Australian Mean Sea Level Survey 2009
National Tidal Centre
Bureau of Meteorology

Australian Government
Bureau of Meteorology

Summary

- There are 39 Australian locations where relative sea levels have been measured for at least 25 years. The average length of these records is 42 years.

- 2 new locations (Wallaroo and Cape Ferguson) qualified in 2009 as long-term stations with more than 25 years of data.

- The average trend from all 39 stations is 0.9 mm/yr with a standard deviation of 1.9 mm/yr. Some of the stations exhibit unrealistic trends due to undocumented datum shifts. A more realistic average trend obtained from 29 stations within 1 standard deviation of the mean is **1.4** mm/yr with a standard deviation of 0.7 mm/yr.

- The geographical pattern of relative sea level trends around the Australian coastline is fairly uniform in general.

- The Australian average relative sea level rise is consistent with the global average sea level rise over the same period.

- Annual mean sea levels around the Australian coastline are strongly correlated with the El Niño – Southern Oscillation (ENSO) signal. Annual mean sea levels generally fluctuate in accordance with the Southern Oscillation Index (SOI).

- The longest sea level records show decadal sea-level oscillations with periods of around 20 years.

The Australian Mean Sea Level Survey is updated annually and provides a synopsis of the annual mean sea levels and trends in longer-term relative sea level records archived at the National Tidal Centre of the Bureau of Meteorology. When interpreting the results it is important to consider the following information about the long-term sea level records, particularly issues relating to data quality, datum stability and land motion.

About the long-term sea level records

A number of Australian long-term sea level records useful for sea level and climate research are archived at the Bureau of Meteorology and are delivered to international sea level centres as part of the Global Sea Level Observing System. The annual mean sea levels and relative sea level trends for those stations with more than 25 years of data are presented in this report.

The archived datasets are hourly sea levels with respect to the tide gauge zero, which is referenced to a land-based tide gauge benchmark at each site. A tide gauge benchmark network is essential to register sea level to stable ground and importantly external to the tide gauge itself (Bevis et al, 2002). Tide gauge benchmarks provide continuity in the sea level timeseries in case the tide gauge is damaged in a storm or accident, or replaced due to harbour development. Datum shifts and errors in the timing of the recorders or in the digitising of paper tide charts are found and corrected wherever possible. Nevertheless, some undocumented historical datum shifts have been identified at a few locations. At Burnie, for example, the annual mean sea levels prior to 1975 are clearly contaminated. Datum shifts of this nature will clearly affect the linear trend and therefore precise datum control and rigorous data management is essential for accurate long-term sea level monitoring.

The sea level datasets have been harmonically analysed for tides and seasonal cycles in addition to a linear trend term. The linear trend values will change as new data is accumulated and will become progressively more indicative of the underlying longer-term signal. Trends from stations with less than 25 years of data are not considered because large inter-annual and inter-decadal sea level fluctuations associated with climate variability (such as El Niño) can obscure the longer-term sea level trend associated with climate change.

Relative sea level trends may also include a contribution from local vertical land movements. Sediment compaction and land subsidence is commonly associated with harbours and tide gauge sites. Postglacial isostatic adjustment of Australia's shelf and coast is occurring on various spatial and temporal scales, while paleo sea level indicators provide evidence of long-term regional geological warping adjacent some tide gauge sites (Belperio, 1993, Harvey et al, 2000). The effects of land motion are generally site specific, and for coastal policy it may be appropriate to address them in site-specific policy documents or regulations (Harvey et al 2000). The relative sea level rise at Port Pirie, for example, is much smaller than at Port Adelaide despite these ports being only several hundred kilometres apart. Although both ports are influenced by a gradual post-glacial rebound of the South Australian coast, Port Adelaide has undergone land subsidence associated with wetland reclamation, urban and industrial development and groundwater withdrawal. A discrepancy in sea level trends also exists between the neighbouring stations at Williamstown and Point Lonsdale.

