NSW coastal inundation hazard study: coastal storms and extreme waves

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Publication details:
Report No. UNSW Water Research Laboratory Technical Report No. 2010/16

Publication Date:
2011

DOI:
https://doi.org/10.4225/53/58e1d86745cd6

THE UNIVERSITY OF NEW SOUTH WALES
water research laboratory
Manly Vale N.S.W. Australia

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NSW COASTAL INUNDATION HAZARD STUDY:
COASTAL STORMS AND EXTREME WAVES

by

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Technical Report No	2010/16
Report Status	Final
Date of Issue	January 2011
WRL Project No.	09095
Project Manager	T D Shand

Title	NSW Coastal Inundation Hazard Study: Coastal Storms and Extreme Waves
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EXECUTIVE SUMMARY

The NSW coast is subject to a generally moderate wave climate periodically affected by large wave events originating from offshore storm systems. Such events, particularly when they occur coincidently with high water levels, may cause coastal inundation, beach erosion, damage to property and marine structures, and risks to public safety. Accurate estimation of the likelihood and magnitude of large wave events is essential for the quantification of extreme beach erosion and inundation levels, design of nearshore structures, and long-term coastal management.

Following a series of intense and damaging storms in 1974, a network of wave buoys has been incrementally established along the NSW coast by the NSW Department of Public Works. Data from this wave buoy network is presently collected by Manly Hydraulics Laboratory (MHL) for the NSW Department of Environment, Climate Change & Water (DECCW). This study, undertaken for DECCW under the Natural Disaster Mitigation Program (NDMP), has used state-wide wave buoy data collected by DECCW, Sydney Ports Corp and Queensland DERM, together with numerical hindcast and nowcast wave data from the US Oceanic and Atmospheric Administration (NOAA) and European Centre of Medium-Range Forecasting (ECMRF) to:

- Critically review the NSW coastal storm types that affect the NSW coast,
- Determine the spatial distribution and seasonal variation of these classified storm types
- Determine the statistical distribution of extreme wave height and storm duration using wave buoy data from nine locations along the NSW and southern Queensland coast spanning the years 1971 to 2009, and
- Derive extreme wave height with different return periods along the NSW coast.

Results show the mean significant wave height (H_{sig}) along the NSW coast to be relatively consistent, ranging from 1.43 m at Batemans Bay to 1.63 m at Sydney, although seasonal variation is evident in the north with larger waves occurring during autumn and smaller waves occurring during spring and summer. Storm wave data has been classified into one of the following six synoptic types: Tropical Cyclone; Easterly Trough Low; Continental Low; Southern Tasman Low; Southern Secondary Low; Inland Trough Low; Anticyclone Intensification; Tropical Low. Major storm events (H_{sig} > 6 m) in the north are a mixture of tropical cyclones, tropical lows and easterly trough lows while in the mid coast, major storm events also include inland trough lows and southern secondary lows. In the south, tropical cyclones and lows do not contribute to major storm events which are instead a combination of easterly trough lows, inland and continental lows and southern secondary lows, with a number of southerly trough (Southern Tasman) lows causing waves in excess of 5 m but not reaching 6 m. A seasonal analysis of storminess (i.e. storm frequency) shows March, July and October

to be the stormiest months, with November, December and January being the least stormy. Tropical cyclones and lows are restricted to December to April with most occurring between January and March. Easterly trough lows are concentrated between April and August.

Extreme statistics were evaluated using standard extreme values analysis techniques with a Weibull probability distribution function was found to provide the best fit to data. Based on approximately 20-30 years of data, 100 year design values can now be estimated with a 90% confidence interval of +/-10%. Results showed the mid NSW coast to exhibit the highest extreme wave climate with a 100 year ARI, one hour exceedance height of 9.0 m at Sydney and 9.1 m at Botany Bay. Extreme height decreases to the north and south reaching 8.0 m at Brisbane and 8.5 m at Eden. Both Batemans Bay and Byron Bay exhibit the lowest extreme heights of 7.7 and 7.6 m respectively. Inclusion of notable missing storm events at Byron Bay and Batemans Bay by interpolation from adjacent buoys were found to increase the extreme statistics slightly, however, the values remained within the 90% confidence limits. Wave direction was found to influence extreme values. The extreme values of wave events arriving from north of 90° were found to be approximately 25% lower of the *'all direction'* values, wave events from the east to southeast were approximately 5% lower than the *'all direction'* values and waves arriving from south of south-east were typically equivalent to the 'all direction' values and would be adopted as the design direction.

Extreme values derived using buoy measurements were compared with those derived using numerical wave datasets (NOAA WW3 and ECMRF ERA-40). Overall, the NWW3 numerical model resulted in over prediction of extreme vales in the north and under prediction in the south, while the ERA-40 dataset resulted in general under prediction of extreme values across all regions. Apart from a limited number of locations, differences were generally outside the evaluated 90% confidence limits. This result indicates that numerical models should not be used to derive extreme wave climates on the NSW coast. The ERA-40 under prediction is of key concern to coastal engineers using this data for design in other regions.

Summary of Spatial Variation in One Hour Exceedance H_{sig} along the NSW Coast

	H_{sig} (m) ± 90% CI			
Buoy	**1 yr ARI**	**10 yr ARI**	**50 yr ARI**	**100 yr ARI**
Brisbane	5.1 (± 0.2)	6.6 (± 0.3)	7.6 (± 0.4)	8.0 (± 0.4)
Byron Bay	5.2 (± 0.2)	6.4 (± 0.2)	7.2 (± 0.3)	7.6 (± 0.3)
Coffs Harbour	5.2 (± 0.2)	6.7 (± 0.3)	7.7 (± 0.4)	8.1 (± 0.4)
Crowdy Head	5.4 (± 0.2)	7.0 (± 0.4)	8.0 (± 0.5)	8.5 (± 0.5)
Sydney	5.9 (± 0.2)	7.5 (± 0.4)	8.6 (± 0.5)	9.0 (± 0.5)
Botany Bay	5.7 (± 0.2)	7.4 (± 0.3)	8.6 (± 0.4)	9.1 (± 0.4)
Port Kembla	5.4 (± 0.2)	7.1 (± 0.3)	8.3 (± 0.4)	8.8 (± 0.5)
Batemans Bay	4.9 (± 0.2)	6.3 (± 0.4)	7.3 (± 0.5)	7.7 (± 0.5)
Eden	5.4 (± 0.2)	7.0 (± 0.3)	8.1 (± 0.4)	8.5 (± 0.5)

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1. INTRODUCTION

The NSW coast is subject to a generally moderate wave climate predominantly from the south to south-east. Previous studies have found an average offshore significant wave height of 1.5 to 1.6 m and average peak period of 9.4 to 9.7 s (Lord and Kulmar, 2000). This generally moderate wave climate is periodically affected by large wave events originating from offshore storm systems. These storms vary both spatially and temporally in their genesis, intensity and track. Storm types which affect the NSW coast include tropical cyclones, easterly trough lows (east coast lows) and southern secondary lows. Full descriptions of NSW coastal storm types including genesis, characteristics and typical coastal effects are provided within Chapter 2.

Very large storm events such as those which occurred in 1974 (*'Sygna Storm'*) , 1997 (the *'Mothers Day Storm'*), 2001 and 2008 (the *'Pasha Bulker Storm'*) occasionally impact the coastline and, particularly when they are co-incident with high water levels, may cause widespread coastal inundation, beach erosion, damage to property and marine structures, and risks to public safety (Figure 1.1). Accurate estimation of the likelihood and magnitude of large wave events is essential for the quantification of extreme beach erosion and inundation levels, design of nearshore structures, and long-term coastal management.

Following a series of intense and damaging storms in 1974, a network of wave buoys was incrementally established along the NSW coast by the NSW Department of Public Works. Data from these buoys is collected by Manly Hydraulics Laboratory for the Department of Environment and Climate Change. Analysis of wave records, collected over a sufficient time period, allows quantification of extreme wave heights and, using appropriate extreme value analysis, characterisation of large, low probability wave events. These low probability events are generally described by either their average recurrence interval (ARI) or return period (RP), both of which describe the average time interval between events exceeding a particular magnitude, or by their annual exceedance probability (AEP). The AEP describes the probability of an event which exceeds a particular magnitude occurring in any given year. The relationship between average recurrence interval and annual exceedance probability is near reciprocal, and given by Eqn. 1-1.

$$AEP = 1 - \exp\left(\frac{-1}{ARI}\right) \qquad (1\text{-}1)$$

While the use of particular terminology to describe extreme events is interchangeable and somewhat arbitrary, the use of average recurrence interval and return period has been criticised for being "*sometimes misinterpreted as implying that the associated magnitude is only exceeded at regular intervals, and that they are referring to the elapsed time to the next exceedance*" (Australian Rainfall and Runoff Guidelines, IE Aust., 1987). The probability of an event of particular magnitude (AEP/ARI) occurring within a specified timeframe (TL) is given by Eqn. 1-2 and presented within Table 1.1.

$$P(Z) = 1 - (1 - AEP)^{T_L} \qquad (1\text{-}2)$$

Table 1.1
Probability of Event Occurrence within a Specified Timeframe

Event Average Recurrence Interval (ARI; Years)		Probability of event occurrence within					
		1 year	5 years	10 years	20 years	50 years	100 years
	1	1.00	1.00	1.00	1.00	1.00	1.00
	5	0.20	0.67	0.89	0.99	1.00	1.00
	10	0.10	0.41	0.65	0.88	0.99	1.00
	50	0.05	0.23	0.40	0.64	0.92	0.99
	100	0.01	0.05	0.10	0.18	0.39	0.63
	1000	0.001	0.005	0.01	0.02	0.05	0.10

Previous evaluations of extreme wave heights along the NSW coast include:

- Lawson and Abernethy (1974) evaluated three years of wave data collected by the Maritime Services Board of New South Wales at Botany Bay, Sydney to derive exceedance statistics. Due to the short record length, ARI type statistics were not derived.
- Blain, Bremner and Williams Pty Ltd and Lawson and Treloar Pty Ltd (PWD, 1985; 1986) evaluated historical storm events between 1880 to 1985. Proxy wave heights were assigned on the basis of historical charts, weather bulletins and reports, newspapers and other studies and theses and extreme wave heights derived for the north, mid-north, central and south coast sector. Derived extreme wave heights generally increased from south to north, with the derived 100 year ARI significant wave height on the north coast estimated at between 12.27 and 12.55 m depending on the selection of extreme value distribution.
- Lord and Kulmar (2000) presented an analysis of wave buoy data at all buoys up until 1999 including evaluation of extreme wave heights for Byron Bay, Sydney and Eden for events of between one and 24 hour duration. The 100 year ARI significant wave height with a 1 hr duration for Byron Bay was estimated at 7.8 m, for Sydney at 8.6 m

and for Eden at 9.3 m. This indicates a reverse spatial trend from the PWD (1985; 1986) studies.

- You (2007) examined the fit of nine extreme value distributions to long term wave data (1988 to 2006) for the Sydney wave buoy and found the 100 year ARI significant wave height to vary between 7.04 m and 9.63 m depending on selection of extreme value distribution. You (2007) found the FT-1 (or Gumbel) and Weibull distributions provided the best fit, with derived 100 year ARI significant wave heights of 8.62 and 8.61 m respectively.

Confidence in predicted extreme values depends primarily on the length and quality of recorded data. Pugh (1987) suggested that extrapolation of extreme value distributions should be limited to three to four times the record length. Analysis undertaken within this present study shows that the 90% confidence limits for design waves along the NSW coast for the 100 year storm are now less than 10%.

A key assumption of this present study and of previous studies is that of statistical stability which is related to stationarity in the long-term climate. Present climate assessments (IPCC, 2007) indicate, however, the intensification of storm events under global warming scenarios (DCC, 2009).

1.1 Scope of Works and Report Structure

The Department of Environment, Climate Change and Water (DECCW) is presently undertaking a state-wide study of Coastal Inundation Hazard under the Natural Disaster Mitigation Program (NDMP), with the study split into *Coastal Storms and Extreme Waves* and *Elevated Coastal Water Levels* components. The Water Research Laboratory, UNSW (WRL), Climate Futures at Macquarie, and Access Macquarie (Macquarie University) were commissioned to investigate the characteristics and impacts of NSW coastal storms and to determine the statistical distribution of extreme storm wave heights along the NSW coast.

A full description of NSW coastal storm climatology is provided within Section 2. This includes a review of the generation mechanisms, typical storm track and coastal impacts of the various storm types known to affect the NSW coast, with specific examples provided for particular types. Section 3 presents sources of wave data including wave buoys and numerical sources. Details of the locations, attributes and completeness of each dataset are presented. Section 4 presents the analysis of wave data sets. Wave data statistics for each of the analysed wave buoy data sets are presented and individual storm events located and assigned storm types. An extreme value analysis using appropriate probability distribution functions was undertaken for each wave buoy with results compared to those derived from numerical sources. The spatial and temporal variation of the different storm types and of the derived extreme values is discussed, along with the effect of storm duration and direction. Section 5 presents conclusions and recommendations based on the study results.

1.2 Significance of Study

This study has reviewed characteristics of storms which impact the NSW coastline using data collected over the past 38 years. Trends in the spatial and temporal distribution of coastal storms causing large wave events are presented and discussed. The study has derived extreme wave heights corresponding to low annual exceedance probability events for a range of storm durations and evaluated the effect of storm direction and spatial variation throughout NSW. Results of this study will have useful and highly practical application in a number of important areas including:

- Evaluation of the contribution of extreme waves to elevated coastal water levels;
- Design of offshore and nearshore structures and infrastructure;
- Providing boundary conditions for study of beach response to extreme wave events;
- Improved understanding of extreme storm climatology leading to large wave events on the NSW coast.

Collaroy-Narrabeen Beach, Sydney. March, 1976. Photograph: A. Short

Jonson St, Byron Bay, 1973. Photograph: K. Dunstone c\ Byron Shire Council.

2. NSW COASTAL STORM CLIMATOLOGY AND IMPACTS

The NSW coast spans the southern Coral Sea to the Southern Tasman Sea across the sub-tropical to mid-latitude zone. Extreme wave energy is mainly generated within the Coral Sea and Tasman Sea window, but can also be generated from outside this zone: in the South – West Pacific tropics; and, in the Southern Ocean in the extra-tropics. Aspects of the wave climate for the NSW coast have been previously described by Short and Trenaman (1992), Kulmar *et al.* (2005), numerous NSW PWD and MHL reports, including an annual wave climate summary, the NSW Coastline Management Manual (NSW Govt., 1990) and Hemer *et al.* (2007). The relationship between the SE Queensland and NSW modal wave climate and hemispheric climate variability modes has been explored by Phinn and Hastings (1999), Ranasinghe *et al.* (2004), Goodwin (2005) and Harley *et al.* (2009). Comprehensive, long-term storm wave climatologies for NSW have been reconstructed from historical records by PWD (1985) and Helman (2007). These studies have estimated quantitative storm parameters and provided information on the impact and effects of particular storm events.

Statistical evaluations of storm wave climates have been undertaken by Lawson and Treloar/PWD (1986), Webb and Kulmar (1990), Lord and Kulmar (2000), You and Lord (2008) and Speer *et al.* (2009), with a specific focus on extreme waves generated by East Coast Cyclones. Extreme storm impacts, including: beach and dune erosion, dune overtopping and inundation, storm surge, and estuarine inlet breakthrough and/or migration are outlined in the Coastline Management Manual (NSW Govt., 1990) and have been reported for individual storm events (e.g. Lord and Kulmar, 2000, Watson *et al.* 2008) and for individual beaches and estuaries.

Due in part to their rapid intensification and complexity, East Coast Cyclones have proven difficult to both forecast and categorise. The Australian Bureau of Meteorology (BOM) used seven different storm categories to compile their NSW maritime low database, while the PWD report used a different six categories. Holland *et al.*(1987) discussed three types of East Coast Cyclone events and Hopkins and Holland (1997) used a different eight classifications. As there is no broad consensus on what constitutes an East Coast Cyclone, discrepancies exist between these reports. The following definition proposed by Hopkins and Holland (1997) is similar to that used by the BOM.

"Any system with closed cyclonic circulation at sea level, which forms in a maritime environment between 20° and 40°S and within 500km of the coast. The Low pressure

system must exhibit at some stage of its lifetime a component of movement parallel to the coastline and have a pressure gradient of at least 4 hPa (100km)$^{-1}$."

Storms which fit this description can be divided into four types based on their origin, namely: East Coast Lows (ECL), Southern Secondary Lows (SSL), Inland Troughs (IT) and Tropical Cyclones (TC). The following definitions have been used to classify storms in this study and are based on the classifications used in PWD (1985) and Hopkins and Holland (1997) .

- East Coast Low (ECL) or Easterly Trough Low (ETL) storms are the primary type of ECC; they initially form as a trough in the easterly flow along the Queensland / Northern NSW coast. These storms move parallel to the coast and often intensify rapidly causing significant damage.
- Southern Secondary Low (SSL) storms form as a cut off low in the wake of a cold front in the mid-latitude westerly circulation.
- Inland Troughs (IT) form as troughs in the tropical heat low regions of Queensland and West Australia and move overland to the East Coast, often re-intensifying in the coastal environment. These storms occur mostly in the warmer months but in the right conditions, can occur at any time of the year.
- Tropical Cyclones (TC) tend to form north of 20°S in a homogeneous atmosphere that is warm and moist and they may sometimes move into higher latitude and re-intensify. TCs are rare in the winter months.

Although ECL, SSL, IT and TC storms all fit the Hopkins and Holland (1997) classification of an East Coast Cyclone, they are different weather systems often occurring under contrasting climatic conditions. ITs and TCs are both warm season weather systems and are rare in winter. The primary winter East Coast Cyclones are SSLs and ECLs; in both cases intensification at the surface is accompanied by an upper atmospheric trough or cut off low.

The storm climatology in this study is based on a synoptic typing approach that has expanded upon that used in the PWD (1985) study. A classification of the storm wave data into one of the following eight synoptic types was made: TC – Tropical Cyclone; TL – Tropical Low; AI – Anticyclone Intensification; ETL – Easterly Trough Low; CL – Continental Low; ITL – Inland Trough Low; STL – Southern Tasman Low and SSL – Southern Secondary Low. Figure 2.1 presents examples of these synoptic types and detailed descriptions of specific storm events are presented in Appendix A.

Between December and March, intense low pressure synoptic systems form in the Coral Sea and track south or south-east. These systems are classified by the BOM (1978) as Tropical Cyclones if the maximum winds occur near the centre of the system and the 10 minute mean winds are at least 17.5 m/s (34 knots) or Tropical Lows (TL) if wind speeds are lower. Tropical cyclones (TCs) are identified in the Australian region either by the BOM, the Fiji Meteorological Service in Nadi, or the NIWA Tropical Cyclone Warning Centre in Wellington, New Zealand. TCs produce extreme waves along the NSW coast with a wave direction from the eastern quadrant. Peak significant wave heights of up to 7.4 m have been observed in the buoy records and total storm duration can be very long as the systems move slowly along the coast or become stationary. Such events have a history of causing severe erosion and inundation along the NSW coastline due to their extreme wave height which often arrives from the easterly quadrant and the large storm surge often reported during such events. A storm surge of 0.68 m was reported to have occurred during Tropical Cyclone Pam in 1974 (Helman, 2007). This storm surge combined with a spring tide and lead to flooding of low lying areas of Brisbane and the Gold Coast and severe erosion on the Gold Coast, Sunshine Coast and Belongil Spit (Gordon *et al.* 1978) which had already been severely eroded by an earlier cyclone (TC Wanda, 24-27 Jan, 1974).

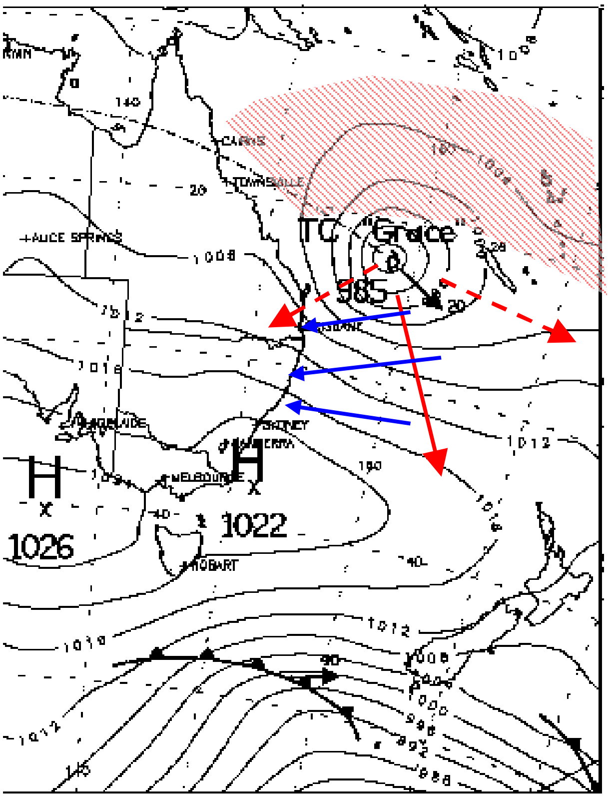
Extreme waves may also develop when the pressure gradient on the northward limb of the subtropical anticyclone (high pressure system) intensifies, which is termed Anticyclone Intensification (AI). Strong east or south-east winds develop across the Tasman Sea and often persist for over 100 hours due to the blocking of the anticyclone. While peak significant wave height induced by these systems rarely exceeds 5 m, the long duration of such events can still result in severe beach erosion.

Easterly Trough Lows (ETLs) are complex cold season meso to synoptic scale (50-500 km) weather systems. They form over the southern Coral Sea and northern to central Tasman Sea, bordering the east coast of Australia, and affect coastal regions from southern Queensland to Victoria. Their intense form and close proximity to the coast means that ETLs are responsible for some of the largest waves on record with a peak wave height of 8.9 m recorded at Botany Bay in May, 1997, but are also relatively confined spatially. ETLs can cause significant storm damage through storm winds, heavy rainfall leading to flooding, heavy seas, storm surge, wave setup and beach erosion. ETLs form on average several times per year, mostly in Autumn and Winter, with a maximum occurrence in June (Holland *et al.* 1987). Events can be as short as 16 hours or last for several days (Hopkins and Holland, 1997) and tend to be clustered over successive weeks when conditions are favourable (Allen and Callaghan, 2001). This tendency for clustering amplifies associated erosion by precluding substantial beach recovery between events.

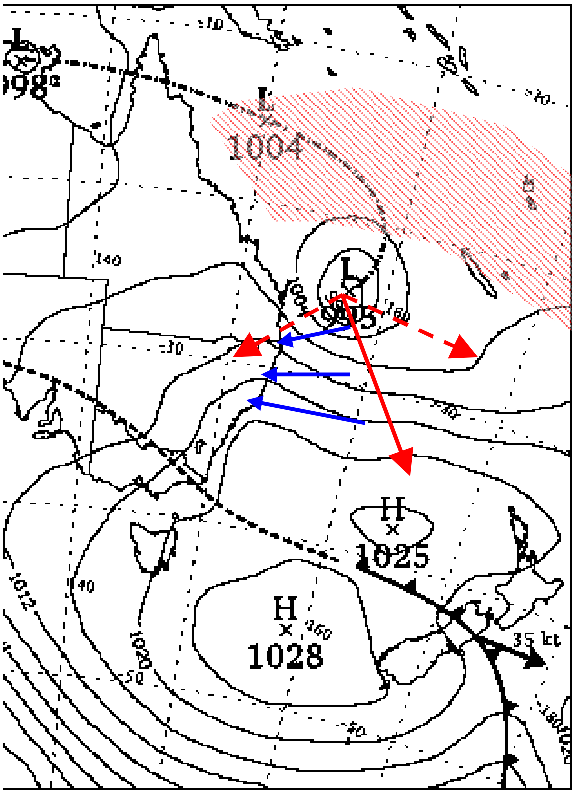
Continental lows form in the westerly airstream over southern Australia and travel eastwards over the continent. As the lows cross the eastern coastline of Australia, they can intensify and produce storm wave erosion. They are often associated with a strengthened subtropical anticyclone centred in the Great Australian Bight. The associated strong south-east wind field in the Southern Tasman, combines with the CL to extend the duration of peak waves. Inland Trough Lows (ITLs) originate in the quasi-permanent low pressure trough over inland Queensland. Their movement to the east coast is often associated with the interaction with a Southern Tasman Low (STL). Hence, the synoptic pattern of the ITL after crossing the east coast, can resemble the pattern associated with the Southern Secondary Lows (SSLs).

Large extra-tropical low pressure systems develop in the atmospheric longwave trough in the southern ocean south of 38°S, and extend northwards into the central Tasman Sea. These systems are classified as STLs and can produce extreme waves along the NSW and Victorian coasts. However, due to the distance from the coast and southerly wave direction, resultant erosion is not typically as severe as for the more local ETL and TC events. SSLs form in association with STL and evolve into a secondary or cut off low in the Tasman Sea region, adjacent to a subtropical anticyclone. These SSL synoptic types produce more extreme wave energy, comparable to the ETL type with peak significant wave heights of over 7 m occurring on occasion. The most notable Southern Secondary Low event was the May, 1974 “Sygna Storm” which caused significant erosion on the central, Sydney and Illawarra coasts and was responsible for the shipwrecking of the Norwegian coal carrier, the *Sygna*, in Stockton Bight north of Newcastle.

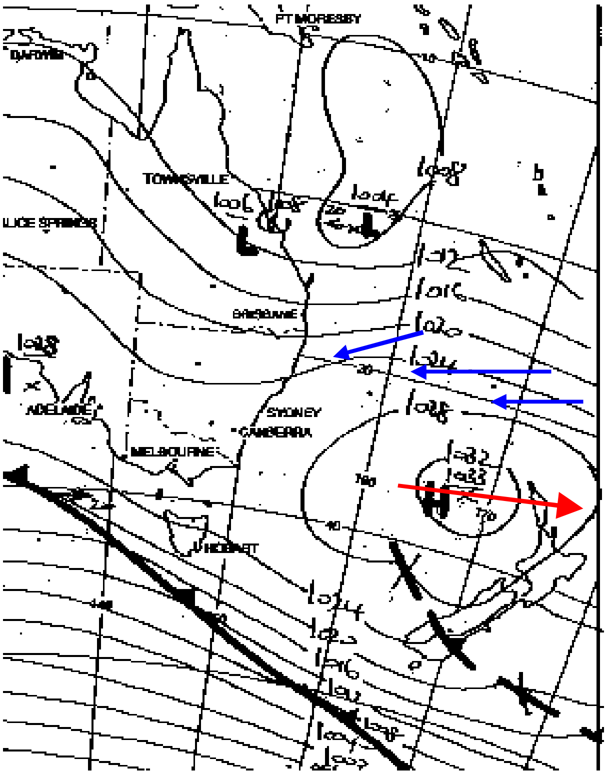
Further examples of specific storm events affecting the NSW coast, their associated synoptic type, storm characteristics and impacts on the coastline where reported are provided within Appendix A.



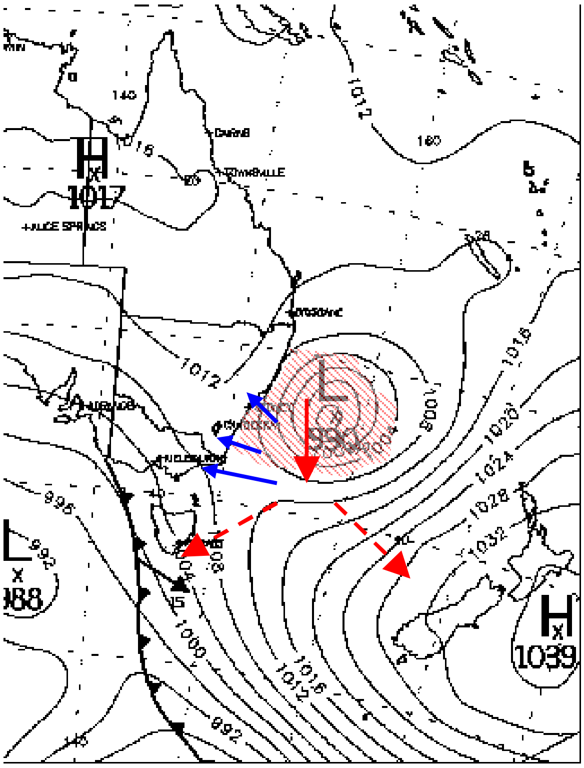
Tropical Cyclone (TC)



Tropical Low (TL)



Anti-cyclone Intensification (AI)

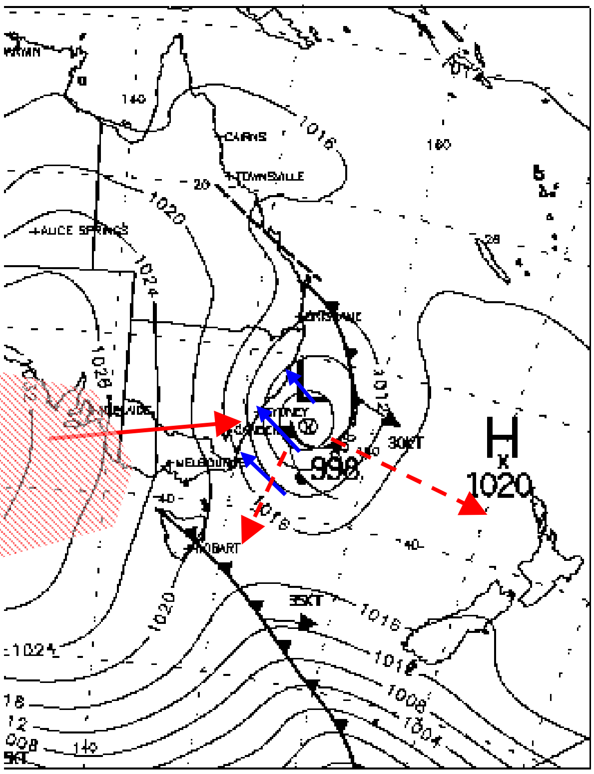


Easterly Trough Low (ETL)

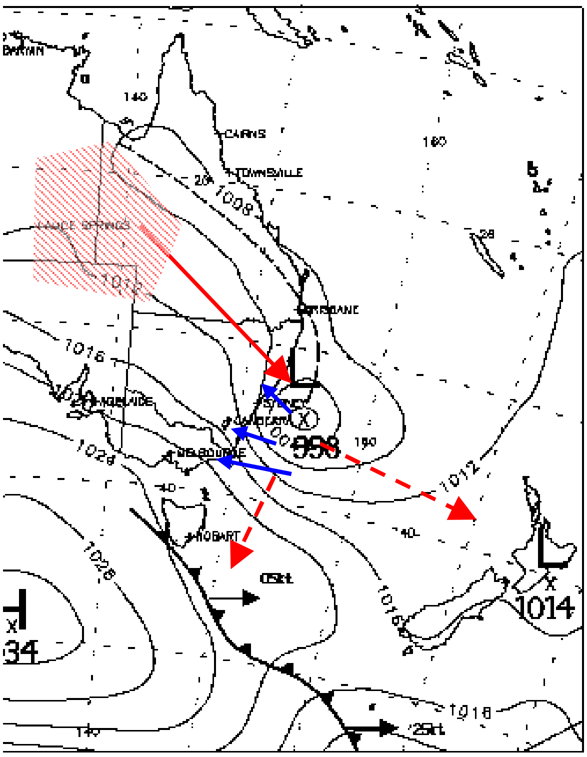
All Charts: Bureau of Meteorology

Storm genesis region — General storm path — Typical Wave Direction

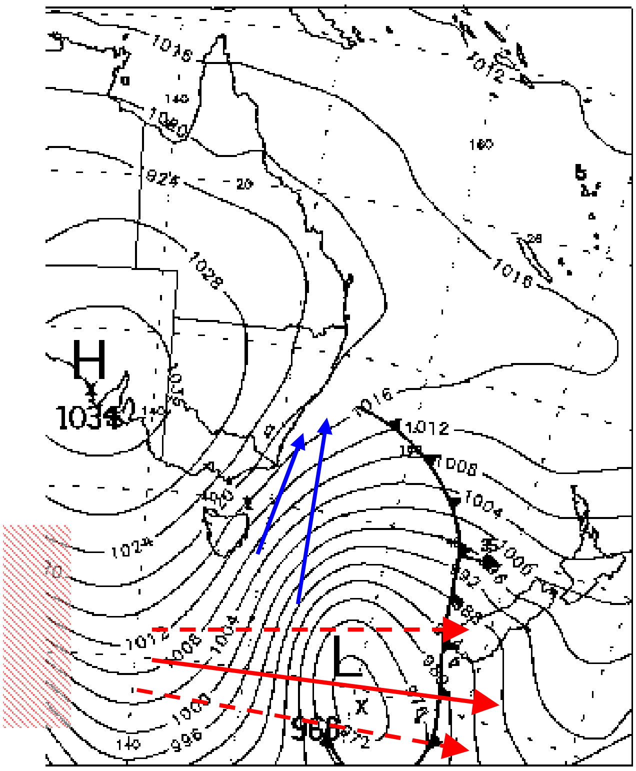
WRL Report No. 2010/16	EXAMPLE SEA LEVEL PRESSURE SYNOPTIC CHARTS FOR SYSTEMS CAUSING STORM WAVES ON THE NSW COAST	Figure 2.1A



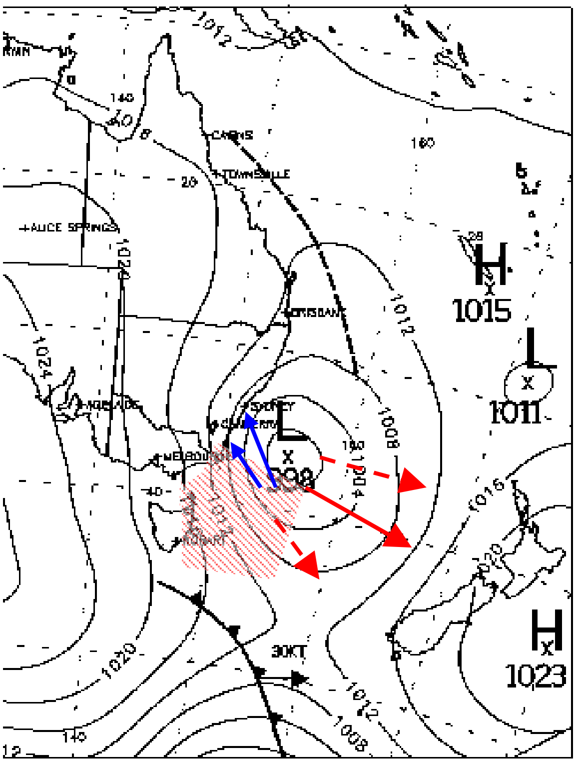
Continental Low (CL)



Inland Trough Low (ITL)



Southern Tasman Low (STL)



Southern Secondary Low (SSL)

All Charts: Bureau of Meteorology

Storm genesis region — General storm path — Typical Wave Direction

WRL Report No. 2010/16	EXAMPLE SEA LEVEL PRESSURE SYNOPTIC CHARTS FOR SYSTEMS CAUSING STORM WAVES ON THE NSW COAST	Figure 2.1B

3. DATA SOURCES

Sources of data which provided quantitative information on wave heights along the NSW coast include:

- Wave buoys (1971 to present);
- The (US) Oceanic and Atmospheric Administration (NOAA) Wavewatch III Numerical Hindcast (1997 to present);
- The European Centre of Medium-Range Forecasting (ECMRF) WAM-cycle 3 ERA-40 Hindcast (1957 to present).

3.1 Wave Buoys

Just prior to a series of large storms in 1974, (including the "Sygna storm") which caused extensive damage along the NSW East Coast, the then NSW Department of Public Works (PWD) initiated a program of wave data collection. This began with the installation of a wave buoy at Port Kembla in February 1974. The large storms of 1974 provided further impetus to extend the wave buoy network, which has been expanded to seven sites along the NSW coast, maintained by Manly Hydraulics Laboratory (MHL) and supported by the NSW Department of Climate Change and Water (DECCW). Wave buoys are presently located off Byron Bay (directional), Coffs Harbour, Crowdy Head, Sydney (directional), Port Kembla, Batemans Bay (directional) and Eden.

Sydney Ports Corporation has maintained a wave buoy offshore of Botany Bay since 1971 to provide real-time oceanographic data to commercial port users and the public. The Queensland Department of Environment and Resource Management (DERM) maintains a network of 12 wave buoys along the Queensland coastline. A wave buoy located offshore of Brisbane (Point Lookout on North Stradbroke Island) since 1976 is also incorporated within this study to improve evaluation of wave height and storm trends in far north NSW.

3.1.1 Locations

The locations of wave buoys have varied through time as wave buoys were lost, removed and replaced during routine maintenance, or repositioned to improve data capture. The present locations of the seven MHL/DECCW, one Sydney Ports Corporation and one Queensland DERM buoy are shown in Table 3.1 and within Figure 3.1. The location history of all MHL/DECCW wave buoys as defined within the NSW Wave Climate and

Coastal Air Pressure Annual Summary 2008-2009 (MHL, 2009) is presented within Appendix G.

Table 3.1
List of Wave Buoys and Locations used within the Present Study

Site	Present Location	Water Depth (m)	Maintained by	Buoy Type	Date Range
Brisbane	153° 37.5' E 27° 28.1' S	76	Queensland DERM	Directional Waverider	Oct 1976 – Dec 2009
Byron Bay	153° 42.1' E 28° 51.2' S	62	MHL/DECCW	Directional Waverider	Oct 1976 – Dec 2009
Coffs Harbour	153° 16.1' E 30° 21.4' S	72	MHL/DECCW	Waverider	May 1976 – Dec 2009
Crowdy Head	152° 51.6' E 31° 49.5' S	79	MHL/DECCW	Waverider	Oct 1985 – Dec 2009
Sydney	151° 25.0' E 33° 46.3' S	92	MHL/DECCW	Directional Waverider	Aug 1987 – Dec 2009
Botany Bay	151° 15.1' E 34° 02.3' S	73	Sydney Ports Corporation	Waverider	Apr 1971 – Dec 2009
Port Kembla	151° 01.6' E 34° 28.5' S	80	MHL/DECCW	Waverider	Feb 1974 – Dec 2009
Batemans Bay	150° 20.6' E 35° 42.2' S	73	MHL/DECCW	Directional Waverider	May 1986 – Dec 2009
Eden	150° 11.1' E 37° 18.1' S	100	MHL/DECCW	Waverider	Feb 1978 – Dec 2009

3.1.2 Instrumentation

Deep water wave buoys maintained by MHL are based on the Waverider system developed by the Dutch company, Datawell. The non-directional Datawell Waverider system uses an accelerometer mounted within a buoy to measure vertical accelerations as the buoy moves with the water surface. Datawell Directional Waverider buoys measure accelerations in the horizontal and vertical directions. These accelerations are integrated twice to obtain displacements. The use of accelerations instead of buoy slope renders measurement insensitive to buoy roll and allows the use of smaller buoys. Measurement range in the directional Waverider buoys is given at ±20 m elevation and 1.6 to 30 s period. Buoy resolution is 1 cm and post-calibration errors are given at 0.5% to 1.0% (www.datawell.nl). Directional resolution is given at 1.4° with error of 0.4 to 2° depending on latitude.

Buoys are tethered to 15 metre rubber shock cords and PVC coated galvanised steel wire rope which is attached to anchor blocks of between 300 and 800 kg. Mooring lines are normally 2.5 times the water depth (Wyllie and Kulmar, 1995). To ensure waves are observed in close to deepwater conditions, buoys are moored in water depths of 60 to 100 m. This is equivalent to theoretical *deepwater* (> $L_0/2$) for waves of less than 9 to

11.3 s period respectively (or around 75% of waves on the NSW coast; Lord and Kulmar, 2000).

3.1.3 Data Capture and Analysis

Data has been captured by the wave buoy network at intervals of 12, 6 and 1 hour, although from 1984 all MHL wave buoys captured data at 1 hour intervals. Table 3.2 shows the date ranges for the various sampling intervals, the total data capture (%) for each buoy, the total record length (years) and the effective record length (years). The effective length is the product of the total record length and the total data capture and is important in calculating extreme values and confidence intervals (refer Section 4). The spatial completeness of the wave buoy record is also presented within Figure 3.3. It is evident within Figure 3.3 that the Byron Bay wave buoy has the highest occurrence of data breaks. This is reflected by the total capture rate of 73.1%. The Batemans Bay buoy has the highest capture rate of 89.7%.

Table 3.2
Details of Wave Buoy Sampling Intervals and Data Capture

Buoy Location	Sampling Interval (hrs)			Total Capture (%)	Total Record Length (yrs)	Effective Record Length (yrs)
	12	6	1			
Brisbane (ND)[1]	31/10/1976 – 13/05/1982	17/06/1982 – 25/10/1991	26/10/1991 – 21/11/1996	85.9	33.2	28.5
Brisbane (D)[2]	-	-	21/11/1996 – 31/12/2009			
Byron Bay (ND)	-	14/10/1976 – 27/06/1984	28/06/1984 – 25/10/1999	73.1	33.2	24.3
Byron Bay (D)	-	-	26/10/1999 – 31/12/2009			
Coffs Harbour	-	26/05/1976 – 05/05/1984	27/06/1984 – 31/12/2009	84.7	33.6	28.5
Crowdy Head	-	-	10/10/1985 – 31/12/2009	85.6	24.2	20.7
Sydney (ND)	-	-	17/07/1987 – 04/10/2000	84.5	22.5	19.0
Sydney (D)	-	-	03/03/1992 – 31/12/2009			
Botany Bay	-	08/04/1971 – 17/06/1980	17/06/1980 – 31/12/2009	87.7	38.8	34.0
Port Kembla	-	07/02/1974 – 14/06/1984	14/06/1984 – 31/12/2009	85.1	35.9	30.6
Batemans Bay (ND)	-	-	27/05/1986 – 21/02/2001	89.7	23.6	21.2
Batemans Bay (D)	-	-	23/02/2001 – 31/12/2009			
Eden	-	08/02/1978 – 22/10/1984	27/03/1985 – 31/12/2009	83.5	31.9	26.6

[1] Non-directional
[2] Directional

Data is captured for 34 minutes every sampling interval, transmitted to shore and logged. Erroneous sample points are removed before processing by zero-crossing and spectral analysis (Figure 3.4). This process extracts a range of wave height, period and direction statistics which are described within Table 3.3 and Figure 3.4 (MHL, 2009).

Table 3.3
Wave Buoy Statistics (MHL, 2009)

Zero Crossing Statistics		
Statistic	**Unit**	**Description**
HMEAN	metres	Mean wave height
HRMS	metres	Root mean square wave height
HSIG	metres	Significant wave height
H10	metres	Average top 10% wave height
HMAX	metres	Maximum wave height
TC	seconds	Crest wave period
TZ	seconds	Zero up-crossing wave period
TSIG	seconds	Significant wave period
Spectral Analysis Statistics		
F0	Hertz	Frequency at first spectral estimate
YRMS	metres	Root mean square sea surface displacement
SPECT_DENS	m^2/Hz	Maximum spectral density
TP1	seconds	Wave period at spectral peak
TP2	seconds	Wave period at second spectral peak
P2ONP1		Ratio 2nd peak spect estimate to 1st
M0 – M3		First to fourth spectral moment
Wave Direction Statistics (relative to True North)		
WDIR	degrees	Best available principal wave direction
WDIR_BUOY	degrees	Mean direction at spectral peak
WDIR_TP1	degrees	Wave direction at spectral peak
WDIR_TP2	degrees	Wave direction at 2nd spectral peak
Miscellaneous Statistics		
DEPTH	metres	Average water depth at instrument
POWER	Watts/m	Wave power per length of wave crest
GROUPI		Wave groupiness factor

Waverider buoys are known to suffer damage due to spinning (Wyllie and Kulmar, 1995). This spinning is most often caused by vessel impact or mooring and may result in corrupt data. Buoy moorings may also fail due to either vessel collision or extreme storms. Other contributors to missing data include receiving station component failure, radio interference, telemetry faults and the loss of shore station power due to extended mains power failure (Wyllie and Kulmar, 1995). Other possible sources of error within wave buoy data include submergence at wave crests (Bettington and Wilkinson, 1997) and due to strong currents leading to underestimation of wave height and increased linearity in observed waveforms due to loose buoy tether lines (Tucker, 1994).

3.2 Numerical Data

3.2.1 Models

Data generated by two deepwater, numerical wave models were also used for comparative analysis. These numerical models included the Wave Watch III (WW3) model, maintained by the United States National Oceanic and Atmospheric Administration (NOAA; NWW3) and the Wave Analysis Model (WAM) maintained by the European Centre of Medium-Range Weather Forecasting (ECMWF).

Wave Watch III is a third generation, phase-averaging spectral wave model which, like other third generation wave models, solves the action balance equation in spherical co-ordinates for the two-dimensional action density ocean wave spectrum $F(\omega,\theta,\phi,\lambda,t)$ with respect to wave frequency (ω) and direction (θ), as a function of latitude (ϕ), longitude (λ) and time (t).

$$\frac{\partial F}{\partial t}+(\cos\phi)^{-1}\frac{\partial}{\partial\phi}(\dot{\phi}\cos\phi F)+\frac{\partial}{\partial\lambda}(\dot{\lambda}F)+\frac{\partial}{\partial\omega}(\dot{\omega}F)+\frac{\partial}{\partial\theta}(\dot{\theta}F)=S \qquad (2\text{-}1)$$

where:
- $\dot{\phi}$: component of group velocity with respect to latitude
- $\dot{\lambda}$: component of group velocity with respect to longitude
- $\dot{\omega}$: rate of change of the dispersion relation
- $\dot{\theta}$: rate of change of direction (due to great circle propagation)
- S: net source function describing the change of energy of a propagating wave group as shown in Equation 2.2

$$S = S_{in} + S_{nl} + S_{ds} + S_{bot} \qquad (2\text{-}2)$$

where:
- S_{in}: atmospheric input from the wind
- S_{nl}: non-linear interactions between spectral components
- S_{ds}: dissipation due to “white capping”
- S_{bot}: dissipation due to interaction with the bottom

A global Wave Watch III model has been operated by NOAA (NWW3) since 1997 and provides freely available wave data on a 1.0° (latitude) by 1.25° (longitude) model grid (~110 × 90 km in NSW) at 3 hour intervals.

The WAM model was used by the ECMWF to generate the ERA-40 hindcast dataset. This global wave hindcast was run between September 1957 and August 2002 (Sterl and Caires,

2005) at a spatial resolution of 2.5°× 2.5° (275 × 225 km in NSW) and temporal resolution of 6 hours.

Validation of modelled wave heights from the ERA-40 dataset against buoy and global satellite altimeter measurements in the northern hemisphere indicated generally good agreement (Caires and Sterl, 2005), although the ERA-40 wave heights were found to systematically overestimate wave heights during calm conditions and underestimate peak wave conditions. Wave heights were also found to contain synthetic biases and trends resulting from assimilation to different altimeter datasets throughout the 45-year period.

Harley *et al.* (2009) compared ECMWF ERA-40 and corrected ERA-40 (C-ERA-40) reanalysis data with wave measurements collected by the Sydney wave buoy. Results show that the numerical datasets represented the Sydney wave climate reasonably well, although westerly waves were significantly over-predicted in the model. Removing these values was found to strengthen correlations between predicted and measured wave heights.

The *skill* of these two models was assessed by Hemer *et al.* (2007) around the Australian coast by comparing the predictions to measurements from 27 wave buoys. The C-ERA-40 model dataset had a Root-Mean-Square-Error (*RMSE*) for significant wave height (H_{sig}) of 0.59 m. The Wave Watch III dataset had an *RMSE* of 0.63 m for H_{sig}. Coghlan (2009), compared a high-resolution WAM model (Hi-WAM) developed by the Australian Bureau of Meteorology (BoM) against wave buoy measurements from 18 locations around Australia over an 11 year period (1997 to 2008) and against a NWW3 dataset at Sydney. Coghlan (2009) noted that wave energy was over predicted by Hi-WAM for extreme wave heights at Sydney, but was under predicted at sites exposed to mid-latitude cyclone (roaring forties) swell in Victoria, Tasmania, South Australia and Western Australia. Coghlan also found the NWW3 model to have slightly superior performance over Hi-WAM when compared to wave buoy data at Sydney.

