South Taranaki Bight Iron Sand Mining: Shoreline Monitoring Data Report

Prepared for Trans-Tasman Resources Limited

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Executive summary

As part of the wide-ranging biogeophysical study, NIWA was commissioned by Trans-Tasman Resources Ltd (TTR) to undertake an 11-month beach monitoring programme along the South Taranaki Bight (STB).The purpose of the monitoring is to provide background data, from which rates of change along the shore (shoreline stability) can be established, before the commencement of any offshore sand extraction.

A network of 32 beach profiles at 8 sites was established to monitor the shoreline stability along the South Taranaki Bight (STB) from Kai Iwi to Ohawe. The sites were selected as lying landward of potential offshore mining sites, away from rivers and headlands which may influence beach processes locally and where there was public access to the beach.

This report describes the criteria for the selection of the 8 sites, along with a detailed description of the methodology used in measuring the beach profiles. The report also presents the results from 11 surveys that measured 352 profiles (100% data capture) over an 11-month period from June 2011 to April 2012. One of the 11 surveys (survey S04) was carried out immediately after a storm. The relative accuracy of the survey data was at worst deemed to be around 6 cm in the horizontal and 3 cm in the vertical. This level of accuracy was more than sufficient for the purposes of measuring changes in beach profiles. The beach profiles show that the shoreline along the STB is very dynamic, with large changes in the beach profiles occurring at nearly all of the 32 profiling sites. At 6 of the 8 sites, there is little accommodation space for beach sand which appears to form a veneer only several meters thick over the rocky shore platform left by the retreating cliff line. Very high tides and waves reach right to the top of the beach and the toe of the cliffs, thus there is no space for sand dunes to build out of the reach of waves. Given the limited storage, potentially a large fraction of the entire beach volume is being washed off and on shore on a regular basis.

In addition to the beach profiles, on a single occasion, surface sediments were collected around the mid tide mark at each of the profiles. The results of the sediment analysis showed that the majority of the surface sediments could be described as either moderately-sorted-slightly-gravelly sand or poorly-sorted-gravelly sand. At some sites, significant differences in sediment characteristics exist between profiles. Typically, gravel contents were less than 10%, a notable exception to this was at Hawera which had gravel contents at all 4 profiles in excess of 20% and as high as 66%.

Information relating to TTR's additional scientific work undertaken since 2014 has been provided and the conclusions is this report remain valid.

1 Introduction

Trans-Tasman Resources Ltd (TTR) have secured permits and are prospecting for offshore iron sands along the West Coast, North Island, within the 12 nautical mile (nm) territorial sea along the southern and northern Taranaki bights (PP 50 383) and for the area beyond the 12 nm sea (PP 50 753) in the South Taranaki Bight (STB). The granted prospecting licence area lying within the 12 nm limit, will be covered by consenting procedures under the Resource Management Act (RMA), and the licence area (beyond the 12 nm territorial sea) will be managed under the Continental Shelf Act (CSA). NIWA is undertaking a range of biogeophysical studies in the STB for TTR to meet the likely requirements of consenting procedures to mine the seabed under the RMA and CSA.

As part of the wide-ranging biogeophysical study, NIWA was commissioned by TTR to undertake an 11-month beach monitoring programme along the STB. The purpose of the monitoring is to provide background data, from which rates of change along the shore (shoreline stability) can be established, before the commencement of any offshore sand extraction.

This report provides TTR and various stakeholders with a summary of the beach profile work undertaken along the STB. The main purpose of this report is to present the beach survey methods and to present the survey data. This report does not provide an in-depth analysis of shoreline change as that work is being presented in a supplementary report (Hume et al. 2012).

2 Methods

A beach profile is a survey of the topography of the beach running from the base of the cliff or the top of the sand dune to about the low water mark. The profile usually runs in a direction that is normal to the direction of the shoreline (i.e., shore normal). By comparing repeat surveys the measured changes can be used to determine rates of erosion or accretion and the size of the beach volume changes. While not the only method available (e.g., aerial photography and LiDAR) beach profiling is by far the most popular method used in assessing shoreline stability, and it is the method adopted in this study.

2.1 Site selection

To maximise the potential benefits of the beach profile data that would be gathered in this study, beach profiles sites would have been ideally situated at locations in which current and/or historical profile information exists. To establish what historical or current beach profiling data exists the following technical reports were consulted: MacDiarmid, et al. (2010), Taranaki Regional Council (2009) and Tonkin & Taylor (2001). A recurring theme in each of these reports is that beach profiling is not regularly untaken in this region, and as a result little historical data exists. What limited data does exist is usually of proprietary nature, and therefore not readily available. Discussion with the Taranaki Regional Council (TRC) also confirmed that little profile data exists in this region. As a consequence of the lack of existing profile sites, a network of new beach profile monitoring sites was established.

The predominant coastal feature along the STB is the almost continuously cliffed coastline (10-50 m high; thus, access to the shoreline along this piece of the coast is very limited. Black-sandy beaches are typically found along the base of the cliffs, but there are a few locations in the north of the area where beaches strewn with cobbles and boulders exist (e.g., Hawera and Manaia). There are numerous small streams in the region, along with a few major rivers (e.g., Patea, Waitotara and Whanganui).

The profile sites were selected from an initial reconnaissance trip of the study area. Prior to the reconnaissance trip a virtual tour of the study site was undertaken using Google Earth, aerial photographs of the region and the Coastal Explorer website. From the virtual tour, a comprehensive list of all possible profiling sites and potential access points along the study area was identified. Using this information, the field reconnaissance trip was carried out over a 3-day period. During this time, the suitability of each of the potential profiling sites was assessed using the following criteria:

1. profile sites must have public beach access, so no future access issues arise from private land owners, and
2. profile sites must be spaced so that they span the area of interest from approximately Wanganui to Hawera, and
3. in order to capture any local variability in shoreline stability, the selected site needs be long enough to accommodate 4 profiles.

In addition to the three criteria above, the location of the four profiles at each site were selected on the basis of:

1. no profile be surveyed within 200 m of a river or stream, and
2. a minimum spacing of 100 m between profiles, and
3. to increase the spatial coverage, where possible profiles 2 and 3 would be spaced 200 m apart.

2.2 Survey methodology

Profile position and elevation data was determined using a Trimble R8 GNSS RTK GPS (Real Time Kinematic Global Position System). All position data was recorded in the New Zealand Transverse Mercator projection (NZTM) while elevations are relative to the Taranaki 1970 vertical datum.

The R8 consists of two main components: a base station and a mobile rover unit (see Figure 2-1). To collect accurate position and elevation information the base station is deployed in a static arrangement over a known position, usually a benchmark (BM). Once the base station is running, the rover unit is then free to move around and survey the area of interest. The only minor limitation is that the base station and rover must remain in constant communication via a radio link.

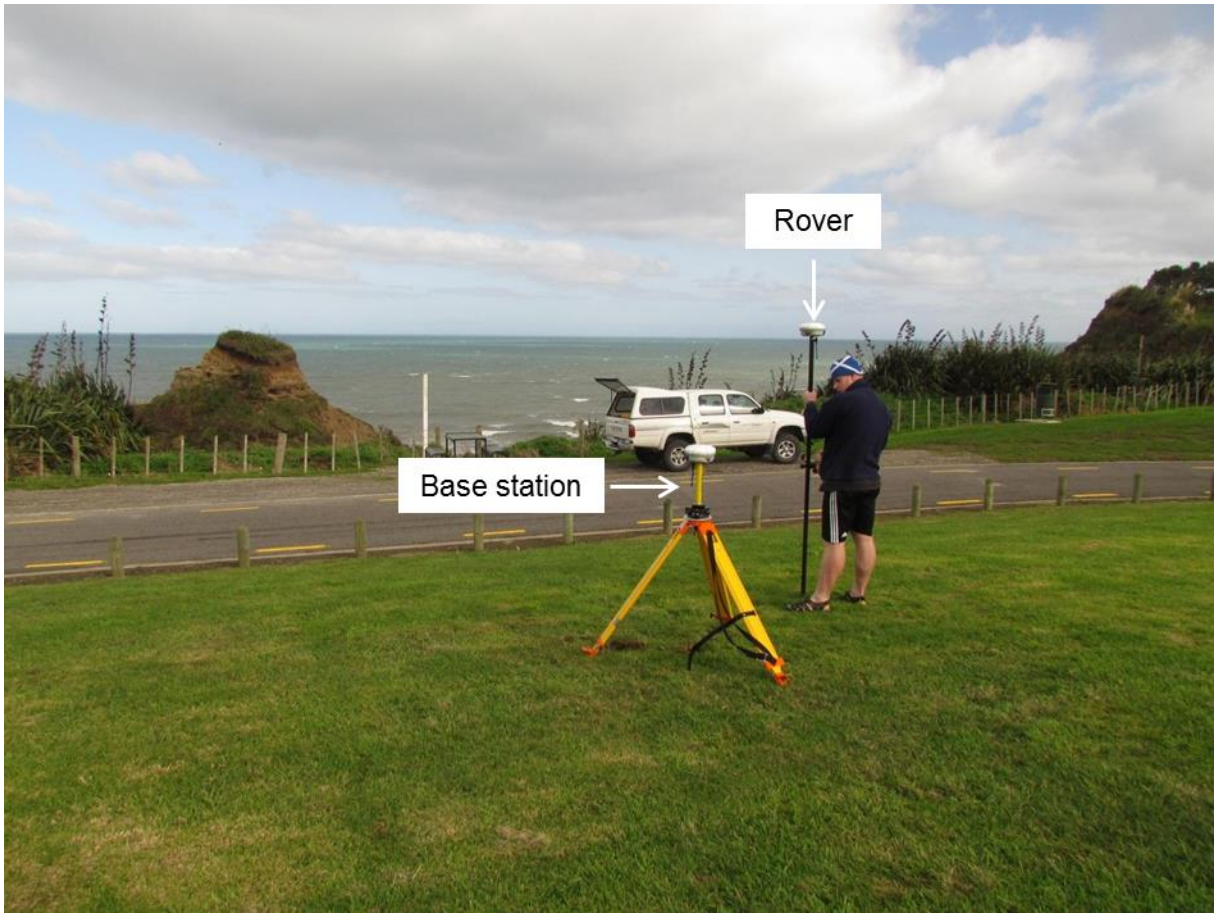

Figure 2-1: Photo showing RTK GPS base station and rover setup at Hawera.

Given the lack of benchmarks in the area, a series of local benchmarks (usually a wooden peg driven into the ground) was established. Locating benchmarks at the base of the cliffs in this area is not possible, due to the occasional catastrophic failure of the sedimentary cliffs that deposit large volumes of sediments at the base. Bench marks were located in stable areas, and where possible located to provide line-of-slight between the base station and the locations of the profiles, thus ensuring good radio communications between the base station and the rover.

To determine the position of the local bench marks, the R8 rover was used in conjunction with an iBASE station. Within New Zealand there exists a network of iBASE stations. These iBASE stations simplify surveying because they remove the need to setup a local base station, i.e., the iBASE and Rover become the RTK GPS system. It is worth noting that instead of using a radio link, communications between the iBASE and the rover is achieved via the cellular phone network. Due to a lack of cell phone coverage at some of the profile sites it was not possible to use the iBASE to survey all the beach profiles. Thus, the iBase was used only once to establish the positions of the local benchmarks, thereafter the R8 base station was used.

The accuracy of the iBASE system was checked by collecting measurements over a Land Information New Zealand (LINZ) survey mark (AFX4). In establishing the local bench mark positions two iBASE stations: OHA (Central North Island – Ohakune) and NPL (Taranaki – New Plymouth) were used. Comparisons of the measured position using the OHA and NPL iBASE stations and the LINZ survey mark AFX4 are shown in Table 2-1. The table shows that the maximum horizontal difference between the iBASE measurements and the actual position was approximately 25 cm. In the vertical the maximum difference was approximately an order of magnitude less at around 2cm. From this we infer that the measured local bench mark positions would lie within a few tens of centimetres in the horizontal and within a few centimetres in the vertical of the actual position. This level of accuracy is more than suitable for the purpose of measuring beach profiles.

	Northing	**Easting**	**Elevation**
AFX4	5579059.017	1774192.321	47.022

iBASE station	**Northing**	**Easting**	**Elevation**
OHA	5579059.271	1774192.322	47.009
NPL	5579058.996	1774192.206	47.000

iBASE station	**ΔNorthing**	**ΔEasting**	**ΔElevation**
OHA	-0.254	-0.001	0.013
NPL	0.021	0.115	0.022

Table 2-1: Comparison of the iBASE measurements and LINZ survey mark AFX4.

Once the local benchmarks were surveyed in, the beach profiles at each site could be readily surveyed. In order to maximise the seaward extent of the profiles, the profiles were measured 2 hours either side of low water. The profiles were collected using the following method:

1. On arrival at the site the base station was installed over the bench mark. The base station was then programmed and started.

2. Once the base station was running, the rover was started and the surveying could begin. Before surveying the beach profiles, measurements were taken at a control point located on some nearby stable platform (e.g., a concrete post). By repeatedly surveying the same control point over time, and by assuming the control point was stationary, the relative accuracy of the survey data was determined.

3. Once the measurements at the control point had been made, the beach profiles were surveyed. One of the most useful features of the rover unit is the ability to guide the user over a predetermined track or runline[1]. Using this capability, beach profiles were collected over the same runline each time the beach was surveyed. The beach profile itself consists of a number of spot measurements taken over the length of the profile. The distance between spot measurements was determined by the surveyor on each survey to ensure an accurate measurement of the beach shape. varied to accurately describe the local beach shape. Typically, in the upper beach spot measurements were taken every 2-3 m, while in the lower beach measurements were taken every 6-8 m.

2.3 Beach sediment analysis

Surface sediments were collected at each profile on a single occasion at approximately the mid-tide level. The surface sediments were collected by scraping off the top 2-3 cm of sediments from the beach face. About a cup sized amount of sediment was collected at each profile.

After returning to the laboratory, the sediment was washed several times with fresh water to remove any salt. The washed sediment was then dried in an oven overnight at a temperature of 60°C.

The dried sediment was then dry-sieved into 1 ϕ size fractions, where $\phi = -\log_2(d)$, with d the particle diameter in millimetres. The aperture of sieve sizes used in the analysis are shown in Table 2-2.

	Sieve aperture							
d (mm)	8.000	4.000	2.000	1.000	0.500	0.250	0.125	0.063
φ	-3	-2	-1	0	1	2	3	4

Table 2-2: Sieve sizes used in the analysis of the beach sediments.

[1] In this study the runlines ran in a direction that was normal to the direction of the shoreline (i.e., shore normal)

The particle size distribution (PSD) was then derived from weighting the sediment that was retained on each sieve. The PSD were analysed in Excel using GRADISTAT version 8.0 (Blott, 2010), which yields various granulometric statistics and a textural description of the processed sediment. The presented granulometric statistics were calculated using the arithmetic method of moments.

The Size scale adopted in the GRADISTAT programme is shown in Table A-1 in Appendix A.

3 Results

3.1 Site selection

The field reconnaissance identified 8 beach profiling sites (see Figure 3-1). These are the few locations on the coast that can be accessed by public road.

Figure 3-1: The locations of the 8 beach profiling sites (yellow triangles).

3.1.1 Kai Iwi

The site at Kai Iwi beach is accessed via Sunset Parade.

Kai Iwi Beach (Figure 3-2) is formed where a small stream cuts through coastal cliffs and emerges on the beach. Here a largely sandy beach about 110-120 m wide is built in front of near vertical 40 m tall and actively-eroding sea cliffs. Rock falls and slumping from the cliff face provides some boulders, cobbles, gravel and sand to the beach. There is little accommodation space for beach sand, which appears to form a veneer only several meters thick over the rocky shore platform left by the retreating cliff line. Very high tides and waves

can reach the top of the beach and the toe of the cliffs, thus there is no space for sand dunes to build out of the reach of waves.

The locations of the 4 beach profiles and the BM for the Kai Iwi site are displayed in Figure 3-2. The coordinates of the start point, end point and bearing for the 4 profiles, along with the coordinates of the BM are specified in Table 3-1. The part of the profile that is surveyed runs for the base of the cliff to about the low water mark.

Sequences of 4 photographs per profile for the Kai Iwi profiles are shown in Figure B-1 to Figure B-4 in Appendix B.

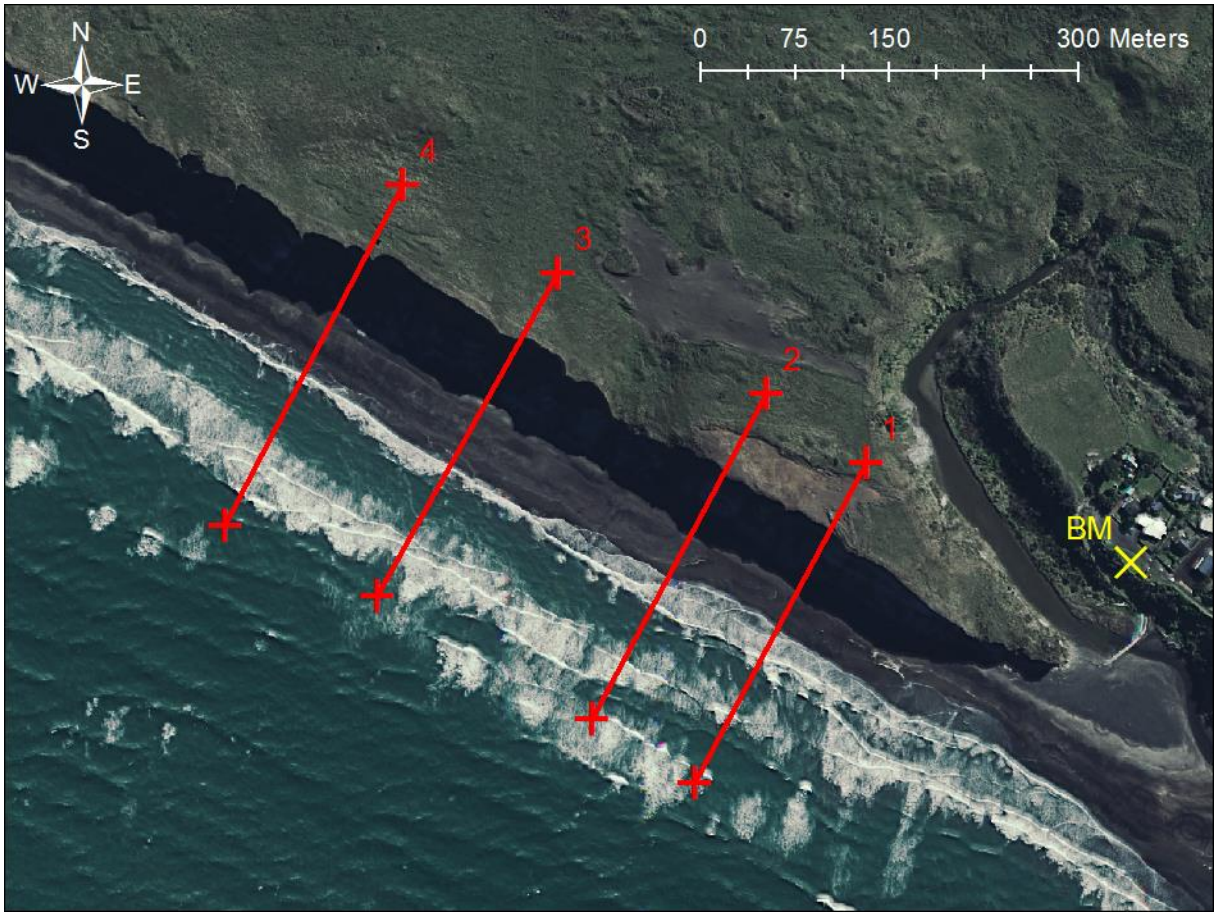

Figure 3-2: Kai Iwi site map showing profile runlines and the location of the benchmark (BM) (Base map: copyright Digital Globe).

Profile Information

	Start		End		
Profile	**Northing**	**Easting**	**Northing**	**Easting**	**Bearing**
1	5583517.52	1762013.09	5583264.28	1761877.91	208.10
2	5583572.31	1761934.77	5583315.09	1761796.03	208.30
3	5583668.65	1761768.59	5583412.15	1761625.61	209.10
4	5583738.13	1761645.62	5583467.87	1761504.38	207.60

Benchmark location

Northing	**Easting**	**Elevation**
5583438.327	1762223.497	18.931

Table 3-1: Kai Iwi profile information.

3.1.2 Ototoka

The site at Ototoka Beach is accessed via Ototoka Beach Road.

Ototoka Beach (Figure 3-3) is formed where a small stream cuts through coastal cliffs and emerges on the beach. Here a largely sandy beach about 100-130 m wide is built in front of near vertical 40 m tall sea cliffs that are stabilised to a large degree by vegetation. The upper beach is commonly strewn with logs and wood debris from nearby rivers. Rocky reef shore platform is exposed in places on the beach face in the northwest. There is little accommodation space for beach sand which appears to form a veneer only several meters thick over the rocky shore platform left by the retreating cliff line. Very high tides and waves can reach the top of the beach and the toe of the cliffs, thus there is no space for sand dunes to build out of the reach of waves.

The locations of the 4 beach profiles and the BM for the Ototoka site are displayed in Figure 3-3. The coordinates of the start point, end point and bearing for the 4 profiles, along with the coordinates of the BM are specified in Table 3-2. The part of the profile that is surveyed runs for the base of the cliff to about the low water mark.

Sequences of 4 photographs per profile for the Ototoka profiles are shown in Figure B-5 to Figure B-8 in Appendix B.

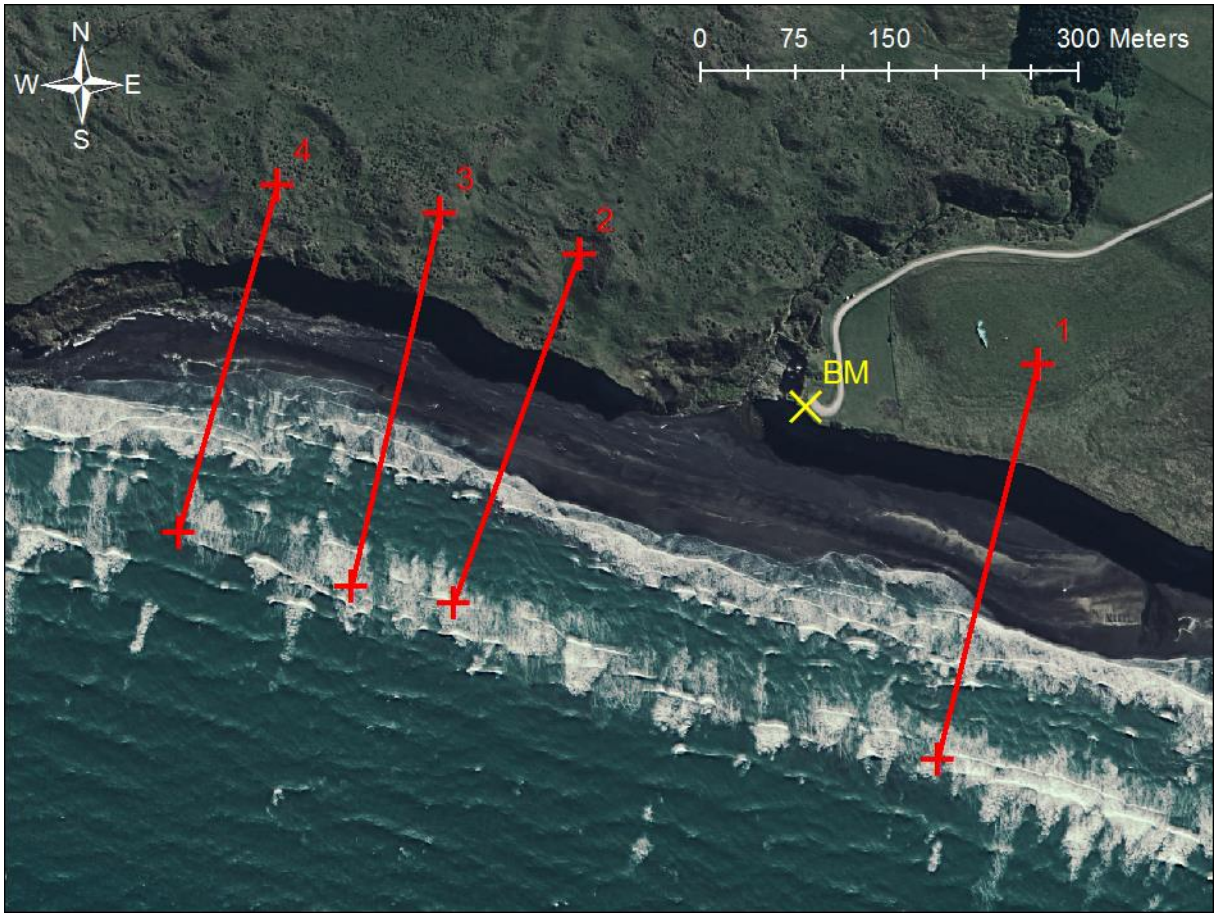

Figure 3-3: Ototoka site map showing profile runlines and the location of the benchmark (BM) (Base map: copyright Digital Globe).