SEA LEVEL TRENDS FROM LEAST SQUARES ANALYSIS (mm/yr)

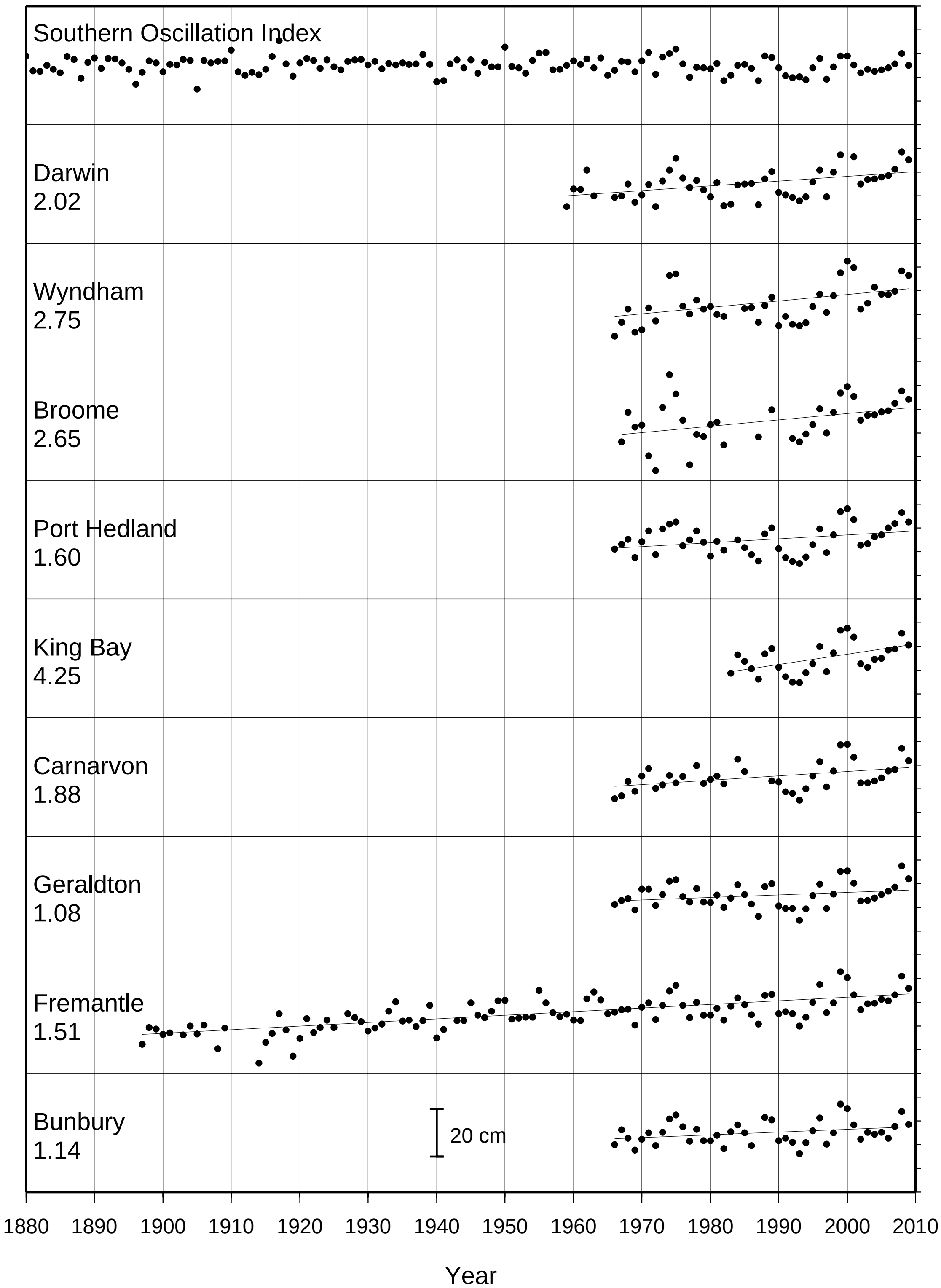

Figure 1a. Relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive. The plotted points represent the observed annual mean sea levels. The annual Southern Oscillation Index is also plotted for comparison.