3.2.2 Locations

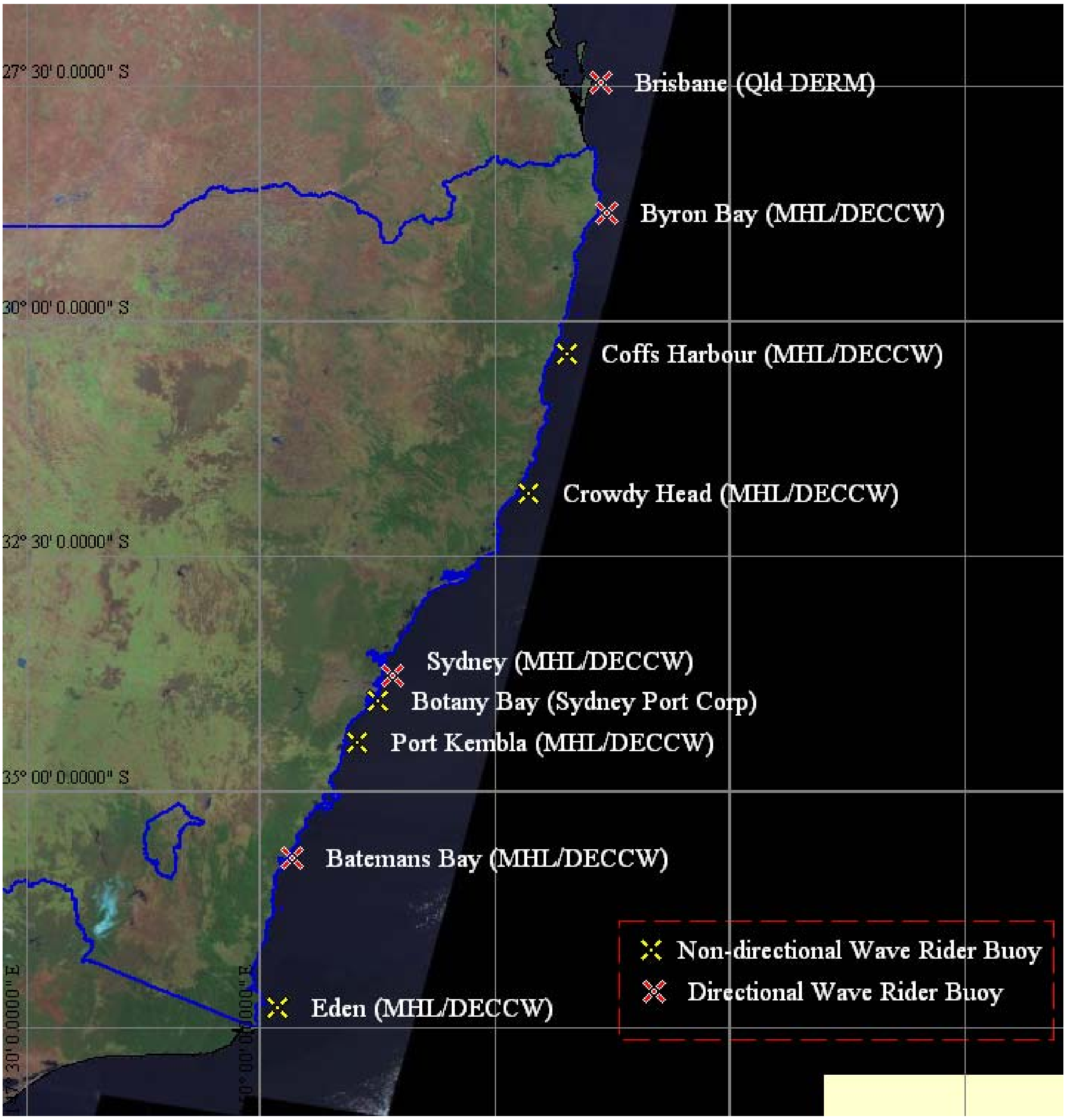
Numerical data was extracted from grid cell locations along the NSW coast most closely representing the wave buoy locations (Figure 3.5). In total, seven NWW3 numerical datasets were extracted. Each corresponding to one wave buoy, except in the vicinity of Sydney, where the numerical grid cell was representative of the Sydney, Botany Bay and Port Kembla wave buoys. In total, five ERA-40 numerical datasets were extracted. These datasets encompassed the entire NSW coast and southeast Queensland. The Queensland cell was noted to be bounded by a 'land' cell immediately to the south. This was expected to result in a significantly reduced southerly component at this buoy location.

3.2.3 Data Capture and Analysis

Data from the NOAA NWW3 model was available for the period January 1997 to August 2009. The data was sampled at 3 hourly intervals, with no irregularities or missing data. The ECMWF ERA-40 dataset extends from September 1957 to September 2002. The data is sampled at 6 hourly intervals with no irregularities. A summary of available data is presented within Table 3.4 and Figure 3.3.

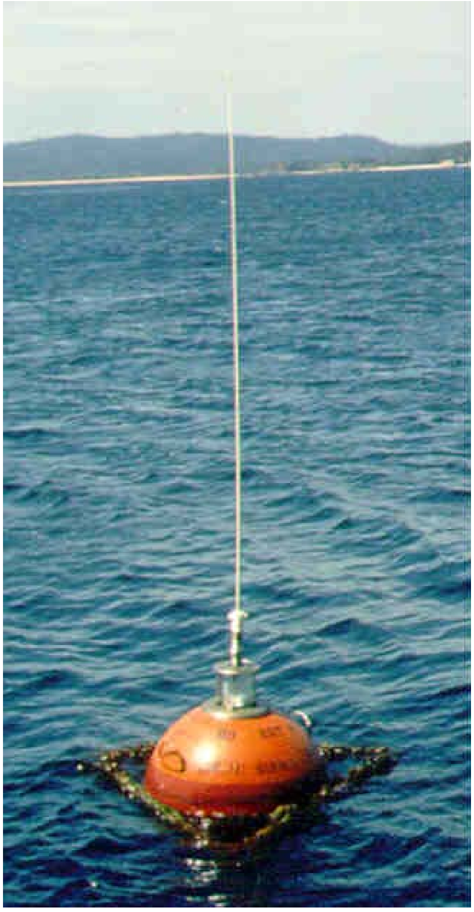
Table 3.4
Details of Numerical Wave Data

Dataset	Location			Date Range	Sampling Interval	Complete (%)	Effective record length (yrs)
	Nearest Buoy	Lat	Long				
NOAA Wave Watch III	Brisbane	-27.0	153.75	30/01/97 - 01/08/09	3 hr	100	12.6
	Byron Bay	-29.0	153.75	30/01/97 - 01/08/09	3 hr	100	12.6
	Coffs Harbour	-30.0	153.75	30/01/97 - 01/08/09	3 hr	100	12.6
	Crowdy Head	-32.0	153.75	30/01/97 - 01/08/09	3 hr	100	12.6
	Sydney/Port Kembla	-34.0	151.25	30/01/97 - 01/08/09	3 hr	100	12.6
	Batemans Bay	-36.0	151.25	30/01/97 - 01/08/09	3 hr	100	12.6
	Eden	-37.0	150.00	30/01/97 - 01/08/09	3 hr	100	12.6
ECMWF ERA-40	Brisbane	-27.5	152.50	01/09/57 - 01/09/02	6 hr	100	45
	Byron/Coffs	-30.0	155.00	01/09/57 - 01/09/02	6 hr	100	45
	Crowdy Head	-32.5	152.50	01/09/57 - 01/09/02	6 hr	100	45
	Sydney/PK/ Batemans	-35.0	152.50	01/09/57 - 01/09/02	6 hr	100	45
	Eden	-37.5	150.00	01/09/57 - 01/09/02	6 hr	100	45

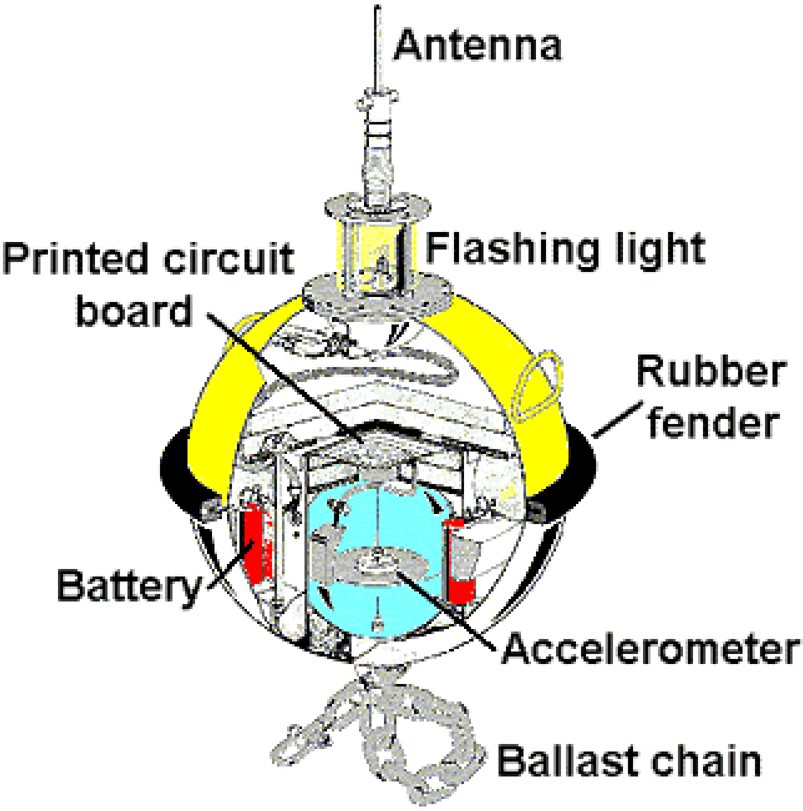


WRL Report No. 2010/16	WAVE BUOY LOCATIONS ALONG THE NEW SOUTH WALES COAST AND OFFSHORE OF BRISBANE	Figure 3.1

WWW.DATAWELL.NL

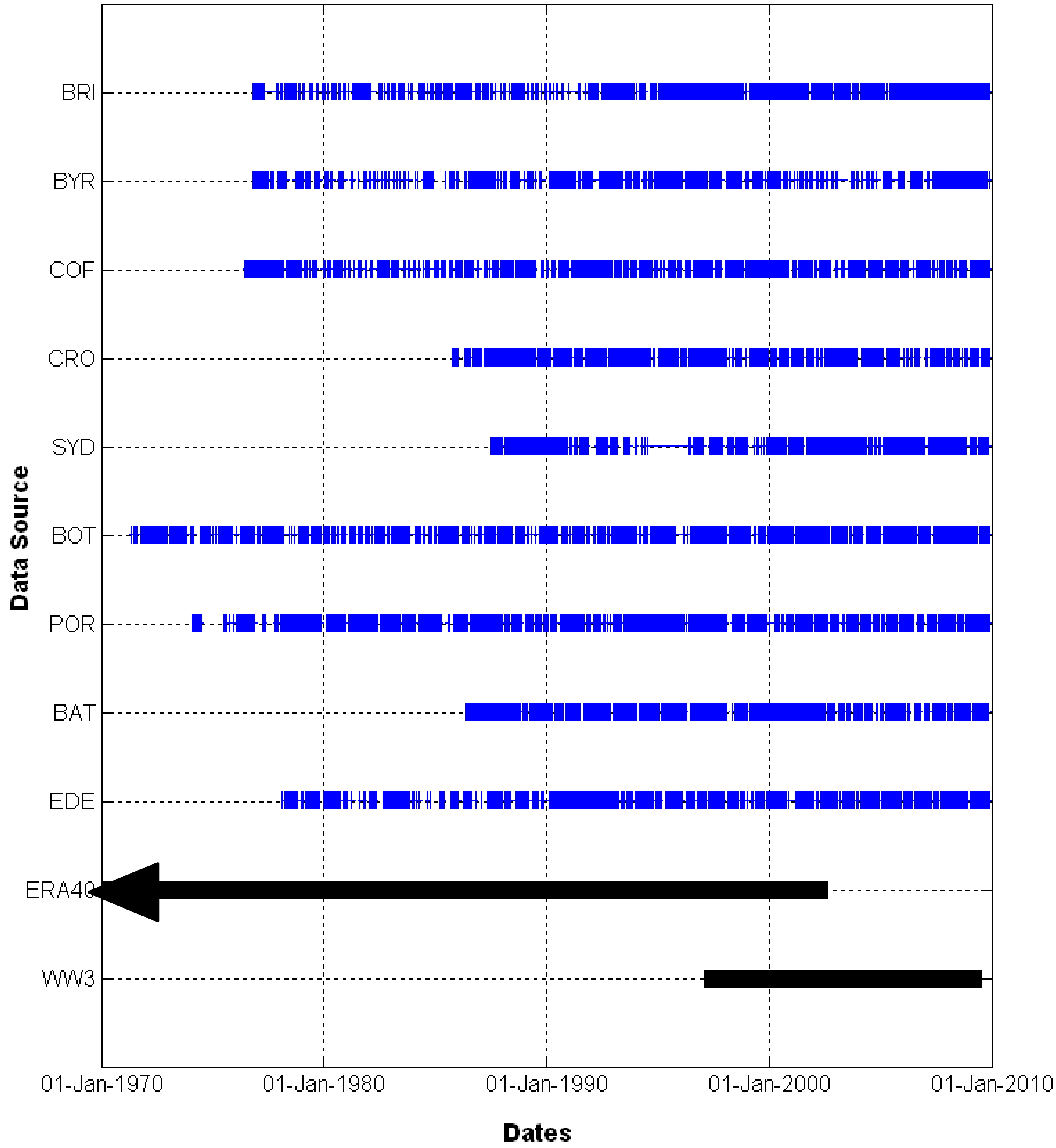


Manly Hydraulics Laboratory

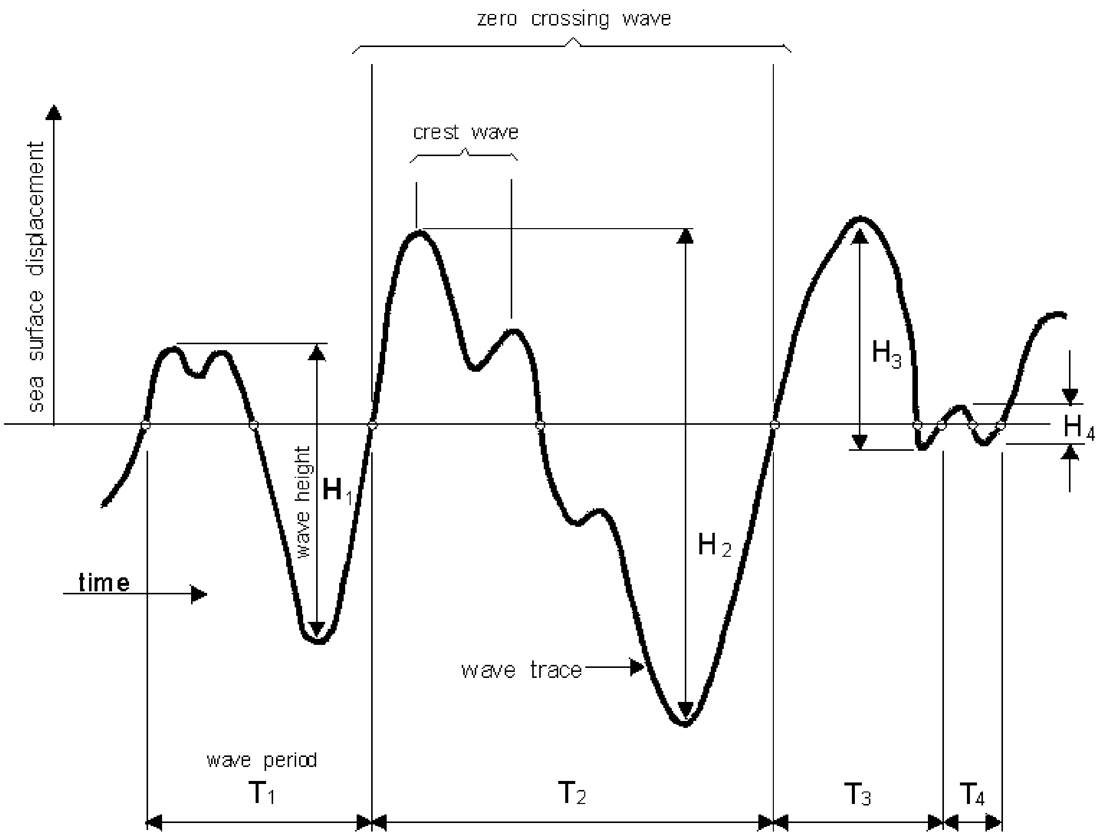


QUEENSLAND DERM

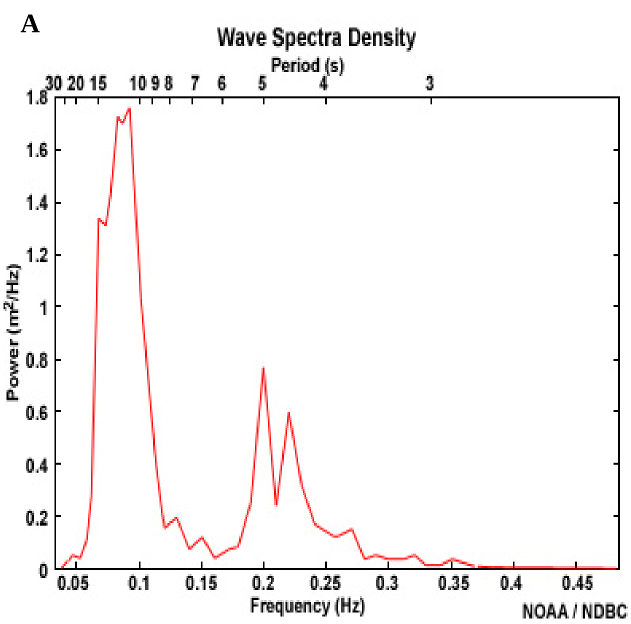
WRL Report No. 2010/16	EXAMPLE IMAGES AND SCHEMATIC DIAGRAM OF A DATAWELL WAVE RIDER BUOY USED BY MHL/DECCW AND QUEENSLAND DERM	Figure 3.2

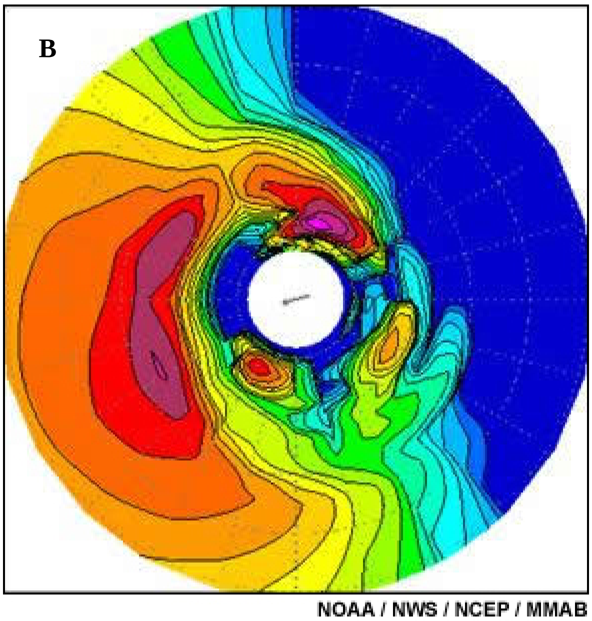


WRL Report No. 2010/16	WAVE BUOY AND NUMERICAL DATA RECORD	Figure 3.3



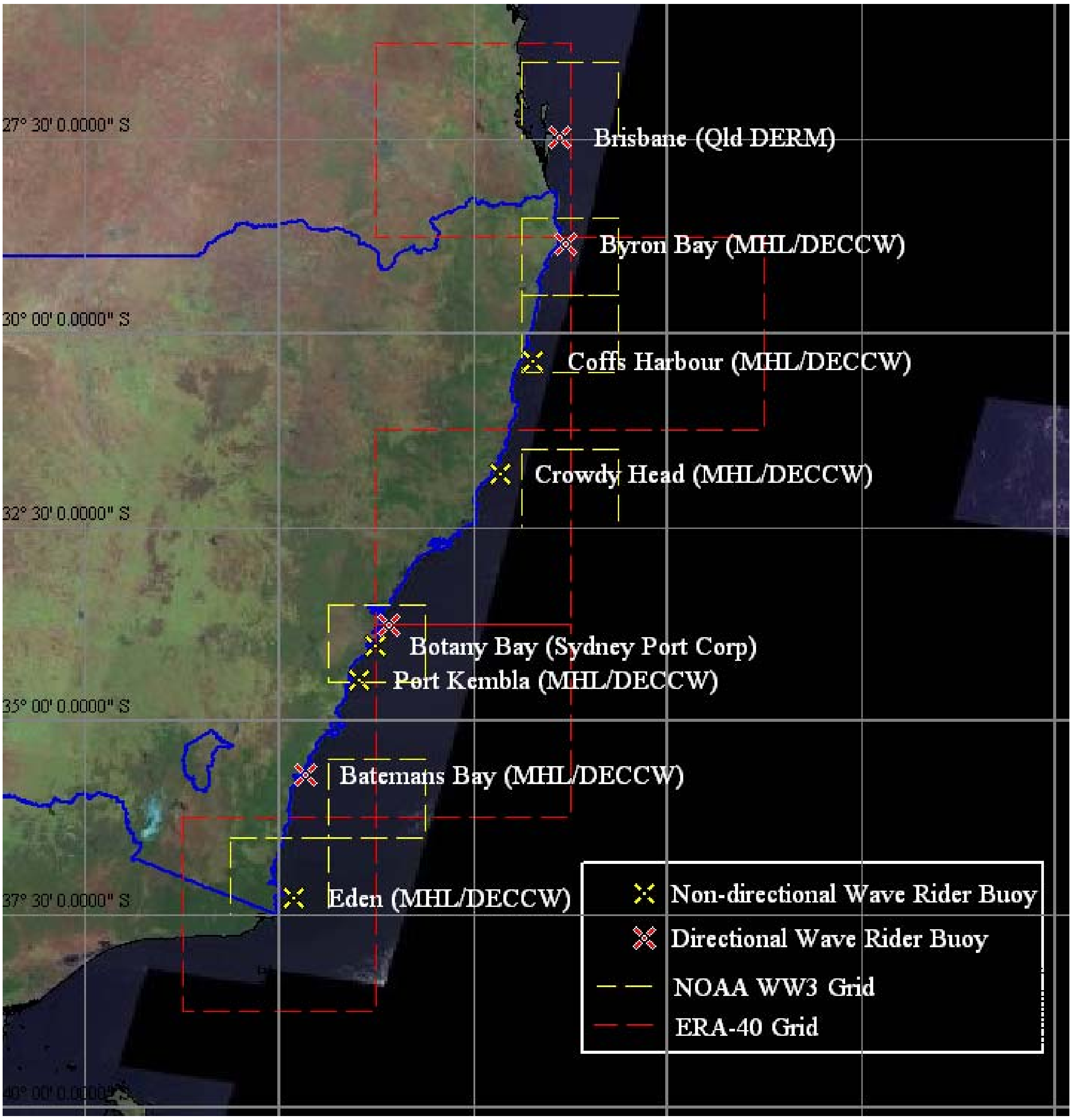
Example of wavy water surface and definitions of wave parameters (source: Manly Hydraulics Laboratory)





Example of two (A) and three-dimensional (B) wave spectra (source: NOAA)

WRL Report No. 2010/16	WAVE PARAMETER AND SPECTRA DEFINITIONS	Figure 3.4



WRL Report No. 2010/16	LOCATION OF EXTRACTED NUMERICAL DATA COMPARED TO WAVE BUOY LOCATIONS	Figure 3.5

4. DATA ANALYSIS

4.1 Descriptive Statistics

Wave buoy characteristics including monthly mean H_{sig} and wave power, the relationship between H_{sig} and T_p, wave height exceedance and directional data (where applicable) is provided for all buoys within Appendix C. Significant wave height (H_{sig}) exceedance and peak wave period (T_p) occurrence tables for each wave buoy are presented within Table 4.1 and 4.2 respectively along with mean statistics. A combined plot of wave height exceedance for all buoys is presented within Figure 4.1. Figure 4.2 presents seasonal and mean significant wave height (A), peak spectral period (B) and peak spectral direction (C) and Figure 4.3 presents a combined wave rose plot for Brisbane (A), Byron Bay (B), Sydney (C) and Batemans Bay (D).

Figure 4.2 and Table 4.1 show that the median (50% exceedance) significant wave height ranges from 1.30 m at Batemans Bay to 1.52 m at Eden, although, with the exception of Batemans Bay, all buoys are relatively uniform. Mean H_{sig} is similarly lowest at Batemans Bay (1.43 m) and largest at Sydney (1.63 m). The 1% exceedance and maximum observed H_{sig} are highest at Sydney and Botany Bay, with a maximum H_{sig} of 8.86 m observed at Botany Bay, followed by Sydney and Port Kembla at 8.43 m. More notable along-coast variation in mean H_{sig} is observed seasonally (Figure 4.2), with larger waves occurring in the north during autumn and lower waves occurring during spring and summer. Wave height in the south is more uniform year-round.

Mean peak wave period (T_p) ranges from 9.27 s at Botany Bay to 9.72 s at Sydney. This difference may indicate minor differences in data processing techniques between the two collecting organisations. Wave period is otherwise largely uniform along the coast although it displays significant seasonal variation, increasing at all buoy locations during autumn and winter and decreasing during spring and summer (Figure 4.2). This change is representative of the seasonal changes in wave generation systems further discussed in Section 4.2.2. From Appendix C, it can be seen that during very large wave events, peak period ranges between 11.0 and 13.0 s. The 1% exceedance T_p ranges from 14.7 and 15.1 s.

Table 4.1
Significant Wave Height Exceedance (%) Table

H_{sig} (m)	Brisbane	Byron Bay	Coffs Harbour	Crowdy Head	Sydney	Botany Bay	Port Kembla	Batemans Bay	Eden
0.5	99.900	99.873	99.888	99.931	99.828	99.533	99.792	99.188	99.802
1.0	84.717	86.024	83.532	85.203	83.785	81.590	83.006	75.961	89.250
1.5	49.644	49.865	44.934	46.717	46.916	45.282	45.048	35.953	51.426
2.0	25.520	25.132	20.685	21.774	22.855	21.901	20.853	14.787	21.641
2.5	11.499	11.627	9.054	9.692	10.811	10.533	9.635	6.167	8.943
3.0	4.927	4.968	4.009	4.422	5.438	5.148	4.369	2.586	3.931
3.5	2.132	2.132	1.815	2.135	2.642	2.587	1.992	1.113	1.869
4.0	0.992	0.878	0.777	0.981	1.299	1.264	0.914	0.497	0.903
4.5	0.406	0.300	0.334	0.472	0.656	0.596	0.438	0.197	0.452
5.0	0.191	0.0896	0.129	0.207	0.311	0.303	0.213	0.0744	0.202
5.5	0.104	0.0369	0.0514	0.0851	0.153	0.135	0.0958	0.0270	0.0790
6.0	0.0676	0.0102	0.0235	0.0337	0.0634	0.0578	0.0432	0.0103	0.0201
6.5	0.0260	0.0051	0.0075	0.0055	0.0193	0.0245	0.0152	0.0038	0.0036
7.0	0.0074	0.0023	0.0010	0.0017	0.0079	0.0104	0.0066	0.0011	0.0010
7.5	0.0000	0.0006	0.0000	0.0000	0.0030	0.0042	0.0024	0.0000	0.0000
8.0	0.0000	0.0000	0.0000	0.0000	0.0024	0.0021	0.0019	0.0000	0.0000
8.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0000	0.0000	0.0000
Descriptive Statistics (H_{sig}, m)									
Mean H_{sig}	1.63	1.66	1.58	1.61	1.63	1.60	1.58	1.43	1.64
Median H_{sig}	1.47	1.50	1.43	1.46	1.46	1.43	1.43	1.30	1.52
10% Exceed	2.57	2.59	2.44	2.48	2.55	2.54	2.47	2.22	2.43
1% Exceed	4.04	3.93	3.85	3.94	4.19	4.17	3.94	3.57	3.93
Maximum	7.36	7.64	7.37	7.35	8.43	8.86	8.43	7.19	7.14
Variance	0.51	0.48	0.44	0.46	0.54	0.55	0.48	0.39	0.42
Effective record length (yrs)	28.5	24.3	28.5	20.7	19	34	30.6	21.2	26.6

Table 4.2
Peak Wave Period Occurrence (%) Table

T_{P1} (s)	Brisbane	Byron Bay	Coffs Harbour	Crowdy Head	Sydney	Botany Bay	Port Kembla	Batemans Bay	Eden
2 – 3.99	0.41	0.36	0.41	0.28	0.44	0.17	0.91	0.36	0.24
4 – 5.99	6.71	5.42	5.78	5.05	6.23	5.62	6.05	6.95	7.46
6 – 7.99	19.82	16.05	15.55	15.43	16.07	19.49	17.22	20.61	19.49
8 – 9.99	37.72	33.65	33.85	33.12	27.70	41.20	31.76	30.74	31.38
10 – 11.99	24.55	28.10	27.73	27.75	31.29	26.06	25.50	25.40	24.28
12 – 13.99	9.17	14.24	14.56	15.66	14.95	6.68	16.00	14.38	15.11
14 – 15.99	1.50	1.95	1.87	2.30	2.73	0.66	2.23	1.35	1.83
16 – 17.99	0.092	0.22	0.24	0.40	0.54	0.057	0.31	0.20	0.21
18 – 19.99	0.001	0.010	0.011	0.022	0.042	0.003	0.022	0.008	0.013
20 – 21.99	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000
Descriptive Statistics (T_{p1}, s)									
Mean T_{p1}	9.32	9.59	9.58	9.71	9.72	9.27	9.57	9.36	9.41
Median T_{p1}	9.31	9.50	9.50	9.50	9.77	9.38	9.50	9.50	9.50
10% Exceed	12.14	12.20	12.20	12.20	12.50	11.98	12.23	12.20	12.20
1% Exceed	14.67	15.10	15.10	15.10	15.10	14.38	15.10	15.10	15.10
Maximum	19.17	19.70	19.79	19.79	20.00	23.65	19.70	19.70	19.69
Variance	4.75	4.92	4.99	5.12	5.57	5.24	5.60	5.17	5.46
Effective record length (yrs)	28.5	24.3	28.5	20.7	19	34	30.6	21.2	26.6

Mean peak wave direction is more east at the northerly buoys (123° at Byron Bay) and becomes slightly more southerly in the southern buoys (135° in Sydney). Seasonal variation of 10 to 20° is observed, with more a southerly mean peak wave direction in winter and more easterly direction in summer. Waves of greater than 5 m occur more commonly from the east to east-south-east in the northern buoys (Appendix C) and from the south-south-east to south-east in the southern buoys. This is reflective of the storm systems responsible for generation of large waves discussed further in the following sections.

4.2 Storm Event History

There are various methods of defining data for extreme value analysis. These include analysis of the entire series (the total sample method), analysis of the largest event per year (annual maxima method), and analysis of values identified using a peaks over threshold (PoT) method, whereby once waves exceed a defined threshold, an event is defined.

Requirements for the statistical sample include independency, whereby one event is not correlated to the prior or next event and homogeneity, where all samples belong to the same population (Goda, 2000). The total sample method does not satisfy the first statistical requirement for wave analysis as storm events typically persist for hours to days, meaning subsequent samples are likely highly correlated. This leaves either the annual maxima method or peaks over threshold method as valid candidates. For relatively short data sets, the peaks over threshold method is generally favoured as it provides a larger sample size and thus reduces the confidence interval (Goda, 2000).

4.2.1 Event Detection

A key component of this present study is evaluating the distribution of extreme, long-duration storm events rather than simply the yearly maxima. The peaks over threshold (PoT) method was therefore used to analyse the wave data and define storm events. An initial PoT analysis was undertaken for $H_{sig} > 2.0$ m with a minimum exceedance duration of three days. A second PoT analysis was then undertaken with a higher threshold of $H_{sig} > 3.0$ m. Thus storms with $H_{sig} > 2.0$ m and duration greater than three days were identified, as well as storms of any duration with $H_{sig} > 3.0$ m. This ensures that enough long duration storm events were captured for extrapolation of extreme wave heights and avoids generation of an excessive number of small and short duration events. You (2007) found the estimated extreme wave height to be largely insensitive to variation in the adopted threshold of between 3.0 and 4.5 m.

A minimum interval between storms was set at one day. This prevents single storms being split into two or more events if wave height temporarily drops below the threshold (i.e. Figure 4.4) as this would violate the assumption of sample independency.

Each detected event was manually checked against the original time series record for that buoy and against adjacent buoys to ensure:

1. erroneous spikes (where present) were removed;
2. single storms that were detected as separate events were combined;
3. multiple storms which may have been detected as a single event were separated.

While missing data within a storm event has been noted, no new data was synthesised as this would introduce a somewhat subjected component to the dataset. Only data missing during the largest events is expected to significantly influence the evaluated extreme wave statistics. This may have occurred at the Batemans Bay buoy where the May 1997 storm was missing and at Byron Bay where a number of large events may have been excluded, supposedly due to buoy submergence.

A summary of detected storm events for each of the NSW wave buoys is presented within Table 4.3 and Figure 4.5. The largest 10 storm events for each wave buoy based on peak H_{sig} are presented within Table 4.4. A complete *Storm History Table* detailing storm characteristics for each storm event detected on the NSW Coast by wave buoys between 1971 and 2009 is presented within Appendix D. For each storm, the table provides detailed wave characteristics (H_{sig}, T_p, duration, total storm energy) observed at the buoy which experienced the largest peak H_{sig}. Additionally, the peak H_{sig} observed at every buoy during that event is provided for comparison. Locations which did not observe a storm event (i.e. H_{sig} remained below the threshold height) are left blank and period where the buoys were not operational during a storm event are noted.

Table 4.3 and Figure 4.5 show the central NSW coast to be subject to the highest number of storm events per year as well as the largest mean and maximum storm peak height. The largest storm on record is the *'Mother's Day'* storm which occurred in May 1997. The storm peaked during the night of the 10^{th}-11^{th} May, with H_{sig} reaching 8.43 m at both Sydney and Port Kembla and 8.86 m at Botany Bay. Peak H_{sig} decreased to the north and south, reaching 5.9 m at Eden and 5.6 m at Coffs Harbour. The Batemans Bay buoy did not log data between 11pm on 8^{th} May and 2 pm on 14^{th} May, 1997. The largest storm event by total storm power was the 'Pasha Bulker Storm' which occurred in June 2007. This storm reached a peak H_{sig} of 6.9 m in Sydney but remained elevated over 3 m for 8 days and over 5 m for nearly 2 days.

Storms observed at the northern buoys tend to exhibit longer durations, with a mean storm duration at Brisbane of 90 hours and mean durations of over 70 hours for Byron Bay, Coffs Harbour and Crowdy Head. Buoys south of this exhibit mean durations under 70 hours, with Batemans Bay having a mean storm duration of 57 hours. This is attributed to the characteristics of the responsible storm systems, further discussed in the following section.

Mean storm direction is slightly more southerly at Sydney (153°) compared with Brisbane (137°), Byron Bay (149°) and Batemans Bay (142°), although the spread of storm directions is also greatest at Sydney (Figure 4.5). Very large storms at Sydney and Batemans Bay (Table 4.4) occur from the south-east to east-south-east, while at Brisbane and Byron Bay very large storms may also occur from the east to east-south-east.

Table 4.3
Summary of Storm Events Detected at Each Wave Buoy

Data source	Number of detected storm events	Effective Record length (years)	Average number of storms/ year	Maximum storm peak wave height $(H_{sig})_{peak}$	Mean storm peak wave height $(H_{sig})_{peak}$	Mean storm duration (hours)	Mean total storm power (kW/m)
Brisbane	456	28.5	16.0	7.36	3.69	90	-
Byron Bay	495	24.3	20.4	7.64	3.75	74	2800
Coffs Harbour	454	28.5	15.9	7.37	3.78	72	2910
Crowdy Head	390	20.7	18.8	7.35	3.84	73	3130
Sydney	451	19	23.7	8.43	3.98	64	2830
Botany Bay	751	34	22.1	8.87	3.91	63	-
Port Kembla	594	30.6	19.4	8.43	3.80	64	2340
Batemans Bay	318	21.2	15.0	7.19	3.71	57	2310
Eden	441	26.6	16.5	7.14	3.87	68	2590

Table 4.4
Largest 10 Storm Events Ranked by Peak H_{sig} for Each Wave Buoy

Brisbane												
	Duration			Storm Peak				Storm Mean			Total	Storm
Rank	Peak	Hours	Storm Type	Hsig	Hmax	Tp	Dirn	Hsig	Tp	Dirn	Power (MW/m)	rms H_{sig}
1	17/03/93	319	TC	7.4	12.9	12.3		3.5	9.7			3.8
2	4/03/06	144	ETL	7.2	11.5	12.2	100	4.1	9.5	116		4.4
3	5/03/04	154	ETL	7.0	14.3	12.1	72	3.2	9.6	110		3.4
4	2/05/96	263	ETL	6.9	10.1	11.9		3.5	9.5			3.8
5	15/02/95	226	TL	6.4	10.8	11.2		3.1	9.3			3.2
6	23/08/08	67	SSL	6.4	9.6	11.5	160	3.4	12.5	153		3.6
7	31/12/07	233	TL	6.3	9.0	13.4	91	3.8	11.0	98		3.9
8	15/02/96	123	TC	6.2	11.9	12.9		3.2	10.7			3.3
9	25/04/89	126	ETL	6.1	9.1	10.6		3.5	9.4			3.7
10	26/03/98	67	TC	6.0	9.5	13.1	77	3.6	10.4	113		3.8

Byron Bay

Rank	Duration		Type	Storm Peak				Storm Mean			Total Power (MW/m)	Storm rms H_{sig}
	Peak	Hours		Hsig	Hmax	Tp	Dirn	Hsig	Tp	Dirn		
1	21/05/09	186	ETL	7.6	12.1	13.0	99	4.0	11.0	100	18.2	4.2
2	14/02/09	107	IT	6.6	10.5	10.9	101	2.8	9.4	126	4.6	2.9
3	11/05/97	284	ETL	6.0	10.2	15.1		2.9	11.0		14.0	3.0
4	15/09/88	90	ETL	6.0	9.2	11.1		3.3	10.0		5.3	3.5
5	4/09/03	38	STL	5.9	10.7	13.5	159	3.5	13.0	155	3.7	3.7
6	26/04/89	147	ETL	5.9	10.0	10.2		3.6	10.0		10.8	3.8
7	15/02/95	291	TL	5.8	8.4	10.2		2.7	9.1		10.5	2.8
8	7/03/95	160	TC	5.8	10.7	12.2		3.4	11.1		10.5	3.5
9	8/05/80	144	ETL	5.8	9.8	10.8		3.2	11.1			3.4
10	8/03/90	74	TC	5.7	9.5	12.2		3.7	11.7		6.3	3.8

Coffs Harbour

Rank	Duration		Type	Storm Peak				Storm Mean			Total Power (MW/m)	Storm rms H_{sig}
	Peak	Hours		Hsig	Hmax	Tp	Dirn	Hsig	Tp	Dirn		
1	22/06/89	299	ETL	7.4	13.5	11.1		3.3	10.3		18.7	3.5
2	14/07/99	107	ETL	6.8	9.8	12.2		3.7	11.4		9.2	3.9
3	9/07/85	25	ETL	6.6	9.7	11.1		4.0	9.6		2.3	4.2
4	22/05/09	200	ETL	6.5	10.2	12.2		3.5	11.1		16.9	3.8
5	25/02/04	182	IT	6.5	10.8	11.1		3.1	10.2		10.1	3.3
6	8/08/86	174	ETL	6.4	11.1	13.5		3.4	12.4		13.9	3.6
7	9/02/88	83	IT	6.4	9.8	15.1		3.4	11.6		6.7	3.6
8	9/04/84	96	TC	6.2	8.6	11.7		3.8	10.1		1.4	3.9
9	7/03/95	139	TC	6.2	9.8	13.5		3.6	11.5		10.8	3.8
10	16/11/05	64	IT	6.0	8.6	13.5		3.7	10.8		5.0	3.8

Crowdy Head

Rank	Duration		Type	Storm Peak				Storm Mean			Total Power (MW/m)	Storm rms H_{sig}
	Peak	Hours		Hsig	Hmax	Tp	Dirn	Hsig	Tp	Dirn		
1	4/03/95	206	TC	7.4	11.0	13.5		3.7	10.9		17.8	3.9
2	15/07/99	104	ETL	6.8	11.2	12.2		4.2	11.6		11.8	4.4
3	29/05/90	70	ETL	6.7	9.3	12.2		3.4	9.7		4.6	3.6
4	9/02/88	93	IT	6.5	10.4	15.1		3.7	11.3		8.5	3.9
5	23/04/99	110	SSL	6.5	10.4	15.1		3.7	11.9		10.4	3.9
6	13/10/90	103	CL	6.4	9.7	15.1		3.5	12.2		8.8	3.7
7	29/07/01	35	ETL	6.3	9.3	15.1		3.4	11.6		3.2	3.7
8	30/06/02	98	SSL	6.3	11.2	15.1		3.9	13.1		11.1	4.1
9	11/05/97	225	ETL	6.3	10.6	15.1		2.9	11.1		11.9	3.1
10	7/03/90	84	TC	6.3	12.9	12.2		3.9	11.4		8.0	4.1

Sydney

Rank	Duration		Type	Storm Peak				Storm Mean			Total Power (MW/m)	Storm rms H_{sig}
	Peak	Hours		Hsig	Hmax	Tp	Dirn	Hsig	Tp	Dirn		
1	11/05/97	303	ETL	8.4	13.7	12.8	151	3.1	11.6	138	21.2	3.5
2	3/08/90	157	ETL	7.2	11.8	10.2		2.9	10.2		7.2	3.0
3	28/07/01	29	ETL	7.0	11.7	13.5	169	5.2	12.3	161	5.5	5.4
4	9/06/07	491	ETL	6.9	14.1	10.8	135	3.2	11.2	153	29.5	3.3
5	12/11/87	78	IT	6.8	10.2	11.1		3.9	9.2		6.1	4.1
6	18/07/04	66	SSL	6.7	8.1	12.2	167	4.0	10.6	159	6.2	4.1
7	23/03/05	285	IT	6.6	11.2	12.2	139	2.8	9.7	157	12.2	3.0
8	19/07/07	73	SSL	6.5	12.3	12.9	158	3.8	11.6	158	6.9	4.0
9	3/06/06	89	SSL	6.5	9.9	13.5	173	3.7	11.1	168	8.1	4.0
10	26/08/90	124	SSL	6.3	11.6	12.2		3.4	11.5		9.1	3.6

Botany Bay

Rank	Duration		Type	Storm Peak				Storm Mean			Total Power (MW/m)	Storm rms H_{sig}
	Peak	Hours		Hsig	Hmax	Tp	Dirn	Hsig	Tp	Dirn		
1	10/05/97	275	ETL	8.9	13.7	13.1		3.3	10.6			3.7
2	28/07/01	99	ETL	8.1	12.7	12.5		4.4	10.7			4.7
3	21/06/75	162	IT	7.4	13.1			3.2	10.3			3.5
4	25/09/95	133	SSL	7.2	10.4	11.7		3.6	10.3			3.9
5	25/10/85	14	IT	7.0	9.5	11.3		5.3	11.4			5.4
6	23/03/05	266	IT	6.9	11.0	12.1		2.8	9.6			3.0
7	1/06/78	90	ETL	6.9	11.5			3.9	11.5			4.1
8	5/08/86	134	ETL	6.8	10.3	10.8		4.5	10.5			4.7
9	28/04/99	254	STL	6.7	10.9	11.8		3.4	10.2			3.6
10	10/07/05	68	IT	6.6	9.3	12.6		3.7	11.5			4.0

Port Kembla

Rank	Duration		Type	Storm Peak				Storm Mean			Total Power (MW/m)	Storm rms H_{sig}
	Peak	Hours		Hsig	Hmax	Tp	Dirn	Hsig	Tp	Dirn		
1	11/05/97	101	ETL	8.4	13.7	12.8		4.4	10.9		6.7	4.7
2	31/08/96	119	IT	7.4	10.5	13.5		3.2	10.3		7.4	3.5
3	19/03/78	102	ETL	6.9	10.4	11.7		4.6	10.7		2.1	4.9
4	6/08/86	248	ETL	6.8	10.8	12.2		3.7	11.7		21.8	3.9
5	2/06/78	120	ETL	6.7	11.1	11.7		4.1	11.0		2.3	4.3
6	26/08/90	140	SSL	6.7	11.9	13.5		3.6	11.5		11.6	3.7
7	25/09/95	120	SSL	6.6	9.5	12.2		3.2	10.4		7.2	3.4
8	13/10/90	66	CL	6.5	10.4	13.5		3.9	12.1		6.5	4.1
9	28/07/01	88	ETL	6.3	9.3	12.2		3.8	11.0		2.0	4.0
10	20/05/78	132	CL	6.3	10.6	12.2		3.5	11.8			3.7

Batemans Bay

Rank	Duration		Type	Storm Peak				Storm Mean			Total Power (MW/m)	Storm rms H_{sig}
	Peak	Hours		Hsig	Hmax	Tp	Dirn	Hsig	Tp	Dirn		
1	31/08/96	107	IT	7.2	10.1	12.2		3.6	10.8		8.9	3.9
2	28/11/05	79	IT	6.6	10.7	12.2	153	3.2	10.2	156	4.9	3.4
3	24/10/99	62	IT	6.6	10.4	12.2		3.8	10.1		5.3	4.1
4	13/10/90	71	CL	6.0	9.9	13.5		3.8	12.2		7.0	4.0
5	19/11/86	72	IT	6.0	7.8	10.2		4.4	11.0		8.7	4.6
6	20/06/07	242	ETL	5.7	10.2	11.5	148	2.8	10.7	138	10.7	2.9
7	6/08/86	242	ETL	5.6	10.3	12.2		3.2	11.2		15.7	3.4
8	28/07/01	87	ETL	5.4	8.4	11.1	146	3.3	10.4	133	5.4	3.5
9	23/06/05	59	SSL	5.4	9.8	11.1	164	2.8	9.8	127	2.3	2.9
10	28/06/07	77	ETL	5.4	9.5	12.9	149	3.2	11.6	137	4.9	3.3

Eden

Rank	Duration		Type	Storm Peak				Storm Mean			Total Power (MW/m)	Storm rms H_{sig}
	Peak	Hours		Hsig	Hmax	Tp	Dirn	Hsig	Tp	Dirn		
1	29/06/02	78	SSL	7.1	13.1	12.2		3.5	11.0		6.1	3.8
2	28/06/07	84	ETL	7.1	10.8	12.2		4.0	11.3		8.4	4.2
3	1/09/96	116	IT	6.8	10.5	13.5		3.4	10.9		8.5	3.6
4	13/03/94	209	IT	6.7	11.0	13.5		3.5	10.8		16.0	3.7
5	11/07/89	100	SSL	6.7	10.1	11.2		3.8	11.8		9.0	4.0
6	2/06/78	90	ETL	6.5	10.9	14.9		4.0	12.2		0.0	4.3
7	23/06/98	96	SSL	6.4	11.8	10.2		3.6	10.6		7.0	3.8
8	12/10/90	110	CL	6.4	10.1	12.2		3.5	11.2		7.9	3.7
9	10/07/05	86	IT	6.3	10.2	11.1		3.6	10.8		6.4	3.9
10	25/10/85	58	IT	6.1	10.4	12.2		4.0	10.1		5.1	4.1

4.2.2 Storm Type

The synoptic type was assigned to each storm event based on the storm classification described in Section 2, using the NCEP-NCAR Reanalysis (NCEP) pressure dataset from 1948 to 2009 (Kalnay *et al.* 1996). These types are provided, in brief, within Table 4.5 and for each observed storm event within the *storm history table* in Appendix D. The types were determined using the 1000 hPa (surface) and 500 hPa pressure field data. The assigned type for each storm event was based on the synoptic genesis of the storm and the synoptic pattern at the time of the observed peak wave climate. We also determined a secondary storm type which produced storm waves during the duration of the observed peak wave conditions. The storm types often are transformed as they move eastwards or southwards in the Tasman Sea region. Whilst most synoptic type classifications were unambiguous, some classifications were difficult due to factors such as change in storm type during wave generation, multiple simultaneous swell generating weather systems.

The total number of storms observed yearly by storm type is presented within Figure 4.6 with the year of wave buoy commission indicated. Storms observed only at the Botany Bay buoy were not assigned types within this study. Total yearly storm numbers since all wave buoys were commissioned (1987) has remained largely constant at around 32 storms per year, with a slight increase observed during the late 1990s. This may be related to the change in phase of the Interdecadal Pacific Oscillation (IPO) (Goodwin and Browning, in prep) from El Niño-like to La Niña-like in the early to mid 2000s. The relationship between storm frequency and the El Niño-Southern Oscillation (ENSO) was examined by You and Lord (2008), who found correlation between average yearly storm intensity and Southern Oscillation Index (SOI) indicating more severe storm events during La Niña years. The Sydney wave buoy was found to detect an average of 23.7 storms per year (Table 4.3) meaning that the Sydney coastline is affected, based on the adopted H_{sig} threshold, by around 75% of all storm wave events on the NSW coast. However, it is important to note that the available buoy data only span the El Niño-like phase of the IPO together with a few recent years of the La Niña-like phase. Hence, it is probable that any trends and relationships between storm type, frequency and severity, ENSO and the IPO are biased towards the El Niño-like phase, where interannual El Niño events are stronger and more persistent over multi-years, and La Niña events weaker and less persistent. Goodwin and Blackmore (in prep) will report the results of hindcasting NSW wave climate over the La Niña-like phase of the IPO prior to the buoy measurement period.

