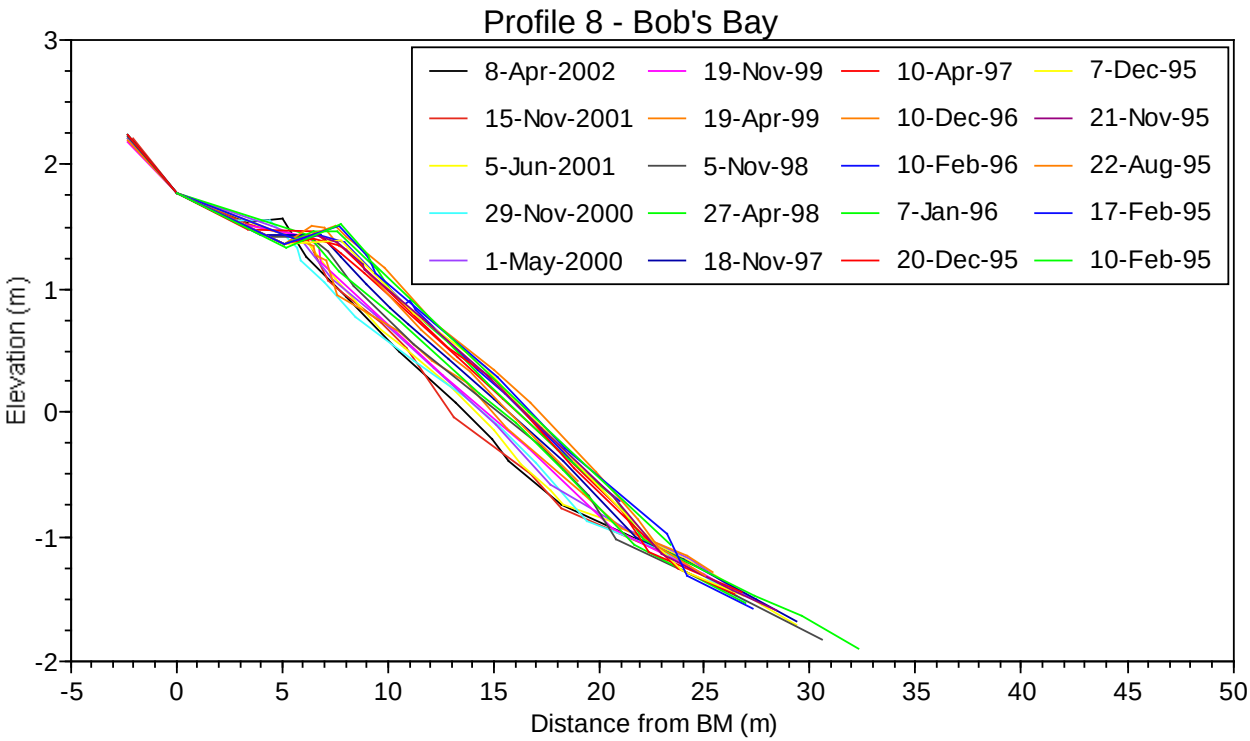
Profile 8 – Bob's Bay

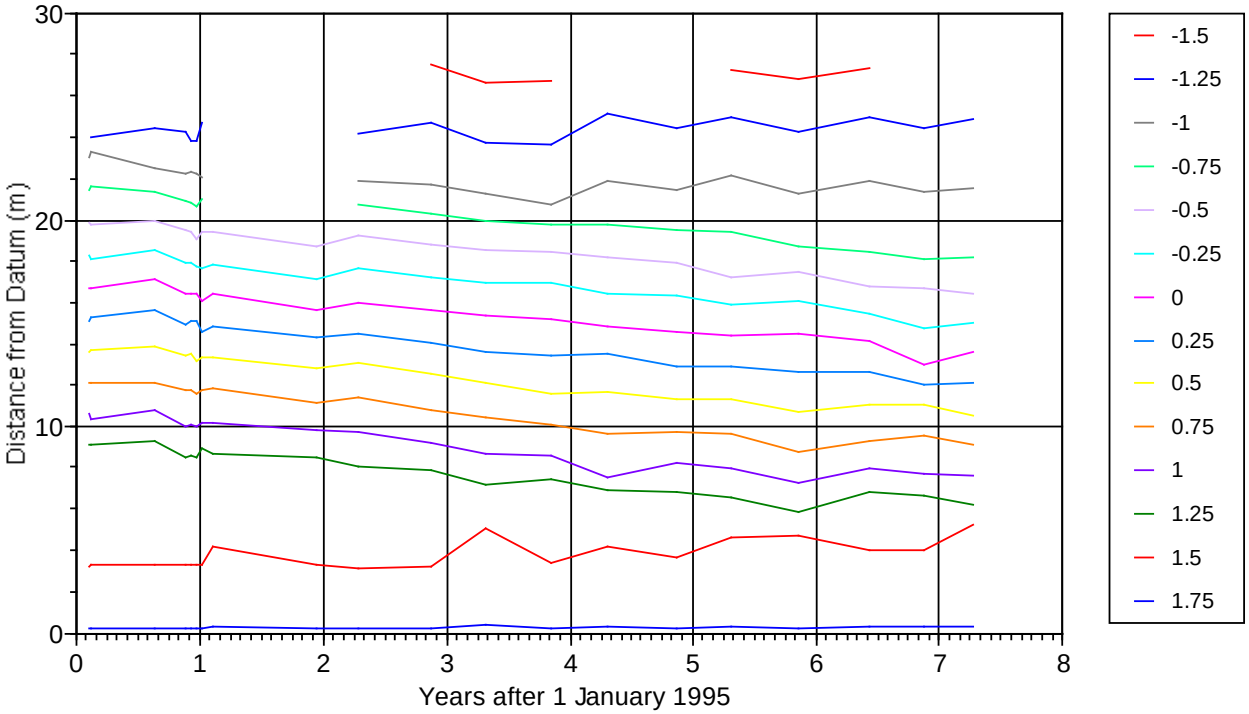
Bob's Bay has demonstrated an almost linear erosion trend since 1995 across the whole beach profile down to the change in slope (and probable closure depth) at about –1 m. Most of the beach has lowered in level by about 0.5m. Volume data shows a loss of approximately 7 m^3/m since 1995. This erosion is significant within the context of beaches in this study. The beach slope has stayed relatively constant. There is an indication that surficial sediment has been becoming finer over the survey period.

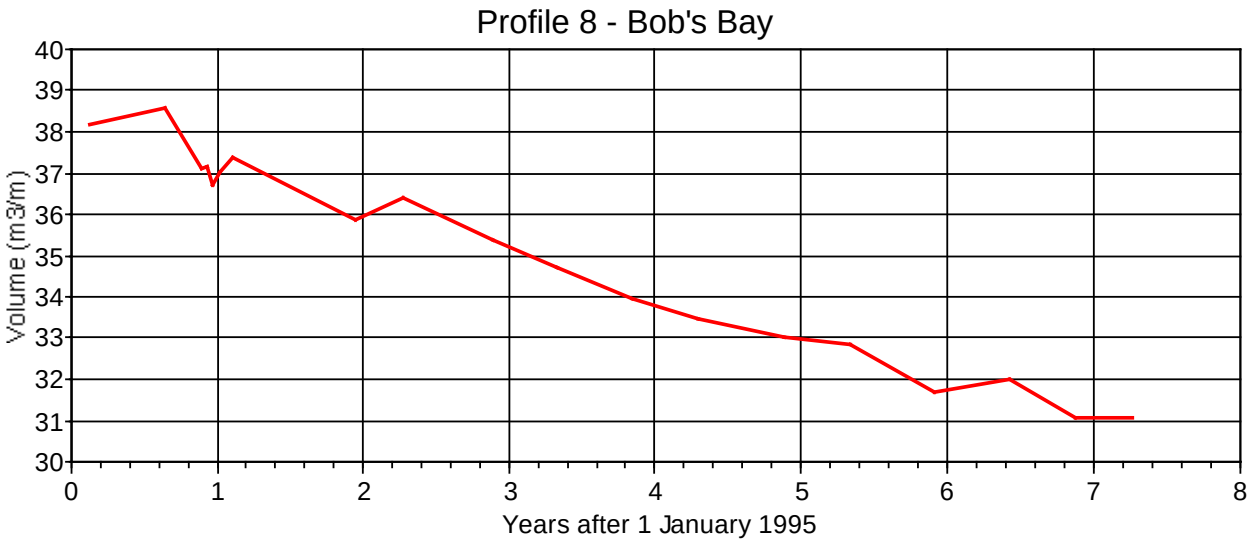

Profile 8 - Bob's Bay
8-Apr-2002
19-Nov-99
10-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 8 - Bob's Bay
8-Apr-2002
15-Nov-2001
5-Jun-2001
29-Nov-2000
1-May-2000
19-Nov-99
19-Apr-99
5-Nov-98
27-Apr-98
18-Nov-97
10-Apr-97
Elevation (m)
Distance from BM (m)


Distance from Datum (m)
Years after 1 January 1995
-1.50
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75


Profile 8 - Bob's Bay
8-Apr-2002
15-Nov-2001
5-Jun-2001
29-Nov-2000
1-May-2000
19-Nov-99
19-Apr-99
5-Nov-98
27-Apr-98
18-Nov-97
10-Apr-97
10-Dec-96
10-Feb-96
7-Jan-96
20-Dec-95
7-Dec-95
21-Nov-95
22-Aug-95
17-Feb-95
10-Feb-95
Elevation (m)
Distance from BM (m)

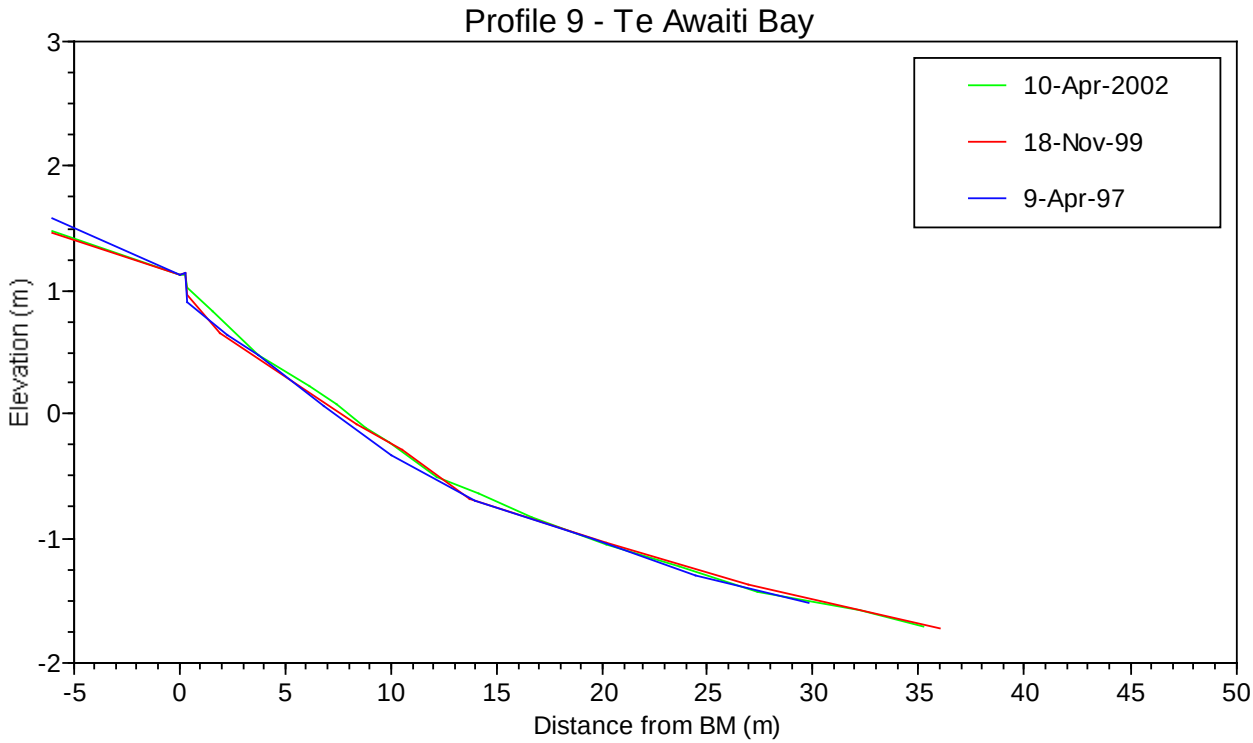

-1.5
-1.25
-1
-0.75
-0.5
-0.25
0
0.25
0.5
0.75
1
1.25
1.5
1.75
Distance from Datum (m)
Years after 1 January 1995

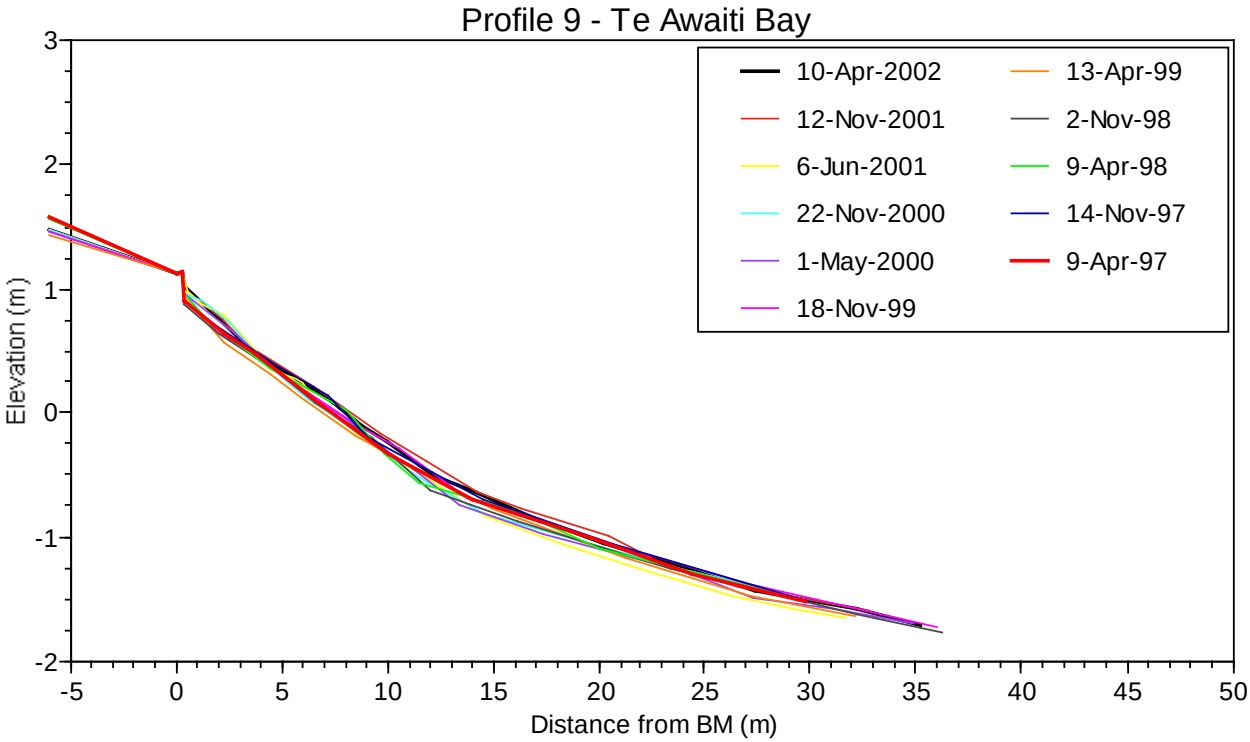


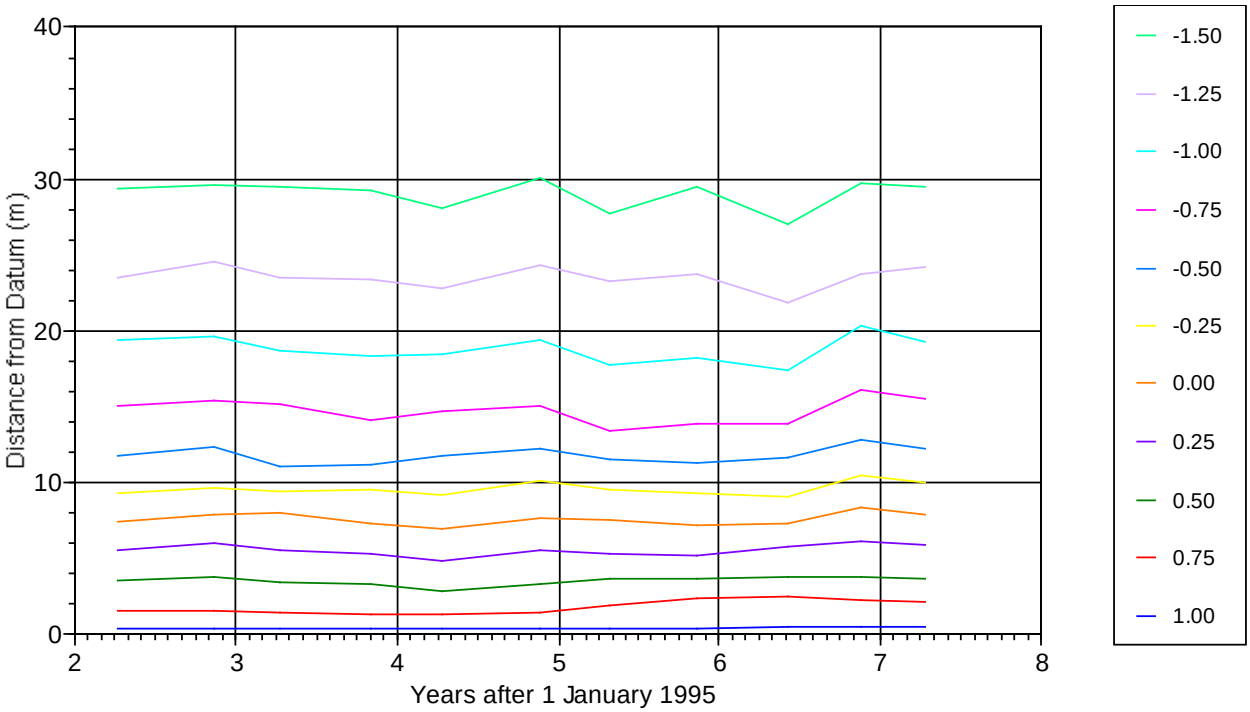
Date	Years after 1/1/95	Volume (m^3/m)
17-Feb-95	0.13	38.2
22-Aug-95	0.64	38.6
21-Nov-95	0.89	37.1
7-Dec-95	0.93	37.1
20-Dec-95	0.97	36.7
7-Jan-96	1.02	37.0
10-Feb-96	1.11	37.4
10-Dec-96	1.94	35.9
10-Apr-97	2.28	36.4
18-Nov-97	2.88	35.4
27-Apr-98	3.32	34.7
5-Nov-98	3.84	34.0
19-Apr-99	4.30	33.5
19-Nov-99	4.88	33.0
1-May-00	5.33	32.8
29-Nov-00	5.91	31.7
5-Jun-01	6.43	32.0
15-Nov-01	6.87	31.1
8-Apr-02	7.27	31.1

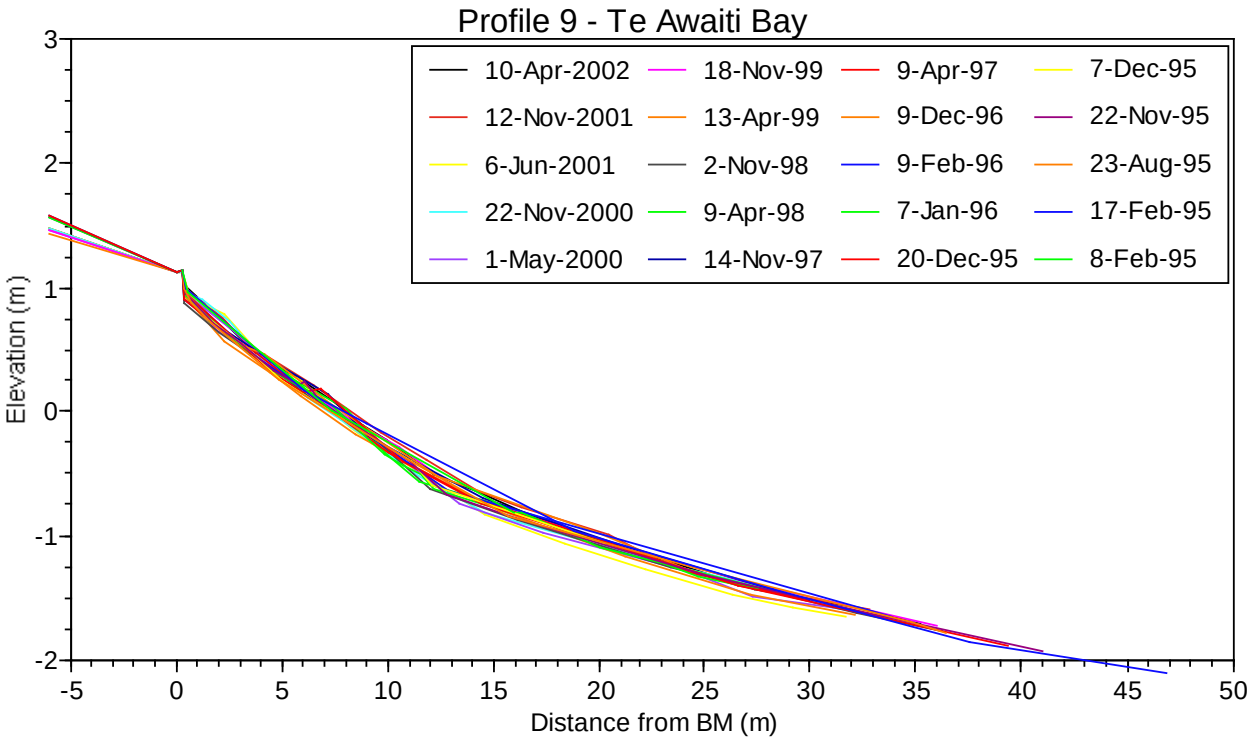
Profile 9 – Te Awaiti

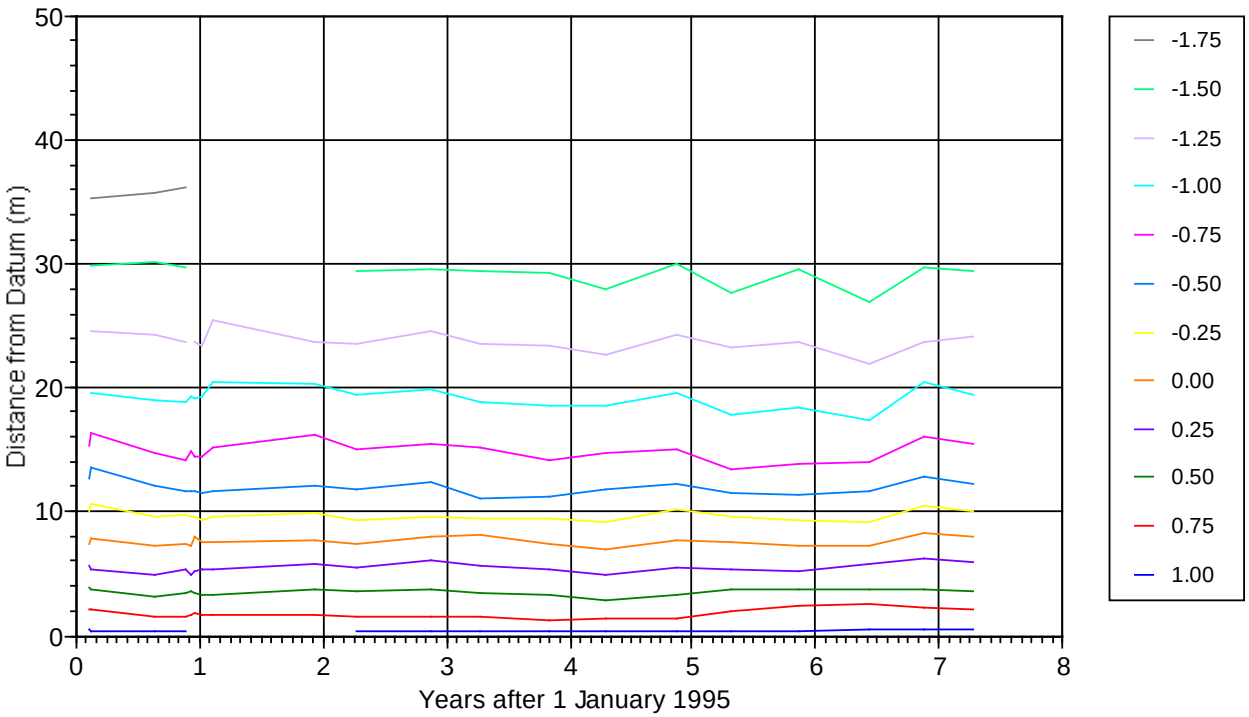
There has been no significant change in the profile of this beach over the survey period. The most remarkable aspect of this beach is the change in surficial sediment characteristics that occurs. This is clearly indicated in the photographs accompanying this report and those in Appendix 2 of the first contract report. The sand forms as a thin veneer, which has little impact on beach sediment volumes. There seems to be a trend of sand deposition over winter and loss over summer, although the trend is not particularly clear. The most significant deposit occurred over winter in 1997.