SEA LEVEL TRENDS FROM LEAST SQUARES ANALYSIS (mm/yr)

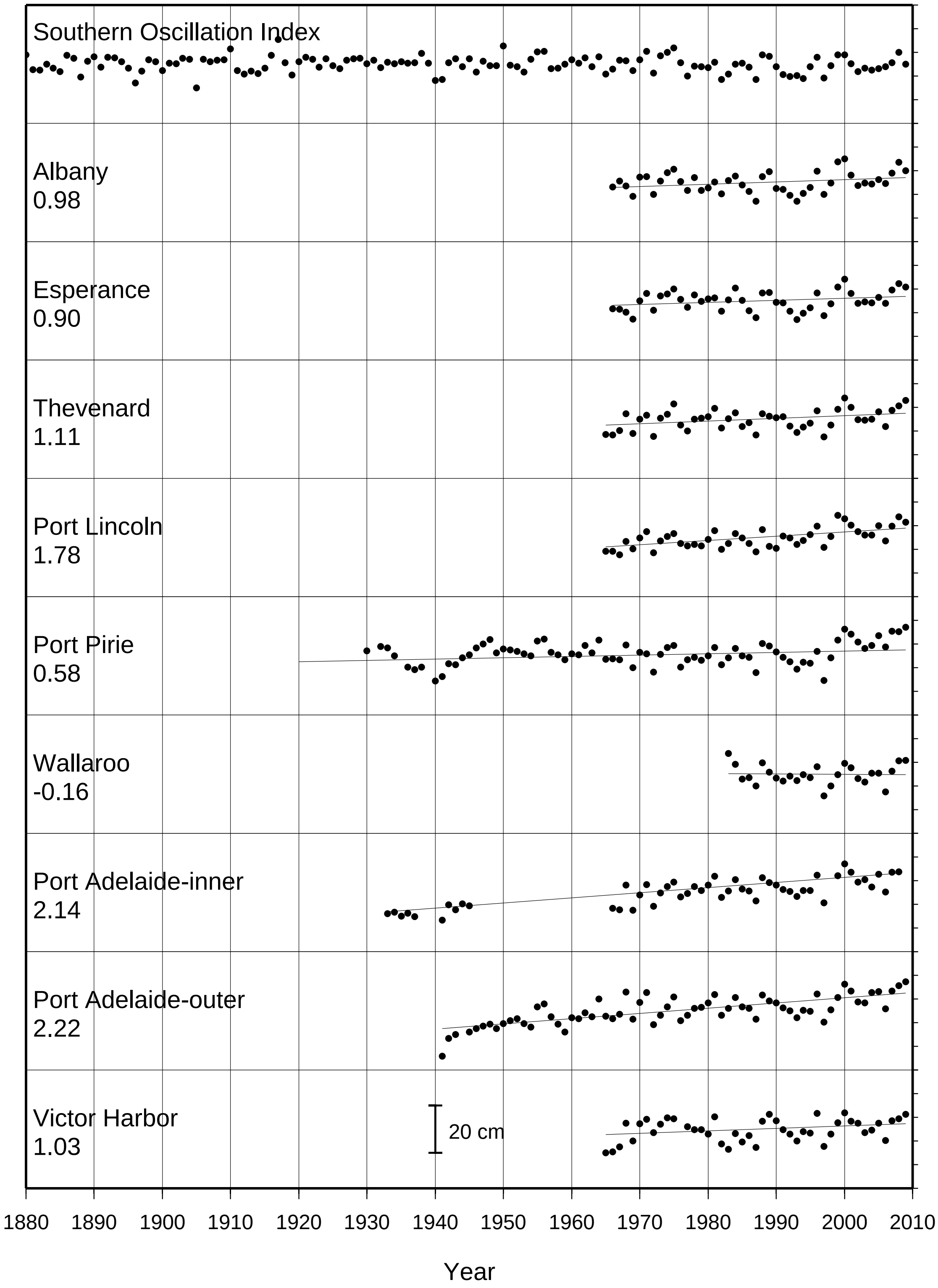

Figure 1b. Relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive. The plotted points represent the observed annual mean sea levels. The annual Southern Oscillation Index is also plotted for comparison.