Profile Information

	Start		End		
Profile	**Northing**	**Easting**	**Northing**	**Easting**	**Bearing**
1	5585525.67	1756870.21	5585212.83	1756790.09	194.40
2	5585613.22	1756506.27	5585336.88	1756406.13	199.90
3	5585645.48	1756395.18	5585350.22	1756324.82	193.40
4	5585668.30	1756266.09	5585392.70	1756187.91	195.80

Benchmark location

Northing	**Easting**	**Elevation**
5585492.746	1756686.039	33.703

Table 3-2: Ototoka profile information.

3.1.3 Waiinu

The site at Waiinu Beach is accessed via the campground on Nukumaru Parade.

Waiinu Beach (Figure 3-4) lies in a prominent indentation in the coastline where the ancient delta of the Waitotara River has created a prominent bulge in the coast. The beach is about 90-110 m wide and comprised of black sand. It has a well-developed and vegetated foredune that is approximately 3 m high. Sand has blown inland to build transgressive dunes over rising ground behind the foredunes. Very high tides and waves can reach and erode the dune face. Ground water drains from cliffs and runs through the beach face to emerge near the mid and low tide level.

The locations of the 4 beach profiles and the BM for the Waiinu site are displayed in Figure 3-4. The coordinates of the start point, end point and bearing for the 4 profiles, along with the coordinates of the BM are specified in Table 3-3. The part of the profile that is surveyed runs from the above the high water mark on the foredune to about the low water mark.

Sequences of 4 photographs per profile for the Waiinu profiles are shown in Figure B-9 to Figure B-12 in Appendix B.

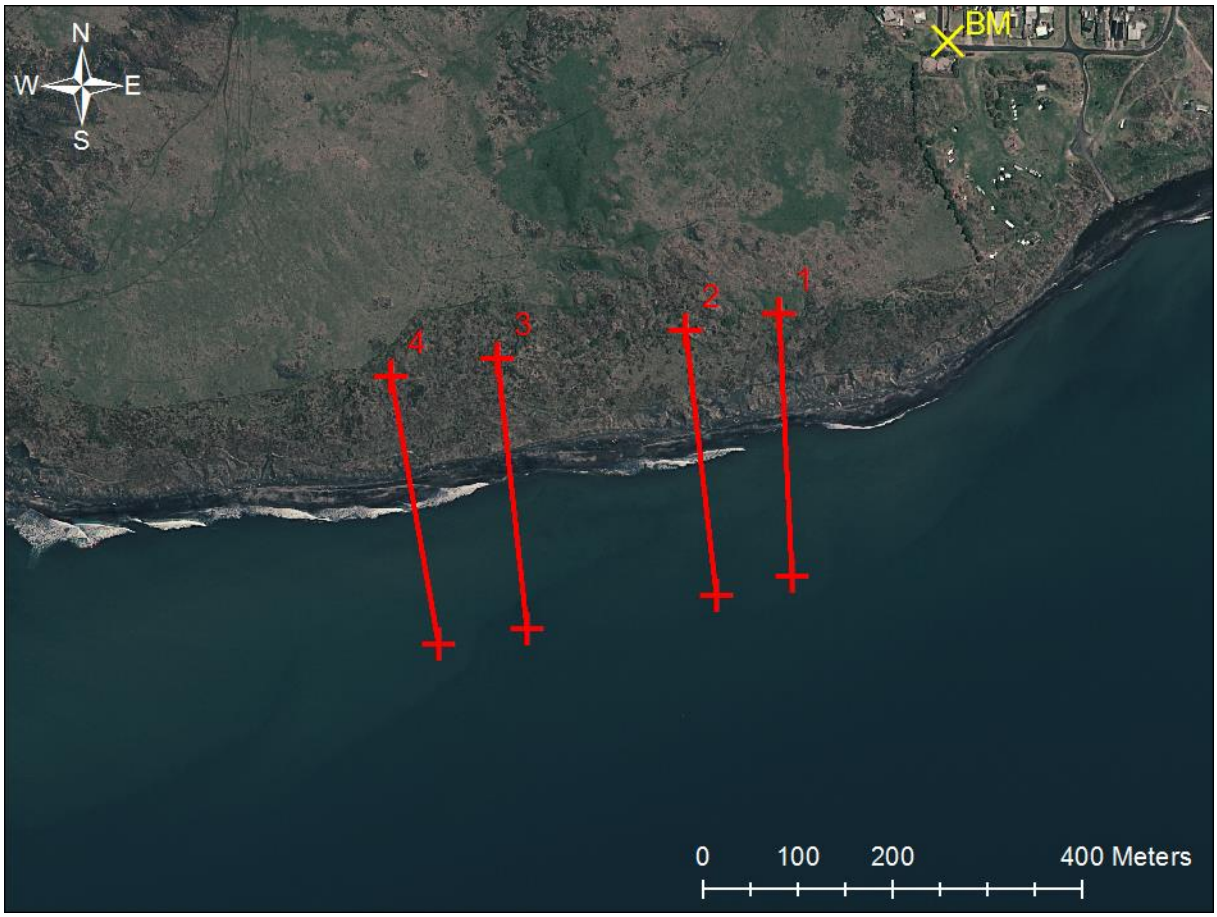

Figure 3-4: Waiinu site map showing profile runlines and the location of the benchmark (BM) (Base map: copyright Digital Globe).

Profile Information

	Start		End		
Profile	**Northing**	**Easting**	**Northing**	**Easting**	**Bearing**
1	5585560.18	1749030.12	5585282.62	1749043.68	177.20
2	5585541.83	1748931.09	5585262.07	1748963.51	173.40
3	5585512.84	1748732.20	5585226.76	1748762.70	173.90
4	5585493.00	1748619.26	5585210.70	1748670.44	169.70

Benchmark location

Northing	**Easting**	**Elevation**
5585848.243	1749209.259	9.975

Table 3-3: Waiinu profile information.

3.1.4 Waverley

The site at Waverley Beach is accessed via Waipipi Road.

Waverley Beach (Figure 3-5) is about 2 km long and 110 m wide and forms in an indentation of the shoreline where the geology of the coastal cliffs has allowed them to cut back about 100 m further than the adjacent coast. The beach is comprised primarily of black sand with small amounts of pebbles and cobbles strewn on the upper beach at the base of vertical 30 m tall and actively-eroding sea cliffs. Rock falls and slumping from the cliff face provides sand and small amounts of cobbles and pebbles to the beach. There are some exposed rocky shore platforms in the northwest sector of the beach. There is little accommodation space for beach sand which appears to form a veneer only several meters thick over the rocky shore platform left by the retreating cliff line. Very high tides and waves can reach the top of the beach and the toe of the cliffs, thus there is no space for sand dunes to build out of the reach of waves. Ground water drains from cliffs and runs through the beach face to emerge near low tide level.

The locations of the 4 beach profiles and the BM for the Waverley site are displayed in Figure 3-5. The coordinates of the start point, end point and bearing for the 4 profiles, along with the coordinates of the BM are specified in Table 3-4. The part of the profile that is surveyed runs for the base of the cliff to about the low water mark.

Sequences of 4 photographs per profile for the Waverley profiles are shown in Figure B-13 to Figure B-16 in Appendix B.

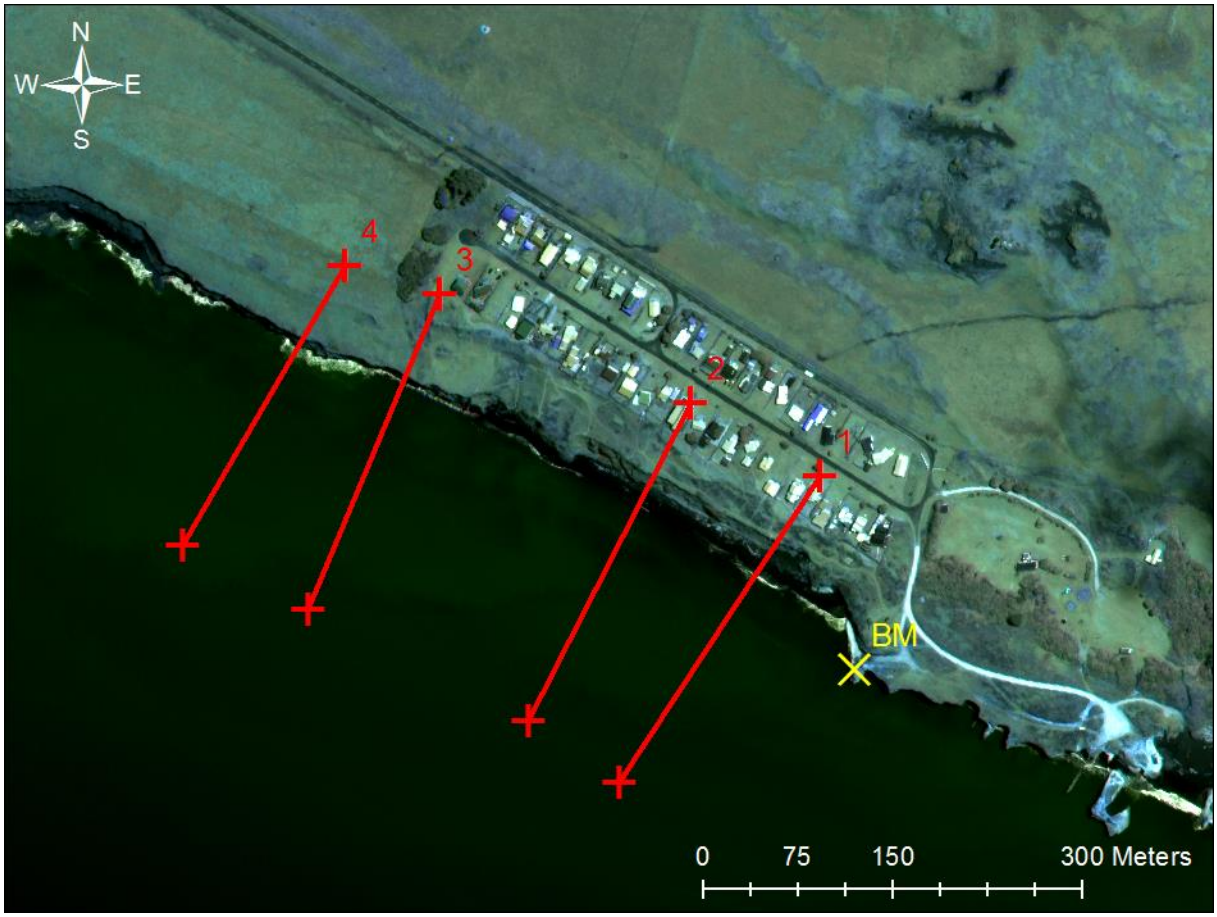

Figure 3-5: Waverley site map showing profile runlines and the location of the benchmark (BM) (Base map: copyright Digital Globe).

Profile Information

	Start		End		
Profile	**Northing**	**Easting**	**Northing**	**Easting**	**Bearing**
1	5589696.09	1739808.33	5589453.71	1739648.57	213.40
2	5589754.50	1739705.89	5589502.90	1739577.01	207.10
3	5589840.85	1739507.31	5589590.65	1739402.59	202.70
4	5589863.62	1739431.35	5589641.58	1739302.65	210.10

Benchmark location

Northing	Easting	Elevation
5589543.075	1739836.042	15.549

Table 3-4: Waverley profile information.

3.1.5 Patea

The site at Patea Beach is accessed via the upper lookout on Taranaki Road.

Patea Beach (Figure 3-6) is formed where the Patea River emerges at the coast. Here there is a 600 m long strip of black sand beach about 90-110 m wide which is backed by 5-10 m tall foredunes. Very high tides and waves reach high on the beach where they can erode the dunes. Behind the foredunes sand has been blown inland to smother low topography and build a transgressive dune.

The locations of the 4 beach profiles and the BM for the Patea site are displayed in Figure 3-6. The coordinates of the start point, end point and bearing for the 4 profiles, along with the coordinates of the BM are specified in Table 3-5. The part of the profile that is surveyed runs from the above the high water mark on the foredune to about the low water mark.

Sequences of 4 photographs per profile for the Patea profiles are shown in Figure B-17 to Figure B-20 in Appendix B.

Figure 3-6: Patea site map showing profile runlines and the location of the benchmark (BM) (Base map: copyright Digital Globe).

Profile Information

	Start		End		
Profile	**Northing**	**Easting**	**Northing**	**Easting**	**Bearing**
1	5596720.92	1727178.30	5596525.98	1726981.20	225.30
2	5596785.30	1727115.90	5596611.80	1726906.50	230.40
3	5596905.61	1727008.82	5596737.39	1726827.98	227.10
4	5596988.56	1726938.72	5596800.64	1726759.98	223.60

Benchmark location

Northing	**Easting**	**Elevation**
5596780.611	1727111.611	32.623

Table 3-5: Patea profile information.

3.1.6 Manawapou

The site at Manawapou Beach is accessed via Manawapou Road.

Manawapou Beach (Figure 3-7) is formed where a small river, the Manawapou, cuts through coastal cliffs and emerges on the beach. Here a largely sandy beach about 70-100 m wide fronts vertical 40 m tall and actively-eroding sea cliffs. Rock falls and slumping from the cliff face provides some boulders, cobbles, gravel and sand to the beach. Rocky reef shore platforms are exposed in places on the lower beach. The Manawapou River and the Tangahoe River (about 600 m along the coast to the northwest) provide sediment to the beach. These rivers also affect beach processes by eroding the beach through direct scour and by maintaining a high water table. There is little accommodation space for beach sand which appears to form a veneer only several meters thick over the rocky shore platform left by the retreating cliff line. Very high tides and waves can reach the top of the beach and the toe of the cliffs, thus there is no space for sand dunes to build out of the reach of waves. Ground water drains from cliffs and runs through the beach face to emerge near the low tide level.

The locations of the 4 beach profiles and the BM for the Manawapou site are displayed in Figure 3-7. The coordinates of the start point, end point and bearing for the 4 profiles, along with the coordinates of the BM are specified in Table 3-6. The part of the profile that is surveyed runs for the base of the cliff to about the low water mark.

Sequences of 4 photographs per profile for the Manawapou profiles are shown in Figure B-21 to Figure B-24 in Appendix B.

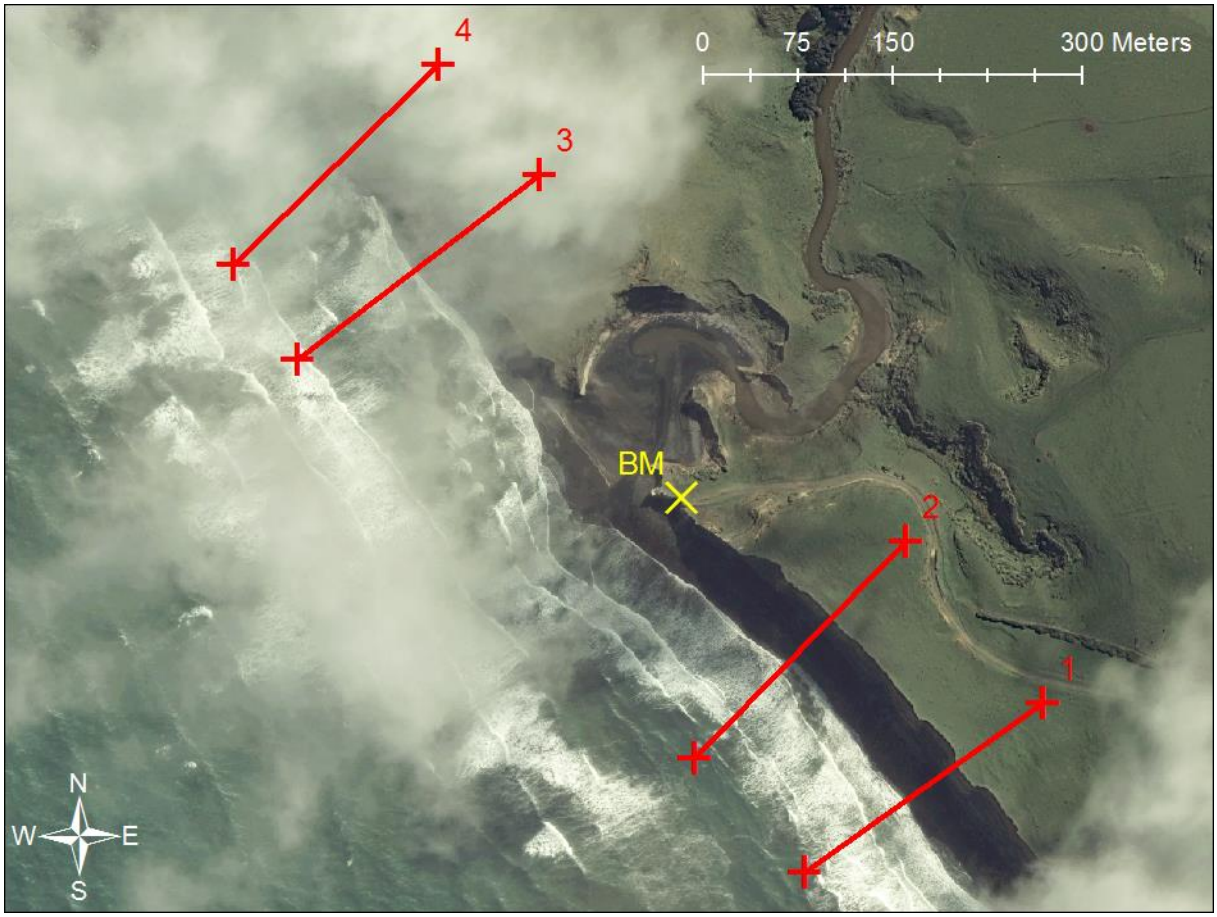

Figure 3-7: Manawapou site map showing profile runlines and the location of the benchmark (BM) (Base map: copyright Digital Globe).

Profile Information

	Start		End		
Profile	**Northing**	**Easting**	**Northing**	**Easting**	**Bearing**
1	5609303.33	1716112.75	5609169.77	1715923.85	234.70
2	5609431.55	1716004.76	5609259.95	1715836.74	224.40
3	5609722.13	1715713.33	5609576.17	1715521.87	232.70
4	5609809.19	1715633.32	5609650.61	1715470.58	225.70

Benchmark location

Northing	Easting	Elevation
5609465.958	1715826.869	16.511

Table 3-6: Manawapou profile information.

3.1.7 Hawera

The site at Hawera Beach is accessed via Denby Road.

Hawera Beach (Figure 3-8) is formed where a small stream cuts through coastal cliffs and emerges on the beach. Here a sandy, boulder and cobble strewn beach about 60-130 m wide fronts vertical 50 m tall and actively-eroding sea cliffs. Rock falls and slumping from the cliff face provides boulders, cobbles, gravel and sand to the beach. A rocky reef shore platform is exposed in places on the beach face in the lower section of the beach. There is little accommodation space for beach sand which appears to form a veneer only several meters thick over the rocky shore platform left by the retreating cliff line. Very high tides and waves reach right to the top of the beach and the toe of the cliffs, thus there is no space for sand dunes to build out of the reach of waves. Ground water drains from cliffs and runs through the beach face to emerge near the low tide level.

The locations of the 4 beach profiles and the BM for the Hawera site are displayed in Figure 3-8. The coordinates of the start point, end point and bearing for the 4 profiles, along with the coordinates of the BM are specified in Table 3-7. The part of the profile that is surveyed runs for the base of the cliff to about the low water mark.

Sequences of 4 photographs per profile for the Hawera profiles are shown in Figure B-25 to Figure B-28 in Appendix B.

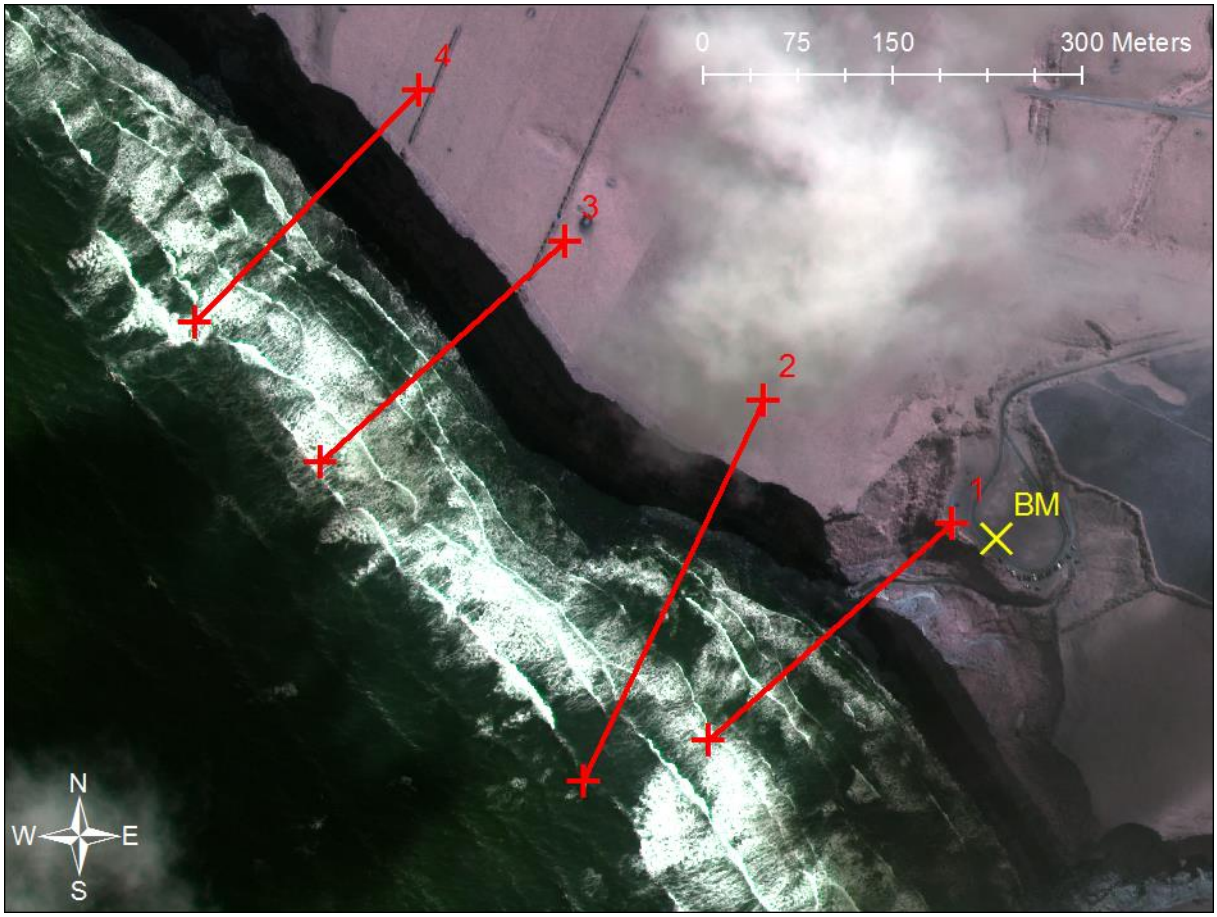

Figure 3-8: Hawera site map showing profile runlines and the location of the benchmark (BM) (Base map: copyright Digital Globe).