Appendix E provides, for each wave buoy, a time series of storm peak H_{sig} and type. Major storm events (> 6 m) on the northern NSW coast are a mixture of tropical cyclones, tropical lows and easterly trough lows while on the central NSW coast, major storm events also include inland trough lows and southern secondary lows. Along the southern NSW coast, major storm events are mainly associated with a combination of easterly trough lows, inland and continental lows and southern secondary lows, with a number of Southern Tasman lows causing waves in excess of 5 m but not reaching 6 m. The latter produce long period oblique swell along the central and northern NSW coasts.

Storm types are presented by percentage for each wave buoy within Figure 4.7. This figure shows a similar spatial variation in the occurrence of particular storm types. A decrease in the occurrence of anticyclone intensification induced events and tropical lows and cyclones to the south and a corresponding increase in southerly trough lows can be observed for all storms. For storms exhibiting peak H_{sig} > 5 m, the reduction in anticyclone intensification induced events and tropical lows and cyclones is more pronounced. An increase in inland trough and continental lows is observed at the southern buoys. Easterly trough lows are largely constant north to south, although reduce in the central coast from Sydney to Port Kembla, where there is a corresponding increase in the occurrence of southern secondary lows.

Seasonal changes in the occurrence of various storm type are shown within Figure 4.8 which provides the total number of storms observed for each month. March, July and October are the stormiest months, with November, December and January being the least stormy. Inland trough lows and southern secondary lows exhibit strong negative-correlation, with greater numbers of southern secondary lows occurring between April and October and larger numbers of inland trough lows occurring between October and March. Tropical cyclones and lows are restricted to December to April with most occurring between January and March. Easterly trough lows are concentrated between April and August. Both anticyclone intensifications and Southern Tasman lows occur throughout the year, although anticyclone intensification events tend to be more concentrated and produce larger wave events between January and June and Southern Tasman lows are concentrated and produce larger wave events between July and December.

Table 4.5
Storm Type Definitions

Number	Abbreviation	Full Name	Description
1	TC	Tropical Cyclone	Swell related to named Tropical Cyclones forming in the Coral Sea between 5-10° latitude.
2	ETL	Easterly Trough Low	Cyclonic depressions generated primarily along the central NSW coast between 25 and 40° latitude
3	CL	Continental Low	Storms originating in Western Australia of the Great Australian Bight and moving overland, often re-intensify upon crossing the east coast
4	STL	Southern Tasman Low	Major lows in the southern ocean south of 38S
5	SSL	Southern Secondary Low	Form in association with STL as a secondary cut off low in the Tasman sea
6	ITL	Inland Trough Low	Originate in the quasi-permanent low pressure trough over inland Qld, their movement to the east coast is often associated with STL
7	AI	Anti-Cyclone Intensification	Form when a high across the Tasman Sea directs onshore E to SE winds to the coast
8	TL	Tropical Low	Low pressure systems forming in the Coral Sea but not reaching the low pressure intensity of a named tropical cyclone

4.2.3 Duration of Wave Height Exceedance

Extreme value analysis of wave data is generally undertaken for the peak significant wave height only. This provides extreme wave heights corresponding to the sampling interval, which is typically one or three hours. However, for many applications such as evaluating beach erosion and coastal inundation, the combination of both wave height and elevated water levels are critical. In these cases, evaluation of extreme wave height over a longer duration is required (Lord and Kulmar, 2000; Carley and Cox, 2003). Thus, an extreme value analysis should also be undertaken for wave height exceedance values over longer durations.

This has been undertaken by assessing the exceedance significant wave height for varying durations from the sampling interval (1 hour) to 144 hours (6 days) for each defined storm event. If a particular storm event does not extend beyond the duration of interest, that storm event does not contribute to the record for extreme value analysis. A reduced number of storm events is therefore noted for longer durations. An example of the change in number and magnitude of detected events as a function of duration is presented in Figure

4.9 for the Sydney wave buoy. It is evident from this figure that while a threshold storm height of 3 m may have been appropriate for assessing storm durations up to 24 hours, the lower 2 m threshold is required for assessing longer duration events.

4.3 Extreme Value Analysis

4.3.1 Background

Large, low probability wave events are generally defined in terms of a return period (RP) or average recurrence interval (ARI). The commonly used approach to derive extreme wave height for a particular ARI is to fit a theoretical distribution to historical storm wave data. If the record is of insufficient length to provide the event magnitude for the return period of interest, the distribution is extrapolated. The reliability of such extrapolation is dependent on selection of an appropriate distribution to best fit the available data and the length of extrapolation relative to data record length.

As described previously, an important requisite of the samples used for extreme value analysis is statistical independence (Goda, 2000). This means that the correlation between successive data should be near zero. While care is taken when defining storm events to ensure each meteorological event produces only one sample, clustering of storms and generation of wave-inducing meteorological events by other wave-inducing meteorological events, i.e. an anticyclone intensification induced by a tropical low, may result in slight dependence. Another important requisite is that of homogeneity where all samples are of the same *population* and belong to a common parent distribution. While all wave events are generally treated as belonging to the same population, generation by differing meteorological events, i.e. southerly trough lows compared with tropical cyclones, will mean that this requirement is not completely satisfied. This is partially addressed by the proxy of storm wave direction. The effect of direction on extreme events is further discussed within Section 4.3.6. The data used within extreme values analysis is also assumed to be statistically stable, i.e. long term change is negligible.

You (2007) describes five steps in calculating extreme wave height: analysing raw wave data to obtain statistically independent storm wave heights; estimating an empirical probability distribution function (pdf); fitting candidate functions to the observed data to obtain the best fit; extrapolating the best fit pdf to the required return value (H_R) and estimating the confidence intervals of the resultant height.

4.3.2 Fitting Probability Distribution Functions

You (2007) examined the fit of nine extreme value distributions to long term wave data (1988 to 2006) for the Sydney wave buoy. These included Exponential, Lognormal, Weibull, Fisher-Tippett type 1 (FT-I or Gumbel), type 2 (FT-II), type 3 (FT-III), Generalised Pareto type 1 (GPD-I), type 2 (GPD-II) and type 3 (GPD-III) distributions. All but two (FT-III and GPD-III) are unbounded at the upper end. You (2007) suggested that use of upper bounded distributions is inappropriate for extreme value analysis of wave heights as they as they tend to underestimate extreme wave height.

You (2007) found both the FT-I (Gumbel) and Weibull distributions to best fit the observed data and suggested the FT-1 as most appropriate due to its simplicity as a two-parameter distribution rather than the three-parameter Weibull. Goda (1988) similarly suggested the FT-I (Gumbel) and Weibull distributions as most appropriate for evaluation of extreme waves. These candidate distributions, presented within Eqns. 4.1 and 4.2, are therefore adopted for consideration within the present study.

FT-1
$$F_{(x)} = \exp\left[-\exp\left(-\frac{x-B}{A}\right)\right] \tag{4.1}$$

Weibull
$$F_{(x)} = 1-\exp\left[-\left(\frac{x-B}{A}\right)^k\right] \tag{4.2}$$

Where $F_{(x)}$ is the distribution function and *A*, *B* and *k* are scale, location and shape parameters.

As can be observed, the FT-1 or Gumbel distribution (4.1) is a function of only the scale and location parameter while the Weibull distribution (4.2) contains an additional shape parameter.

4.3.3 Evaluating Goodness of Fit

The *expected* probability ($F_{(m)}$) of the observed data or variates is evaluated using an appropriate plotting position formula. The simplest plotting position formula is the Weibull formula (Eqn. 4.3). However, this formula has been found to produce a positive bias, particularly in small data sets (Goda, 1988). More appropriate plotting position formula producing minimal bias are the Gringorten plotting position formula (Gringorten, 1963) for the FT-1 distribution and the modified Petruaskas and Aagaard formula proposed by Goda (1988) for the Weibull distribution (Eqn. 4.4).

$$F_{(m)} = 1 - \left(\frac{m}{N+1} \right) \tag{4.3}$$

$$F_{(m)} = 1 - \left(\frac{m-\alpha}{N+\beta} \right) \tag{4.4}$$

Where $F_{(m)}$ is the expected probability of the m^{th} ordered variates, N is the number of samples and α and β are constants given as 0.44 and 0.12 for the FT-1 distribution (Gringorten, 1965) and ($0.2 + 0.27/k^{0.5}$) and ($0.2 + 0.23/k^{0.5}$) where *k* is the distribution shape parameter (Goda, 1988).

By plotting observed height (H) of each data against a reduced variate (X), calculated according to Eqns. 4.5 (FT-1) and 4.6 (Weibull), scale, location and shape parameters (A, B and *k*) may be estimated for Eqns. 4.1 and 4.2 using a fitting method.

$$X = -\ln(-\ln F_{(m)}) \tag{4.5}$$

$$X = \left[-\ln(1 - F_{(m)}) \right]^{1/k} \tag{4.6}$$

There are a variety of methods available including the graphical fitting method, least squares method, method of moments and maximum likelihood method. Goda (2003) advocates the use of the least squares method with appropriate plotting position formula over the other methods on the basis of bias and efficiency. This least-squares method was similarly used by You (2007). Scale and location parameters are determined based on the relation shown within Eqn. 4.7. The goodness of fit may be evaluated by a variety of tests. In this case, the coefficient of regression, R^2, the sum of the squares of the error (SSE), evaluated according to Eqn. 4.8, and a visual assessment of goodness of fit are used. This visual assessment is important as the goodness of fit compared to the data extremes is very important and may not be adequately assessed by evaluation of the R^2 and SSE only.

$$H = AX + B \tag{4.7}$$

$$SSE(H) = \sum_{i=1}^{m} (H_i - H)^2 \tag{4.8}$$

Where H_i is the i[th] peak storm wave height and H is the equivalent value evaluated according to (4.7).

While the parameter assessment is relatively simple for the FT-1 method, the shape parameter, k, in the Weibull distribution influences both the plotting position formula and reduced variates and is not assessed implicitly. The shape parameter k is therefore estimated using the optimisation method described in You (2007), where k is incrementally varied until $|W-1|^{0.5}$ is ≈ 0 where W is evaluated by Eqn. 4.9. This optimisation is shown within Figure 4.10A.

$$W = \frac{\sum_{i=1}^{m}(H_i - \overline{H})(X_i - \overline{X})}{\sum_{i=1}^{m}(X_i - \overline{X})} \times \frac{\sum_{i=1}^{m}(X_i^* - \overline{X^*})(X_i - \overline{X})}{\sum_{i=1}^{m}(X_i^* - \overline{X}^*)(H_i - \overline{H})} \tag{4.9}$$

Where H_i is the i^{th} peak storm wave height, X_i is given by (4.6) and $X_i^* = X[-ln(1-F_{(m)})]$.

Table 4.6 compares the SSE and R^2 obtained using the FT-1 distribution and Weibull distribution with individually optimised shape parameters for a range of storm durations observed at the Sydney wave buoy. While the R^2 value is high for both distributions, the SSE value is substantially lower for the Weibull distribution. This distribution is also visually the most appropriate across the range of exceedance durations due to the greater flexibility afforded by the three parameter fit. The Weibull distribution with a shape parameter optimised for each data set has therefore been adopted within this study.

Table 4.6
Evaluation of Goodness of Fit for FT-1 and Weibull distributions for Sydney

Coefficient of Regression (R^2)

Distribution	Shape parameter	1 hr	3 hr	6 hr	12 hr	24 hr	48 hr	96 hr	144 hr
FT-1	-	0.981	0.981	0.988	0.994	0.992	0.979	0.949	0.899
Weibull	Variable: k = 0.76 to 1.24	0.991	0.989	0.995	0.997	0.995	0.989	0.974	0.967

Sum of Squares of the Error (SSE)

Distribution	Threshold	1 hr	3 hr	6 hr	12 hr	24 hr	48 hr	96 hr	144 hr
FT-1	-	6.66	6.07	3.66	1.76	1.43	1.60	0.55	0.30
Weibull	Variable: k = 0.76 to 1.24	1.59	2.01	0.78	0.49	0.52	0.73	0.25	0.08

4.3.4 Evaluating Annual Recurrence Interval and Confidence Interval

Once the appropriate probability distribution function and function coefficients have been determined, the annual recurrence interval (ARI) and return value (H_R) can be assessed by Eqn. 4.9 and 4.10 respectively

$$ARI = \frac{1}{\lambda\left[1 - F(x_u)\right]} \quad (4.9)$$

$$H_R = F^{-1}\left(1 - \frac{1}{\lambda ARI}\right) \quad (4.10)$$

Where $F(x_u)$ probability of non-exceedance of a variate (x_u) and λ is the average number of events per year.

Confidence intervals are assessed based on the standard deviation for each return value (Eqn. 4.11),

$$\sigma(x_R) = \sigma_z \times \sigma_x \quad (4.11)$$

Where σ_x is the sample standard deviation and σ_z is the standard deviation of the reduced variate given by Eqn. 4.12 (Goda, 1988) as:

$$\sigma_z = \left[1.0 + a(y_R - c + \alpha \ln v)^2\right]^{1/2} / \sqrt{N} \quad (4.12)$$

With *a* being:

$$a = a_{1\exp}\left[a_2 N^{-1.3} + \kappa(-\ln v)^2\right] \quad (4.13)$$

and the constants within Eqns. 4.12 and 4.13 interpolated from empirical values derived by Monte Carlo simulation in Goda (1988) and presented in Table 4.7.

Table 4.7
Constants for the Standard Deviation of the Return Value (Goda, 1988)

Distribution	a_1	a_2	κ	c	α
Weibull (k = 0.75)	1.65	11.4	-0.63	0.0	1.15
Weibull (k = 1.0)	1.92	11.4	0.00	0.3	0.90
Weibull (k = 1.4)	2.05	11.4	0.69	0.4	0.72
Weibull (k = 2.0)	2.24	11.4	1.34	0.5	0.54

A 90% confidence interval as suggested by Goda (2000) has been adopted within the present study. Alternative methods of defining confidence intervals were considered including assessment of the confidence in the least squares slope. The derived confidence intervals were, however, insensitive to such alternatives.

Extreme waves with average recurrence intervals of between 1 and 100 years and durations between 1 hour and 144 hours (6 days) are presented for each wave buoy within Appendix F along with numerical results for the 3 hourly NWW3 data and 6 hourly ERA-40 data.

4.3.5 Spatial Variation

The 1 hour exceedance H_{sig} for all buoys for average recurrence intervals of between 1 and 100 years is shown in Figure 4.11 and summarised for the 1, 10, 50 and 100 year ARI along with 90% confidence intervals in Table 4.8. The mid NSW coast exhibits the highest extreme wave climate, with both Sydney and Botany Bay showing similar extreme statistics with 100 year ARI H_{sig} values of 9.0 and 9.1 m respectively. Port Kembla exhibits slightly lower 100 year ARI H_{sig} of 8.8 m, although this is within the confidence intervals of Sydney. Both Eden and Crowdy Head have 100 year ARI H_{sig} of 8.5 ±0.5 m. The difference between this value and Sydney is at, or outside, the confidence limits, indicating a statistically valid spatial difference.

Table 4.8
Summary of Spatial Variation in One Hour Exceedance H_{sig} along the NSW Coast

	H_{sig} (m) ± 90% CI			
Buoy	**1 yr ARI**	**10 yr ARI**	**50 yr ARI**	**100 yr ARI**
Brisbane	5.1 (± 0.2)	6.6 (± 0.3)	7.6 (± 0.4)	8.0 (± 0.4)
Byron Bay	5.2 (± 0.2)	6.4 (± 0.2)	7.2 (± 0.3)	7.6 (± 0.3)
Coffs Harbour	5.2 (± 0.2)	6.7 (± 0.3)	7.7 (± 0.4)	8.1 (± 0.4)
Crowdy Head	5.4 (± 0.2)	7.0 (± 0.4)	8.0 (± 0.5)	8.5 (± 0.5)
Sydney	5.9 (± 0.2)	7.5 (± 0.4)	8.6 (± 0.5)	9.0 (± 0.5)
Botany Bay	5.7 (± 0.2)	7.4 (± 0.3)	8.6 (± 0.4)	9.1 (± 0.4)
Port Kembla	5.4 (± 0.2)	7.1 (± 0.3)	8.3 (± 0.4)	8.8 (± 0.5)
Batemans Bay	4.9 (± 0.2)	6.3 (± 0.4)	7.3 (± 0.5)	7.7 (± 0.5)
Eden	5.4 (± 0.2)	7.0 (± 0.3)	8.1 (± 0.4)	8.5 (± 0.5)

Batemans Bay is substantially lower at 7.7 m ±0.5 m. While Batemans Bay is known to have missed a number of large events including the May 1997 event, the mean and 50% exceedance value at Batemans Bay are also lowest indicating a more systematic difference. Calculated extreme wave heights to the north of Crowdy Head decrease with Coffs Harbour, Byron Bay and Brisbane exhibiting 8.1, 7.6 and 8.0 ±0.5 m respectively. Again, Byron Bay is known to have missed a number of large events, although its two largest events of 7.6 m and 6.6 m on 21st May and 14th February 2009 were captured. The effect of missing data is addressed within Section 4.4 but interpolation of major missing storms from adjacent buoys is not found to substantially change extreme statistics (i.e. values remain within the assessed confidence limits).

4.3.6 Storm Duration

As discussed earlier, many applications requiring extreme wave height (i.e. assessment of coastal inundation) are also influenced by elevated water levels. In these cases, the height exceedance for longer durations is important. However, as less data is available for storms of long duration, confidence intervals are proportionally larger. Appendix F presents wave height exceedance for events of duration up to 144 hours (6 days). The change in exceeded wave height as a function of duration for the Sydney buoy is presented within Figure 4.12. This figure shows that for all ARI events, height drops by around 20% from the 1 hour height at 12 hours and by 50 % at 72 hours (3 days), before asymptoting to between 35% and 40% of the 1 hour height at 6 days.

Comparison of the 100 year ARI values for all buoys within Figure 4.12 shows the wave height at the northern buoys of Brisbane and Byron Bay to drop more slowly and the southern buoy at Eden to drop more quickly. This is, again, a function of the type and track of storms causing the wave events with longer duration events such as anticyclone intensification and slow moving tropical cyclones and lows affecting the northern coast to a greater extent. Extreme wave height does not decrease to 50% of the one hour height until after 132 hours (5.5 days) at Brisbane and 108 hours (4.5 days) at Byron Bay.

4.3.7 Numerical Comparisons

Comparison of the extreme wave heights derived using buoy measurements and those derived using NOAA's Wavewatch III (NWW3) numerical wave model and the ERA-40 numerical hindcast dataset are presented within Figure 4.13 for the one hour exceedance event and for the 10 and 100 year ARI events within Table 4.9.

The NWW3 model provides very good agreement with the Brisbane buoy and Port Kembla buoy. The model over predicts extreme wave height at Byron Bay, Coffs Harbour, Crowdy Head and Batemans Bay. In all cases, the over prediction is outside the wave buoy confidence limits and the over prediction is severe at Crowdy Head (1.5 m over prediction). The NWW3 model under predicts extreme wave height at Sydney, Botany Bay and Eden, although the under prediction at Sydney and Botany Bay is at the confidence limit level. Confidence limits for the NWW3 predictions are higher than for the buoys due to the shorter record length (±0.9 to 1.2 m for the 100 year ARI height cf. ±0.3 to 0.5 m for the buoys). It should be noted that the numerical output from the grid cell containing the wave buoy location was used rather than the weighted average from a number of adjacent cells.

The ERA-40 hindcast dataset under predicts wave height in most locations except Byron Bay, Batemans Bay and Coffs Harbour where agreement with buoy values is reasonable. At Byron and Batemans Bay, the over prediction is at around the buoy confidence limit. Severe under prediction occurs at Brisbane and Eden. This under prediction is likely due to adjacent land cells limiting the input of wave energy from particular directions. It should be noted that, due to the large size of the ERA-40 spatial domain, the same numerical output is used at Byron Bay and Coffs Harbour, and at Sydney, Botany Bay, Port Kembla and Batemans Bay.

Table 4.9
One Hour Exceedance 50 and 100 year ARI H_{sig} For Wave Buoys and Numerical

	10 year ARI			100 year ARI		
Buoy	**Wave Buoy**	**NWW3**	**ERA-40**	**Wave Buoy**	**NWW3**	**ERA-40**
Brisbane	6.6 (± 0.3)	6.6 (± 0.5)	4.3 (± 0.3)	8.0 (± 0.4)	8.0 (± 0.8)	5.3 (± 0.5)
Byron Bay	6.4 (± 0.2)	7.0 (± 0.6)	6.7 (± 0.3)	7.6 (± 0.3)	8.4 (± 0.8)	8.2 (± 0.5)
Coffs Harbour	6.7 (± 0.3)	7.4 (± 0.6)	6.7 (± 0.3)	8.1 (± 0.4)	8.9 (± 0.9)	8.2 (± 0.5)
Crowdy Head	7.0 (± 0.4)	8.3 (± 0.8)	6.5 (± 0.3)	8.5 (± 0.5)	10.0 (± 1.2)	8.1 (± 0.5)
Sydney	7.5 (± 0.4)	7.0 (± 0.6)	6.7 (± 0.3)	9.0 (± 0.5)	8.6 (± 0.9)	8.2 (± 0.5)
Botany Bay	7.4 (± 0.3)	7.0 (± 0.6)	6.7 (± 0.3)	9.1 (± 0.4)	8.6 (± 0.9)	8.2 (± 0.5)
Port Kembla	7.1 (± 0.3)	7.0 (± 0.6)	6.7 (± 0.3)	8.8 (± 0.5)	8.6 (± 0.9)	8.2 (± 0.5)
Batemans Bay	6.3 (± 0.4)	7.5 (± 0.6)	6.7 (± 0.3)	7.7 (± 0.5)	8.8 (± 0.9)	8.2 (± 0.5)
Eden	7.0 (± 0.3)	5.9 (± 0.4)	5.2 (± 0.2)	8.5 (± 0.5)	6.8 (± 0.5)	6.1 (± 0.2)

Selection of an appropriate buoy duration to compare with the numerical data sets is also problematic as the numerical datasets are provided at three hour (NWW3) and six hour (ERA-40) intervals, yet are instantaneous samples rather than three or six hour averages. While the peak of an event could be missed by the numerical model run, the fact that they are '*instantaneous*' values rather than averages meant it was deemed appropriate to compare the numerical outputs to the one hour (or peak) buoy values. Overall, the NWW3 numerical model resulted in over prediction of extreme vales in the north and under prediction in the south, while the ERA-40 dataset resulted in general under prediction of extreme values across all regions.

4.3.8 Storm Direction

The effect of storm direction on extreme wave height is shown within Figure 4.13. In all cases, extreme waves arriving from north of 90° are predicted to be lowest. Brisbane and Byron Bay predict extreme waves from between east and south-east (90 to 135°) to be largest, while Sydney and Batemans Bay predict extreme waves from south of 135° to be largest. Due to the short length of directional record at Byron Bay, the extrapolated extreme values from the east and south-east (90 to 135°) are predicted to exceed the '*all directions'* values. This is inappropriate and should converge to agreement with the '*all directions'* value once the record length increases. In practice, the '*all directions'* value should be adopted as an upper limit.

Table 4.10 shows the extreme directional statistics for the 10 year ARI events. Confidence limits increase markedly for directions where a limited number of storm are available for analysis. Only five storms with a direction north of 90° were available at Byron Bay resulting in 90% confidence limits of ± 2.1 m. This indicates very low statistical confidence, although the extreme distribution fits the data well.

Table 4.10
One Hour Exceedance 10 year ARI H_{sig} For Directional Wave Buoys

	H_{sig} (m) ± 90% CI			
Buoy	**All**	**0 - 90°**	**90 - 135°**	**135 - 225°**
Brisbane	6.6 (± 0.3)	4.6 (± 1.2)	6.8 (± 0.6)	5.7 (± 0.4)
Byron Bay	6.4 (± 0.2)	4.3 (± 2.1)	7.1 (± 1.6)	6.1 (± 0.4)
Sydney	7.5 (± 0.4)	4.5 (± 0.7)	6.2 (± 0.7)	7.5 (± 0.5)
Batemans Bay	6.3 (± 0.4)	4.5 (± 1.4)	5.6 (± 1.2)	6.1 (± 0.7)

4.4 Study Uncertainties and Limitations

Uncertainties in extreme value analysis may arise from several sources. Most influential are in the accuracy and completeness of original data and in the appropriateness of the fitted extreme value distribution.

4.4.1 Data Accuracy and Completeness

The accuracy of Datawell Waverider Buoys is indicated by the manufacturer at ±0.5 to 1 %. Translating this to the derived 100 year ARI 1 hour H_{sig} values of 7.6 to 9.1 m gives uncertainties of 0.05 to 0.1 m. These uncertainties are well within confidence limits.

The most serious uncertainty is related to data censoring, where major storm events are excluded due to instrument damage or other factors. Data capture has improved over time and the only real solution to this problem is to continue to collect data including large events. An example of this is the May and February 2009 events captured at Byron Bay where H_{sig} reached 7.6 and 6.6 m respectively. The previous maximum measured wave height was 6.0 m. Calculation of extreme height excluding these recent events would have resulted in underestimation of extreme values by up to 0.5 m (100 year ARI, 1 hr H_{sig} of 7.1 m excluding events cf. 7.6 m including). Table 4.11 presents a list of notable storm events, i.e. an event ranking in the top 10 for a particular buoy, where data from an adjacent buoy was missing (excludes events which occurred before a buoy was commissioned). This table interpolates a peak significant wave height for the missing buoy based on adjacent values and indicates the ranking which that interpolated event would have for the respective buoy record.

Results show that the Byron Bay buoy was missing data during a number of large adjacent events. However, the interpolated values would not have been within the 10 largest for the Byron buoy and therefore do not change the extreme statistics markedly with the 100 yr ARI, 1 hr H_{sig} increasing from 7.60 m to 7.65 m, a change which is well within the 90% confidence limits. While there is a possibility that the storm peak may have affected Byron Bay more than the adjacent sites due to the relatively small-scale nature of storm systems on the NSW coast, this specific detail cannot be resolved using the data analysis methods of this study.

Similarly, values interpolated from adjacent buoys for missing events at Coffs Harbour, Crowdy Head and Eden were outside the 10 largest events at each buoy and, as such, are not expected to change the extreme statistics notably. The notable missing storm at Batemans Bay is more significant, constituting the equal largest event on record. Inclusion of this record increased the 100 yr ARI, 1 hr H_{sig} from 7.7 m to 8.0 m, although this increase is still within the 90% confidence limits of ± 0.5 m. As previously described, the wave height during a particular event is highly dependent on the specific storm track and fetch orientation with large variation observed between the peak storm height observed at Port Kembla (8.4 m) and Eden (5.9 m). The exact height experienced at Batemans Bay is unknown, although the smaller wave heights typically observed at Batemans Bay indicates that a linear interpolation is likely conservative.

Table 4.11
Notable Missing Storm Data in Wave Buoy Record

Date	Peak H_{sig} (m)									Missing Buoy	Interpolated	Would be xth largest
	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE			
9/04/1984	5.2	-	6.2	-	-	4.0	3.6	-	< 2	Byron	5.7	10
4/03/2006	7.2	-	4.1	3.1	< 2	< 2	< 2	< 2	< 2	Byron	5.7	10
5/03/2004	7.0	-	4.1	-	3.1	3.1		< 2	< 2	Byron	5.6	14
7/03/1990	3.3	5.7	-	6.3	4.7	5.0	4.8	3.3	3.1	Coffs	6.0	11
7/03/1990	3.3	5.7	-	6.3	4.7	5.0	4.8	3.3	3.1	Coffs	6.0	11
25/02/2004	3.7	-	6.5	-	5.5	4.7	5.1	3.5	3.9	Crowdy	6.0	13
10/05/1997	4.3	6.0	5.6	6.3	8.4	8.9	8.4	-	5.9	Batemans	7.2	1 or 2
20/11/1986	3.2		3.9	4.2	-	6.3	4.9	6.0	-	Eden	6.0	12

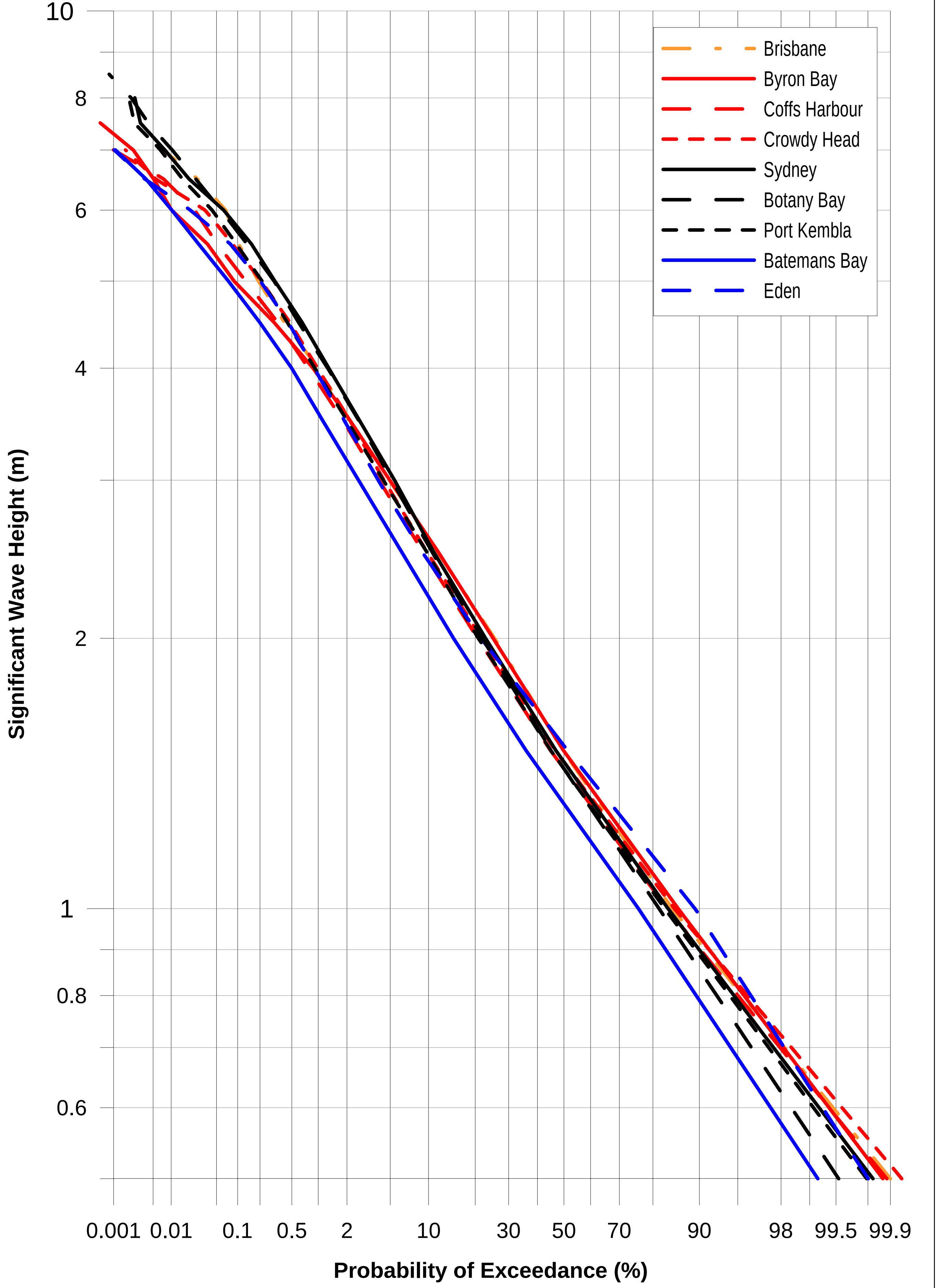
Note: missing storm data denoted by –
shaded cells indicate most significant missing event

The length of reliable extrapolation is a function of effective record length. As previously stated, Pugh (2004) suggests that reliable extrapolation can be undertaken up to three to four times the record length. All buoy records are now of sufficient length that 50 year ARI values may be considered reliable and 100 year ARI events nearly so. This is, however, less true for long duration events and for specific storm wave directions where a low number of storm events have been recorded to date. The reliability of such statistical analysis will improve in the future as more data is collected.

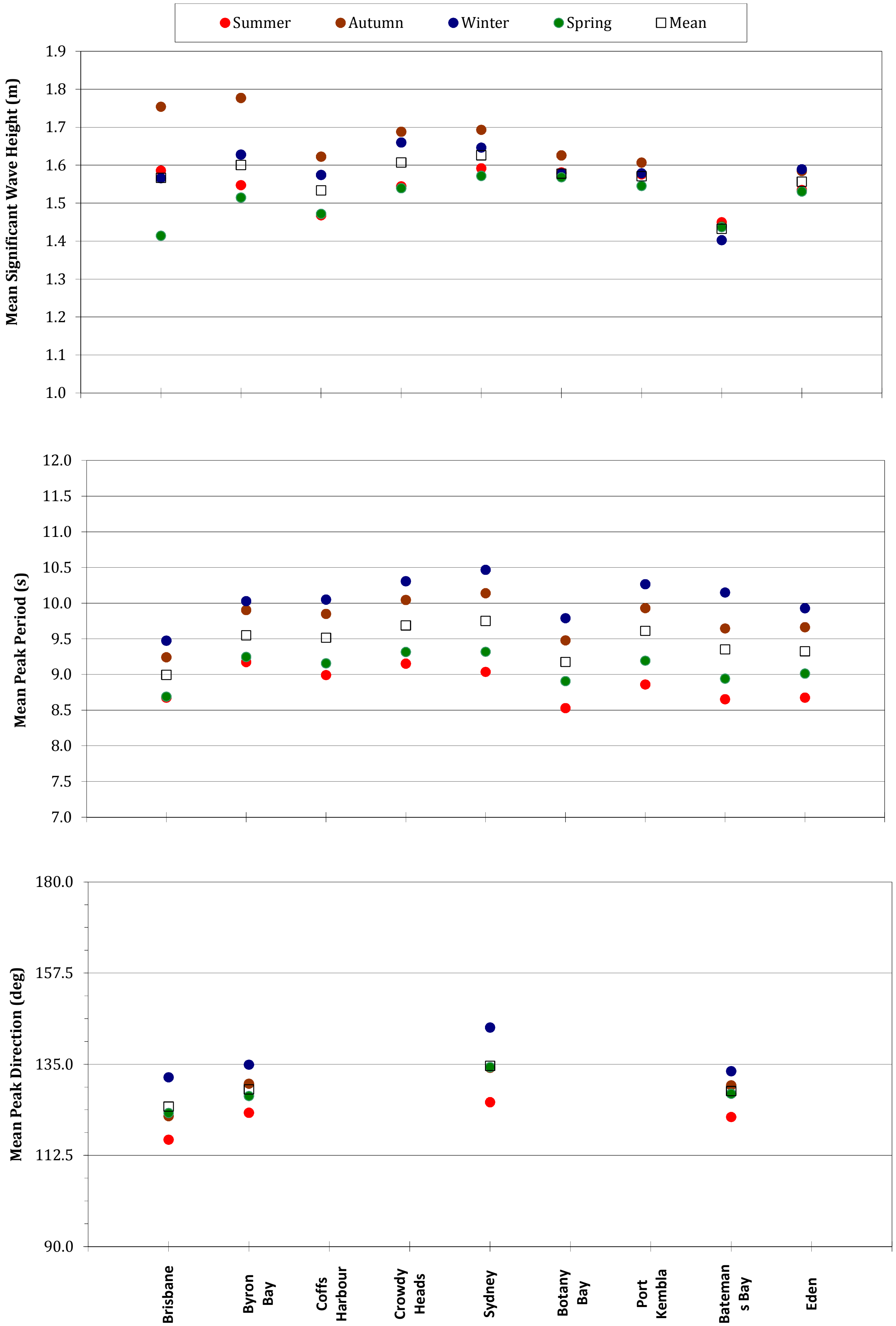
4.4.2 Extreme Value Analysis

The extreme value distributions employed in this study are those recommended as most generically appropriate by Goda (2000; 1988) and for Sydney by You (2007) who undertook comparative analysis using nine candidate functions. The confidence limits provide some measure of statistical certainty and sensitivity assessment using the upper confidence limit values as well as the best-fit values is recommended in practice.

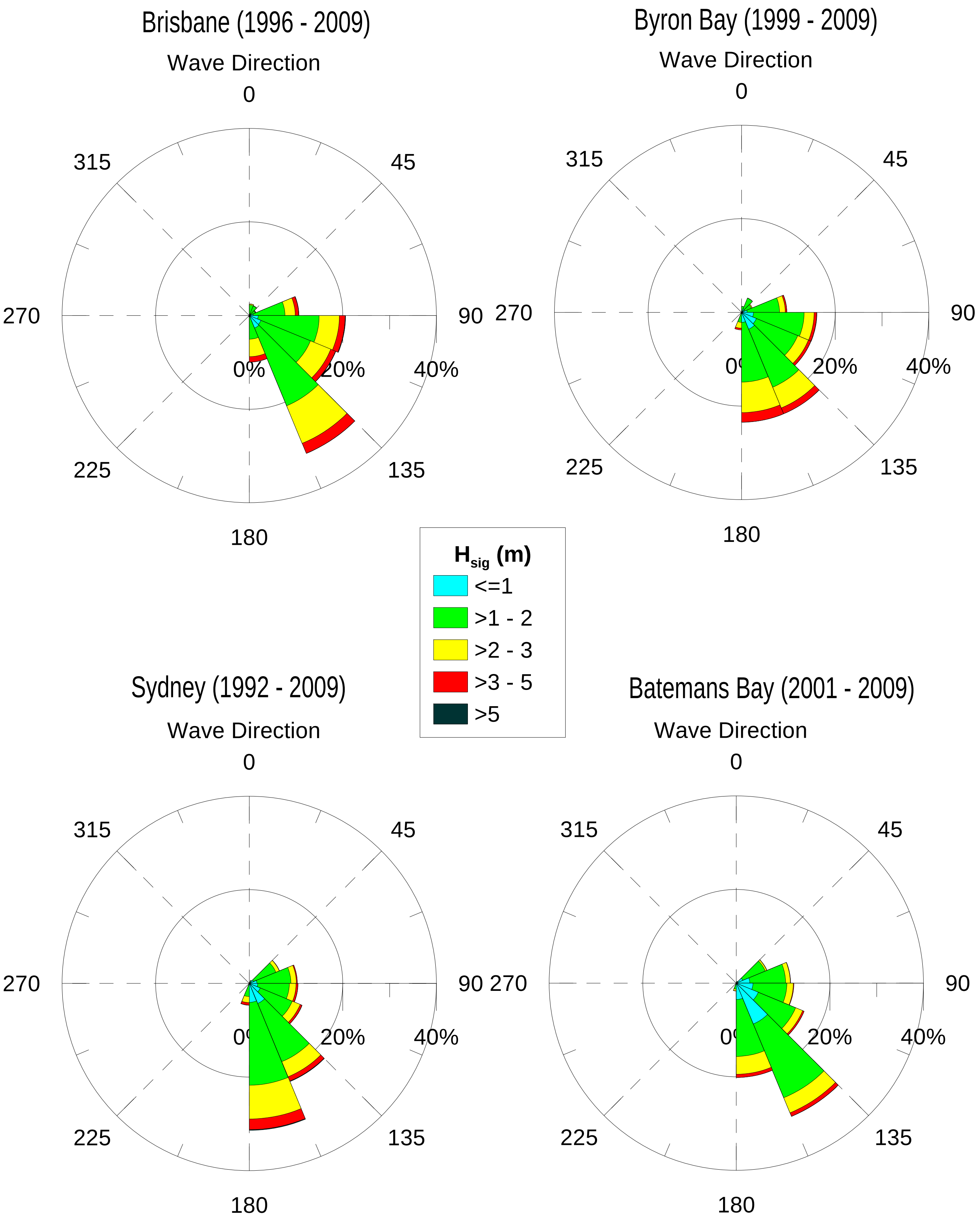
As previously discussed, a key assumption in this study is that the data is statistically stable. Any future increase in storm intensity and corresponding wave heights as suggested by DCC (2009) would likely result in larger return values than estimated within this study. Examination of changes in mean or storm wave height over time have not been undertaken within this study. Such an examination should be undertaken for the NSW wave data along with a sensitivity assessment on effects of an increasing storm wave climate on derived extreme wave height.



WRL Report No. 2010/16	SIGNIFICANT WAVE HEIGHT EXCEEDANCE FOR NEW SOUTH WALES WAVE BUOYS AND BRISBANE	Figure 4.1 4.1 EXCEEDANCE.grf