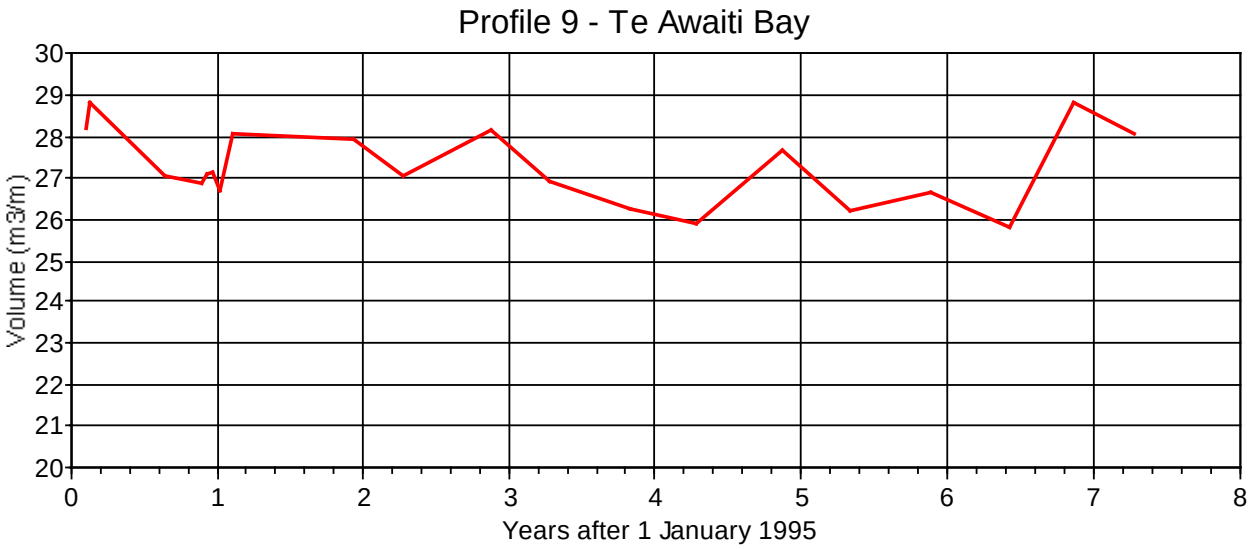

Profile 9 - Te Awaiti Bay
10-Apr-2002
18-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 9 - Te Awaiti Bay
10-Apr-2002
12-Nov-2001
6-Jun-2001
22-Nov-2000
1-May-2000
18-Nov-99
13-Apr-99
2-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)


Distance from Datum (m)
Years after 1 January 1995
-1.50
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00


Profile 9 - Te Awaiti Bay
10-Apr-2002
12-Nov-2001
6-Jun-2001
22-Nov-2000
1-May-2000
18-Nov-99
13-Apr-99
2-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
9-Dec-96
9-Feb-96
7-Jan-96
20-Dec-95
7-Dec-95
22-Nov-95
23-Aug-95
17-Feb-95
8-Feb-95
Elevation (m)
Distance from BM (m)

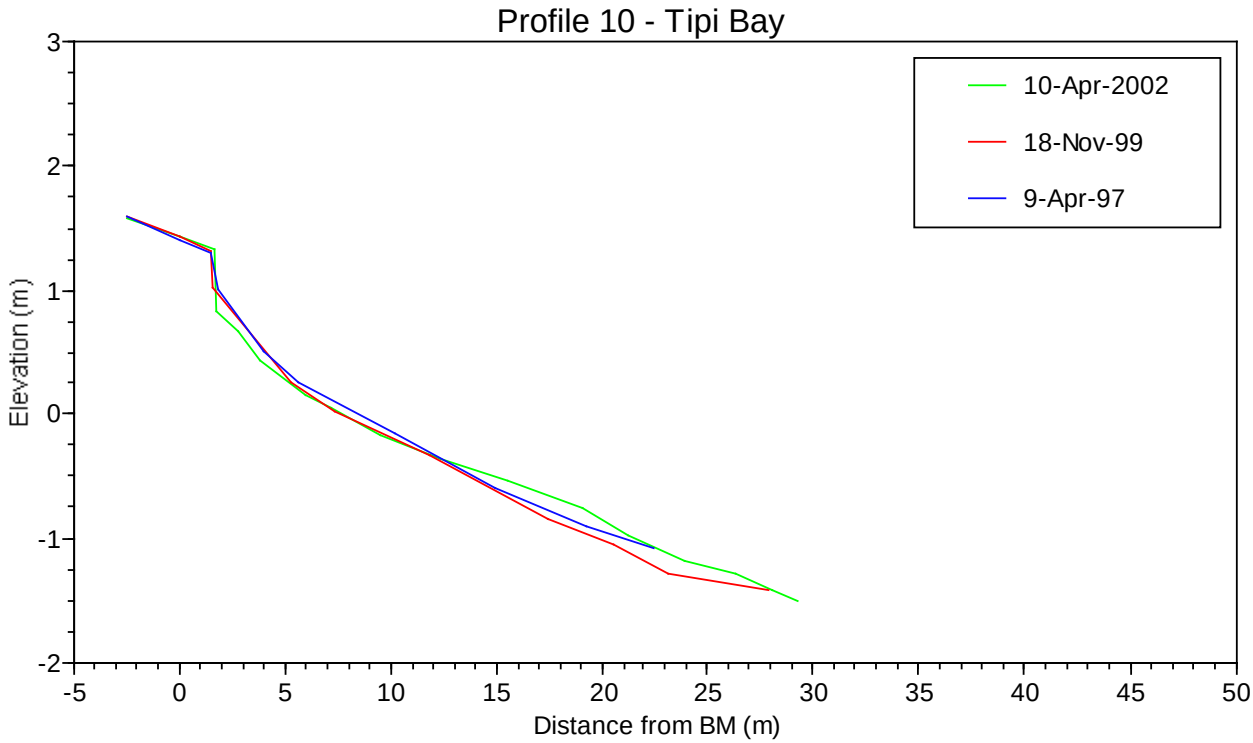

-1.75
-1.50
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
Distance from Datum (m)
Years after 1 January 1995

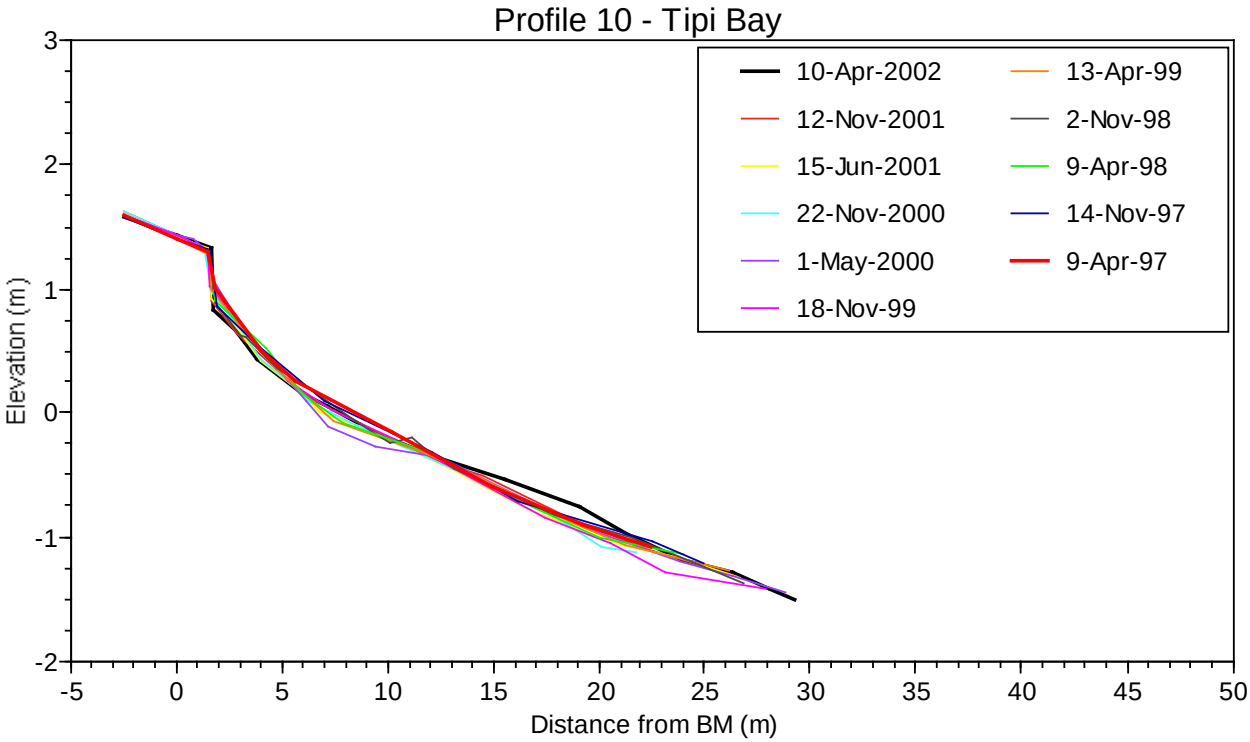


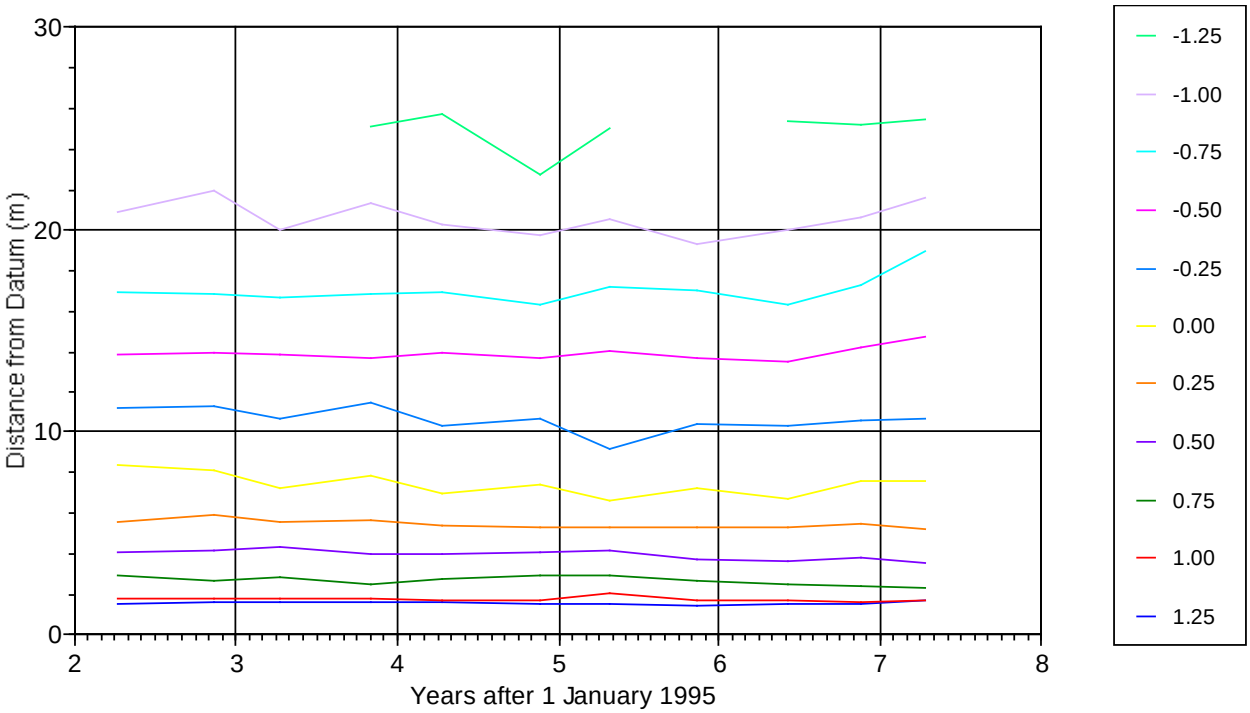
Date	Years after 1/1/95	Volume (m^3/m)
8-Feb-95	0.10	28.2
17-Feb-95	0.13	28.8
23-Aug-95	0.64	27.1
22-Nov-95	0.89	26.9
7-Dec-95	0.93	27.1
20-Dec-95	0.97	27.1
7-Jan-96	1.02	26.7
9-Feb-96	1.11	28.1
9-Dec-96	1.94	27.9
9-Apr-97	2.27	27.1
14-Nov-97	2.87	28.1
9-Apr-98	3.27	26.9
2-Nov-98	3.84	26.3
13-Apr-99	4.28	25.9
18-Nov-99	4.88	27.7
1-May-00	5.33	26.2
22-Nov-00	5.89	26.7
6-Jun-01	6.43	25.8
12-Nov-01	6.86	28.8
10-Apr-02	7.28	28.1

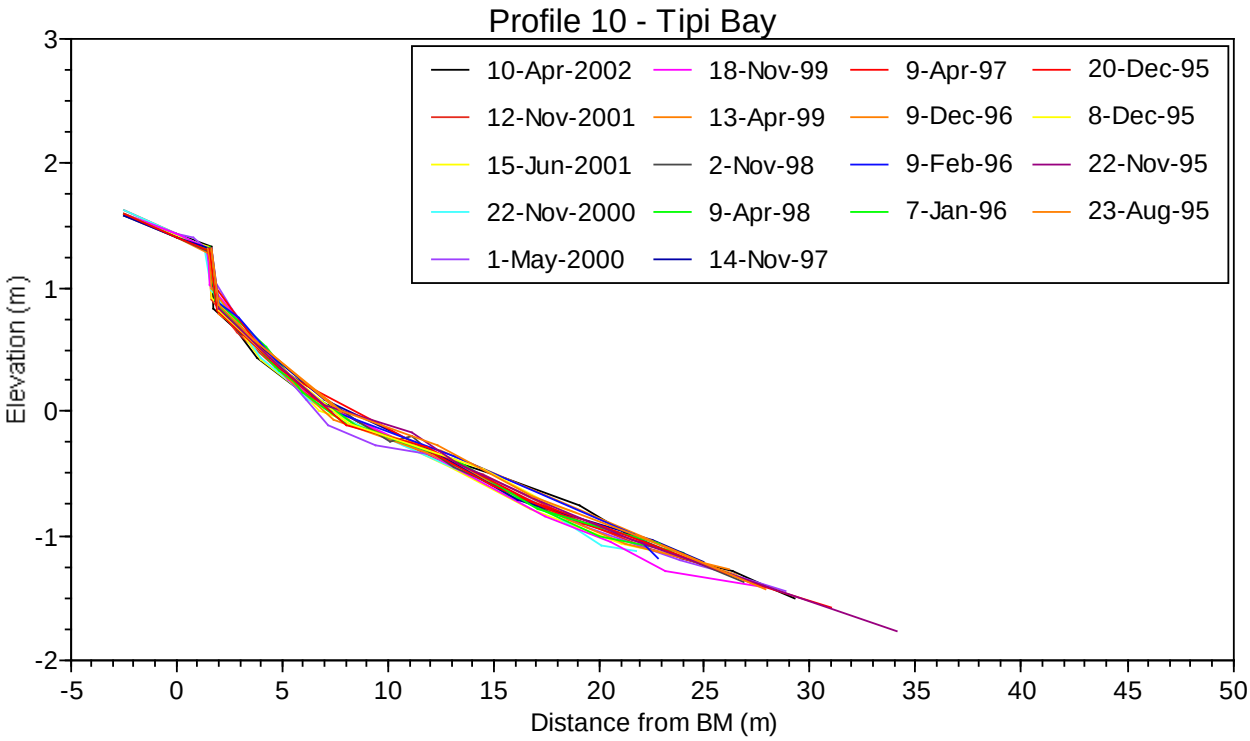
Profile 10 – Tipi Bay

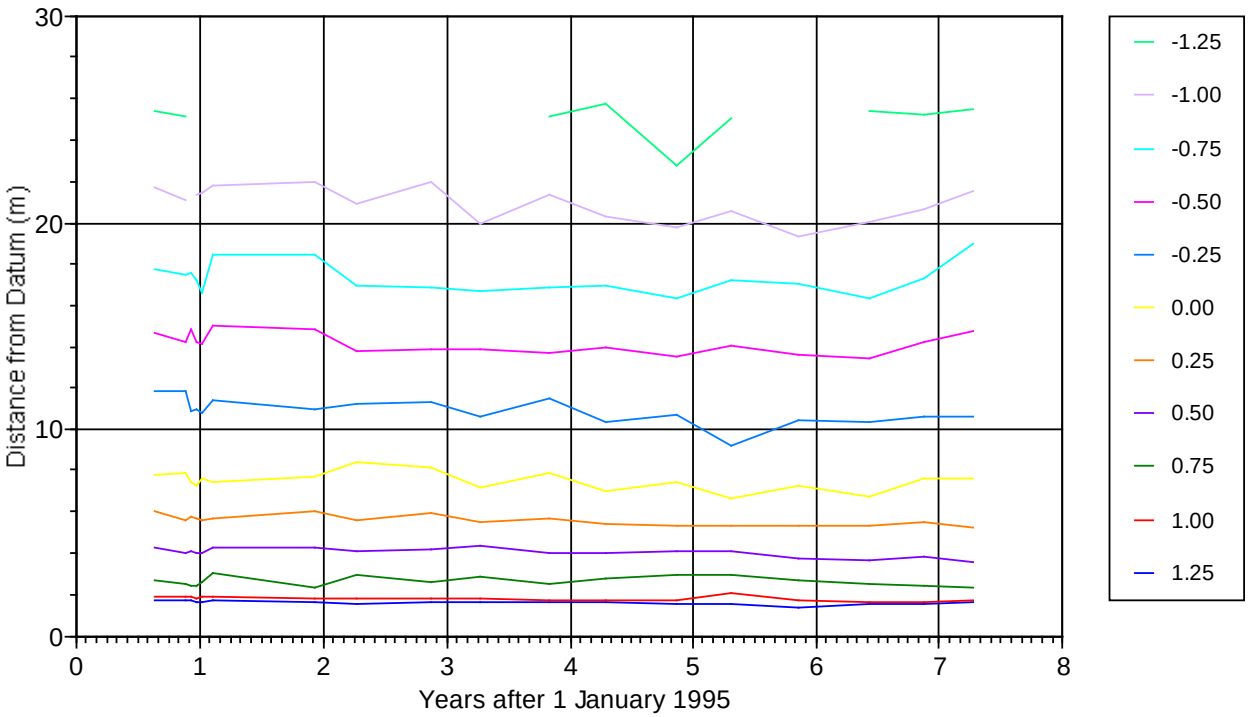
Tipi Bay has shown no significant change since 1997, and this is confirmed by Kirk and Single's longer term record. Because of the relatively coarse nature of the sediments, the placement of the survey staff can have significant impact on the apparent appearance of the profile line. There have been no apparent trends in sediment composition.

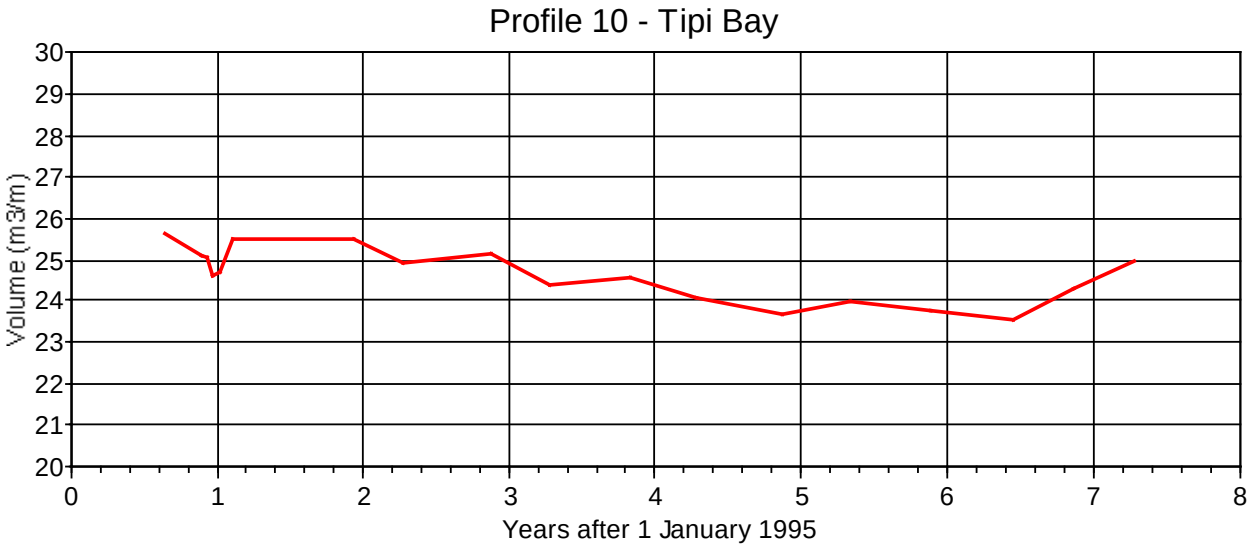

Profile 10 - Tipi Bay
10-Apr-2002
18-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 10 - Tipi Bay
10-Apr-2002
12-Nov-2001
15-Jun-2001
22-Nov-2000
1-May-2000
18-Nov-99
13-Apr-99
2-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)


-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
Distance from Datum (m)
Years after 1 January 1995


Profile 10 - Tipi Bay
10-Apr-2002
12-Nov-2001
15-Jun-2001
22-Nov-2000
1-May-2000
18-Nov-99
13-Apr-99
2-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
9-Dec-96
9-Feb-96
7-Jan-96
20-Dec-95
8-Dec-95
22-Nov-95
23-Aug-95
Elevation (m)
Distance from BM (m)

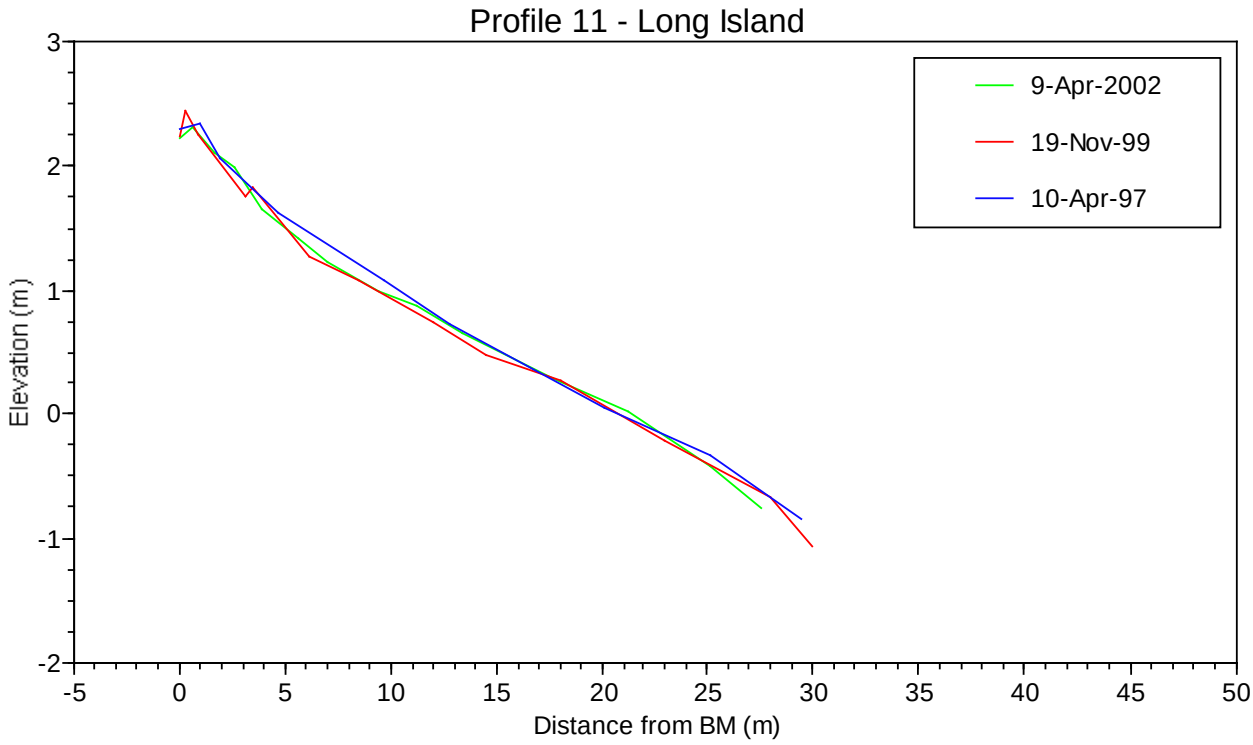

-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
Distance from Datum (m)
Years after 1 January 1995

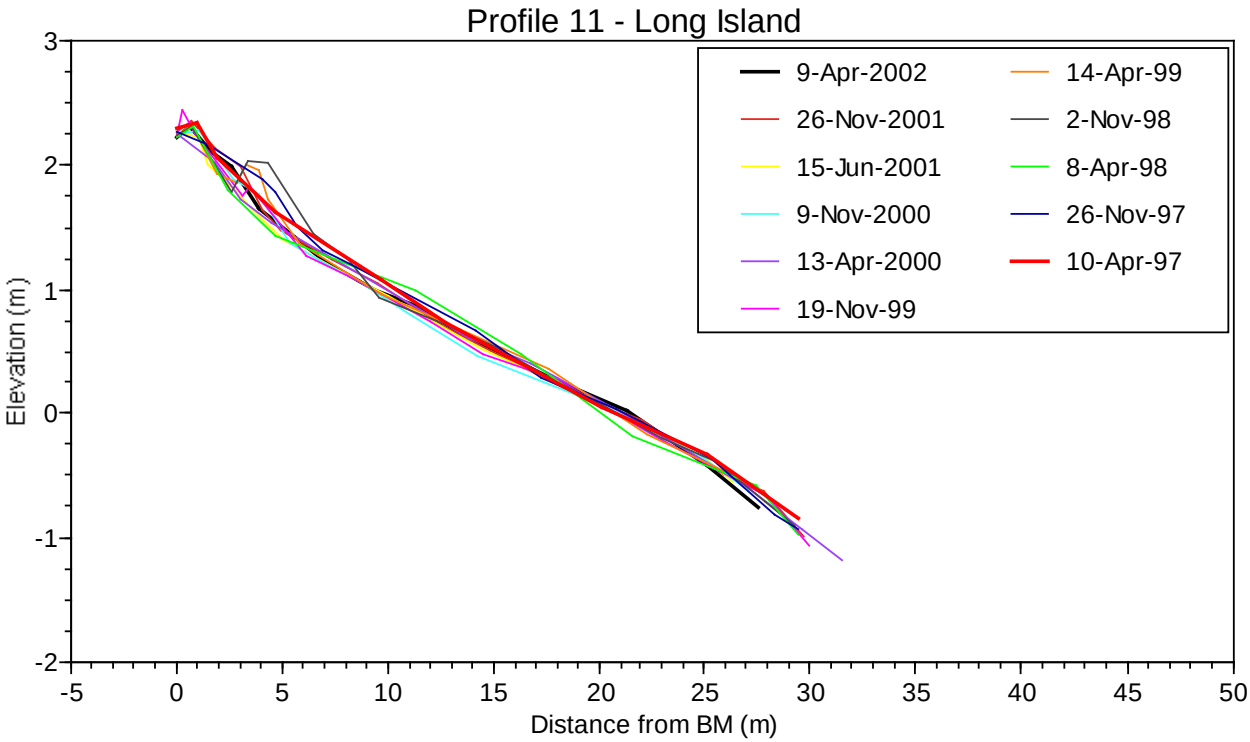


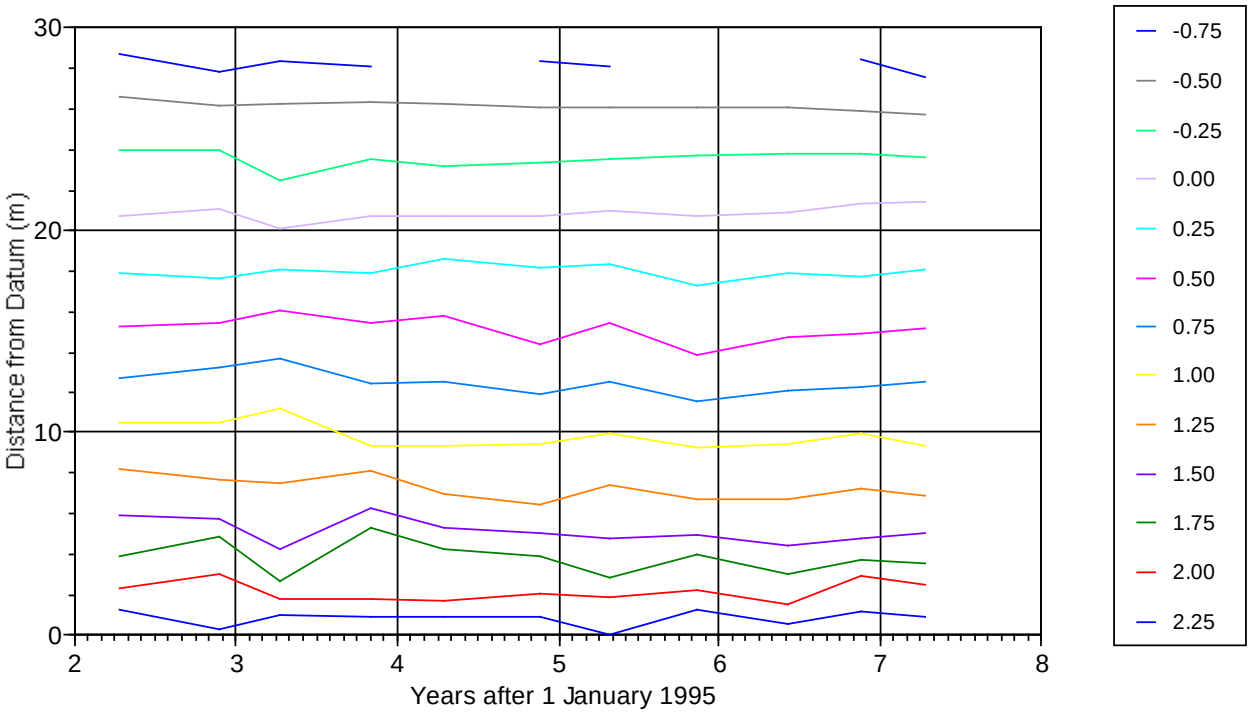
Date	Years after 1/1/95	Volume (m^3/m)
23-Aug-95	0.64	25.6
22-Nov-95	0.89	25.1
8-Dec-95	0.94	25.1
20-Dec-95	0.97	24.6
7-Jan-96	1.02	24.7
9-Feb-96	1.11	25.5
9-Dec-96	1.94	25.5
9-Apr-97	2.27	24.9
14-Nov-97	2.87	25.2
9-Apr-98	3.27	24.4
2-Nov-98	3.84	24.5
13-Apr-99	4.28	24.0
18-Nov-99	4.88	23.7
1-May-00	5.33	24.0
22-Nov-00	5.89	23.7
15-Jun-01	6.46	23.5
12-Nov-01	6.86	24.3
10-Apr-02	7.28	25.0

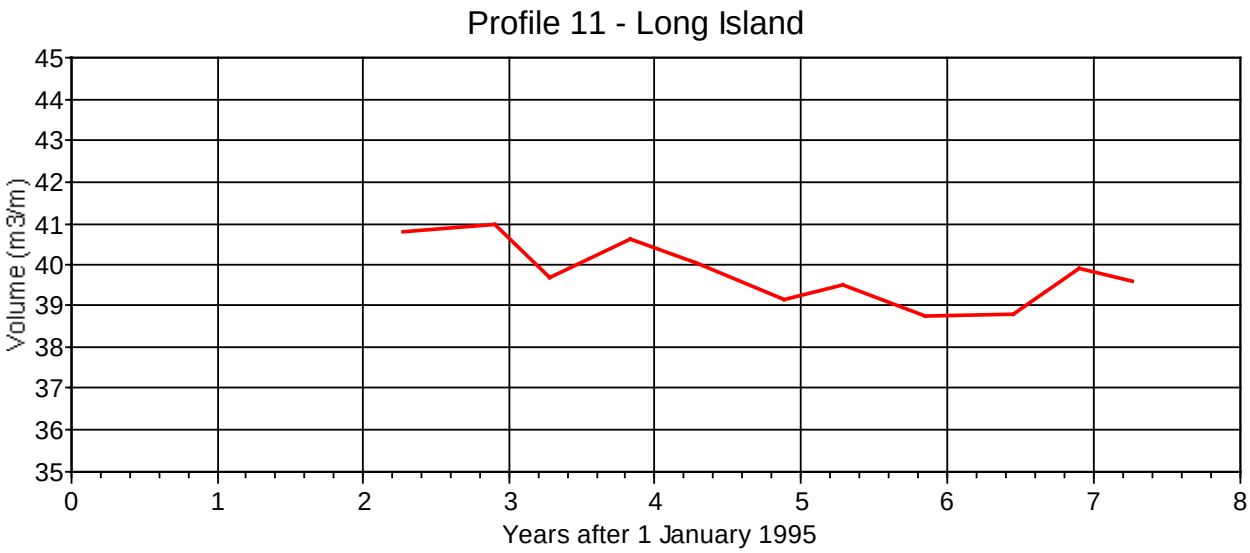
Profile 11 – Long Island

The Long Island profile is relatively exposed to storm events that cause waves to propagate through the northern entrance to Queen Charlotte Sound. There is considerable variability in the level of the upper beach, with the build up and removal of a berm, although this has been less evident over the last 5 surveys. The most significant berm construction took place between April 1998 and November 1998. The level of the middle and lower beach also shows some variability, but with no obvious seasonal trends. There are no significant sedimentary trends.