Profile Information

	Start		End		
Profile	**Northing**	**Easting**	**Northing**	**Easting**	**Bearing**
1	5615310.85	1706614.17	5615138.41	1706421.07	228.20
2	5615408.38	1706464.78	5615106.47	1706322.14	205.30
3	5615533.89	1706307.83	5615359.45	1706113.85	228.00
4	5615653.95	1706191.51	5615470.10	1706014.15	224.00

Benchmark location

Northing	**Easting**	**Elevation**
5615298.649	1706650.414	43.174

Table 3-7: Hawera profile information.

3.1.8 Ohawe

The site at Ohawe Beach is accessed via Rangatapu Street.

Ohawe Beach (Figure 3-9) is formed where a small stream cuts through coastal cliffs and emerges on the beach. Here a largely sandy beach about 70-130 m wide fronts vertical 40 m tall and actively-eroding sea cliffs. Rock falls and slumping from the cliff face provides boulders, cobbles, gravel and sand to the beach. A rocky reef shore platform is exposed in places on the beach face in the mid and lower beach. There is little accommodation space for beach sand which appears to form a veneer only several meters thick over the rocky shore platform left by the retreating cliff line. Very high tides and waves reach right to the top of the beach and the toe of the cliffs, thus there is no space for sand dunes to build out of the reach of waves. Ground water drains from cliffs and runs through the beach face to emerge near the low tide level.

The locations of the 4 beach profiles and the BM for the Ohawe site are displayed in Figure 3-9. The coordinates of the start point, end point and bearing for the 4 profiles, along with the coordinates of the BM are specified in Table 3-8. The part of the profile that is surveyed runs for the base of the cliff to about the low water mark.

Sequences of 4 photographs per profile for the Ohawe profiles are shown in Figure B-29 to Figure B-32 in Appendix B.

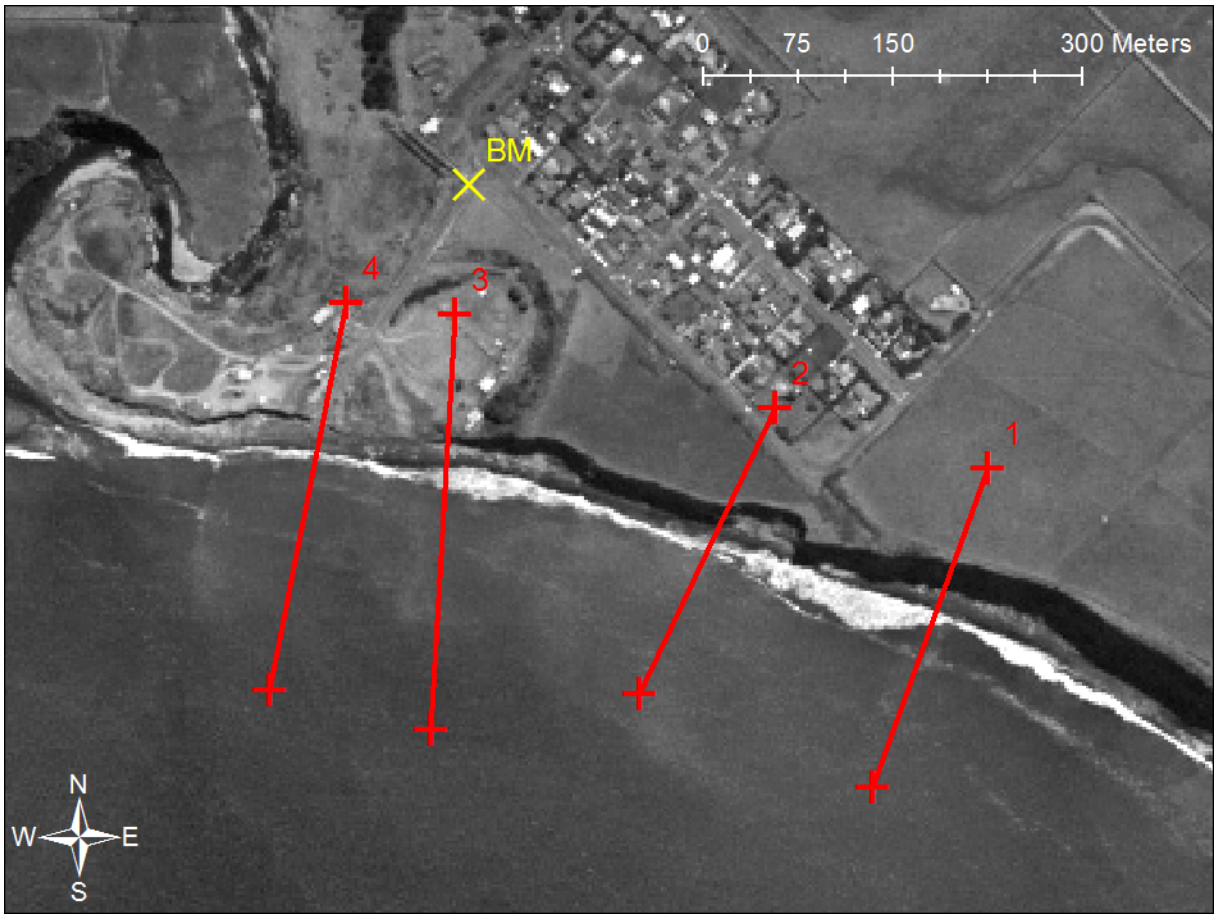

Figure 3-9: Ohawe site map showing profile runlines and the location of the benchmark (BM).

Profile Information

	Start		End		
Profile	Northing	Easting	Northing	Easting	Bearing
1	5617412.59	1703190.63	5617159.32	1703099.33	199.80
2	5617459.49	1703022.64	5617233.43	1702914.17	205.60
3	5617533.82	1702767.96	5617205.20	1702748.80	183.30
4	5617543.18	1702682.49	5617236.14	1702620.73	191.40

Benchmark location

Northing	Easting	Elevation
5617636.923	1702779.854	26.603

Table 3-8: Ohawe profile information.

3.2 Beach profiles

Beach profiles were surveyed on 11 occasions between June 2011 and April 2012 (Table 3-9). The table also shows that surveys S03 and S04 both took place during September 2011. Survey S03 was the regular monthly survey, while the S04 survey was performed after a storm. A time series of measured near-shore significant wave height at 4 locations along the STB are shown in Figure 3-10. The region bound by blue vertical lines indicate the times over which survey S04 took place, this figure clearly demonstrates that survey S04 took place immediate after a period of large waves.

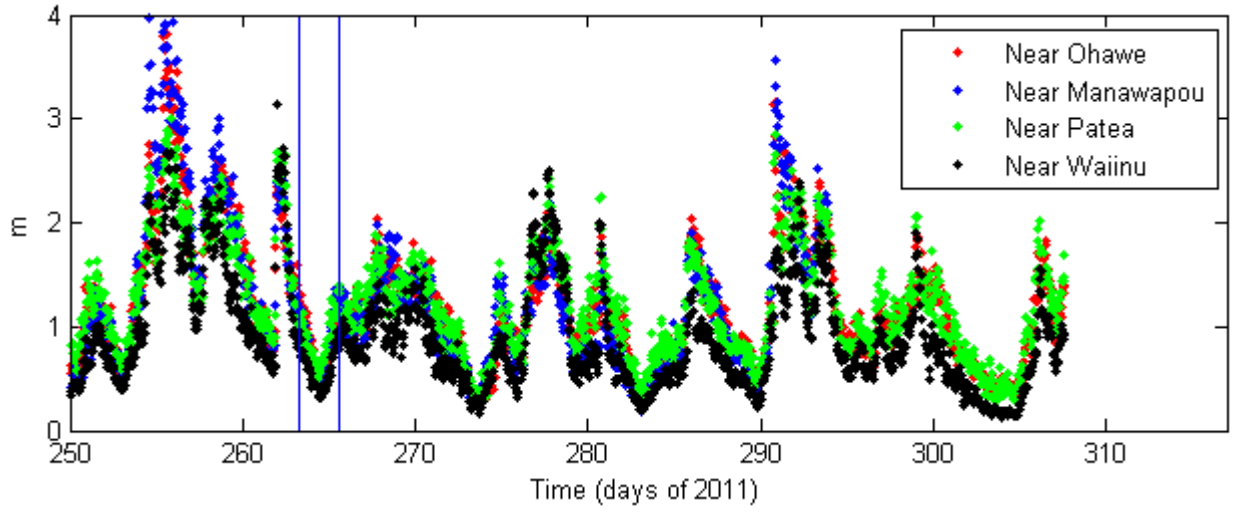

Figure 3-10: Time-series of near-shore significant wave height. The region bound by the blue lines indicate the time in which the storm survey (S04) took place.

The survey control points for the 8 sites were resurveyed on every visit (Table 3-10 and Table 3-11) to establish the relative accuracy of the survey data. In Table 3-10 and Table 3-11 the final row for each survey displays the range of measured values. From all sites, the maximum variation between surveys in the horizontal is around 6 cm. The maximum variation between surveys in the vertical from all sites is 3 cm. This level of accuracy is more than sufficient for the purposes of measuring changes in beach profiles.

Survey	Kai Iwi	Ototoka	Waiinu	Waverley	Patea	Manawapou	Hawera	Ohawe
S01	13/06/2011 1258 to 1410	13/06/2011 1450 to 1610	14/06/2011 1604 to 1714	14/06/2011 1420 to 1510	14/06/2011 1219 to 1343	15/06/2011 1313 to 1420	15/06/2011 1509 to 1612	15/06/2011 1647 to 1748
S02	25/08/2011 1221 to 1335	25/08/2011 1515 to 1628	26/08/2011 1528 to 1616	26/08/2011 1356 to 1455	26/08/2011 1220 to 1325	27/08/2011 1200 to 1315	27/08/2011 1400 to 1500	27/08/2011 1600 to 1642
S03	06/09/2011 1030 to 1140	06/09/2011 1217 to 1316	07/09/2011 0852 to 0948	07/09/2011 1044 to 1147	07/09/2011 1228 to 1324	08/09/2011 0925 to 1057	08/09/2011 1143 to 1251	08/09/2011 1346 to 1456
S04	21/09/2011 0719 to 0831	21/09/2011 0914 to 1025	21/09/2011 1109 to 1326	22/09/2011 1154 to 1334	22/09/2011 0736 to 0843	22/09/2011 0926 to 1043	23/09/2011 1037 to 1209	23/09/2011 1242 to 1410
S05	05/10/2011 1055 to 1159	05/10/2011 1229 to 1353	06/10/2011 0943 to 1100	06/10/2011 1143 to 1240	06/10/2011 1321 to 1428	07/10/2011 1310 to 1404	07/10/2011 1038 to 1225	07/10/2011 1450 to 1610
S06	02/11/2011 0814 to 0938	02/11/2011 1018 to 1138	03/11/2011 0741 to 0854	03/11/2011 0940 to 1042	03/11/2011 1120 to 1231	04/11/2011 1100 to 1150	04/11/2011 0843 to 1015	04/11/2011 1244 to 1344
S07	07/12/2011 1517 to 1626	07/12/2011 1249 to 1426	06/12/2011 1500 to 1602	06/12/2011 1310 to 1400	06/12/2011 1123 to 1225	05/12/2011 1203 to 1252	05/12/2011 1400 to 1513	05/12/2011 1036 to 1117
S08	17/01/2012 1008 to 1140	17/01/2012 1245 to 1350	18/01/2012 1306 to 1446	18/01/2012 1112 to 1215	18/01/2012 0907 to 1021	19/01/2012 1222 to 1324	19/01/2012 1010 to 1133	19/01/2012 1421 to 1539
S09	15/02/2012 1017 to 1134	15/02/2012 1204 to 1318	16/02/2012 1224 to 1344	16/02/2012 1024 to 1137	16/02/2012 0823 to 0934	17/02/2012 1211 to 1306	17/02/2012 0926 to 1122	17/02/2012 1354 to 1459
S10	21/03/2012 1351 to 1504	21/03/2012 1535 to 1649	20/03/2012 1337 to 1424	20/03/2012 1508 to 1555	20/03/2012 1638 to 1743	19/03/2012 1514 to 1612	19/03/2012 1251 to 1424	19/03/2012 1711 to 1759
S11	16/04/2012 1148 to 1249	16/04/2012 1335 to 1438	17/04/2012 1142 to 1239	17/04/2012 1311 to 1401	17/04/2012 1449 to 1554	18/04/2012 1146 to 1309	18/04/2012 1351 to 1445	18/04/2012 1536 to 1638

Table 3-9: Survey Dates and Times (New Zealand Standard Time (NZST)).

	Kai Iwi			Ototoka		
Survey	Northing	Easting	Elevation	Northing	Easting	Elevation
S01		No data			No data	
S02	5583357.93	1762212.61	2.70	5585478.69	1756717.40	32.21
S03	5583357.92	1762212.62	2.69	5585478.72	1756717.41	32.21
S04	5583357.92	1762212.62	2.69	5585478.72	1756717.39	32.21
S05	5583357.93	1762212.61	2.69	5585478.70	1756717.41	32.21
S06	5583357.92	1762212.61	2.69	5585478.72	1756717.41	32.21
S07	5583357.94	1762212.58	2.69	5585478.71	1756717.40	32.21
S08	5583357.92	1762212.61	2.69	5585478.70	1756717.39	32.21
S09	5583357.91	1762212.61	2.68	5585478.70	1756717.40	32.21
S10	5583357.91	1762212.61	2.69	5585478.71	1756717.40	32.22
S11	5583357.92	1762212.59	2.69	5585478.71	1756717.38	32.23
Range	0.03	0.03	0.02	0.03	0.03	0.02

	Waiinu			Waverley		
Survey	Northing	Easting	Elevation	Northing	Easting	Elevation
S01		No data			No data	
S02	5585843.64	1749353.33	10.28	5589556.06	1739844.77	15.95
S03	5585843.63	1749353.34	10.27	5589556.04	1739844.77	15.95
S04	5585843.65	1749353.33	10.27	5589556.03	1739844.77	15.94
S05	5585843.63	1749353.33	10.28	5589556.05	1739844.78	15.95
S06	5585843.65	1749353.32	10.27	5589556.05	1739844.79	15.95
S07	5585843.64	1749353.33	10.27	5589556.04	1739844.78	15.96
S08	5585843.63	1749353.33	10.27	5589556.04	1739844.79	15.95
S09	5585843.65	1749353.34	10.27	5589556.04	1739844.78	15.95
S10	5585843.62	1749353.32	10.27	5589556.05	1739844.78	15.95
S11	5585843.63	1749353.33	10.27	5589556.04	1739844.77	15.95
Range	0.03	0.02	0.01	0.02	0.02	0.01

Table 3-10: Summary of survey control point data for Kai Iwi, Ototoka, Waiinu and Waverley.

	Patea			Manawapou		
Survey	Northing	Easting	Elevation	Northing	Easting	Elevation
S01		No data			No data	
S02	5596771.24	1727132.21	32.99	5609482.55	1715880.06	17.46
S03	5596771.25	1727132.21	32.98	5609482.56	1715880.05	17.45
S04	5596771.27	1727132.24	32.98	5609482.56	1715880.04	17.47
S05	5596771.24	1727132.21	32.98	5609482.56	1715880.05	17.47
S06	5596771.24	1727132.22	32.98	5609482.55	1715880.05	17.47
S07	5596771.23	1727132.20	32.98	5609482.57	1715880.07	17.47
S08	5596771.25	1727132.22	32.98	5609482.55	1715880.04	17.47
S09	5596771.23	1727132.23	32.98	5609482.55	1715880.05	17.47
S10	5596771.23	1727132.22	32.98	5609482.57	1715880.06	17.47
S11	5596771.22	1727132.21	32.98	5609482.56	1715880.05	17.47
Range	0.05	0.04	0.01	0.03	0.02	0.02

	Hawera			Ohawe		
Survey	Northing	Easting	Elevation	Northing	Easting	Elevation
S01		No data			No data	
S02	5615272.19	1706703.34	42.23		No data	
S03	5615272.17	1706703.36	42.25	5617461.82	1702638.12	13.07
S04	5615272.17	1706703.34	42.23	5617461.83	1702638.11	13.07
S05	5615272.17	1706703.34	42.23	5617461.81	1702638.11	13.08
S06	5615272.18	1706703.33	42.23	5617461.81	1702638.11	13.07
S07	5615272.17	1706703.34	42.23	5617461.81	1702638.12	13.08
S08	5615272.18	1706703.33	42.23	5617461.82	1702638.11	13.08
S09	5615272.18	1706703.33	42.25	5617461.83	1702638.12	13.06
S10	5615272.18	1706703.34	42.24	5617461.81	1702638.17	13.08
S11	5615272.17	1706703.39	42.25	5617461.82	1702638.14	13.09
Range	0.02	0.06	0.02	0.02	0.06	0.03

Table 3-11: Summary of survey control point data for Patea, Manawapou, Hawera and Ohawe.

The figures displaying the results of the surveyed profiles are shown at the end of this section. For each site a brief description is given about some of the observed changes in the profiles, for an in-depth analysis and discussion on the measured changes the reader is directed to Hume et al. (2012).

3.2.1 Kai Iwi

The measured beach profiles for the Kai Iwi site are shown in Figure 3-11 and Figure 3-12.

The beach profile data show a very active beach. The beach level fluctuates up and down 1.4 to 2.1 m, and the beach face shows excursions back and forth of about 35 m, as sand comes and goes in response to wave events. The S04 survey following a storm event showed erosion on all 4 profiles with the greatest erosion at profile 1 in the SE. Beach build-

up is evidenced in the profile record by swash bars coming ashore. Over the 11-month record the changes in the profiles suggest that a slug of sand (accretion) moved NW to SE (from profile 4 to profile 1) along the shore.

3.2.2 Ototoka

The measured beach profiles for the Ototoka site are shown in Figure 3-13 and Figure 3-14.

The beach profile data show a very active beach. The beach level fluctuates up and down 0.6 to 1.7 m, and the beach face shows excursions back and forth of about 29 m, as sand comes and goes in response to wave events. The S04 survey following a storm event showed erosion at profile 1 and accretion at profiles 2-4. Beach build-up is evidenced in the profile record as a result of swash bars coming ashore. Over the 11-month record the changes in profiles suggest that slugs of sand (accretion) moved west to east (from profile 4 in the NW to profile 1 in the SE) along the shore.

3.2.3 Waiinu

The measured beach profiles for the Waiinu site are shown in Figure 3-15 and Figure 3-16.

The beach profile data show a very active beach. The beach level fluctuates up and down 0.6 to 1.0 m, and the beach face shows excursions back and forth of about 22 m, as sand comes and goes in response to wave events. The S04 survey 2011 following a storm event showed only a small change at the 4 profile sites, with only minor erosion at profile 1 and minor accretion at profiles 2-4. Beach build-up is evidenced in the profile record as a result of swash bars coming ashore.

3.2.4 Waverley

The measured beach profiles for the Waverley site are shown in Figure 3-17 and Figure 3-18.

The beach profile data show a very active beach. The beach level fluctuates up and down 0.8 to 2.0 m, and the beach face shows excursions back and forth of about 16 m, as sand comes and goes in response to wave events. The S04 survey following a storm event showed accretion on profile 1 (in the SE), and erosion on profiles 2, 3 and 4. Over the 11 month record profiles 1 and 3 showed net erosion, while profiles 2 and 4 showed net accretion. Beach build-up is evidenced in the profile record as a result of swash bars coming ashore.

3.2.5 Patea

The measured beach profiles for the Patea site are shown in Figure 3-19 and Figure 3-20.

The beach profile data show a very active beach. The beach level fluctuates up and down 0.8 to 2.0 m, and the beach face shows excursions back and forth of about 22 m, as sand comes and goes in response to wave events. The S04 survey following a storm event showed a quite different beach response to the event at the 4 profile sites. While the beach built-up on profile 1 in the SE, erosion became progressively more severe along profiles 2, 3 and 4 (to the NW).

3.2.6 Manawapou

The measured beach profiles for the Manawapou site are shown in Figure 3-21 and Figure 3-22.

The beach profile data show a very active beach. The beach level fluctuates up and down 0.6 to 1.8 m, and the beach face shows excursions back and forth of about 12 m, as sand comes and goes in response to wave events. The S04 survey following a storm event showed quite different amounts of erosion on profiles 2-4 and a slight net build-up of sand on profile 1. Over the 11-month record profiles 1, 2 and 4 showed net accretion (with profile 1 showing substantial accretion), while profile 3 showed only minor net erosion.

3.2.7 Hawera

The measured beach profiles for the Hawera site are shown in Figure 3-23 and Figure 3-24.

The beach profile data show a very active beach. The beach level fluctuates up and down 0.4 to 1.2 m, and the beach face shows excursions back and forth of about 8 m, as sand comes and goes in response to wave events. The S04 survey following a storm event showed erosion on profile 1, accretion on profiles 2 and 3, while profile 4 was neutral. Over the 11-month record profile 1 showed net accretion while profiles 2-4 showed net erosion.

3.2.8 Ohawe

The measured beach profiles for the Ohawe site are shown in Figure 3-25 and Figure 3-26.

The beach profile data show a very active beach. The beach level fluctuates up and down 0.8 to 1.4 m, and the beach face shows excursions back and forth of about 13 m, as sand comes and goes in response to wave events. The S04 survey following a storm event resulted in a small amount of erosion on all 4 profiles. Beach build-up is evidenced in the profile record as a result of large swash bars coming ashore. Over the 11-month record the outer (profiles 1 and 4) profiles showed net erosion, while the inner two profiles (profiles 2 and 3) showed net accretion.

