Australian Mean Sea Level Survey 2003
National Tidal Centre
Bureau of Meteorology

Australian Government

Bureau of Meteorology

Trends in relative sea level have been derived for 32 Australian long-term sea level records (>25 years) that are archived at the National Tidal Centre (NTC). The datasets are hourly sea levels with respect to the tide gauge zero, which is tied to the primary 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). This provides continuity in the sea level timeseries in the event the tide gauge is damaged in a storm or accident, or replaced due to harbour development. Errors in the timing of the recorders, digitising and datum shifts are found and corrected wherever possible. Nevertheless, some undocumented datum shifts have been identified at a few locations.

The sea level data is harmonically analysed for tides and seasonal cycles in addition to the linear trend term. The trend estimate will change as new data is accumulated, and its confidence interval or precision will improve with the length of the record. The minimum length of sea level record used in this survey is 25 years, which provides a reasonable initial estimate of the underlying long-term secular sea level trend aside from the effects of inter-annual and inter-decadal sea level fluctuations associated with variations in climate, such as El Niño – Southern Oscillation and Pacific Decadal Oscillation. It also allows for a complete cycle of the nodal recession of the Moon, which has a period of 18.6 years.

The observed trend in relative sea level will include the effect of any vertical land movement at the tide gauge site, which must be taken into account in order to estimate absolute sea level rise. The contribution of vertical land movement to relative sea level trend is generally site specific, and for coastal policy it may be appropriate to address this issue in site-specific policy documents or regulations (Harvey et al 2000). Sediment compaction and land subsidence is commonly associated with harbours and tide gauge sites (Belperio, 1993, Harvey et al, 2000). 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 (Harvey et al, 2000).

The trend estimates for each of the long-term relative sea level records are listed in Table 1. The majority are found to be in the 0 - 2 mm/yr range (Figure 1), which are distributed reasonably uniformly around the Australian coastline (Figure 2). The overall average relative sea level trend for all 32 long-term stations around Australia to December 2003 is 0.9 mm/yr. The negative trends at Point Lonsdale (-1.57), Burnie (-1.59) and Melville Bay (-2.43) are notable outliers to the national average, suggesting substantial contamination due to unstable tide gauge datum. Excluding these stations, and with no further account for the contribution from vertical land movement, the overall average relative sea level rise around Australia is 1.2 mm/yr. This is consistent with a global average sea level rise over the last 100 years of 1 – 2 mm/yr (IPCC, 2001).

The annual mean sea levels and computed trendlines for each station are plotted in Figures 3a-3d. A striking feature is the degree of correlation in the annual sea levels, particularly anticlockwise from Darwin through to Victor Harbor. The annual sea levels are also strongly correlated with El Niño – Southern Oscillation, as indicated by the Southern Oscillation Index (SOI) which is plotted for comparison. Coherent inter-decadal sea level oscillations with periods of around 20 years are also notable, which can mask the longer-term secular trend and has implications for the length of record required to detect it.

The effect of site-specific land movements or datum shifts can be demonstrated through differences in the relative sea level trends between neighbouring tide gauge sites. Port Pirie for example is located on land undergoing postglacial rebound (Harvey et al, 1999), which contributes to a net rate of relative sea level rise of only 0.07 mm/yr. In contrast Port Adelaide (several hundred kilometres to the south) has undergone land subsidence associated with wetland reclamation, urban and industrial development and groundwater withdrawal (Belperio, 1993), which has resulted in a net relative sea level rise measured by the two tide gauges there of 2.1 mm/yr. Similar discrepancies in the relative sea level trend are found between Williamstown (1.08 mm/yr) and Point Lonsdale (-1.57 mm/yr). At Burnie the annual mean sea levels early in the record are clearly contaminated, the lower quality data contributing to an unlikely trend (-1.59 mm/yr) that illustrates the importance of precise datum control and rigorous data management for long-term sea level monitoring.

References

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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

Harvey, N., E. Barnett, R.P. Bourman, and A.P. Belperio (1999). Holocene sea-level change at Port Pirie, South Australia: A contribution to global sea-level rise estimates from tide gauges. *Journal of Coastal Research* 15(3), 607-615.