Profile 11 - Long Island
9-Apr-2002
19-Nov-99
10-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 11 - Long Island
9-Apr-2002
26-Nov-2001
15-Jun-2001
9-Nov-2000
13-Apr-2000
19-Nov-99
14-Apr-99
2-Nov-98
8-Apr-98
26-Nov-97
10-Apr-97
Elevation (m)
Distance from BM (m)

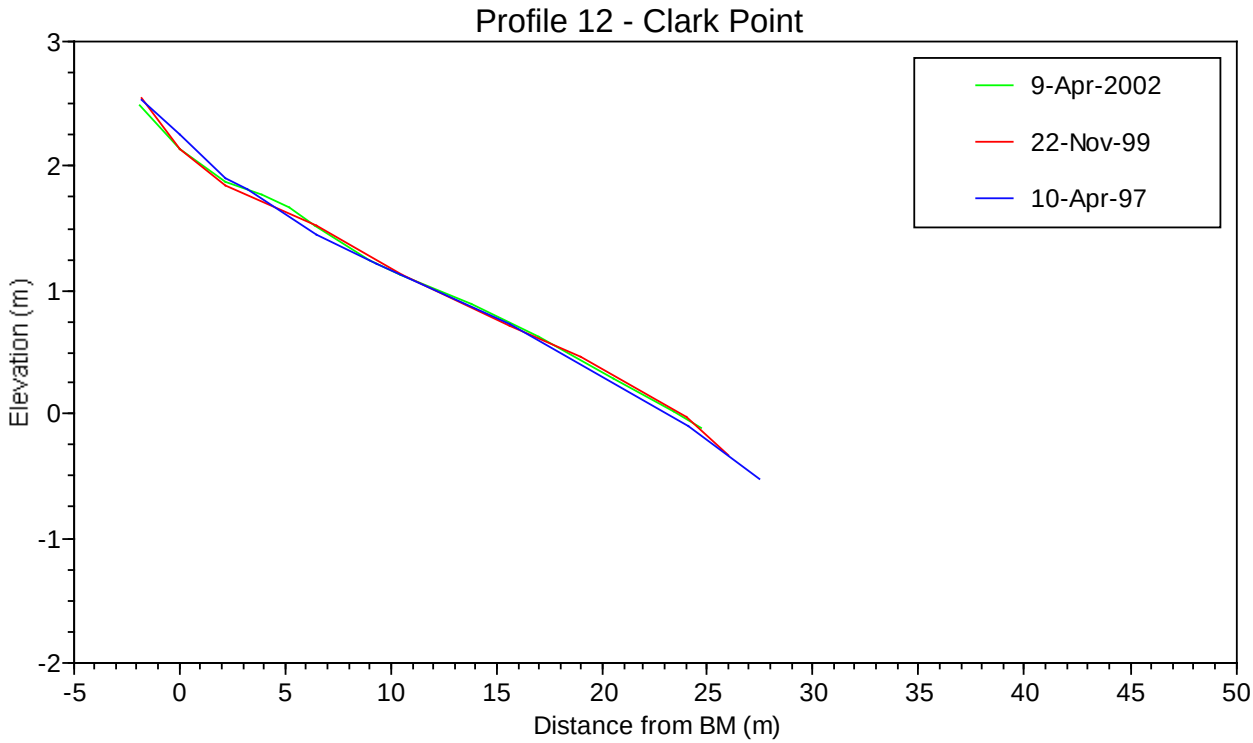

-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
Distance from Datum (m)
Years after 1 January 1995

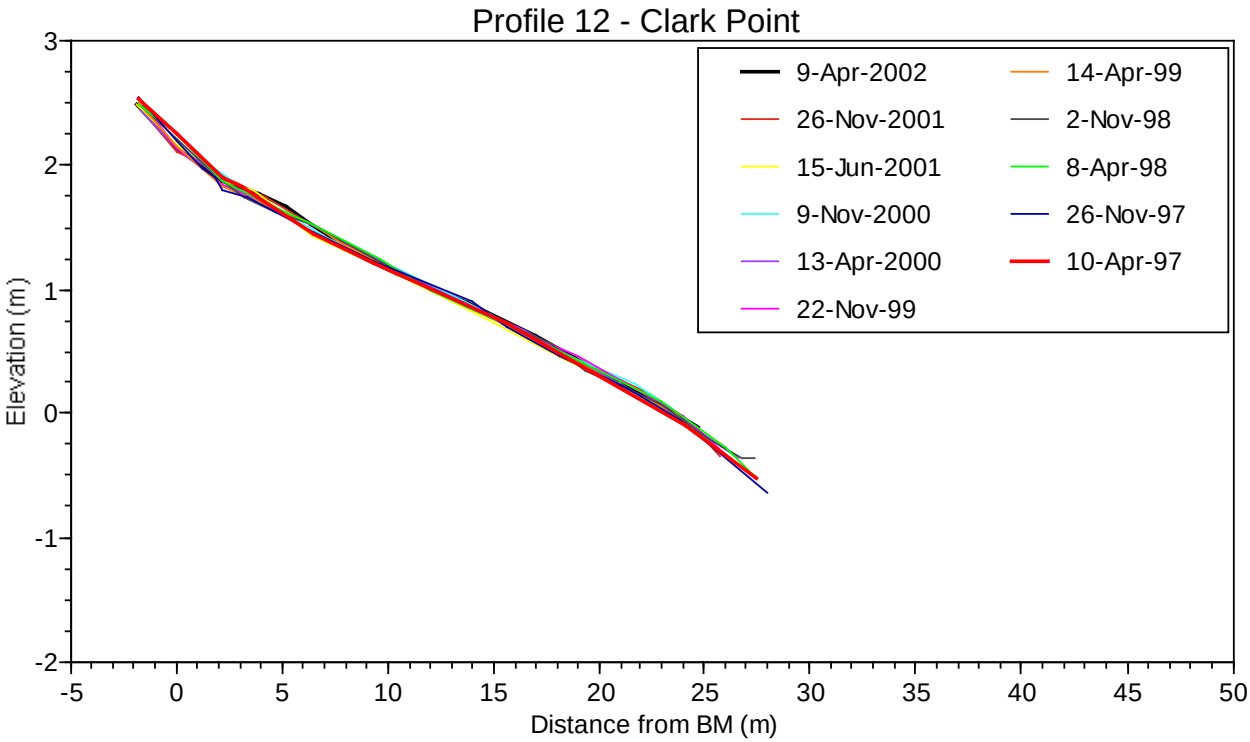


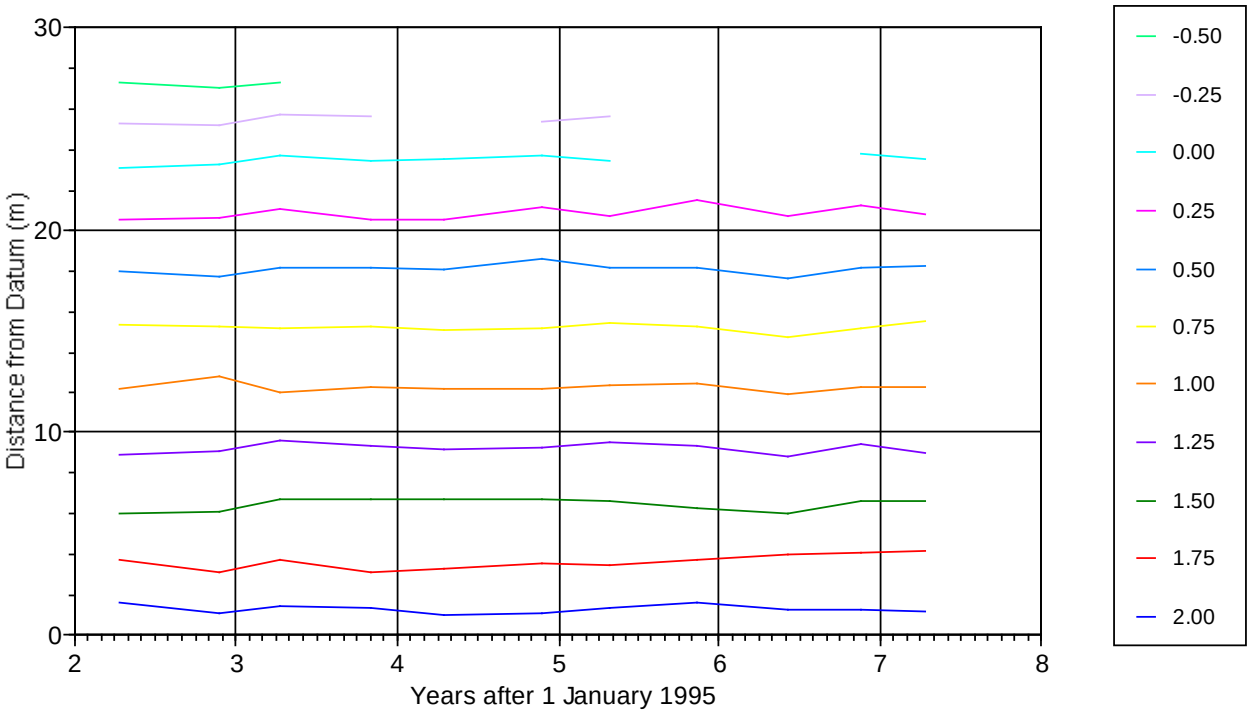
Date	Years after 1/1/95	Volume (m^3/m)
10-Apr-97	2.28	40.8
26-Nov-97	2.90	41.0
8-Apr-98	3.27	39.7
2-Nov-98	3.84	40.6
14-Apr-99	4.29	40.0
19-Nov-99	4.88	39.1
13-Apr-00	5.28	39.5
9-Nov-00	5.86	38.7
15-Jun-01	6.46	38.8
26-Nov-01	6.90	39.9
9-Apr-02	7.27	39.5

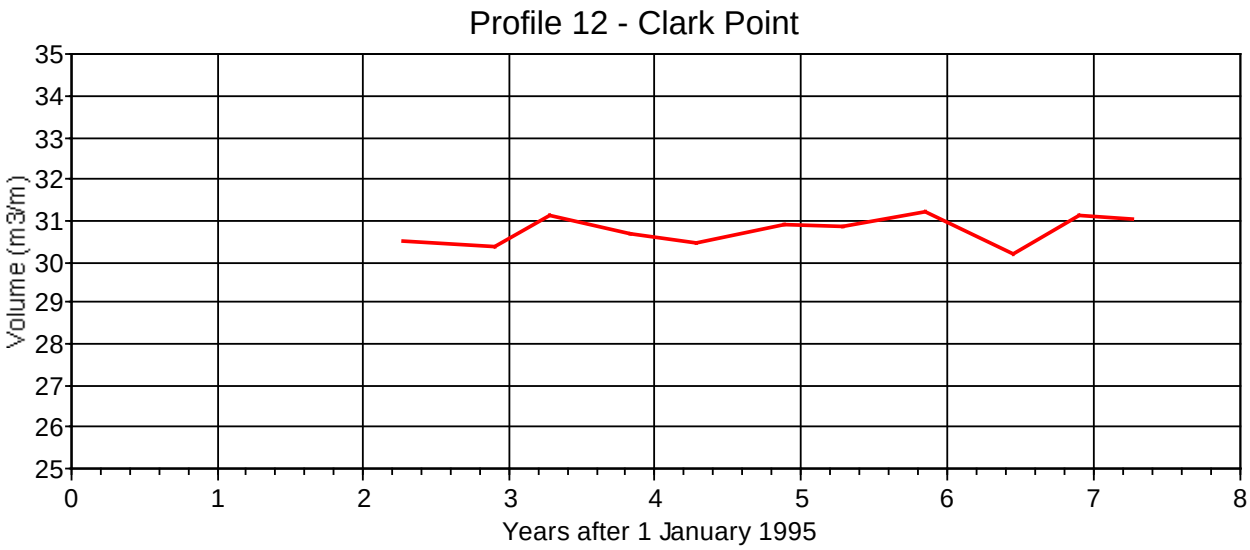
Profile 12 – Clark Point

This profile, with a similar aspect to Profile 11 (Long Island), has shown no significant change in level or sedimentary characteristics since 1997.


Profile 12 - Clark Point
9-Apr-2002
22-Nov-99
10-Apr-97
Elevation (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50
Distance from BM (m)


Profile 12 - Clark Point
9-Apr-2002
26-Nov-2001
15-Jun-2001
9-Nov-2000
13-Apr-2000
22-Nov-99
14-Apr-99
2-Nov-98
8-Apr-98
26-Nov-97
10-Apr-97
Elevation (m)
Distance from BM (m)


-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Distance from Datum (m)
Years after 1 January 1995



Date	Years after 1/1/95	Volume (m^3/m)
10-Apr-97	2.28	30.5
26-Nov-97	2.90	30.4
8-Apr-98	3.27	31.1
2-Nov-98	3.84	30.7
14-Apr-99	4.29	30.5
22-Nov-99	4.89	30.9
13-Apr-00	5.28	30.9
9-Nov-00	5.86	31.2
15-Jun-01	6.46	30.2
26-Nov-01	6.90	31.1
9-Apr-02	7.27	31.0

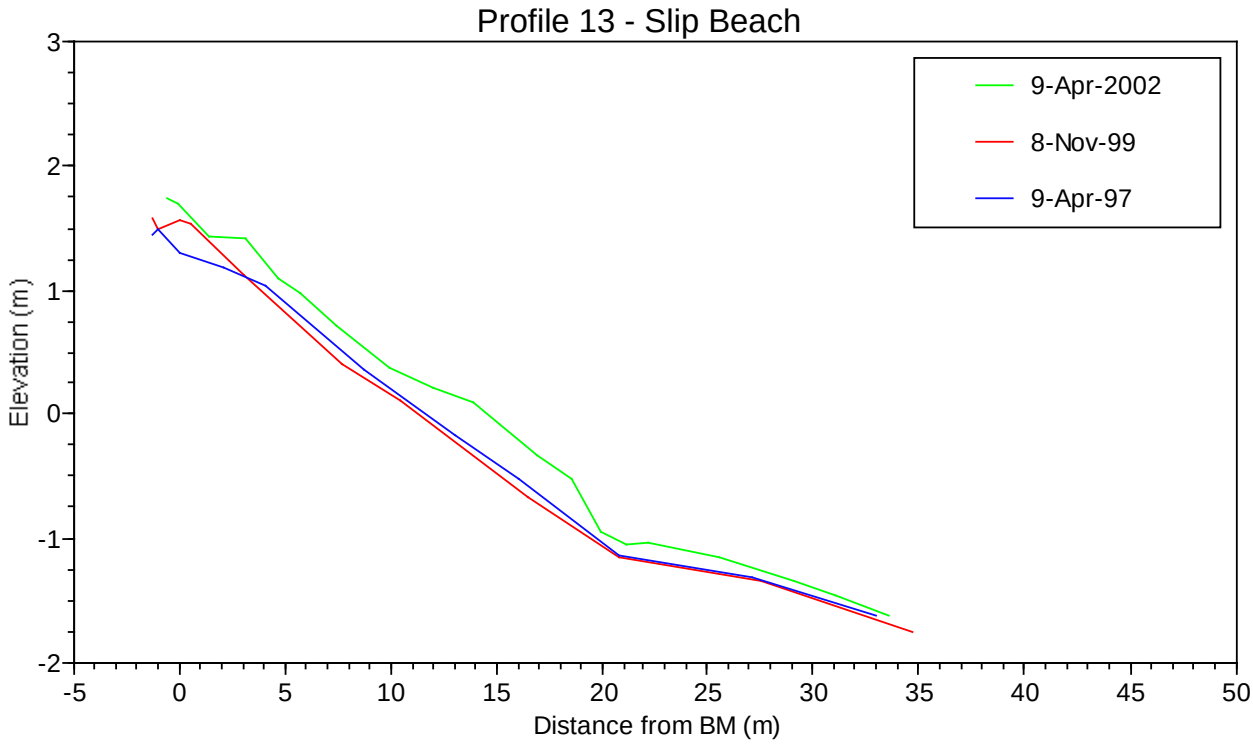
Profile 13 – Slip Beach

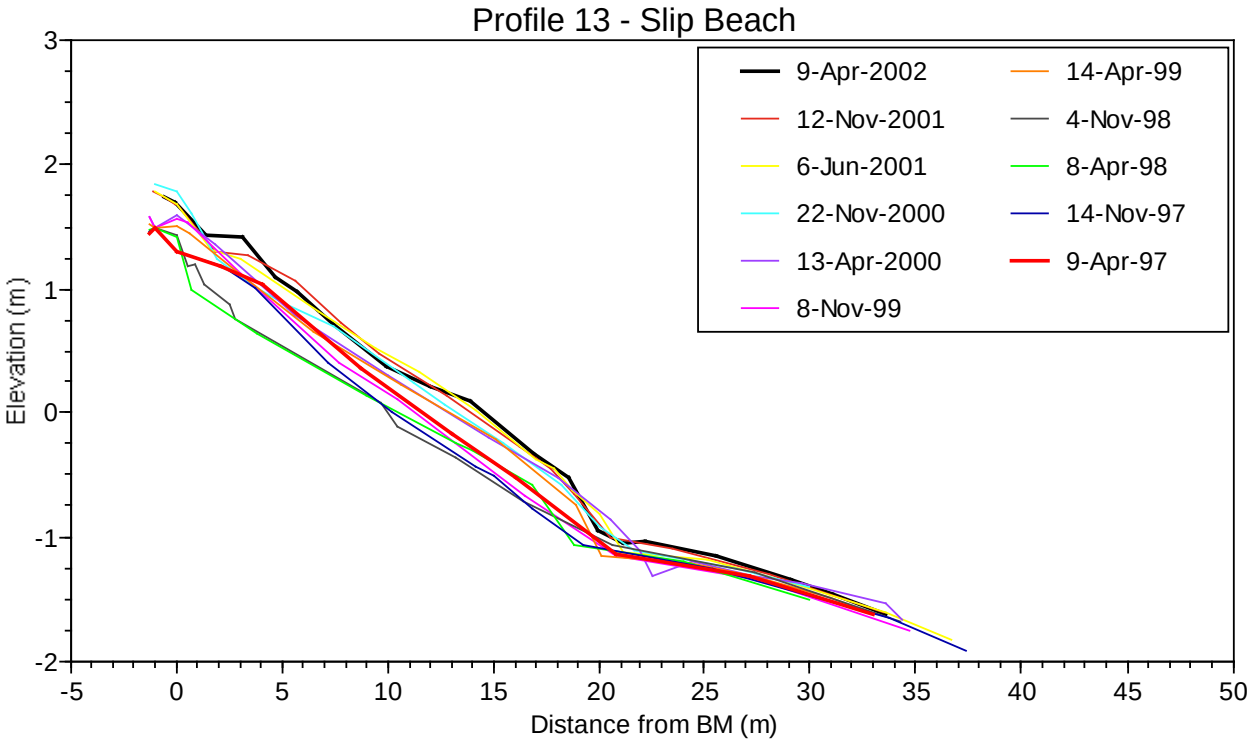
Slip Beach demonstrated considerable variability between 1995 and April 1998 when it reached its lowest level. Since that time, and with the single exception of the period between April 1999 and November 1999, there has been a trend of accretion, with about 0.5 m of sediment deposited across the beach profile to closure depth at about –1.0m. The beach is currently as full as it has been at ay time, and the volumes of sediment held in it indicate this.

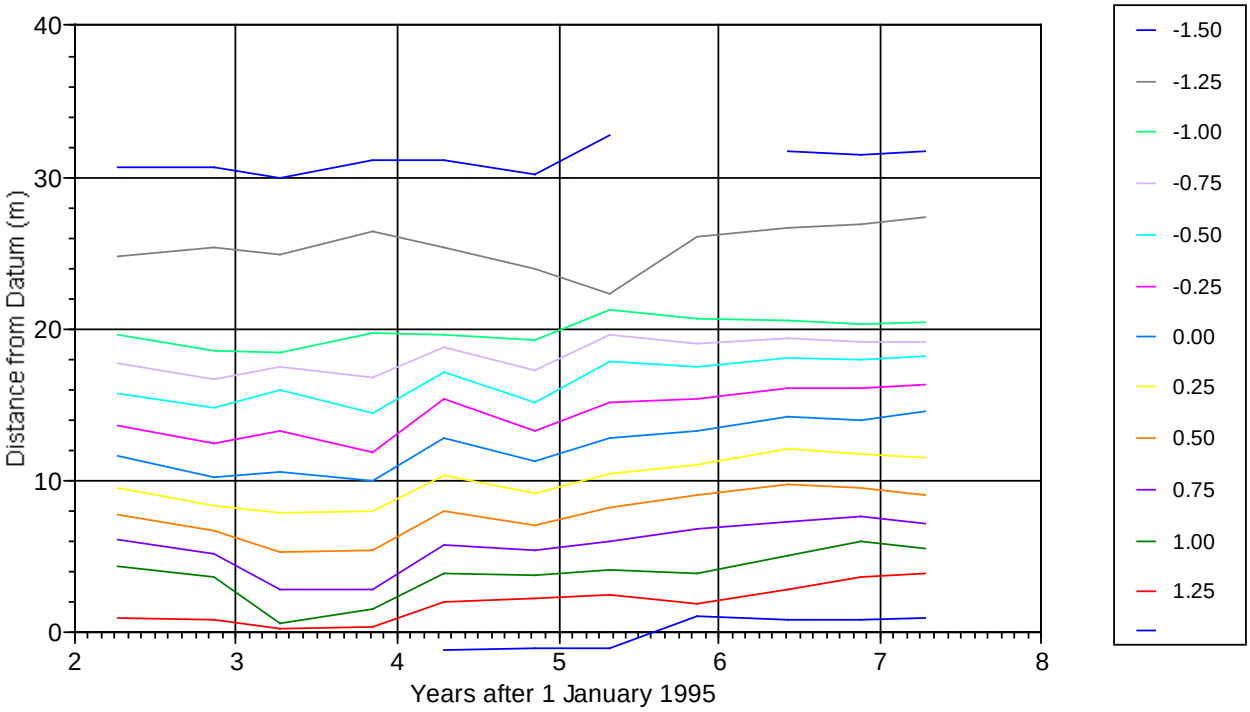
The 1977 plots derived from Newton's work indicate that at that time Slip Beach was significantly depleted.

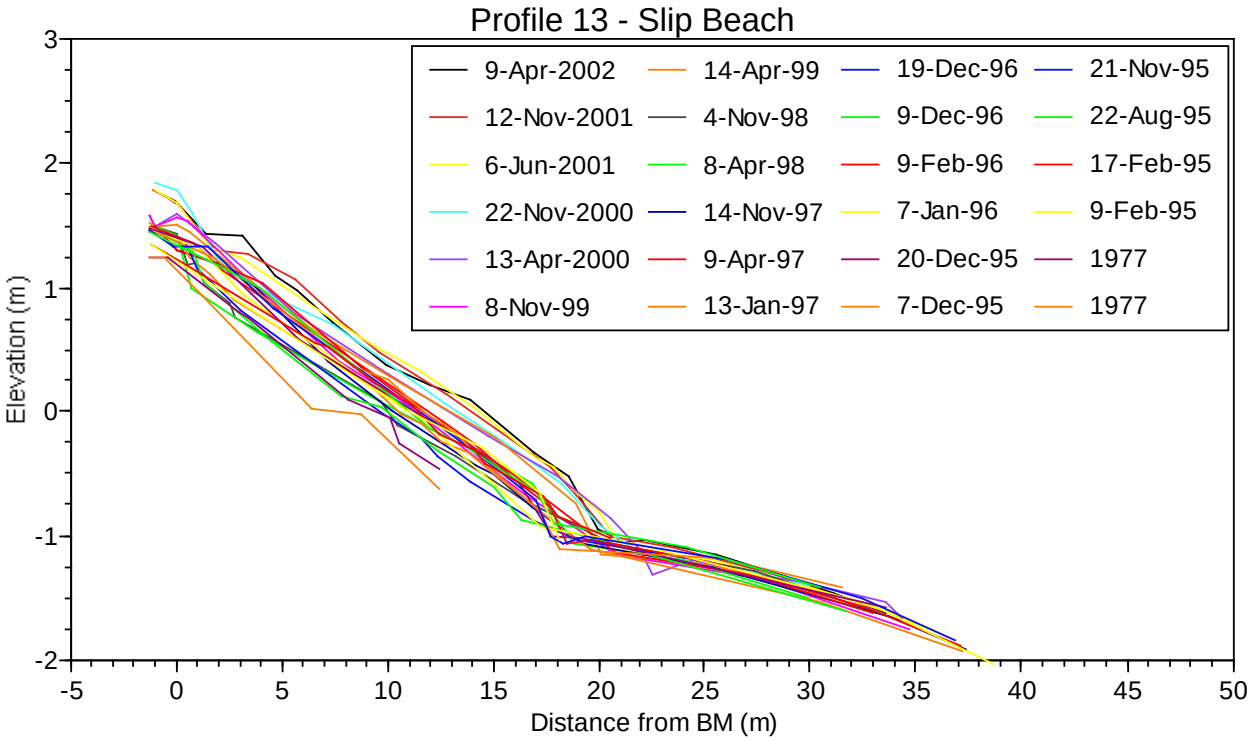
The photographs indicate that the dominant sediment type is sand with some small cobbles and pebbles.

