

National Report of New Zealand

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GLOSS Experts 13 Meeting

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1. Introduction

New Zealand does not have a formal, nationally administered, network of sea-level gauges. Instead, sea-level gauges are mostly operated independently by various agencies, with some national coordination of daily downloads of data, post processing and archiving undertaken through voluntary partnerships with either Land Information NZ (LINZ) or National Institute of Water and Atmospheric Research Ltd (NIWA). NIWA has been funded in the past by the NZ Foundation for Research Science and Technology (now Ministry of Business, Innovation and Employment) to support and coordinate an informal open-coast network. However, significant funding cuts in 2012/13 have resulted in closure of 5 NIWA stations and have curtailed processing of quality-assured datasets to New Zealand and international science and geodetic communities. Quality assurance of NIWA sites up to the end of 2012 is almost complete and should be available to PSMSL by the end of the year.

The following brief report outlines activities in New Zealand associated with sea-level gauges and availability of data. The main developments since the last report have been:

- a) further cuts in operational budgets prompted a review of the open-coast network which resulted in the closure of 5 gauge sites by NIWA in 2012/13;
- b) negotiations between NIWA and the National Tidal Centre, Bureau of Meteorology (Australia) regarding the replacement of the Jackson Bay gauge that was damaged by fire in January 2012;
- c) through tank testing under simulated wave orbital motions, NIWA have developed a pragmatic small bell-housing to shroud the bubbler orifice for bubbler-gauge systems. Implementation of the bell-housing at two open-coast gauge sites has shown a dramatic improvement in performance during high wave activity, and
- d) the analysis of near-coastal continuous GPS data to assess short-term rates of vertical deformation that could have an impact on relative sea level rise.

2. Sea Level Stations

A large number of organisations own and operate sea level stations in New Zealand. These stations can be grouped into four categories; a) sites at major ports operated by the local port company or regional council; b) an open coast network coordinated

by NIWA (which includes some regional and local councils); c) a tsunami monitoring network established by LINZ in partnership with the Crown-owned research organisation GNS Science's GeoNet Project and d) other sites.

2.1 Stations at Major Ports

Table 1: Sea level stations whose data is used to produce daily tide predictions.

Station	Latitude	Longitude
Marsden Point	35° 50' S	174° 30' E
Auckland	36° 51' S	174° 46' E
Onehunga	36° 56' S	174° 47' E
Tauranga	37° 39' S	176° 11' E
Gisborne	38° 40' S	178° 02' E
Port Taranaki	39° 03' S	174° 02' E
Napier	39° 29' S	176° 55' E
Nelson	41° 16' S	173° 16' E
Wellington	41° 17' S	174° 47' E
Picton	41° 17' S	174° 00' E
Westport	41° 45' S	171° 36' E
Lyttelton	43° 36' S	172° 43' E
Timaru	44° 23' S	171° 15' E
Port Chalmers	45° 49' S	170° 39' E
Dunedin	45° 53' S	170° 30' E
Bluff	46° 36' S	168° 21' E

2.2 Open Coast Network

NIWA coordinates an informal nation-wide network of open-coast sea-level gauges in partnership with some port companies (counted above), regional and local councils and for one installation each, the National Tidal Centre, Bureau of Meteorology (Australia) and Antarctica New Zealand. There were 17 gauges coordinated and/or archived by NIWA, (excluding those stations counted above in Section 2.1), 10 of which are operated by NIWA itself, but in 2012/13, five of the NIWA gauges were closed. This network of stations complement the gauges operated by individual ports (section 2.1) and other local/regional councils (section 2.4). Details on sites and the characteristics of the 18 stations in the open-coast network are listed in Table 2.

Table 2: Sea level gauges in an open-coast network (excluding Standard Port Stations). Gauge type abbreviations are: B = gas bubbler with ParoScientific PS2 pressure sensor; SW = still-well float/counter weight + digital logger; US = ultrasonic in air; SEAFR = SEAFRAME acoustic gauge; R = radar. Blue-shaded sites have closed in 2012/13.

Agency abbreviations: WRC [Waikato Regional Council]; ECan [Environment Canterbury]; NTC [National Tidal Centre, Bureau of Meteorology, Australia]; NRC [Northland Regional Council]; TDC [Tasman District Council]; ORC [Otago Regional Council].