Harvey, N., A.P. Belperio and R.P. Bourman (2000). Regional Coastal Response to Sea Level Rise: Relevance for Coastal Policy and Vulnerability Studies. *Proceedings of the Pacific Islands Conference on Climate Change, Climate Variability and Sea Level Rise. Raratoga, Cook Islands 3-7 April 2000. National Tidal Facility Australia, Flinders University of South Australia*.

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Location	Longitude	Latitude	Years of Data	Trend (mm/yr)
Darwin	130.85	-12.4667	40.9	1.54
Wyndham	128.1	-15.45	32.2	2.06
Broome	122.217	-18	29.6	2.23
Port Hedland	118.583	-20.3	33.9	0.79
Carnarvon	113.617	-24.8833	29.8	1.68
Geraldton	114.583	-28.7833	37.9	0.46
Fremantle	115.733	-32.05	96.6	1.47
Bunbury	115.633	-33.3167	36.5	1.03
Albany	117.883	-35.0333	37.4	0.6
Esperance	121.9	-33.8667	37.2	0.47
Thevenard	133.65	-32.15	36.9	0.77
Port Lincoln	135.867	-34.7167	38.2	1.57
Port Pirie	138.017	-33.1667	60.4	0.07
Port Adelaide - Inner	138.5	-34.85	42.0	2.1
Port Adelaide - Outer	138.483	-34.7833	61.1	2.09
Victor Harbor	138.633	-35.5667	36.5	0.88
Williamstown	144.917	-37.8667	37.8	1.08
Geelong	144.433	-38.1667	30.8	0.5
Point Lonsdale *	144.617	-38.3	40.1	-1.57
Burnie *	145.917	-41.05	31.2	-1.59
Georgetown	146.85	-41.1333	28.8	0.3
Hobart	147.333	-42.8833	34.8	0.91
Port Kembla	150.917	-34.4833	25.6	0.65
Fort Denison	151.233	-33.85	87.7	0.91
Newcastle	151.8	-32.9167	37.8	0.87
Brisbane	153.167	-27.3667	31.6	1.9
Bundaberg	152.383	-24.7667	36.2	0.39
Mackay	149.233	-21.1167	30.5	1.62
Townsville	146.833	-19.25	44.3	1.33
Cairns	145.783	-16.9167	30.0	1.66
Weipa	141.883	-12.6667	26.7	3.07
Melville Bay *	136.7	-12.2167	26.2	-2.43
Average (all stations)			**39.6**	**0.9**
Average (excluding *)			**40.3**	**1.2**

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.

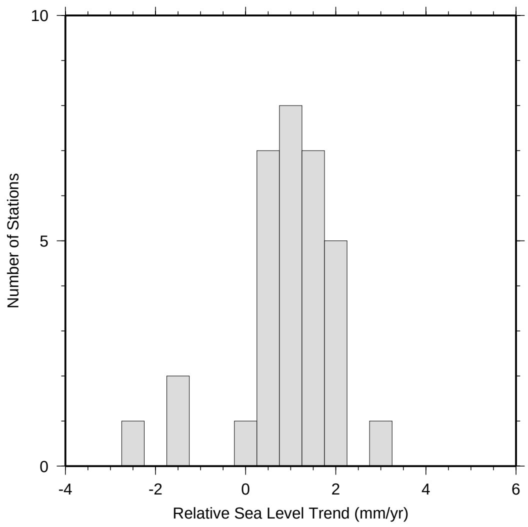

Figure 1. Histogram of relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive.