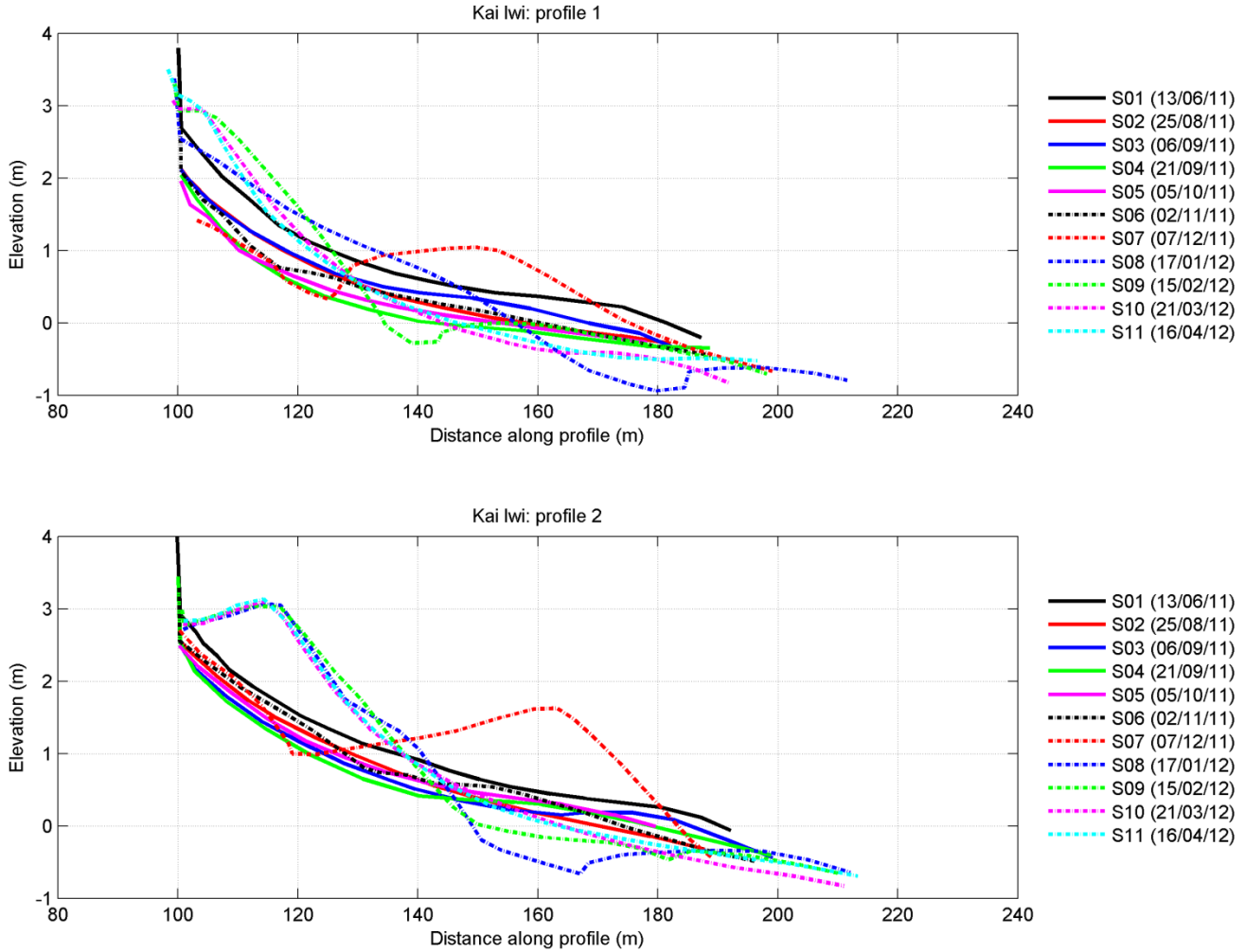

Figure 3-11: Kai Iwi profiles 1 and 2.

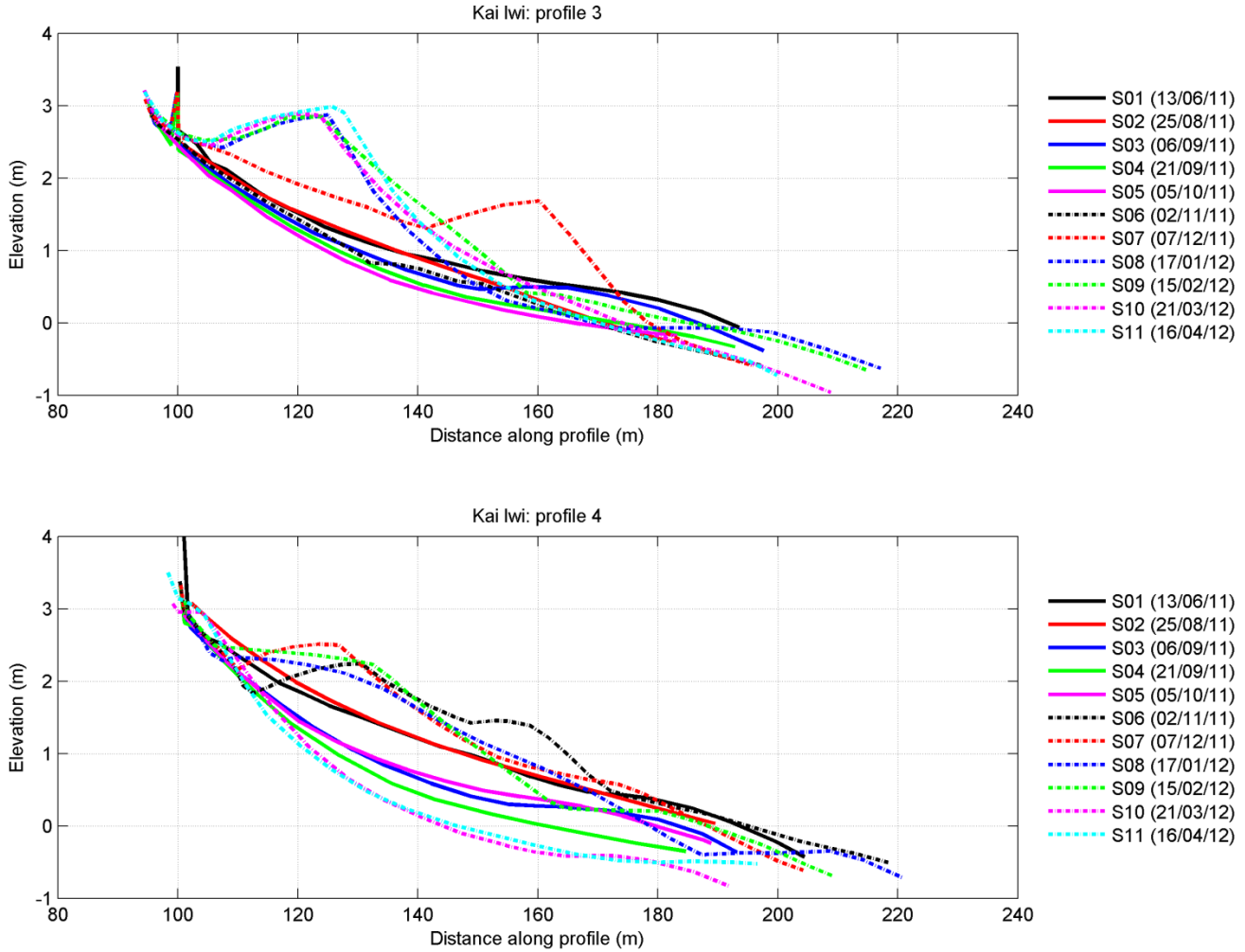

Figure 3-12: Kai Iwi profiles 3 and 4.

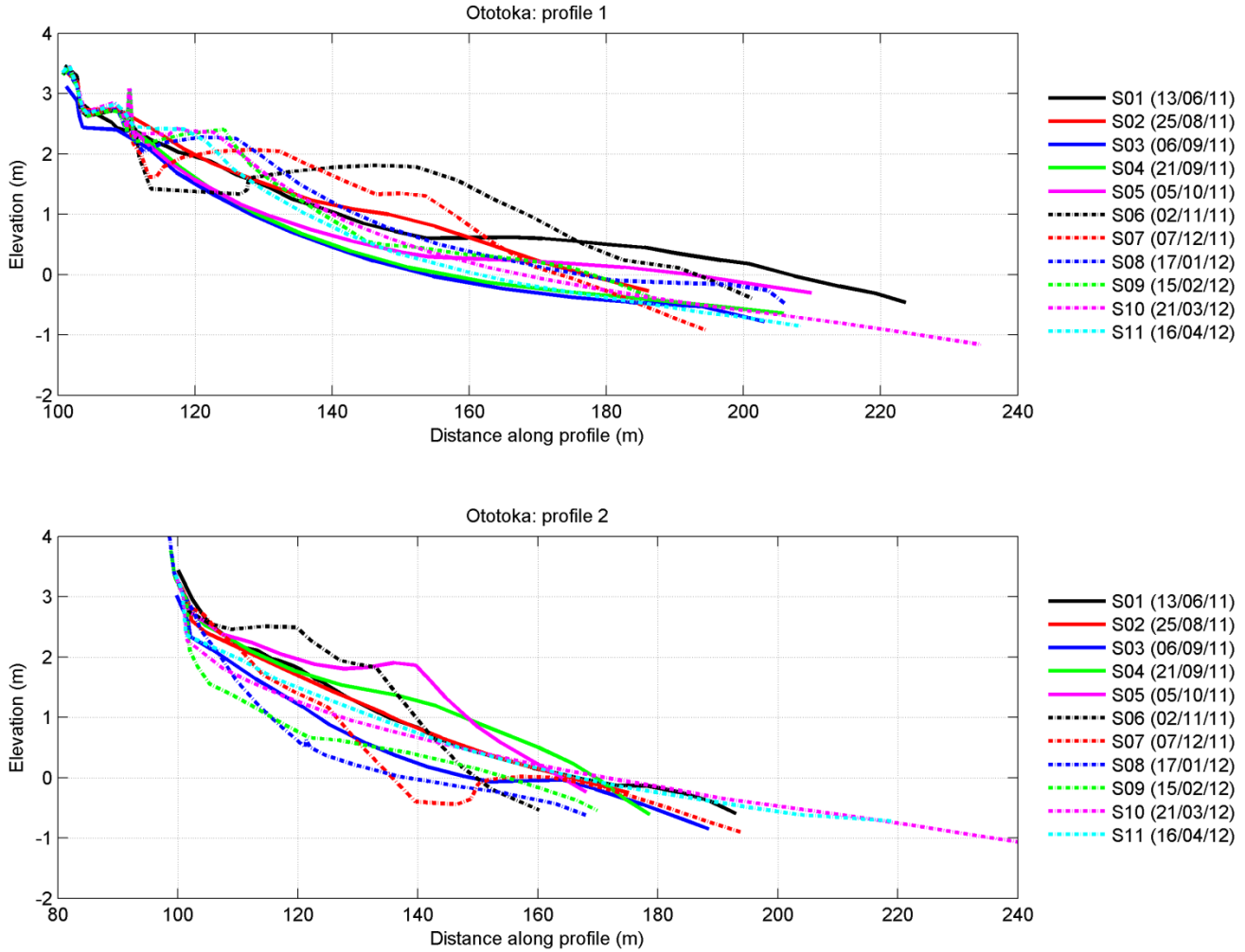

Figure 3-13: Ototoka profiles 1 and 2.

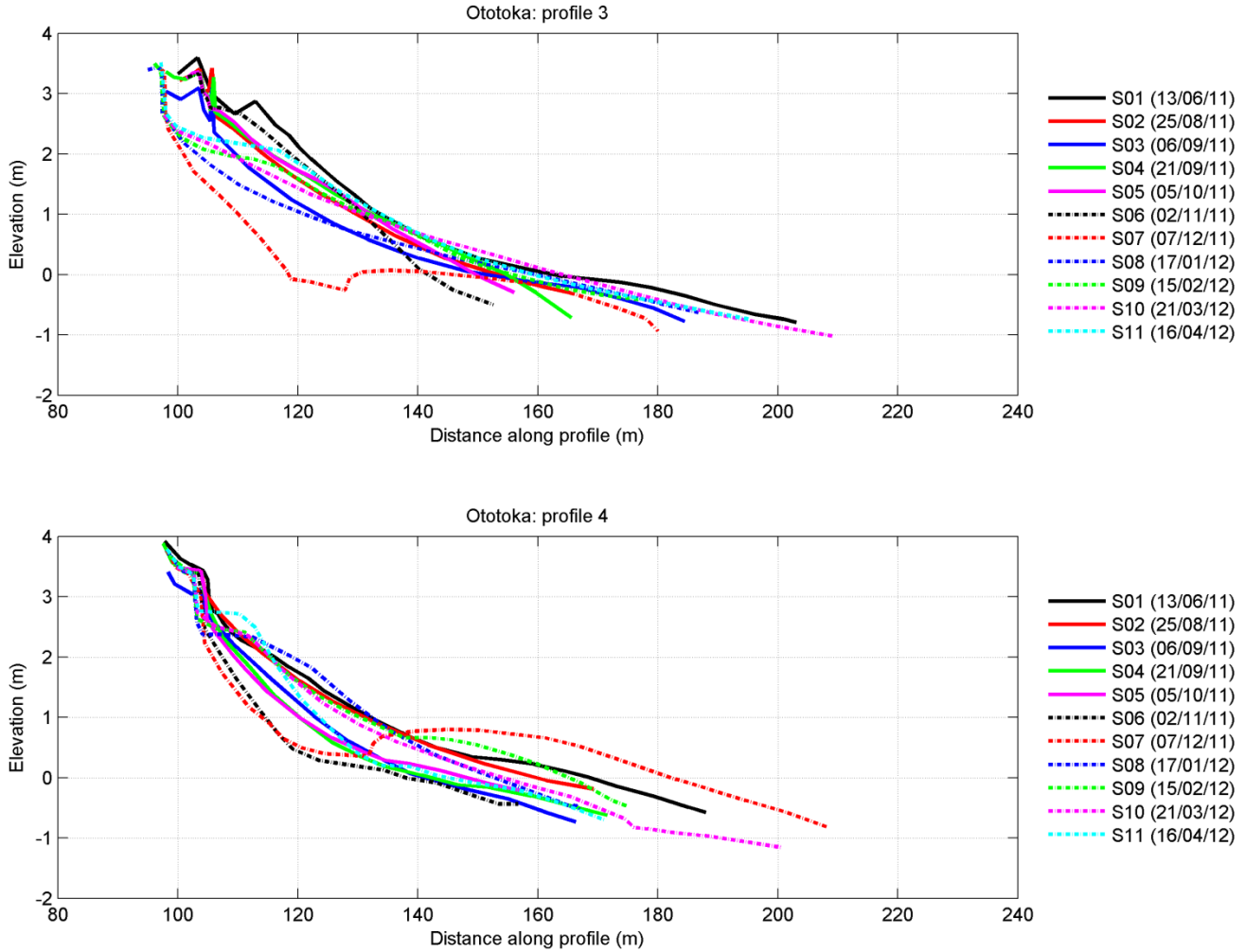

Figure 3-14: Ototoka profiles 3 and 4.

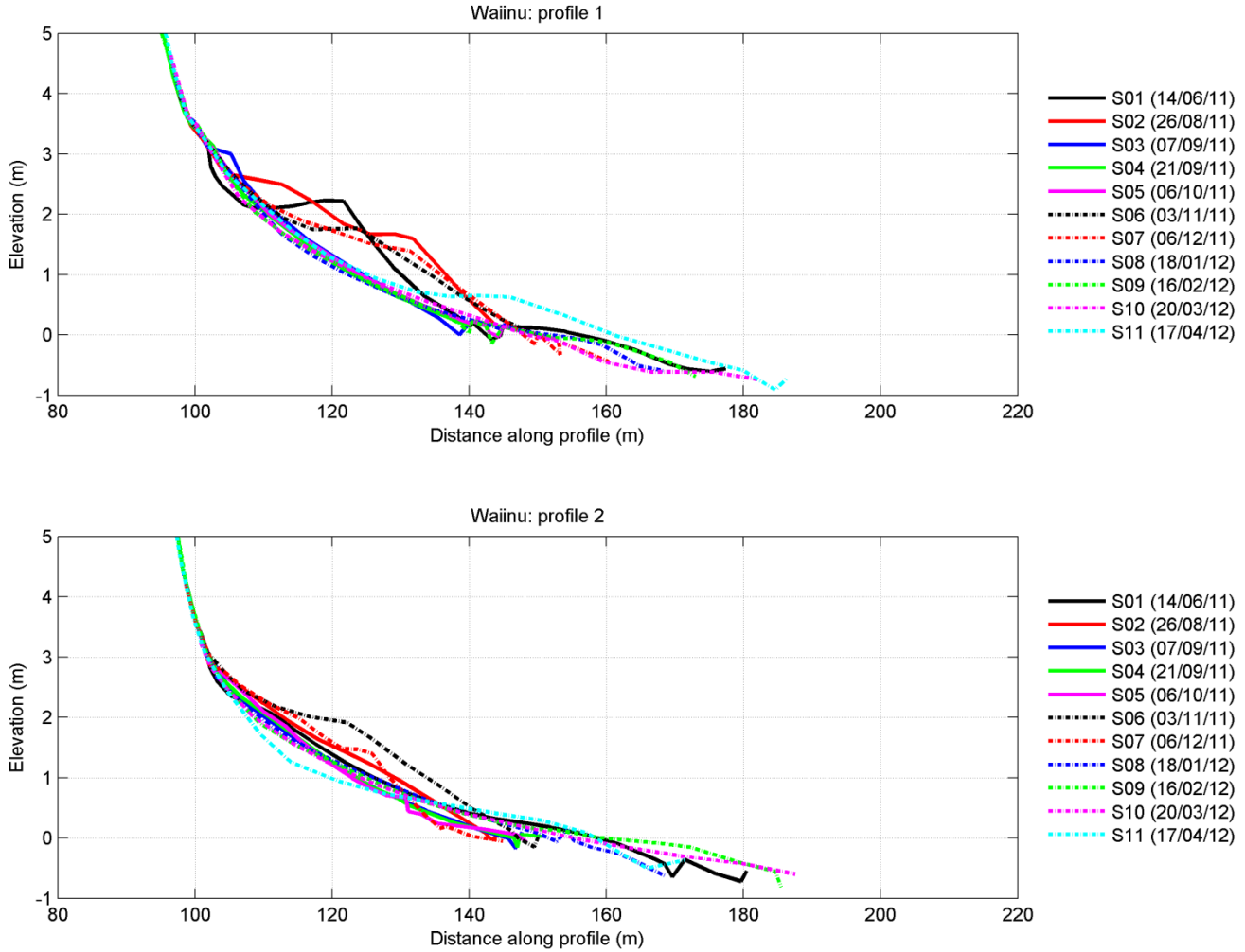

Figure 3-15: Waiinu profiles 1 and 2.

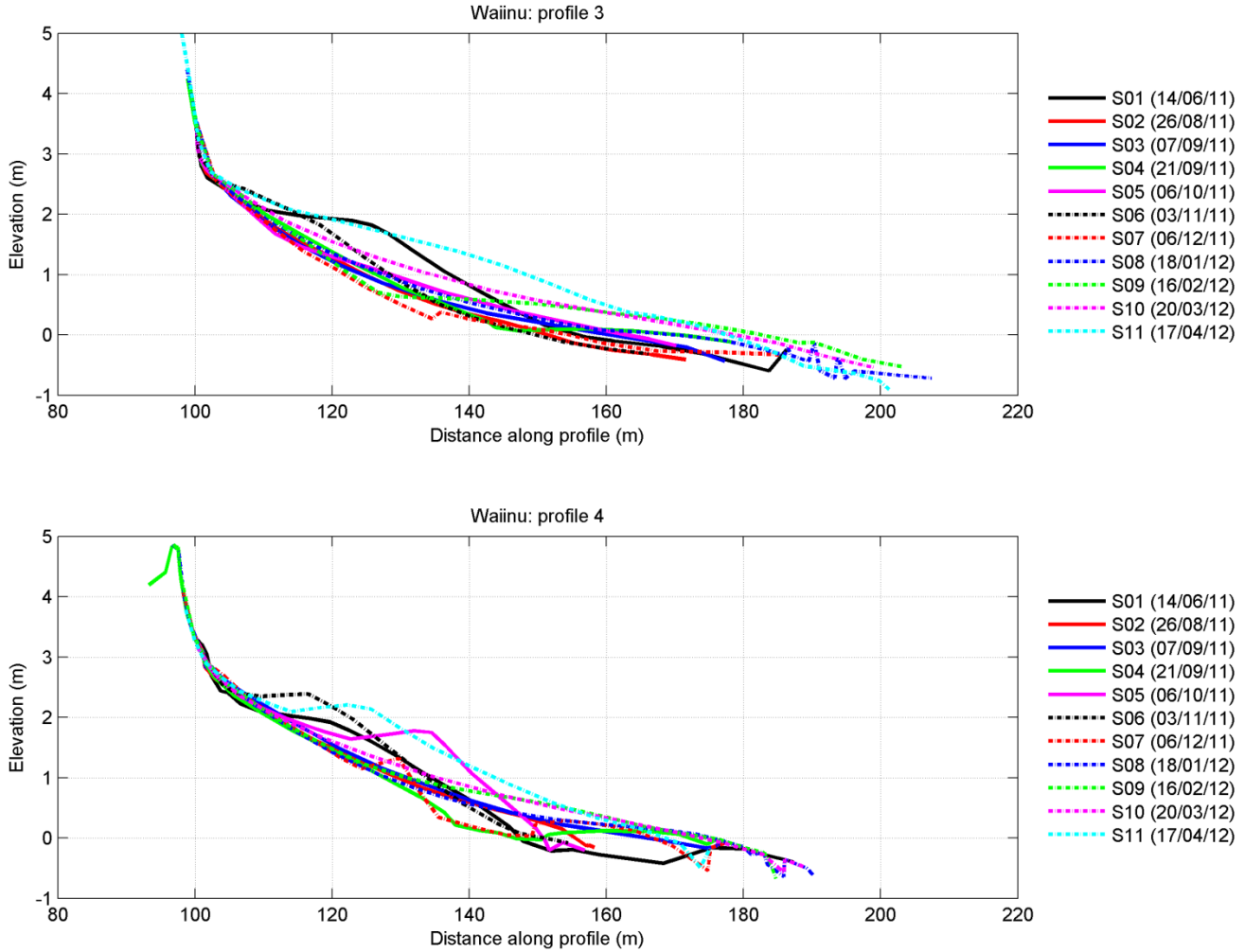

Figure 3-16: Waiinu profiles 3 and 4.

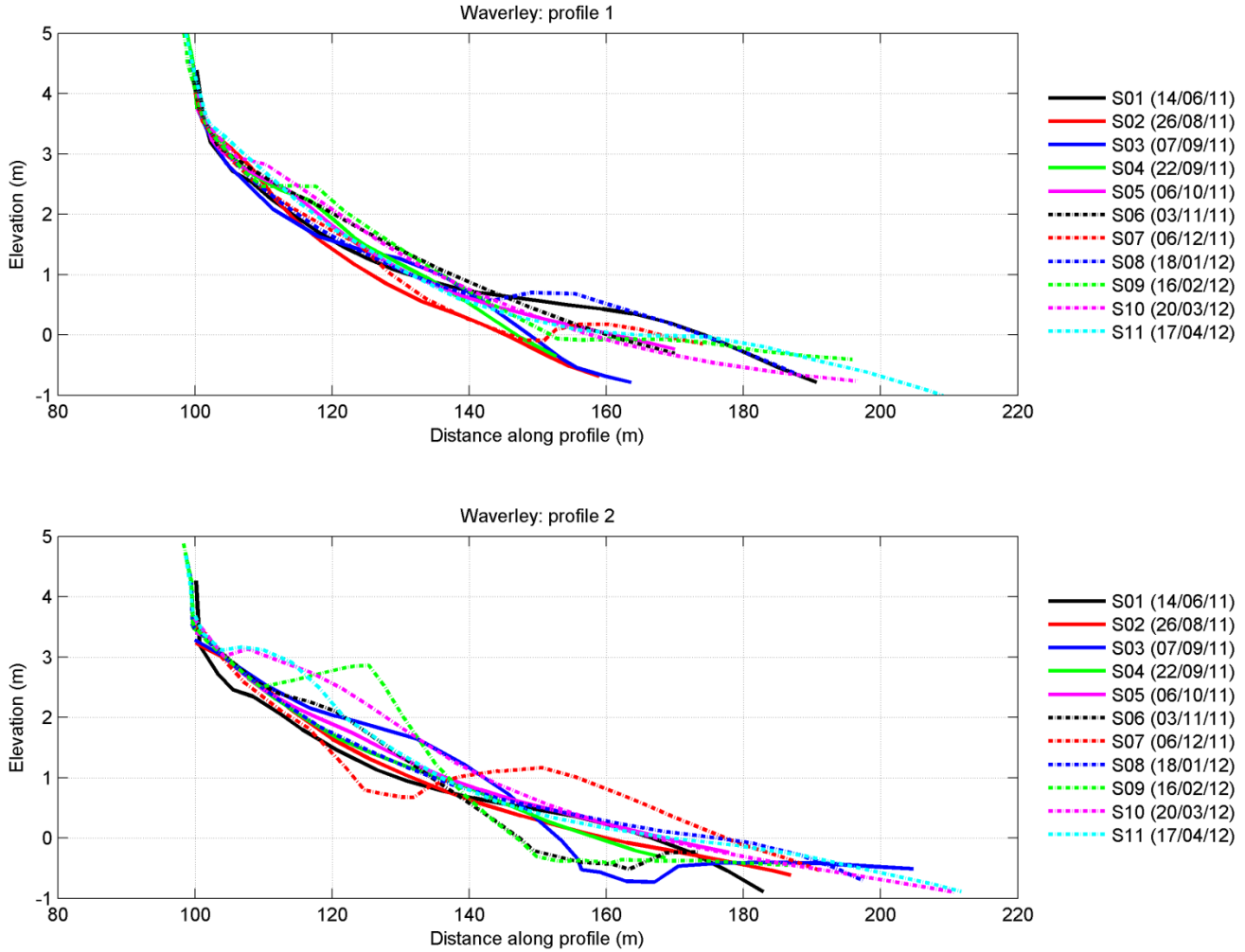

Figure 3-17: Waverley profiles 1 and 2.