SEA LEVEL TRENDS FROM LEAST SQUARES ANALYSIS (mm/yr)

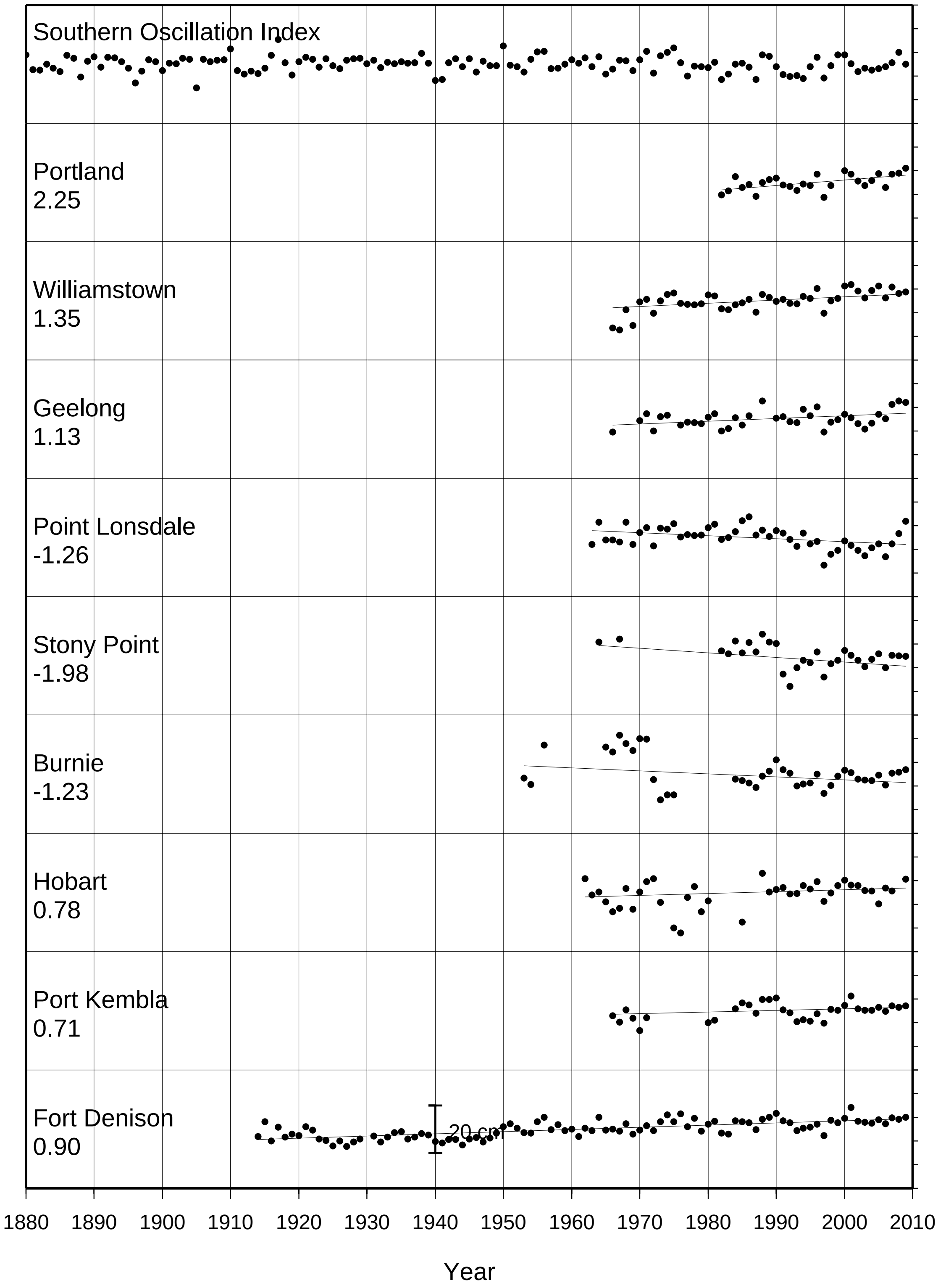

Figure 1c. Relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive. The plotted points represent the observed annual mean sea levels. The annual Southern Oscillation Index is also plotted for comparison.