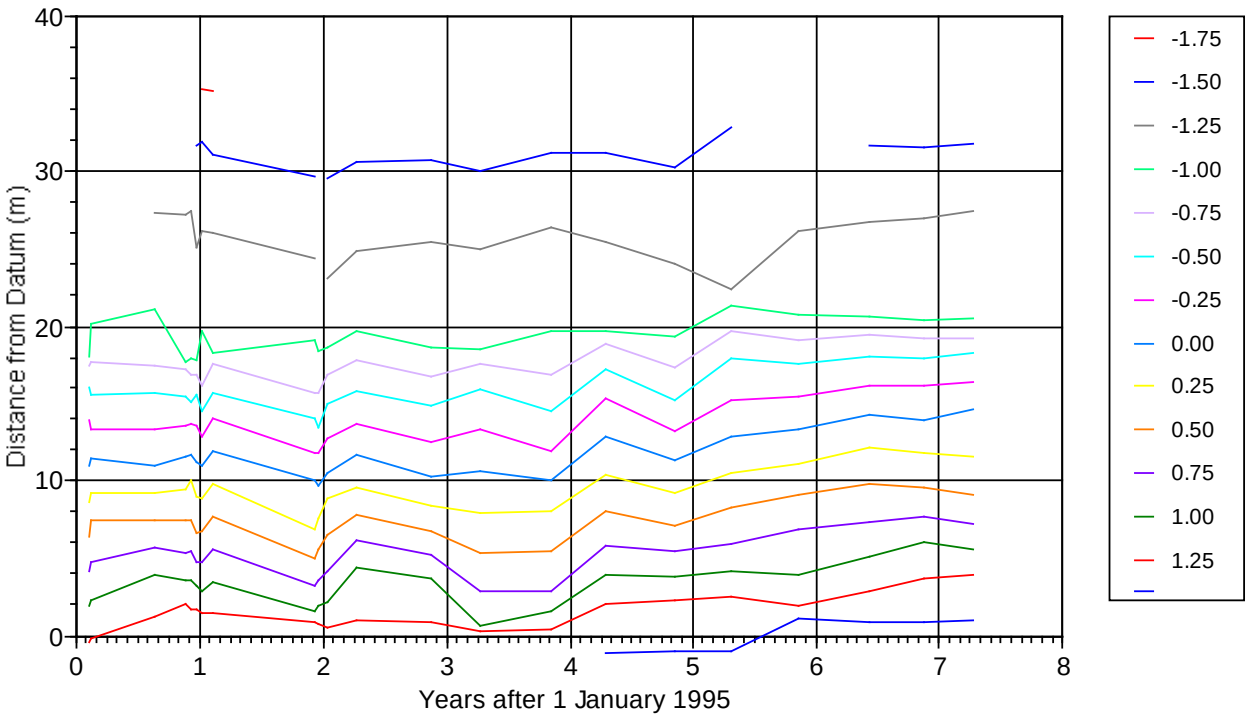
There are no obvious relationships between ferry operations and beach change. Slip beach has a considerable fetch into Queen Charlotte Sound to the north, and natural waves may be substantial. However, wave measurements at this site have indicated substantial wake events that continue for unusually long periods of time. Because of its unusual exposure, unusual wakes and, for the area, fine sediments, this location is of particular interest.

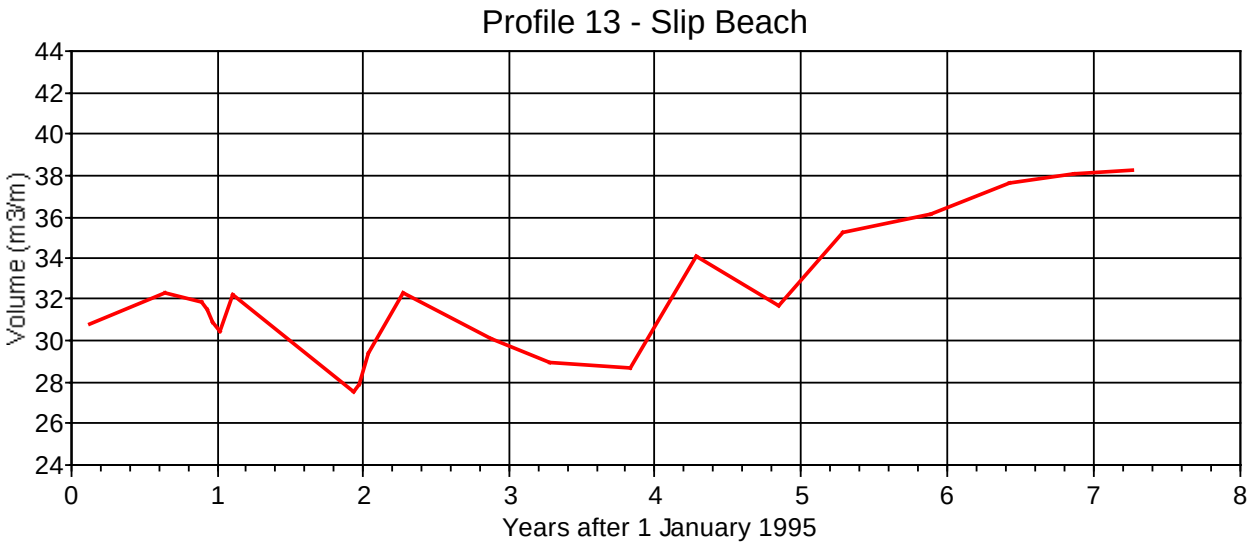

Profile 13 - Slip Beach
9-Apr-2002
8-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 13 - Slip Beach
9-Apr-2002
12-Nov-2001
6-Jun-2001
22-Nov-2000
13-Apr-2000
8-Nov-99
14-Apr-99
4-Nov-98
8-Apr-98
14-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)


Distance from Datum (m)
Years after 1 January 1995
-1.50
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25


Profile 13 - Slip Beach
9-Apr-2002
12-Nov-2001
6-Jun-2001
22-Nov-2000
13-Apr-2000
8-Nov-99
14-Apr-99
4-Nov-98
8-Apr-98
14-Nov-97
9-Apr-97
13-Jan-97
19-Dec-96
9-Dec-96
9-Feb-96
7-Jan-96
20-Dec-95
7-Dec-95
21-Nov-95
22-Aug-95
17-Feb-95
9-Feb-95
1977
1977
Elevation (m)
Distance from BM (m)


-1.75
-1.50
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
Distance from Datum (m)
Years after 1 January 1995

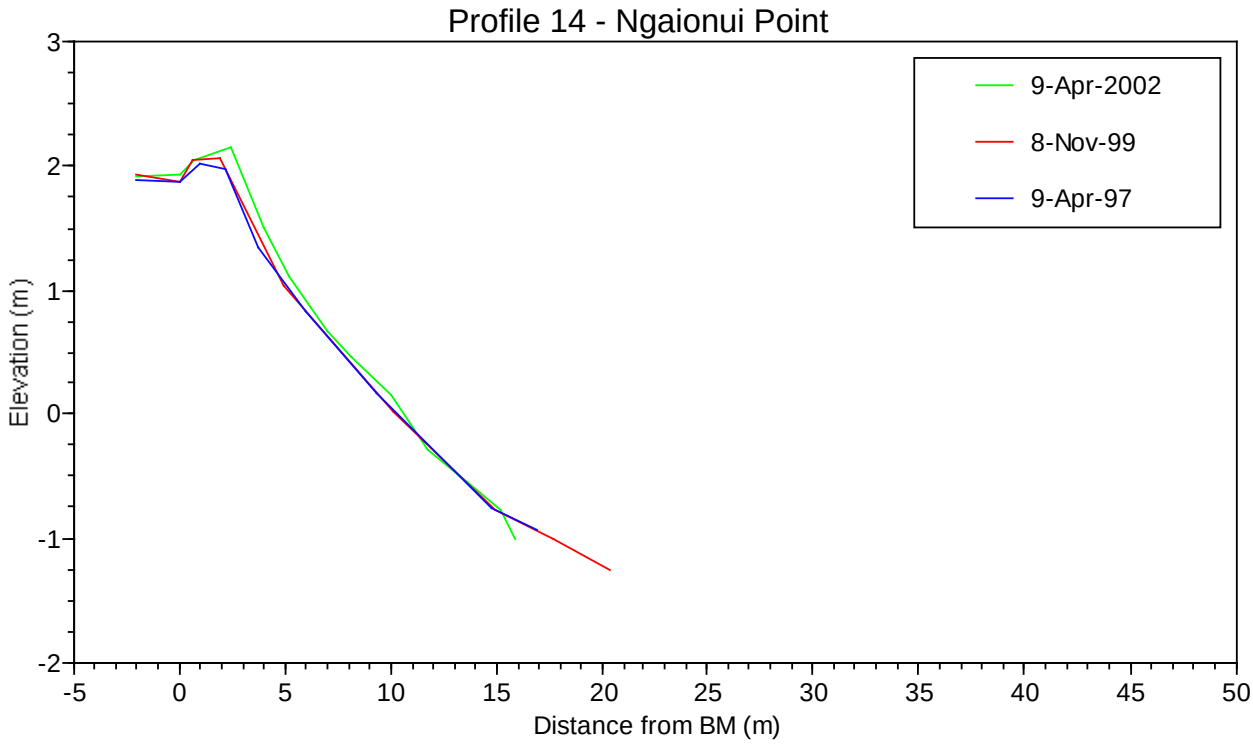


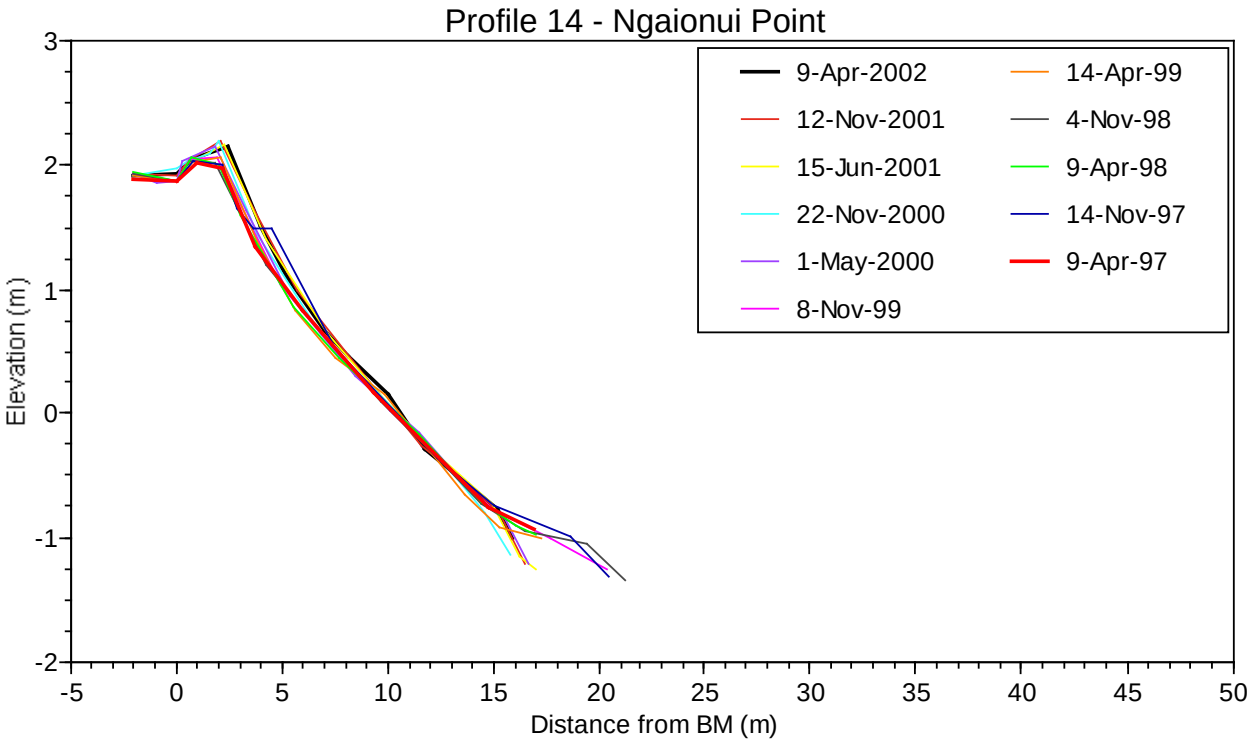
Date	Years after 1/1/95	Volume (m^3/m)
17-Feb-95	0.13	30.8
22-Aug-95	0.64	32.3
21-Nov-95	0.89	31.9
7-Dec-95	0.93	31.5
20-Dec-95	0.97	30.9
7-Jan-96	1.02	30.4
9-Feb-96	1.11	32.2
9-Dec-96	1.94	27.5
19-Dec-96	1.97	27.8
13-Jan-97	2.03	29.4
9-Apr-97	2.27	32.3
14-Nov-97	2.87	30.0
8-Apr-98	3.27	29.0
4-Nov-98	3.84	28.7
14-Apr-99	4.29	34.2
8-Nov-99	4.85	31.7
13-Apr-00	5.28	35.3
22-Nov-00	5.89	36.2
6-Jun-01	6.43	37.6
12-Nov-01	6.86	38.1
9-Apr-02	7.27	38.3

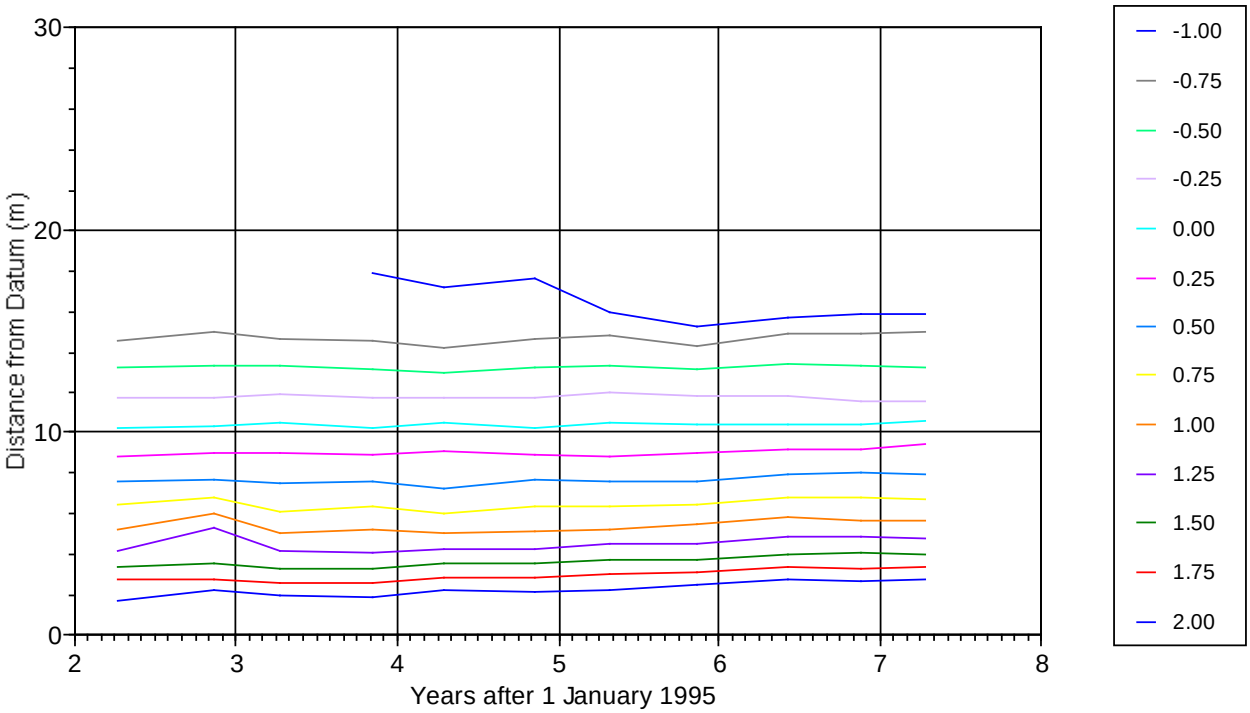
Profile 14 – Ngaionui Point

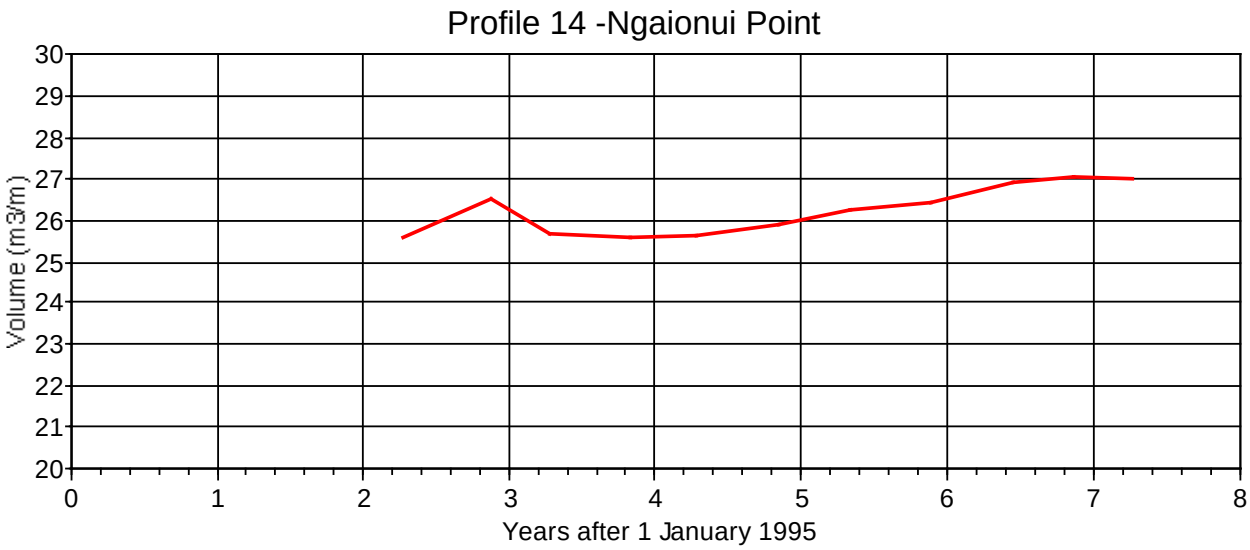
The beach on Ngaionui Point has shown surprisingly little change, particularly given its proximity to the sailing line of vessels in Tory Channel. It is most likely that significant change occurred when the fast ferry first started operation, and that the beach form has held since that time. There has been a slow trend of accretion since surveys started, perhaps increasing slowly in recent years. A small berm on the middle to upper beach that was recorded in November 1997, caused a small 'bump' in an otherwise consistent pattern of minor change.

Apparent changes at the very lower beach are probably the result of different survey placement. There have been no significant changes in sediments.


Profile 14 - Ngaionui Point
9-Apr-2002
8-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 14 - Ngaionui Point
9-Apr-2002
12-Nov-2001
15-Jun-2001
22-Nov-2000
1-May-2000
8-Nov-99
14-Apr-99
4-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)


Distance from Datum (m)
Years after 1 January 1995
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

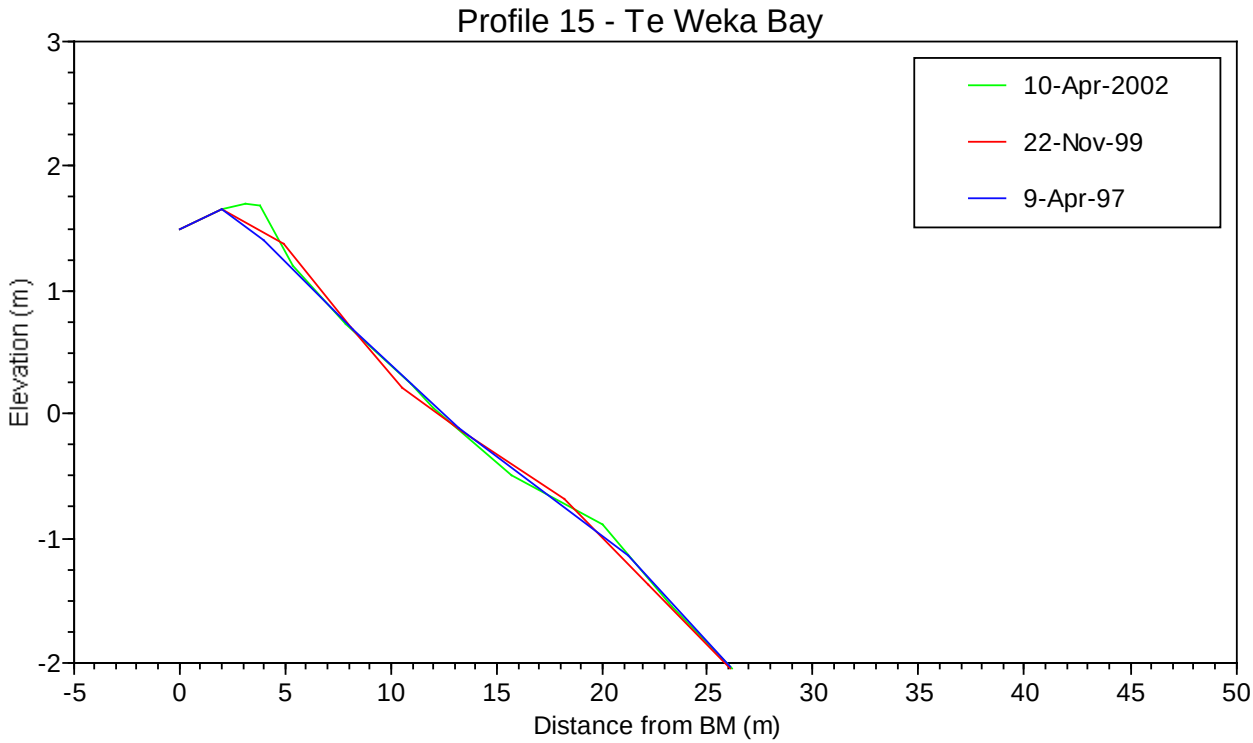


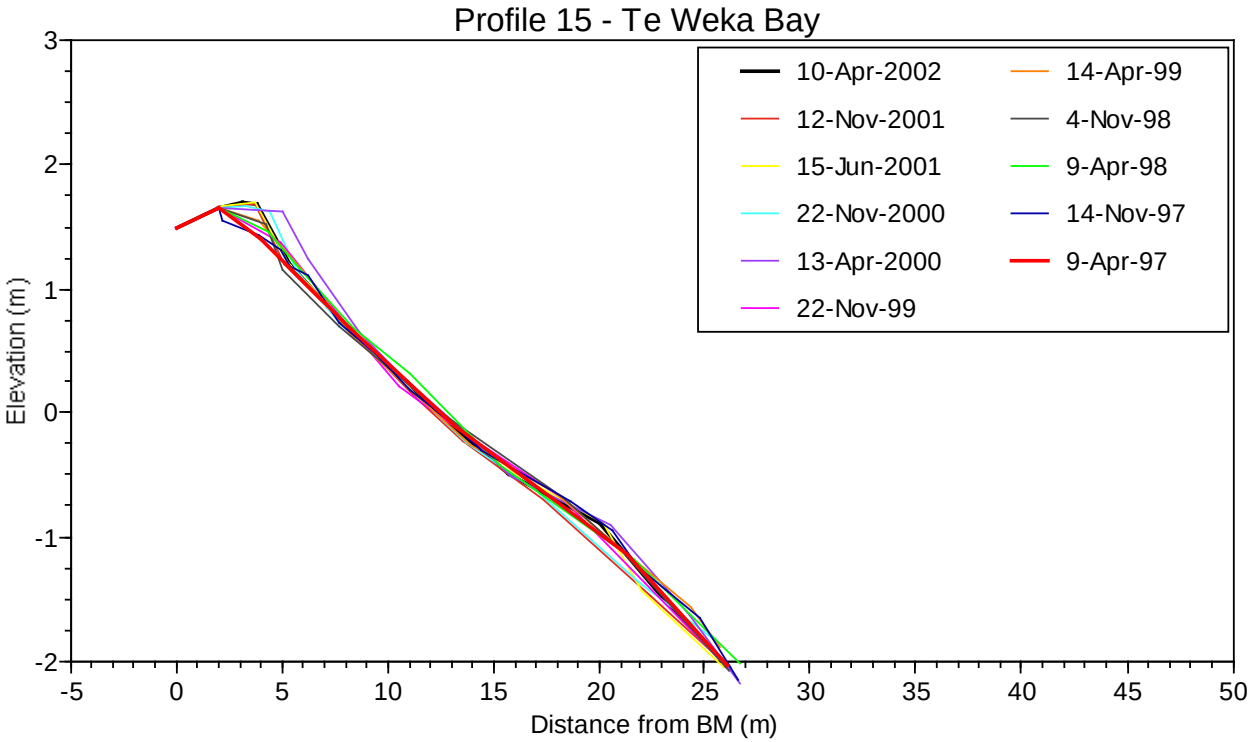
Date	Years after 1/1/95	Volume (m^3/m)
9-Apr-97	2.27	25.6
14-Nov-97	2.87	26.5
9-Apr-98	3.27	25.7
4-Nov-98	3.84	25.6
14-Apr-99	4.29	25.7
8-Nov-99	4.85	25.9
1-May-00	5.33	26.2
22-Nov-00	5.89	26.4
15-Jun-01	6.46	26.9
12-Nov-01	6.86	27.0
9-Apr-02	7.27	27.0

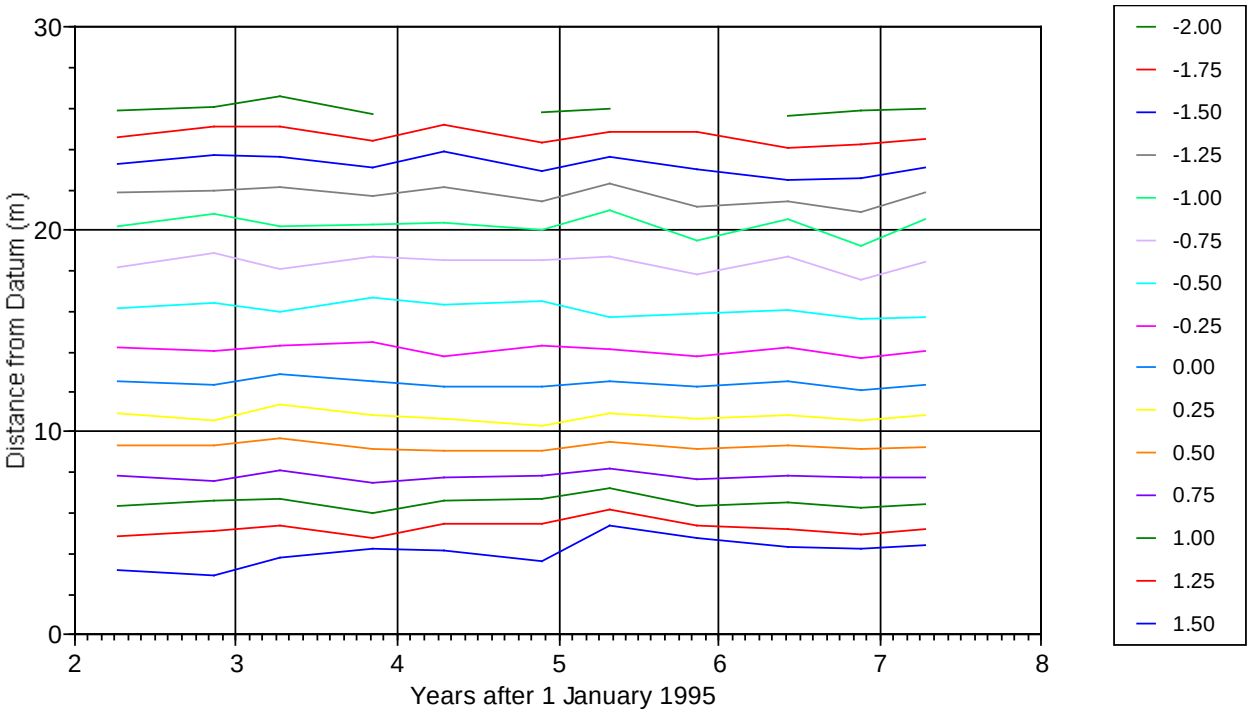
Profile 15 – Te Weka Bay

The Te Weka Bay profile, adjacent to the jetty, has been stable over the short term and long term survey periods, particularly as indicated by the volume data. A small upper beach berm accumulated between November 1999 and April 2000. This berm remains to the present, but has reduced slightly in size. The upper beach is fuller than it was in 1995, and Newton's 1977 data indicates it is now much fuller than it was then. Small changes occur over the middle to lower beach.

There have been no significant sedimentary changes.