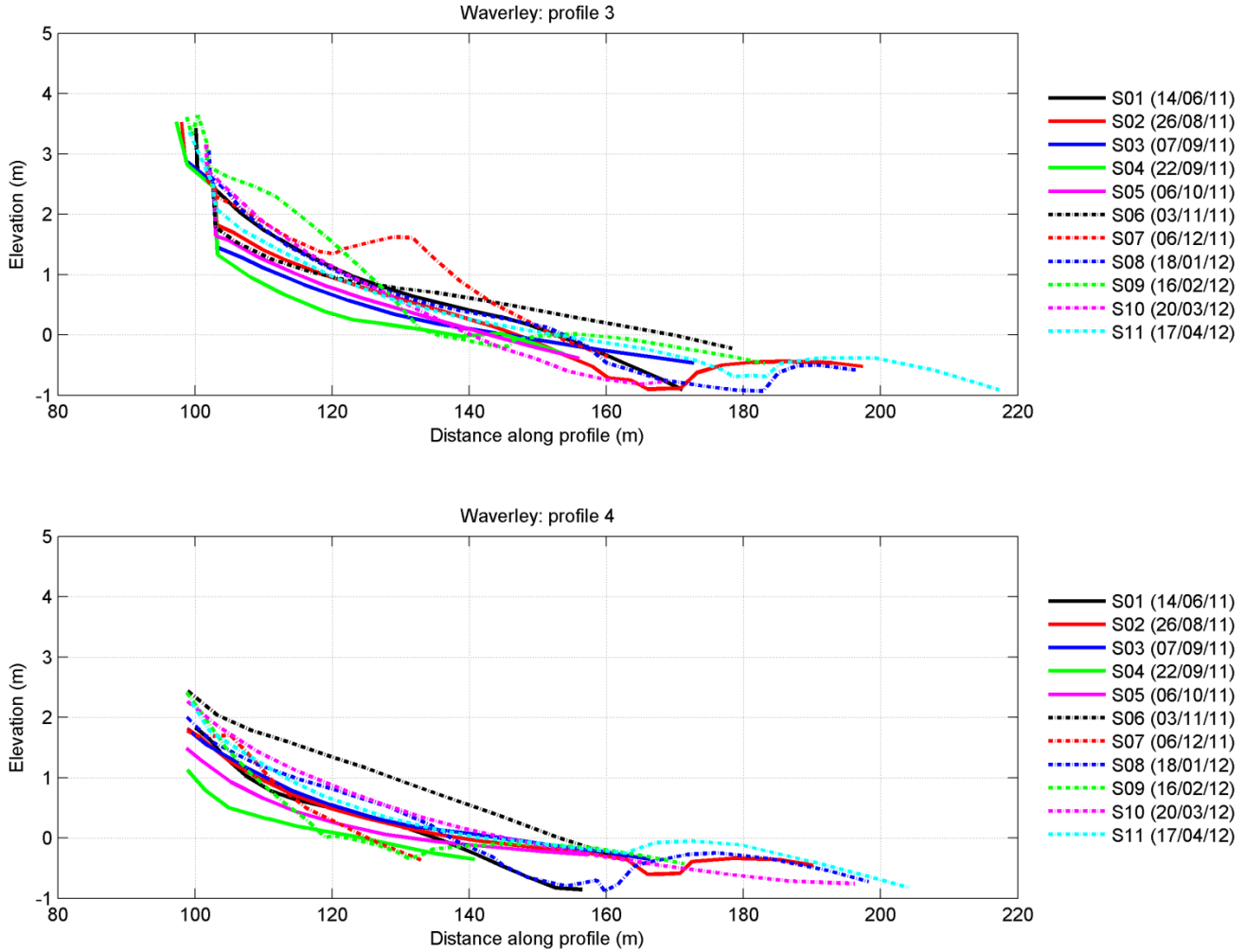

Figure 3-18: Waverley profiles 3 and 4.

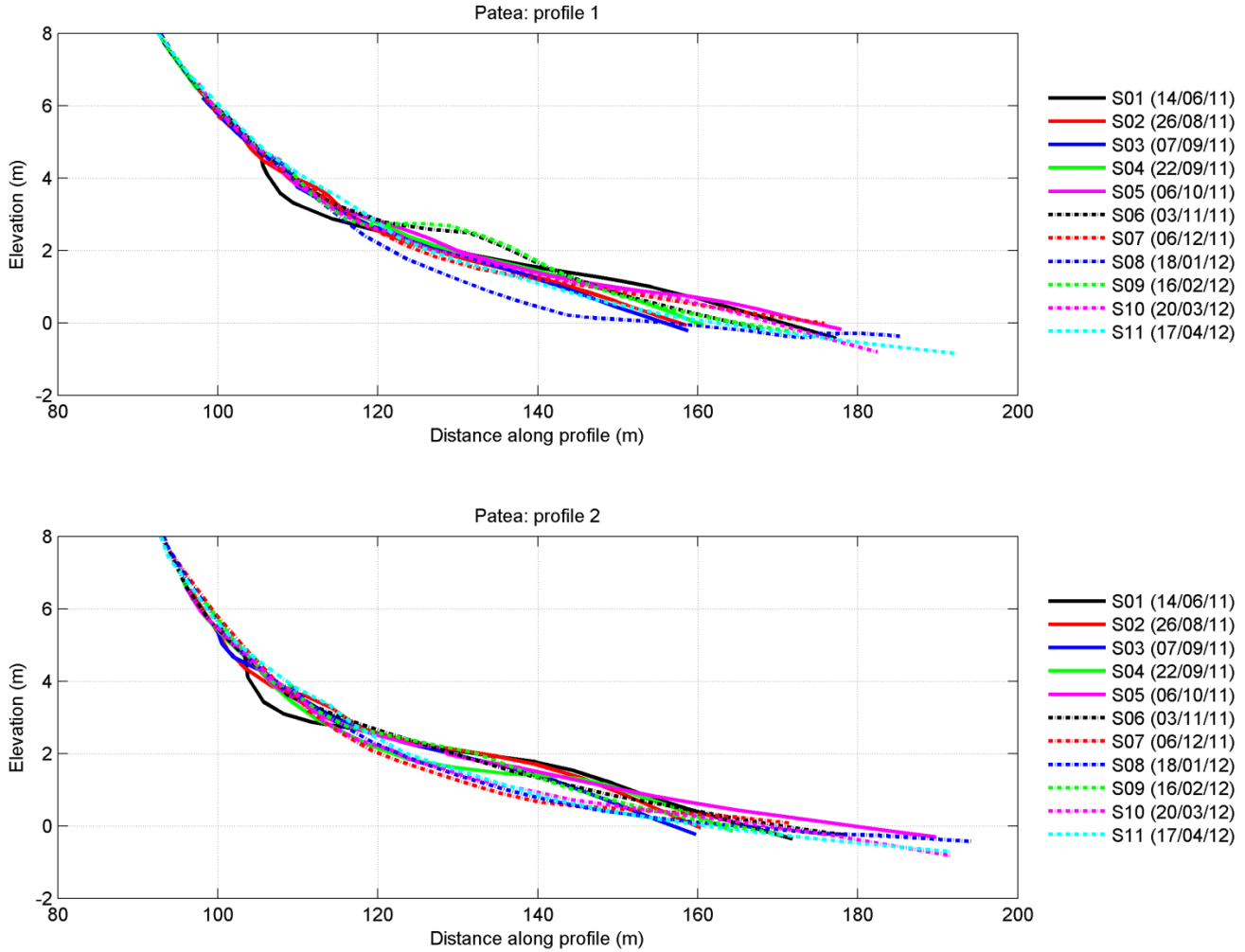

Figure 3-19: Patea profiles 1 and 2.

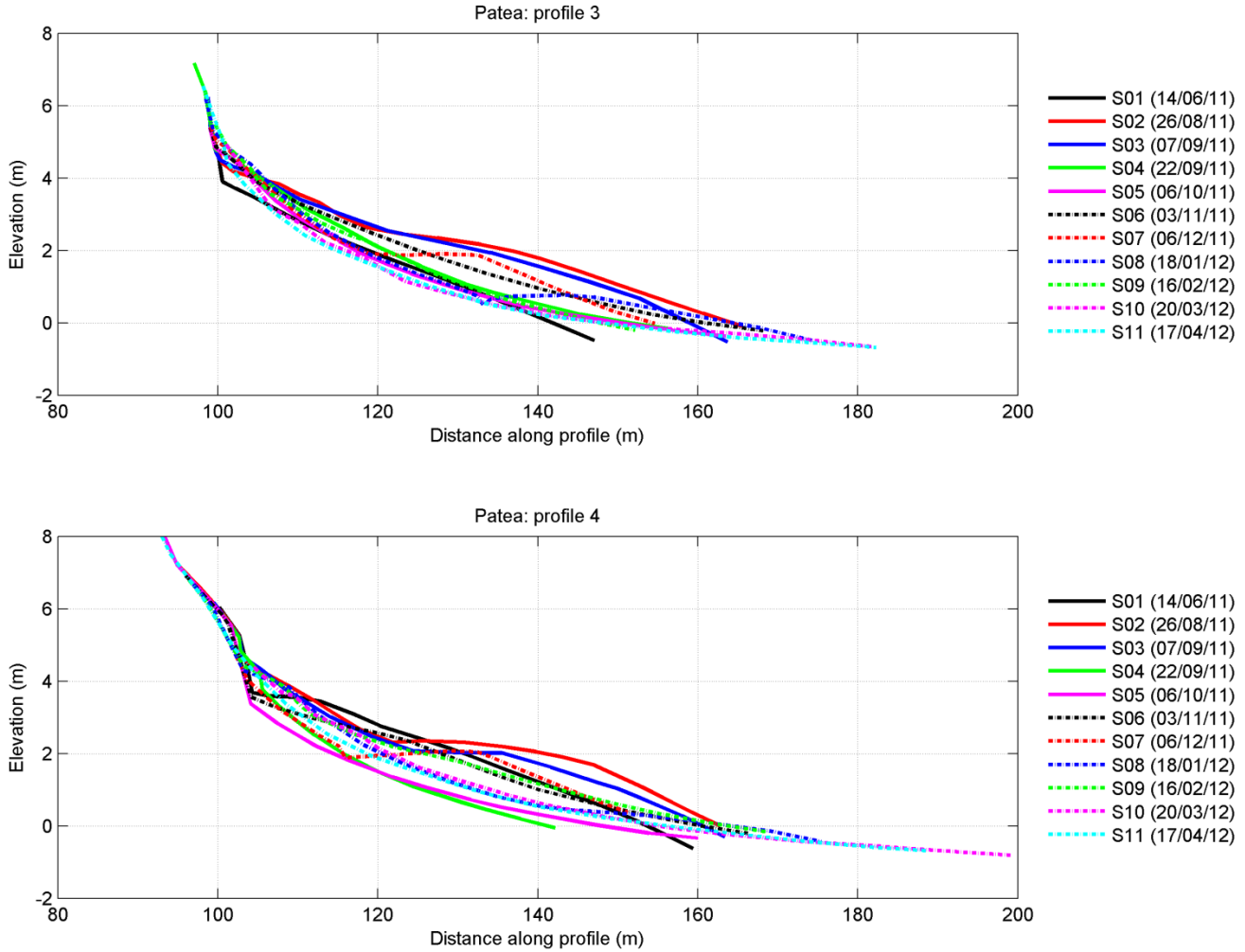

Figure 3-20: Patea profiles 3 and 4.

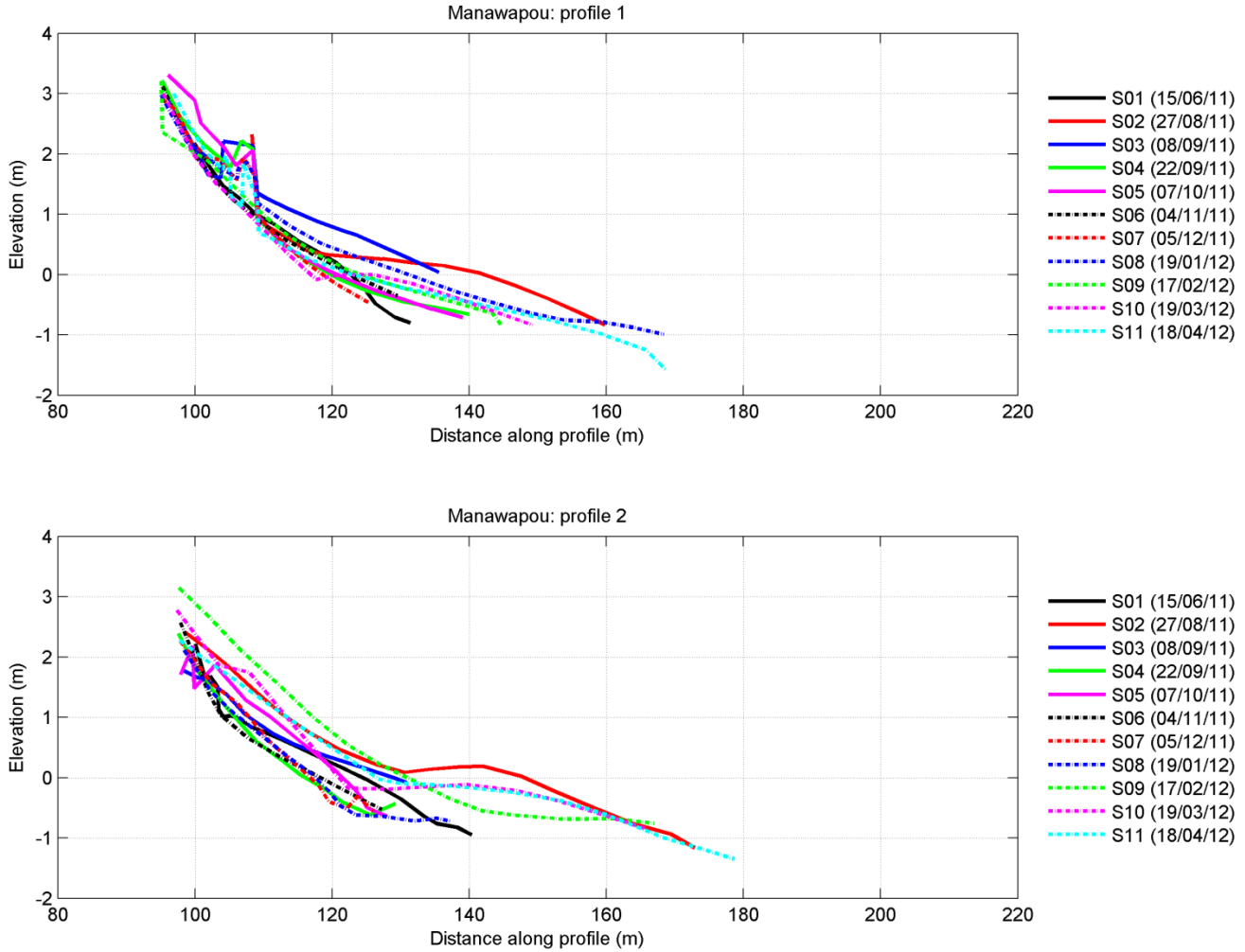

Figure 3-21: Manawapou profiles 1 and 2.

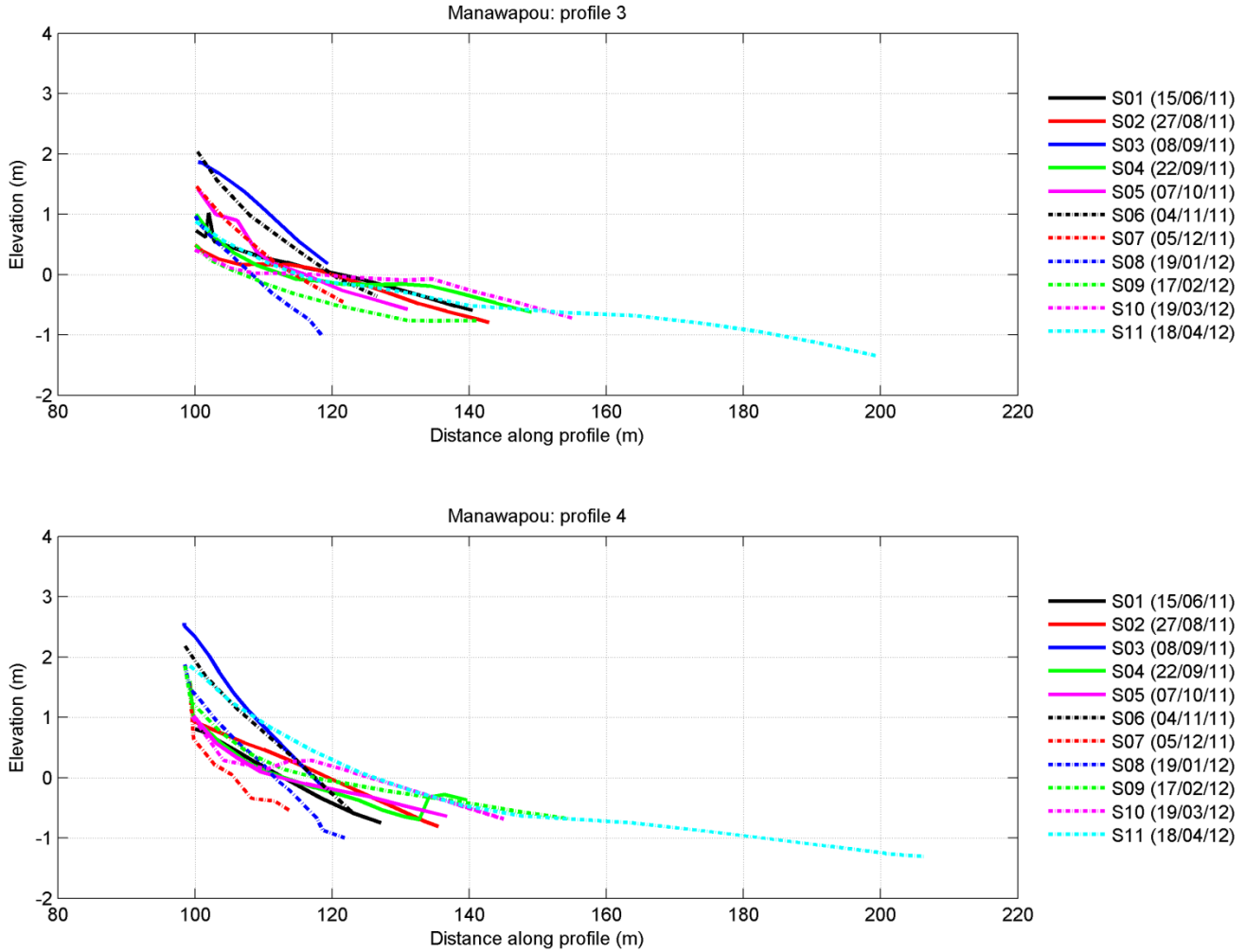

Figure 3-22: Manawapou profiles 3 and 4.

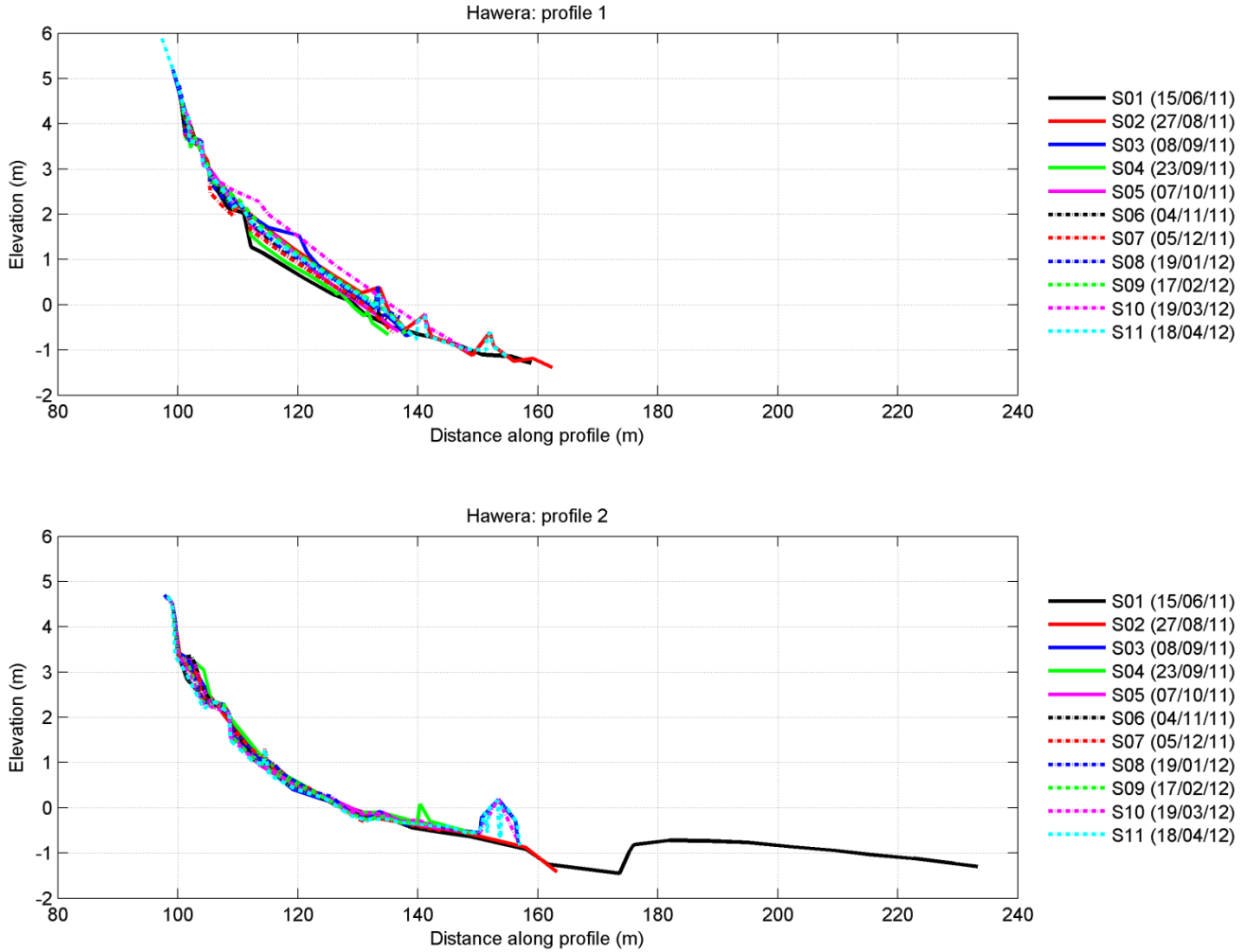

Figure 3-23: Hawera profiles 1 and 2.