SEA LEVEL TRENDS FROM LEAST SQUARES ANALYSIS (mm/yr)

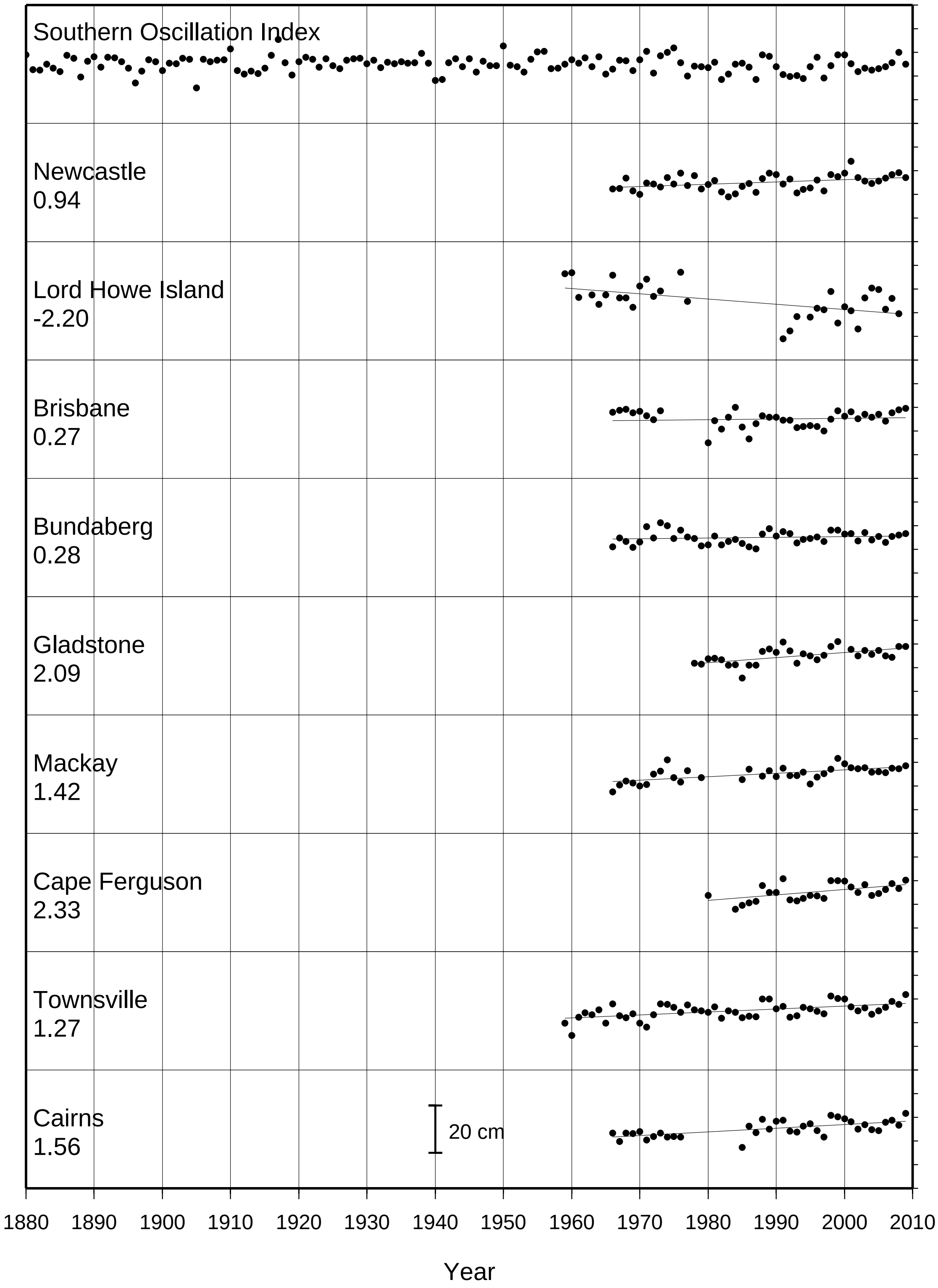

Figure 1d. Relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive. The plotted points represent the observed annual mean sea levels. The annual Southern Oscillation Index is also plotted for comparison.