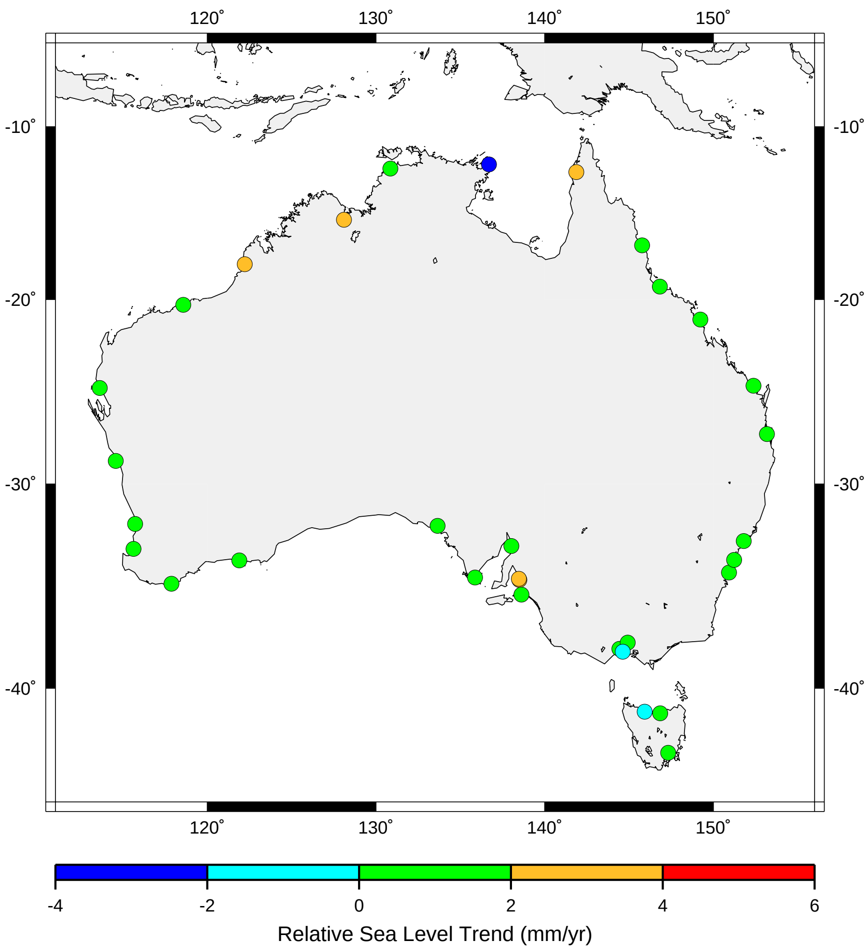

Figure 2. Distribution of relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive.