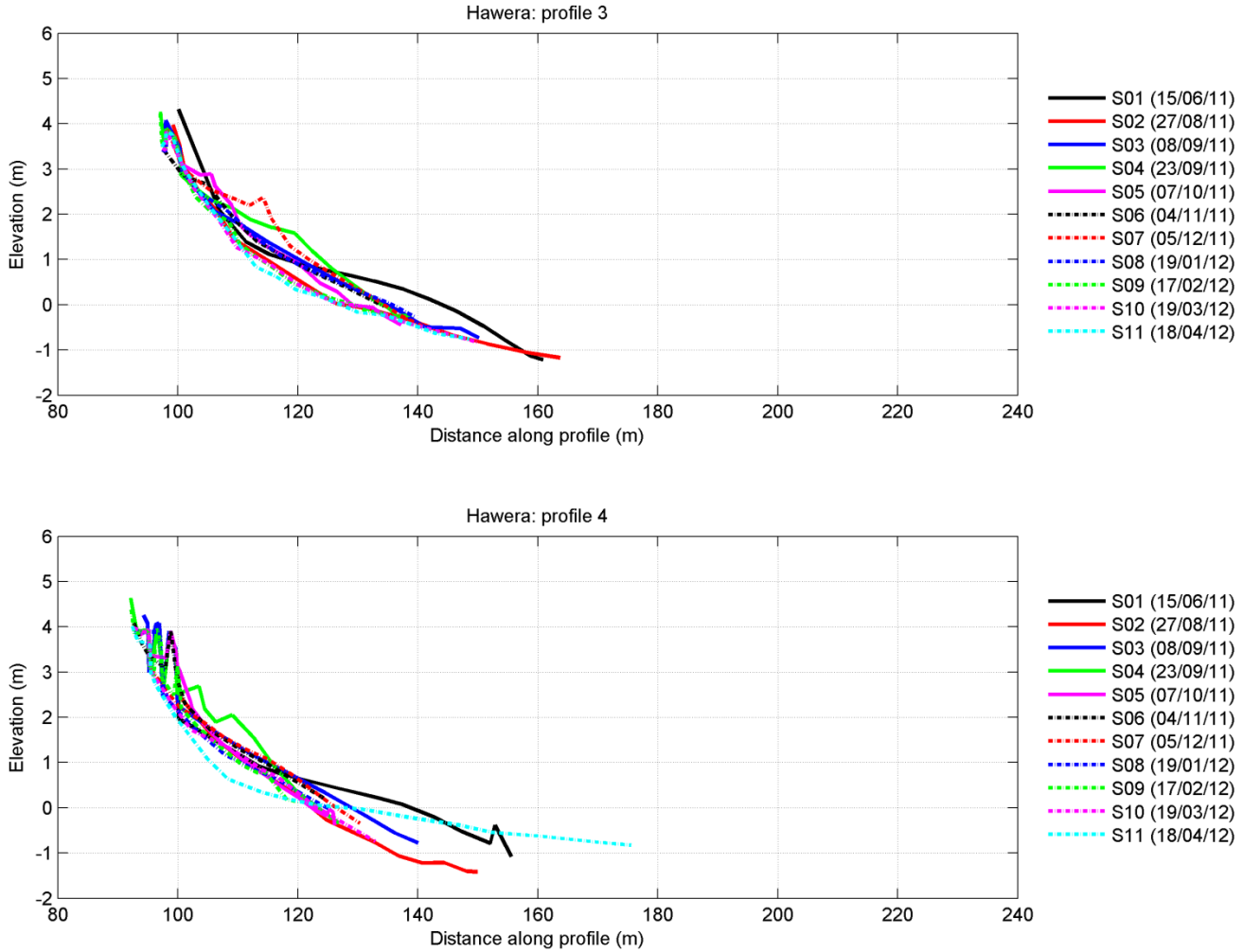

Figure 3-24: Hawera profiles 3 and 4.

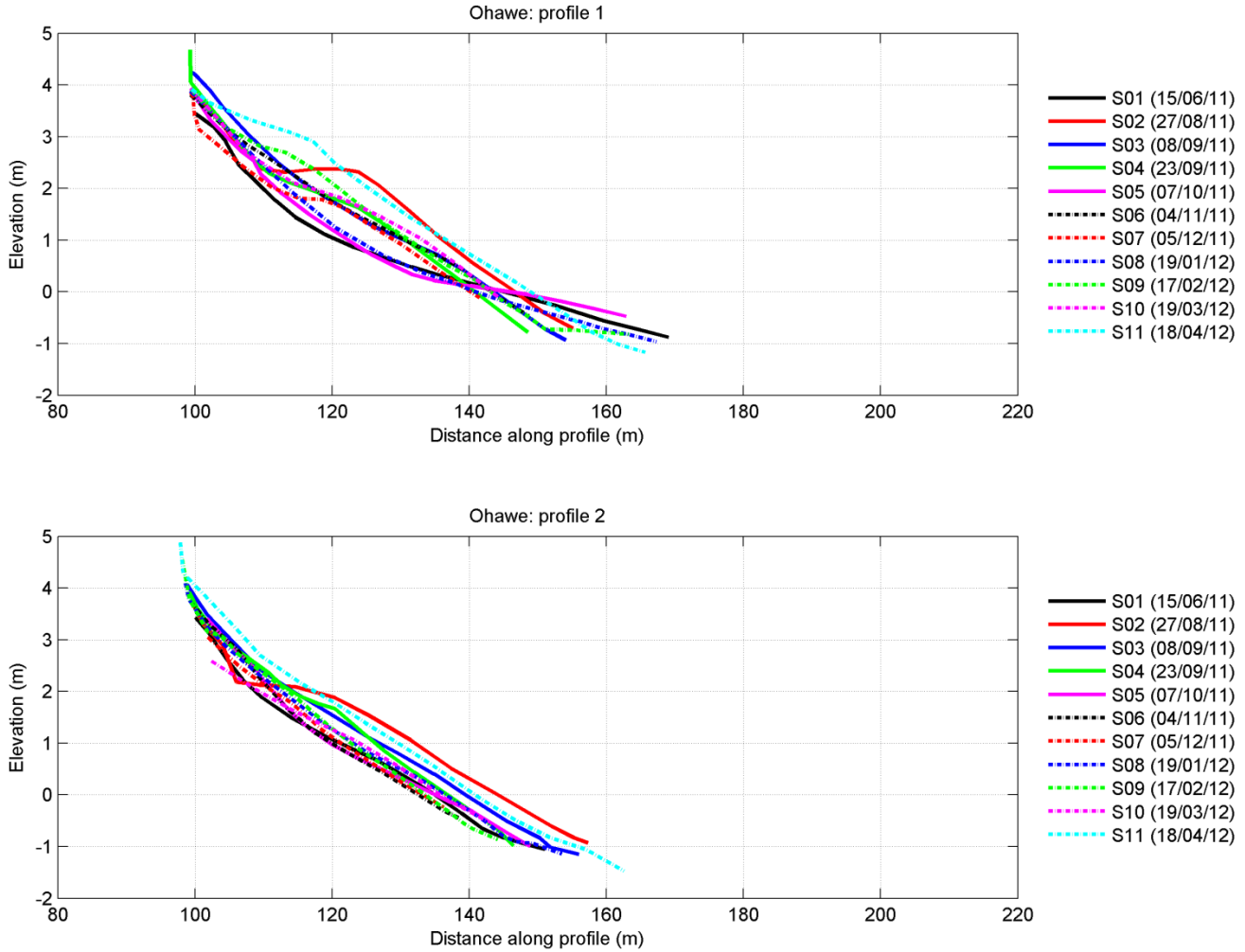

Figure 3-25: Ohawe profiles 1 and 2.

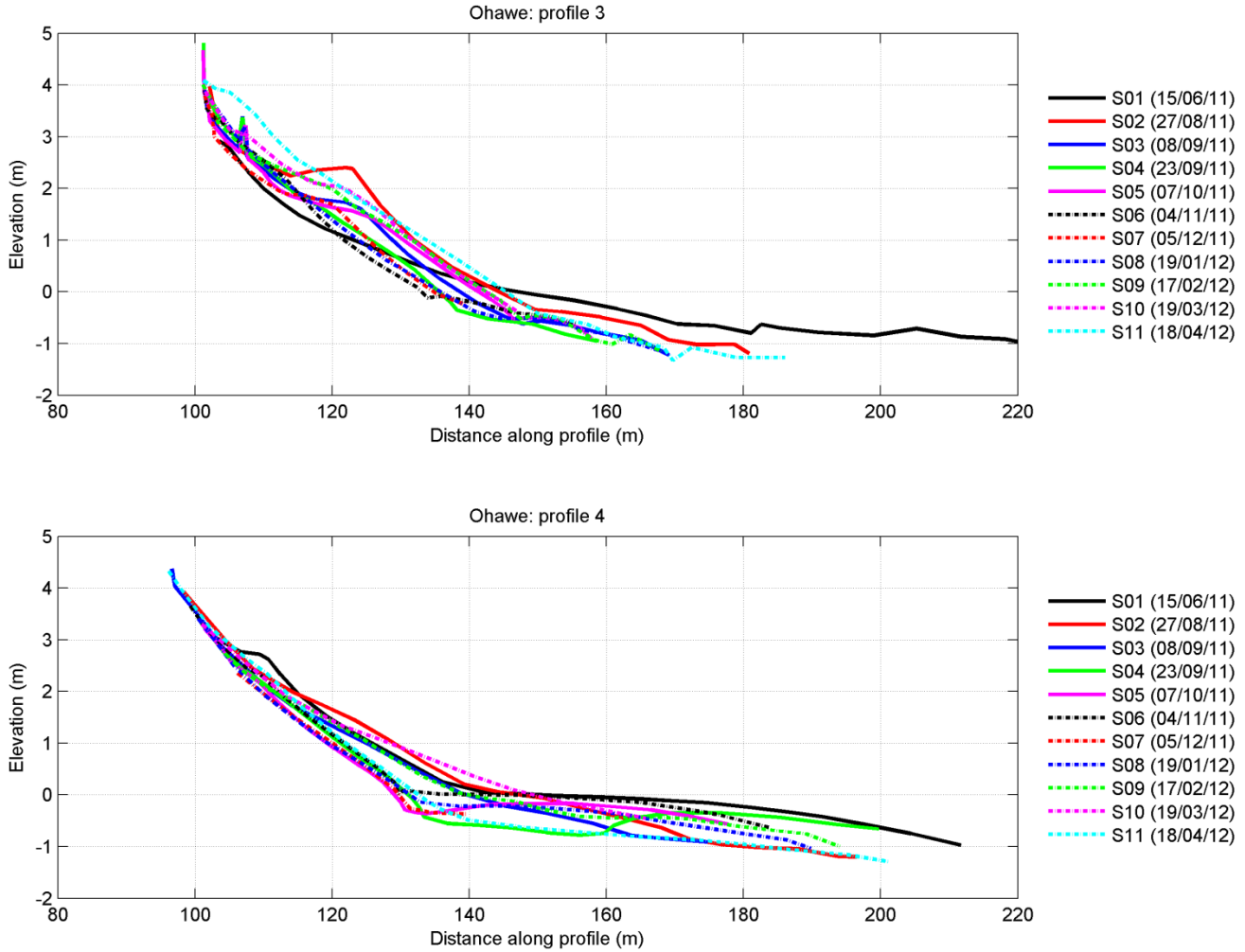

Figure 3-26: Ohawe profiles 3 and 4.

3.3 Beach sediments

The GRADISTAT results for the granulometric classifications and descriptions for the surface beach sediments for the 8 sites are shown in Table 3-13 and Table 3-14. The size fraction data is reported in Table 3-15 and Table 3-16. Plots of the particle size distributions are shown in Figure C-1 to Figure C-8 in Appendix B.

The particle size data indicates the majority of the surface sediments to be either moderately-sorted-slightly-gravelly sand or poorly-sorted-gravelly sand. At some sites there are significant differences in sediment characteristics between profiles (e.g., compare Ototoka profile 1 with profiles 2, 3 and 4).

Typically, gravel contents were less than 10%, a notable exception to this was at Hawera which had gravel contents at all 4 profiles in excess of 20%.

3.4 Data storage

All data used to generate the tables and figures presented in this report are stored on NIWA's secure projects drive (see Table 3-12 for details).

Data type	Site	Directory and filename
Profile data (all surveys)	Kai Iwi	O:\TTR11201\Final\Shoreline\data\Profile Data Kai Iwi.xlsx
Profile data (all surveys)	Ototoka	O:\TTR11201\Final\Shoreline\data\Profile Data Ototoka.xlsx
Profile data (all surveys)	Waiinu	O:\TTR11201\Final\Shoreline\data\Profile Data Waiinu.xlsx
Profile data (all surveys)	Waverley	O:\TTR11201\Final\Shoreline\data\Profile Data Waverley.xlsx
Profile data (all surveys)	Patea	O:\TTR11201\Final\Shoreline\data\Profile Data Patea.xlsx
Profile data (all surveys)	Manawapou	O:\TTR11201\Final\Shoreline\data\Profile Data Manawapou.xlsx
Profile data (all surveys)	Hawera	O:\TTR11201\Final\Shoreline\data\Profile Data Hawera.xlsx
Profile data (all surveys)	Ohawe	O:\TTR11201\Final\Shoreline\data\Profile Data Ohawe.xlsx
Survey dates and times	All sites	O:\TTR11201\Final\Shoreline\data\Survey dates and times.xlsx
Survey control points	All sites	O:\TTR11201\Final\Shoreline\data\Survey control points.xlsx
Profile positions and benchmarks	All sites	O:\TTR11201\Final\Shoreline\data\Beach profile information.xlsx
Particle size distributions	All sites	O:\TTR11201\Final\Shoreline\data\Beach profile PSDs.xlsx

Table 3-12: Data storage.

Site	Profile	Sediment type	Textural group	Sediment Name	Mean (µm)	Sorting (µm)	Skewness (µm)
Kai Iwi	1	Unimodal, Moderately Well Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	393.5	519.1	8.5
Kai Iwi	2	Unimodal, Poorly Sorted	Gravelly Sand	Fine Gravelly Medium Sand	629.9	948.4	4.3
Kai Iwi	3	Unimodal, Poorly Sorted	Gravelly Sand	Fine Gravelly Coarse Sand	690.5	781.0	4.8
Kai Iwi	4	Unimodal, Poorly Sorted	Gravelly Sand	Fine Gravelly Coarse Sand	809.9	1043.1	3.8
Ototoka	1	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	466.5	375.6	3.5
Ototoka	2	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	590.5	634.6	4.7
Ototoka	3	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	429.8	377.0	4.7
Ototoka	4	Unimodal, Poorly Sorted	Sandy Gravel	Sandy Fine Gravel	1431.2	1702.5	1.7
Waiinu	1	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	573.8	335.9	1.7
Waiinu	2	Unimodal, Poorly Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Coarse Sand	782.6	554.7	2.8
Waiinu	3	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	537.2	306.4	4.3
Waiinu	4	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Fine Gravelly Medium Sand	468.6	267.3	5.6
Waverley	1	Unimodal, Moderately Well Sorted	Sand	Moderately Well Sorted Medium Sand	304.9	101.1	0.4
Waverley	2	Unimodal, Poorly Sorted	Gravelly Sand	Very Fine Gravelly Medium Sand	732.2	879.6	3.9
Waverley	3	Unimodal, Poorly Sorted	Gravelly Sand	Fine Gravelly Medium Sand	774.4	1069.4	3.5
Waverley	4	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	463.0	330.2	5.5

Table 3-13: Summary of GRADISAT granulometric results for Kai Iwi, Ototoka, Waiinu and Waverly profiles.

Site	Profile	Sediment type	Textural group	Sediment Name	Mean (µm)	Sorting (µm)	Skewness (µm)
Patea	1	Bimodal, Poorly Sorted	Gravelly Sand	Very Fine Gravelly Medium Sand	1342.6	1718.5	1.8
Patea	2	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Coarse Sand	580.8	259.9	2.7
Patea	3	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	475.7	325.3	5.8
Patea	4	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	477.2	269.5	2.8
Manawapou	1	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	489.1	304.4	7.9
Manawapou	2	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Fine Gravelly Coarse Sand	605.9	489.9	6.2
Manawapou	3	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	691.7	810.2	4.6
Manawapou	4	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Fine Gravelly Medium Sand	634.9	871.9	4.9
Hawera	1	Unimodal, Poorly Sorted	Gravelly Sand	Fine Gravelly Coarse Sand	1197.9	1418.0	2.3
Hawera	2	Unimodal, Poorly Sorted	Gravelly Sand	Fine Gravelly Coarse Sand	1395.4	1454.5	2.0
Hawera	3	Bimodal, Poorly Sorted	Gravelly Sand	Fine Gravelly Medium Sand	1443.0	1818.5	1.7
Hawera	4	Bimodal, Poorly Sorted	Sandy Gravel	Sandy Very Fine Gravel	1780.8	1674.2	0.8
Ohawe	1	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	435.8	400.3	7.4
Ohawe	2	Unimodal, Poorly Sorted	Gravelly Sand	Very Fine Gravelly Medium Sand	790.3	987.3	3.8
Ohawe	3	Unimodal, Poorly Sorted	Gravelly Sand	Fine Gravelly Medium Sand	1124.4	1504.1	2.3
Ohawe	4	Unimodal, Moderately Sorted	Slightly Gravelly Sand	Slightly Very Fine Gravelly Medium Sand	512.0	630.4	5.8

Table 3-14: Summary of GRADISTAT granulometric results for Patea, Manawapou, Hawera and Ohawe profiles..

Site	Profile	% Gravel:	% Sand:	% Fine Gravel:	% V Fine Gravel:	% V Coarse Sand:	% Coarse Sand:	% Medium Sand:	% Fine Sand:	% V Fine Sand:
Kai Iwi	1	1%	99%	1%	1%	1%	4%	63%	28%	3%
Kai Iwi	2	10%	90%	7%	3%	4%	17%	49%	18%	2%
Kai Iwi	3	6%	94%	3%	2%	5%	41%	38%	10%	1%
Kai Iwi	4	6%	94%	3%	3%	9%	37%	29%	18%	1%
Ototoka	1	1%	99%	0%	1%	3%	23%	44%	27%	2%
Ototoka	2	3%	97%	1%	2%	6%	23%	52%	16%	1%
Ototoka	3	1%	99%	0%	1%	3%	14%	53%	26%	3%
Ototoka	4	33%	67%	19%	14%	14%	21%	24%	8%	0%
Waiinu	1	0%	100%	0%	0%	6%	40%	41%	12%	1%
Waiinu	2	2%	98%	0%	2%	19%	45%	23%	11%	1%
Waiinu	3	0%	100%	0%	0%	3%	39%	47%	10%	1%
Waiinu	4	0%	100%	0%	0%	1%	32%	47%	19%	1%
Waverley	1	0%	100%	0%	0%	0%	0%	63%	34%	3%
Waverley	2	5%	95%	2%	4%	9%	28%	39%	17%	1%
Waverley	3	10%	90%	5%	5%	7%	22%	47%	12%	2%
Waverley	4	0%	100%	0%	0%	3%	20%	58%	17%	1%
Patea	1	22%	78%	10%	12%	9%	13%	45%	10%	0%
Patea	2	0%	100%	0%	0%	1%	54%	35%	9%	0%
Patea	3	0%	100%	0%	0%	2%	28%	50%	19%	1%
Patea	4	0%	100%	0%	0%	2%	29%	54%	15%	1%
Manawapou	1	0%	100%	0%	0%	1%	29%	60%	10%	0%
Manawapou	2	2%	98%	1%	1%	3%	46%	39%	10%	0%
Manawapou	3	5%	95%	2%	3%	5%	36%	41%	12%	1%
Manawapou	4	4%	96%	2%	2%	4%	25%	51%	16%	0%

Table 3-15: Summary of size fraction information for Kai Iwi, Ototoka, Waiinu, Waverley, Patea and Manawapou profiles.

Site	Profile	% Gravel:	% Sand:	% Fine Gravel:	% V Fine Gravel:	% V Coarse Sand:	% Coarse Sand:	% Medium Sand:	% Fine Sand:	% V Fine Sand:
Hawera	1	21%	79%	12%	10%	15%	31%	28%	4%	0%
Hawera	2	28%	72%	16%	11%	26%	30%	15%	1%	0%
Hawera	3	30%	70%	23%	7%	17%	23%	26%	4%	0%
Hawera	4	66%	34%	29%	36%	14%	7%	8%	5%	1%
Ohawe	1	1%	99%	0%	1%	2%	16%	56%	23%	2%
Ohawe	2	6%	94%	2%	3%	9%	32%	37%	14%	1%
Ohawe	3	16%	84%	8%	8%	13%	18%	36%	15%	1%
Ohawe	4	2%	98%	1%	1%	4%	18%	49%	25%	2%

Table 3-16: Summary of size fraction information for Hawera and Ohawe profiles.

4 Summary

A network of 32 beach profiles at 8 sites was established to monitor the shoreline stability along the South Taranaki Bight from Kai Iwi to Ohawe. The sites were selected as lying landward of potential offshore mining sites, away from rivers and headlands which may influence beach processes locally and where there was public access to the beach.

This report describes the criteria for the selection of the 8 sites, along with a detailed description of the methodology used in measuring the beach profiles. The report also presents the results from 11 surveys that measured 352 profiles (100% data capture) over an 11 month period from June 2011 to April 2012. One of the 11 surveys (survey S04) was carried out immediately after a storm. The relative accuracy of the survey data was at worst deemed to be around 6 cm in the horizontal and 3 cm in the vertical. This level of accuracy is more than sufficient for the purposes of measuring changes in beach profiles. The beach profiles show that the shoreline along the STB is very dynamic, with large changes in the beach profiles occurring at nearly all of the 32 profiling sites. At 6 of the 8 sites, there is little accommodation space for beach sand which appears to form a veneer only several meters thick over the rocky shore platform left by the retreating cliff line. Very high tides and waves reach right to the top of the beach and the toe of the cliffs, thus there is no space for sand dunes to build out of the reach of waves. Given the limited storage, potentially a large fraction of the entire beach volume is being washed off and on shore on a regular basis.

In addition to the beach profiles, on a single occasion, surface sediments were collected around the mid tide mark at each of the profiles. The results of the sediment analysis showed that the majority of the surface sediments could be described as either moderately-sorted-slightly-gravelly sand or poorly-sorted-gravelly sand. At some sites significant differences in sediment characteristics exist between profiles. Typically, gravel contents were less than 10%, a notable exception to this was at Hawera which had gravel contents at all 4 profiles in excess of 20% and as high as 66%.

Information relating to TTR's additional scientific work undertaken since 2014 has been provided and the conclusions is this report remain valid.

5 Acknowledgements

We thank the many people who assisted in the field, especially Chris Ormandy, Margaret Bellingham and Scott Edhouse. We would also like to thank Glenys Crocker for processing the beach sediments and Dr Scott Stephens for his review of this report.

6 References

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Appendix A GRADISTAT size scale.

Grain Size phi	Grain Size mm	Descriptive term	
-10	1024	Very Large	Boulder
-9	512	Large	
-8	256	Medium	
-7	128	Small	
-6	64	Very small	
-5	32	Very coarse	Gravel
-4	16	Coarse	
-3	8	Medium	
-2	4	Fine	
-1	2	Very fine	
0	1	Very coarse	Sand
1	microns 500	Coarse	
2	250	Medium	
3	125	Fine	
4	63	very fine	
5	31	Very coarse	Silt
6	16	Coarse	
7	8	Medium	
8	4	Fine	
9	2	Very fine	
		Clay	

Table A-1: Size scale adopted in the GRADISTAT programme.