SEA LEVEL TRENDS FROM LEAST SQUARES ANALYSIS (mm/yr)

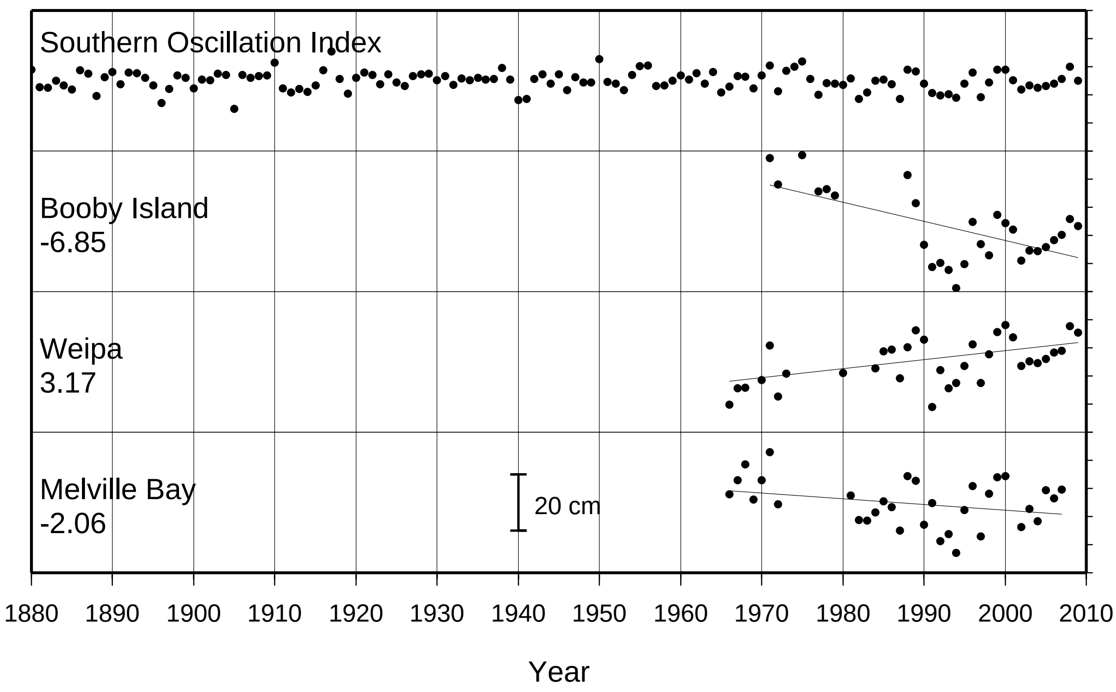

Figure 1e Relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive. The plotted points represent the observed annual mean sea levels. The annual Southern Oscillation Index is also plotted for comparison.

Trends in long-term sea level records (> 25 years)