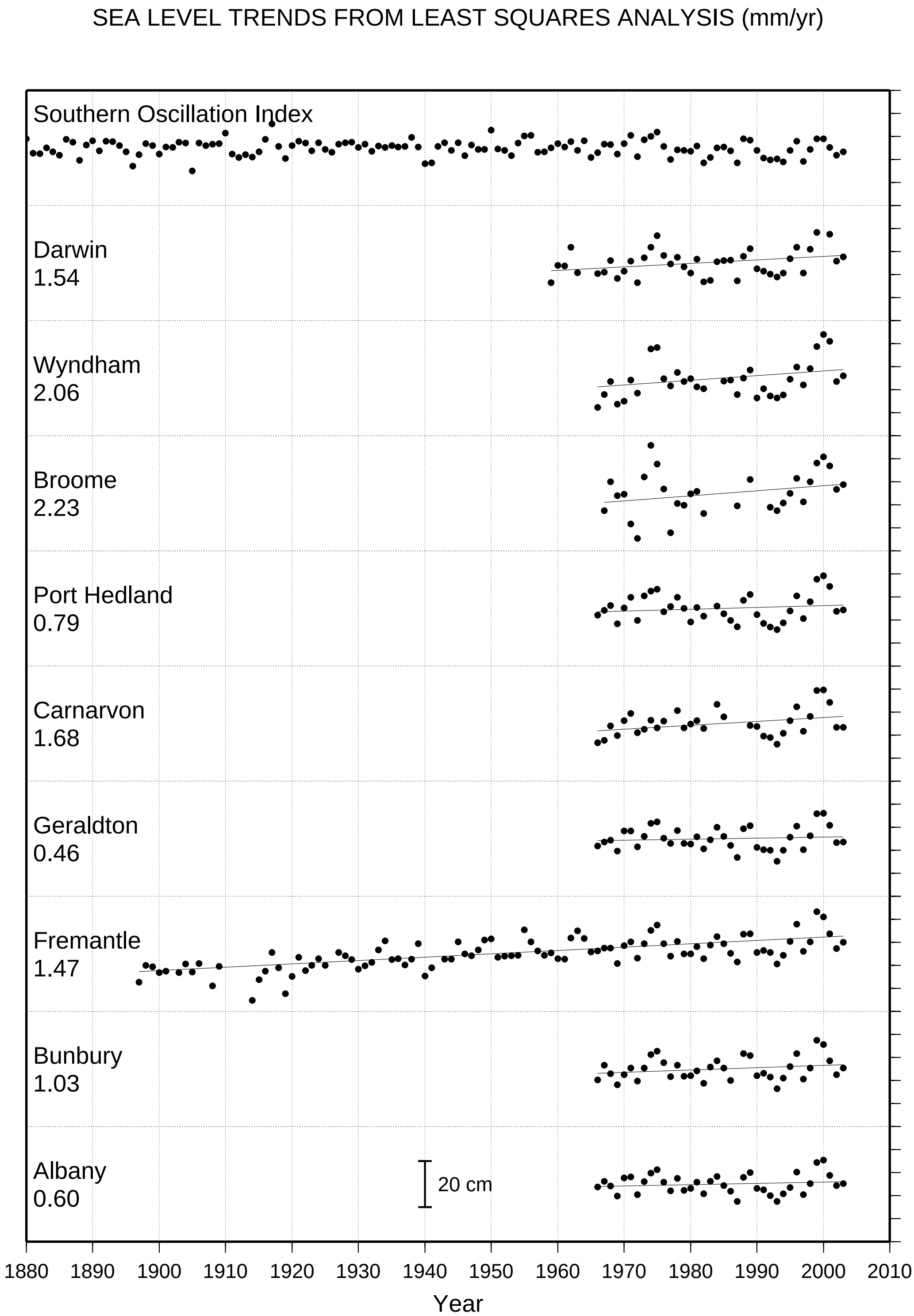

Figure 3a. Relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive. The plotted points represent the observed annual mean sea levels. The annual Southern Oscillation Index is also plotted for comparison.