Appendix B Profile photos.

Kai Iwi profile 1

Figure B-1: Photographs taken from Kai Iwi profile 1. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Kai Iwi profile 2

Figure B-2: Photographs taken from Kai Iwi profile 2. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Kai Iwi profile 3

Figure B-3: Photographs taken from Kai Iwi profile 3. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Kai Iwi profile 4

Figure B-4: Photographs taken from Kai Iwi profile 4. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Ototoka profile 1

Figure B-5: Photographs taken from Ototoka profile 1. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Ototoka profile 2

Figure B-6: Photographs taken from Ototoka profile 2. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Ototoka profile 3

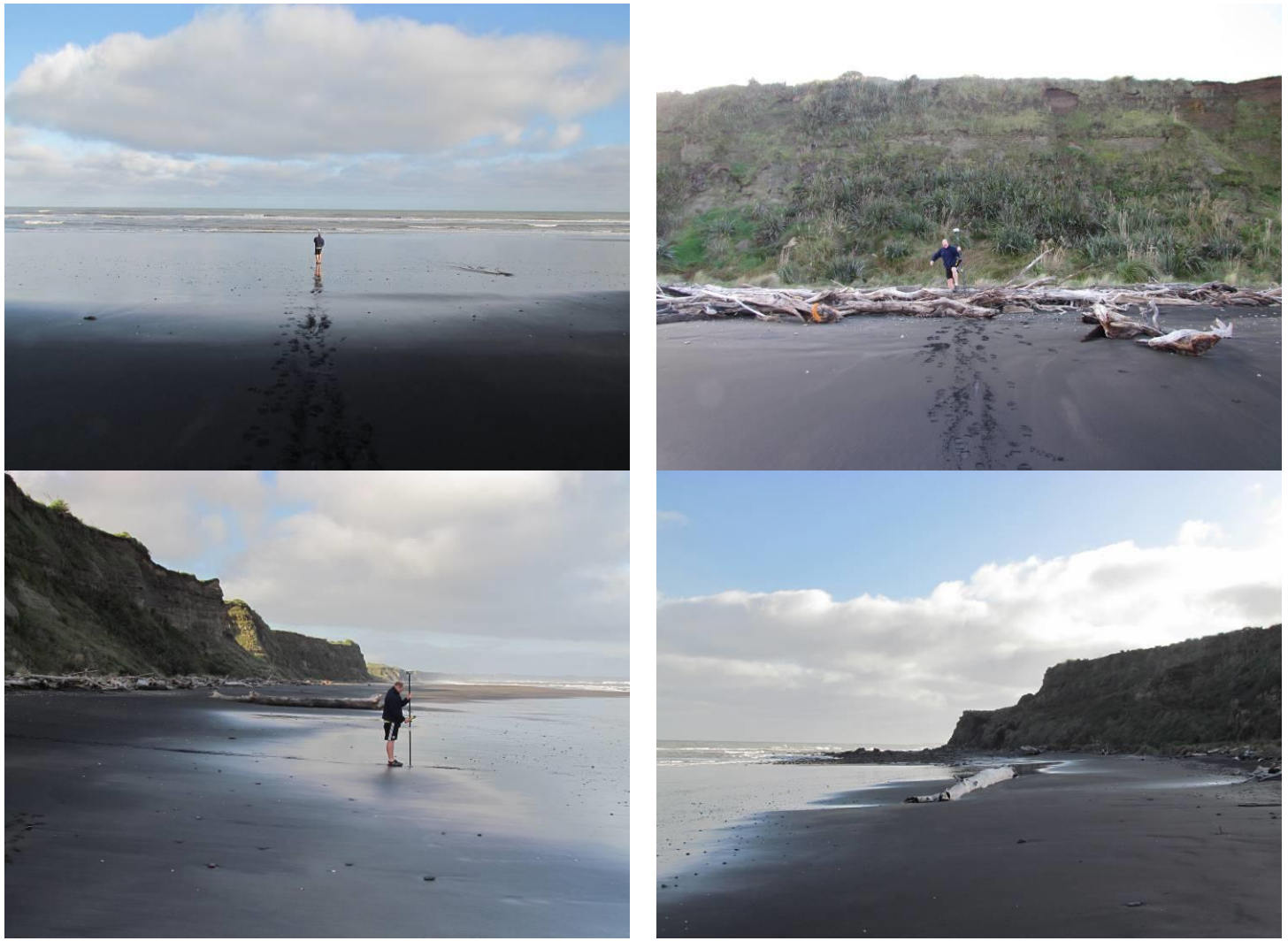

Figure B-7: Photographs taken from Ototoka profile 3. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Ototoka profile 4

Figure B-8: Photographs taken from Ototoka profile 4. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Waiinu profile 1

Figure B-9: Photographs taken from Waiinu profile 1. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Waiinu profile 2

Figure B-10: Photographs taken from Waiinu profile 2. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Waiinu profile 3

Figure B-11: Photographs taken from Waiinu profile 3. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Waiinu profile 4

Figure B-12: Photographs taken from Waiinu profile 4. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Waverley profile 1

Figure B-13: Photographs taken from Waverley (Long Beach) profile 1. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Waverley profile 2

Figure B-14: Photographs taken from Waverley (Long Beach) profile 2. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Waverley profile 3

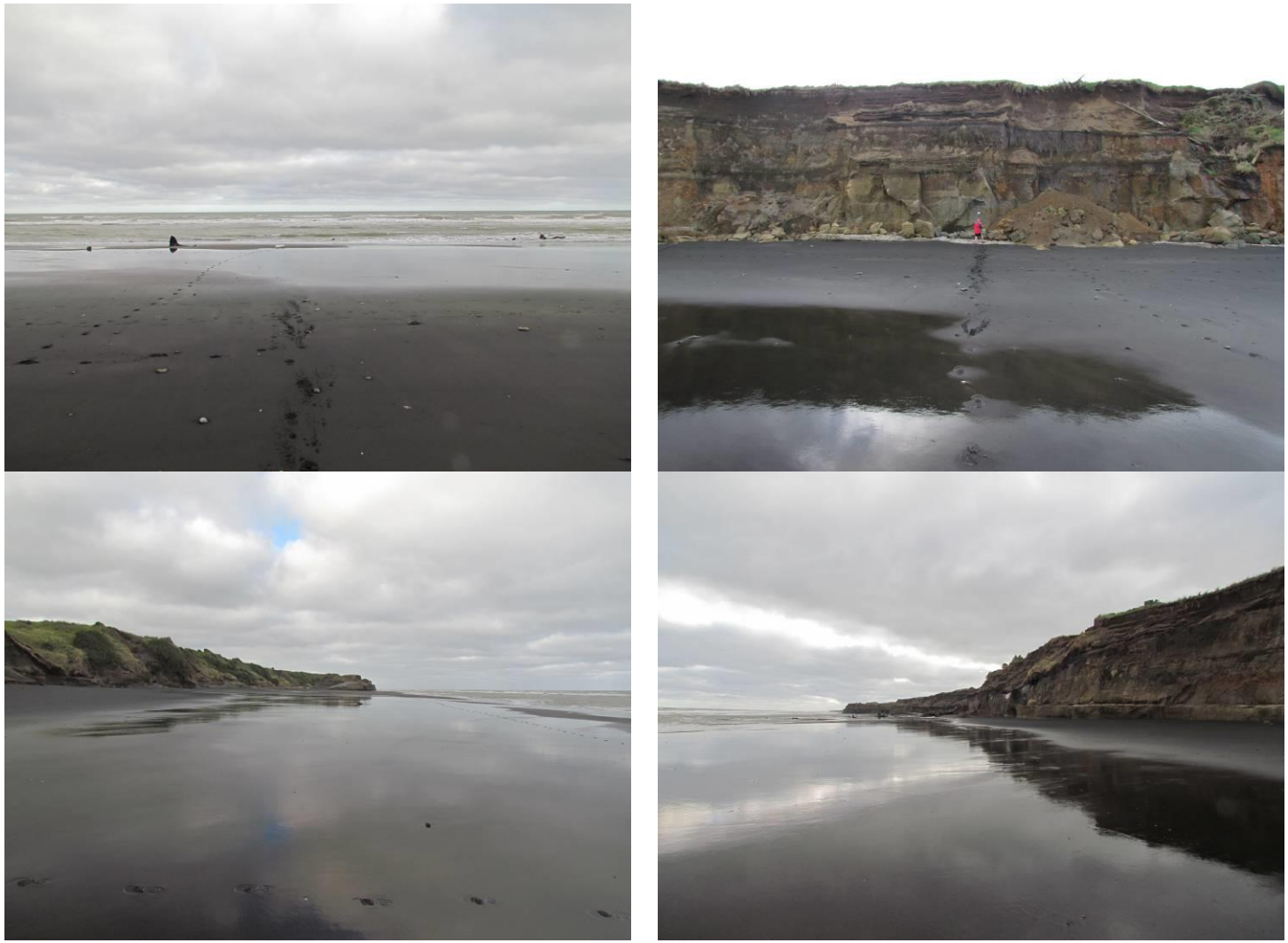

Figure B-15: Photographs taken from Waverley (Long Beach) profile 3. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Waverley profile 4

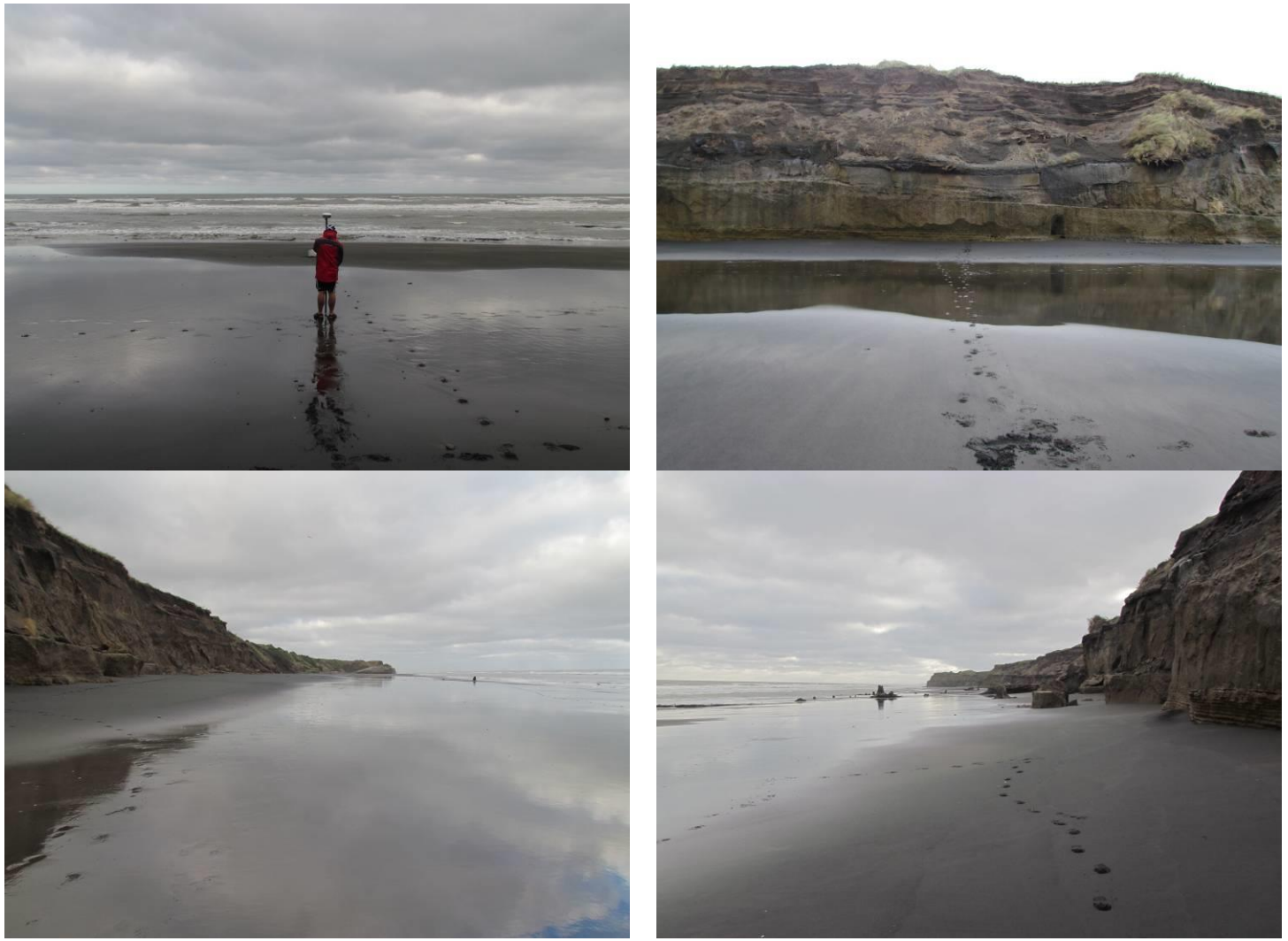

Figure B-16: Photographs taken from Waverley (Long Beach) profile 4. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Patea profile 1

Figure B-17: Photographs taken from Patea profile 1. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Patea profile 2

Figure B-18: Photographs taken from Patea profile 2. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Patea profile 3

Figure B-19: Photographs taken from Patea profile 3. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Patea profile 4

Figure B-20: Photographs taken from Patea profile 4. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Manawapou profile 1

Figure B-21: Photographs taken from Manawapou profile 1. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Manawapou profile 2

Figure B-22: Photographs taken from Manawapou profile 2. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Manawapou profile 3

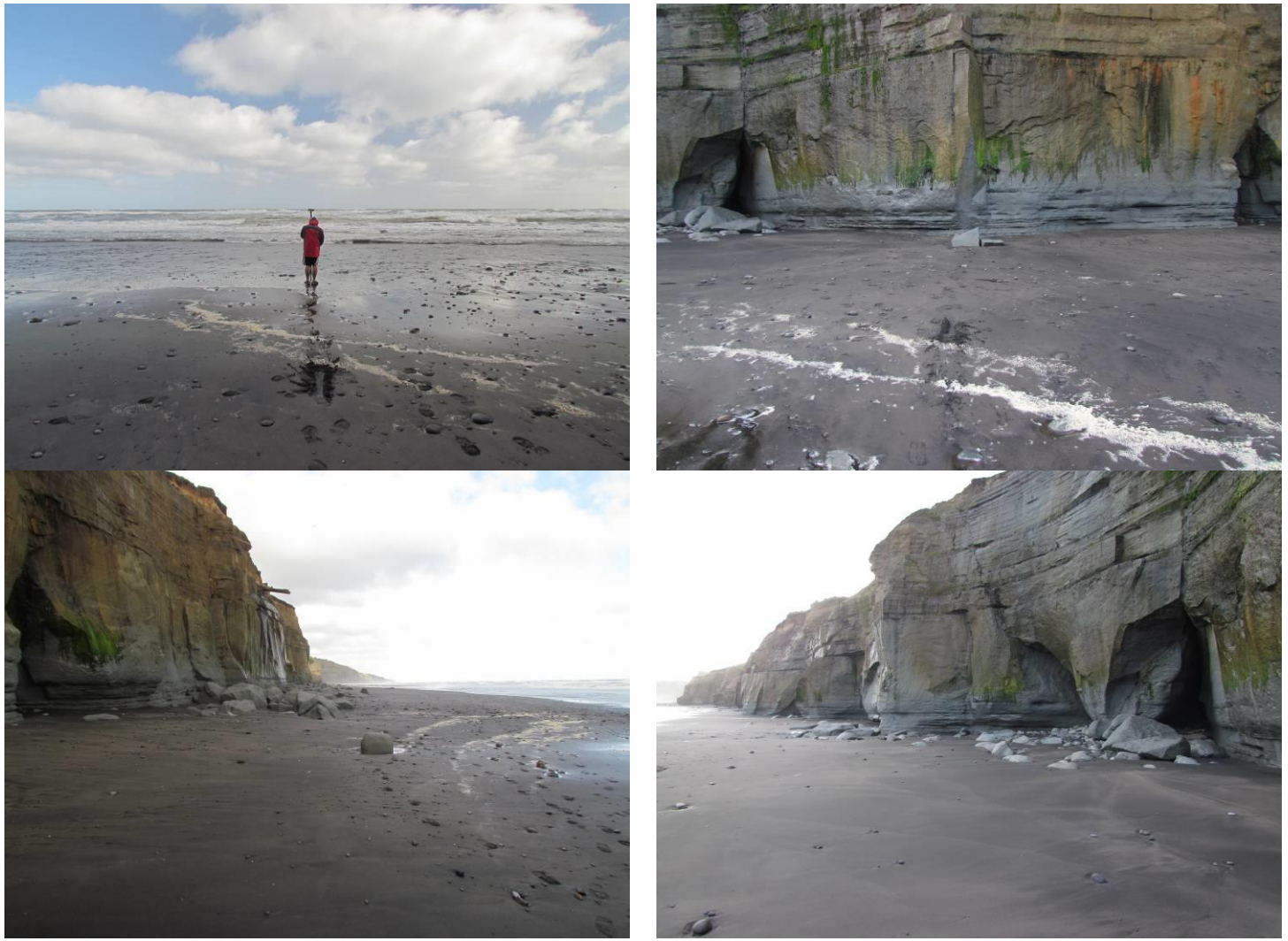

Figure B-23: Photographs taken from Manawapou profile 3. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Manawapou profile 4

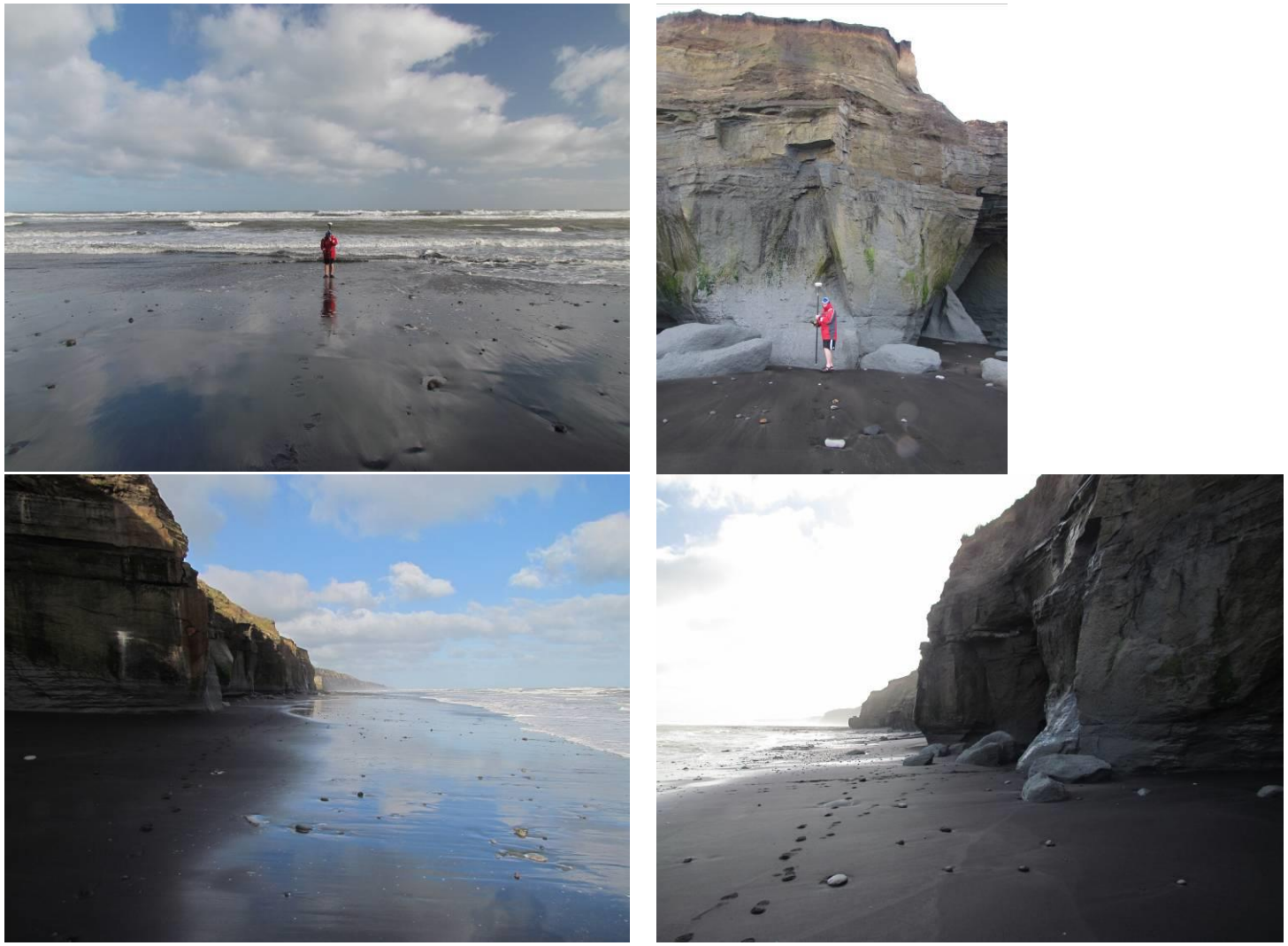

Figure B-24: Photographs taken from Manawapou profile 4. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Hawera profile 1

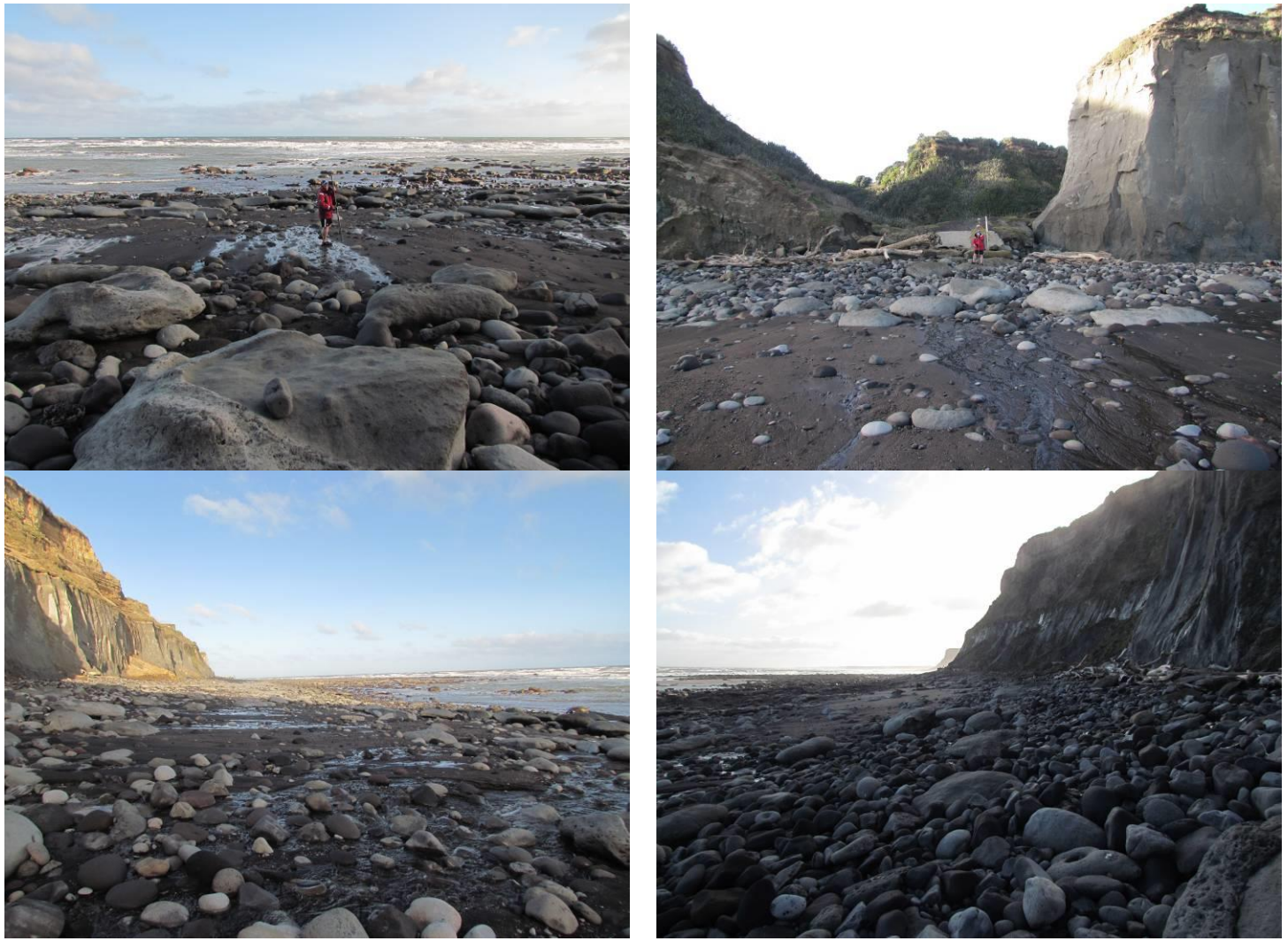

Figure B-25: Photographs taken from Hawera profile 1. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Hawera profile 2