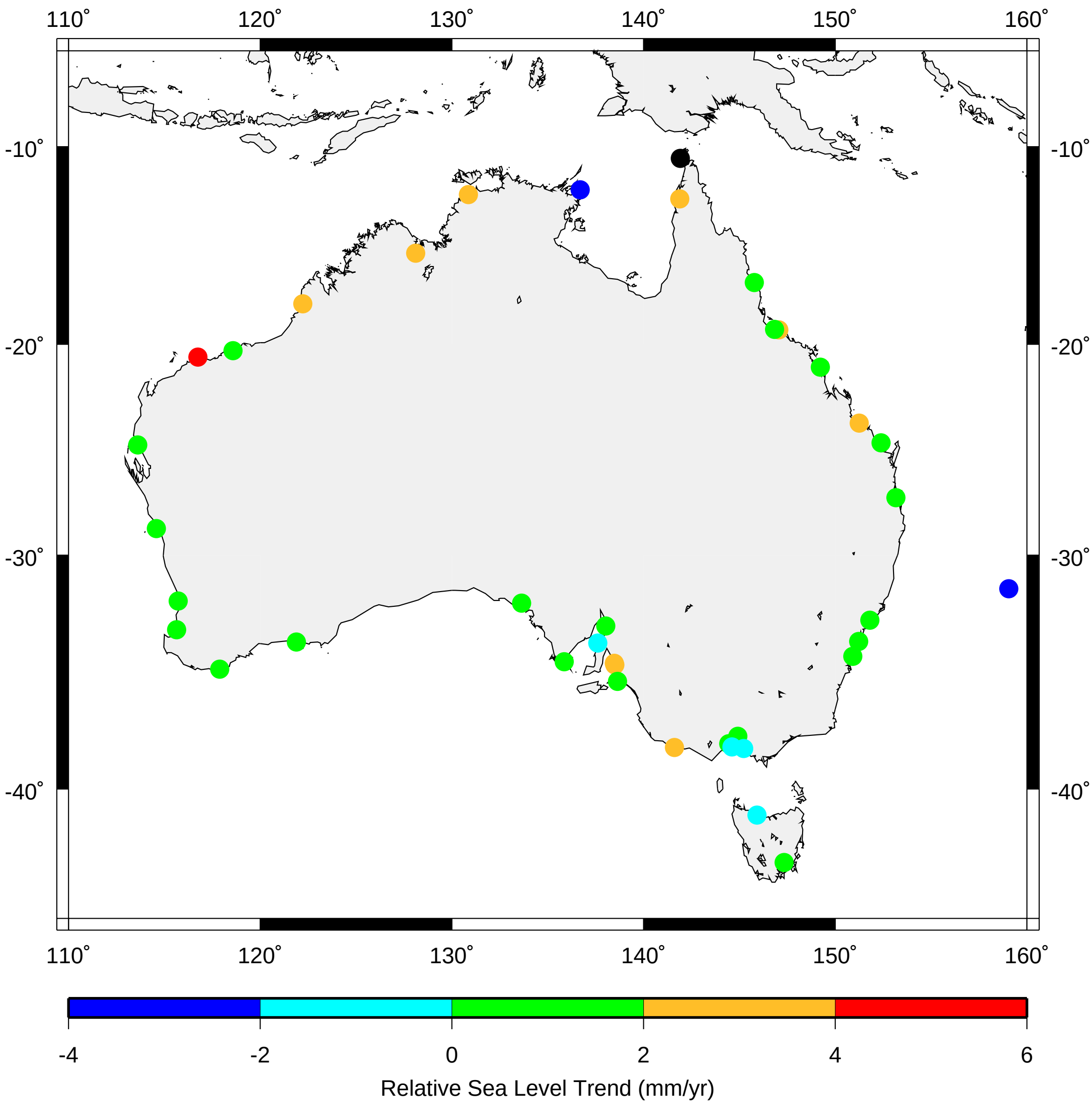

Figure 2. Distribution of relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive.