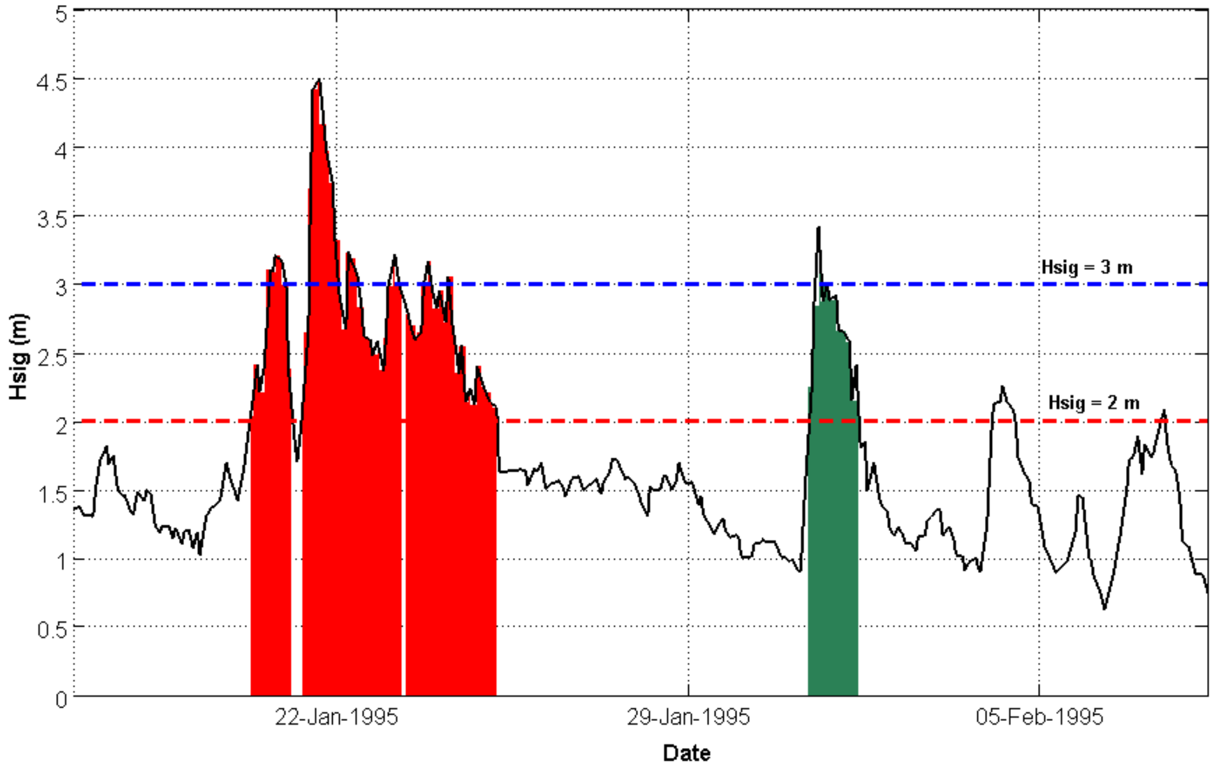


WRL Report No. 2010/16	SEASONAL AND OVERALL MEAN WAVE STATISTICS	Figure 4.2

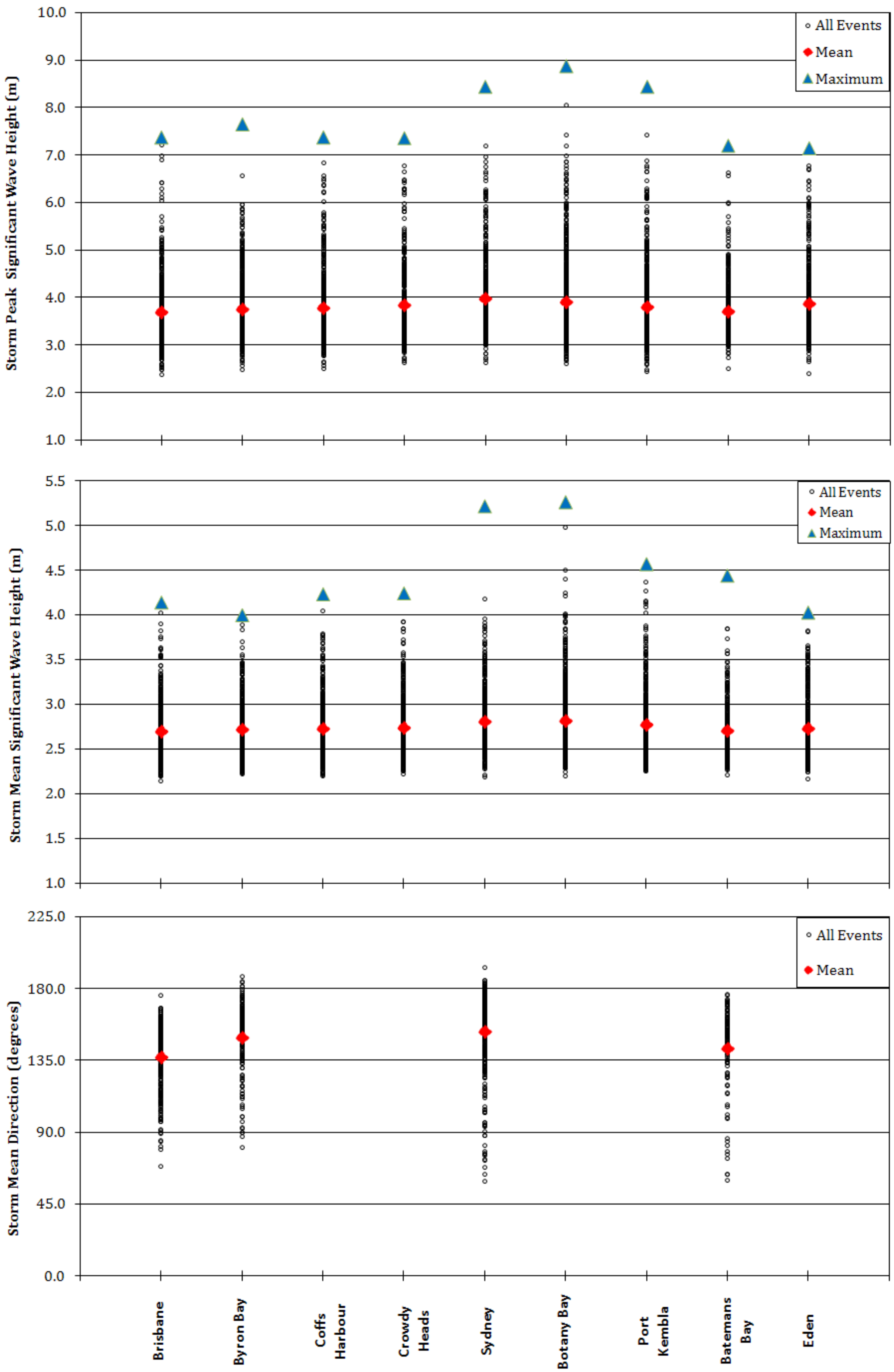


WRL Report No. 2010/16	WAVE ROSES FOR DIRECTIONAL WAVE BUOYS	Figure 4.3

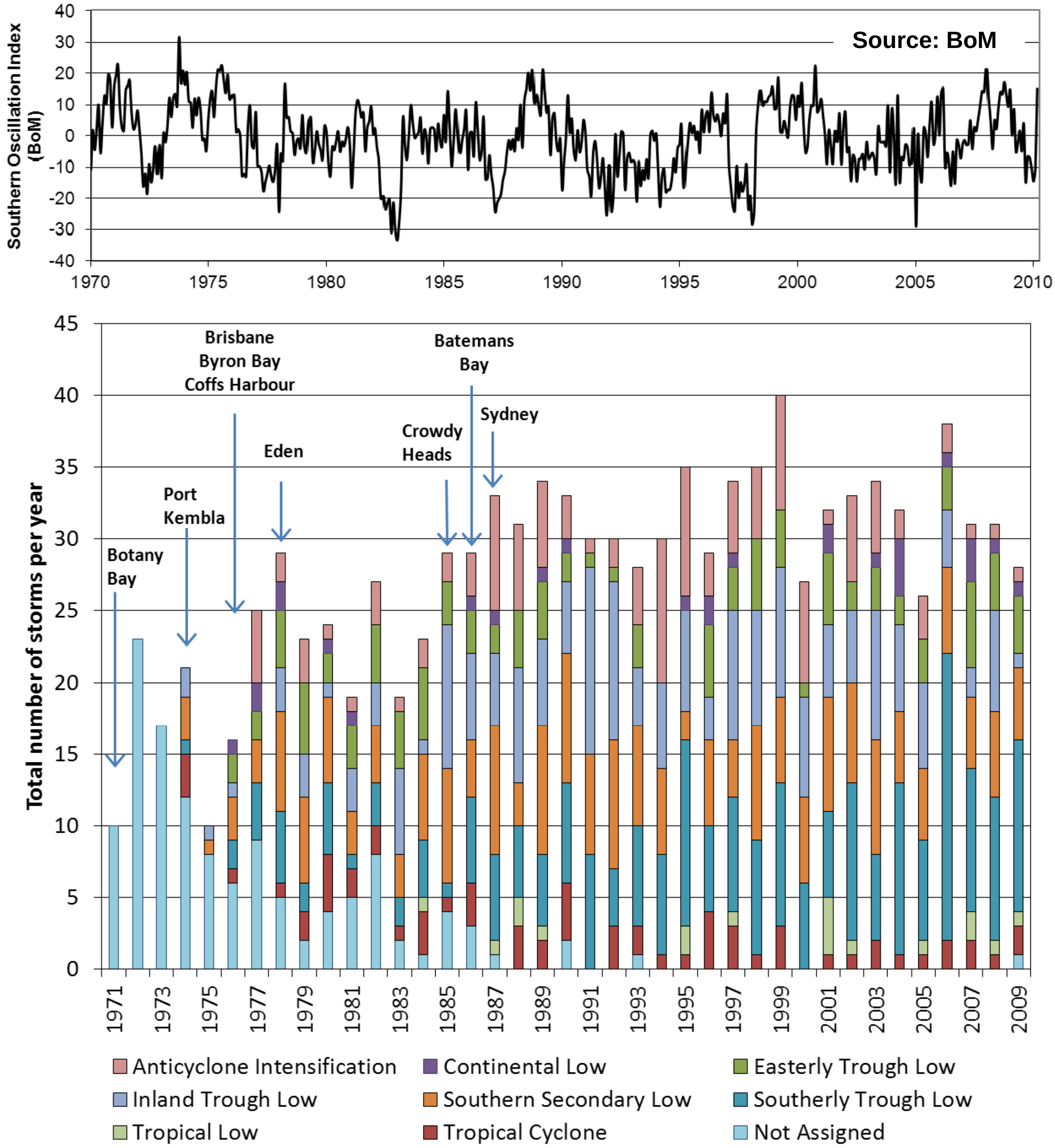
4.3 DirectionalWaveRoses.grf



WRL Report No. 2010/16	EXAMPLES OF DEFINING STORM EVENTS	Figure 4.4

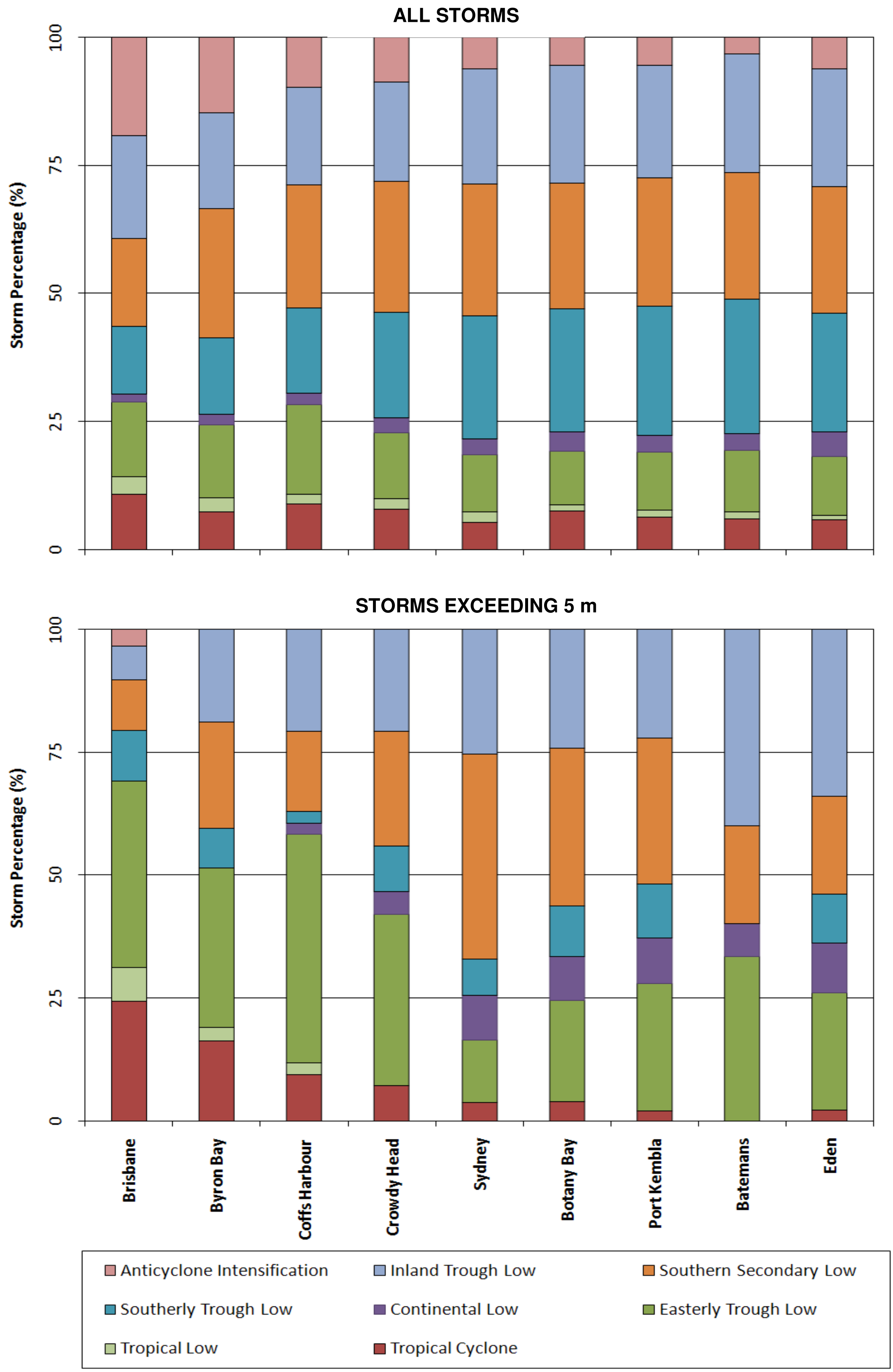


WRL Report No. 2010/16	STORM PEAK (A) AND MEAN (B) SIGNIFICANT WAVE HEIGHT AND MEAN SPECTRAL DIRECTION (C)	Figure 4.5

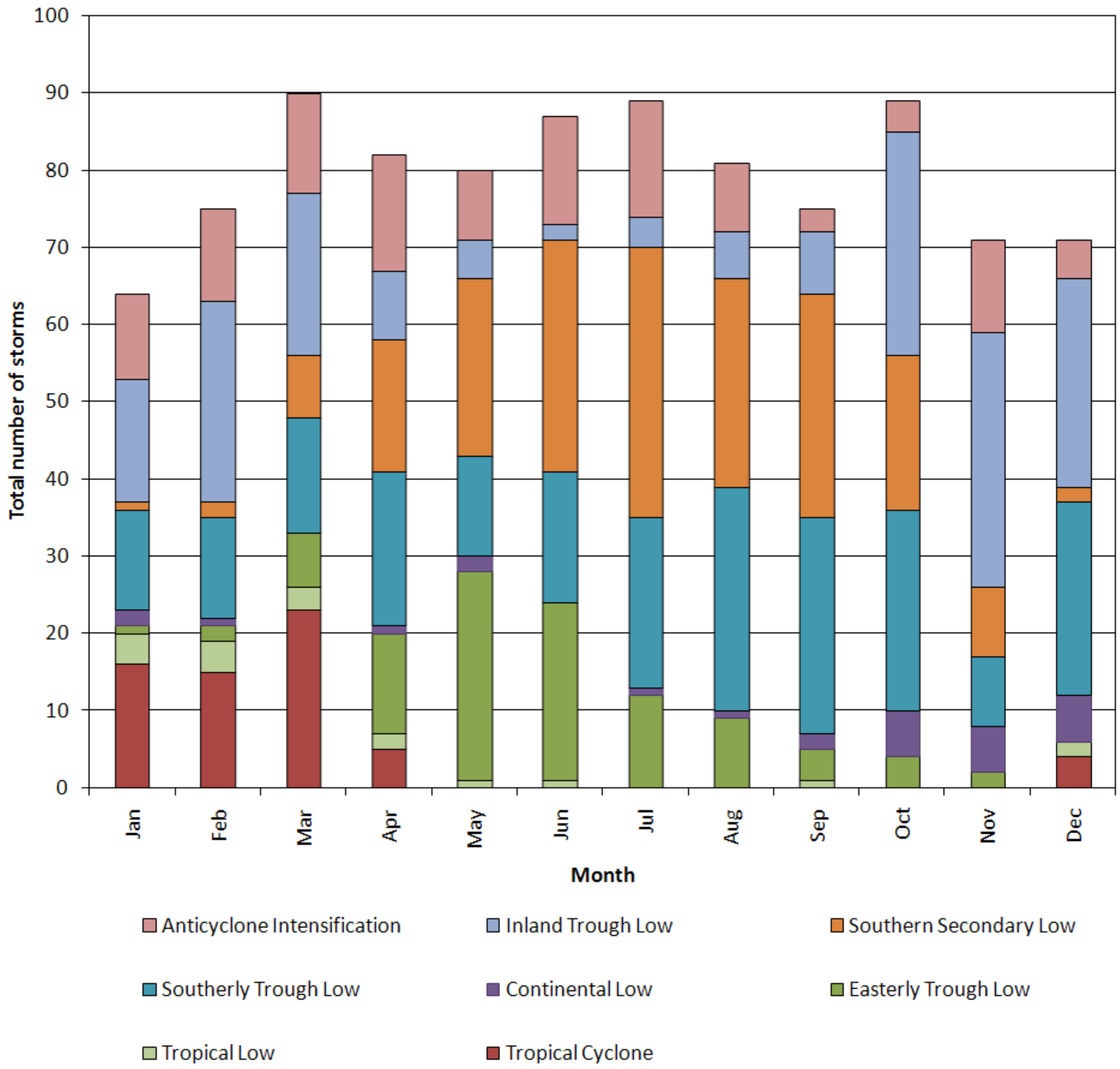


Arrows indicate year of wave rider buoy commission

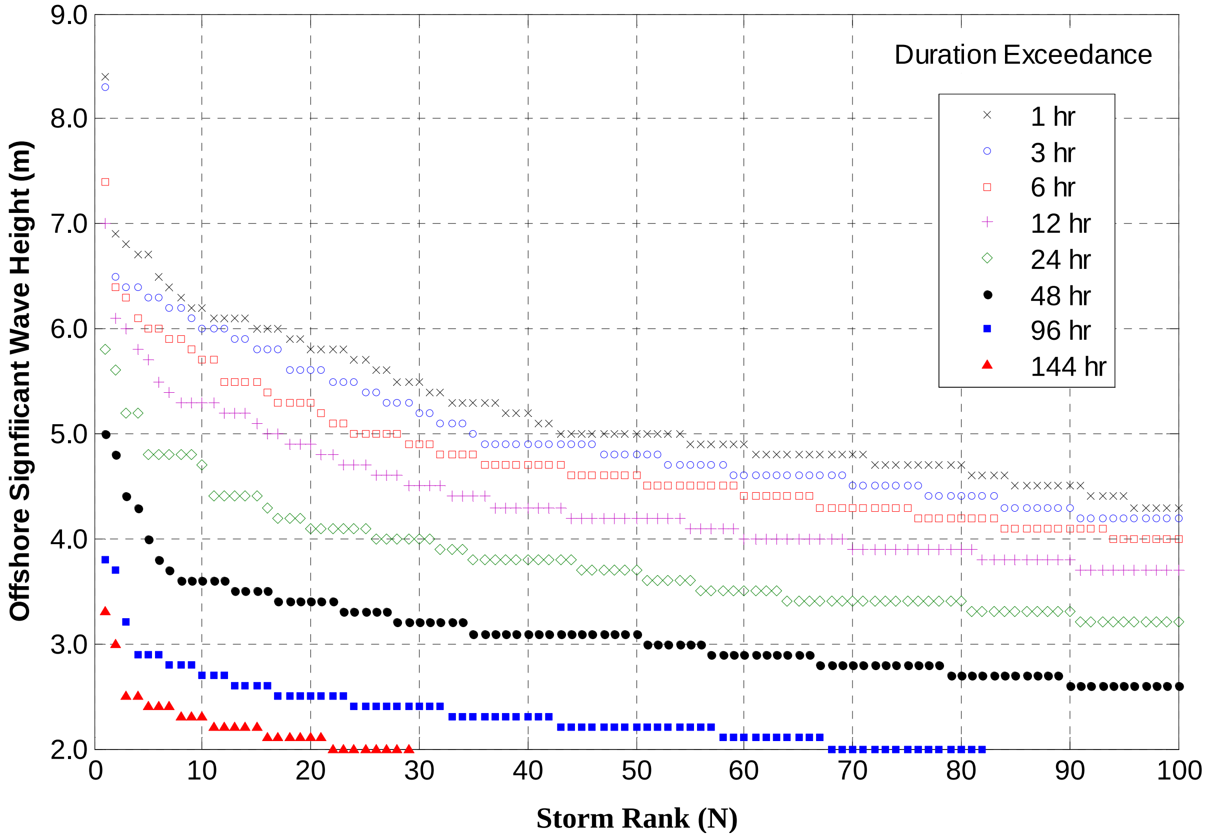
WRL Report No. 2010/16	TOTAL NUMBER OF STORMS TYPES OBSERVED YEARLY	Figure 4.6



WRL Report No. 2010/16	STORM TYPES BY PERCENTAGE FOR EACH WAVE BUOY FOR ALL STORMS AND STORMS >5 m	Figure 4.7

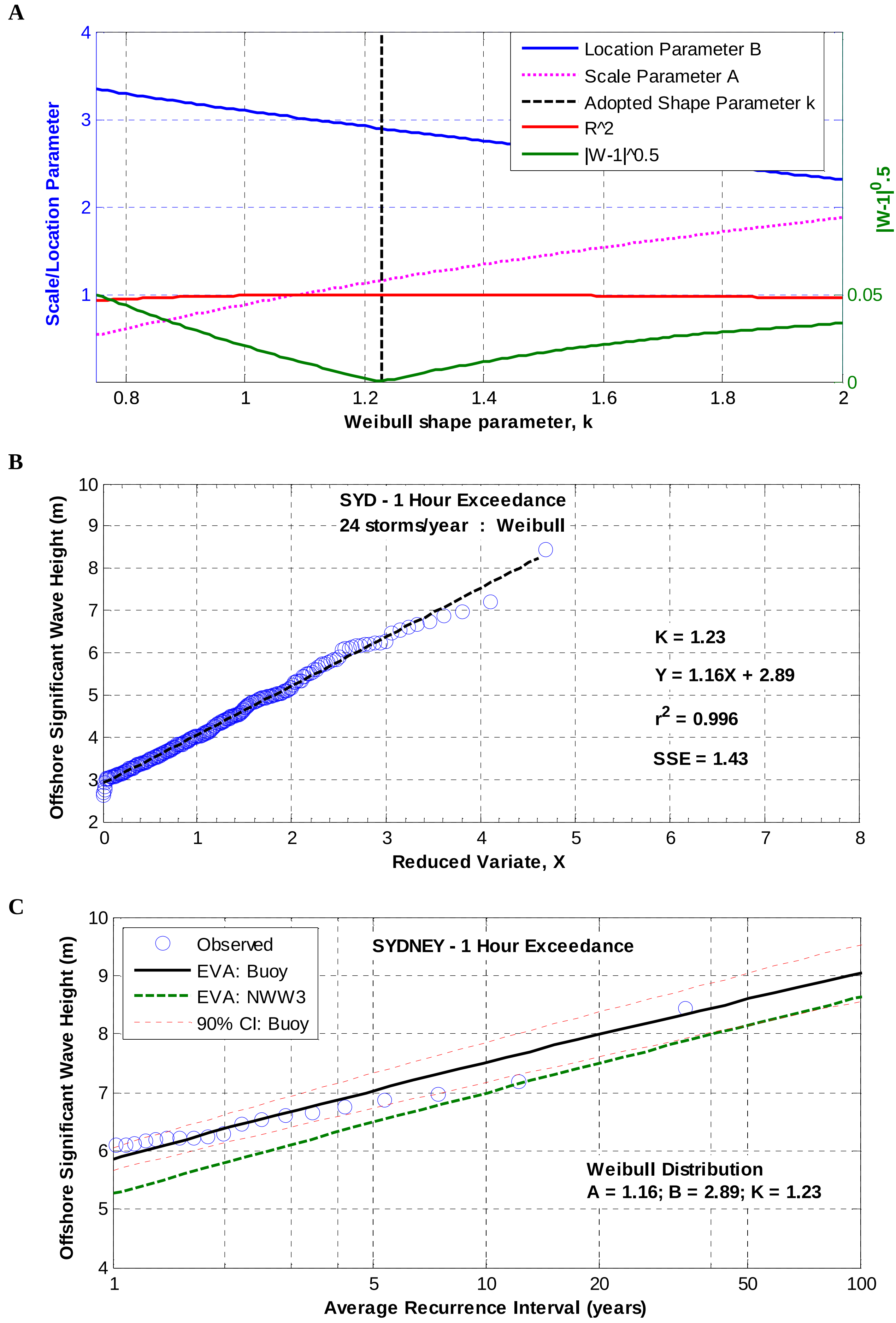


WRL Report No. 2010/16	TOTAL NUMBER OF STORMS OBSERVED FOR EACH MONTH	Figure 4.8

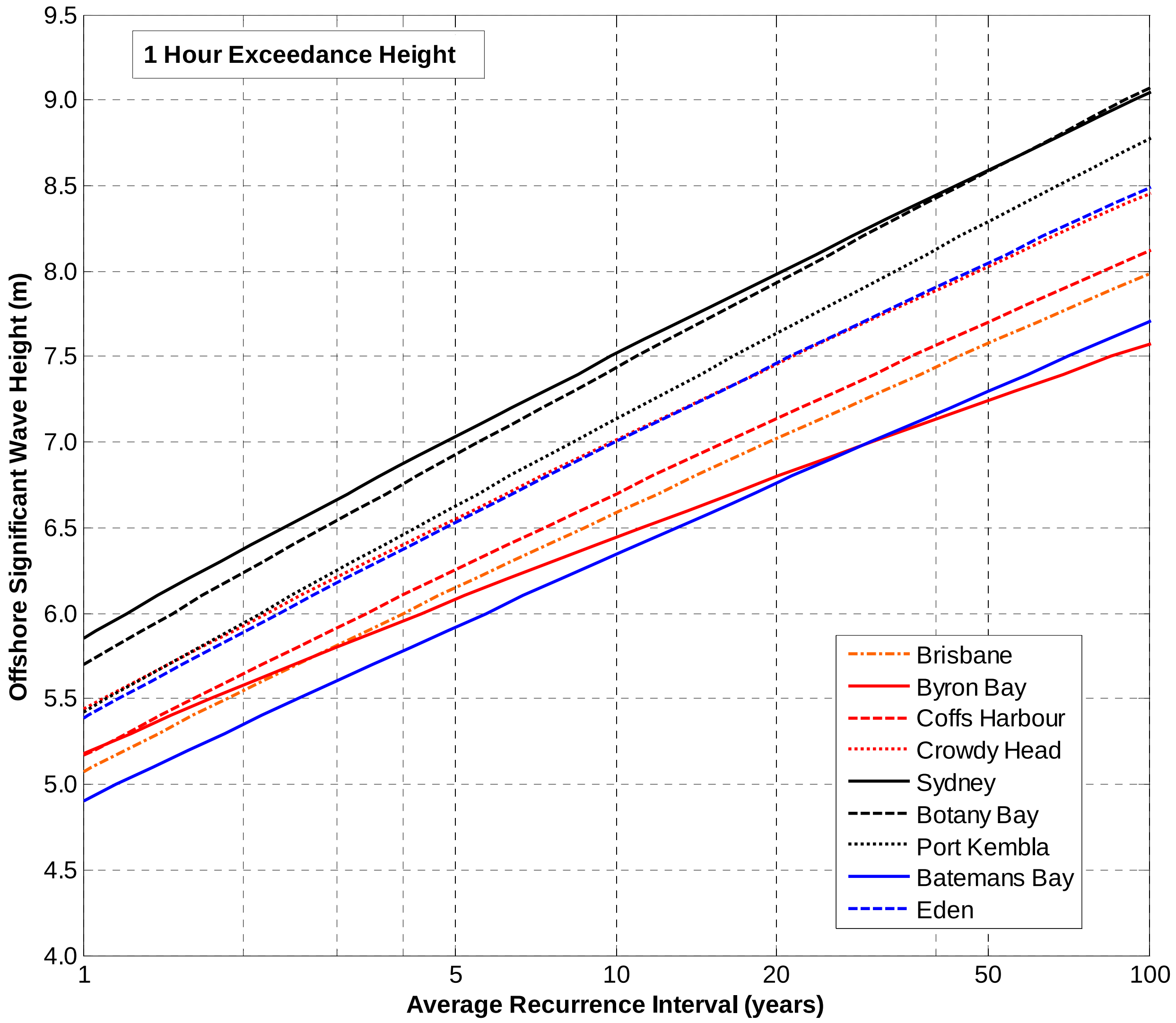


Note: First 100 storms only shown

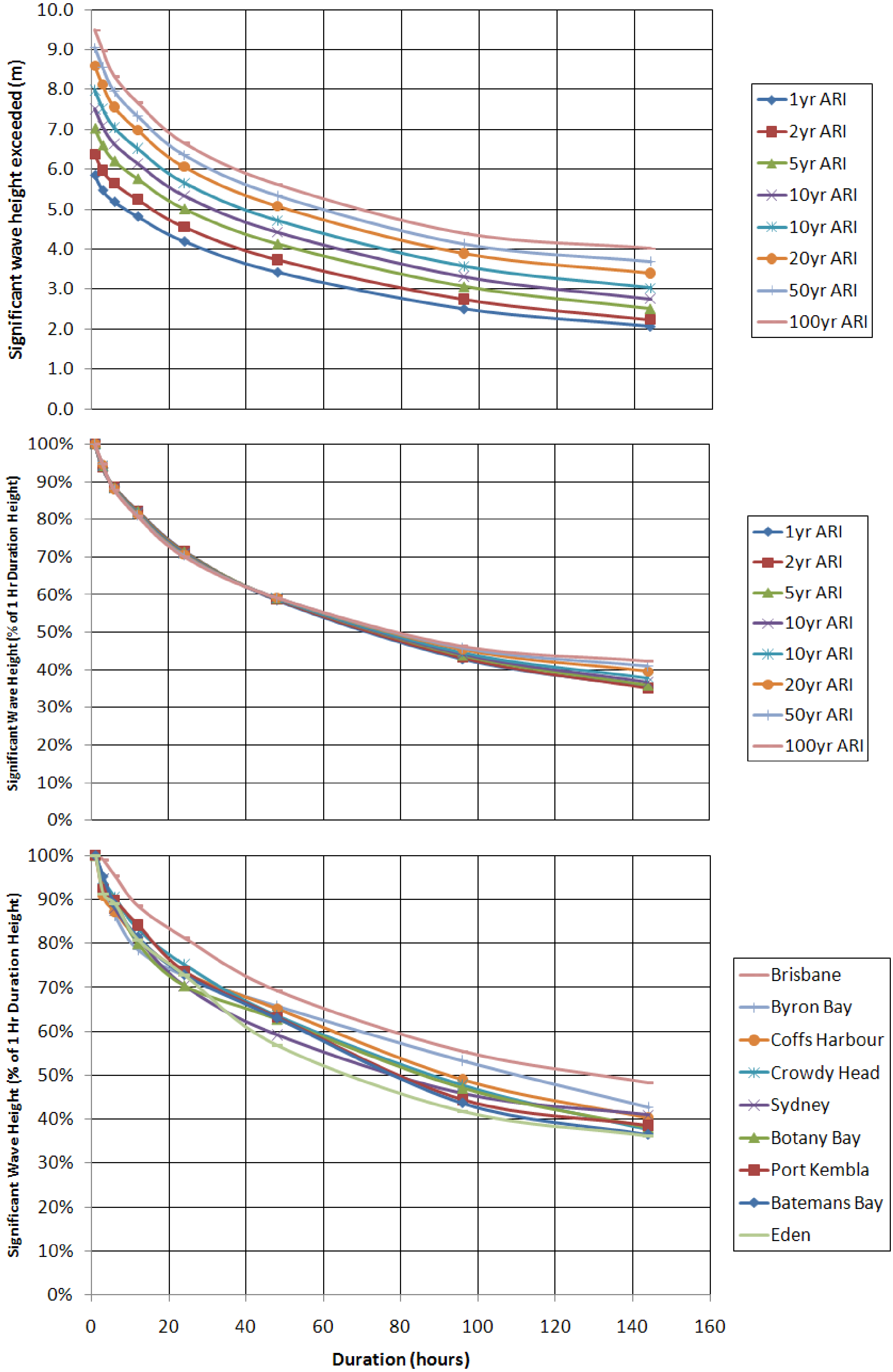
WRL Report No. 2010/16	CHANGE IN H_{sig} EXCEEDANCE AND NUMBER OF EVENTS WITH STORM DURATION FOR SYDNEY	Figure 4.9



WRL Report No. 2010/16	EXAMPLE OF SHAPE PARAMETER OPTIMISATION (A), DETERMINATION OF SHAPE AND LOCATION PARAMETERS (B) AND FITTING THE PDF TO OBSERVED DATA (C) FOR THE SYDNEY BUOY	Figure 4.10



WRL Report No. 2010/16	ONE HOUR EXCEEDANCE SIGNIFICANT WAVE HEIGHT FOR ALL WAVE BUOYS	Figure 4.11



WRL Report No. 2010/16	DURATION EFFECTS ON EXTREME VALUES	Figure 4.12

EXTREME SIGNIFICANT WAVE HEIGHT (1 HR) COMPARED TO OBSERVED VALUES AND NUMERICAL

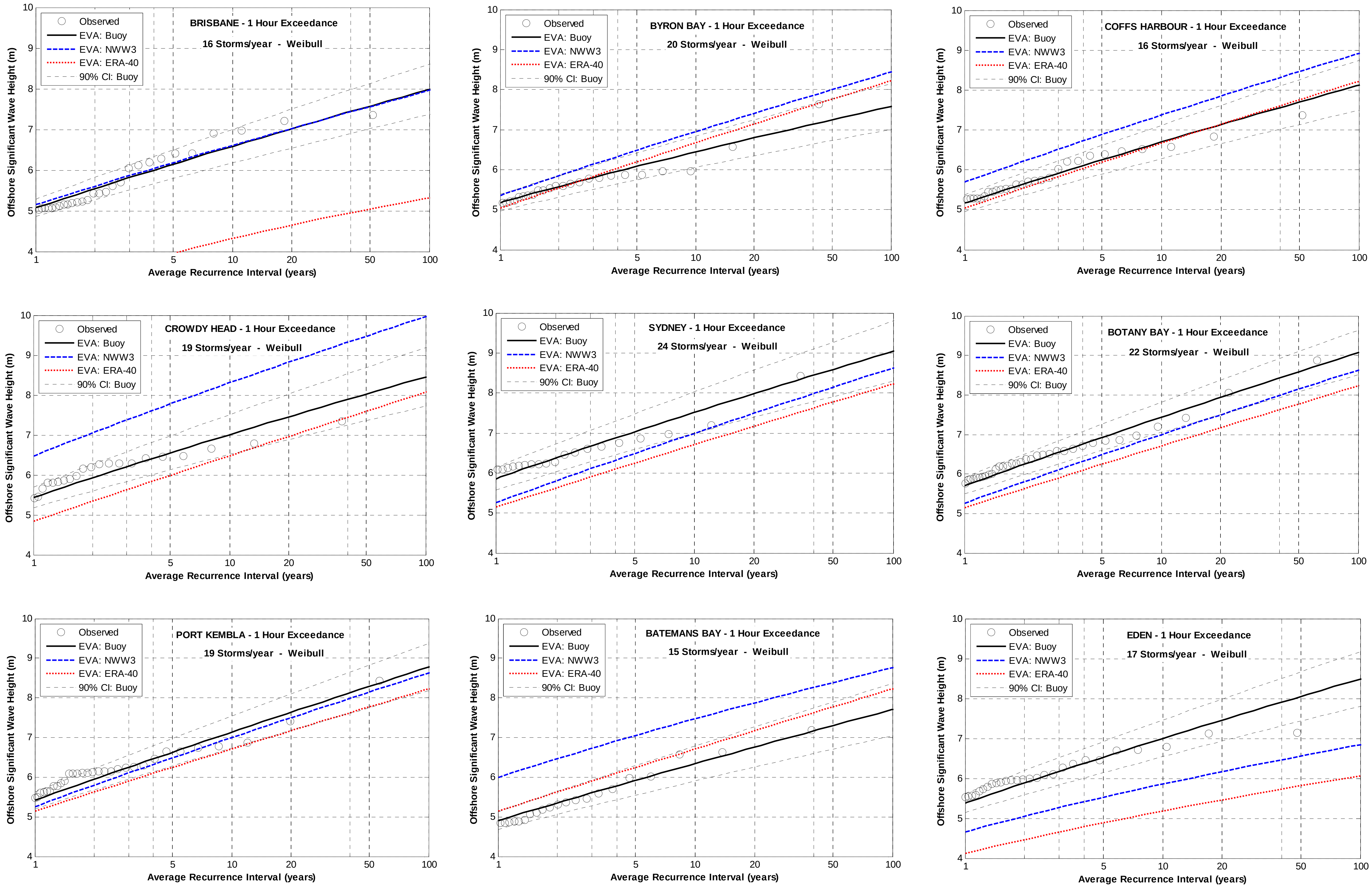
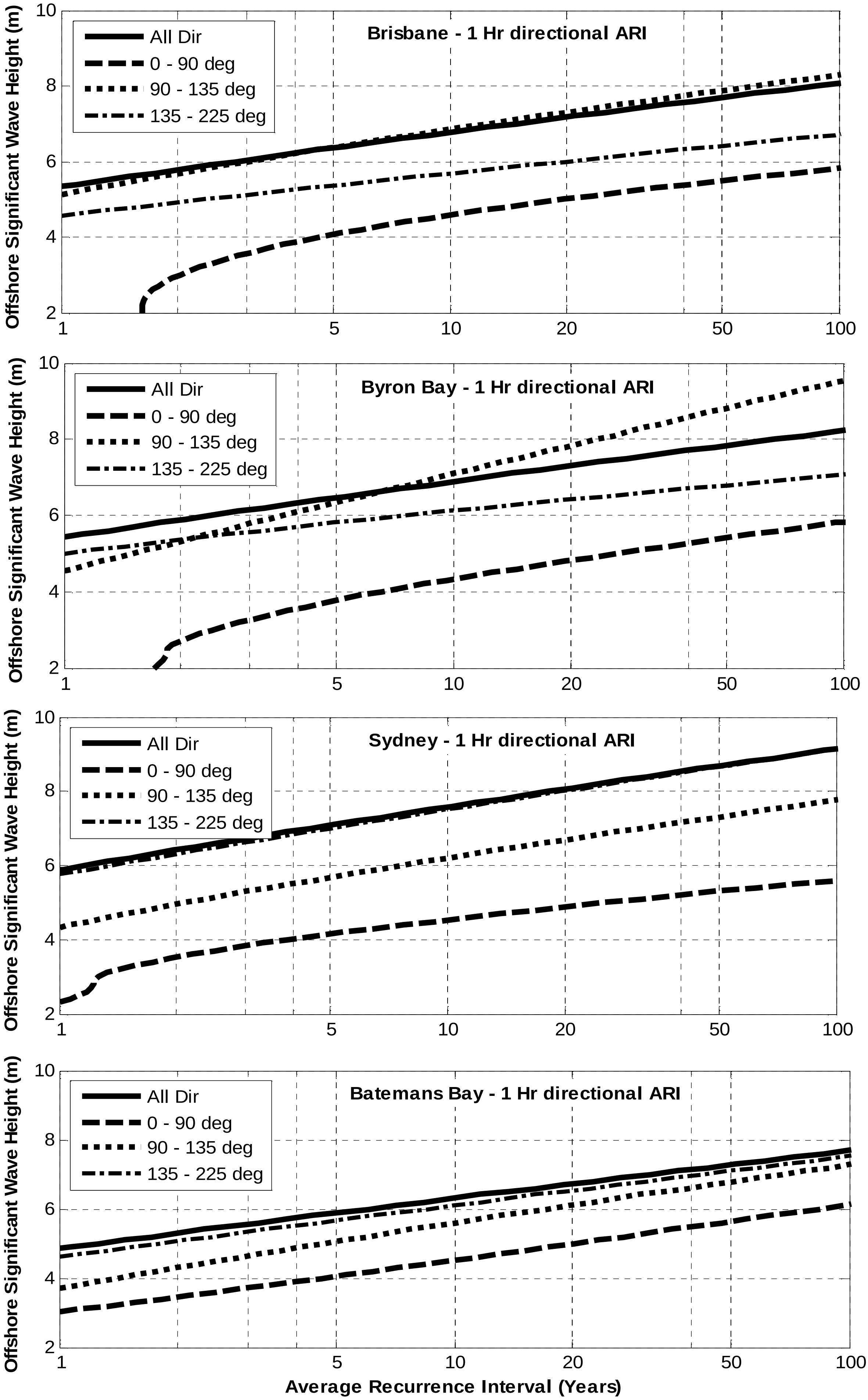


Figure 4.13



WRL Report No. 2010/16	EFFECT OF WAVE DIRECTION ON EXTREME VALUES	Figure 4.14

5. SUMMARY AND RECOMMENDATIONS

5.1 Overview

The Water Research Laboratory, UNSW (WRL) and Climate Futures at Macquarie University were commissioned by the Department of Environment, Climate Change and Water to investigate coastal storms affecting the NSW coastline. This involved:

- Critically reviewing the NSW coastal storm types that affect the NSW coast;
- Determining the spatial distribution and seasonal variation of these classified storm types;
- Determining the statistical distribution of extreme wave height and storm duration using wave buoy data from nine locations along the NSW and southern Queensland coast spanning the years 1971 to 2009, and
- Deriving extreme wave height with different return periods along the NSW coast.

5.2 New South Wales Wave Climate

Mean significant wave height (H_{sig}) along the NSW coast was found to be relatively consistent, ranging from 1.43 m at Batemans Bay to 1.63 m at Sydney. The 1% exceedance and maximum observed H_{sig} were highest at Sydney and Botany Bay, with a maximum H_{sig} of 8.86 m observed at Botany Bay, followed by Sydney and Port Kembla at 8.43 m. More notable along-coast variation in mean H_{sig} was observed seasonally, with larger waves occurring in the north during autumn and smaller waves occurring during spring and summer. Wave height in the south was more uniform year-round. Similarly, mean peak wave period (T_p) was longer and direction more southerly during winter and shorter and more easterly during summer months. The significant wave height exceedance and peak wave period occurrence tables are presented for each wave buoy within the report.

5.3 NSW Storm Climatology

The NSW coast spans from the southern Coral Sea to Southern Tasman Sea across the sub-tropical to mid-latitude zone. Extreme wave energy is mainly generated within the Coral Sea and Tasman Sea window, but can also be generated from outside this zone: in the South – West Pacific tropics; and in the Southern Ocean in the extra-tropics.

To ensure both long and short duration storm events are included in statistical analysis, storms were defined based on the significant wave height exceeding a specific threshold for a specific duration. This threshold was 2.0 m for storms of duration greater than three days or 3.0 m for any duration. The storm climatology in this study is based on a synoptic classification approach which expanded upon that used in the PWD (1985) study. Storm wave data has been classified into one of the following six synoptic types: Tropical Cyclone; Easterly Trough Low; Continental Low; Southern Tasman Low; Southern Secondary Low; Inland Trough Low; Anticyclone Intensification; Tropical Low.

Major storm events (H_{sig} > 6 m) in the north are a mixture of tropical cyclones, tropical lows and easterly trough lows while in the mid coast, major storm events also include inland trough lows and southern secondary lows. In the south, tropical cyclones and lows do not contribute to major storm events which are instead a combination of easterly trough lows, inland and continental lows and southern secondary lows, with a number of southerly trough (Southern Tasman) lows causing waves in excess of 5 m but not reaching 6 m. A seasonal analysis of storminess (i.e. storm frequency) shows March, July and October to be the stormiest months, with November, December and January being the least stormy. Tropical cyclones and lows are restricted to December to April with most occurring between January and March. Easterly trough lows are concentrated between April and August.

5.4 Extreme Value Analysis

Extreme value statistics were derived based on the peaks over threshold method with an average number of between 15 and 24 storms detected per year depending on spatial location. Storm data was interrogated to provide wave height exceedance for a range of durations from 1 hour to 144 hours (6 days). The height exceedance and number of detected storms reduced for the long duration events. The Weibull probability distribution function was found to provide the best fit to data across a wide number of locations and for a range of exceedance durations.

The 1 hour exceedance H_{sig} for all buoys for the 10, 50 and 100 year ARI along with 90% confidence intervals are presented below. ***These results show the mid NSW coast to exhibit the highest extreme wave climate with a 100 year ARI, one hour exceedance height of 9.0 m at Sydney and 9.1 m at Botany Bay***. Extreme height decreases to the north and south reaching 8.0 m at Brisbane and 8.5 m at Eden. Both Batemans Bay and Byron Bay exhibit the lowest extreme heights of 7.7 and 7.6 m respectively. Inclusion of notable missing storm events at Byron Bay and Batemans Bay by interpolation from adjacent buoys were found to increase the extreme statistics slightly, however, the values remained within the 90% confidence limits.

The effect of direction on extreme wave height was similarly investigated. Results showed that for wave events arriving from north of 90°, the extreme values were approximately 75% of the *'all direction'* values, wave events from the east to southeast were approximately 5% lower than the *'all direction'* values and ***waves arriving from south of south-east were typically 100% of the 'all direction' values and would be adopted as the design direction***.

Extreme values derived using buoy measurements were compared with those derived using NOAA's Wavewatch III (NWW3) numerical wave model and the ERA-40 numerical hindcast dataset. Overall, the NWW3 numerical model resulted in over prediction of extreme values in the north and under prediction in the south, while the ERA-40 dataset resulted in general under prediction of extreme values across all regions. Apart from a limited number of locations, differences were generally outside the evaluated 90% confidence limits. This result indicates that numerical models should not be used to derive extreme wave climates on the NSW coast.

Analysis undertaken within this present study shows that the 90% confidence limits for design waves along the NSW coast for the 100 year storm are now less than 10%. Examination of changes in mean or peak storm wave height over time have not been undertaken within this study with statistics assumed to be static for the purposes of extreme value analysis.

5.5 Recommendations

A number of recommendations are presented based on the results of this investigation:

- That wave buoy monitoring is continued to improve the accuracy of long duration and directional events and to quantify long term changes in wave climate on the NSW coast – the longer the dataset, the greater is its value.
- That the detailed, event-specific studies by the Public Works Department (PWD, 1985; 1986) are extended to cover the period from 1985 to present.
- Due to issues with data completeness and validity at Byron Bay and Batemans Bay, it is recommended that the upper 90% confidence interval values are used for these buoys until additional wave buoy data becomes available or site-specific assessments of these buoy locations is undertaken.

- A specific study of the Batemans Bay Region should be undertaken to ascertain reasons for the lower observed mean and extreme wave heights and whether a shift in buoy position would result in observed values more similar to those of Eden and Port Kembla.
- Investigate physical reasons (i.e. storm genesis, track, speed, etc.) for the very rare, large events which appear to exceed the fitted extreme distributions (i.e. at Sydney and Byron Bay) as these appear to belong to a different statistical population.
- Examination of changes in mean or storm wave height over time have not been undertaken within this study. Any future increase in storm intensity and corresponding wave heights would likely result in the derivation of larger extreme wave values. It is suggested that a sensitivity assessment is undertaken investigating the effects of an increasing storm wave climate on derived extreme wave height.
- Investigate physical reasons for the differences in buoy and numerical model wave climates evident at particular locations along the NSW coast. Resolving these differences is of high importance for coastal engineers and scientists who use such model results for engineering design, nearshore research and public weather forecasting and hazard prediction.
- Using the combined results of this and the extreme water levels component of the State-wide Coastal Inundation Study, a joint probability assessment of extreme waves and water level along the NSW coast should be undertaken for use in coastal and floodplain hazard assessment and climate change adaptation planning.

6. ACKNOWLEDGMENTS

Funding for this project was provided by the New South Wales Department of Environment, Climate Change and Water as part of the Natural Disaster Mitigation Program, NSW Coastal Inundation Hazard Study. NSW wave buoy data was kindly supplied by Manly Hydraulics Laboratory, Department of Services, Technology and Administration with the permission of NSW Department of Environment, Climate Change and Water. Wave data for Brisbane was kindly supplied by Queensland Environmental Protection Agency, Department of Environment and Resource Management. Sydney Ports Corporation and Mr Garry Noyes are thanked for the supply of the Botany Bay wave data.

Dr Bob You of the Coastal Science Unit, NSW Department of Environment, Climate Change and Water is acknowledged and thanked for his discussion and advice on extreme value analysis. Mr Mark Kulmar of Manly Hydraulics Laboratory is thanked for his assistance in the supply of NSW wave buoy data and advice on data processing. Professor Peter Nielsen of the University of Queensland is thanked for his insightful and useful comments during the project.

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APPENDIX A
NSW COASTAL STORM EXAMPLES: CHARACTERISTICS AND IMPACTS

APPENDIX A: NSW COASTAL STORM EXAMPLES

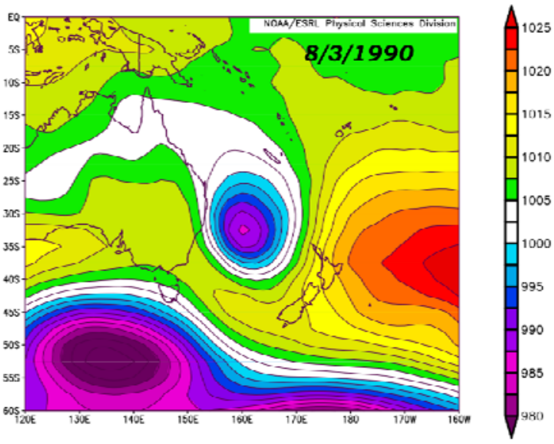
This appendix discusses and presents select examples of the major wave-generating storm systems which affect the NSW coastline. The selected events are non-exhaustive and include only events that have occurred since wave buoy records began on the NSW coast. For more complete descriptions of earlier storm events and resultant damage see PWD (1985, 1986). This study recommends that the detailed, event-specific studies by the Public Works Department (PWD, 1985; 1986) are extended to cover the period from 1985 to present.

1. Tropical Cyclone

During December, January, February and March, intense low pressure synoptic systems form in the Coral Sea and track south or south-east. These systems are classified by the BoM (1978) as Tropical Cyclones if the maximum winds occur near the centre of the system and the 10 minute mean winds are at least 17.5 m/s (34 knots). Tropical cyclones (TCs) are identified in the Australian region either by the BOM, the Fiji Meteorological Service in Nadi, or the NIWA Tropical Cyclone Warning Centre in Wellington, New Zealand. TCs produce extreme waves along the NSW coast with a wave direction from the eastern quadrant. H_{max} wave heights between 3.79 m to 12.88 m have been observed in the buoy records. Some example TCs and their coastal impacts are discussed below.

TC Hilda (4-7th March 1990)

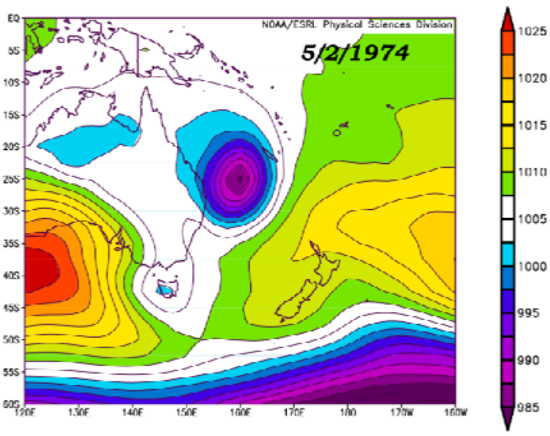
TC Hilda generated the largest storm waves along the NSW for this ST. The swell was maintained as TC Hilda moved poleward and constrained to the east by anticyclone intensification over New Zealand and the south-west Pacific. The SLP field for the 7/03/90 showing TC Hilda is shown in the below figure. TC Hilda produced H_{max} and H_{sig} wave heights at the Crowdy Buoy of 12.85 m and 6.28 m respectively, with H_{sig} wave heights recorded at Brisbane (3.27 m), Byron Bay (5.69 m), Coffs Harbour (N/A), Crowdy Head (6.28 m), Sydney (4.73 m), Port Kembla (4.80 m), Batemans Bay (3.35 m) and Eden (3.09 m). The duration of storm wave conditions was 152 hours, with a mean H_{sig} of 3.29 m and a T_p of 10.3 s. These large waves, sustained over a long duration (storm waves persisted for over one week) resulted in significant coastal erosion along the lower North coast of NSW.



TC Hilda (4-7th March, 1990)

TC Pam (4-6th February 1974)

TC Pam in February 1974 also produced significant coastal erosion. In 1974, only the Port Botany buoy (Sydney) and Port Kembla buoys were in operation, and extreme waves from TC Pam at the Port Botany buoy were recorded with an H_{sig} of 4.83 m on the 7th February, 1974. The duration of storm wave conditions was 60 hours, with a mean H_{sig} of 2.67 m and a T_p of 10.3 s. Helman (2007) reported storm surge of 0.68 m combined with a spring tide leading to flooding of low lying areas of Brisbane and the Gold Coast and severe erosion on the Gold Coast, Sunshine Coast and Belongil Spit (Gordon et al., 1978) which had already been severely eroded by an earlier cyclone (TC Wanda, 24-27 Jan, 1974). 30 properties were abandoned at Brunswick Heads and Sheltering Palms and land at Sheltering Palms was eventually purchased under the NSW Coastal Lands Protection Scheme (Helman, 2007).



TC Pam (4-6th February, 1974)

Other notable TCs

TC Barbara 17 to 22nd February, 1967 and TC Zoe 7th to 14th March, 1974 made landfall near Byron Bay causing extreme coastal erosion. TC Dinah 23rd January to 2nd February, 1967 caused greater coastal erosion along the Gold Coast. More recently, TC Hamish (4 to 11th March, 2009) tracked close to Fraser Island and caused significant erosion from the Fraser coast to the Gold Coast. The duration of the storm wave conditions was 132 hours, with a mean H_{sig} of 3.08 m, a T_p of 9.1 s, and a mean wave direction of 97.6° TN.

2. Tropical Low

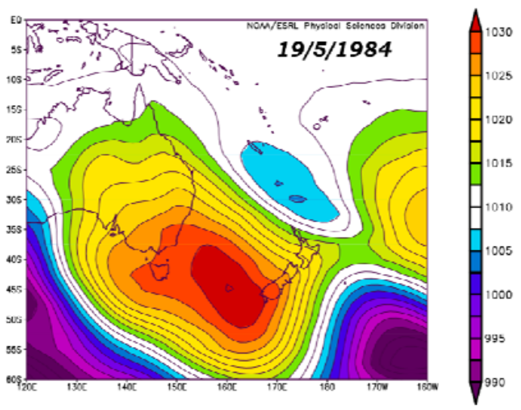
This synoptic type has not been used in previous extreme wave climate studies in NSW. However, the Tropical Low (TL) type category has been included in this study because it results in extreme waves that were generated by tropical Lows but not classified as Tropical Cyclones. Typical TLs that produced extreme waves along the northern NSW coast, extending down the coast to the Sydney region, occurred on the 19th May 1984, and the 6th April 2008.