Profile 15 - Te Weka Bay
10-Apr-2002
22-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 15 - Te Weka Bay
10-Apr-2002
12-Nov-2001
15-Jun-2001
22-Nov-2000
13-Apr-2000
22-Nov-99
14-Apr-99
4-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)


-2.00
-1.75
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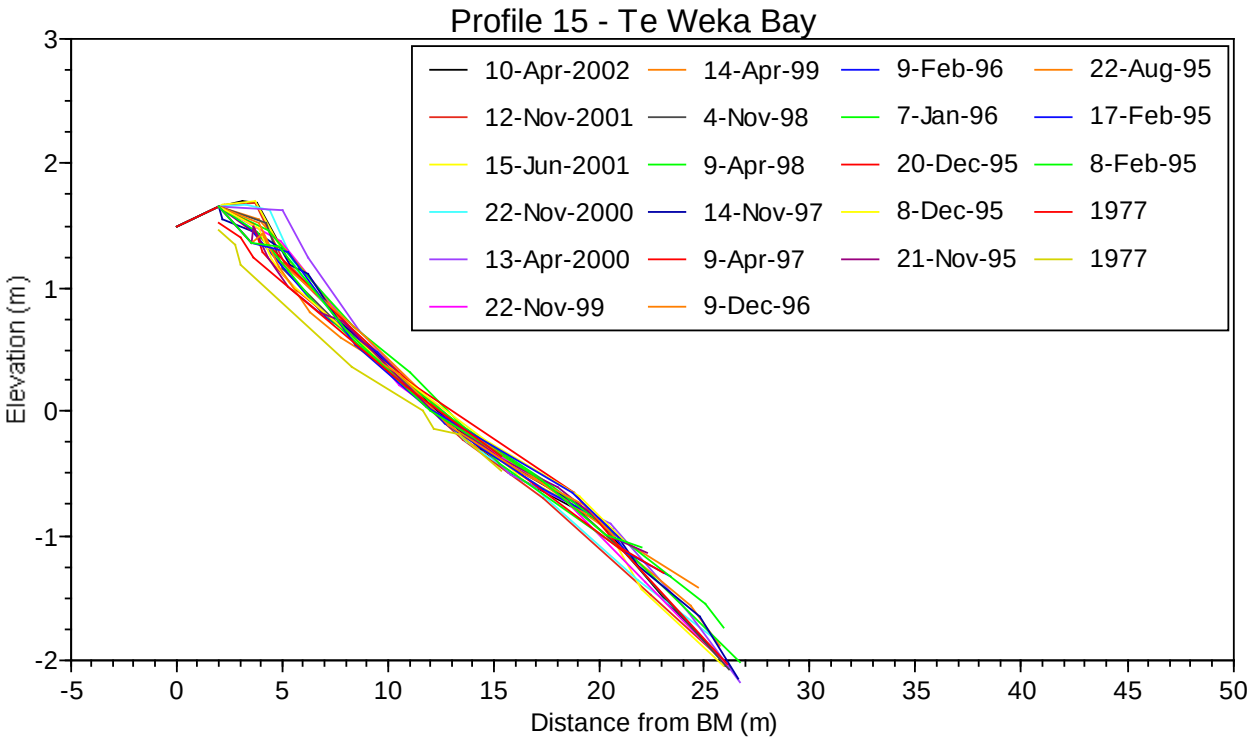
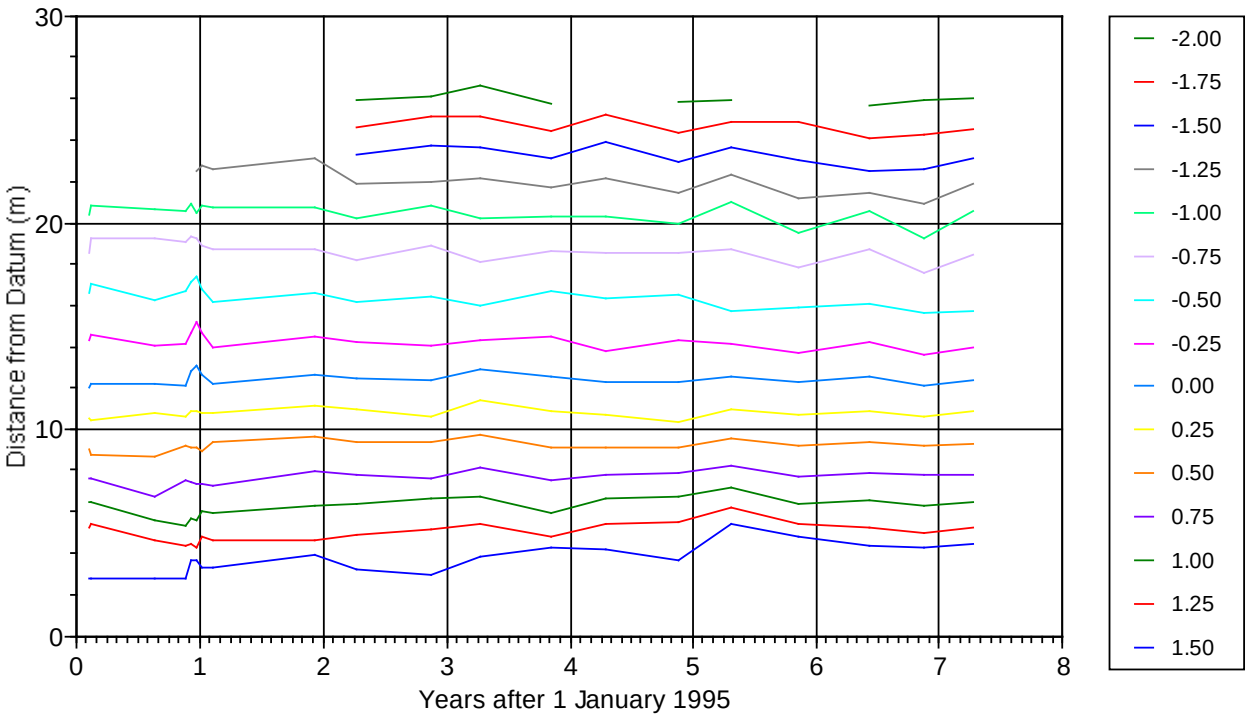
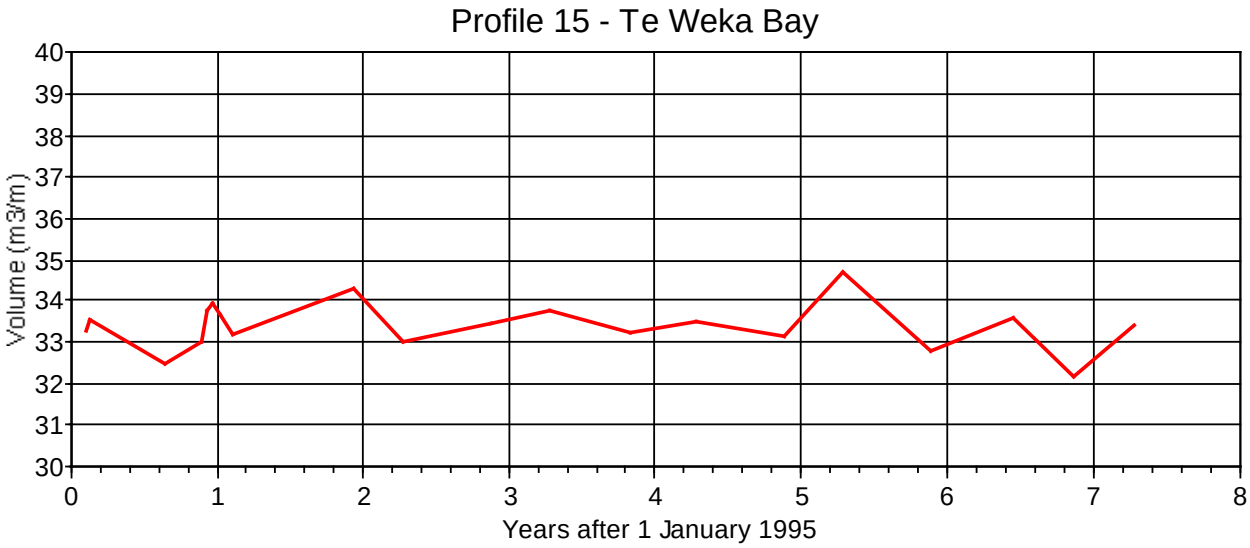
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Distance from Datum (m)
Years after 1 January 1995


Profile 15 - Te Weka Bay
10-Apr-2002
14-Apr-99
9-Feb-96
22-Aug-95
12-Nov-2001
4-Nov-98
7-Jan-96
17-Feb-95
15-Jun-2001
9-Apr-98
20-Dec-95
8-Feb-95
22-Nov-2000
14-Nov-97
8-Dec-95
1977
13-Apr-2000
9-Apr-97
21-Nov-95
1977
22-Nov-99
9-Dec-96
Elevation (m)
Distance from BM (m)


-2.00
-1.75
-1.50
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Distance from Datum (m)
Years after 1 January 1995



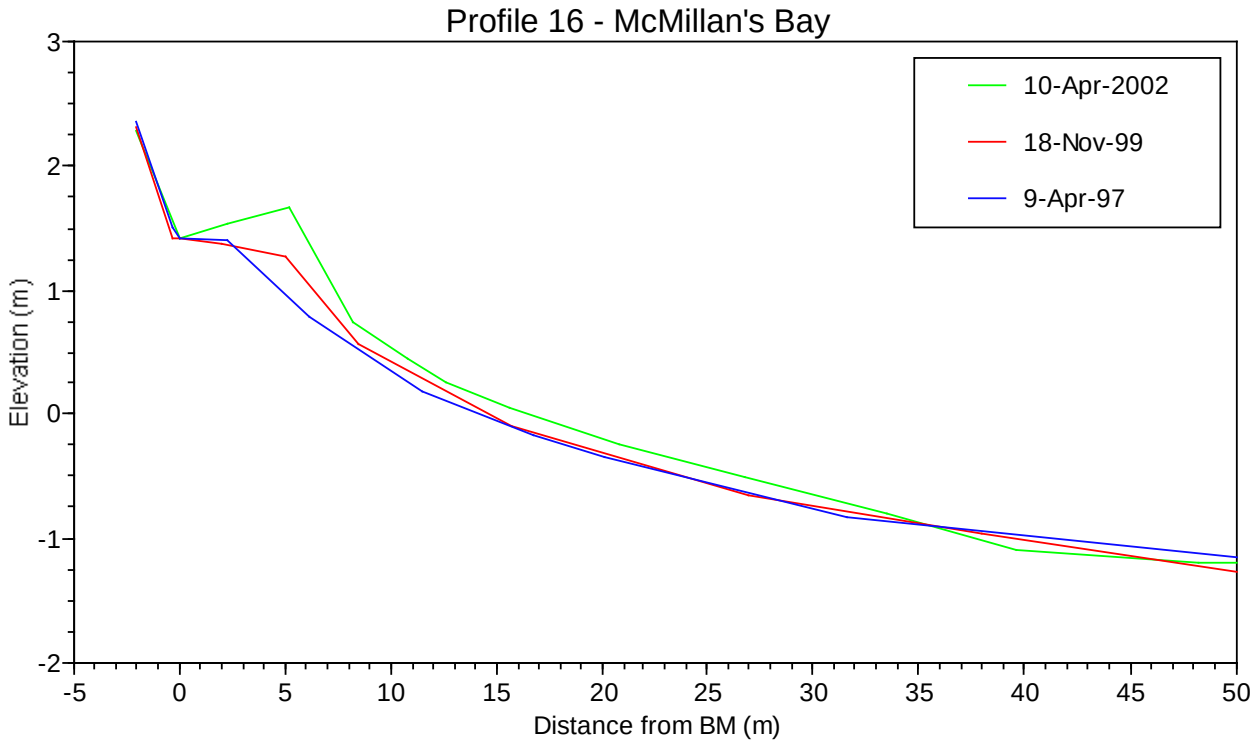
Date	Years after 1/1/95	Volume (m^3/m)
8-Feb-95	0.10	33.27
17-Feb-95	0.13	33.52
22-Aug-95	0.64	32.48
21-Nov-95	0.89	33.01
8-Dec-95	0.94	33.76
20-Dec-95	0.97	33.91
7-Jan-96	1.02	33.68
9-Feb-96	1.11	33.17
9-Dec-96	1.94	34.30
9-Apr-97	2.27	33.02
14-Nov-97	2.87	33.43
9-Apr-98	3.27	33.77
4-Nov-98	3.84	33.22
14-Apr-99	4.29	33.49
22-Nov-99	4.89	33.13
13-Apr-00	5.28	34.72
22-Nov-00	5.89	32.79
15-Jun-01	6.46	33.58
12-Nov-01	6.86	32.15
10-Apr-02	7.28	33.38

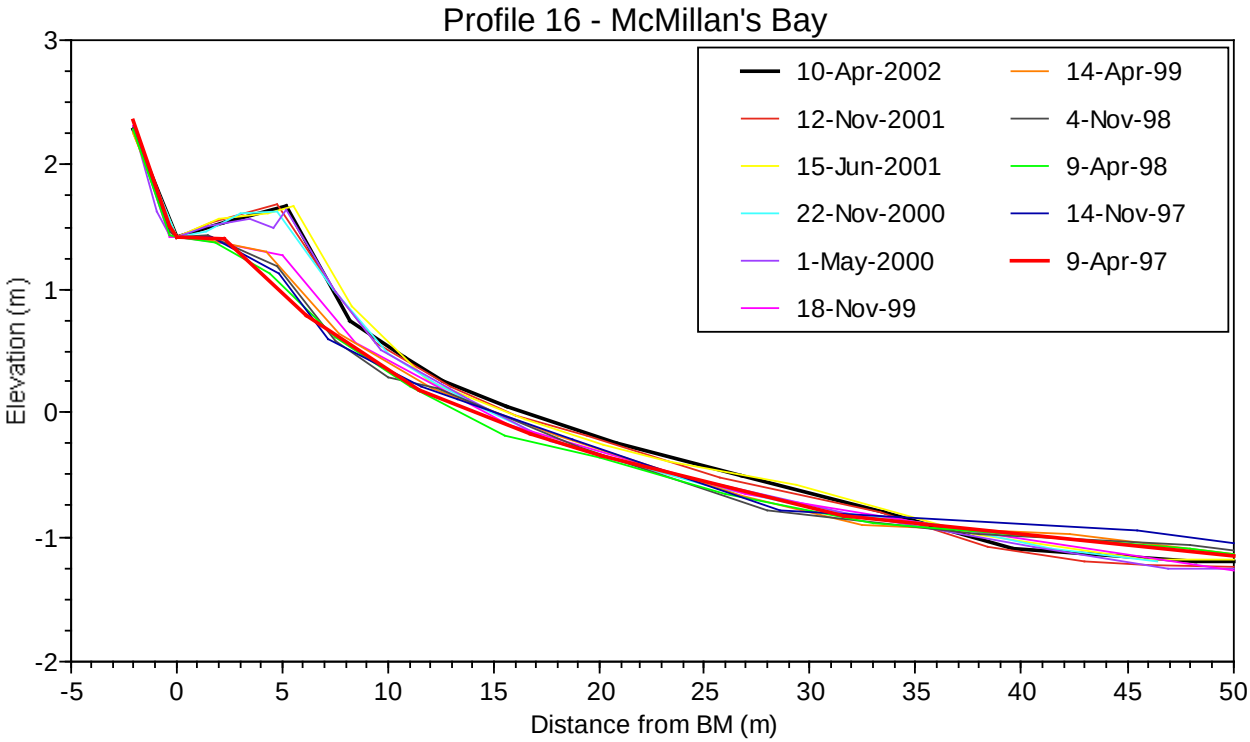
Profile 16 – McMillan's Bay

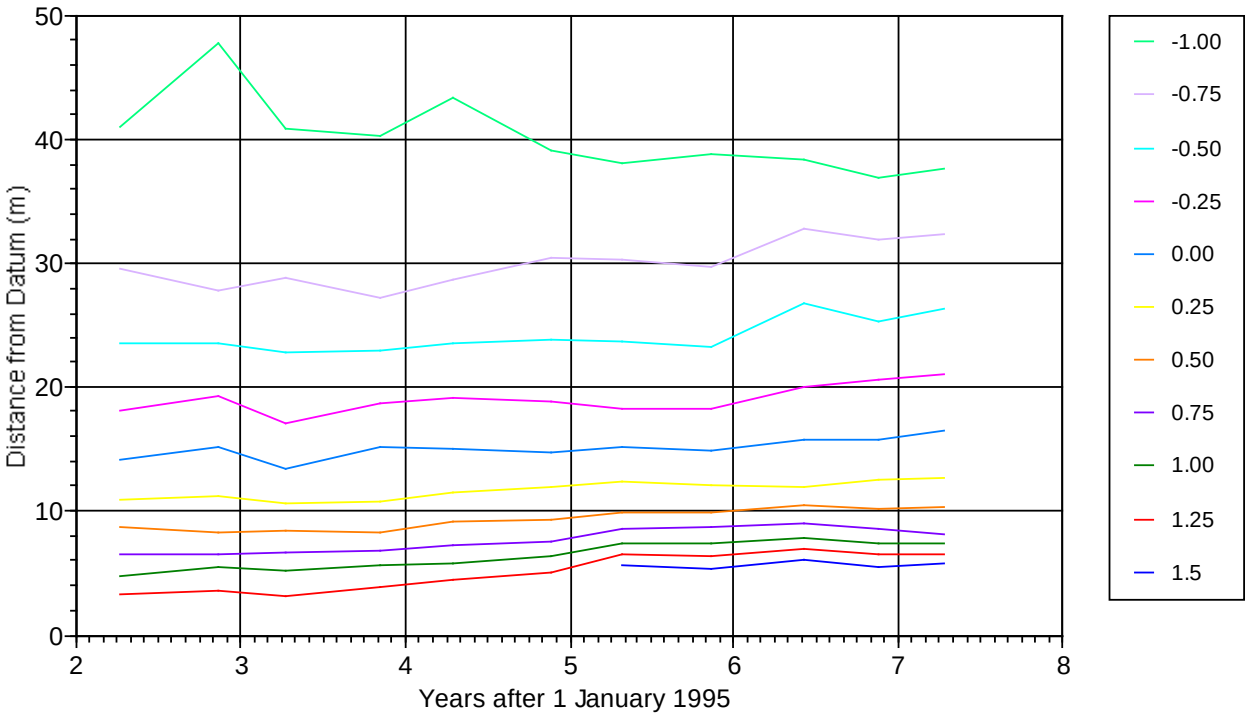
Up until November 1999 there had been a gradual accretion of the upper McMillan's Bay profile. The change was fairly constant with no indication of seasonality. Kirk and Single's data supported this trend. The accretion was mainly comprised of gravels that were moving along the beach from the direction of Arrowsmith Point, although there had been some rise in the middle beach level, due to deposition of sand. Between November 1999 and May 2000 a major increase in the height of the upper beach berm occurred, with a very large deposit of gravel, again coming from the direction of Arrowsmith Point. This deposit has remained almost unchanged since that time. The middle beach continued to build with the deposition of sand. Sand has also been deposited over the gravels to the east of the profile line. The lower beach has been relatively stable, perhaps with a small amount of bed lowering.

This profile line is clearly being influenced by longshore transport of gravels from west to east. It may also be that there is transport of sand either onshore or alongshore. It is most likely that the mechanism of accretion is the result of ferry generated wake waves but that an increase in sediment supply has occurred. This is further discussed in relation to Profile 17.

McMillan's Bay is quite unusual in the context of the Tory Channel, being wide and with a relatively small slope. It has a wide 'surf' zone, unlike almost all other shorelines in the area.


Profile 16 - McMillan's Bay
10-Apr-2002
18-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 16 - McMillan's Bay
10-Apr-2002
12-Nov-2001
15-Jun-2001
22-Nov-2000
1-May-2000
18-Nov-99
14-Apr-99
4-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)


Distance from Datum (m)
Years after 1 January 1995
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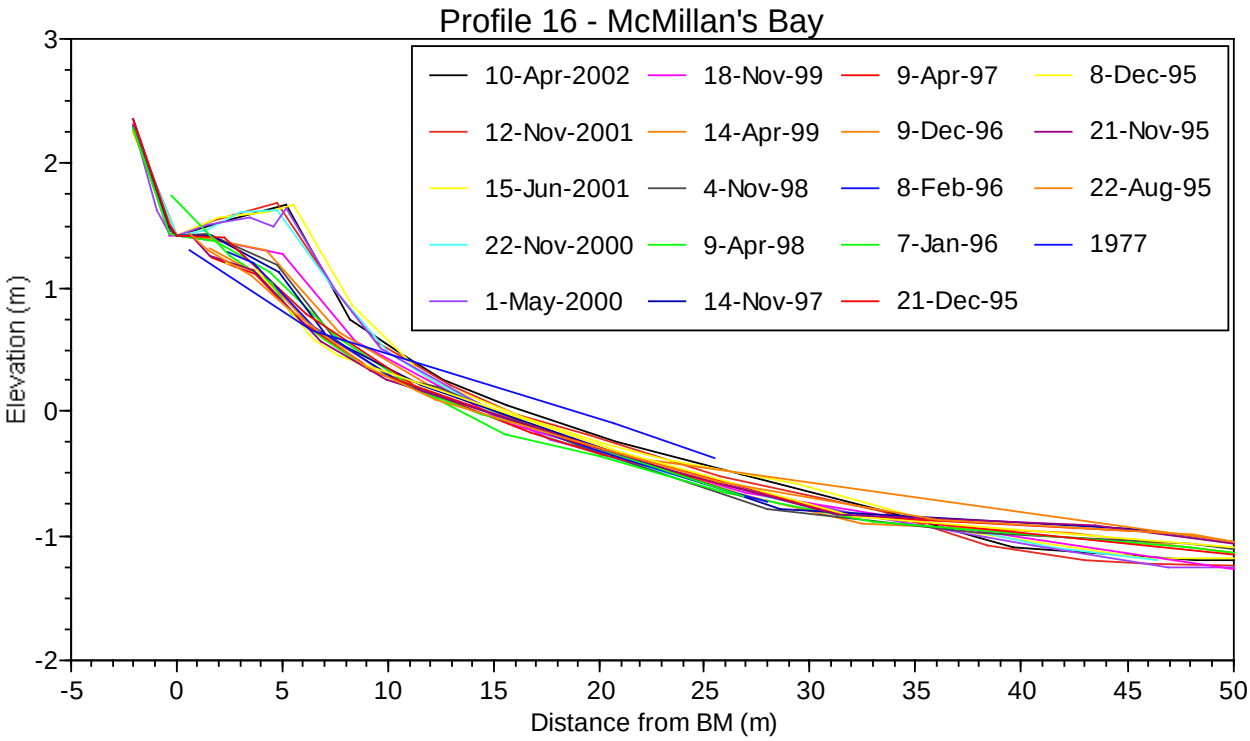
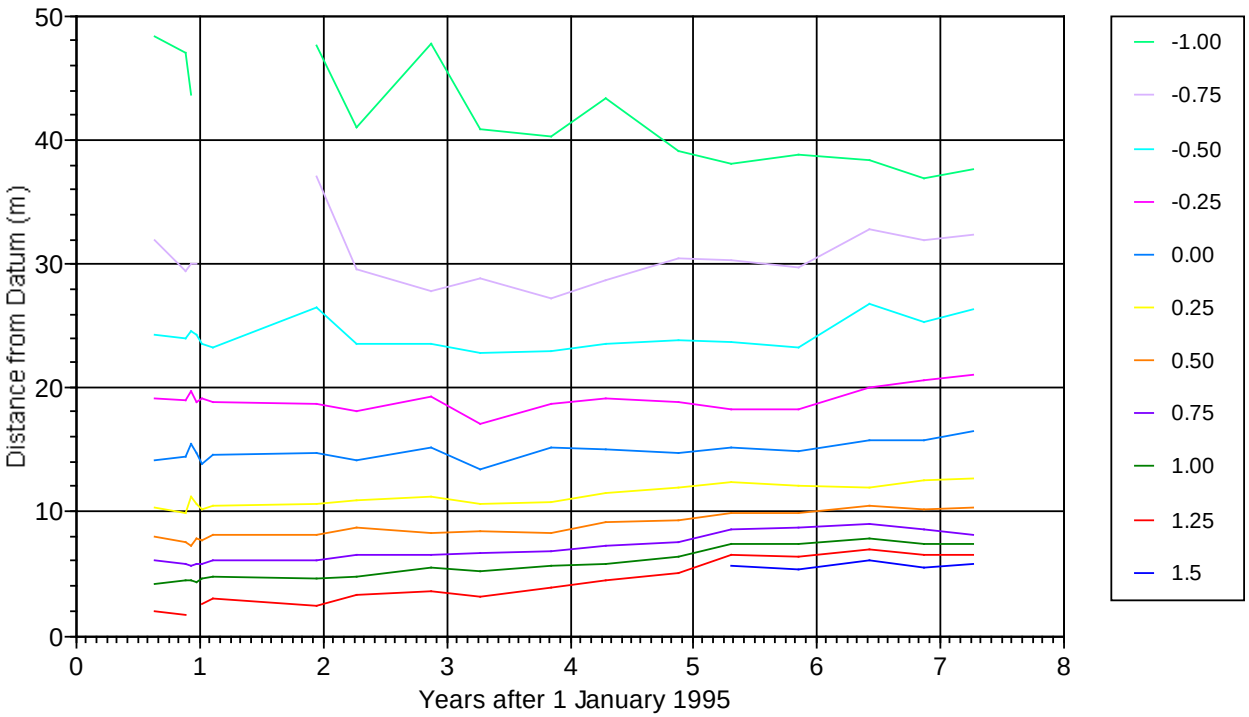
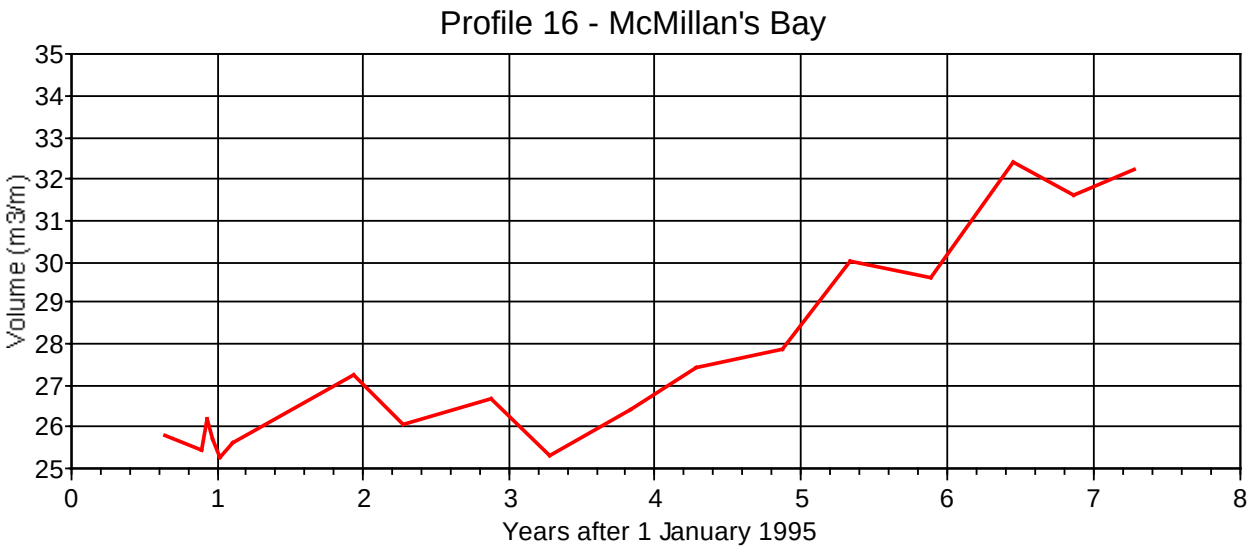
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.5


Profile 16 - McMillan's Bay
10-Apr-2002
18-Nov-99
9-Apr-97
8-Dec-95
12-Nov-2001
14-Apr-99
9-Dec-96
21-Nov-95
15-Jun-2001
4-Nov-98
8-Feb-96
22-Aug-95
22-Nov-2000
9-Apr-98
7-Jan-96
1977
1-May-2000
14-Nov-97
21-Dec-95
Elevation (m)
Distance from BM (m)


-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.5
Distance from Datum (m)
Years after 1 January 1995