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

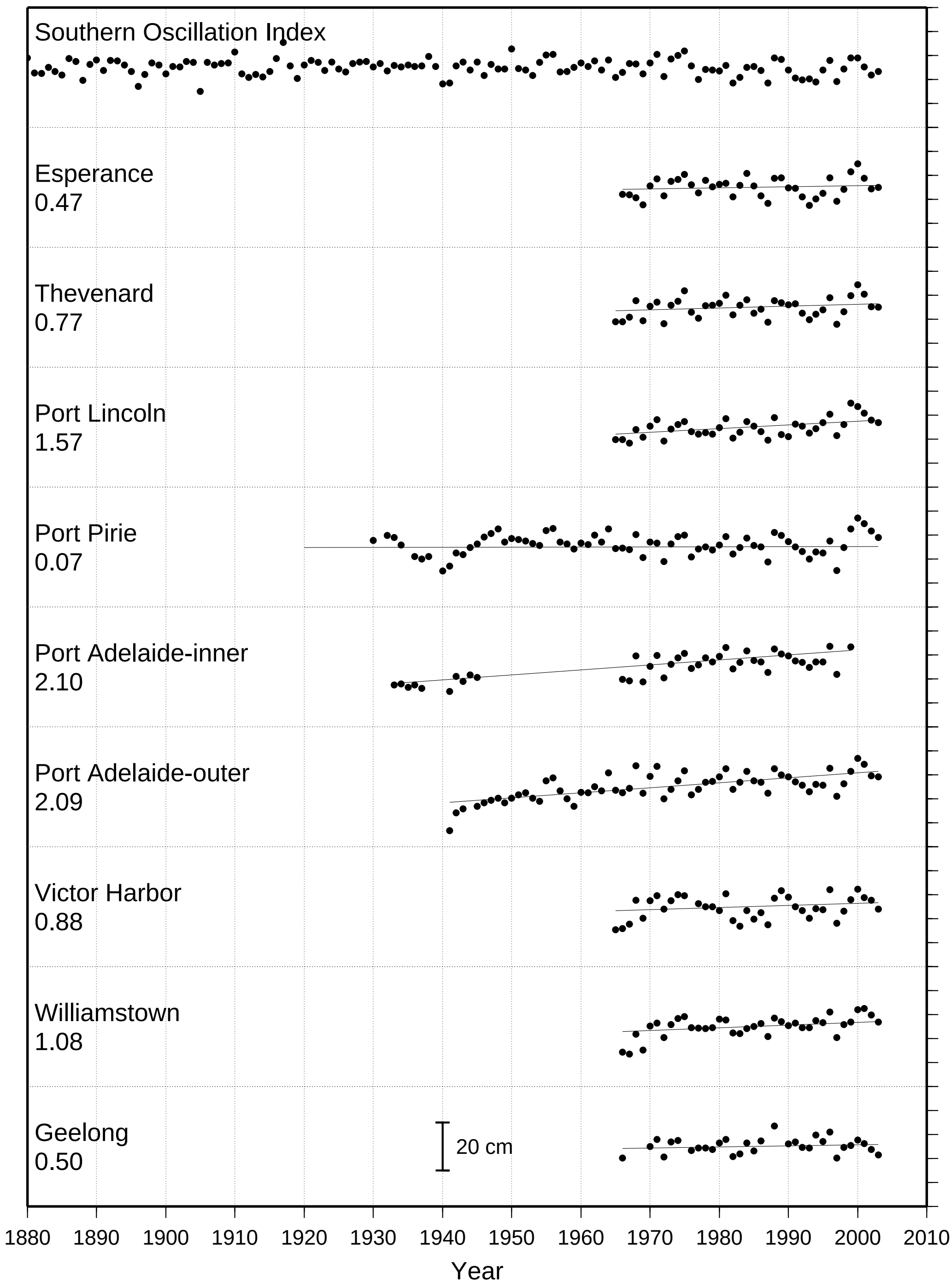

Figure 3b. Relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive. The plotted points represent the observed annual mean sea levels. The annual Southern Oscillation Index is also plotted for comparison.