TL of 19th May 1984

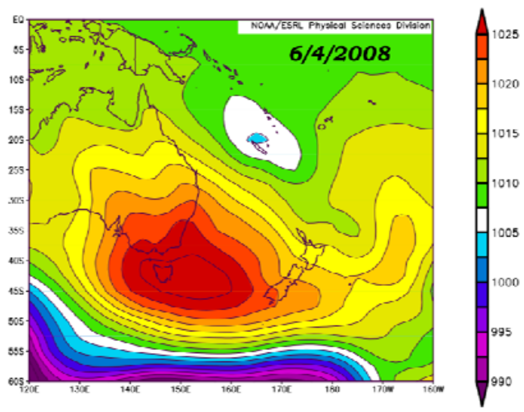
The TL on the 19th May, 1984 produced peak H_{sig} values of 4.43 m (Byron Bay, H_{max} of 7.50 m, T_p of 11.6 s), 4.13 m (Brisbane), 2.64 m (Port Botany), 2.93 m (Port Kembla), and 2.27 m (Eden). The duration of the storm waves was 108 hours with an H_{sig} of 3.23 m, and a Tp of 11.6 s.

TL of 6th April 2008

The TL on the 6th April, 2008 produced peak H_{sig} values of 2.73 m (Brisbane, H_{max} of 4.35 m, T_p of 8.4 s, and a mean wave direction of 127°), 2.05 m (Coffs Harbour, T_p of 7.3 s), 2.02 m (Crowdy Head, T_p of 7.3 s), and 2.26 m (Sydney, T_p of 8.2 s). The duration of the storm waves was 137 hours with an H_{sig} of 2.24 m, a T_p of 8.0 s, and a mean wave direction of 123°.



19th May, 1984



6th April, 2008

3. Anticyclone Intensification

Extreme waves develop when the pressure gradient on the northward limb of the subtropical anticyclone (high pressure system) intensifies, which is termed anticyclone intensification (AI). Strong east or south-east winds develop across the Tasman Sea, and often persist for over 100 hours due to the blocking of the anticyclone. The range of AI types that produce extreme waves along the NSW coast are represented by the synoptic patterns on the 4th February 1977, 2nd May 2000, 17th July 2003, and the 22nd November 2004.

AI of 4th February 1977

The AI on the 4th February, 1977 produced peak H_{sig} values of 2.48 m (Brisbane, H_{max} of 4.34 m, T_p of 8.4 s), 2.50 m (Byron Bay, T_p of 9.5 s), 2.12 m (Coffs Harbour, T_p of 9.5 s) and 3.09 m (Botany Bay). The duration of storm waves was 120 hours with an H_{sig} of 2.2 m and a T_p of 9.1 s.

AI of 2nd May 2000

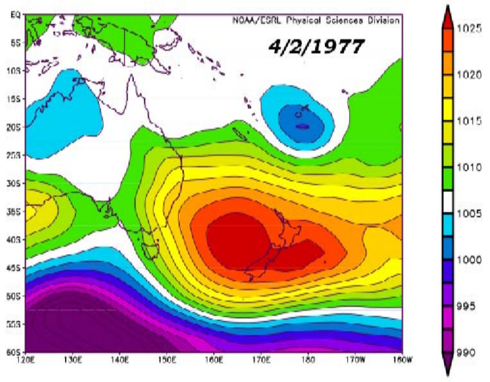
The AI on the 2nd May 2000 produced peak H_{sig} values of 4.79 m (Brisbane, H_{max} of 7.2 m, T_p of 12.1 s, and a mean wave direction of 96°), 4.07 m (Byron Bay, T_p of 12.2 s, and mean wave direction of 66°), 3.85 m (Coffs Harbour, T_p of 12.2 s), 2.94 m (Crowdy Head, T_p of 12.2 s), 3.67 m (Sydney, T_p of 12.2 s, mean wave direction of 80°), 3.08 m (Port Kembla), and 3.45 m (Eden). The duration of the storm waves was 454 hours with an H_{sig} of 2.9 m, a T_p of 9.9 s, and a mean wave direction of 121°.

AI of 17th July, 2003

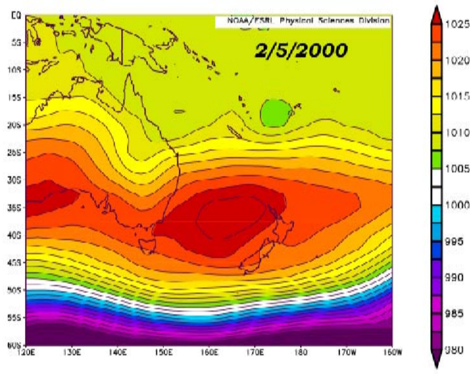
The AI on the 17th July 2003 produced peak H_{sig} values of 3.12 m (Brisbane, H_{max} of 6.13 m, T_p of 12.2 s, and a mean wave direction of 77°), 2.12 m (Byron Bay, T_p of 11.1 s), 2.12 m (Coffs Harbour, T_p of 15.1 s), and 2.22 m (Sydney, T_p of 7.3 s, mean wave direction of 170°). The duration of the storm waves was 143 hours with an H_{sig} of 2.52 m, a T_p of 9.3 s, and a mean wave direction of 121°.

AI of 22nd November, 2004

The AI on the 22nd November, 2004 produced peak H_{sig} values of 4.21 m (Brisbane, H_{max} of 7.26 m, T_p of 9.5 s, and a mean wave direction of 166°), 3.47 m (Coffs Harbour, T_p of 7.7 s), 3.57 m (Crowdy Head, T_p of 11.1 s), 3.07 m (Sydney, T_p of 9.4 s, mean wave direction of 180°), 3.17 m (Port Kembla, T_p of 10.2 s), and 3.43 m (Batemans Bay, T_p of 8.2 s, and a mean wave direction of 171°). The duration of the storm waves was 106 hours with an H_{sig} of 3.05 m, a T_p of 9.7 s, and a mean wave direction of 154°.



4th February, 1977



2nd May, 2000

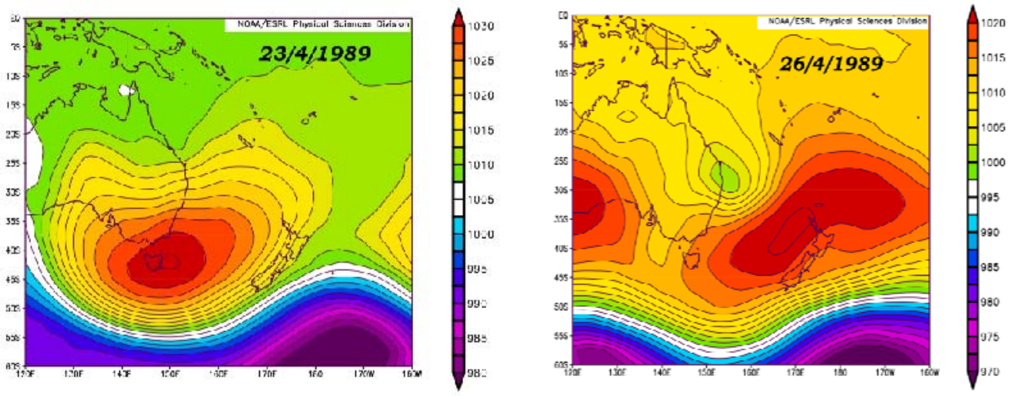
4. Easterly Trough Low

Easterly Trough Lows (ETLs) are complex cold season meso to synoptic scale (50-500 km) weather systems. They form over the southern Coral Sea and northern to central Tasman Sea, bordering the east coast of Australia and affect coastal regions from southern Queensland to Victoria. ETLs can cause significant storm damage through storm winds, heavy rainfall leading to flooding, heavy seas, storm surge, wave setup and beach erosion. ETLs form on average several times per year, mostly in Autumn and Winter, with a maximum occurrence in June (Holland et al., 1987). Events can be as short as 16 hours or last for several days (Hopkins and Holland, 1997) and tend to be clustered over successive weeks when conditions are favourable (Allen and Callaghan, 2001).

The ETLs can be further subdivided into systems that have primary impacts on the (i) north coast, (ii) the central coast, and less frequently, (iii) the south coast. ETLs in April 1989, May 1999 and June 2007 are discussed below.

ETL of 19th April to 1st May 1989

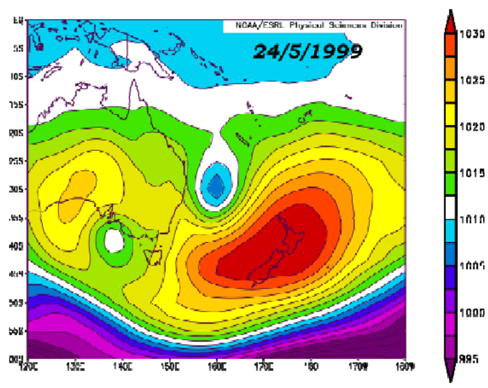
The ETL on the 19th April to 1st May, 1989 formed in the easterly airstream over the Coral Sea and northern Tasman Sea associated with a strong subtropical anticyclone centred on Tasmania and the southern Tasman Sea, between the 23rd and 26th April, 1989. The peak storm wave conditions were observed at Brisbane, with an H_{sig} of 6.11 m, and a T_p of 9.1 s. The duration of the storm wave conditions was 156 hours, with a mean H_{sig} of 3.25 m and a T_p of 9.3 s. Peak storm wave conditions with a H_{sig} of 5.87 m, 5.64 m, and 5.32 m were observed from the ETL on the 26th April, 1989 at Byron Bay, Coffs Harbour and Crowdy Head, respectively. As the ETL tracked south on the 27th and 28th April, 1989, peak storm wave conditions with a H_{sig} of 4.38 m, 3.72 m, and 3.83 m were observed at Sydney, Port Kembla and Eden, respectively. Helman (2007) reported damage from gale to storm force winds along the northern NSW and southeast Queensland coast and storm surge of 0.5m in Brisbane.



19th April to 1st May, 1989

ETL of 24th to 25th May 1999

The ETL on the 24th to 25th May, 1999 formed in an easterly dip within an easterly airstream over the northern Tasman Sea associated with a strong subtropical anticyclone centred on New Zealand, between the 24th to 25th May 1989. The peak storm wave conditions were observed at Brisbane, with an H_{sig} of 5.42 m, and a T_p of 8.0 s and a mean wave direction of 88.9° TN. The duration of storm wave conditions was 214 hours, with a mean H_{sig} of 3.25 m and a T_p of 10.9 s, and mean wave direction 100.5° TN. Peak storm wave conditions with a H_{sig} of 4.97 m, 5.28 m, and 4.32 m were observed from the ETL on the 24th May at Byron Bay, Coffs Harbour and Crowdy Head, respectively. As the ETL tracked south on the 25th May, peak storm wave conditions with a H_{sig} of 4.53 m, 4.05 m, and 4.0 m were observed at Sydney, Port Kembla and Eden, respectively, with a mean wave direction of 56° TN at Sydney. This caused the most significant extent of coastal erosion along the mid-north coast NSW to the Gold Coast since the mid 1970s. An emergency meeting of Byron Shire Council approved the use of sand bags to protect vulnerable houses at Belongil Spit (Helman, 2007) and high tides and swell throughout June and July continued to erode Belongil Spil.

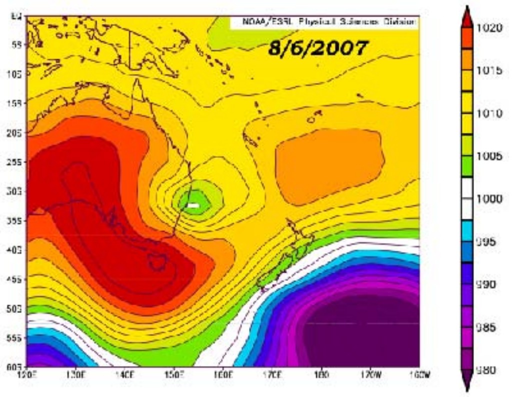


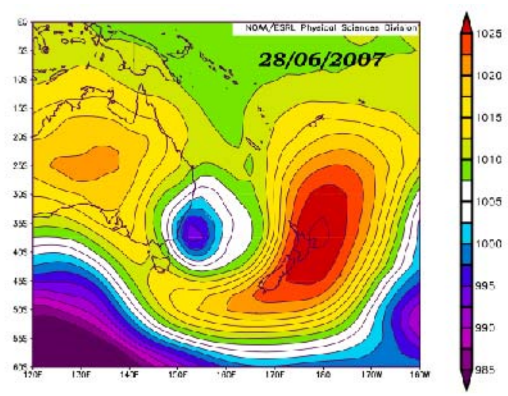
24th to 25th May, 1999

ETL of 8th to 11th June ("Pasha Bulker Storm") and 28th June 2007

The ETL on the 8th to 11th June, and 28th June, 2007 formed throughout June 2007. The most extreme ETL, known as the Pasha Bulker storm formed off the Central Coast and was named after the bulk coal loader ship *Pasha Bulker* that ran aground at Nobbys Beach, Newcastle at the height of the storm, on the 8th June. This ETL formed in an easterly dip within the easterly airstream over the northern Tasman Sea associated with a strong subtropical anticyclone centred on Central Australia producing a strong meridional airstream along the east coast of Australia. Storm wave conditions continued for 65 hours, with a peak H_{sig} of 6.87 m, an H_{max} of 14.13 m, and a mean wave direction of 135° TN. H_{sig} > 3 m was observed for 65 hours. Severe rainfall occurred around the Newcastle area resulting in flash flooding and the collapse of roads (Watson et al., 2007)

The total duration of storm wave conditions (H_{sig} > 3 m) during June 2007 was 449 hours, with a mean H_{sig} of 3.27 m and a T_p of 11.1 s, and a total storm wave power of 28.98 x 10^6 N.m/s, off the Newcastle and Central Coast. Eden recorded a peak H_{sig} of 7.12 m, with an H_{max} of 10.8 m. Peak storm wave conditions with an H_{sig} of 3.22 m and a mean wave direction of 165° T (Byron Bay), 3.75 m (Coffs Harbour), 4.64 m (Crowdy Head) were observed during the ETL on the 8th to 11th June. North of South-West Rocks this oblique wave energy drove a strong longshore current. South, along the Central and south coasts the wave energy was destructive and resulted in widespread erosion. By the 27-28th June, 2007, another ETL formed off the far south coast, creating peak storm wave conditions at Batemans Bay with a H_{sig} of 5.37 m, a T_p of 9.5 s with a mean wave direction of 149° TN. Watson et al. (2007) reported 9 lives lost as a result of the June storm events (primarily as a result of flash flooding) and estimated losses of over $1BN reported by the Insurance Council of Australia.





June, 2007

5. Continental Low

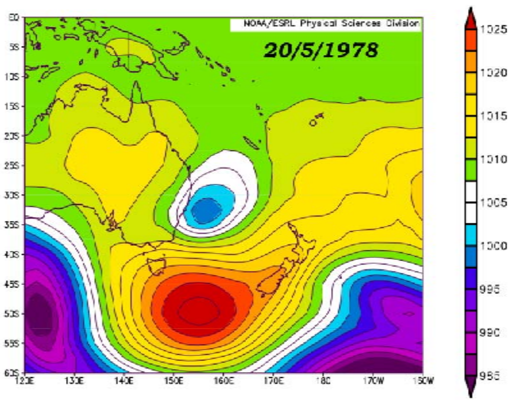
Continental lows form in the westerly airstream over southern Australia and travel eastwards over the continent. As the lows travel over the east coast of Australia, they can intensify and produce storm wave erosion. They are often associated with a strengthened subtropical anticyclone centred in the Great Australian Bight. The associated strong south-east windfield in the Southern Tasman, combines with the CL to extend the duration of peak waves.

CL of 4th November, 2007

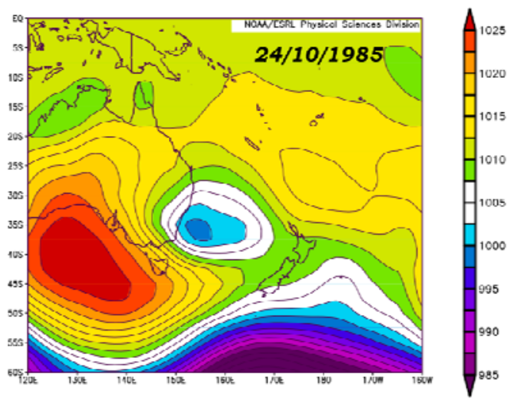
A CL formed over the south coast of NSW on the 4th November, 2007. Peak storm wave conditions with an H_{sig} of 5.16 m, an H_{max} of 7.82 m, a T_p of 12.1 s and a mean wave direction of 163° TN at Sydney. The duration of storm wave conditions was 80 hours, with a mean H_{sig} of 2.99 m and a T_p of 10.0 s, and a mean wave direction of 148° TN. The CL produced storm wave conditions along the entire NSW coast, with a H_{sig} of 2.96 m at Brisbane, H_{sig} of 4.38 m at Byron, H_{sig} of 4.50 m at Coffs Harbour, H_{sig} of 4.0 m at Crowdy Head, H_{sig} of 5.16 m at Sydney, H_{sig} of 4.76 m at Port Kembla, H_{sig} of 4.62 m at Batemans Bay, and an H_{sig} of 4.83 m at Eden.

CL of 20th May 1978, and 24th October 1985

Additional examples of storm wave events produced by CLs are the 20th May, 1978, and 24th October, 1985. The CL on 20th May, 1978 had a duration of 132 hours with a mean H_{sig} of 3.45 m and a T_p of 11.8 s. At Port Kembla, the buoy recorded a peak H_{sig} of 6.26 m and a T_p of 10.6 s. The CL on 24th October, 1985 had a duration of 164 hours with a mean H_{sig} of 3.09 m and a T_p of 10.1 s. At Eden the buoy recorded a peak H_{sig} of 6.10 m, and H_{max} of 10.39 m and a T_p of 12.2 s. Contemporaneous observations at Byron and Crowdy Head were H_{sig} of 3.04 m and 3.09 m respectively.



20th May, 1978



24th October, 1985

6. Inland Trough Low

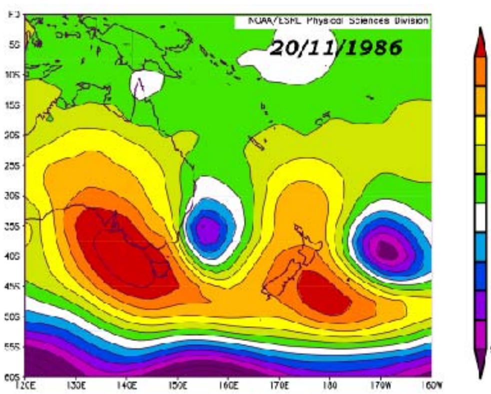
Inland Trough Lows (ITLs) originate in the quasi-permanent low pressure trough over inland Queensland. Their movement to the east coast is often associated with the interaction with a STL. Hence, the synoptic pattern of the ITL after crossing the east coast, can resemble the pattern associated with the SSL. Representative ITL large wave climate events occurred on 20th November 1986 and 22nd March 2005.

ITL of 19th November 1986

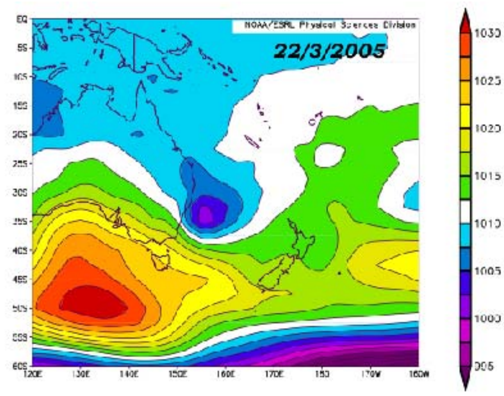
The ITL on the 19th November, 1986 produced peak storm waves at Batemans Bay with an H_{sig} of 5.98 m, an H_{max} of 7.81 m and a T_p of 10.2 s. On the 21st November, 1986, the ITL produced peak storm waves at Coffs Harbour with an H_{sig} of 3.86 m, an H_{max} of 6.73 m and a T_p of 10.3 s. Peak H_{sig} values of 3.2 m (Brisbane, T_p of 10.6 s), 3.0 m (Byron Bay, T_p of 9.5 s), 4.24 m (Crowdy Head, T_p of 13.5 s), and 4.93 m (Port Kembla, T_p of 12.2 s). The duration of storm waves was 72 hours, with an H_{sig} of 4.44 m and a T_p of 11.0 s.

ITL of 22nd March 2005

The ITL on the 22nd March, 2005 produced peak storm waves at Sydney with an H_{sig} of 6.61 m, an H_{max} of 11.16 m and a T_p of 12.2 s. Peak H_{sig} values of 4.93 m (Byron Bay), 6.1 m (Port Kembla), and 3.97 m (Eden). The duration of storm waves was 285 hours, with an H_{sig} of 2.83 m, a T_p of 9.7 s and a mean wave direction of 157°.



19th November, 1986



22nd March, 2005

7. Southern Tasman Low

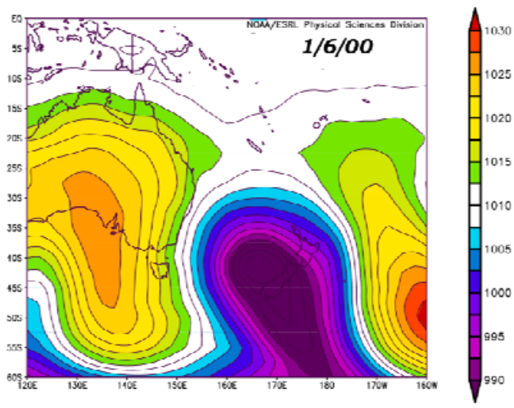
Large extratropical low pressure systems develop in the atmospheric longwave trough in the southern ocean south of 38°S, and extend northwards into the central Tasman Sea. These systems are classified as Southern Tasman Lows (STLs) and can produce extreme waves along the NSW and Victorian coasts. Some STL events are: 1st June, 2000, 20th March, 2003, and the 8th April, 2006.

STL of 1st June 2000

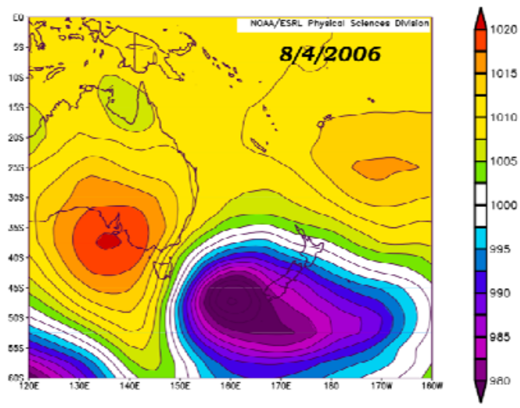
The STL on the 1st June, 2000 stretched across the Tasman Sea and produced peak wave conditions along the entire NSW coast with an H_{sig} of 5.85 m, H_{max} of 9.50 m and a T_p of 13.5 s at Eden. Associated peak H_{sig} of 4.29 m (Byron Bay), 4.74 m (Coffs Harbour), 4.76 m (Sydney), 5.65 m (Port Kembla), and 3.91 m (Batemans Bay) were also observed. The duration of storm wave conditions was 114 hours with an H_{sig} of 3.16 and a T_p of 10.9 s.

STL of 8th to 9th April 2006

The STL on the 8th to 9th April, 2006 was part of a sequence of STLs that occurred during April 2006. This STL produced peak wave conditions along the NSW coast with an H_{sig} of 5.23 m, H_{max} of 9.03 m and a T_p of 17.1 s at Port Kembla. Associated peak H_{sig} of 3.82 m (Crowdy Head), 4.90 m (Sydney), 3.21 m and mean wave direction of 142° (Batemans Bay), and 4.63 m (Eden) were also observed. The duration of storm wave conditions was 87 hours with an H_{sig} of 3.47 m and a mean wave direction of 178°. On the 9th April, 2006, storm wave conditions were observed from Sydney to Brisbane as the STL moved eastward across the Tasman. At the Brisbane buoy an H_{sig} of 1.56 m, with T_p of 15.4 s and a mean wave direction of 155° was observed. In northern NSW, an H_{sig} of 2.31m (Byron Bay), 4.90 m (Coffs Harbour), 4.51 m (Crowdy Head) was observed, while Sydney received an H_{sig} of 4.67 m, a T_p of 15.0 s and a mean wave direction of 171°.



1st June, 2000



8th to 9th April, 2006

8. Southern Secondary Low

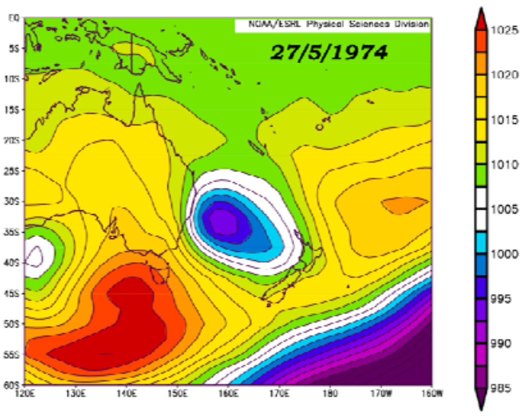
Southern Secondary Lows (SSLs) form in association with STL and evolve into a secondary or cut off low in the Tasman Sea region, adjacent to a subtropical anticyclone. These SSL synoptic types produce more extreme wave energy, comparable to the ETL type. Two such SSL events occurring on 27th May 1974 and 23rd August 2008.

SSL of 27th May 1974 ("Sygna Storm")

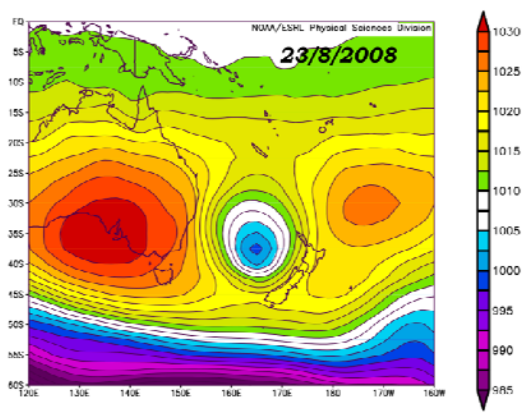
The 27th May, 1974 event known as the 'Sygna Storm' caused significant erosion on the central, Sydney and Illawarra coasts. Only the Port Kembla wave buoy was operational during this event. The Port Kembla buoy recorded peak H_{sig} of 6.15 m, an H_{max} of 10.42 and a T_p of 12.8 s. The duration of storm conditions was 96 hours with an H_{sig} of 4.09 m and a T_p of 11.9 s. The storm caused the shipwrecking of the 53,000t Norwegian coal carrier, the *Sygna*, in Stockton Bight north of Newcastle. Foster et al (1975) cited evidence that this storm was most intense in the region between Sydney and Newcastle and hindcast a peak H_{sig} of 9.2 m based on synoptic charts. Helman (2007) reported wind gusts up to 170 km/hr, houses and cars blown away in central NSW and several lives lost. Seas were reported to have caused ongoing erosion along the coast with several houses damaged.

SSL of 23rd August 2008

The SSL on the 23rd August, 2008 produced storm wave conditions along the entire NSW coast, with the higher wave energy focused on the coast from Sydney to the Gold Coast. Mean wave directions of 160°, 179° and 152° were recorded for Brisbane, Sydney and Bateman's Bay. An H_{max} of 9.56 m was recorded at Brisbane. Peak H_{sig} values of 6.42 (Brisbane, T_p of 11.5 s), 5.14 m (Coffs Harbour, T_p of 13.5 s), 4.78 m (Crowdy Head, T_p of 11.2 s), 6.08 m (Sydney, T_p of 11.45 s), 5.09 m (Port Kembla, T_p of 11.2 s), 3.53 m (Batemans Bay, T_p of 9.8 s), and 3.26 m (Eden, T_p of 8.9 s). The duration of storm waves was 67 hours, with an H_{sig} of 3.43 m, a T_p of 12.5 s and a mean wave direction of 153°.

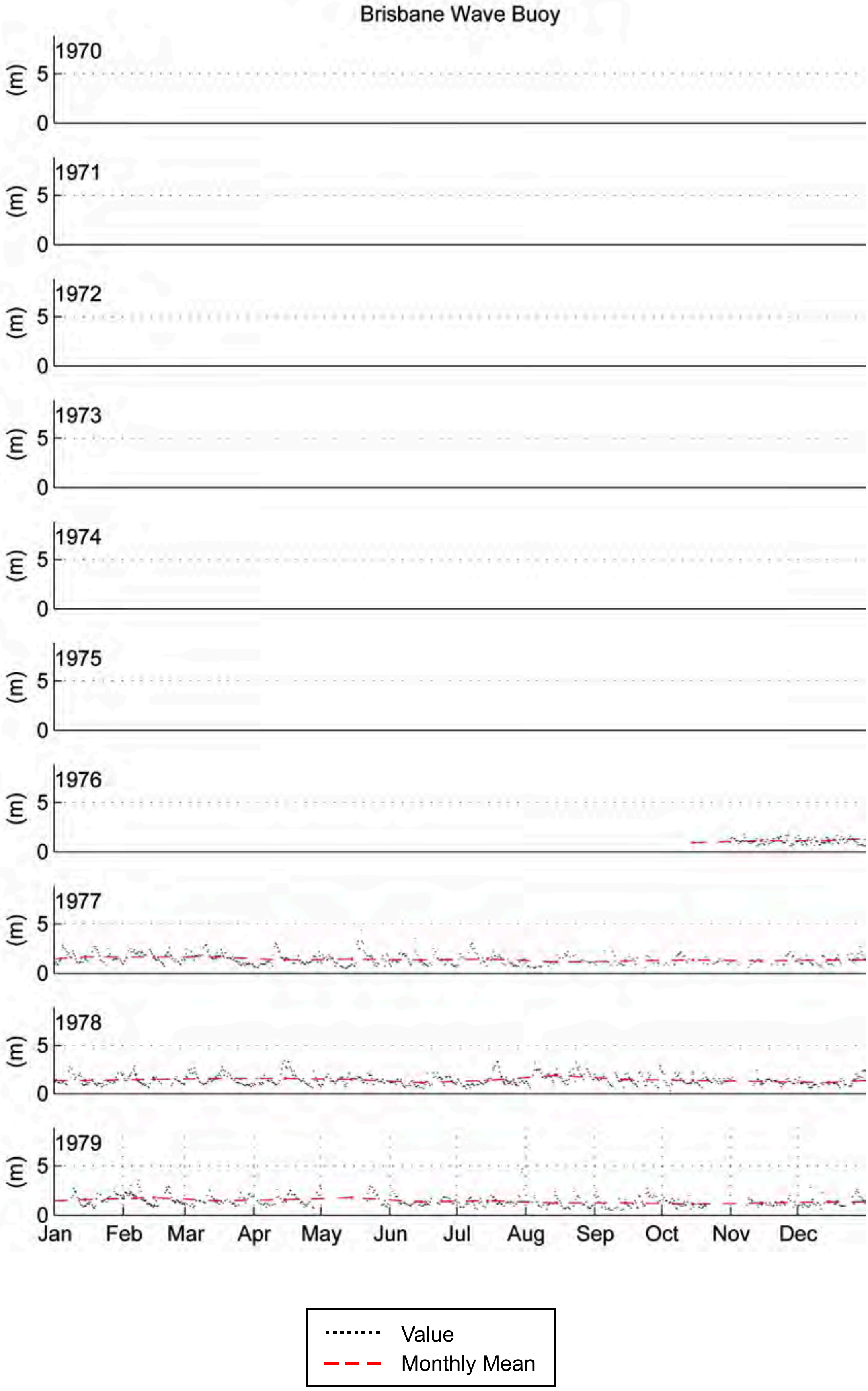


27th May, 1974



23rd August, 2008

APPENDIX B
WAVE BUOY TIME SERIES



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TIME SERIES OF WAVE BUOY DATA

Figure B

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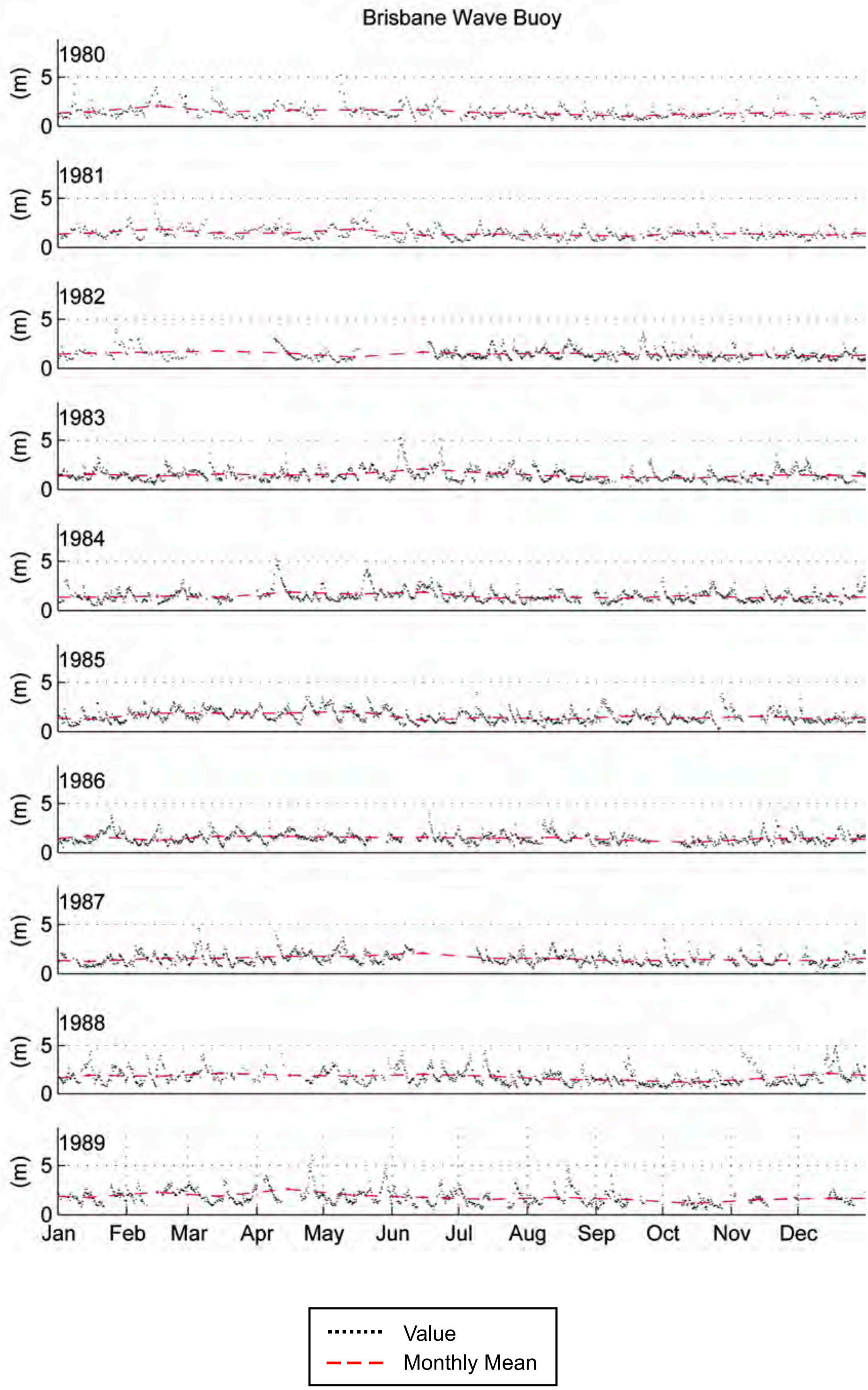

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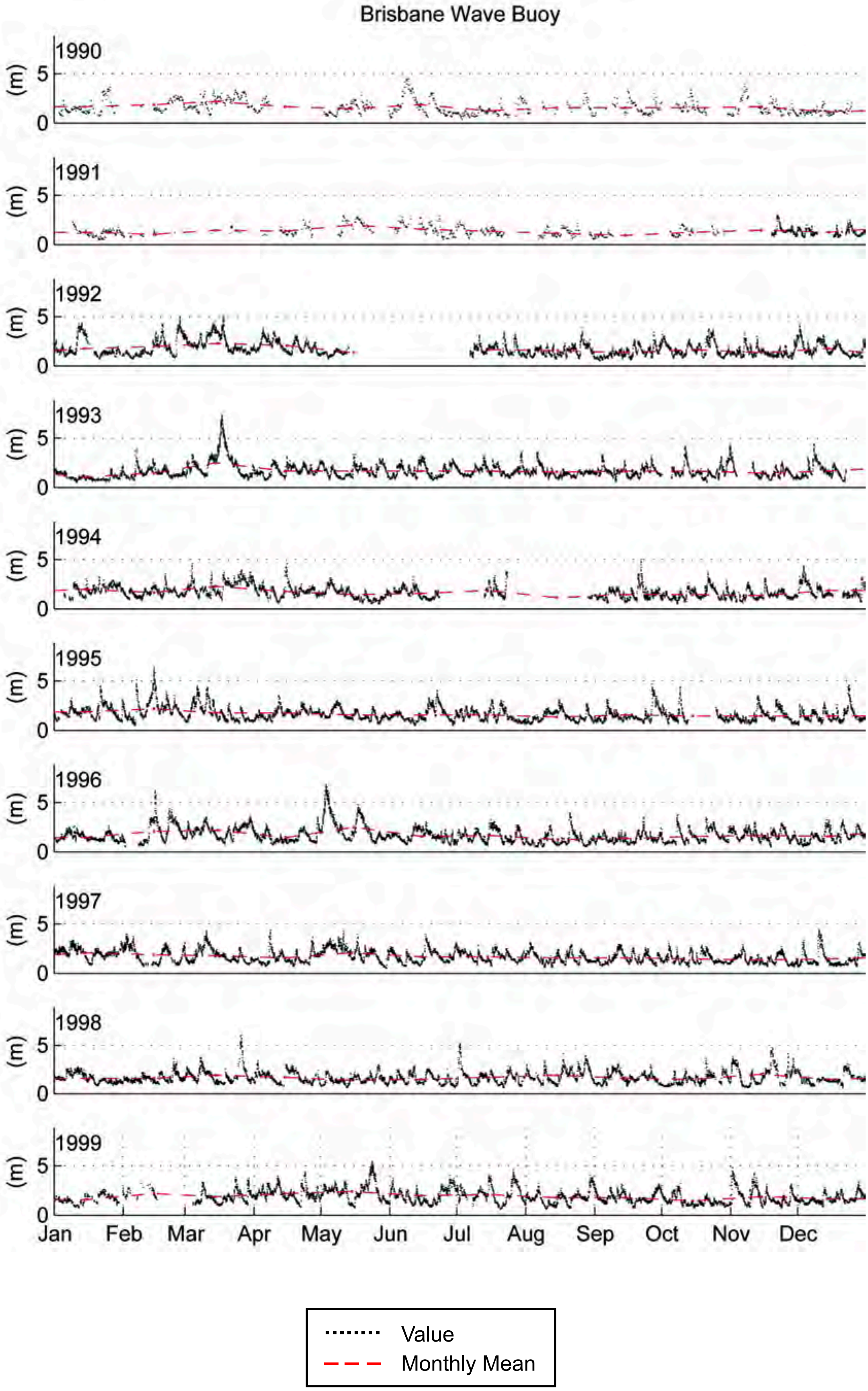

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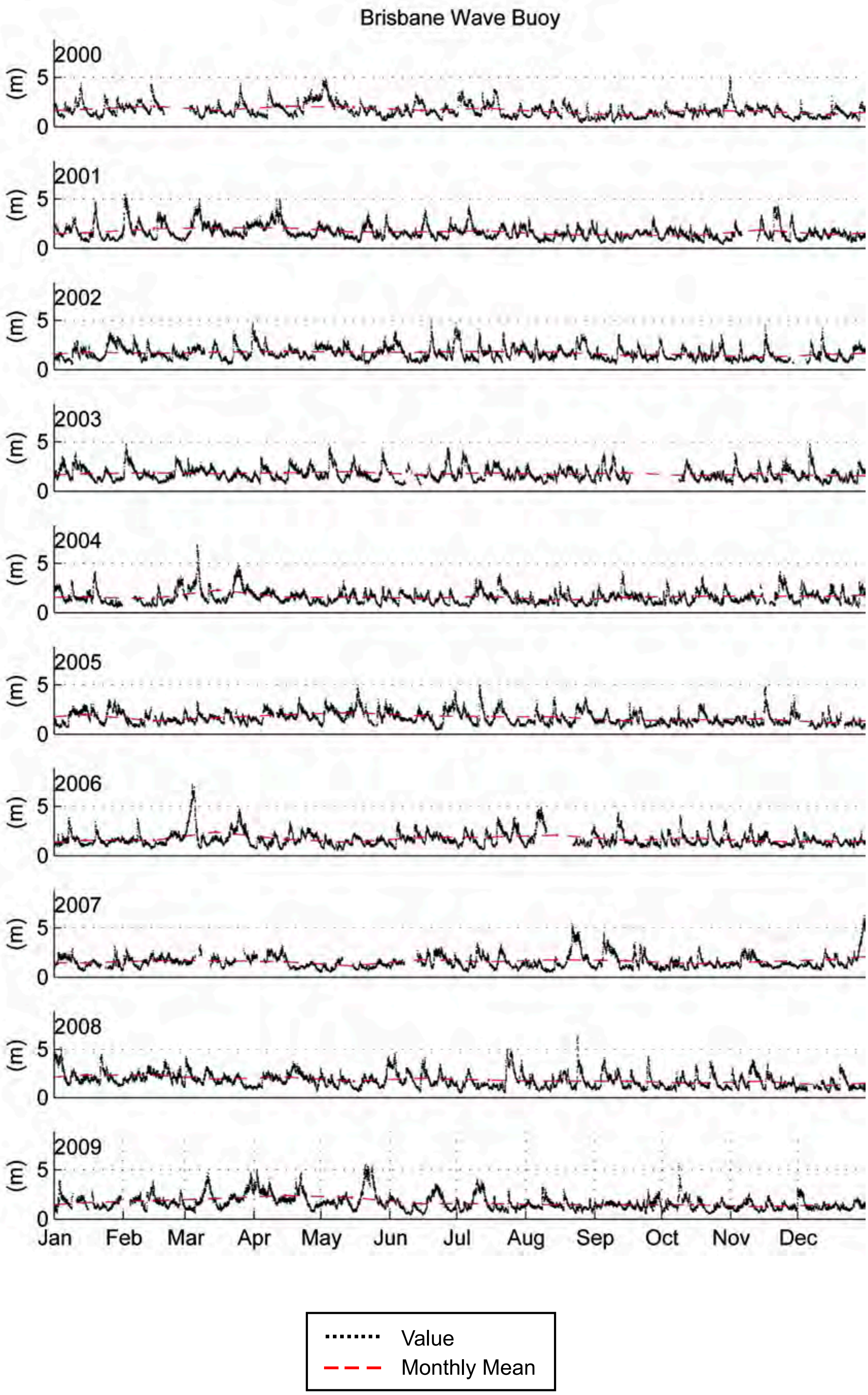

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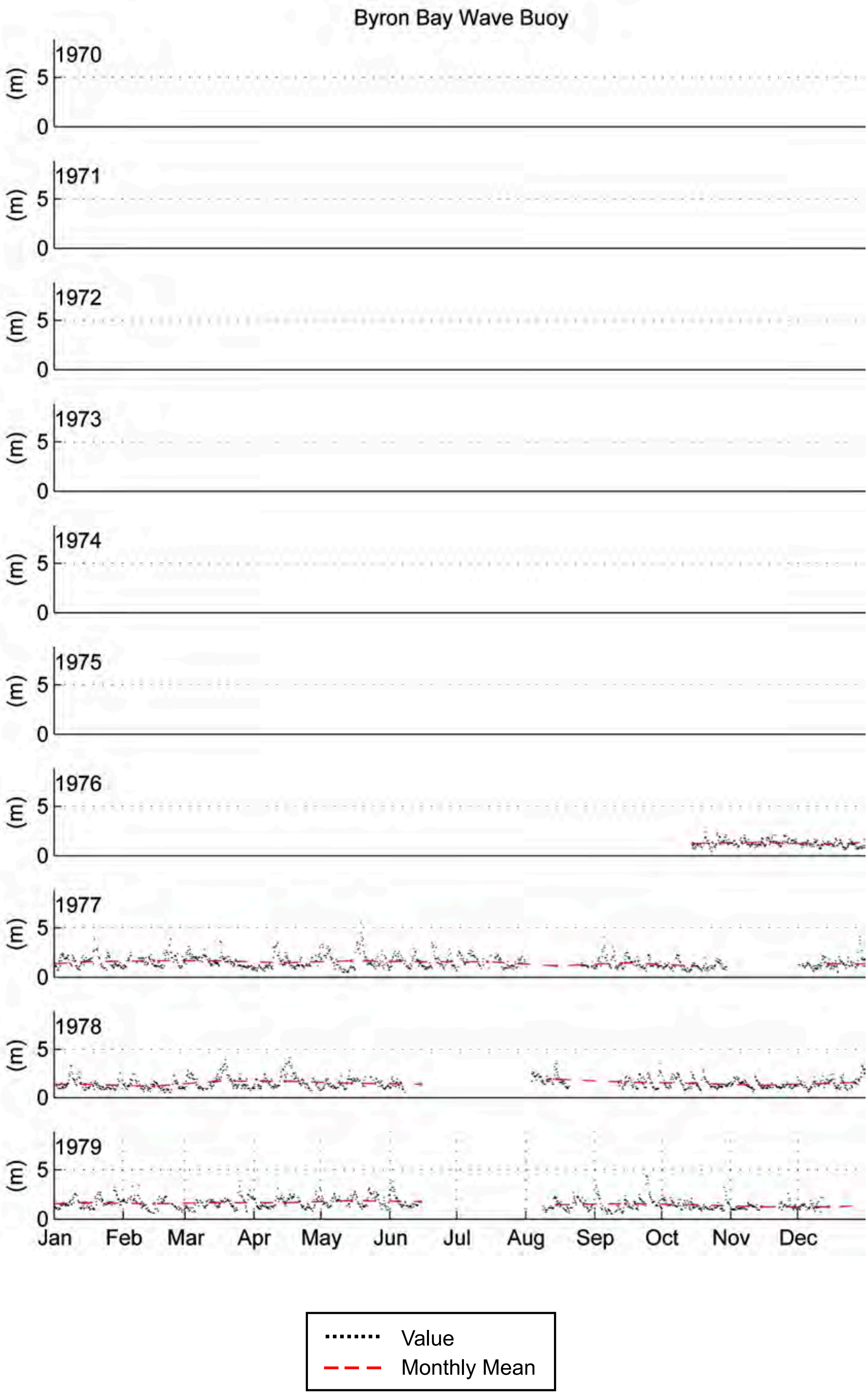

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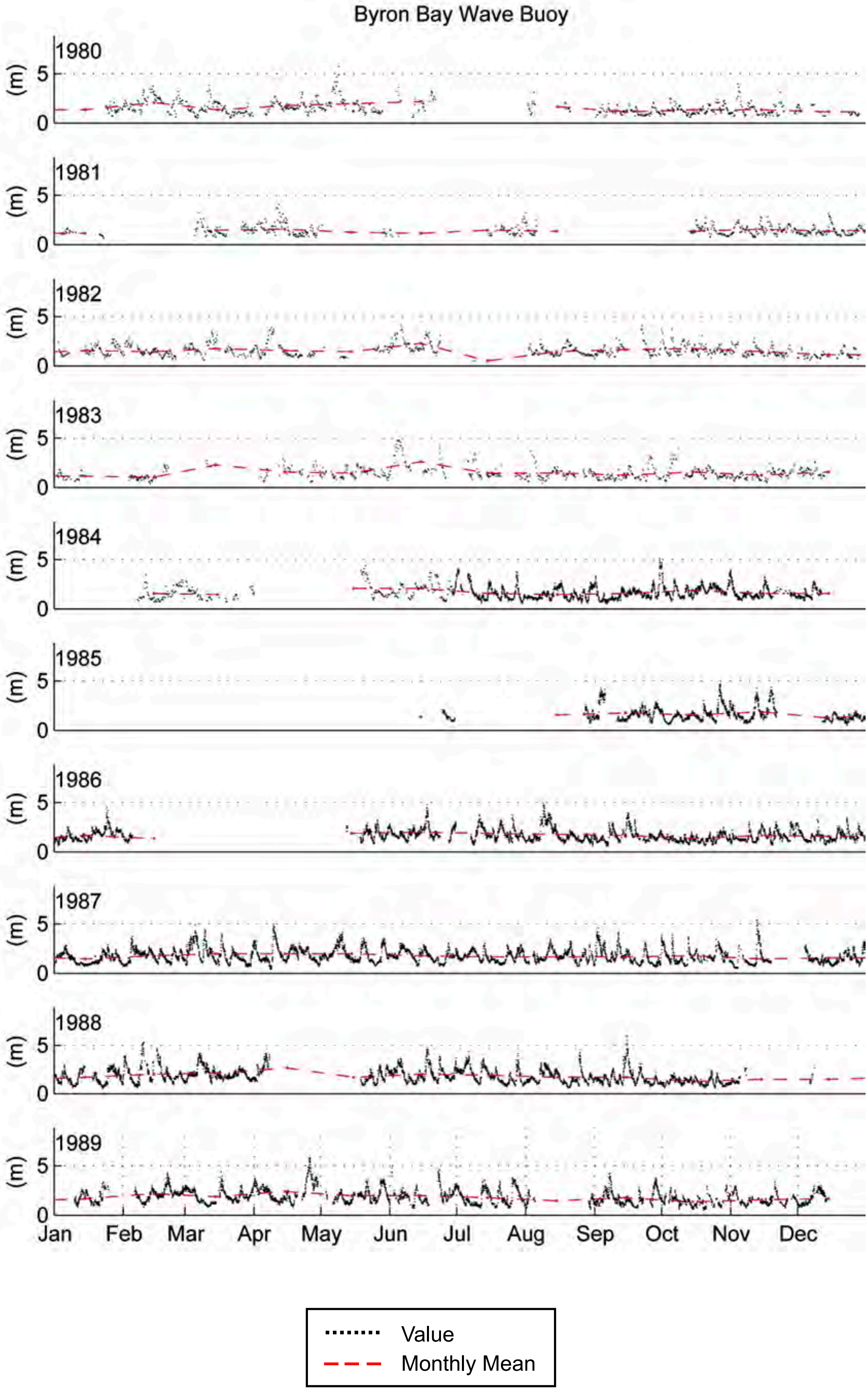