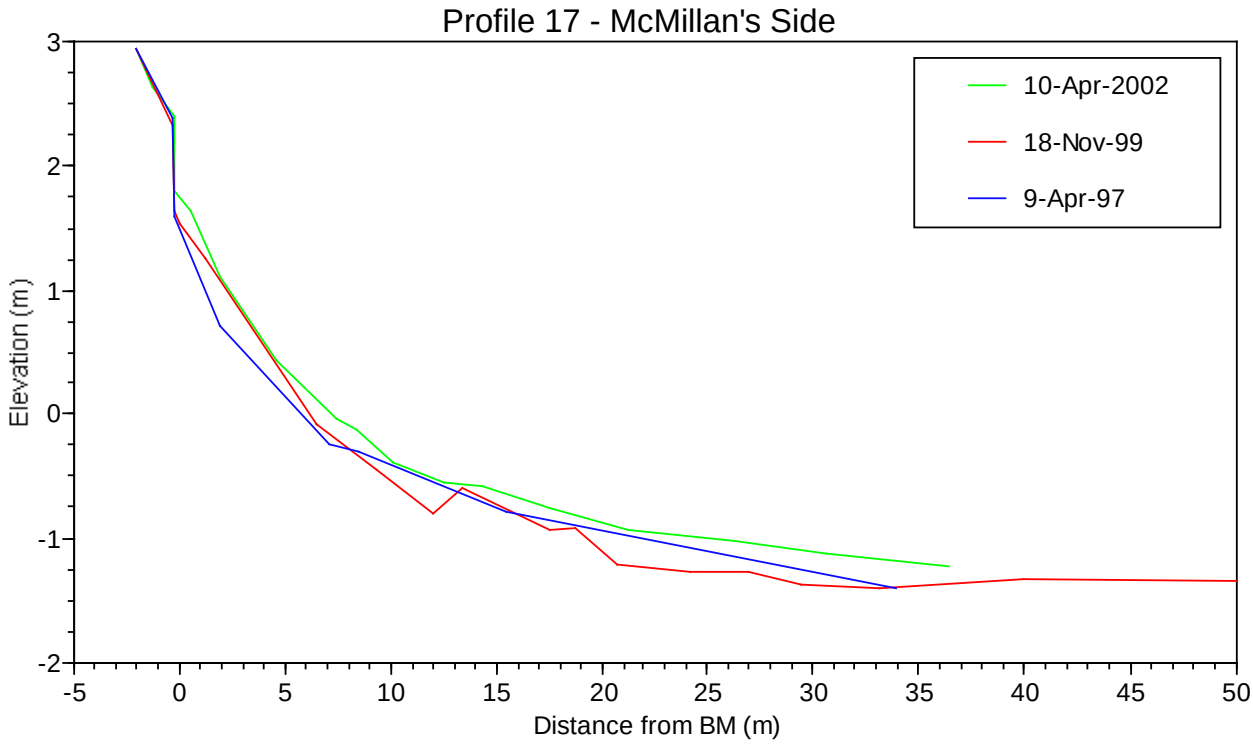
Date	Years after 1/1/95	Volume (m^3/m)
22-Aug-95	0.64	25.8
21-Nov-95	0.89	25.4
8-Dec-95	0.94	26.2
21-Dec-95	0.97	25.7
7-Jan-96	1.02	25.3
8-Feb-96	1.10	25.6
9-Dec-96	1.94	27.2
9-Apr-97	2.27	26.1
14-Nov-97	2.87	26.7
9-Apr-98	3.27	25.3
4-Nov-98	3.84	26.4
14-Apr-99	4.29	27.4
18-Nov-99	4.88	27.9
1-May-00	5.33	30.0
22-Nov-00	5.89	29.7
15-Jun-01	6.46	32.4
12-Nov-01	6.86	31.6
10-Apr-02	7.28	32.2

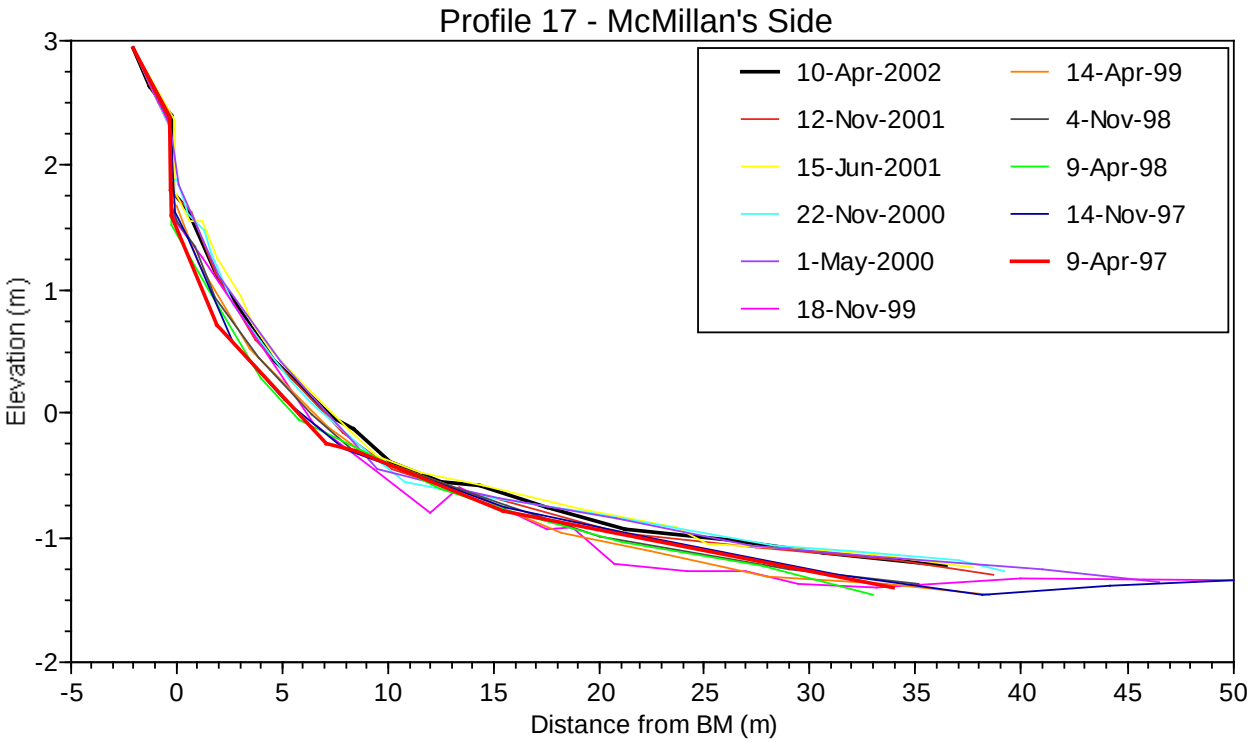
Profile 17 – McMillan's Side

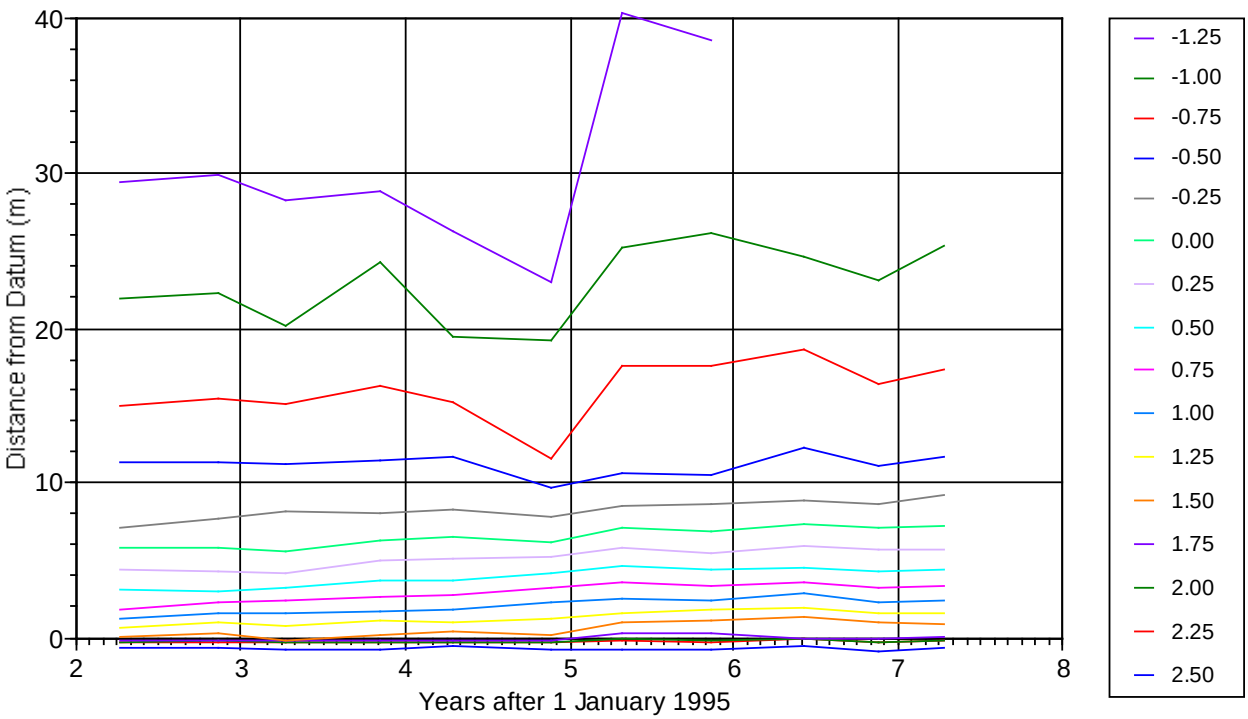
Between November 1999 and May 2000, at the same time as there was a major increase in the volume of the berm on Profile 16, there was a very significant deposition of sediment on the lower profile on Profile 17. Up until this time, the profile had been generally stable, with some accumulation on the upper beach, and perhaps some minor adjustments elsewhere on the profile line. The rather unusual shape of the profile line in November 1999 is indicative of an unusually comprehensive survey.

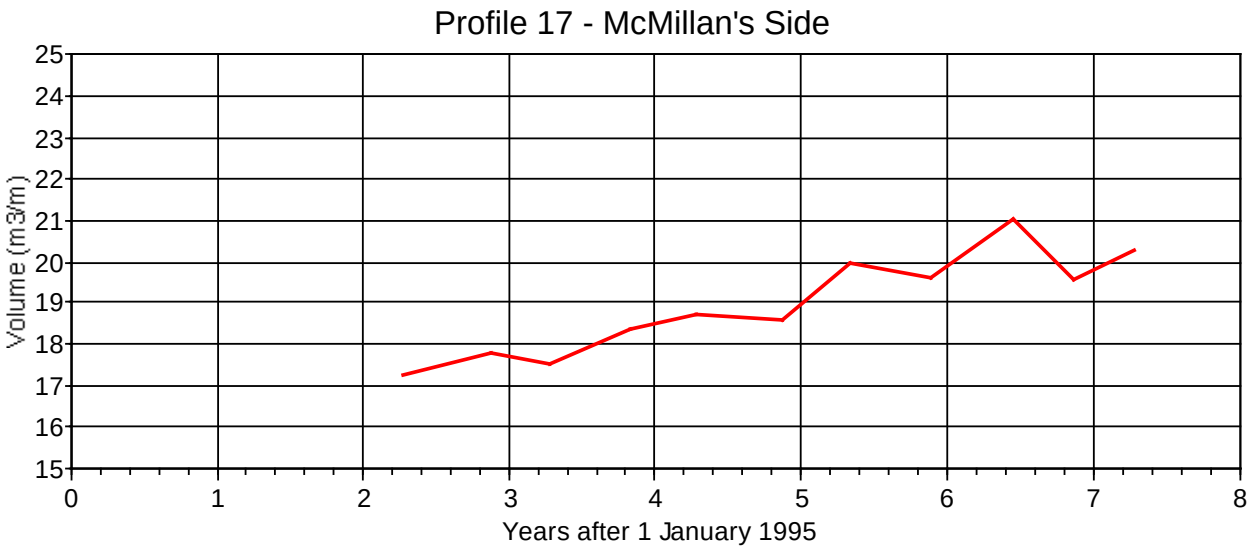
Beach volumes have been increasing, with most of the accumulation on the lower profile.

The reason for the major deposition between November 1999 and May 2000, reflected also on Profile 16, is unknown. However, there must have been a significant increase in sediment supply, perhaps a slip in the vicinity of Arrowsmith Point.


Profile 17 - McMillan's Side
10-Apr-2002
18-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 17 - McMillan's Side
10-Apr-2002
12-Nov-2001
15-Jun-2001
22-Nov-2000
1-May-2000
18-Nov-99
14-Apr-99
4-Nov-98
9-Apr-98
14-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)


Distance from Datum (m)
Years after 1 January 1995
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50



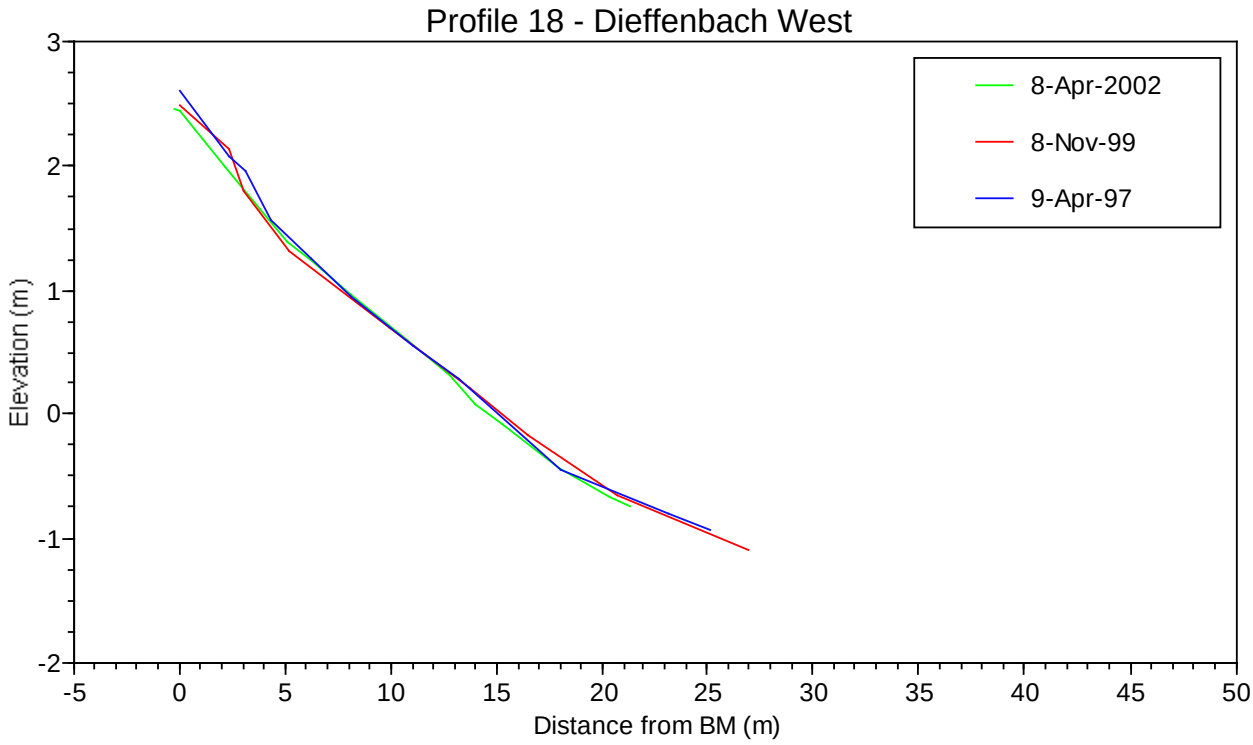
Date	Years after 1/1/95	Volume (m^3/m)
9-Apr-97	2.27	17.3
14-Nov-97	2.87	17.8
9-Apr-98	3.27	17.5
4-Nov-98	3.84	18.4
14-Apr-99	4.29	18.7
18-Nov-99	4.88	18.6
1-May-00	5.33	20.0
22-Nov-00	5.89	19.6
15-Jun-01	6.46	21.0
12-Nov-01	6.86	19.6
10-Apr-02	7.28	20.3

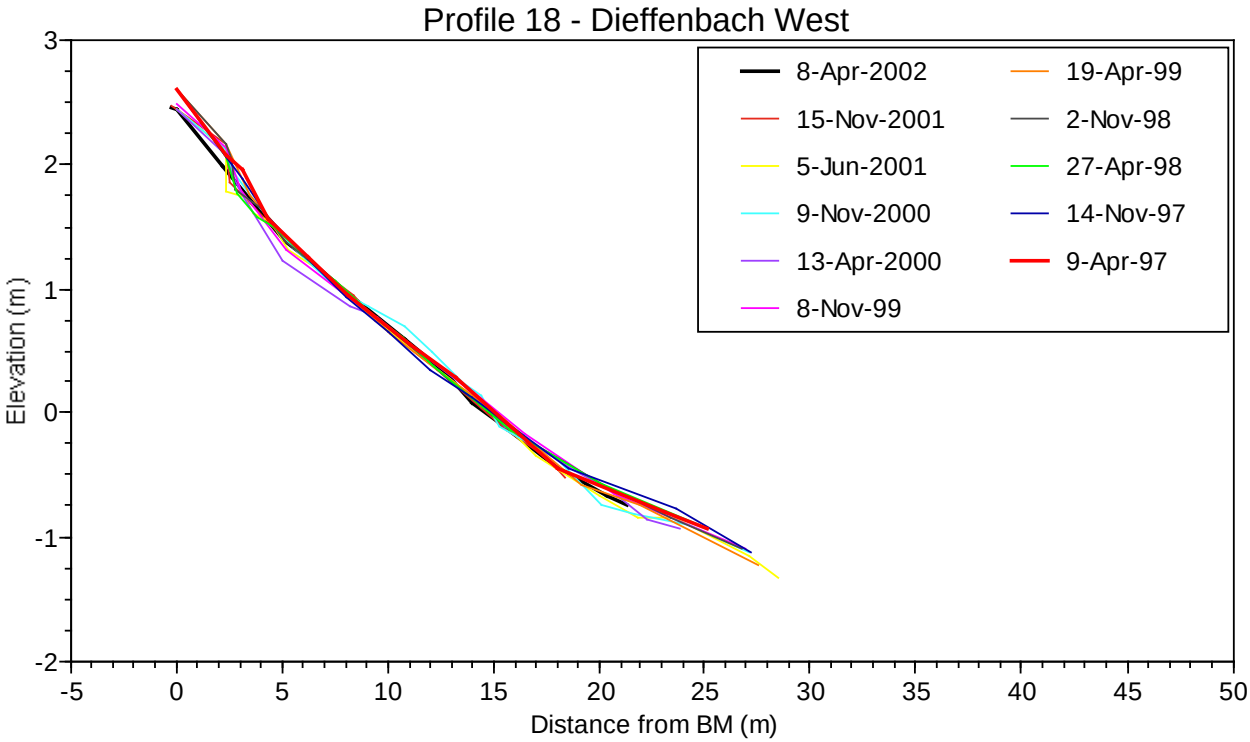
Profile 18 – Dieffenbach West

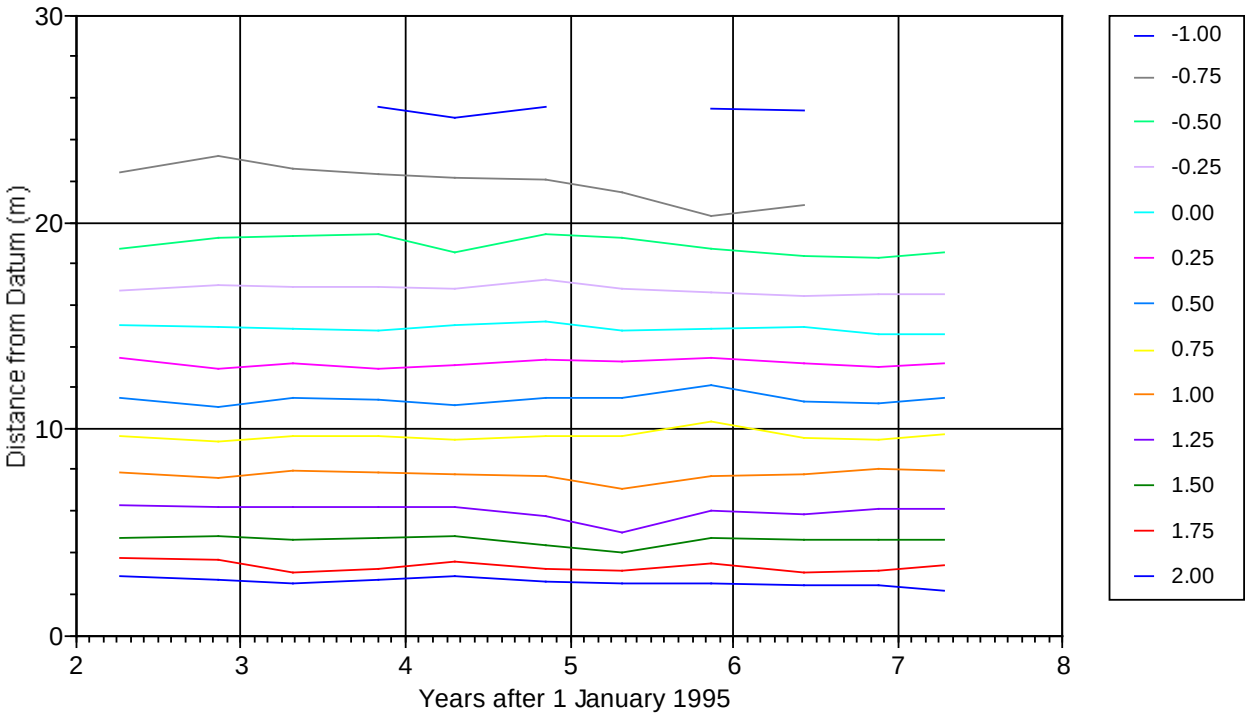
There has been no significant change in the profile shape over the survey period, or the extended survey period.

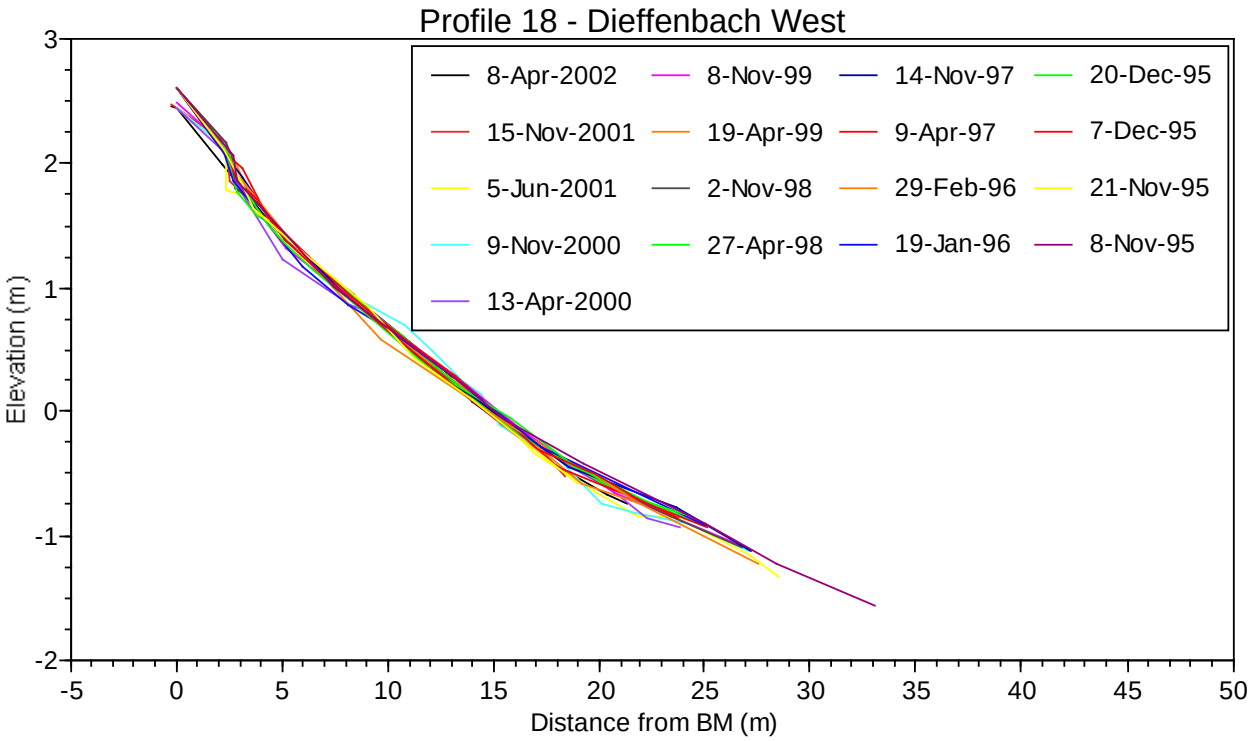
There is some indication that there is a fining of surficial sediments over the winter months, although this is not particularly clear.

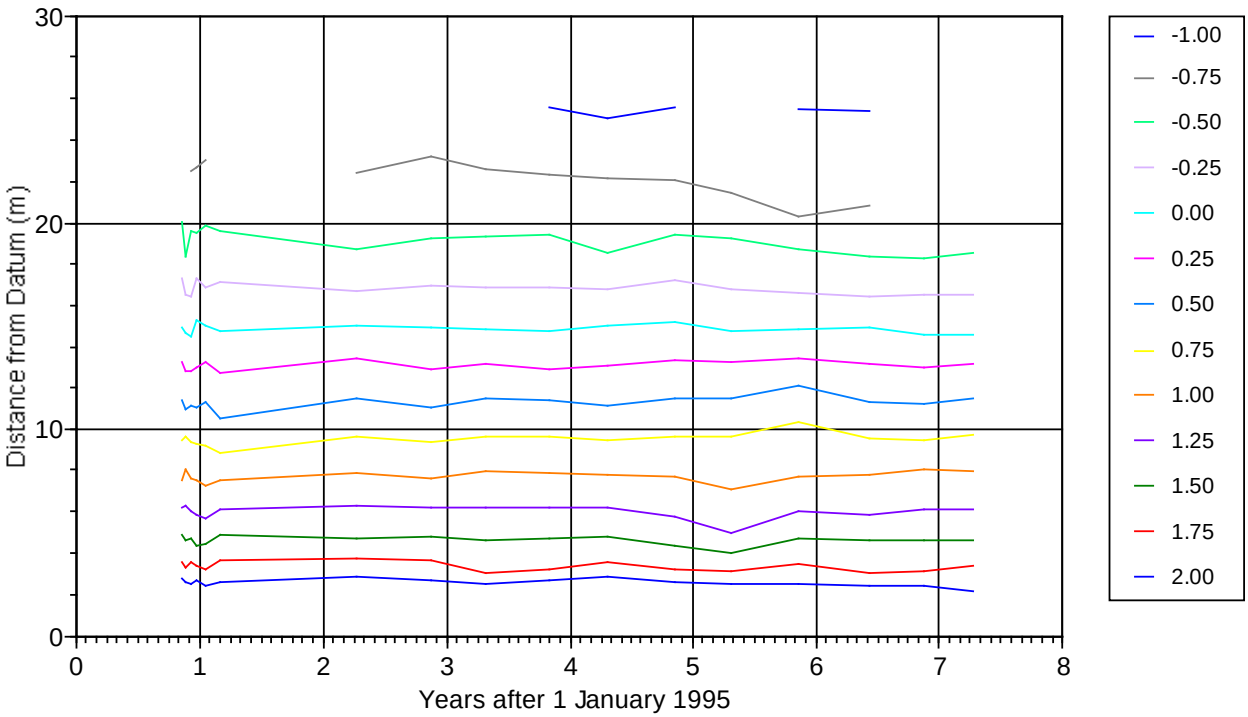
During 2000 a small cottage was built at the northern end of this beach.