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

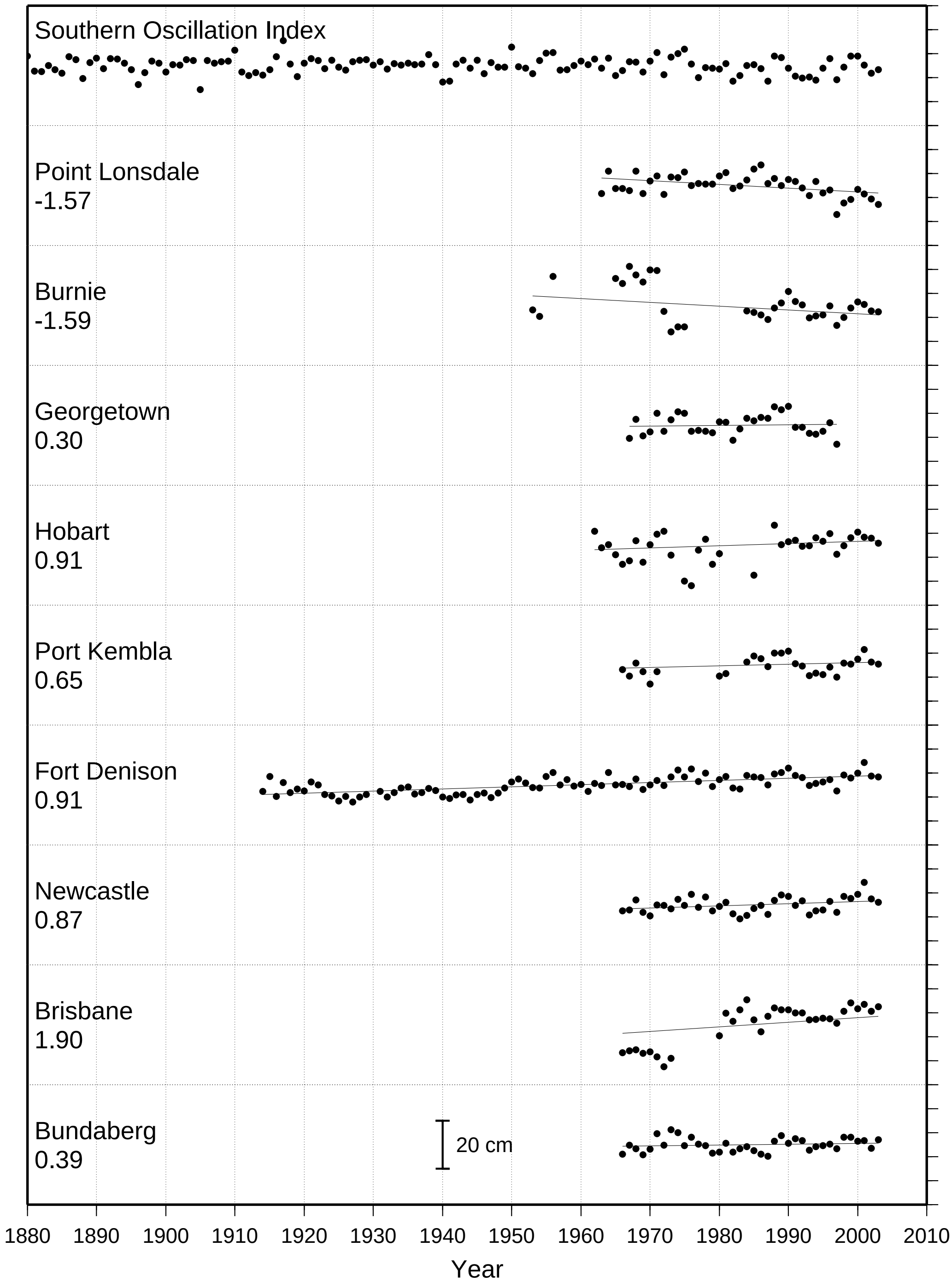

Figure 3c. Relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive. The plotted points represent the observed annual mean sea levels. The annual Southern Oscillation Index is also plotted for comparison.

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

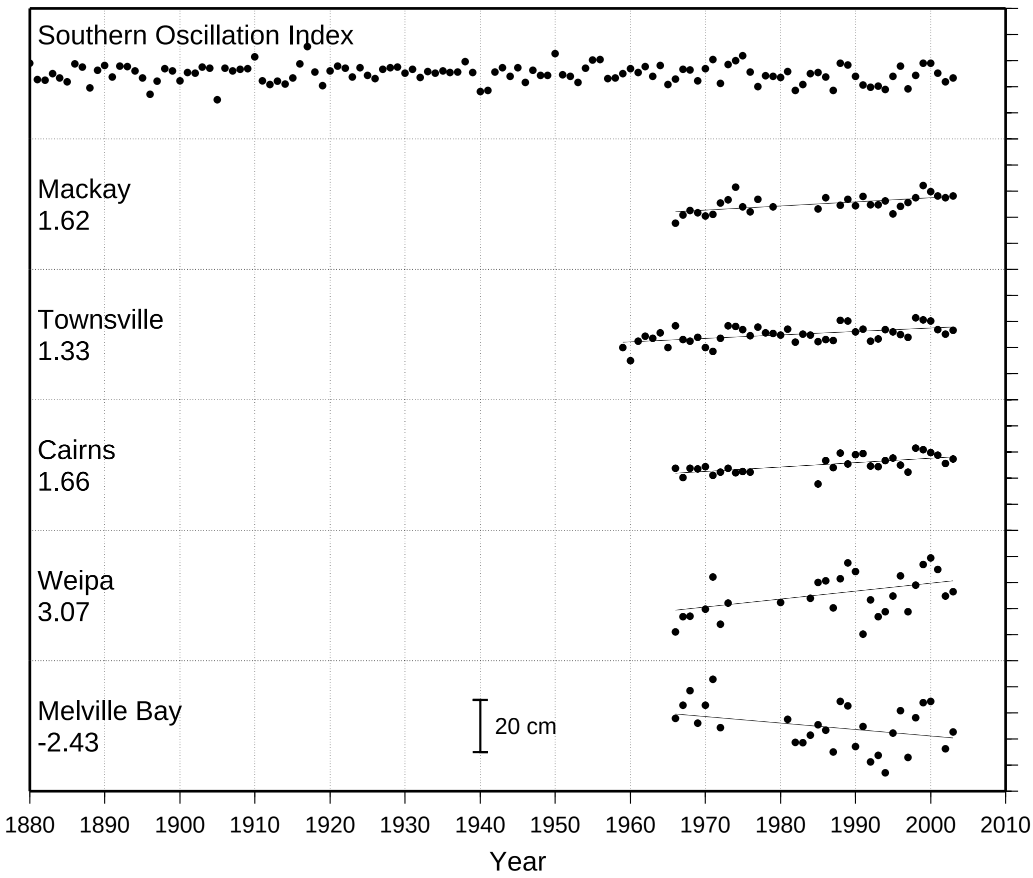

Figure 3d. Relative sea level trend estimates for tide gauges around Australia that have at least 25 years of hourly data on the NTC archive. The plotted points represent the observed annual mean sea levels. The annual Southern Oscillation Index is also plotted for comparison.