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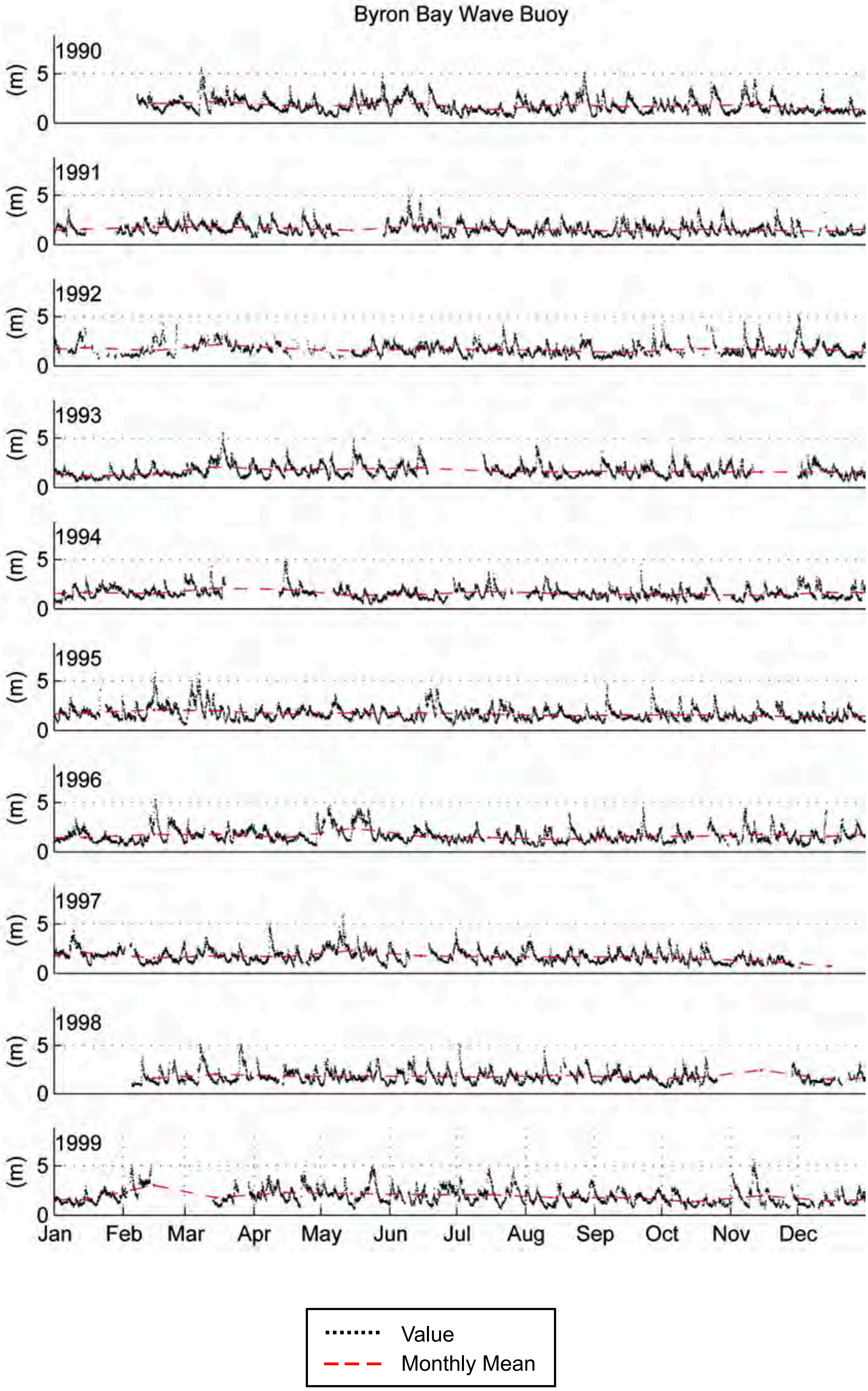

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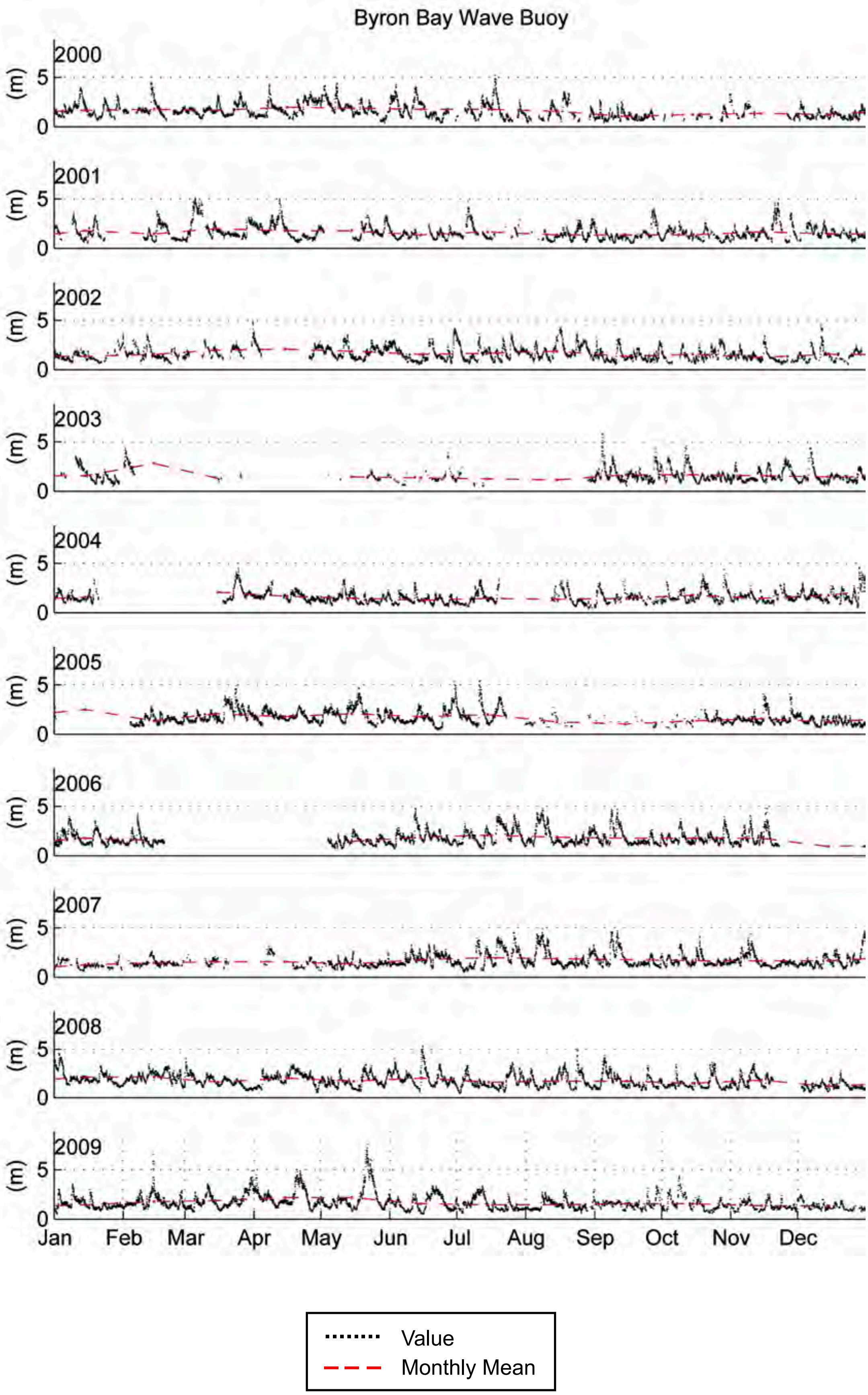

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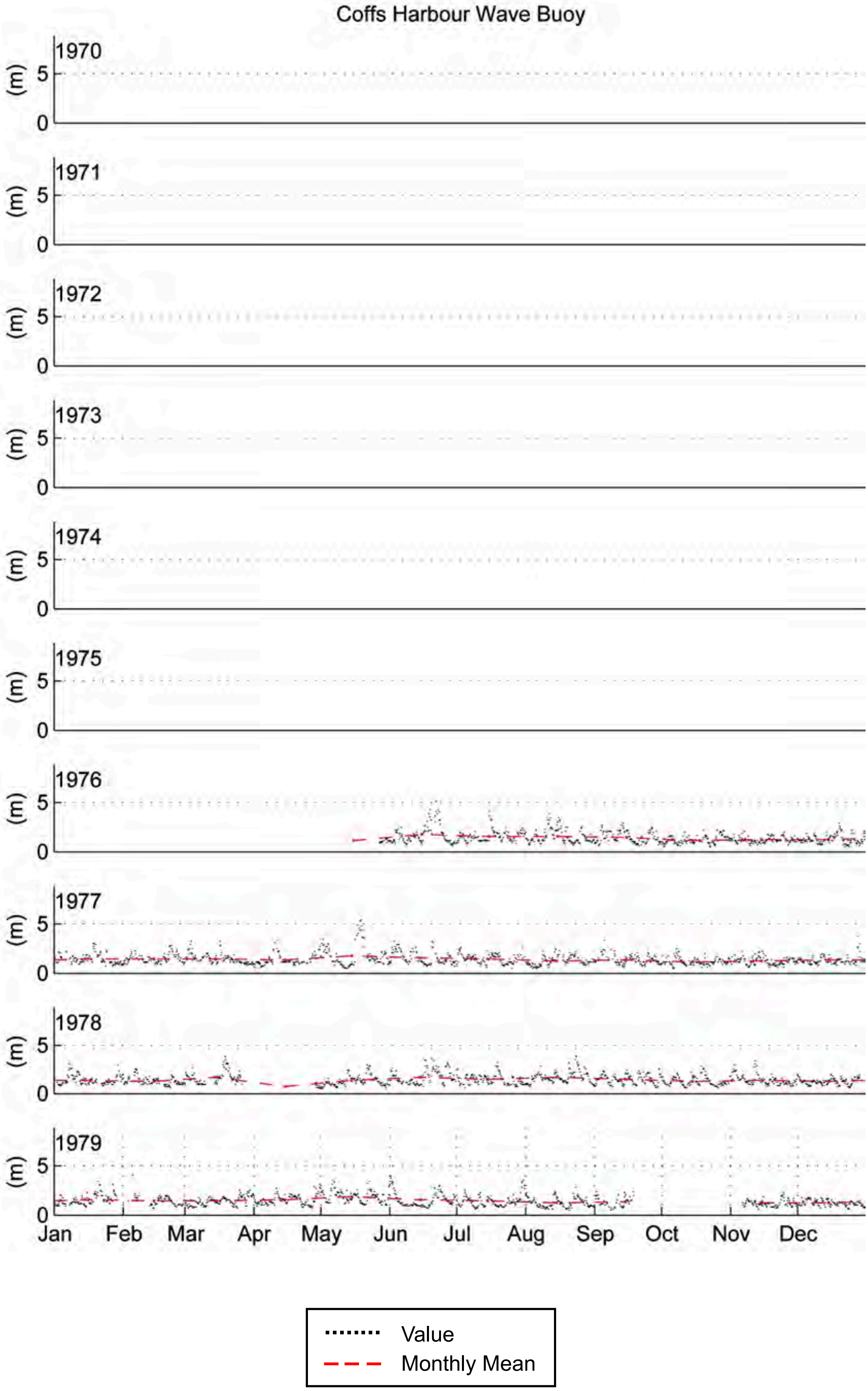

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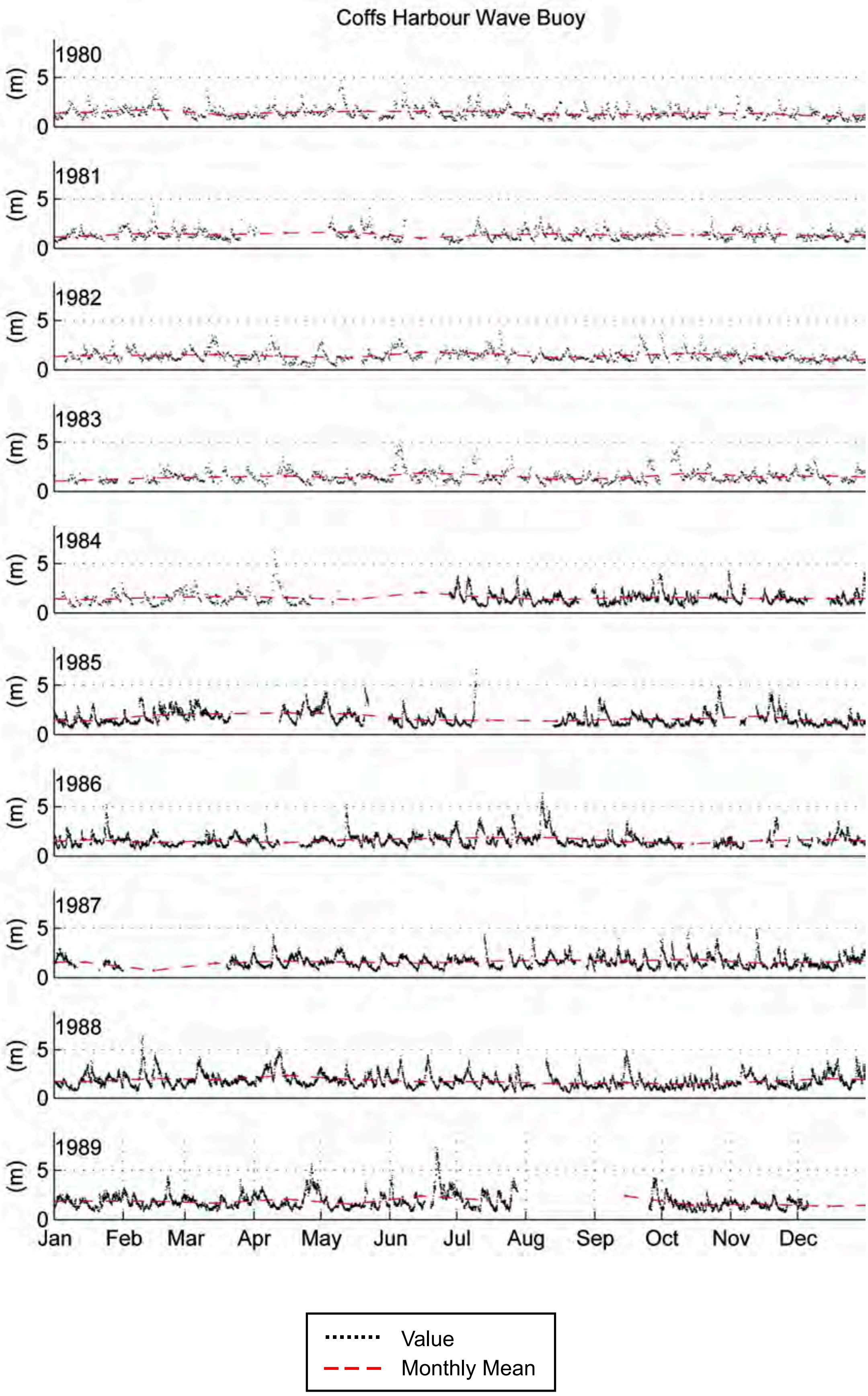

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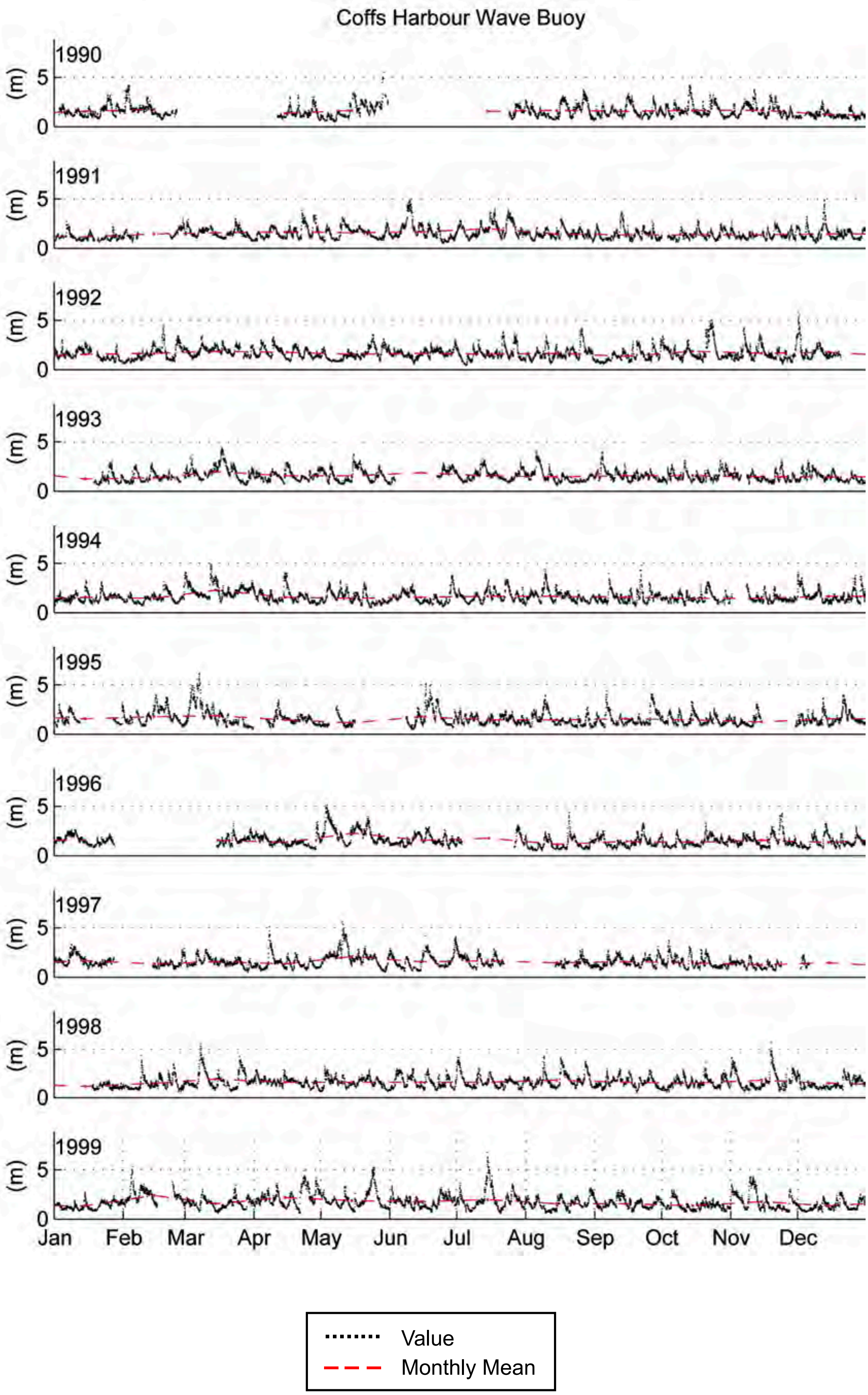

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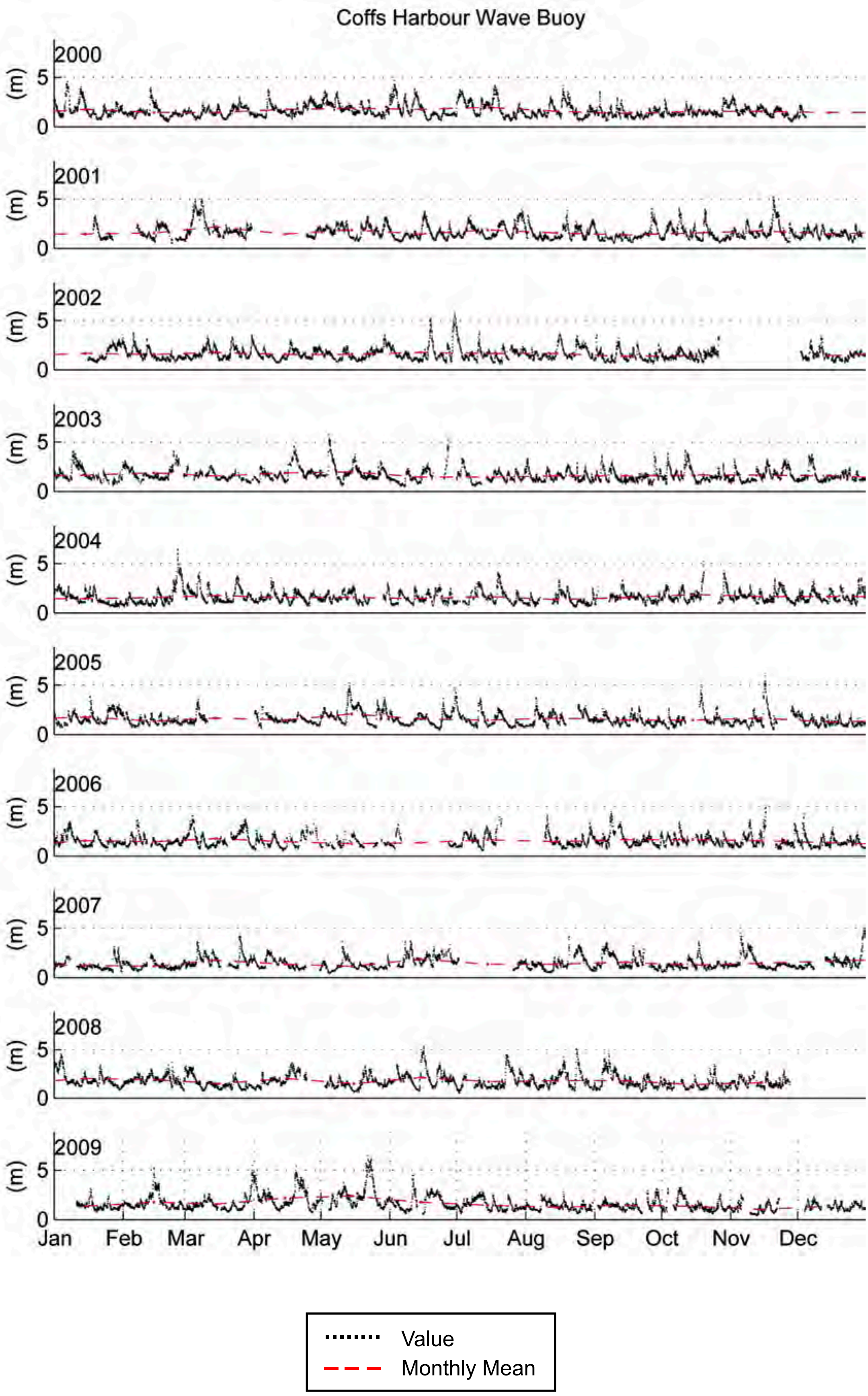

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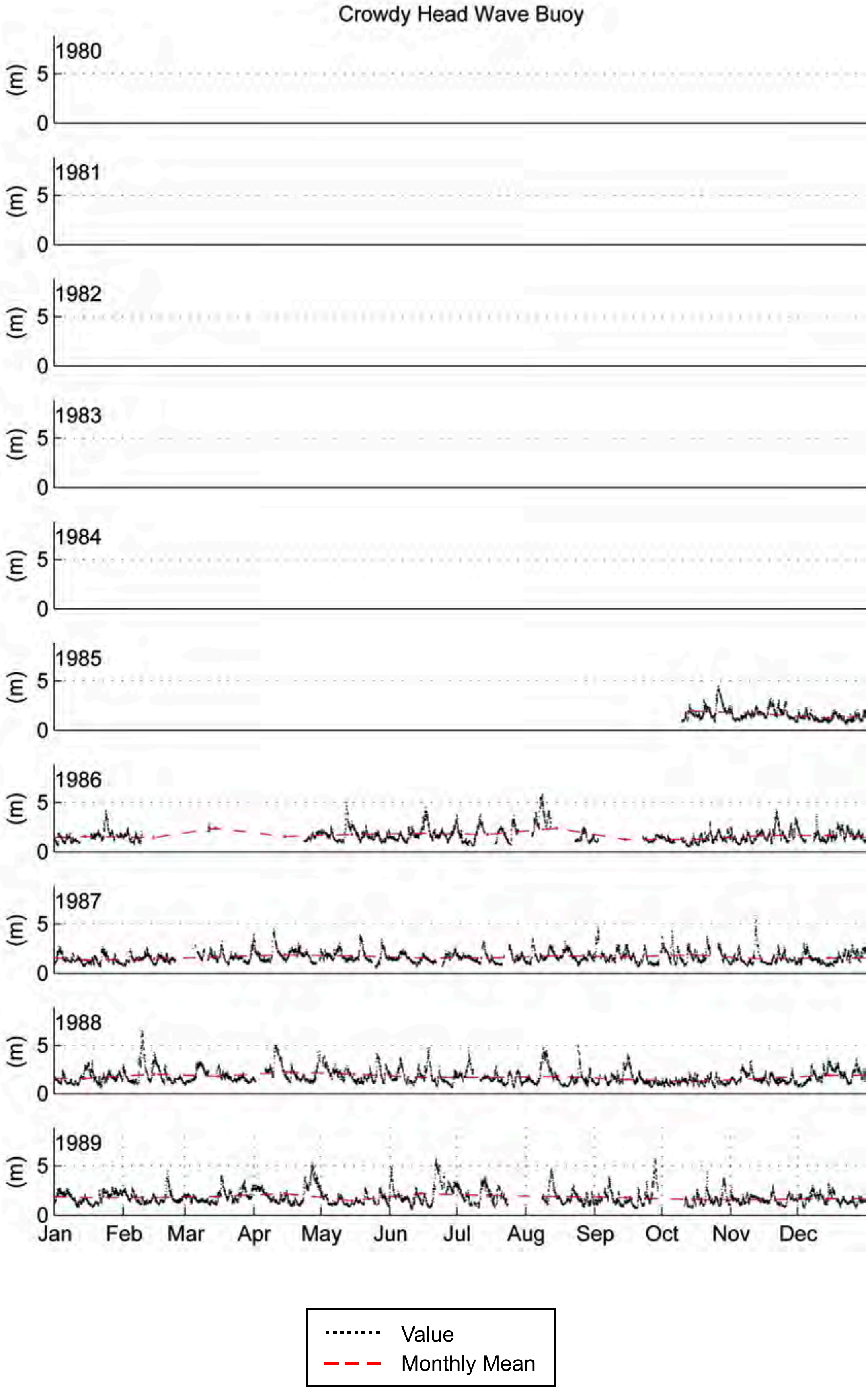

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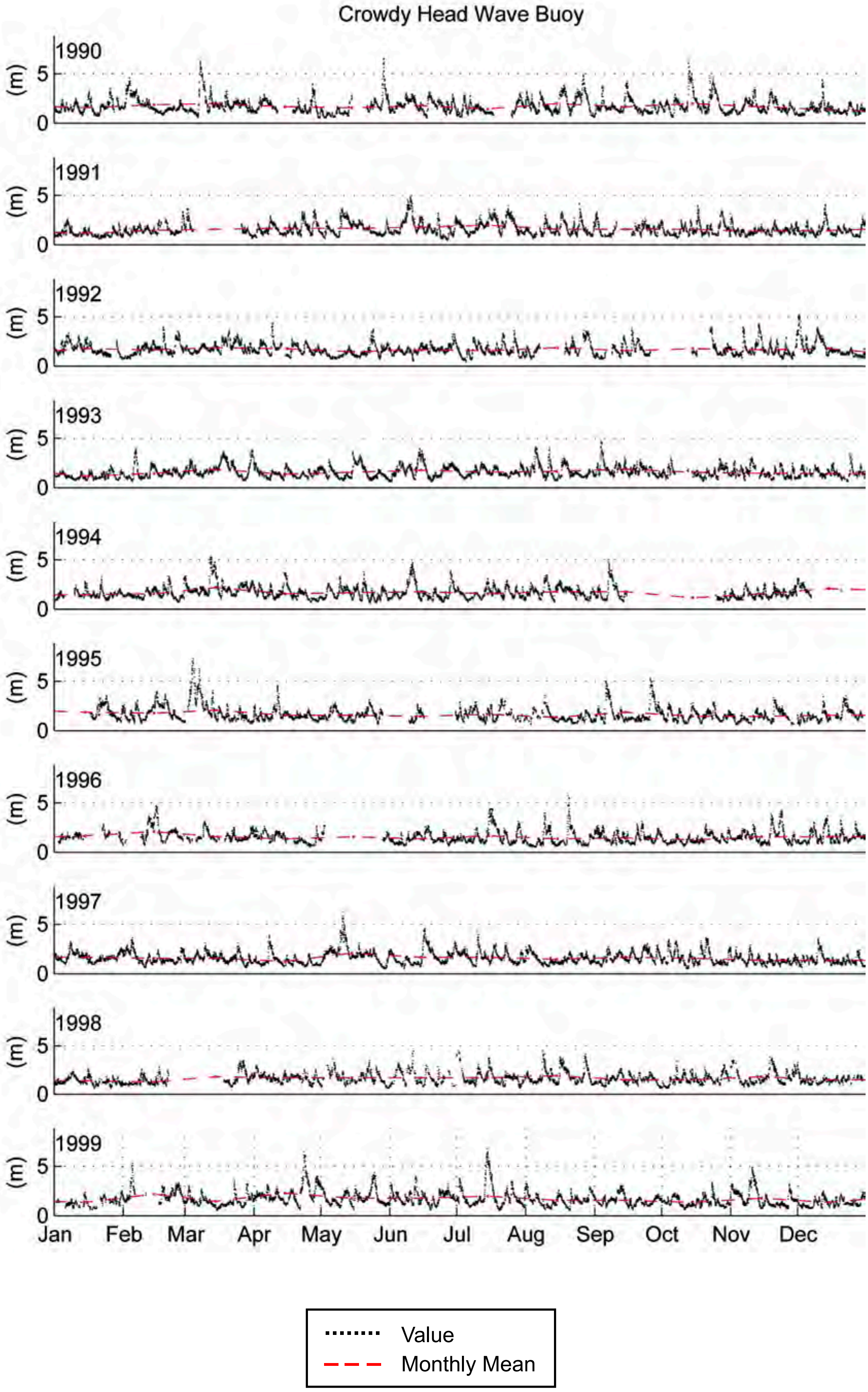

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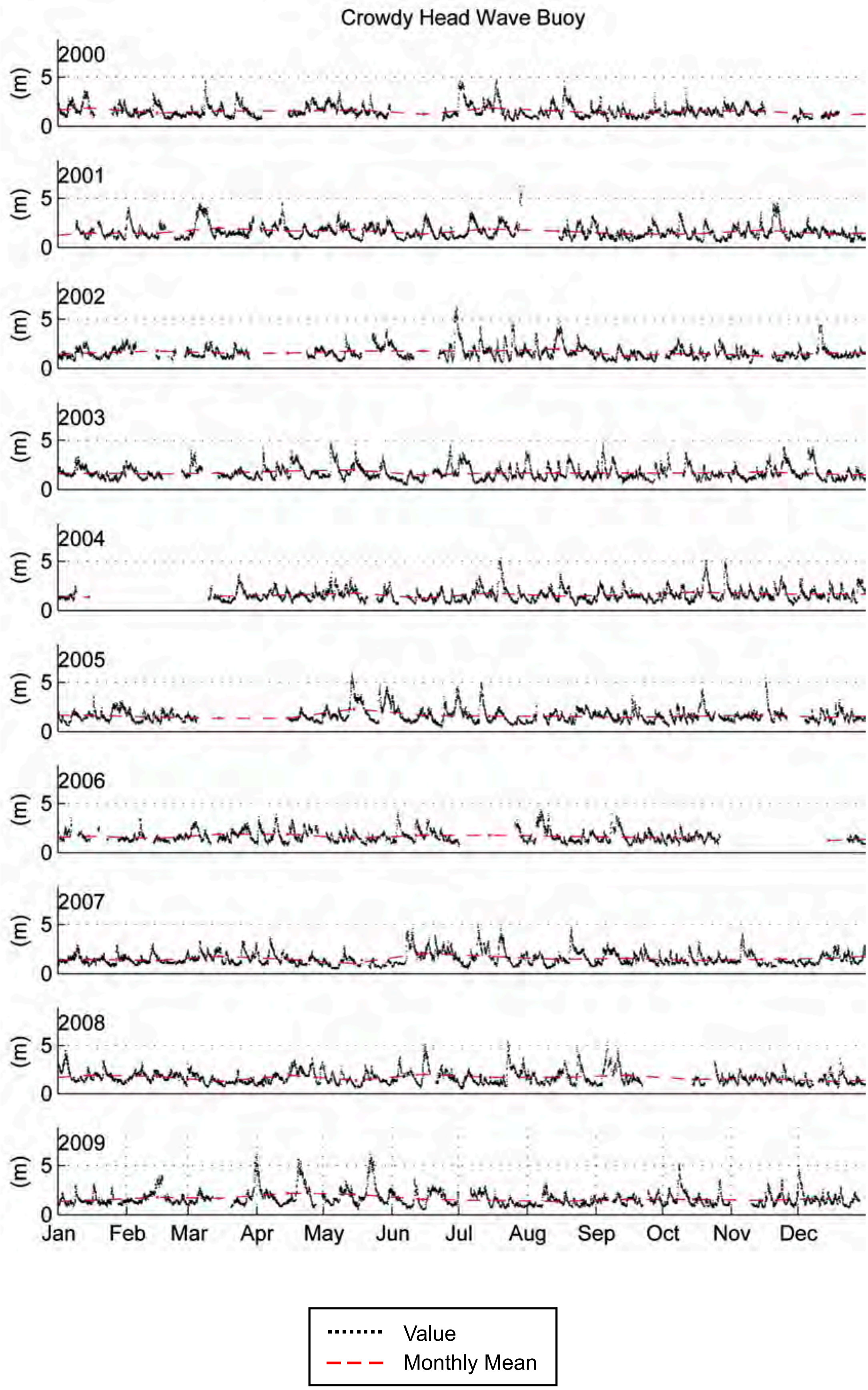

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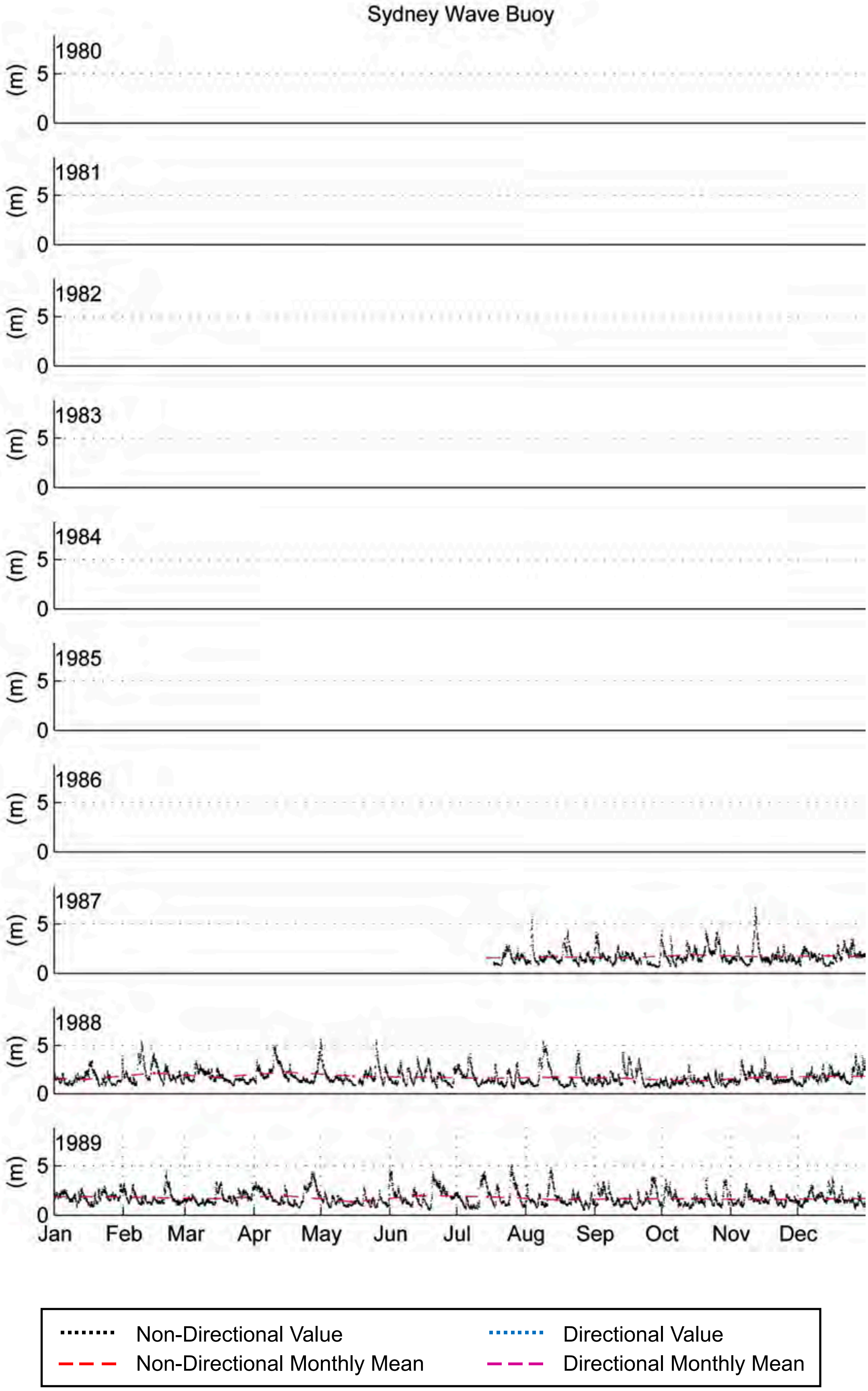

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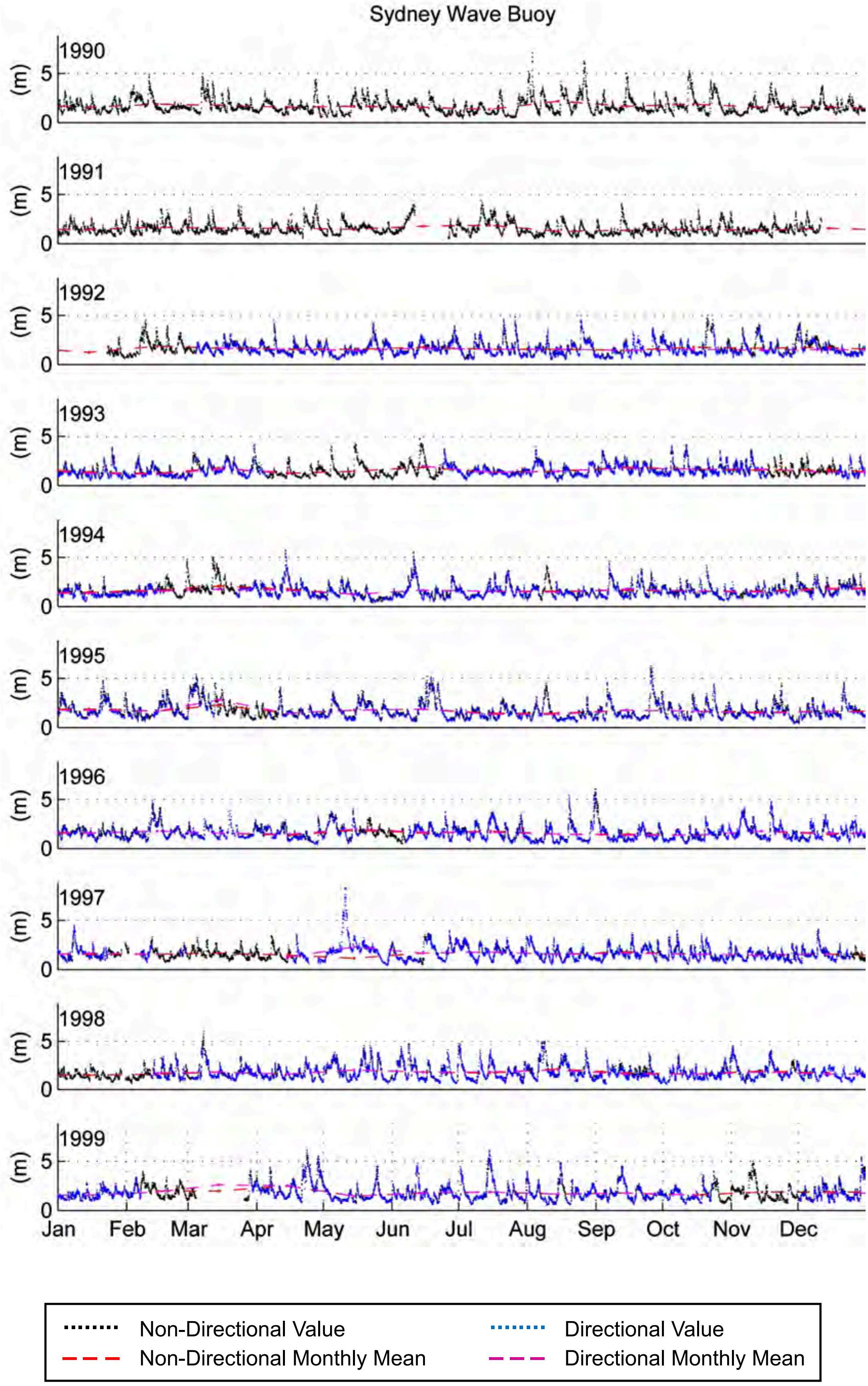

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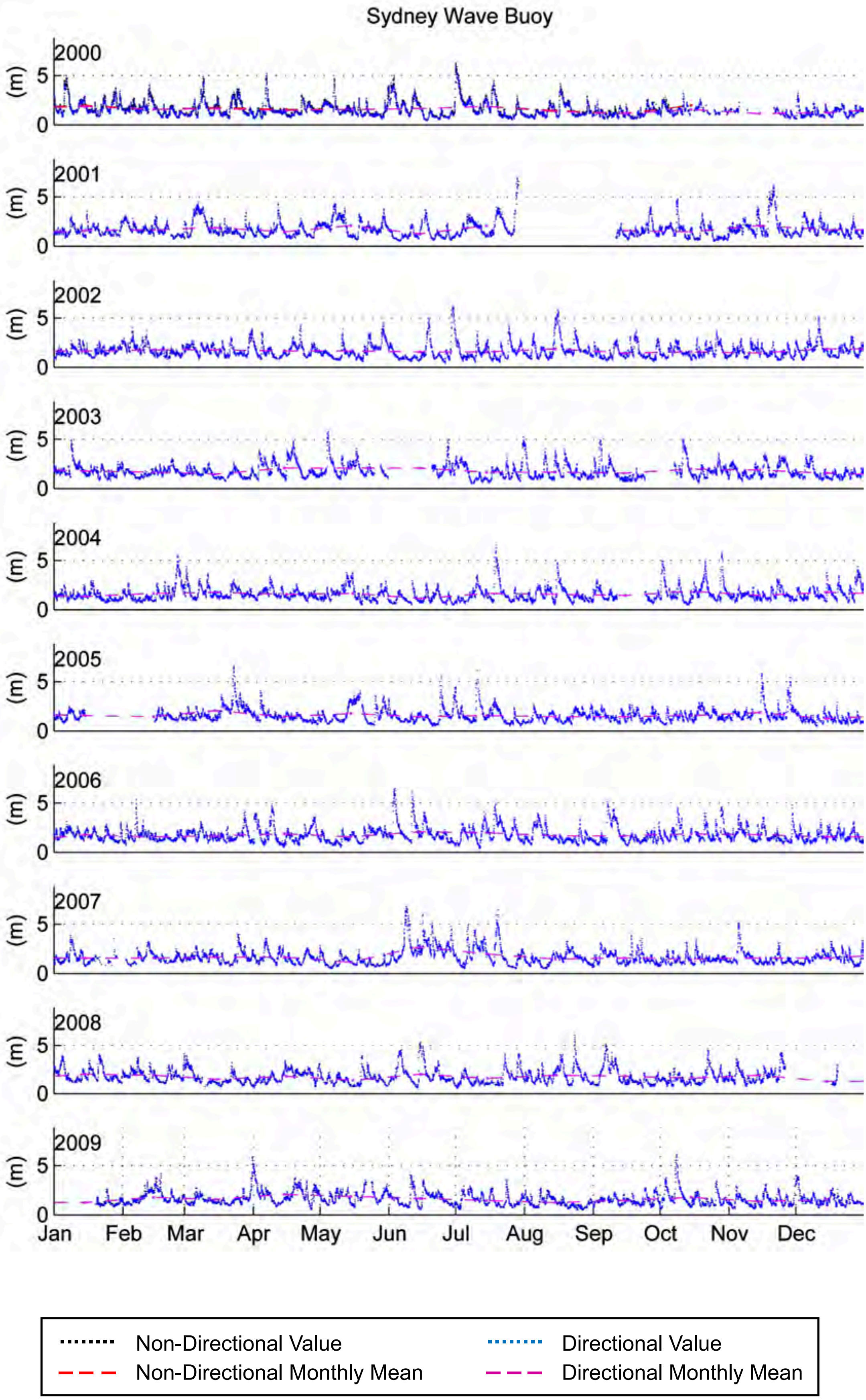

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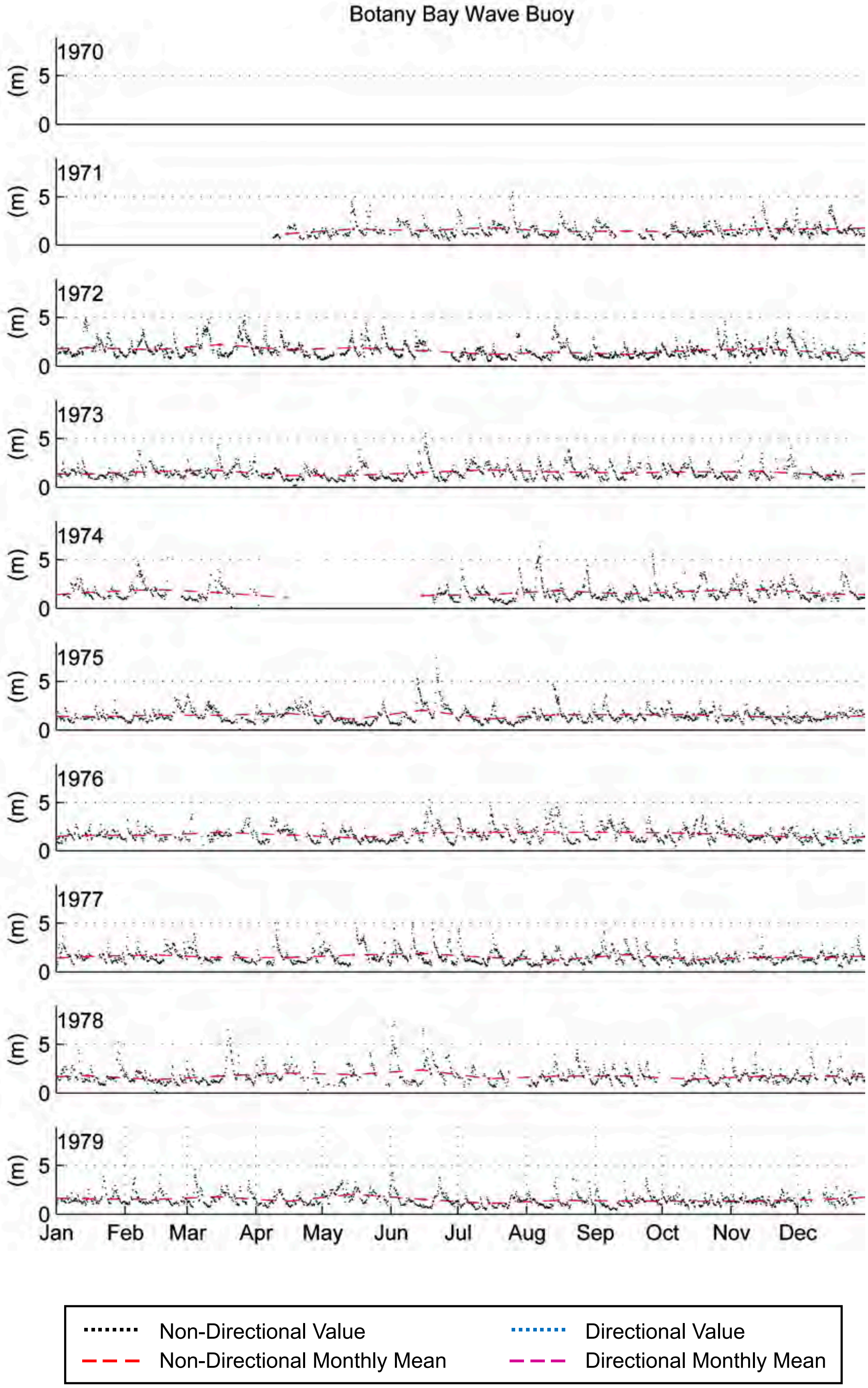