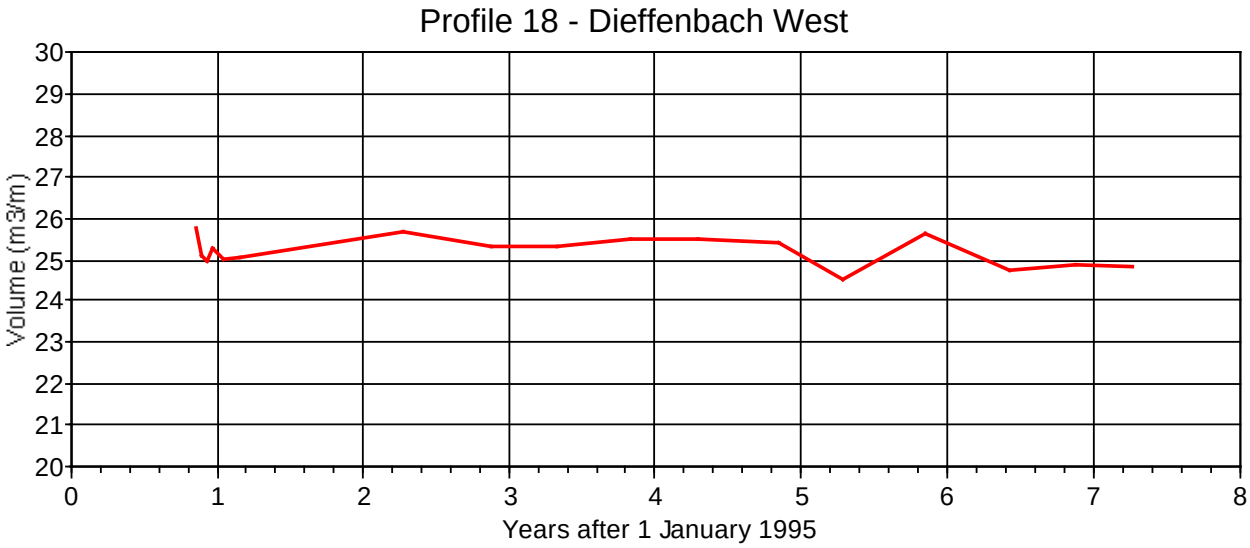

Profile 18 - Dieffenbach West
8-Apr-2002
8-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 18 - Dieffenbach West
8-Apr-2002
15-Nov-2001
5-Jun-2001
9-Nov-2000
13-Apr-2000
8-Nov-99
19-Apr-99
2-Nov-98
27-Apr-98
14-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)


Distance from Datum (m)
Years after 1 January 1995
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00


Profile 18 - Dieffenbach West
8-Apr-2002
8-Nov-99
14-Nov-97
20-Dec-95
15-Nov-2001
19-Apr-99
9-Apr-97
7-Dec-95
5-Jun-2001
2-Nov-98
29-Feb-96
21-Nov-95
9-Nov-2000
27-Apr-98
19-Jan-96
8-Nov-95
13-Apr-2000
Elevation (m)
Distance from BM (m)


-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Distance from Datum (m)
Years after 1 January 1995

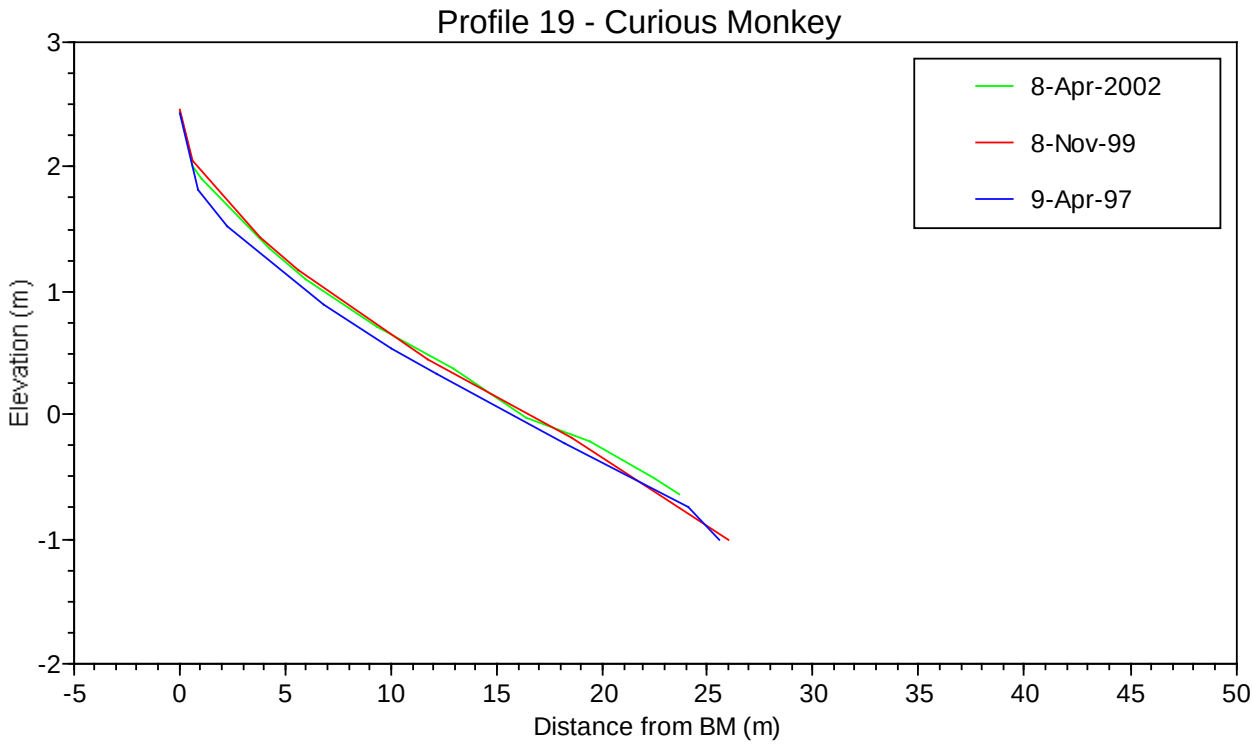


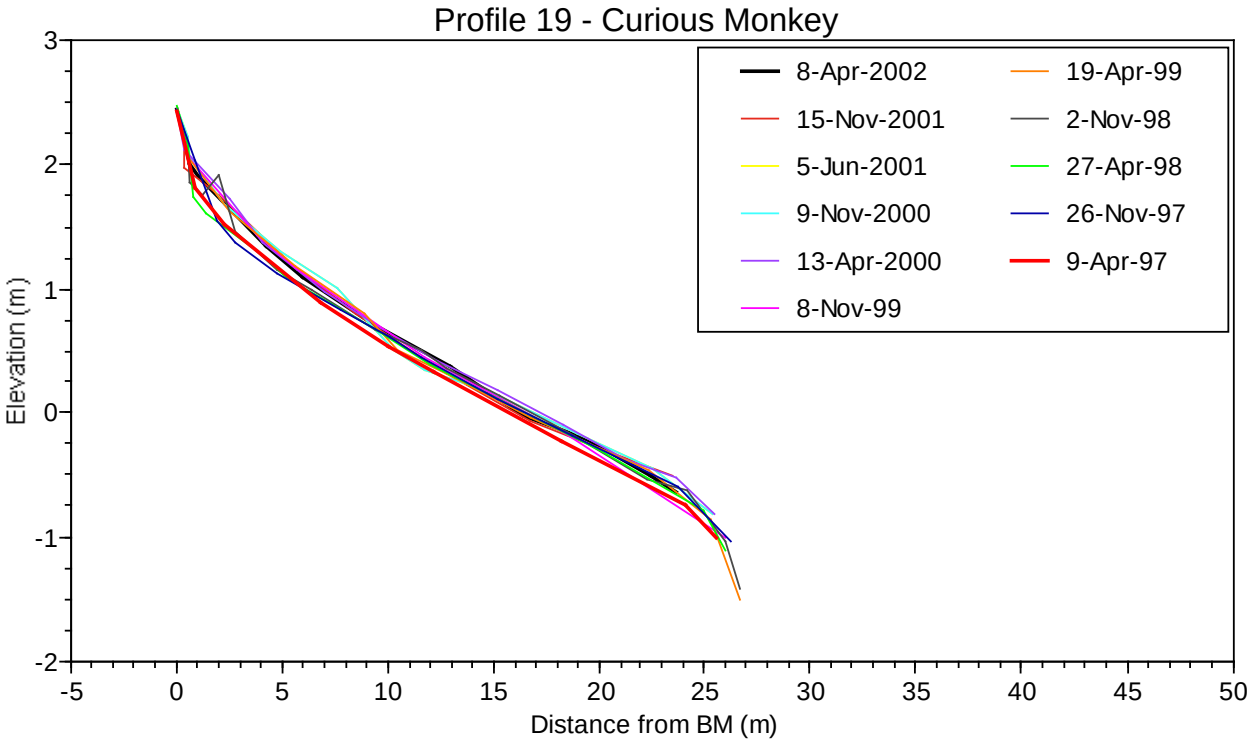
Date	Years after 1/1/95	Volume (m^3/m)
8-Nov-95	0.85	25.8
21-Nov-95	0.89	25.1
7-Dec-95	0.93	25.0
20-Dec-95	0.97	25.3
19-Jan-96	1.05	25.0
29-Feb-96	1.16	25.1
9-Apr-97	2.27	25.7
14-Nov-97	2.87	25.3
27-Apr-98	3.32	25.4
2-Nov-98	3.84	25.5
19-Apr-99	4.30	25.5
8-Nov-99	4.85	25.4
13-Apr-00	5.28	24.5
9-Nov-00	5.86	25.6
5-Jun-01	6.43	24.7
15-Nov-01	6.87	24.9
8-Apr-02	7.27	24.9

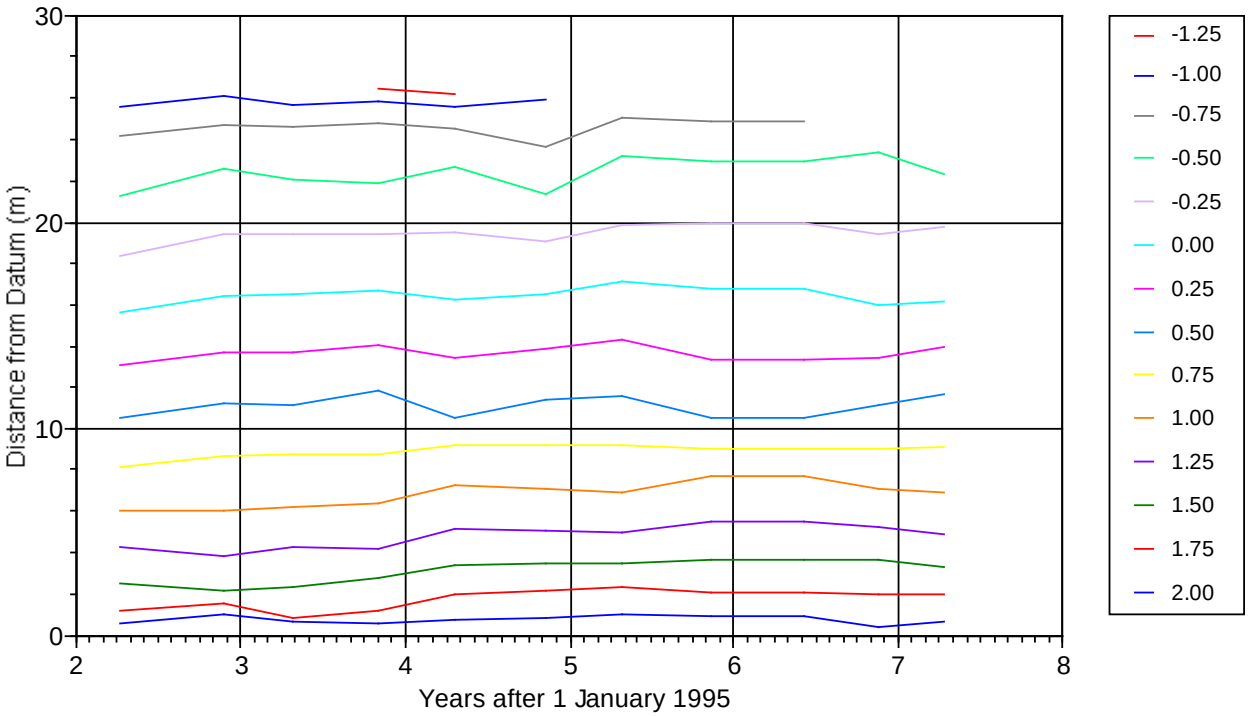
Profile 19 – Curious Monkey

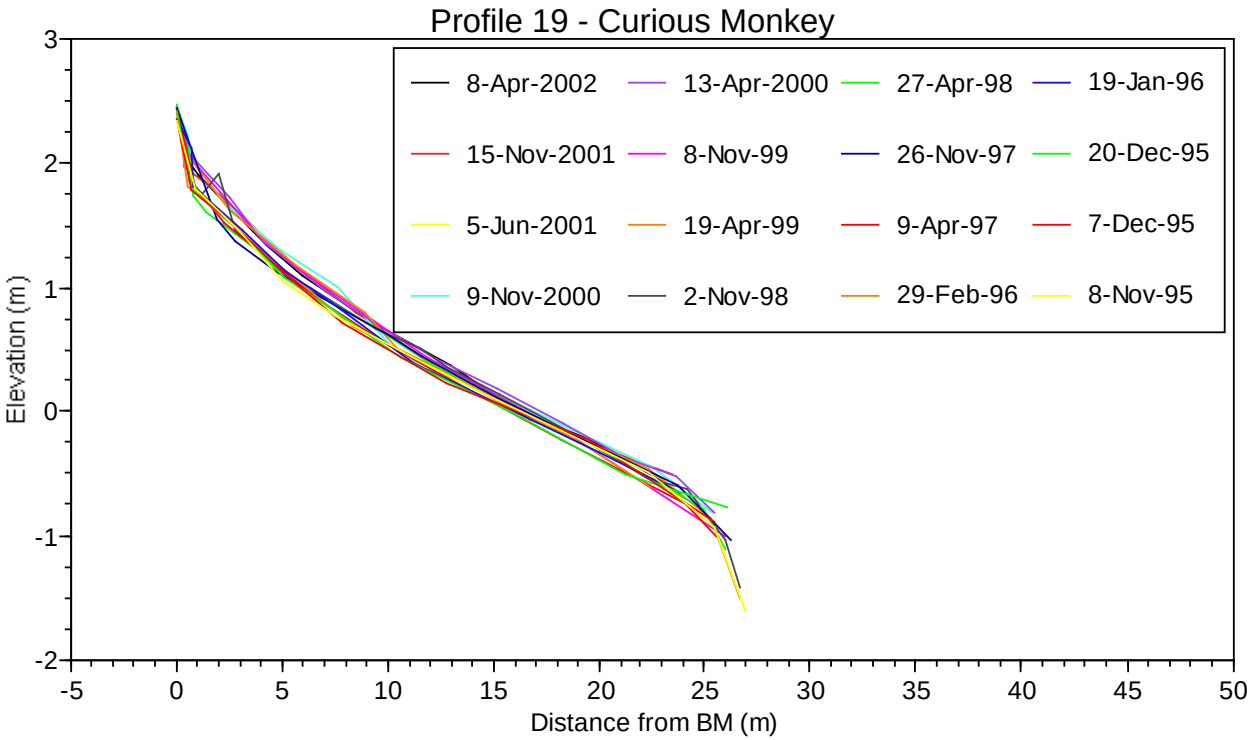
Between April 1997 and April 2000 there was a small gradual accumulation of sand across the entire profile. Since that time there has been stability, or perhaps a small reversal of this trend. However, overall, the beach has been stable.

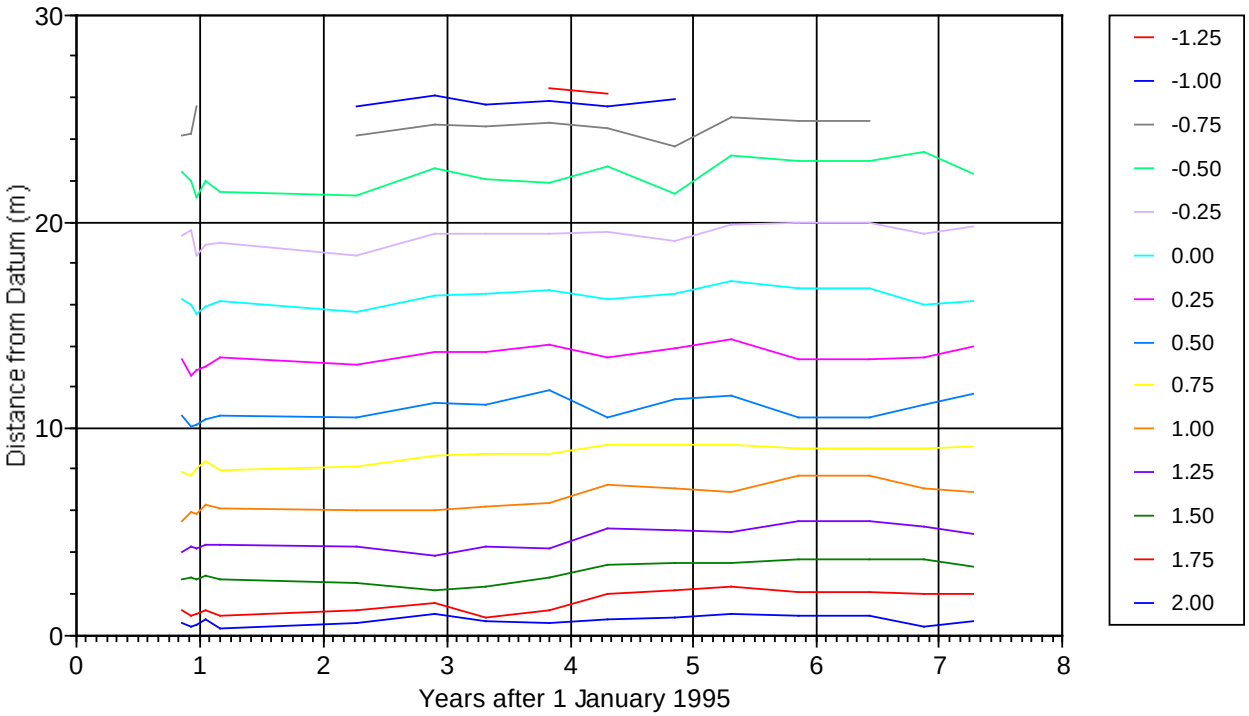
There have been no notable changes in sediment characteristics.

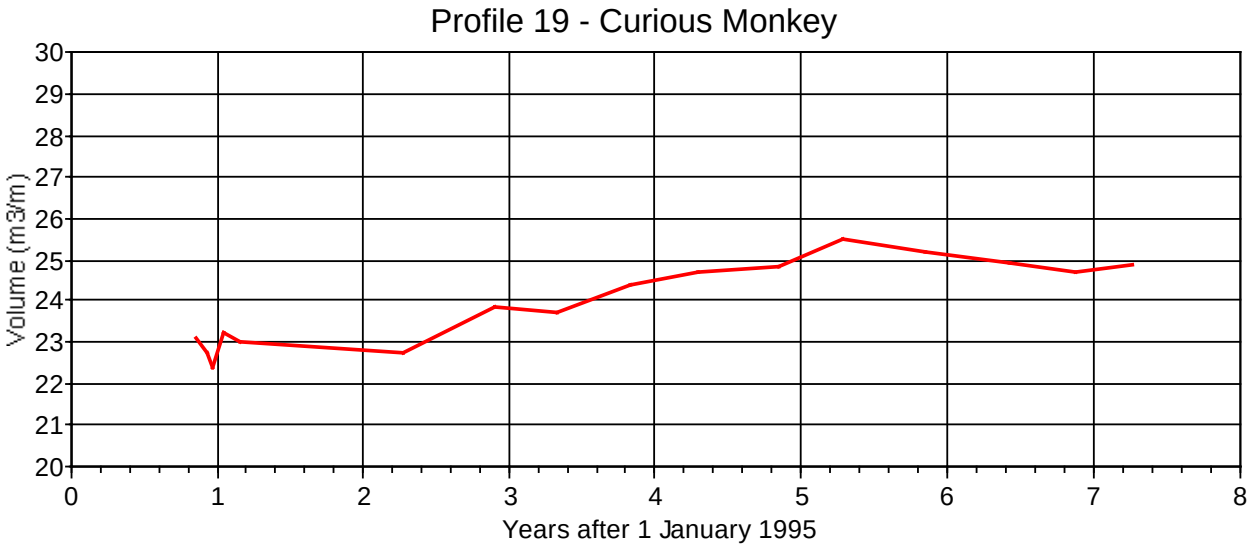

Profile 19 - Curious Monkey
8-Apr-2002
8-Nov-99
9-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 19 - Curious Monkey
8-Apr-2002
15-Nov-2001
5-Jun-2001
9-Nov-2000
13-Apr-2000
8-Nov-99
19-Apr-99
2-Nov-98
27-Apr-98
26-Nov-97
9-Apr-97
Elevation (m)
Distance from BM (m)


Distance from Datum (m)
Years after 1 January 1995
-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00


Profile 19 - Curious Monkey
8-Apr-2002
13-Apr-2000
27-Apr-98
19-Jan-96
15-Nov-2001
8-Nov-99
26-Nov-97
20-Dec-95
5-Jun-2001
19-Apr-99
9-Apr-97
7-Dec-95
9-Nov-2000
2-Nov-98
29-Feb-96
8-Nov-95
Elevation (m)
Distance from BM (m)

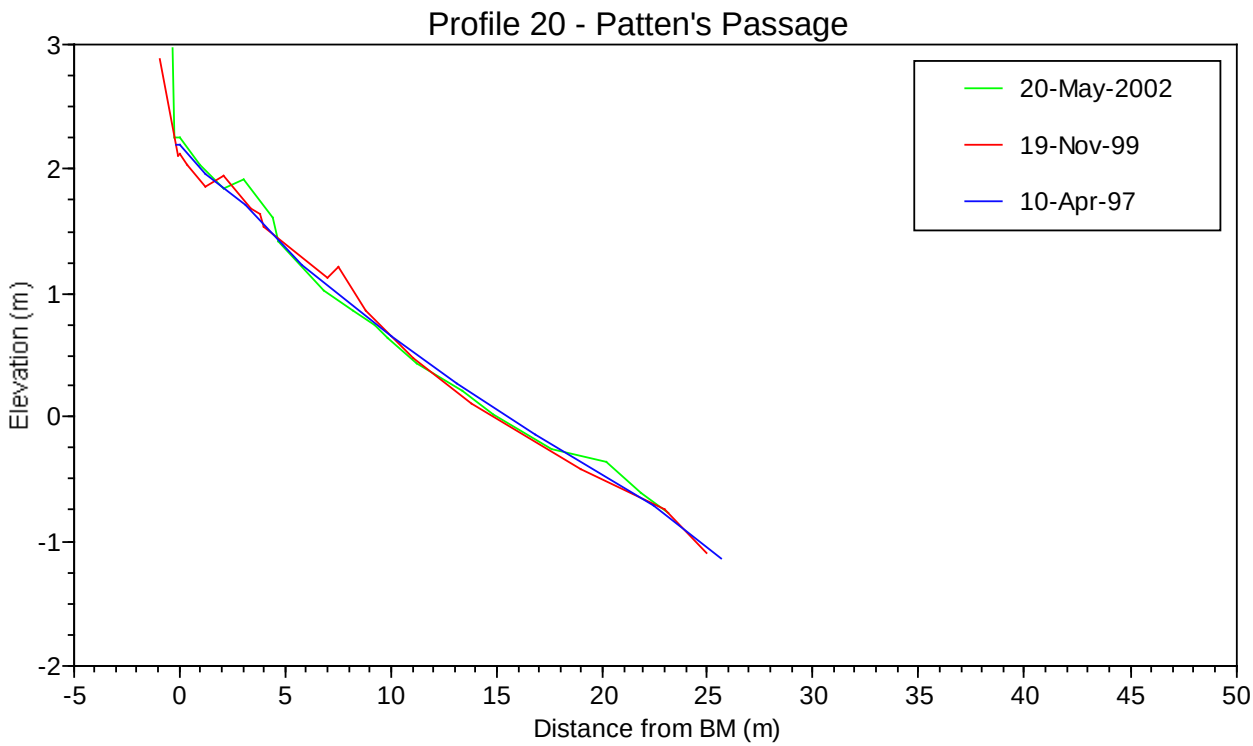

-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Distance from Datum (m)
Years after 1 January 1995

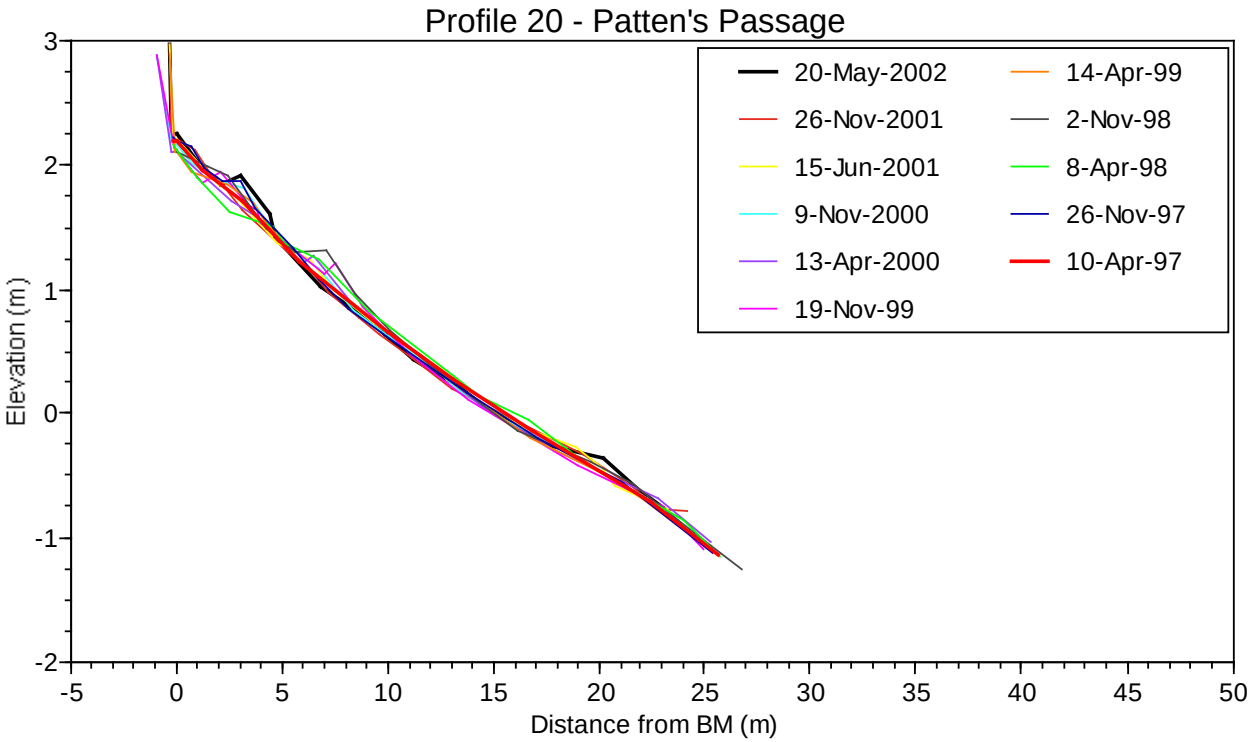


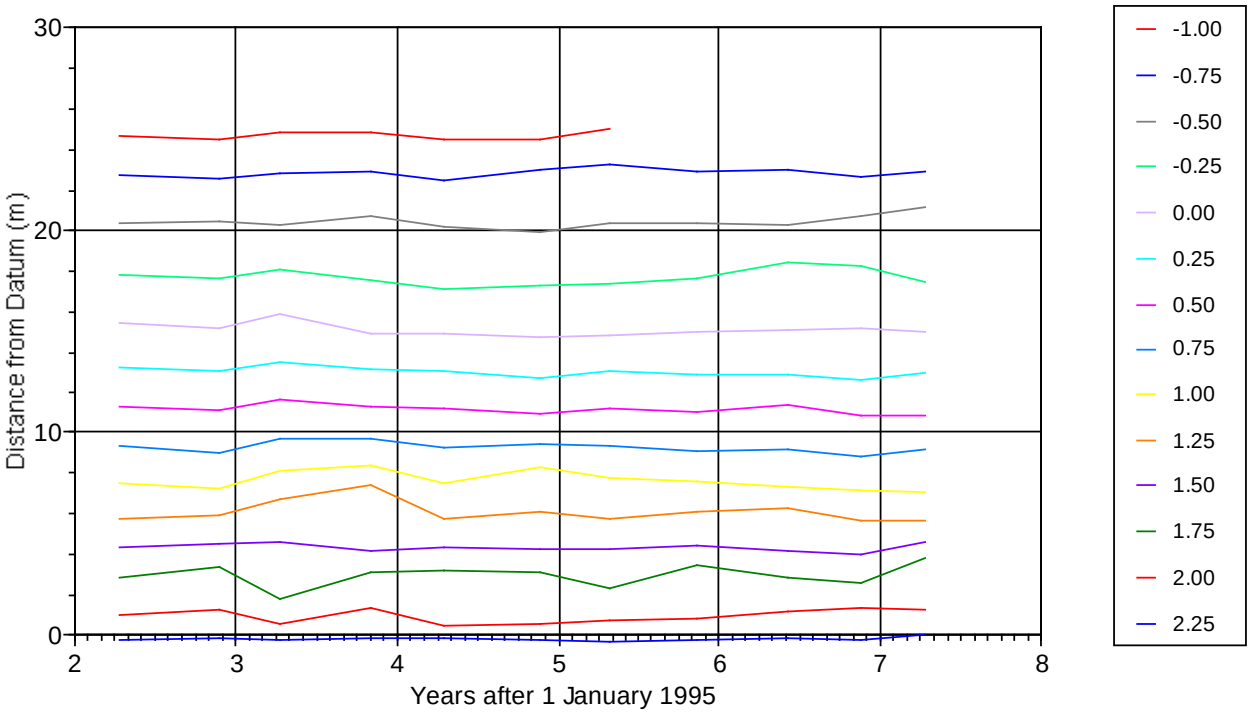
Date	Years after 1/1/95	Volume (m^3/m)
8-Nov-95	0.85	23.1
7-Dec-95	0.93	22.8
20-Dec-95	0.97	22.4
19-Jan-96	1.05	23.2
29-Feb-96	1.16	23.0
9-Apr-97	2.27	22.7
26-Nov-97	2.90	23.8
27-Apr-98	3.32	23.7
2-Nov-98	3.84	24.4
19-Apr-99	4.30	24.7
8-Nov-99	4.85	24.8
13-Apr-00	5.28	25.5
9-Nov-00	5.86	25.2
5-Jun-01	6.43	25.0
15-Nov-01	6.87	24.7
8-Apr-02	7.27	24.9

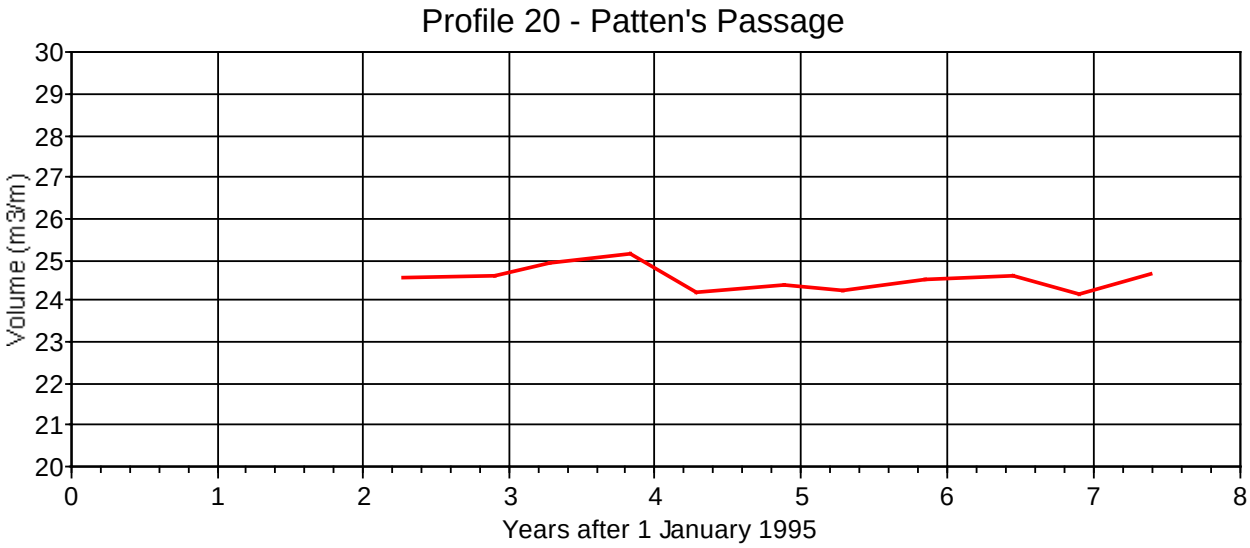
Profile 20 – Patten's Passage

Although there is considerable variability on the upper and middle beach, there has been no trend of erosion or accretion. Small berms build and are removed on the upper beach, with no particular seasonal pattern. Sediments are gravels and sands, and there is frequent banding, but no significant trends are obvious. Volume data indicate considerable stability.