Station [Agency]	Latitude	Longitude	Start date of NIWA archive	Record interval (min)	Gauge Type
Poutu Point [NRC]	36° 22' S	174° 11' E	21-Apr-2002	5	B
Whitianga [WRC]	36° 50' S	175° 43' E	13-Jul-1999	5	R
Anawhata [NIWA]	36° 55' S	174° 28' E	19-Nov-1998	1	B
Tararu [WRC]	37° 08' S	175° 31' E	1-Nov-1992	5	US
Moturiki Is. [NIWA]	37° 38' S	176° 12' E	27-May-1971	1, 5	B+SW
Raglan Wharf*** [WRC]	37° 48' S	174° 53' E	1-Jul-2008	1	R
Kawhia Harbour [WRC]	38° 04' S	174° 49' E	29-Aug-2008	1	B
Tarakohe [TDC]	40° 49' S	172° 54' E	28-Jan-2005	1	B
Kapiti Is. [NIWA]	40° 51' S	174° 56' E	24-Jul-1997	1	B
Little Kaiteriteri [TDC]	41° 03' S	173° 02' E	17-Jun-2000	1	B
Charleston [NIWA]	41° 54' S	171° 26' E	25-Apr-1998	1	B
Kaikoura [NIWA]	42° 25' S	173° 42' E	10-Aug-1994	1	B
Sumner Head* [NIWA, ECan]	43° 34' S	172° 46' E	3-Jun-1994	1	B
Kaingaroa (Chatham Island) [NIWA]	43° 44' S	176° 16' W	2-May-2002	1, 5	B
Jackson Bay** [NTC, NIWA]	43° 57' S	168° 37' E	13-Dec-1996	1, 6	SEAFR R
Green Is. [NIWA, ORC]	45° 57' S	170° 23' E	4-Dec-2002	1	B
Dog Island [NIWA]	46° 39' S	168° 25' E	2-Feb-1997	1	B
Scott Base [Antarctica NZ, NIWA]	77° 51' S	166° 46' E	15-Jan-2001	5	B

* a rock-slide following an earthquake aftershock in January 2013 damaged the bubbler orifice and infilled the sub-tidal water around the orifice – gauge was subsequently re-located nearby on 15-May-2013

** fire damaged gauge in January 2012 – currently not operational

*** fire destroyed gauge in 2011, site re-instated in September 2012

2.3 Tsunami Monitoring Network

LINZ has partnered with GeoNet to improve the system of sea level recorders around New Zealand and its off-shore islands to allow better detection and confirmation of tsunamis.

The data from these sites is transmitted to GeoNet which is responsible for monitoring New Zealand's geophysical hazards (earthquakes, volcanoes, landslides and tsunamis). Real time data from this network is available via the Global Telecommunications System (GTS) and plots of the observed and de-tided data are updated every 5 minutes on the GeoNet web-site. Data is also archived and made freely available from the GeoNet and LINZ web-sites.

The Pacific Tsunami Warning Center (PTWC) has a tsunami monitoring station at Waitangi on Chatham Island.

Table 3: Operational sea level stations in the tsunami monitoring network.

Dates indicate when the LINZ/GeoNet sites commenced operation.

Station	Latitude	Longitude	Start date
Fishing Rock (Raoul Island)	29° 15' S	177° 55' W	29-May-2009
Boat Cove (Raoul Island)	29° 17' S	177° 54' W	29-May-2009
North Cape	34° 25' S	173° 03' E	24-Dec-2008
Korotiti Bay (Great Barrier Is)	36° 11' S	175° 29' E	31-Jul-2010
Devonport	36° 50' S	174° 47' E	26-Mar-2009
Manukau	37° 03' S	174° 31' E	28-Jul-2010
Lottin Point	37° 33' S	178° 10' E	10-Oct-2008
Tauranga	37° 39' S	176° 11' E	6-Jul-2008
Gisborne	38° 40' S	178° 02' E	11-Mar-2008
Napier	39° 29' S	176° 55' E	20-Sept-2007
Castlepoint	40° 55' S	176° 13' E	7-Oct-2009
Wellington	41° 17' S	174° 47' E	23-Mar-2007
Kaikoura	42° 25' S	173° 42' E	27-May-2010
Sumner	43° 34' S	172° 34' E	11-Aug-2010
Waitangi (Chatham Island)	43° 57' S	166° 33' W	
Owenga (Chatham Island)	44° 02' S	176° 22' W	7-Dec-2007
Port Chalmers	45° 49' S	170° 39' E	25-Feb-2010
Puysegur	46° 05' S	166° 35' E	14-Dec-2009

2.4 Other Sea-level Gauge Sites

In addition to the sites described above, continuous sea level measurements are also taken at sites at minor ports, by supplementary gauges at major ports and within several estuaries. Most of these stations are owned and operated by either local/regional councils or port companies.