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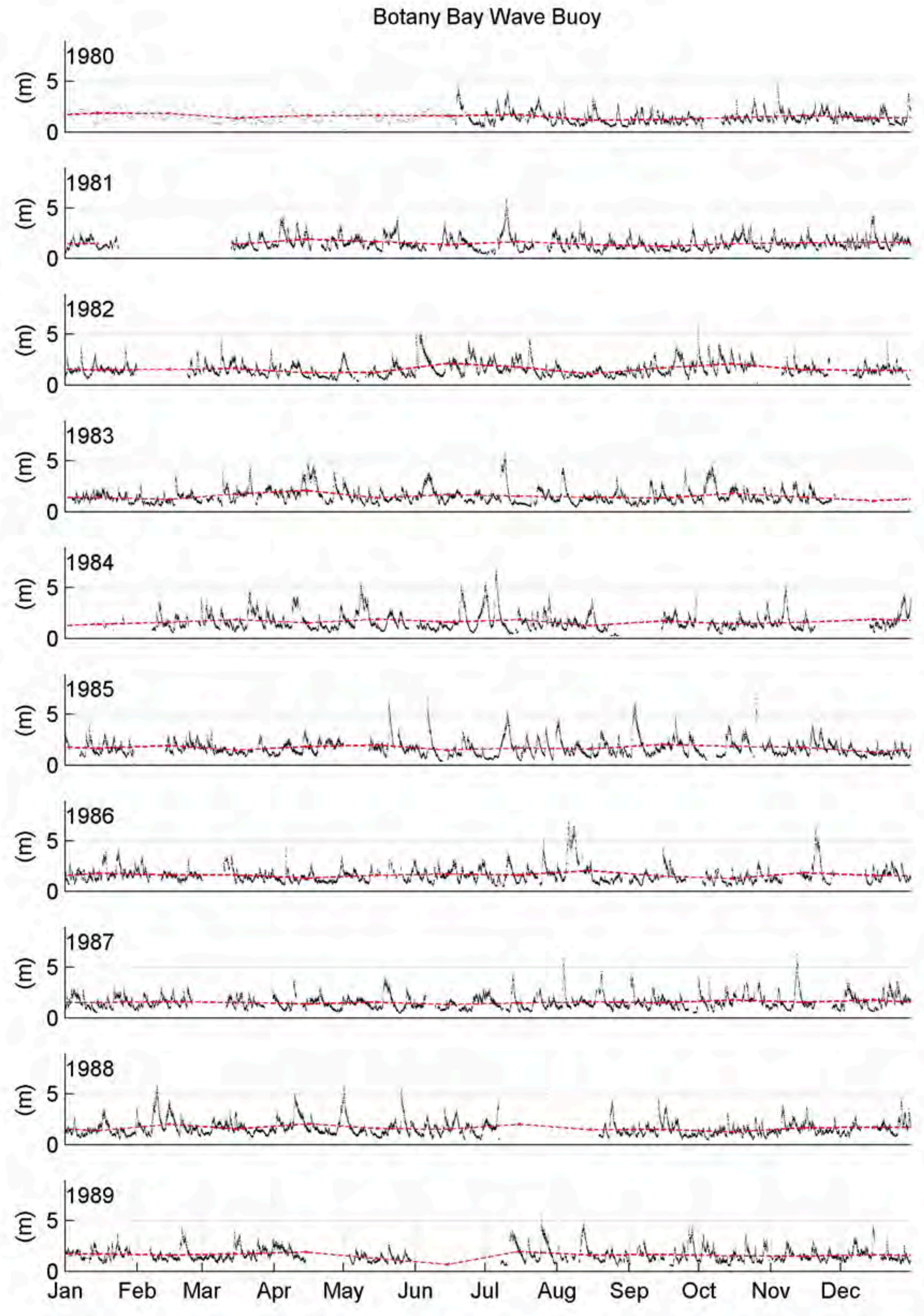

Non-Directional Value	Directional Value
Non-Directional Monthly Mean	Directional Monthly Mean

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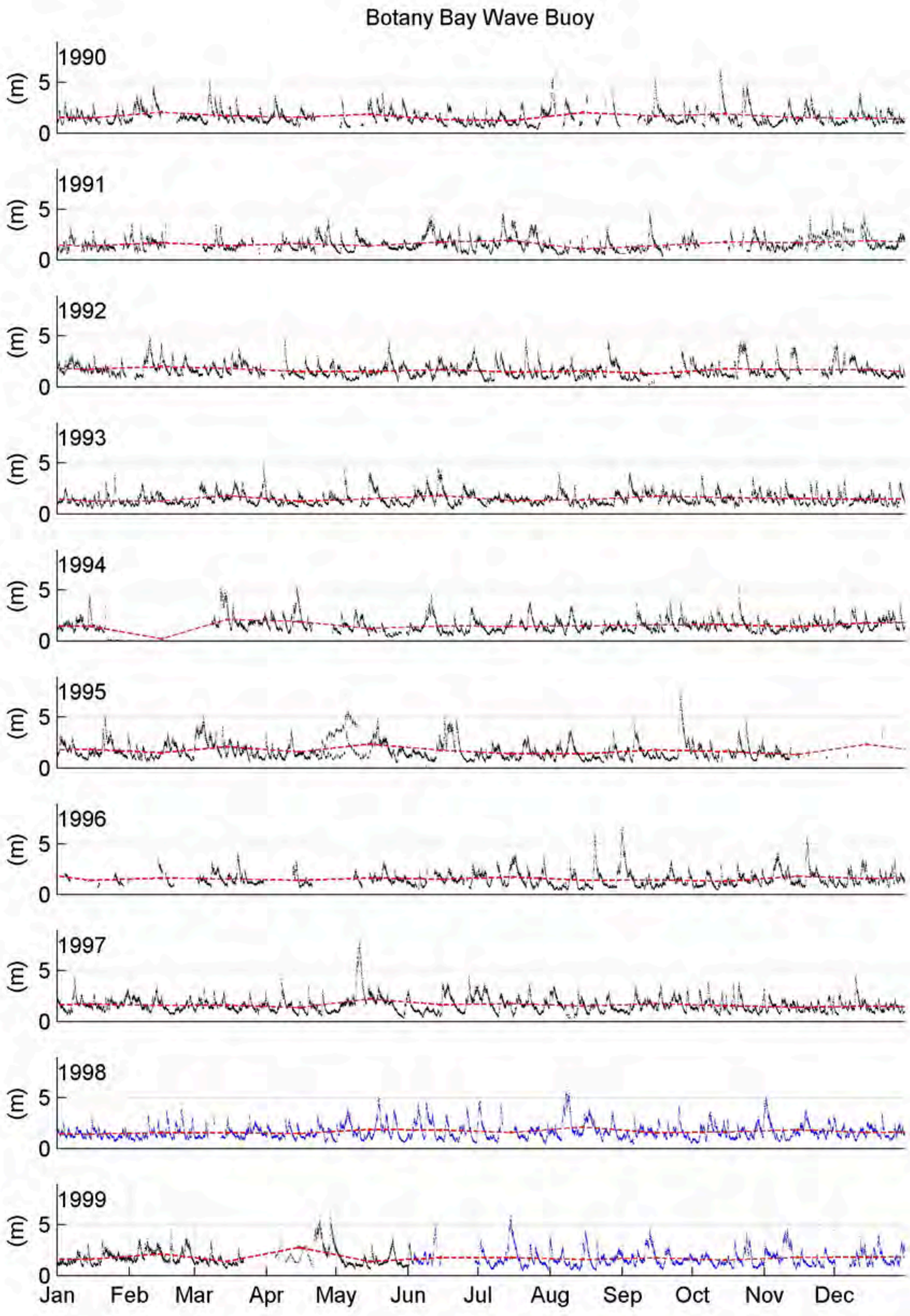

Non-Directional Value	Directional Value
Non-Directional Monthly Mean	Directional Monthly Mean

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Report No. 2010/16

TIME SERIES OF WAVE BUOY DATA

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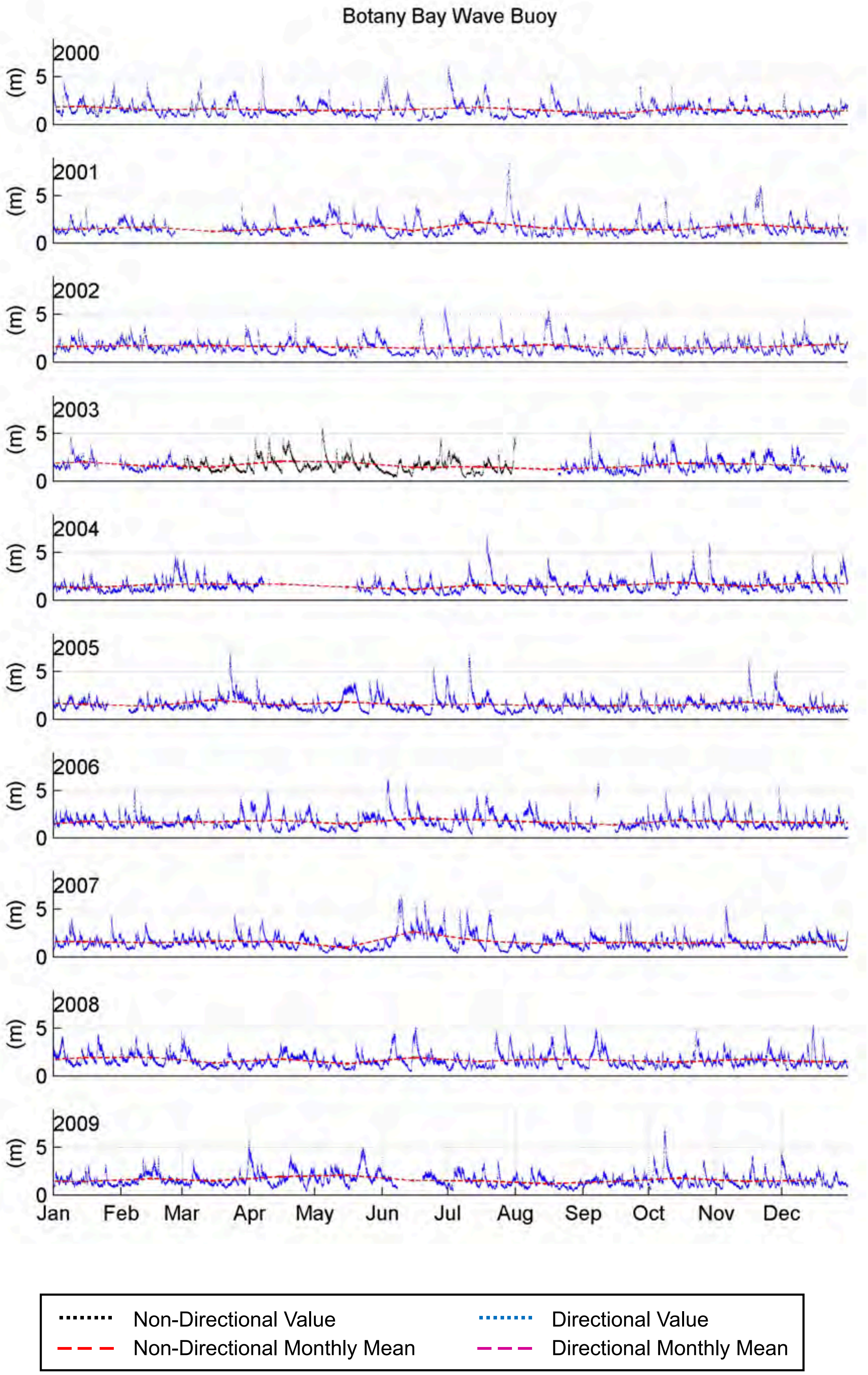

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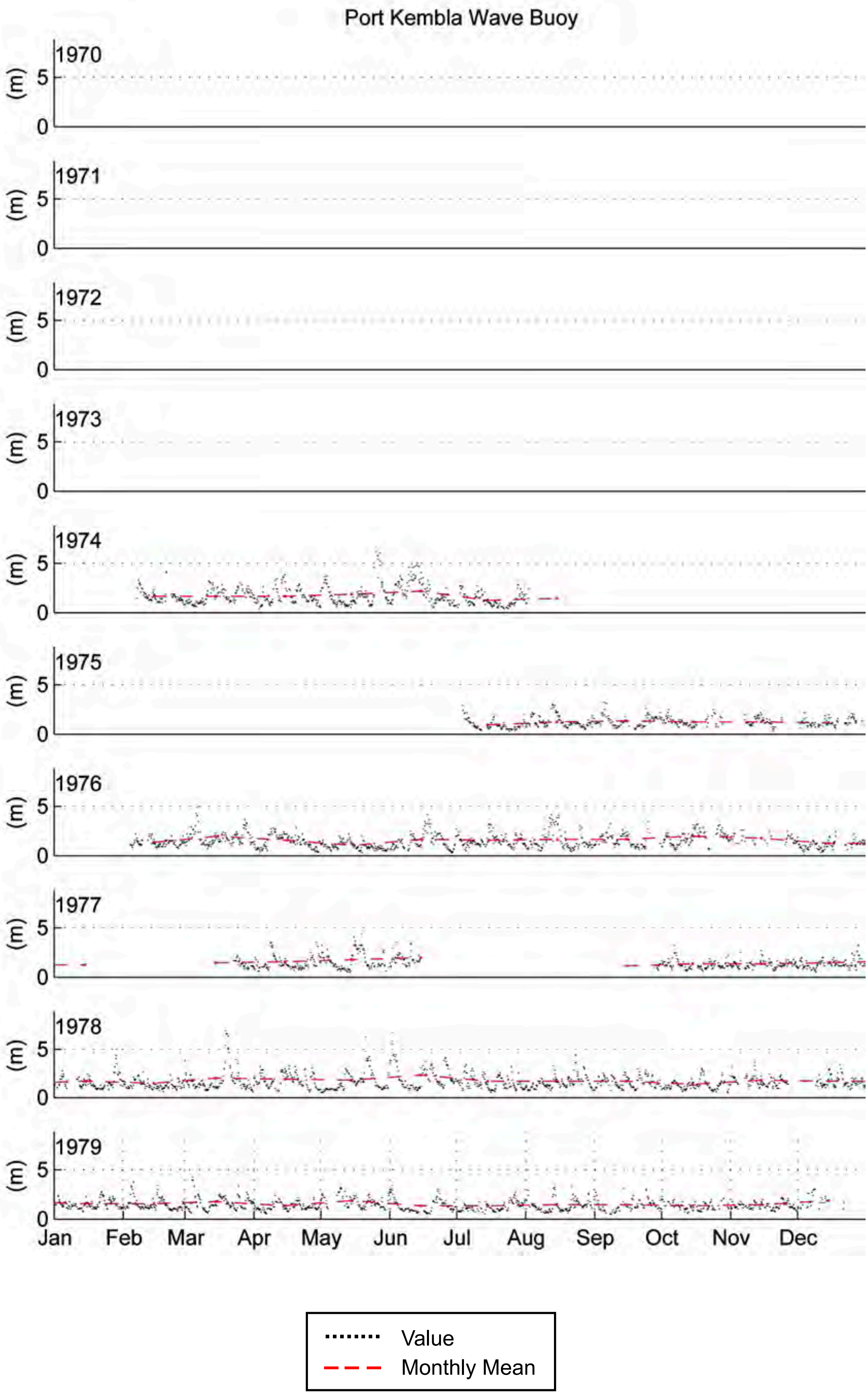

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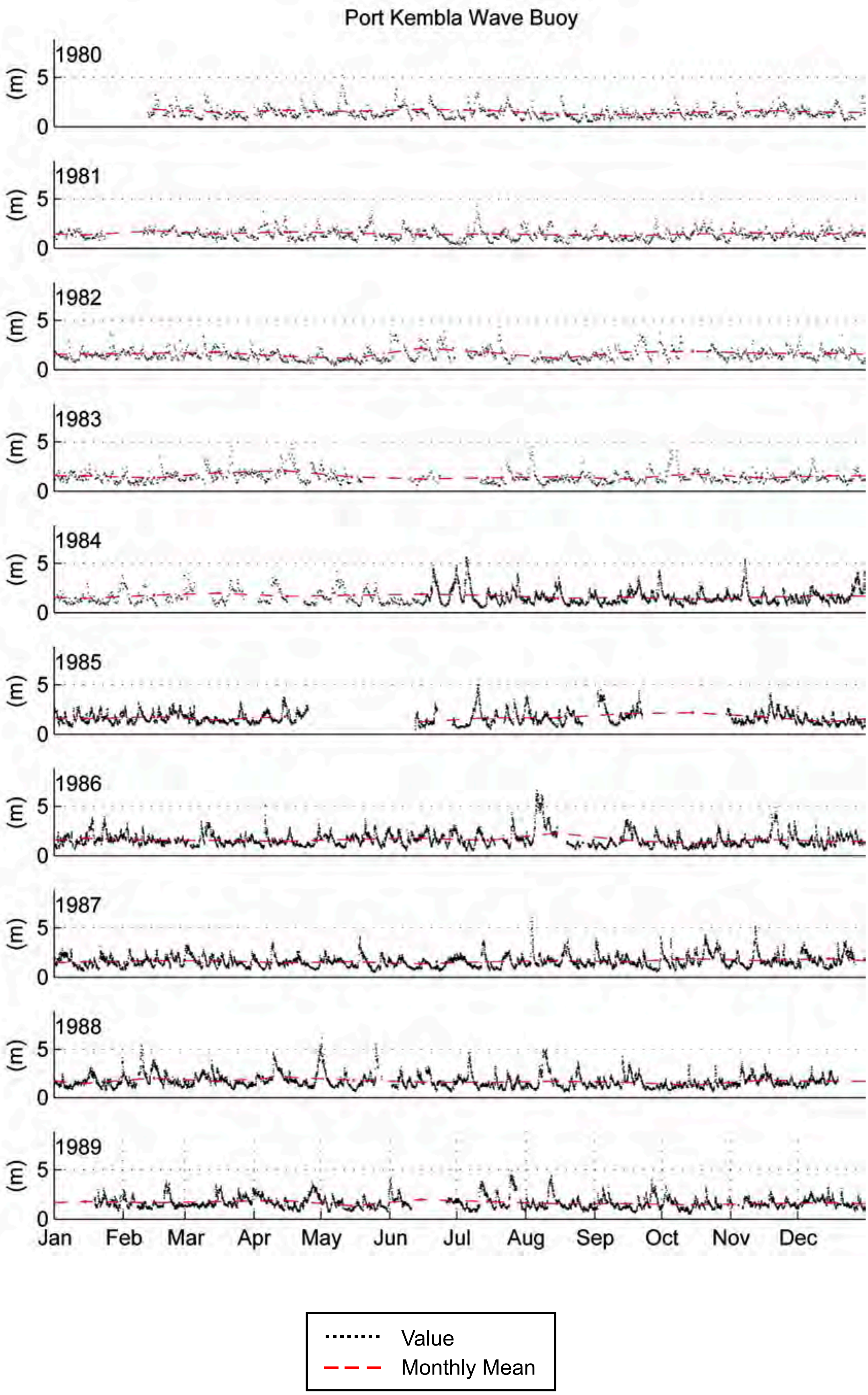

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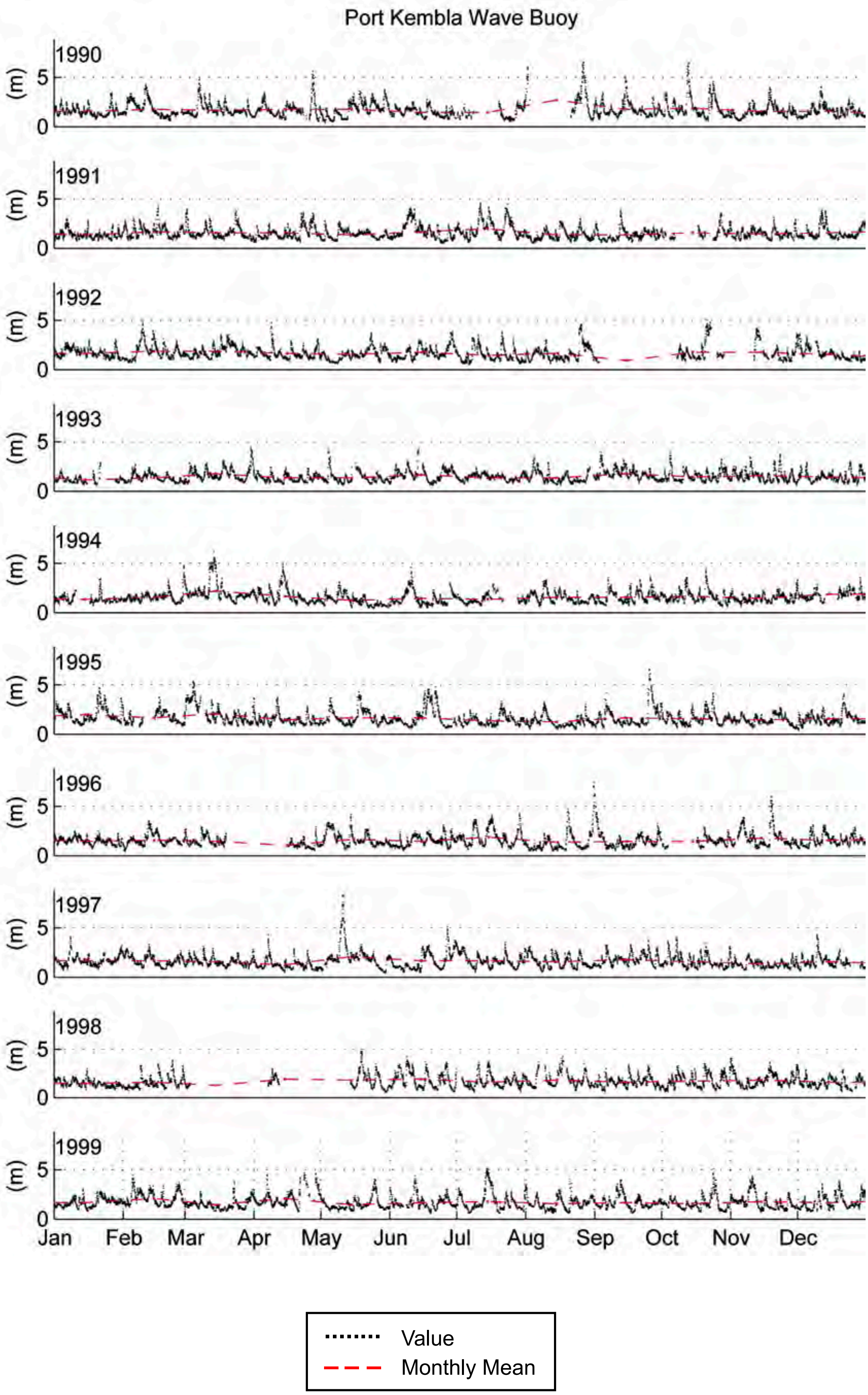

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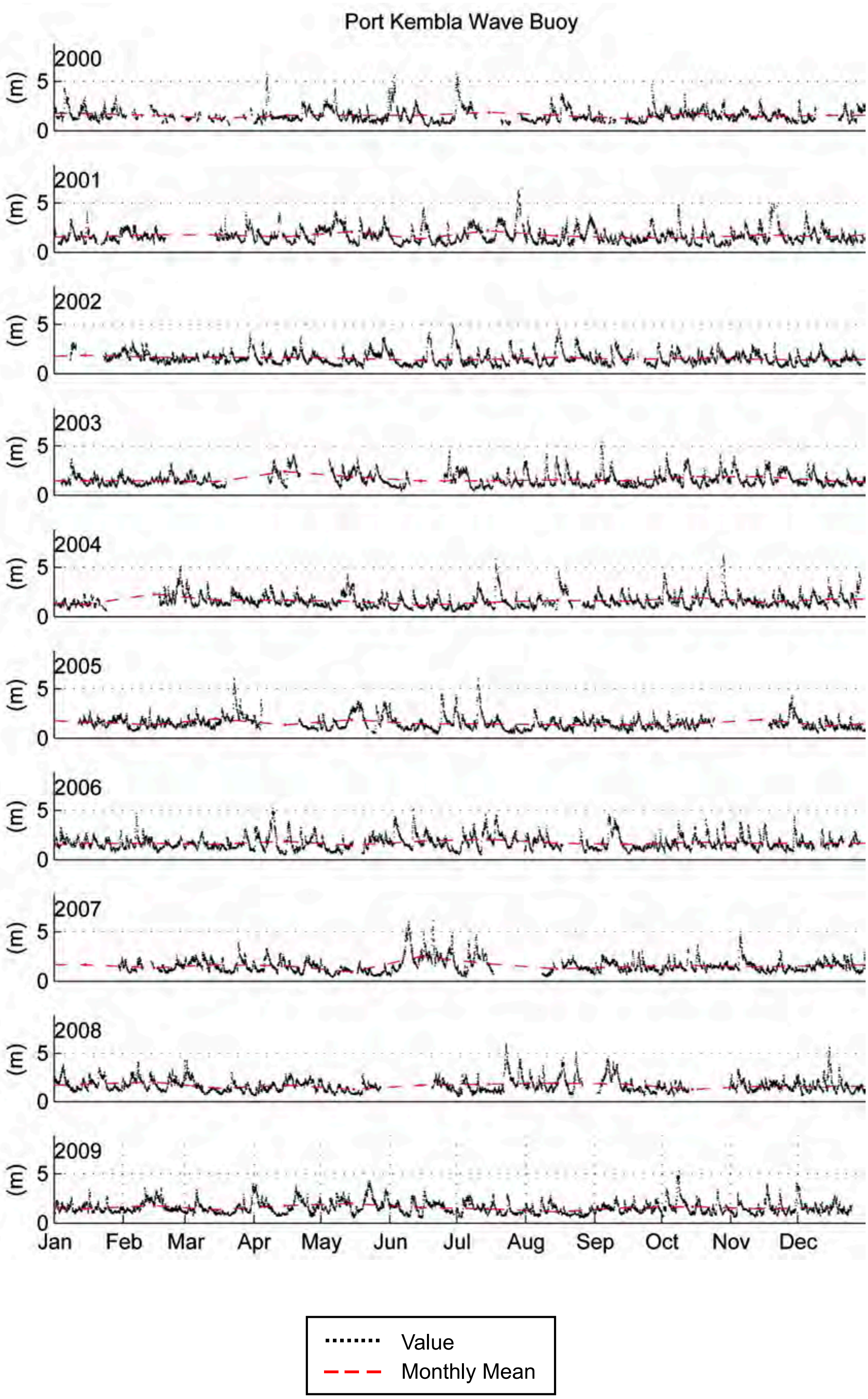

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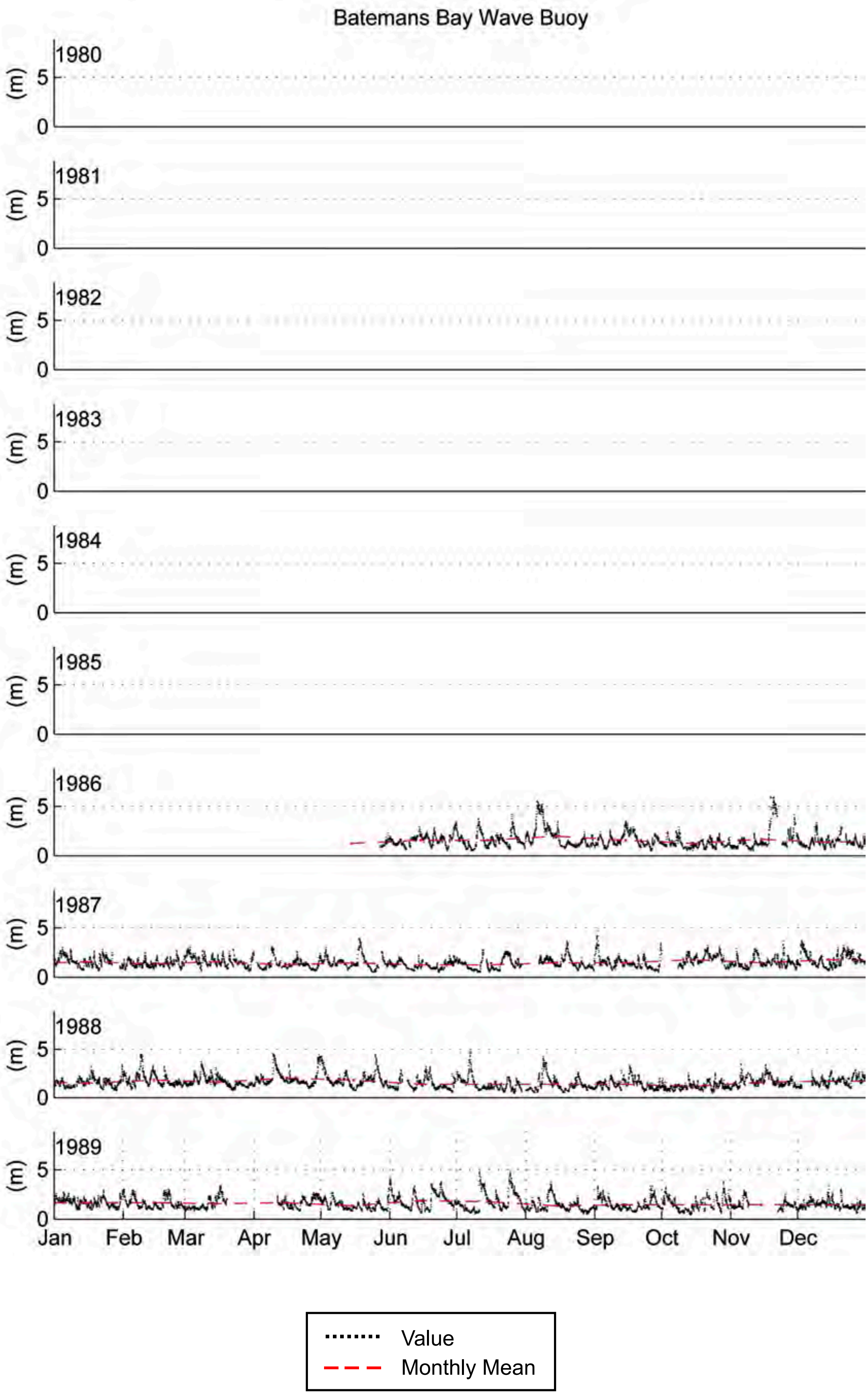

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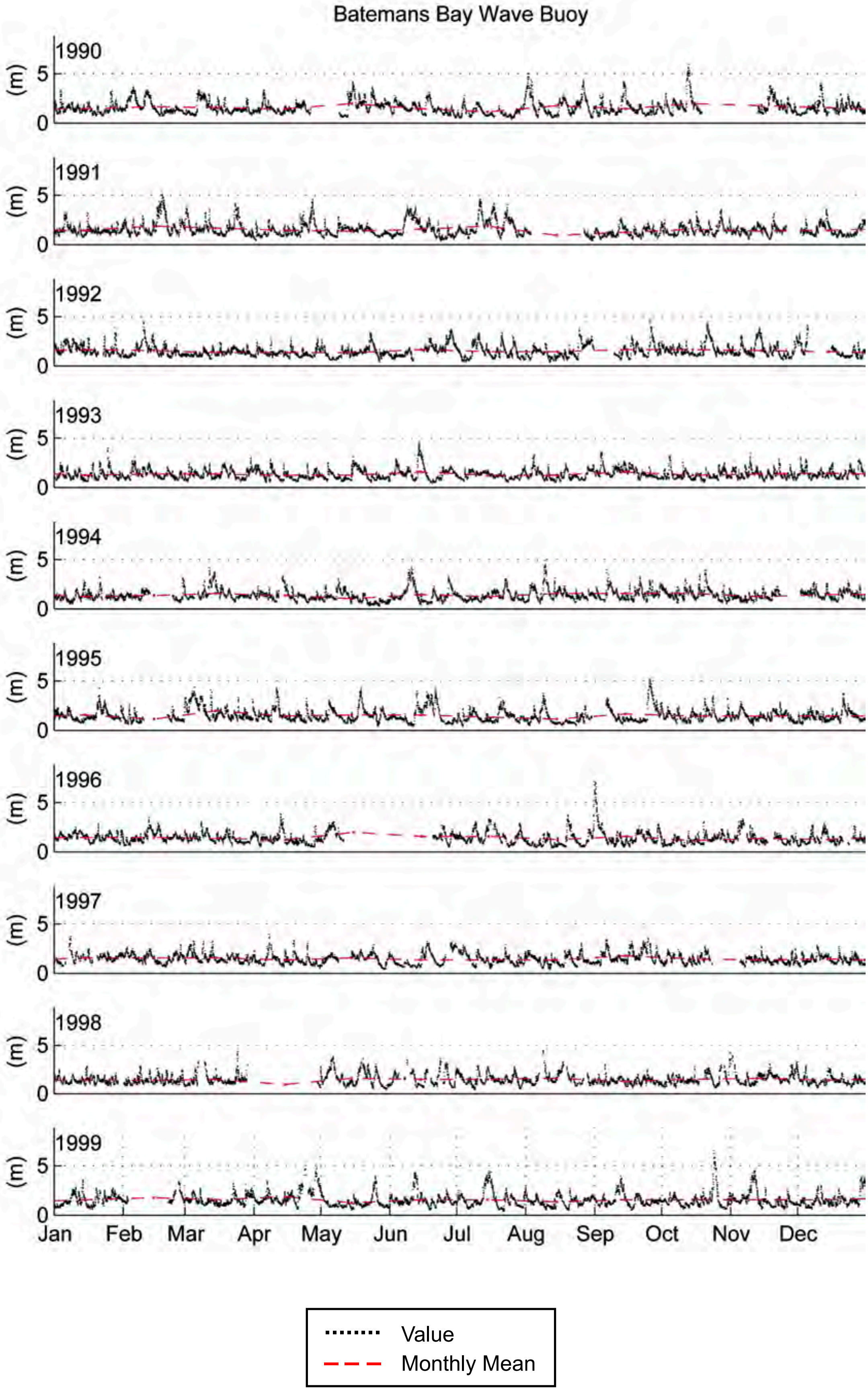
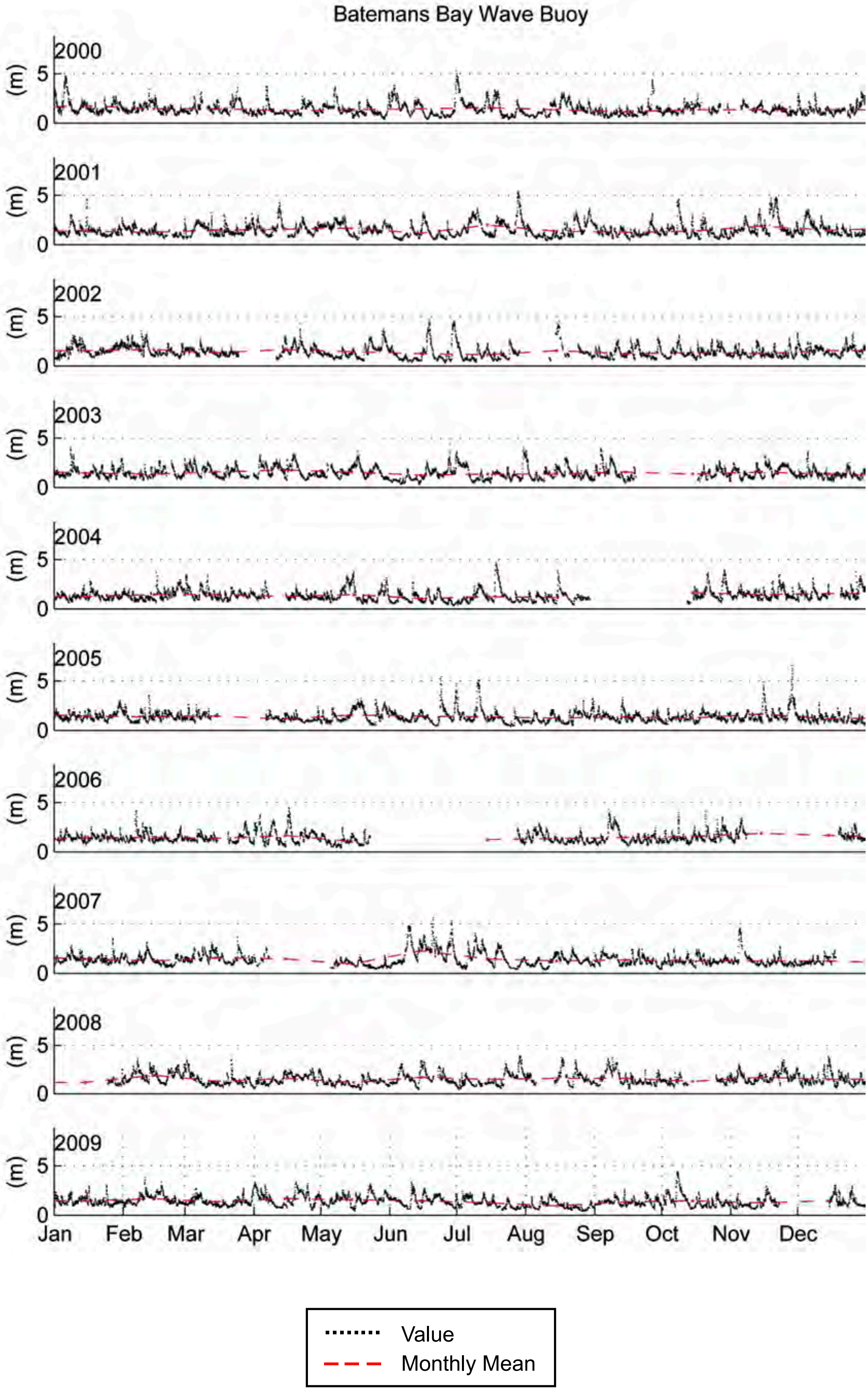
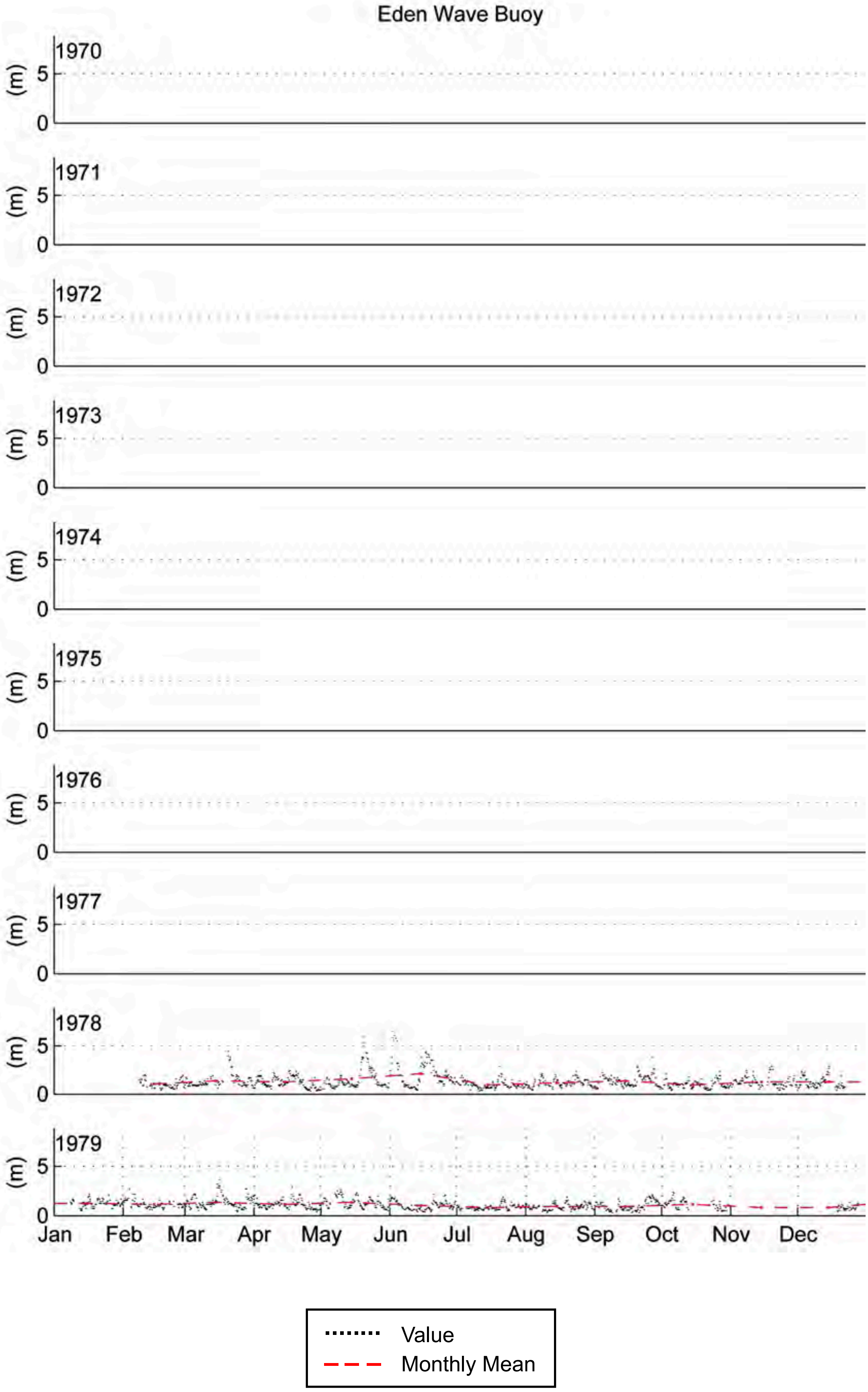


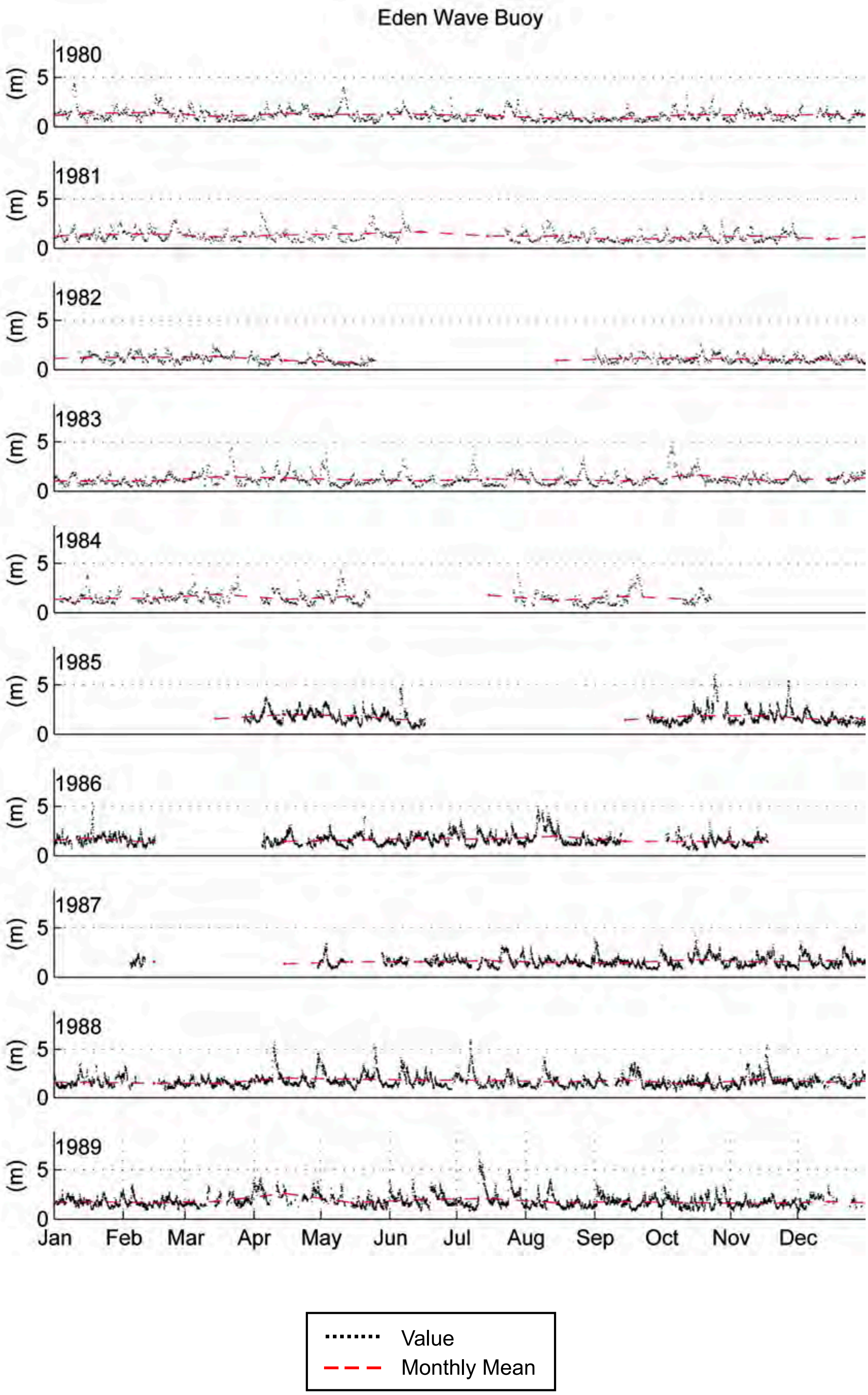
WRL Report No. 2010/16	TIME SERIES OF WAVE BUOY DATA	Figure B 09095-B.cdr