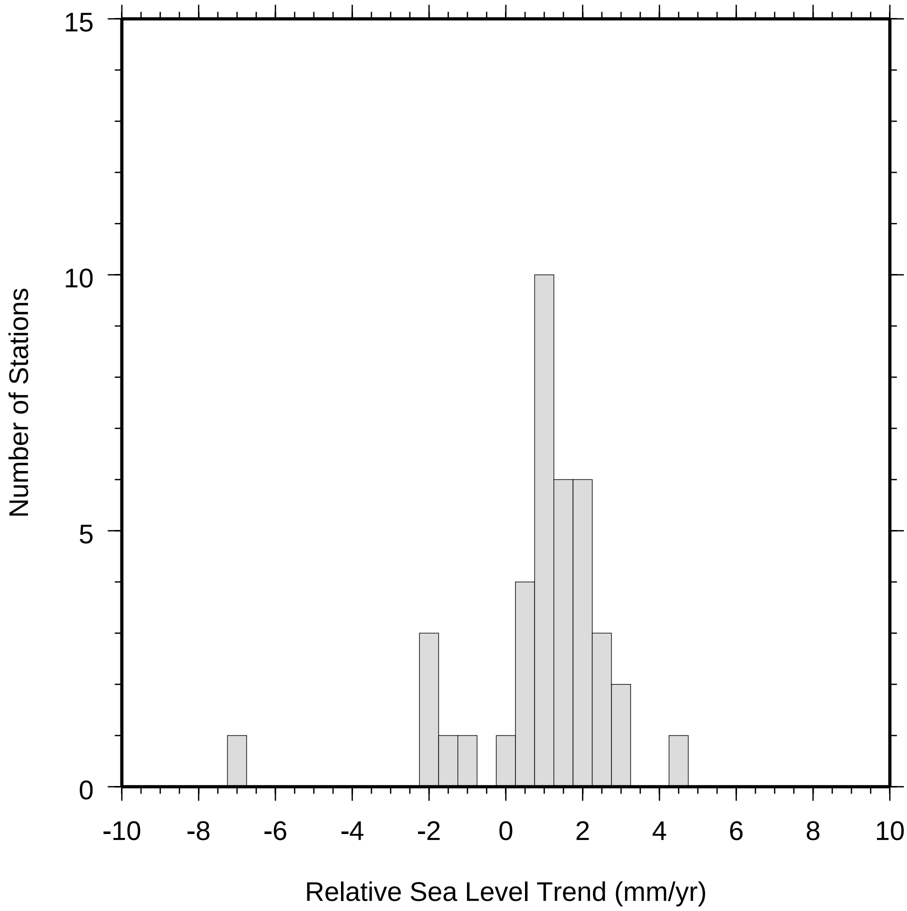

Figure 3. Histogram of relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive.

Location	Longitude	Latitude	Years of Data	Trend (mm/yr)
Darwin	130.850	-12.467	46.9	2.0
Wyndham	128.100	-15.450	38.0	2.8
Broome	122.217	-18.000	35.4	2.7
Port Hedland	118.583	-20.300	39.9	1.6
King Bay [1]	116.750	-20.633	26.8	4.3
Carnarvon	113.617	-24.883	35.8	1.9
Geraldton	114.583	-28.783	43.9	1.1
Fremantle	115.733	-32.050	102.6	1.5
Bunbury	115.633	-33.317	42.3	1.1
Albany	117.883	-35.033	43.4	1.0
Esperance	121.900	-33.867	43.2	0.9
Thevenard	133.650	-32.150	42.9	1.1
PortLincoln	135.867	-34.717	44.0	1.8
PortPirie	138.017	-33.167	66.3	0.6
Wallaroo	137.600	-33.900	25.8	-0.2
PortAdelaide-inner	138.500	-34.850	50.7	2.1
PortAdelaide-outer	138.483	-34.783	67.1	2.2
VictorHarbor	138.633	-35.567	42.5	1.0
Portland	141.600	-38.333	27.2	2.3
Williamstown	144.917	-37.867	43.5	1.4
Geelong	144.433	-38.167	36.3	1.1
PointLonsdale [1]	144.617	-38.300	45.9	-1.3
StonyPoint [1]	145.217	-38.367	29.8	-2.0
Burnie [1]	145.917	-41.050	37.2	-1.2
Hobart	147.333	-42.883	38.6	0.8
PortKembla	150.917	-34.483	31.6	0.7
FortDenison	151.233	-33.850	93.7	0.9
Newcastle	151.800	-32.917	43.8	0.9
LordHowe [1]	159.067	-31.517	31.1	-2.2
Brisbane	153.167	-27.367	37.6	0.3
Bundaberg	152.383	-24.767	42.2	0.3
Gladstone	151.250	-23.833	30.3	2.1
Mackay	149.233	-21.117	36.5	1.4
Cape Ferguson	147.058	-19.277	25.8	2.3
Townsville	146.833	-19.250	50.3	1.3
Cairns	145.783	-16.917	36.0	1.6
Booby Island [1]	141.917	-10.600	26.2	-6.9
Weipa [1]	141.883	-12.667	32.7	3.2
MelvilleBay [1]	136.700	-12.217	29.4	-2.1

Locations	Number of stations	Years of Data	Trend (mm/yr)	
		Avg	Avg	Std Dev
All	39	42.1	0.9	1.9
Excluding [1]	31	44.6	**1.4**	0.7

[1] Trend values that differ by more than +/- 1 standard deviation from the overall mean.

Table 1. Relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive.

References

Belperio, A.P. (1993). Land subsidence and sea level rise in the Port Adelaide estuary: implications for monitoring the greenhouse effect. *Australian Journal of Earth Sciences* 40, 359-368.

Bevis M., W. Scherer and M. Merrifield (2002). Technical Issues and Recommendations Related to the Installation of Continuous GPS Stations at Tide Gauges*. Marine Geodesy* 25 (1-2), 87-99

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