Profile 20 - Patten's Passage
20-May-2002
19-Nov-99
10-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 20 - Patten's Passage
20-May-2002
26-Nov-2001
15-Jun-2001
9-Nov-2000
13-Apr-2000
19-Nov-99
14-Apr-99
2-Nov-98
8-Apr-98
26-Nov-97
10-Apr-97
Elevation (m)
Distance from BM (m)

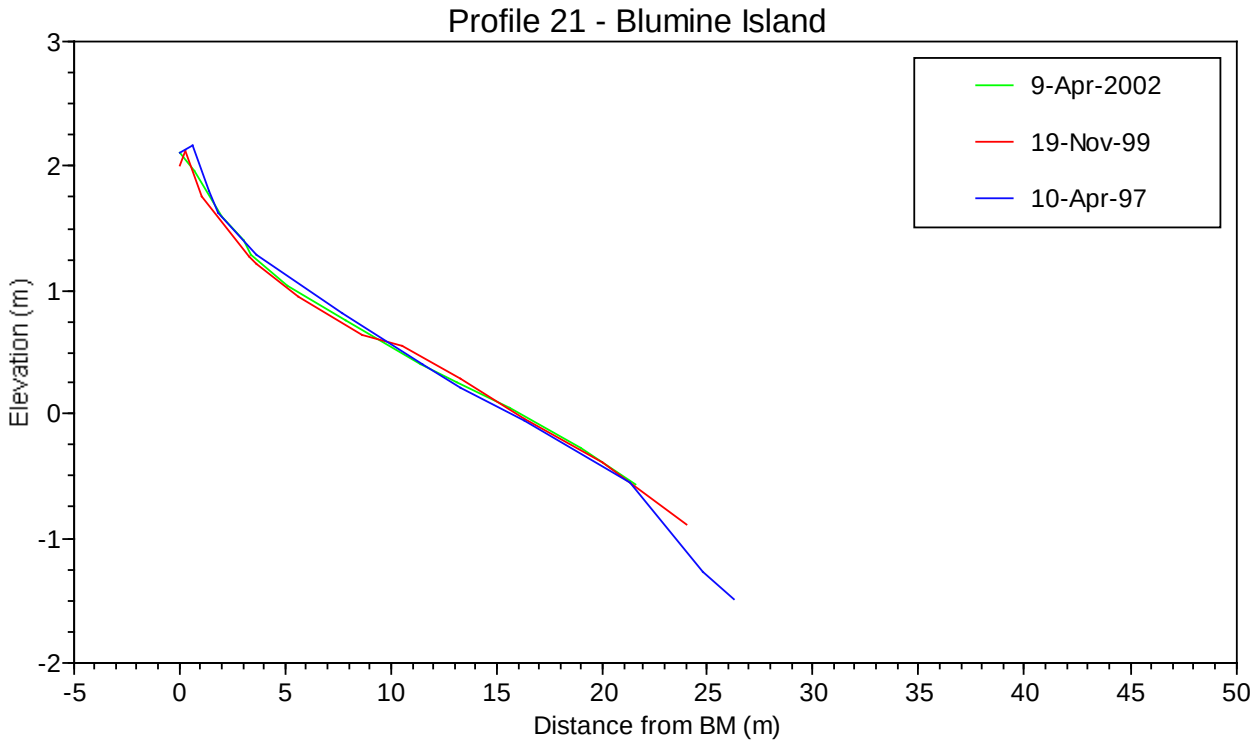

Distance from Datum (m)
Years after 1 January 1995
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25

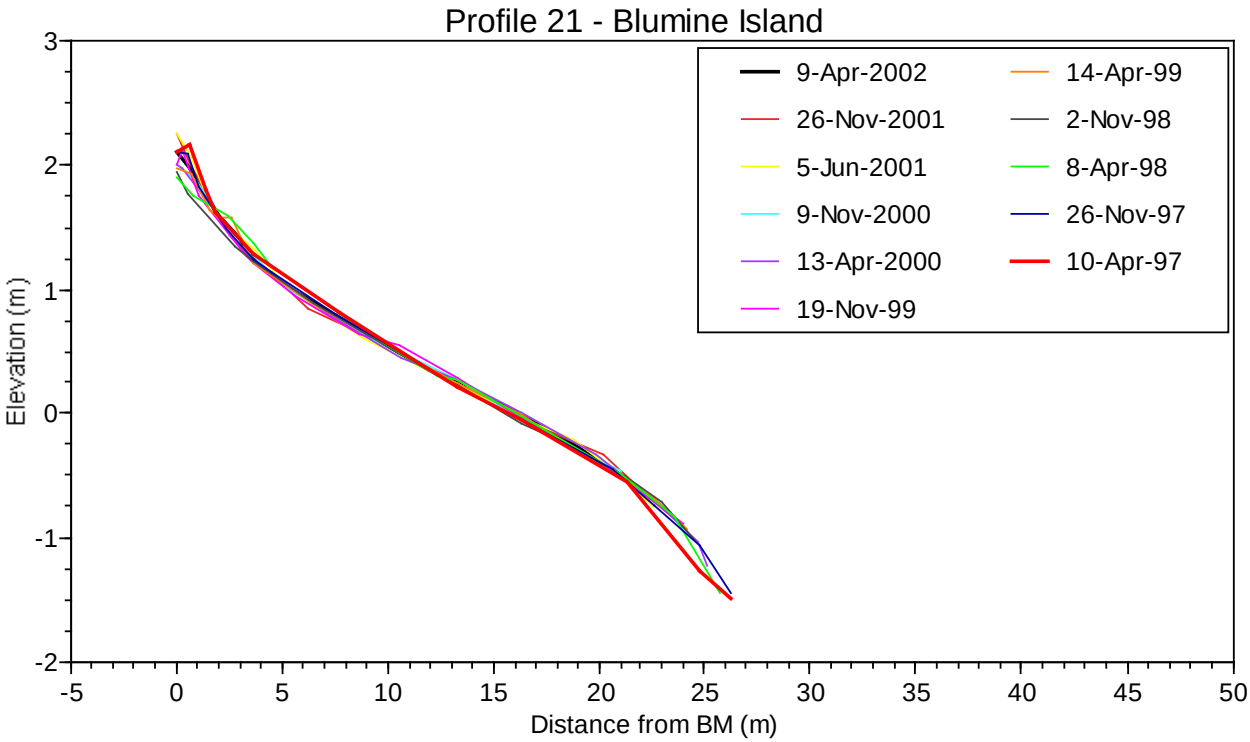


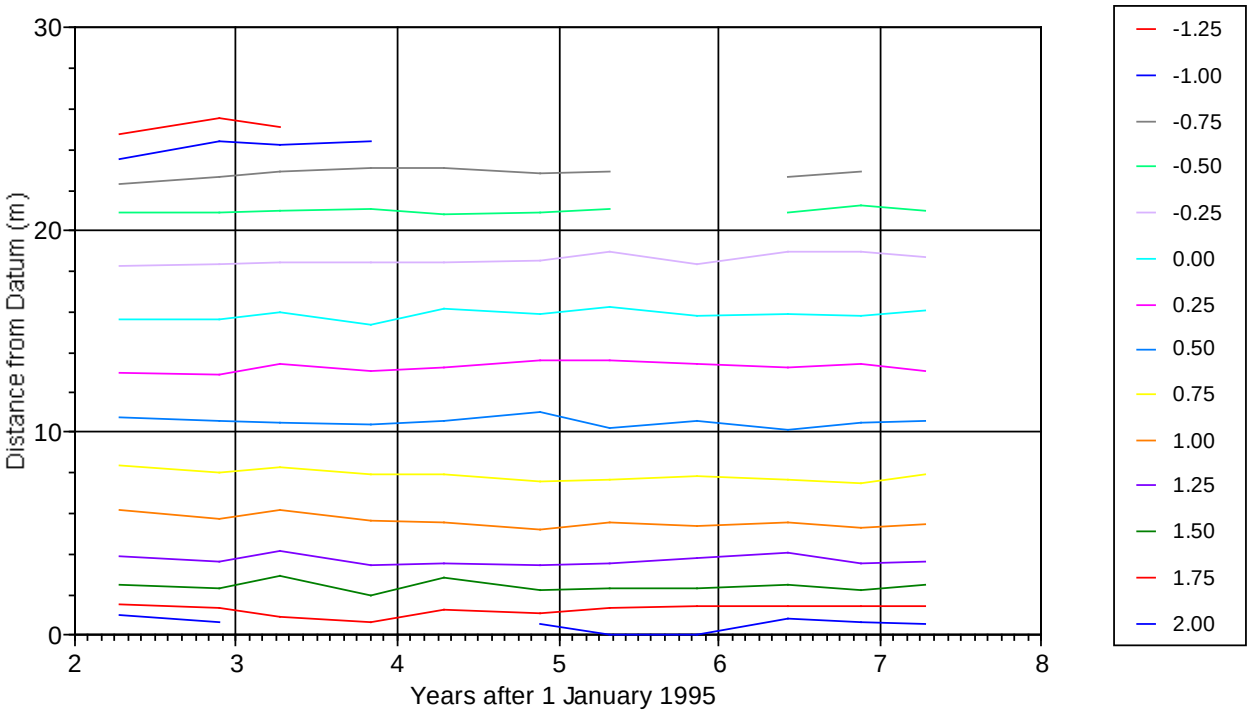
Date	Years after 1/1/95	Volume (m^3/m)
10-Apr-97	2.28	24.6
26-Nov-97	2.90	24.6
8-Apr-98	3.27	25.0
2-Nov-98	3.84	25.2
14-Apr-99	4.29	24.2
19-Nov-99	4.88	24.4
13-Apr-00	5.28	24.3
9-Nov-00	5.86	24.5
15-Jun-01	6.46	24.6
26-Nov-01	6.90	24.2
20-May-02	7.39	24.7

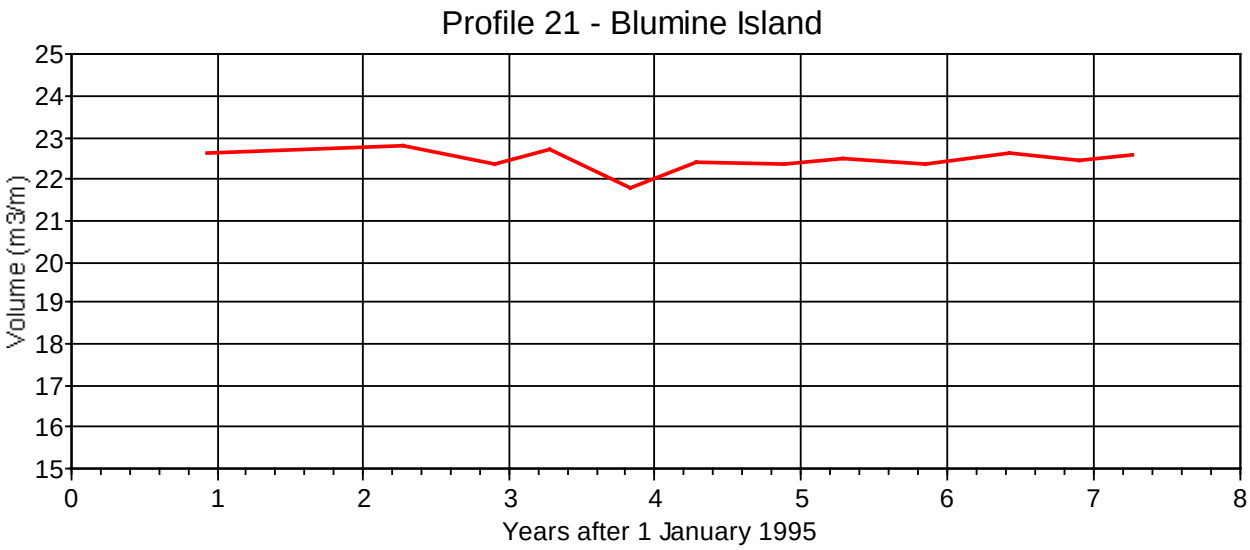
Profile 21 – Blumine Island

Blumine Island has a similar aspect to the Patten's Passage profile. There have only been minor changes (<10cm) across the profile. There is no indication of seasonality, and no indication of sediment characteristic change. Beach volumes have been very stable.


Profile 21 - Blumine Island
9-Apr-2002
19-Nov-99
10-Apr-97
Elevation (m)
Distance from BM (m)
3
2
1
0
-1
-2
-5
0
5
10
15
20
25
30
35
40
45
50


Profile 21 - Blumine Island
9-Apr-2002
26-Nov-2001
5-Jun-2001
9-Nov-2000
13-Apr-2000
19-Nov-99
14-Apr-99
2-Nov-98
8-Apr-98
26-Nov-97
10-Apr-97
Elevation (m)
Distance from BM (m)


-1.25
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Distance from Datum (m)
Years after 1 January 1995



Date	Years after 1/1/95	Volume (m^3/m)
7-Dec-95	0.93	22.6
10-Apr-97	2.28	22.8
26-Nov-97	2.90	22.4
8-Apr-98	3.27	22.7
2-Nov-98	3.84	21.8
14-Apr-99	4.29	22.4
19-Nov-99	4.88	22.4
13-Apr-00	5.28	22.5
9-Nov-00	5.86	22.4
5-Jun-01	6.43	22.6
26-Nov-01	6.90	22.5
9-Apr-02	7.27	22.6

6. Summary of beach changes and the effects of vessel wakes

This summary is divided into three sections, comprising those sites that are conceivably influenced by vessels travelling in Tory Channel and Inner Queen Charlotte Sound (on the ferry sailing route), those sites in the outer Queen Charlotte Sound, and the Picton Foreshore site, which is possibly influenced by vessels moving within the port area.

a) Picton foreshore

There is no indication that this site is affected by vessel operation, with the beach being relatively stable despite being highly modified. However, I do not have data on the timing and extent of renourishment programmes. If these data are available, they would assist interpretation.

b) Sites in outer Queen Charlotte Sound

There are five profiles located at sites in the outer Queen Charlotte Sound: Double Bay, Long Island, Clark Point, Patten's Passage and Blumine Island. The sites in outer Queen Charlotte Sound are not influenced by ferry traffic, although some are on the sailing line of larger vessels using Shakespeare Bay. All five sites have been very stable over the survey period since April 1997, showing only minor adjustments in beach shape, beach volume and sediment composition. It is interesting to note that even sites with considerable exposure to reasonably high energy, show little change.

c) Sites in Tory Channel and inner Queen Charlotte Sound

Many of the sites on the ferry route have exhibited change. However, trends or seasonality consistent between sites is not apparent. It is possible to make tentative links between the changing beach shape and the ferry operational regime at individual sites. Sites seem to be primarily influenced by the local circumstance, particularly with respect to sediment supply.

Two sites have demonstrated consistent erosion. Blackmore's at Waikawa has been stripped to bedrock, and therefore no further erosion is likely. There has been some construction activity adjacent to the profile that may have had some influence. This profile is some distance from the ferry route, and may be behaving similarly to sites up the Grove Arm, also some distance from the route, where erosion of beaches has been indicated. Bob's Bay is located on the route, but at a position where ferries are likely to be operating relatively slowly as they arrive in, or leave, Picton. There has been a consistent erosion trend across the whole profile. The particular circumstances that lead to erosion at this site are not understood, although the high number of boats of all types passing this point may be a factor.

A number of profiles exhibit no significant change. These are Te Awaiti (although there are significant changes in surficial sediments as a thin layer of sand is deposited and removed) and Tipi Bay in Tory Channel, and Dieffenbach West and Curious Monkey on the eastern shore of inner Queen Charlotte Sound.

Profile 2, The Snout at Picton Point, indicates accretion at the top of the profile and significant erosion at the bottom. The deep water channel is clearly cutting into the shoreline at this point. The reason may be related to vessel traffic, or may be entirely natural.

A number of locations demonstrate accretion. Slip Beach, Ngaionui Bay, Ngaionui Point, McMillan's Bay, McMillan's Side and to a lesser extent Te Weka Bay all show a trend of beach building. Ngaionui Bay has had considerable sediment removed by the residents, but it is clear that sediment accumulation is occurring. in Ngaionui Bay this appears to be the result of ferry traffic, although there is probably a sediment surplus in the bay due to a slip that occurred some years ago. McMillan's Bay and McMillan's Side, were relatively stable with a small amount of accretion until an event between November 1999 and May 2000 when a large amount of sediment accumulated on both profiles. It is probable that this related to a mass movement event towards Arrowsmith Point, although I have no evidence for this.

Moioio Island is an unusual case, being a beach adjacent to a major landslide, and being towards the back of the island, not directly parallel to the ferry route. Seasonality

was evident when the fast ferries were operating seasonally. Presently, Profile 6 (closest to the slip) is relatively depleted and Profile 7 is relatively full of sediment on the upper and middle beach. Both profiles show that the beach is extending into the deep water channel over time. These profiles are almost certainly influenced by changes in ferry operations, being almost completely sheltered from natural wind generated waves. However, the sediment supply from the landslide is likely to dominate the beach behaviour.

With the exception of Bob's Bay near Picton, it is clear that the beaches on the ferry route are accreting (or are stable) as opposed to eroding, although it is equally clear that local circumstances (particularly sediment supply) play a very significant role. The effect of the various operating regimes (seasonal operation, speed restrictions for the fast ferries) is not clear, although as yet there is no indication of major change as a result of all ferries traveling slowly.

7. The future of the monitoring programme

Beach monitoring requires a long term commitment to provide value. After five years, however, it is possible to reconsider the programme as a whole, and the usefulness of individual profiles. The value of the monitoring programme comes in understanding how beaches of the region function, both in response to vessel wakes and in response to natural events. Having these data should be of value to the Marlborough District Council in relation to the requirements under Section 35 of the Resource Management Act (1991).

Profiles in the outer Queen Charlotte Sound, off the ferry route, were established to provide an element of control, and in response to the possibility of significant boat traffic using port facilities in Shakespeare Bay, using the northern entrance to Queen Charlotte Sound. I am unaware as to whether this has happened or is still likely. These profiles have been very stable, and unless circumstances change, they are likely to remain stable. Depending on what is regarded as the purpose or the purposes of the monitoring programme, these sites could be abandoned, or the frequency of survey

reduced. Some thought needs to be given, however, to the likely future changes in vessel operation through the northern entrance to Queen Charlotte Sound.

Profile 5 (Blackmore's at Waikawa) was established at the request of Council. This site has demonstrated erosion, but it is unlikely that interpretation of the reason for change is ever going to be forthcoming. I see no good reason for maintaining this site.

Profile 1 (Picton Foreshore) does not seem to be changing, and certainly not with respect to vessel traffic. In terms of the purposes of this monitoring programme, continued monitoring is probably unnecessary, although there may be other reasons to continue. If this site is continued, provision of other data, such as the dates and amounts of maintenance nourishment, is required.

Other sites in Tory Channel and inner Queen Charlotte Sound are providing good data. It is debatable as to whether it is necessary to continue frequent monitoring of sites that have shown no change under the variety of ferry operating regimes that have existed since April 1997. However, it is possible that a particular combination of vessel and operating regime may cause changes in the future, and present sites showing no change under the past regimes but with a long record, may become extremely useful.

It will always be difficult to build into interpretations natural and human related events that may happen in the vicinity of the profile sites. Construction activities and landslides are two obvious examples. It would be very useful if the surveyors could make a brief reconnaissance of the nearby environment, and note any obvious events that may have occurred. For this to be effective, it is important that there is some continuity of survey personnel.

The frequency of surveys could also be reconsidered. There is now no obvious reason for surveys to be undertaken in April and November, as all ferry services currently operate all year. Unless there are changes in the vessels operating, or the nature of the operation, one survey a year may be all that is necessary to maintain a useful record. However, it would be very useful to be able to institute extra surveys if the situation changes. This may be operationally and financially difficult to organize. Reduced survey frequency also carries with it dangers in terms of loss of datum marks,

which can be difficult to replace should all datum pegs on a profile be lost. Complete loss of profile datum pegs is more likely if surveys are less frequent.

Although the present monitoring programme is effective, there is room for some rationalization. I am happy to discuss various options with Council staff.

Appendix 1

Survey Datums

Levels used in this report are in BOLD

Pr	Name	Peg	Est.	Dist	Ayson RL	KP RL	Kirk RL	SL RL	Notes
1	Picton Foreshore	Screw	04/97					**3.808**	In concrete
1	Picton Foreshore	IT	Council					**3.550**	Buried - put in by MDC
1	Picton Foreshore	Seawall	04/97	0.00				**2.430**	Drill hole in top of wall
1	NEWPicton Foreshore	C	Council	O = -6.8				**2.550**	C" hole in grey stone
2	The Snout at Picton Point	IT	04/97	-1.00	10.34			**3.293**	
2	The Snout at Picton Point	W	04/97	0.00	10.00			**2.950**	
3	Double Bay	W	04/97	-1.50	10.74			**2.720**	
3	Double Bay	IT	04/97	0.00	10.00			**1.980**	
4	Ngaionui Bay (C Thomas)	W	11/01	-2.00	10.31			**2.680**	
4	Ngaionui Bay (C Thomas)	IT	11/01	-2.5	10.02			**2.39**	
5	Blackmore's at Waikawa	Nail	04/97	0.00	10.00			**1.900**	In round post
6	Moioio Island 2	W	04/97	-2.00		0.33		**1.740**	Based on Kirk and SL Difference
6	Moioio Island 2	0IS A	11/95	0.00		0.00		**1.410**	KP Peg
6	Moioio Island 2	W	Riwaka	2.00		0.19		**1.603**	Riwaka
6	Moioio Island 2	W	Riwaka	8.90		-0.33		**1.077**	Riwaka
6	Moioio Island 2	W	Riwaka	11.90		-0.97		**0.444**	Riwaka
7	Moioio Island 1	W	04/97	-2.00	10.36		1.70	**1.700**	
7	Moioio Island 1	IT	04/97	0.00	10.00		1.34	**1.340**	
7	Moioio Island 1	Yellow Rock	Kirk	0.45	9.99		1.33	**1.330**	Kirk datum
8	Bob's Bay	Wood stake	Kirk	-2.30	10.75		2.52	**2.523**	Kirk peg
8	Bob's Bay	W	04/97	-2.00	11.19		2.96	**2.959**	
8	Bob's Bay	IT	04/97	0.00	10.00		1.77	**1.769**	
9	Te Awaiti	W	04/97	-6.00	10.87		2.01	**2.006**	
9	Te Awaiti	IT	04/97	0.00	10.00		1.13	**1.133**	
9	Te Awaiti	Crack Rock	Kirk	0.30	10.01		1.14	**1.141**	Kirk peg
10	Tipi Bay	W	04/97	-2.50	10.65		2.19	**2.188**	
10	Tipi Bay	Tube	Kirk	0.00	10.00		1.54	**1.538**	Kirk peg

11	Long Island	W	04/97	0.00	10.00			**2.840**	
11	Long Island	IT	04/97	4.70	8.85			**1.692**	LOST 11/98
11	Long Island	IT	11/98	-2.50	9.30			**2.140**	
12	Clark Point	IT	04/97	0.00	10.00			**1.620**	
12	Clark Point	OISA	Biol	2.20	9.75			**1.373**	Biol peg
12	Clark Point	W	Biol	6.50					Biol peg
12	Clark Point	W	Biol	15.60					Biol peg
13	Slip Beach	IT	11/01	-0.55	10.25		1.74	**1.740**	
13	Slip Beach	W	11/01	-0.10	10.51		2.00	**2.000**	
13	Slip Beach	W	04/97	0.00	10.19		1.68	**1.683**	
14	Ngaionui Point	W	04/97	-2.00	10.52			**2.386**	
14	Ngaionui Point	IT	04/97	0.00	10.00			**1.870**	
15	Te Weka Bay	IT	04/97	0.00	10.00		1.50	**1.498**	
15	Te Weka Bay	Wood board	Kirk	2.00	10.15		1.65	**1.648**	Kirk datum
16	McMillan's Bay	W	04/97	-2.00	11.49		2.91	**2.908**	
16	McMillan's Bay	Wood Peg	Kirk	-0.30	10.32		1.74	**1.738**	Kirk peg
16	McMillan's Bay	IT	04/97	0.00	10.00		1.42	**1.418**	
17	McMillan's Side	IT	04/97	-2.00	11.15			**2.938**	Based on Kirk and SL Difference
17	McMillan's Side	W	11/01	-1.3	11.48			**3.263**	
18	Dieffenbach West	W	04/97	-0.20		0.38		**2.988**	
18	Dieffenbach West	OIS A	Parnell	0.00		0.00		**2.610**	KP peg
18	Dieffenbach West	OIS B	Parnell	2.37		-0.35		**2.264**	KP peg
									KP peg
19	Curious Monkey	W	04/97	-1.00		1.10		**3.620**	
19	Curious Monkey	OIS A	Parnell	0.00		0.00		**2.520**	KP peg
20	Patten's Passage	IT	04/97	-1.10	10.85			**3.488**	KP peg
20	Patten's Passage	W	04/97	0.00	10.00			**2.640**	KP peg
21	Blumine Island	OIS A	Parnell	0.00		0.00		**2.210**	KP peg
21	Blumine Island	Railway iron	Parnell	3.60		0.23		**2.440**	KP peg
21	Blumine Island	Railway iron	Parnell	13.30		-1.90		**0.313**	KP peg
21	Blumine Island	Railway iron	Parnell	16.30		-2.10		**0.110**	KP peg

Appendix 2

Profile Photographs

Photographs are taken looking alongshore from both sides of the profile line, looking back towards the profile line. The profile line is approximately 20m from the camera, and appears in all photographs.