LINZ operates a sea level station in Antarctica at Cape Roberts.

Table 4: Other sea-level gauge sites.

Agency abbreviations: BRC [Bay of Plenty Regional Council]; CCC [Christchurch City Council]; GWRC [Greater Wellington Regional Council]; NRC [Northland Regional Council]; POT [Port of Tauranga]; POL [Port Otago Ltd.]; TCC [Tauranga City Council]; WCRC [West Coast Regional Council]; WRC [Waikato Regional Council]

Station	Latitude	Longitude
Ben Gunn Wharf (Awanui) [NRC]	35° 00' S	173° 15' E
Whangaroa Harbour [NRC]	35° 01' S	173° 45' E
Opua (Bay of Islands) [NRC]	35° 19' S	174° 07' E
Frenchman Is. (Marsden Point) [NorthPort]	35° 52' S	174° 32' E
Dargaville [NRC]	35° 56' S	173° 52' E
Tauranga Harbour (Omokoroa) [BRC]	37° 40' S	176° 03' E

Tauranga Harbour (Sulphur Pt.) [POT]	37° 41' S	176° 10' E
Tauranga Harbour (Oruamatua) [TCC/BRC]	37° 42' S	176° 13' E
Tauranga Harbour (Hairini Bridge) [TCC/BRC]	37° 43' S	176° 10' E
Kaituna River [BRC]	37° 45' S	176° 25' E
Manu Bay (Raglan) [WRC]	37° 49' S	174° 49' E
Rangitaiki River [BRC]	37° 55' S	176° 52' E
Whakatane Town Wharf [BRC]	37° 57' S	177° 00' E
Ohiwa Harbour (Ohope Wharf) [BRC]	37° 59' S	177° 06' E
Opotiki Wharf [BRC]	38° 02' S	177° 14' E
Mana (Porirua Harbour) [GWRC]	41° 06' S	174° 52' E
Havelock [Port Marlborough NZ]	41° 17' S	173° 46' E
Greymouth [WCRC]	42° 26' S	171° 13' E
Bridge St, Christchurch [CCC]	43° 31' S	172° 43' E
Avon/Heathcote (Ferrymead) [CCC]	43° 33' S	172° 43' E
Milford Sound [Environment Southland]	44° 40' S	167° 56' E
Spit Wharf (Otago Harbour) [POL]	45° 47' S	170° 43' E
Cape Roberts (Antarctica) [LINZ]	77° 02' S	163° 12' E

2.5 GLOSS Stations

Five stations in the GLOSS Core Network are located within New Zealand.

GLOSS stations 101, 127 and 129 appear in Table 1, station 128 is included in Table 3 and station 134 is part of Table 2.

Table 5: New Zealand's GLOSS Core Network stations.

GLOSS ID	Station
101	Wellington
127	Auckland
128	Waitangi (Chatham Island)
129	Bluff
134	Scott Base (Antarctica)

3. Sea Level Measurement Technologies

3.1 Stations at Major Ports

Sea level data at all major ports (Table 1) is recorded digitally.

A variety of sea level measurement technologies are used, including sub-surface pressure transducers, float and stilling well, downward-looking radar and ultrasonic systems.

Data is recorded once every minute at half of the sites with the balance producing data at intervals of either 5 or 10 minutes.

3.2 Open Coast Network

As listed in Table 2, most of the sites operated by NIWA use a bubbler gauge technology with PS2 ParoScientific pressure sensors, while other installations use either radar, acoustic, ultrasonic or float/counter weight systems (see Table 2).

To improve the performance of bubbler gauges in open-coast situations, NIWA has undertaken tank testing of various bell shrouds over bubbler orifices under cyclic orbital motion to simulate wave effects. A co-located bubbler gauge with a stilling-tower float and counterweight gauge at the Moturiki Island site (Table 2) revealed significant decreases in measured water level from the bubbler gauge around low tide when significant wave activity was present. The tank testing confirmed this behaviour and lead to a pragmatic design of a bell-housing to shroud the bubbler orifice. Subsequently, these shrouds have been attached to the bubbler orifices at both Sumner Head and Moturiki Island (Table 2) with dramatic improvement in performance during high wave activity.

All sites record data in digital form, mostly at 1 minute recording intervals, with the remaining gauges recording at 5 minute intervals.

3.3 Tsunami Monitoring Network

Each of the LINZ/GeoNet tsunami monitoring sites listed in Table 3 incorporates a pair of Druck PTX 1830 pressure sensors. The vented sensors have a range of 0 – 20 metres and output a 4-20mA signal. Sea level is measured at a rate of 10Hz and a record is output at 1 minute intervals.