Figure B-26: Photographs taken from Hawera profile 2. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Hawera profile 3

Figure B-27: Photographs taken from Hawera profile 3. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Hawera profile 4

Figure B-28 Photographs taken from Hawera profile 4. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Ohawe profile 1

Figure B-29: Photographs taken from Ohawe profile 1. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Ohawe profile 2

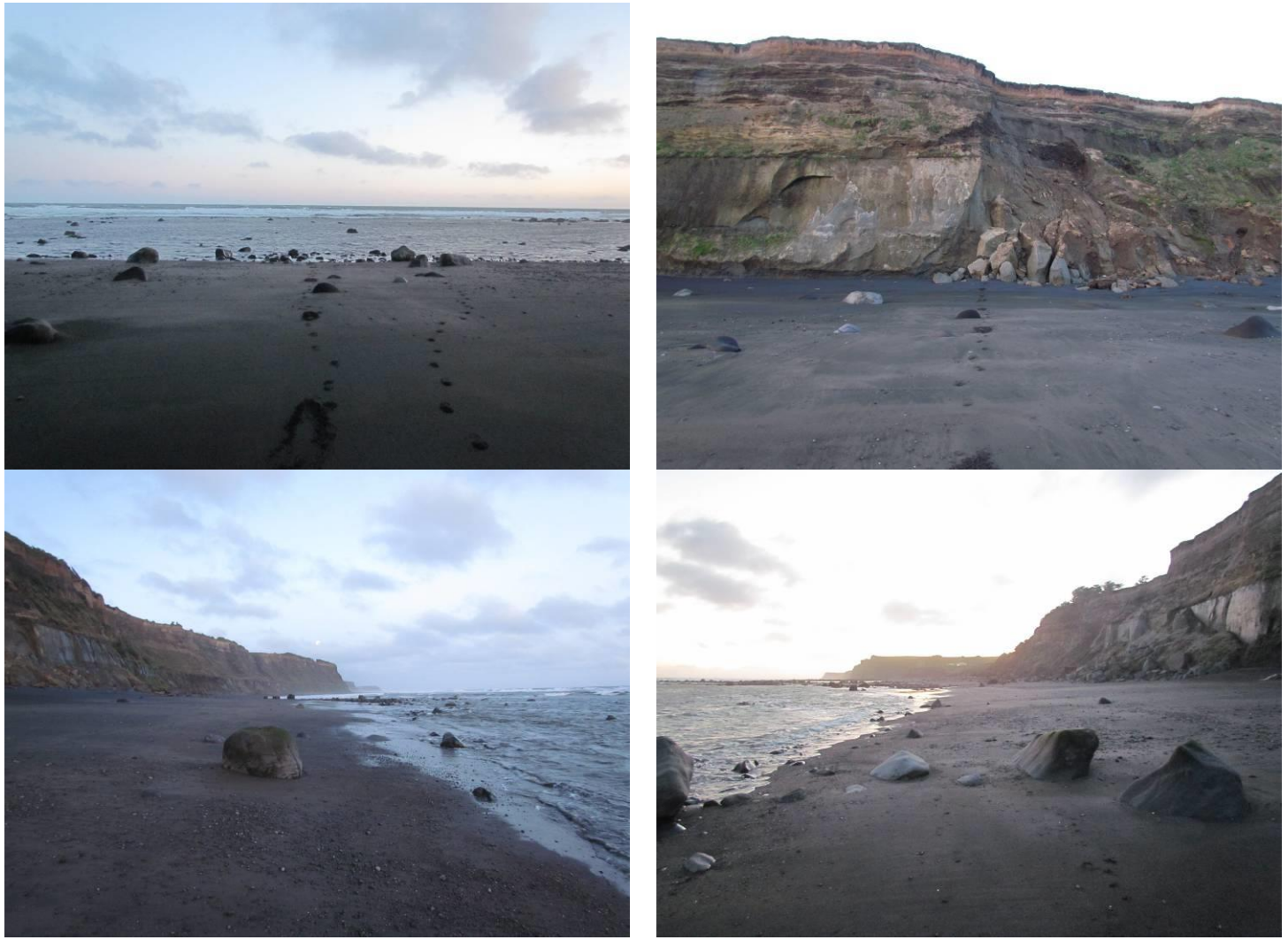

Figure B-30: Photographs taken from Ohawe profile 2. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Ohawe profile 3

Figure B-31: Photographs taken from Ohawe profile 3. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Ohawe profile 4

Figure B-32: Photographs taken from Ohawe profile 4. Panels: (top-left) looking seaward, (top-right) looking landward, (bottom-right) looking to the right of the profile, and (bottom-left) looking to the left of the profile. Note: left and right are relative to looking seaward.

Appendix C Particle size distributions

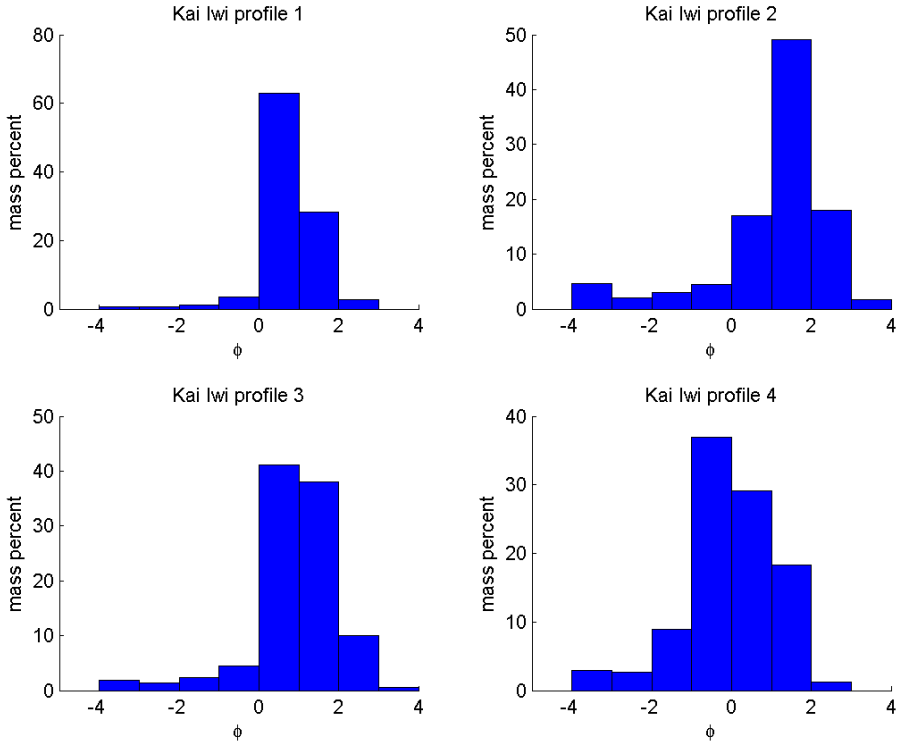

Figure C-1: Kai Iwi Beach sediment grain size distributions.

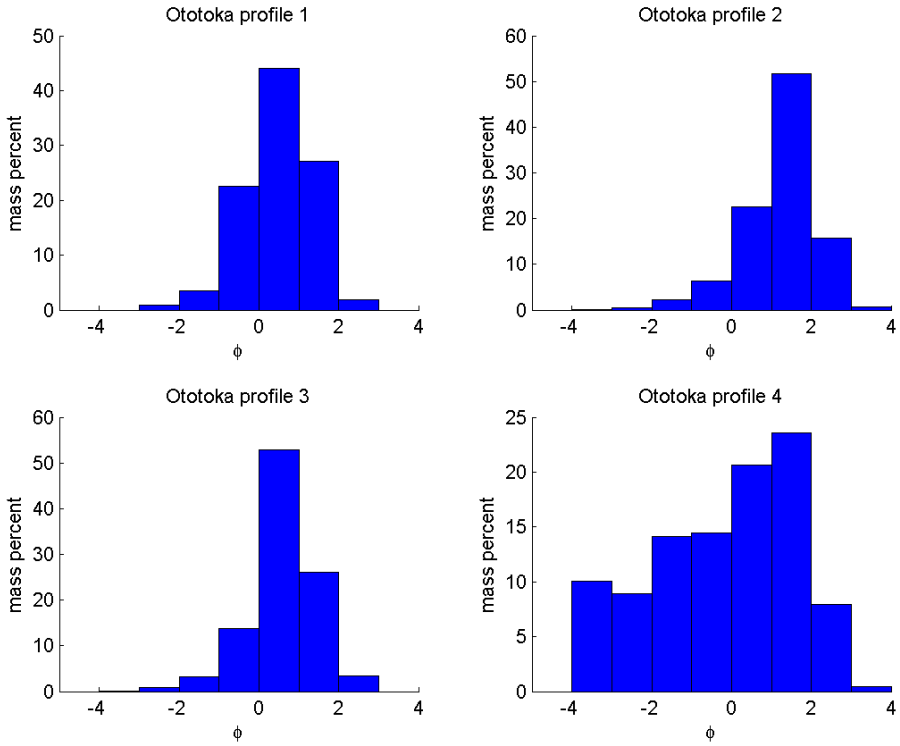

Figure C-2: Ototoka Beach sediment grain size distributions.

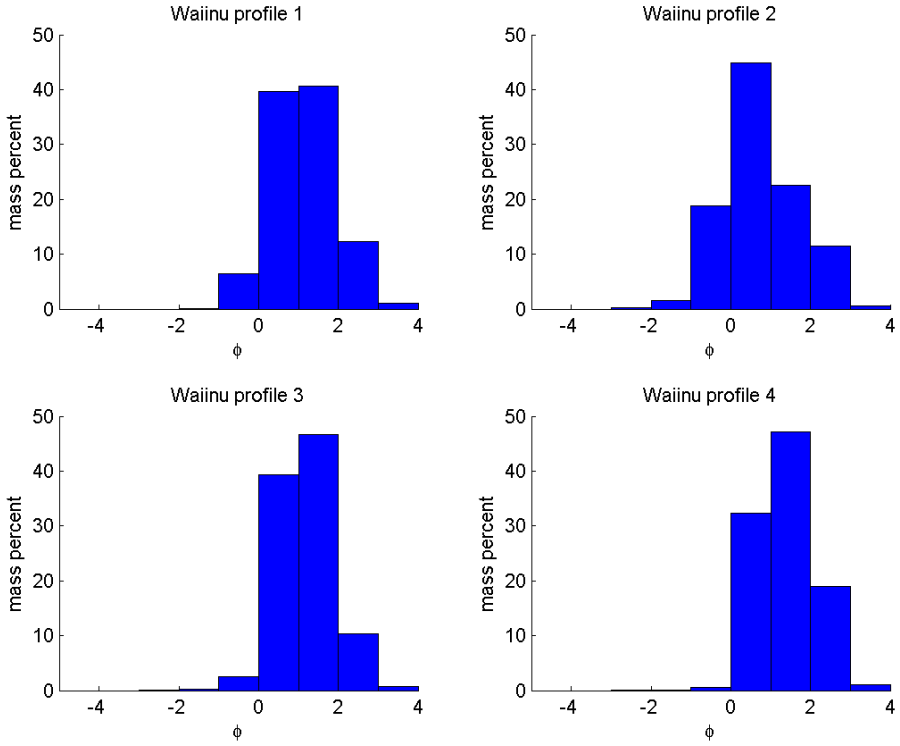

Figure C-3: Waiinu Beach sediment grain size distributions.

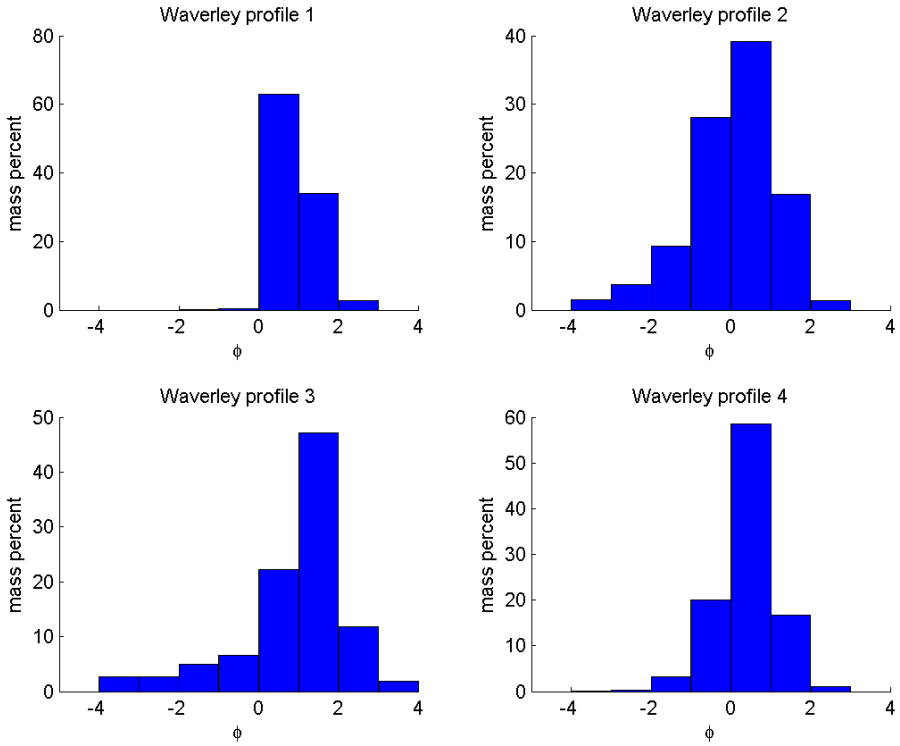

Figure C-4: Waverley Beach sediment grain size distributions.

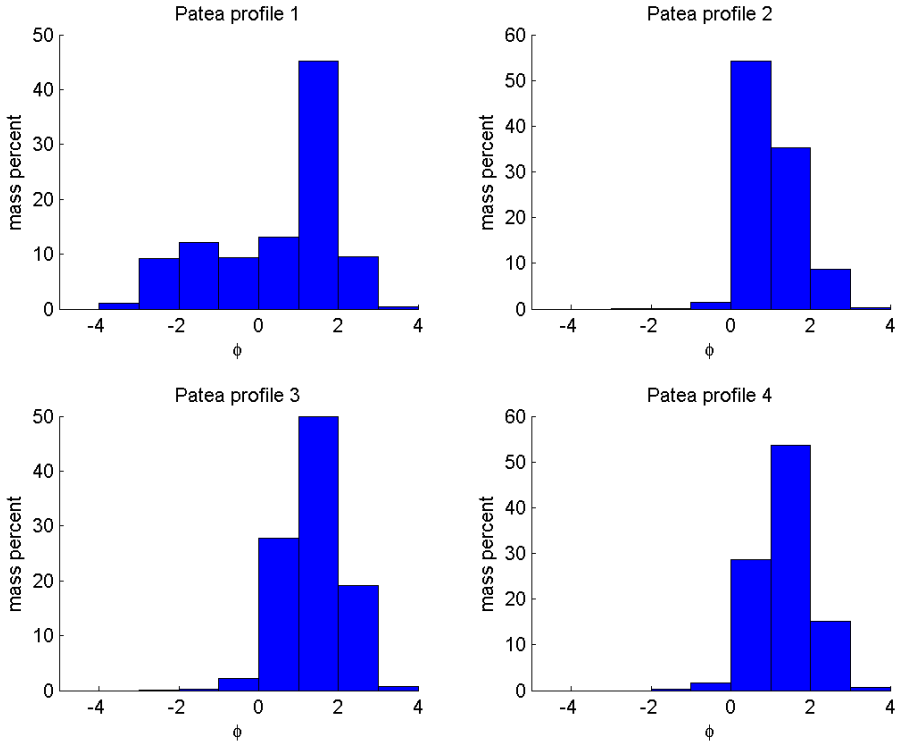

Figure C-5: Patea Beach sediment grain size distributions.

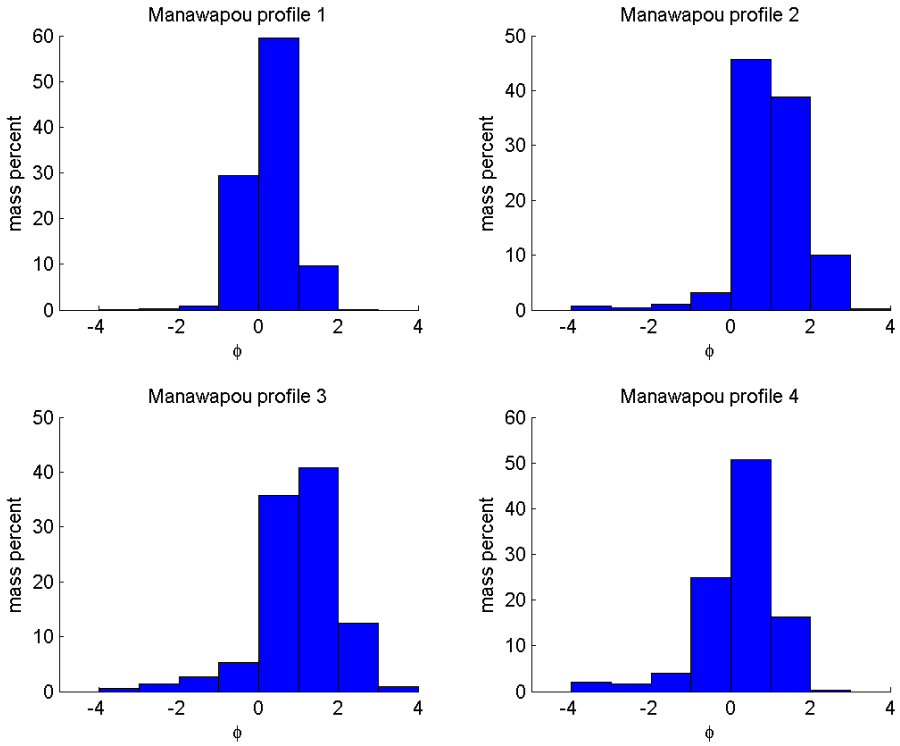

Figure C-6: Manawapou Beach sediment grain size distributions.

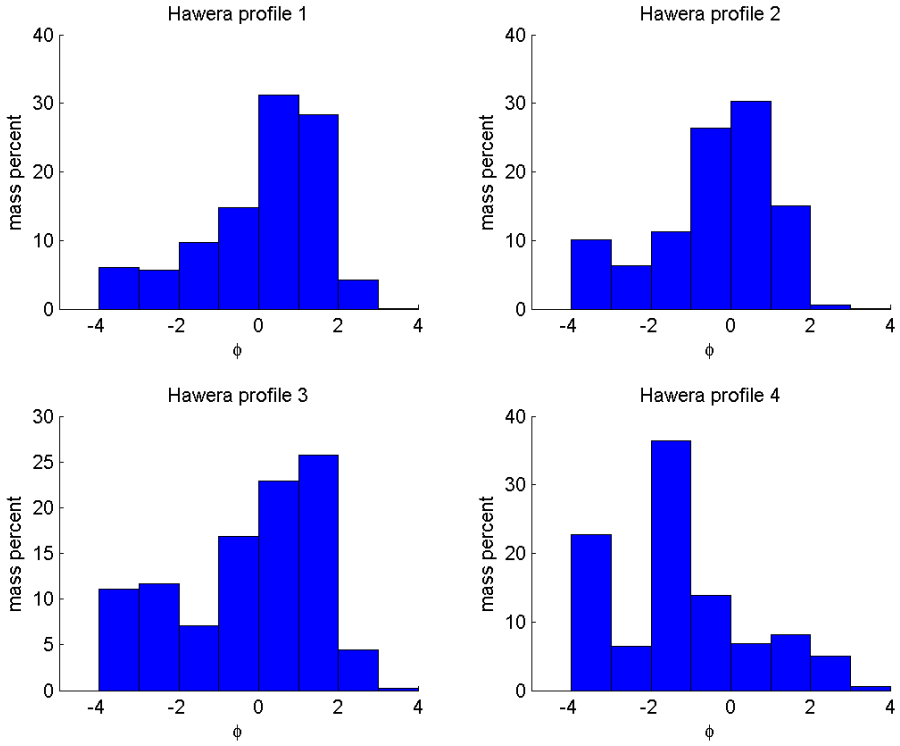

Figure C-7: Hawera Beach sediment grain size distributions.

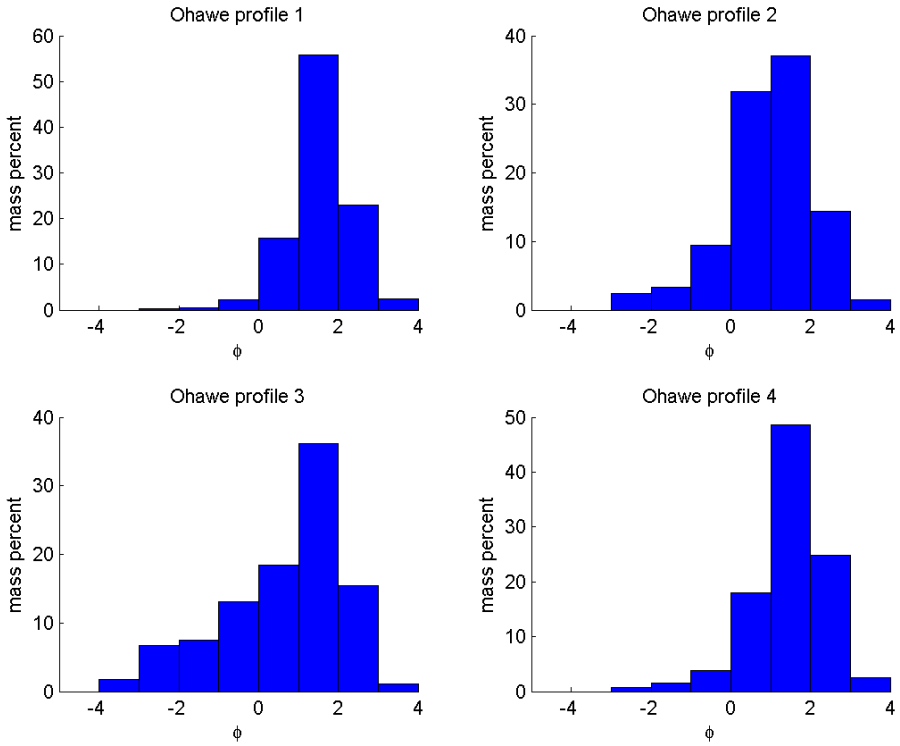

Figure C-8: Ohawe Beach sediment grain size distributions.