3.4 Other Sea-level Gauge Sites

Details of equipment used at these sites has not been collated, however pressure sensors, ultrasonic, bubbler and float/counter weight technologies would be most likely.

4. Continuous GPS (CGPS)

CGPS observations have been made at the major ports (Wellington, Lyttelton and Dunedin since late 1999 and Auckland since 2009). These stations are operated by GNS Science.

5. Data Availability

5.1 Hourly Data for GLOSS stations

- a) Wellington (101) and Bluff (129):
Fast delivery of data for these GLOSS stations is forwarded to UHSLC each month.
- b) Auckland (127):
The port company operating this site has refused to make this data available to the international community free of charge.

- c) Chatham Island (128):
Near real-time data is provided through PTWC.
- d) Scott Base (134): The entire dataset up to the start of 2007 was quality-assured by PSMSL after receipt of data from NIWA and also submitted to UHSLC. Subsequent data for calendar years 2007 to 2010 have been provided to PSMSL by NIWA..

5.2 Monthly and Annual Means (PSMSL)

Data held by PSMSL for other New Zealand stations is improving with new data being added annually. Data supplied to PSMSL since the last GE meeting are summarised in the following table.

Table 6: Stations for which monthly and annual mean sea level data has been submitted to PSMSL since the GE XII meeting in 2011.

Station	Data submitted to PSMSL	
	Start date	End date
Marsden Point	January 2011	December 2012
Tauranga	January 2011	December 2012
Napier	January 2011	December 2012
Port Taranaki	January 2011	December 2012
Nelson	January 2011	December 2012
Lyttelton	January 2011	December 2012
Timaru	January 2011	December 2012
Dunedin	January 2011	December 2012
Port Chalmers	January 2011	December 2012

5.3 Open Coast Network

The open-coast network data (Table 2) is processed nightly and uploaded to the internet in the form of plots from tide, storm surge and long-wave/tsunami analyses. The web site is:

<http://www.niwa.co.nz/our-services/online-services/sea-levels>

A replacement data delivery system is being developed to make available the processed and quality-assured datasets for the NIWA-operated gauges.

Requests for information or data relating to the NIWA-operated gauges can be made to the second author of this report – contact details shown on the first page.

5.4 Tsunami Monitoring Network

Data recorded by the tsunami monitoring sites is available for free download in the form of daily files. Metadata about the sites and the data can be accessed at the following web site: <http://www.linz.govt.nz/hydro/tidal-info/gauges/sea-level-data-downloads/index.aspx>

5.5 Other requests

Metadata for Antarctica gauges at Scott Base and Cape Roberts are listed at: http://gcmd.nasa.gov/KeywordSearch/Home.do?Portal=amd_nz&MetadataType=0 under the Oceans and Tide Gauges sub-sections.

Requests for information or data not covered above can be made to the authors of this report – contact details shown on the first page.

6.0 Research applications

An analysis of “near-coastal” cGPS site records, within a few kilometres of the coastline around New Zealand, was undertaken by Beavan & Litchfield (2012).¹ The main finding was subsidence rates of 1–4 mm/year over the past decade in the lower North Island, probably due to slow-slip seismic activity. If these rates persist over longer planning time-frames (decades to 100+ years), they could have significant implications for relative sea-level rise in these areas

An alternative approach to derive historic sea-level trends from sea-level gauge stations with very discontinuous records was used by Hannah & Bell (2012)² to estimate sea-level rise for an additional six sites in New Zealand. The average relative sea level rise calculated from these six newly derived trends was 1.7 ± 0.1 mm/yr, a result that is completely consistent with the analysis of the long-term gauge records from the four main ports Auckland, Wellington, Lyttelton and Dunedin (Table 1).

¹ Beavan, R.J. and N.J. Litchfield (2012). Vertical land movement around the New Zealand coastline: Implications for sea-level rise. GNS Science Report 2012/29, September 2012, 41 p.

² Hannah, J.; Bell, R.G. (2012). Regional sea level trends in New Zealand. *Journal of Geophysical Research–Oceans* 117, C01004; doi:10.1029/2011JC007591

SEA LEVEL SITES IN NEW ZEALAND

Major port sites (Table 1) are shown in **red**
 Open coast sites (Table 2) are shown in **green**
 Tsunami monitoring sites (Table 3) are shown in **brown**
 Other sites (Table 4) are shown in **blue**

Names of GLOSS stations are appended with their GLOSS ID number, names of the tsunami monitoring sites are appended with their code