WRL Report No. 2010/16	TIME SERIES OF WAVE BUOY DATA	Figure B 09095-B.cdr

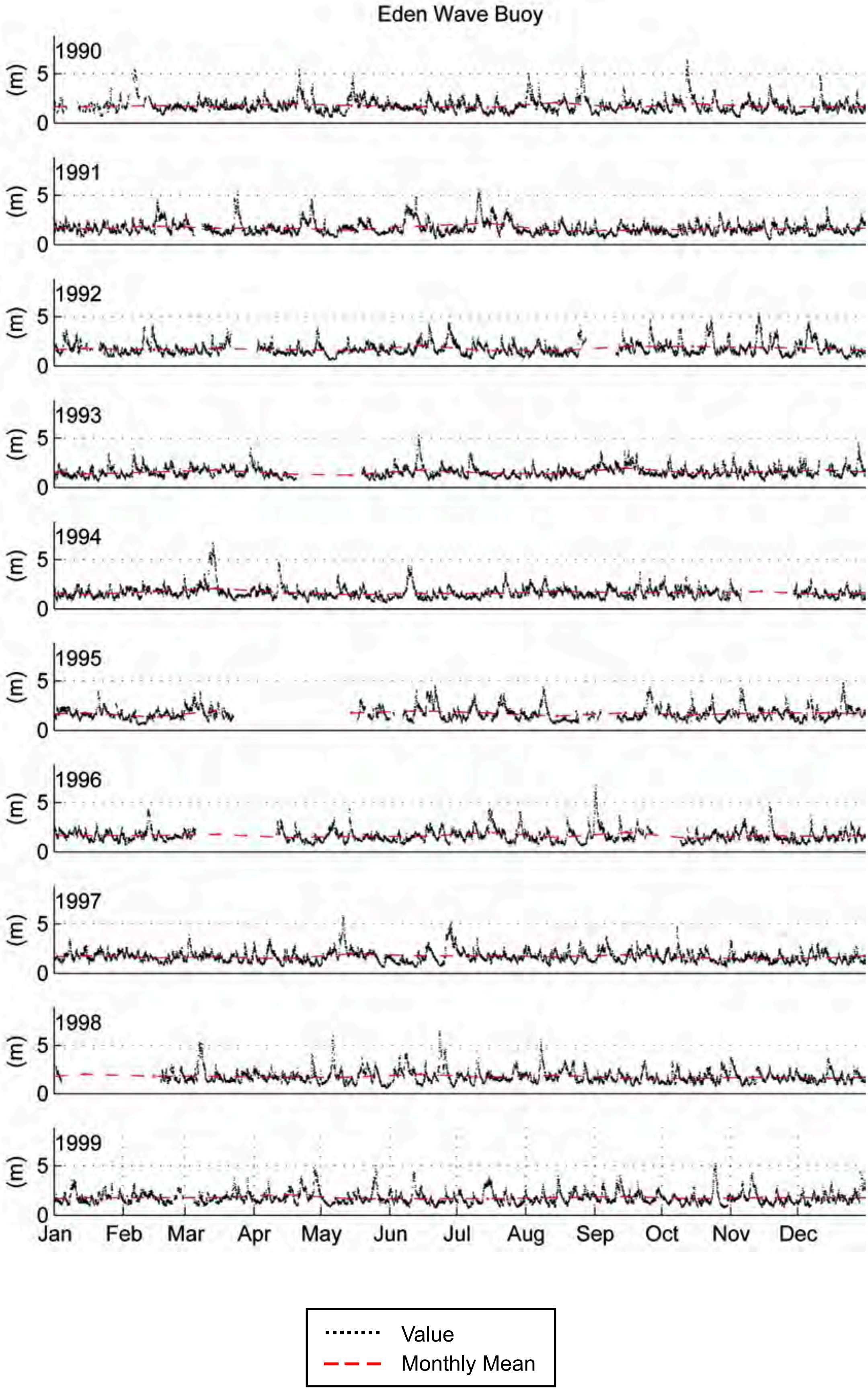


WRL Report No. 2010/16	TIME SERIES OF WAVE BUOY DATA	Figure B 09095-B.cdr



WRL Report No. 2010/16	TIME SERIES OF WAVE BUOY DATA	Figure B

09095-B.cdr



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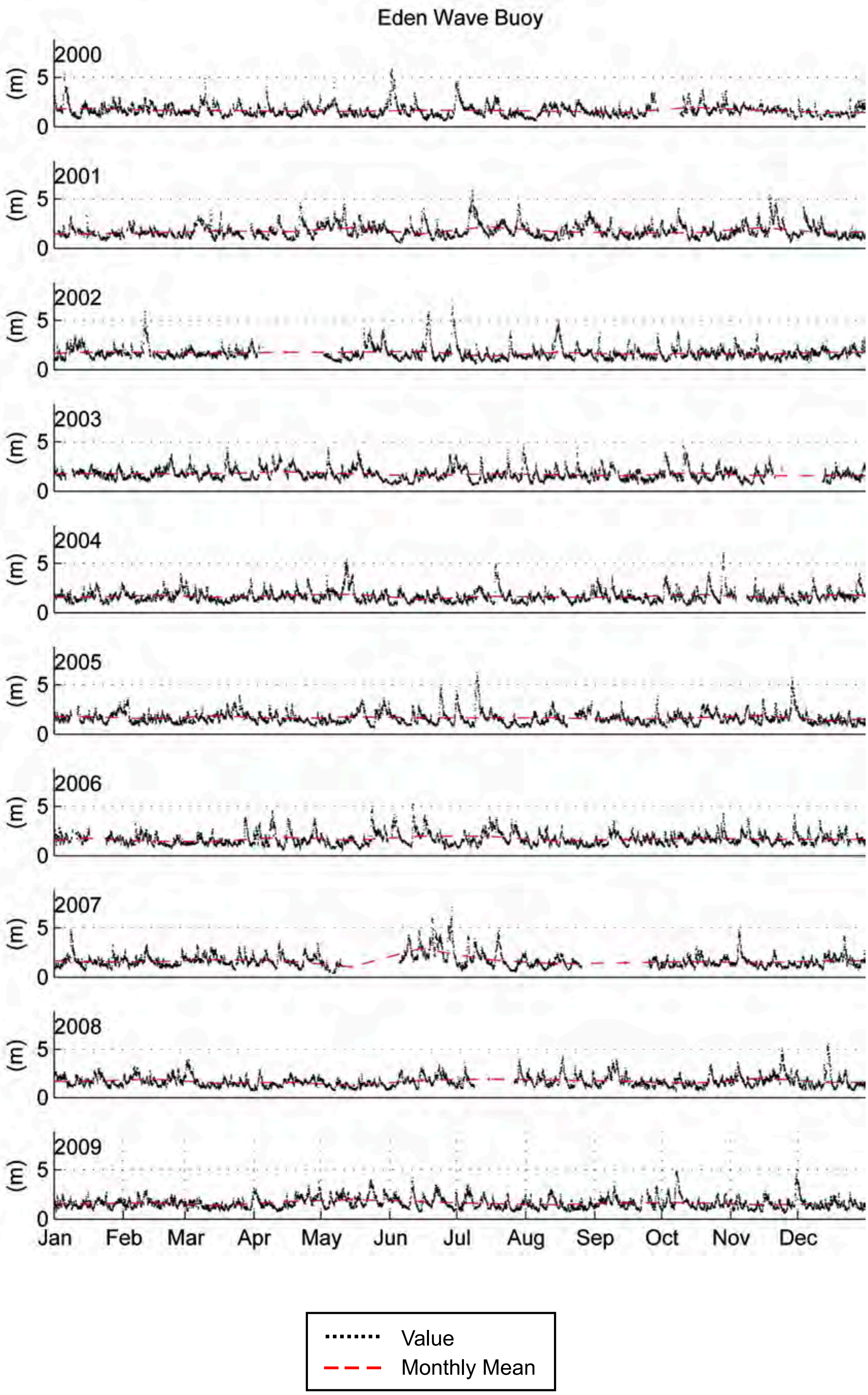


WRL

Report No. 2010/16

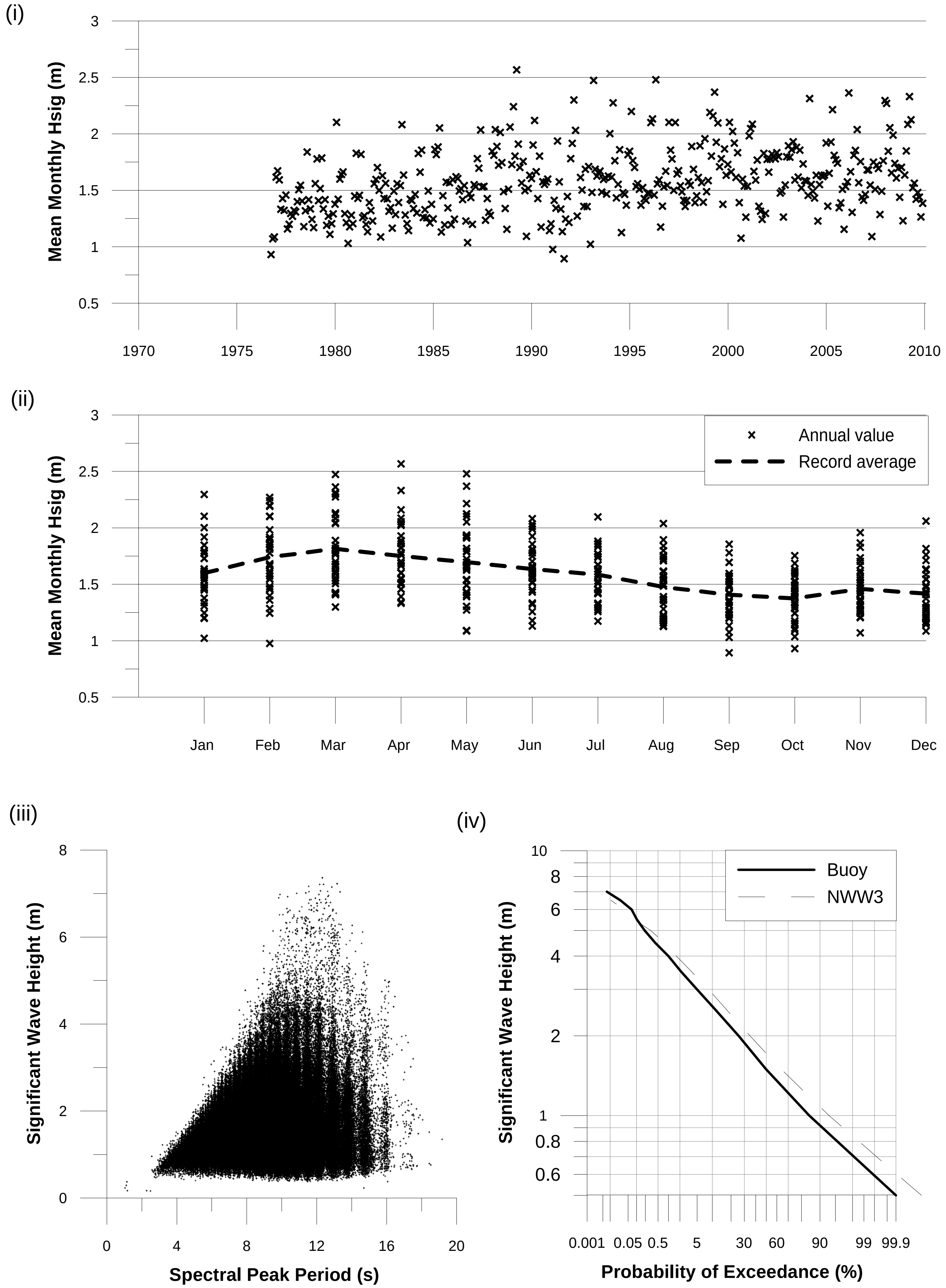
TIME SERIES OF WAVE BUOY DATA

Figure

B

09095-B.cdr

APPENDIX C
WAVE STATISTICS



WRL Report No. 2010/16	BRISBANE WAVE BUOY STATISTICS	Figure C.1 BrisStats.grf

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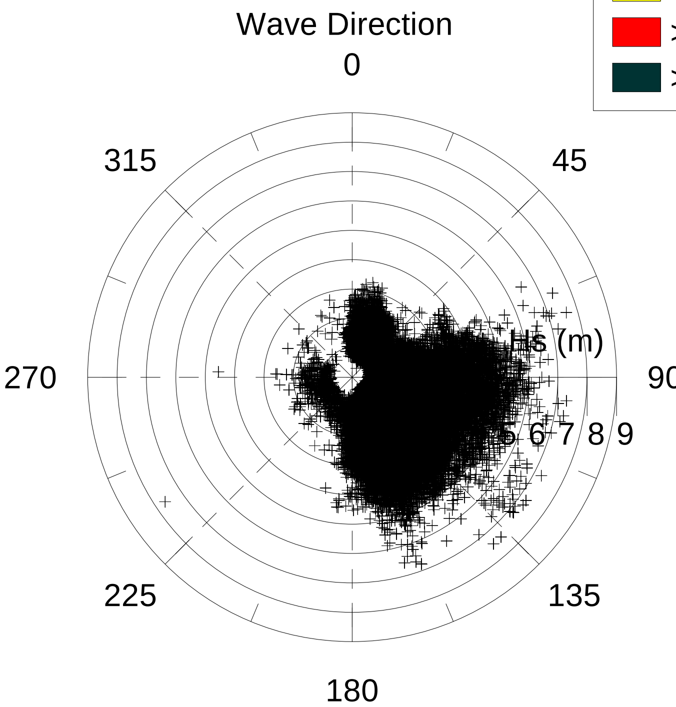

Hsig (m)
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>2 - 3
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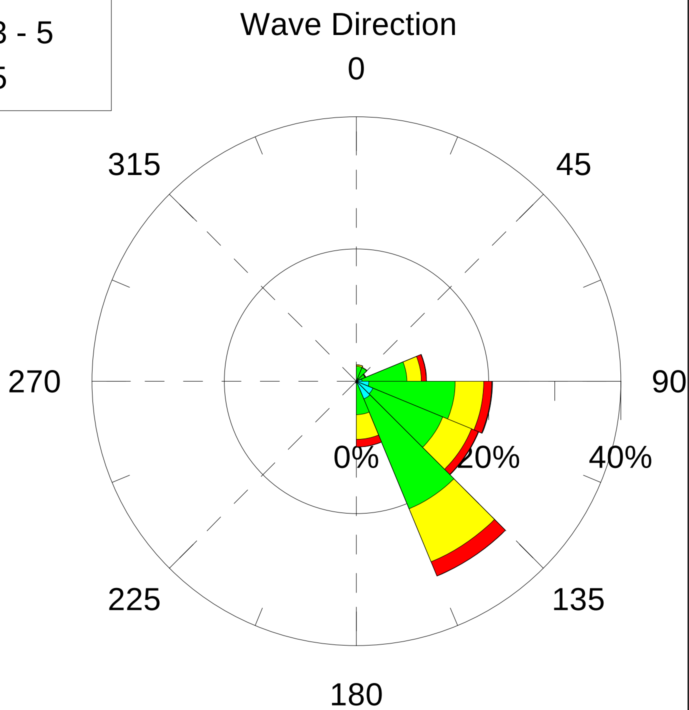

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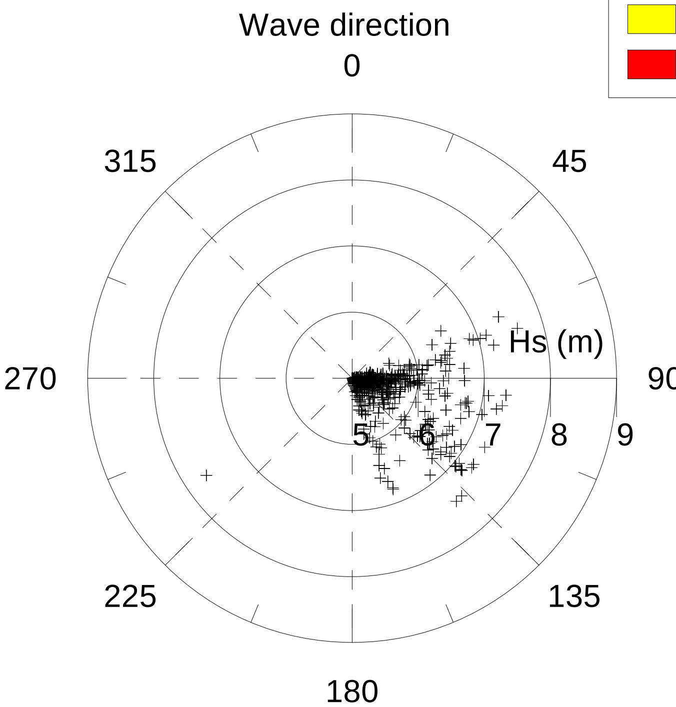

Hsig (m)
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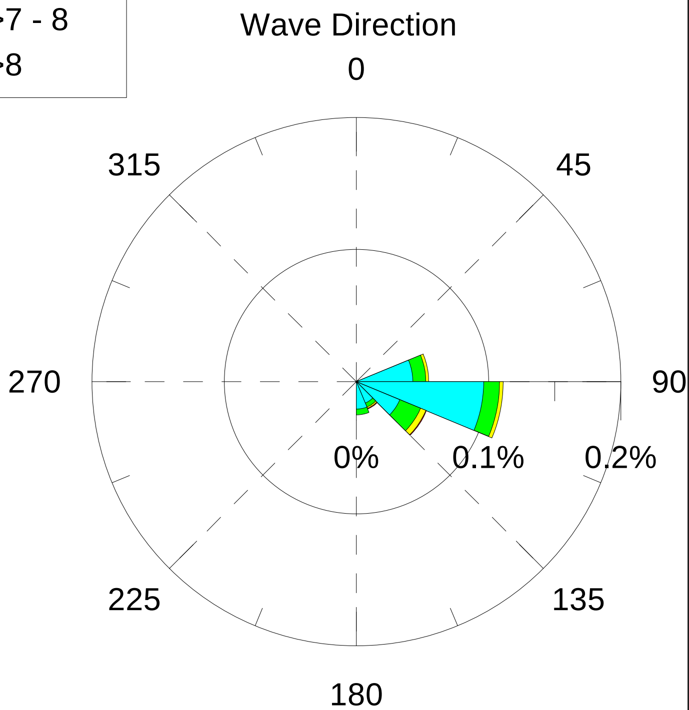
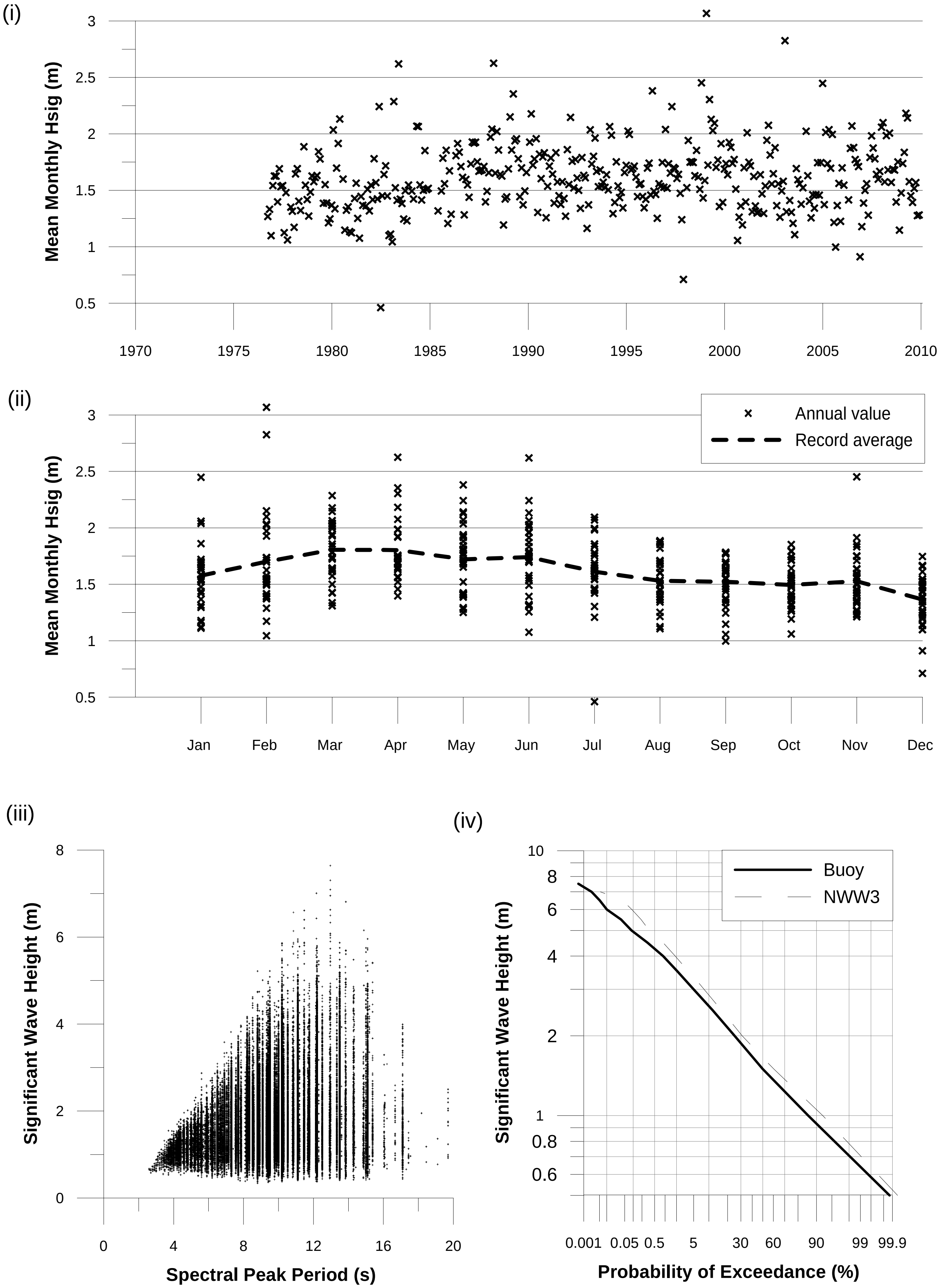
>6 - 7
>7 - 8
>8



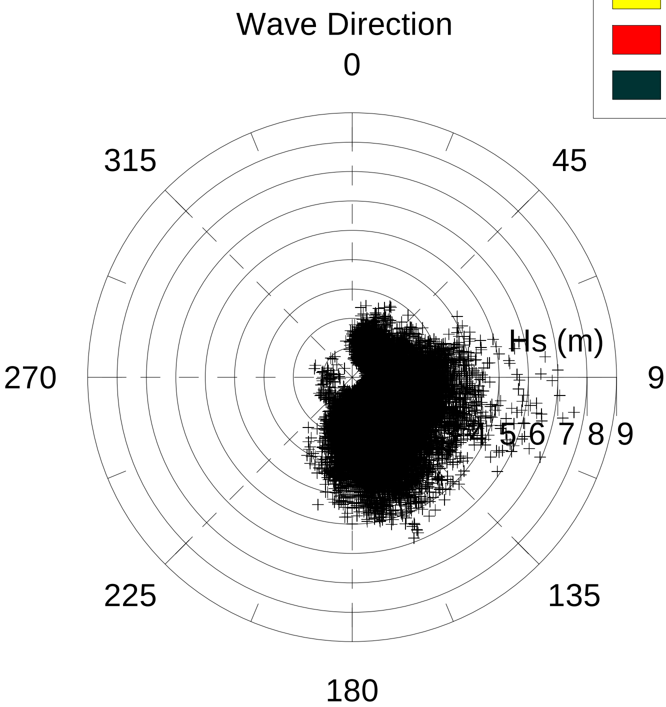
WRL Report No. 2010/16	BRISBANE DIRECTIONAL WAVE BUOY 1996 - 2009	Figure C.1 BrisbaneDir.grf

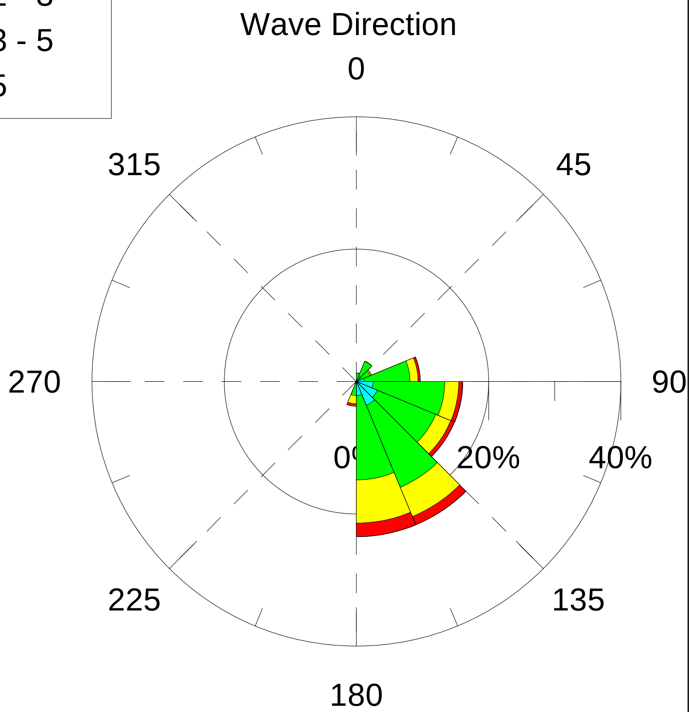


WRL Report No. 2010/16	BYRON BAY WAVE BUOY STATISTICS	Figure C.2

filename.grf

All data





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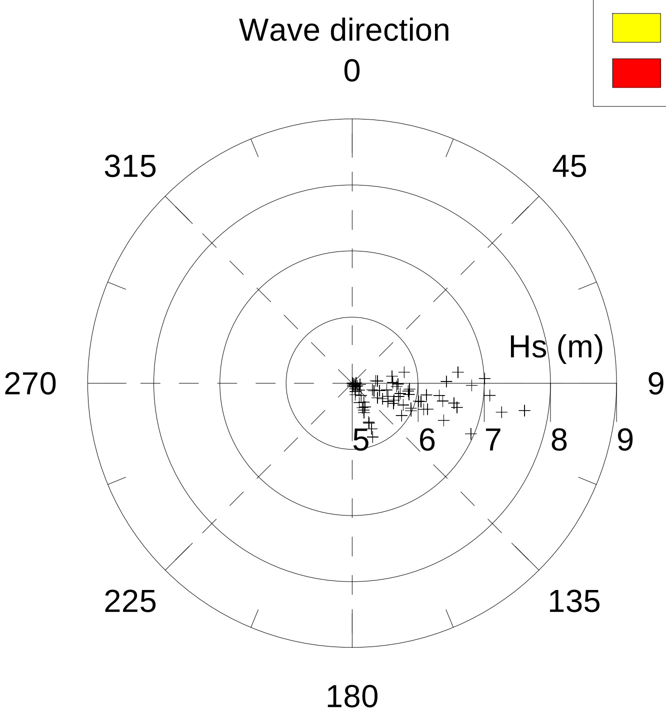
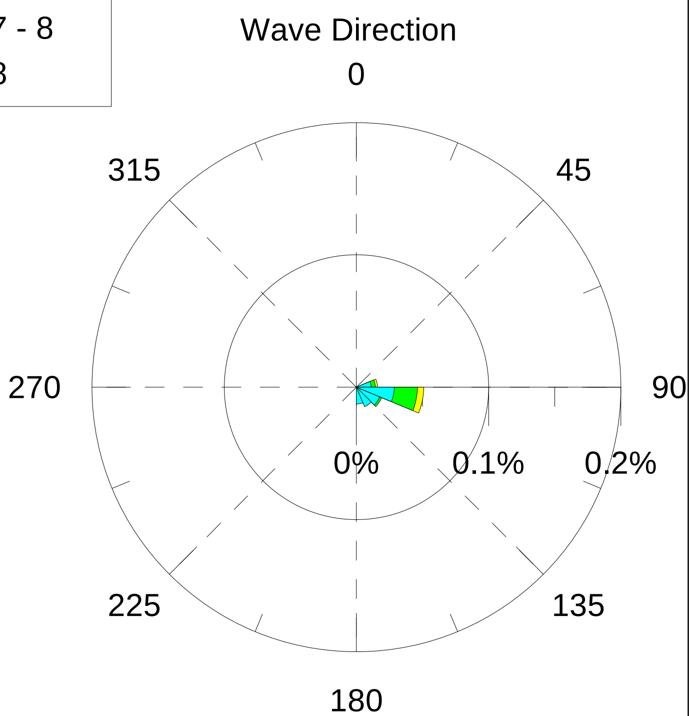
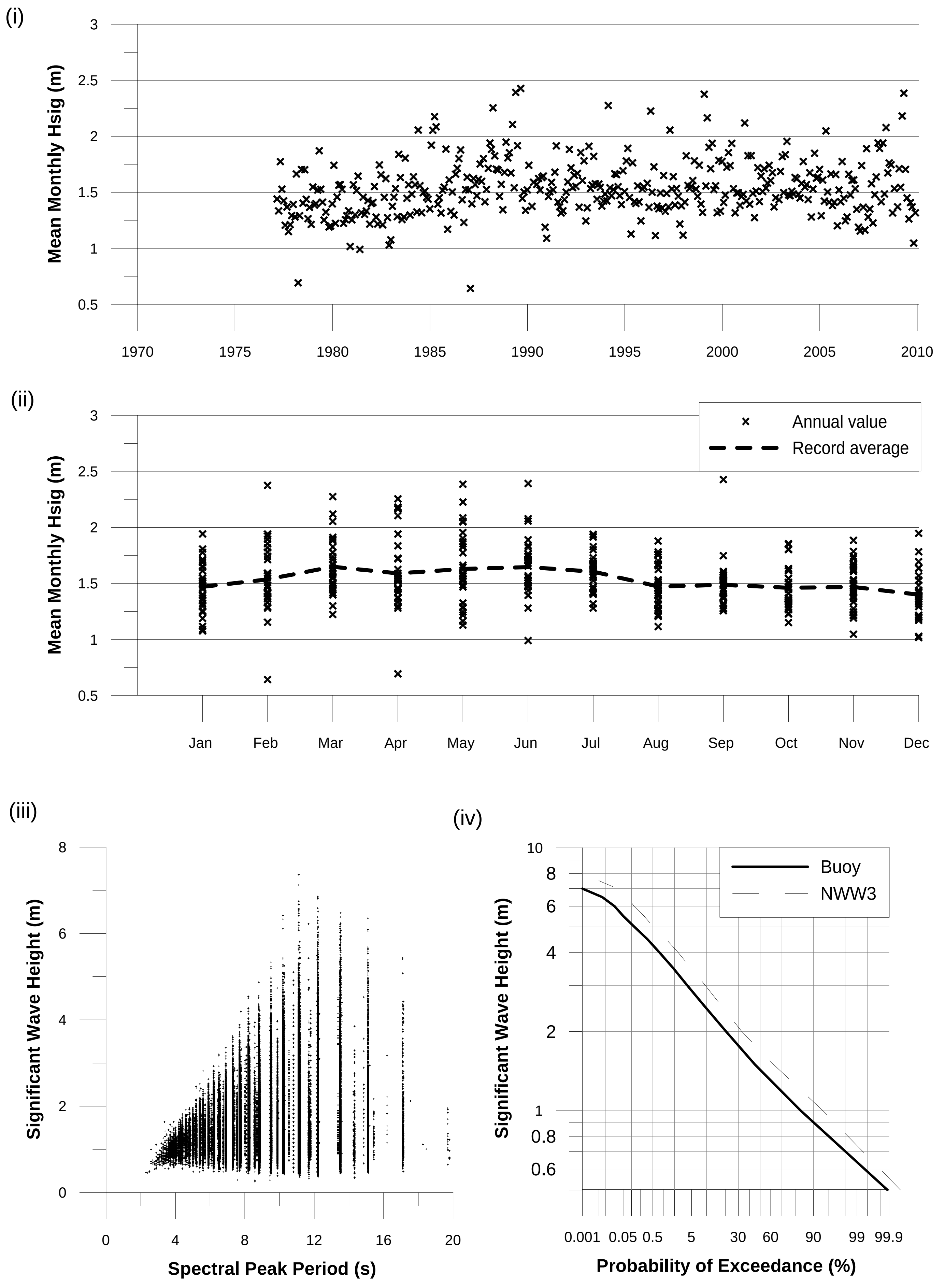


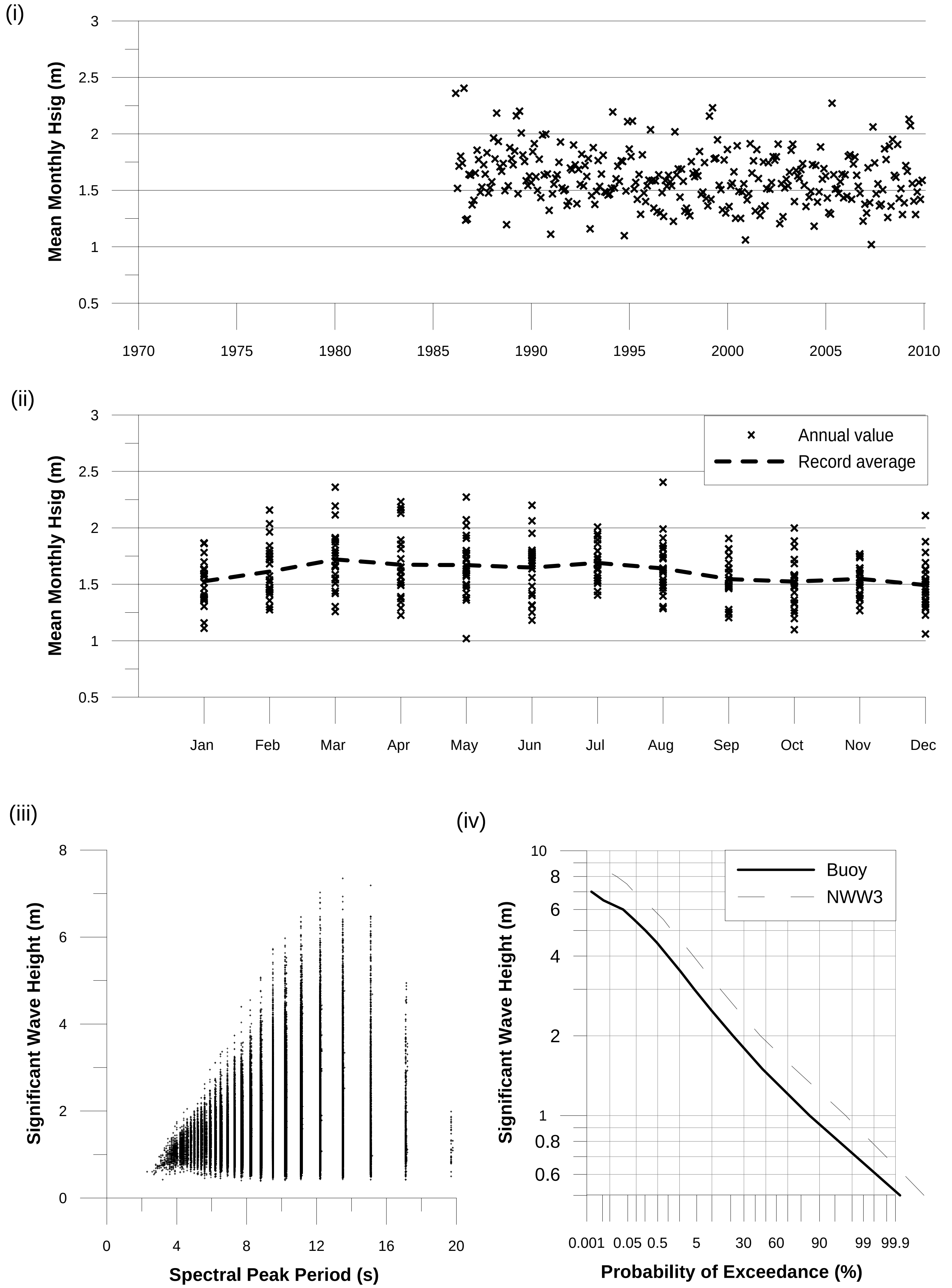


WRL	BYRON DIRECTIONAL WAVE BUOY 1999 - 2009	Figure C.2
Report No. 2010/16		filename.grf



WRL Report No. 2010/16	COFFS HARBOUR WAVE BUOY STATISTICS	Figure C.3

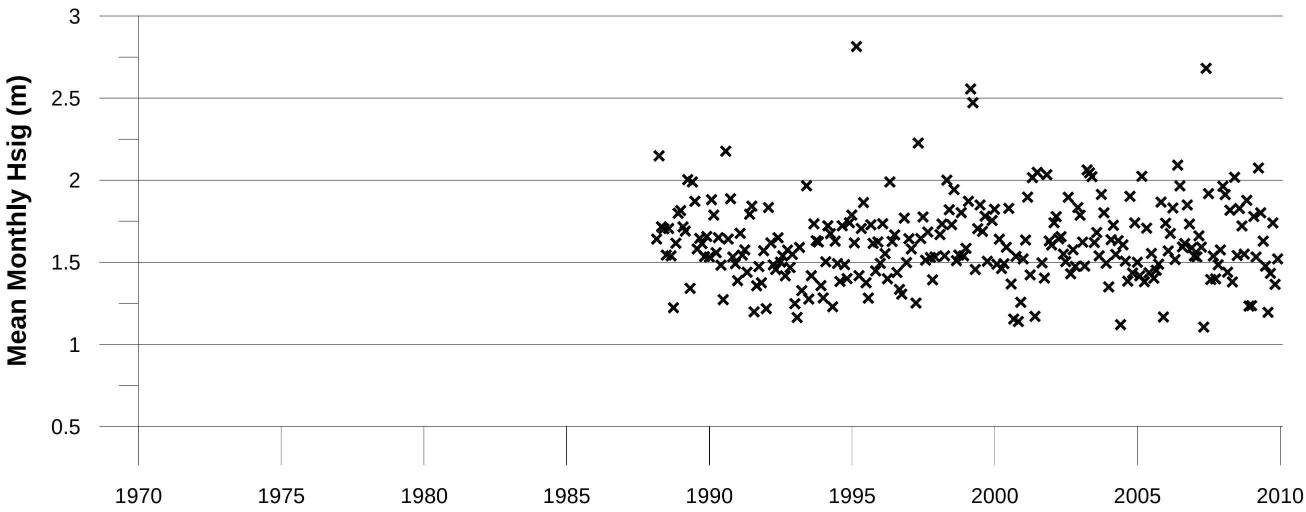
CoffsStats.grf



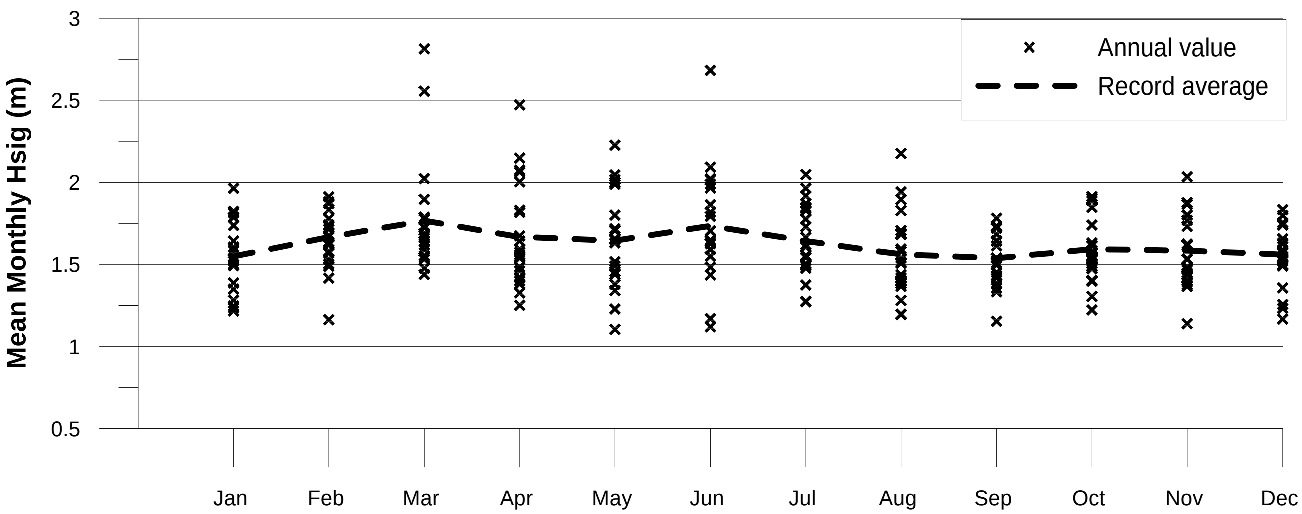
WRL Report No. 2010/16	CROWDY HEAD WAVE BUOY STATISTICS	Figure C.4

filename.grf

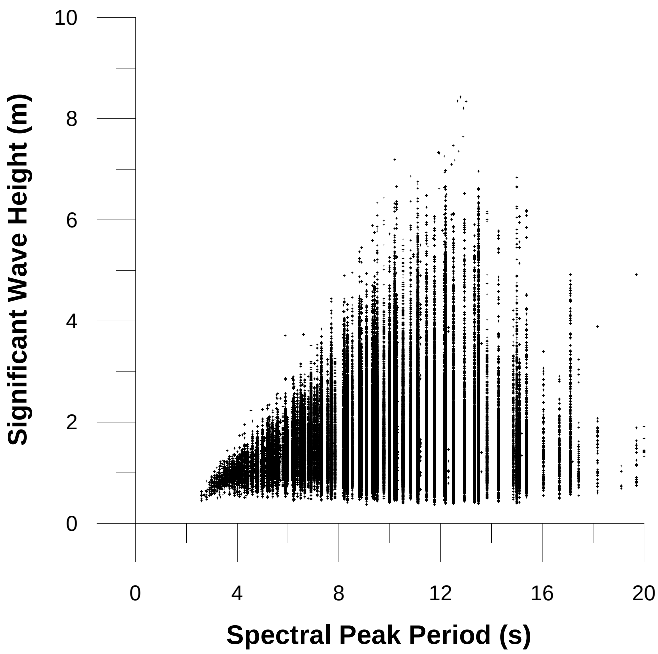
(i)



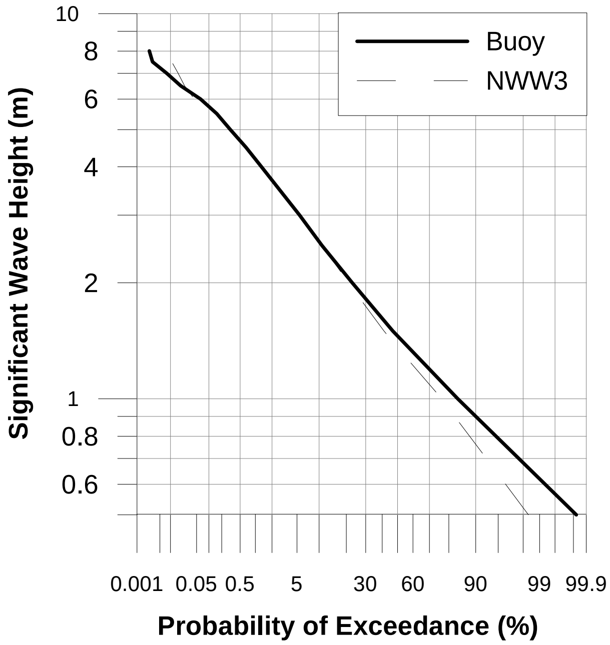
(ii)



(iii)

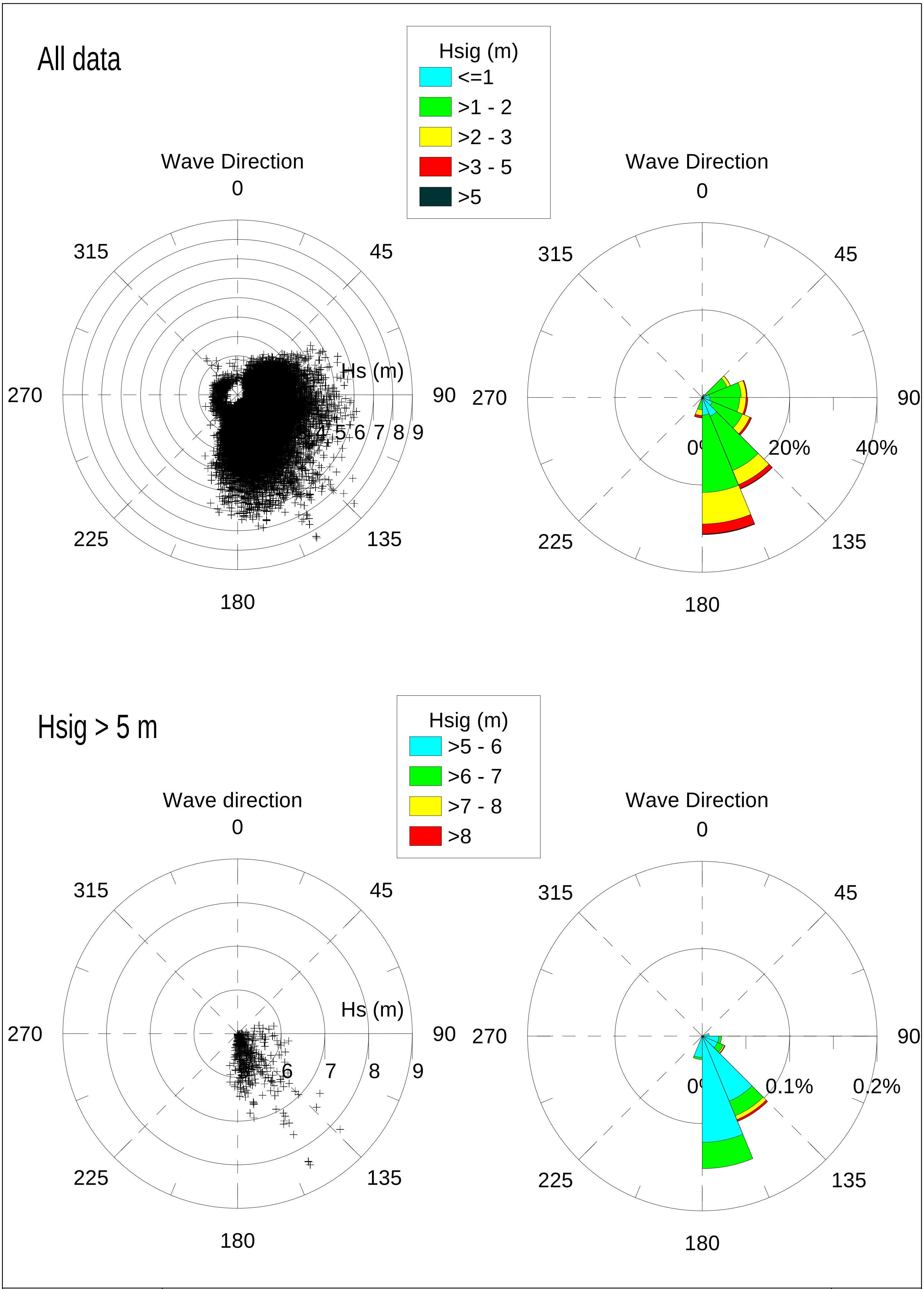


(iv)



WRL Report No. 2010/16	SYDNEY WAVE BUOY STATISTICS	Figure C.5

SydStats.grf



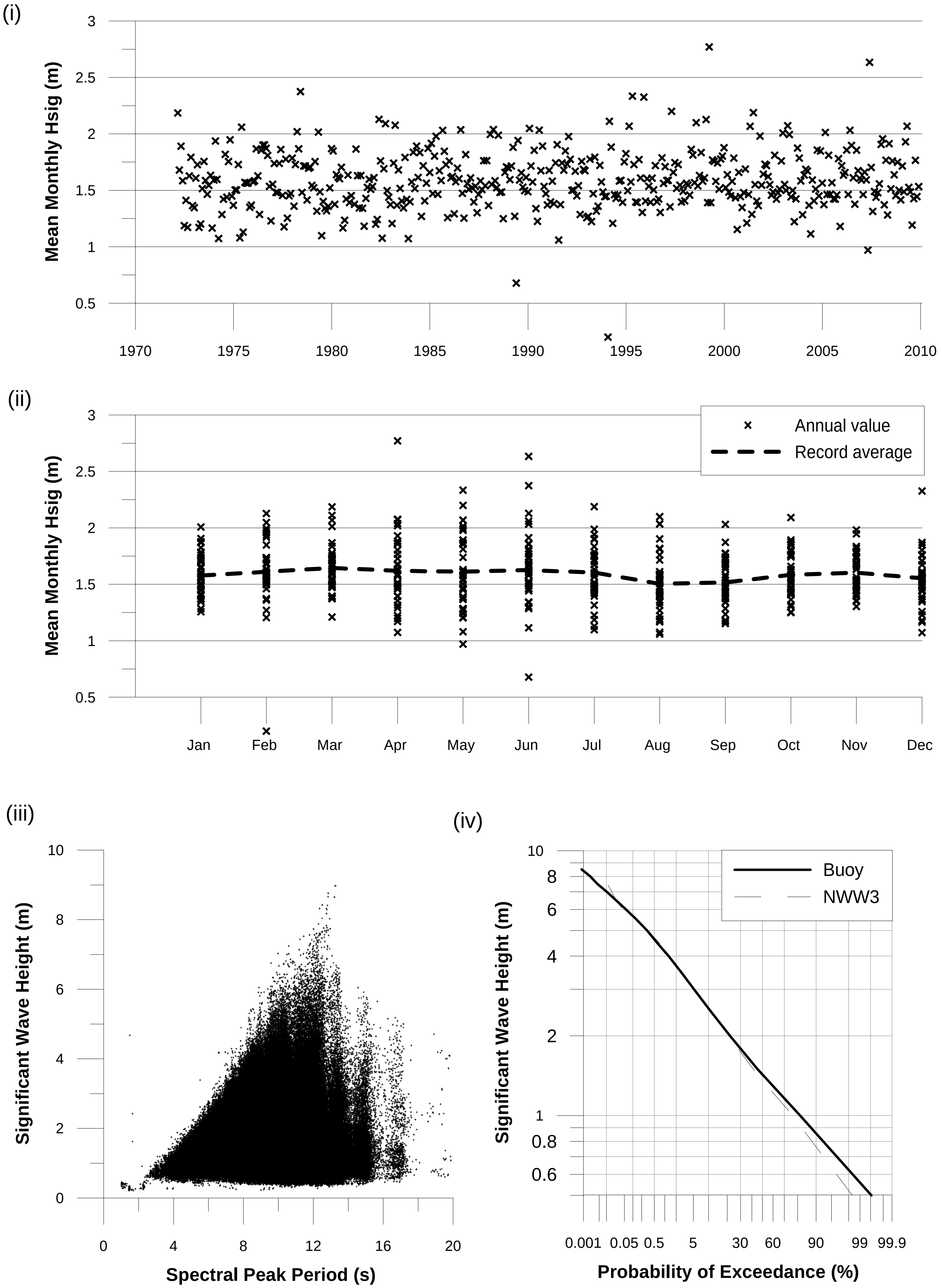
WRL

Report No. 2010/16

SYDNEY DIRECTIONAL WAVE BUOY 1992 - 2009

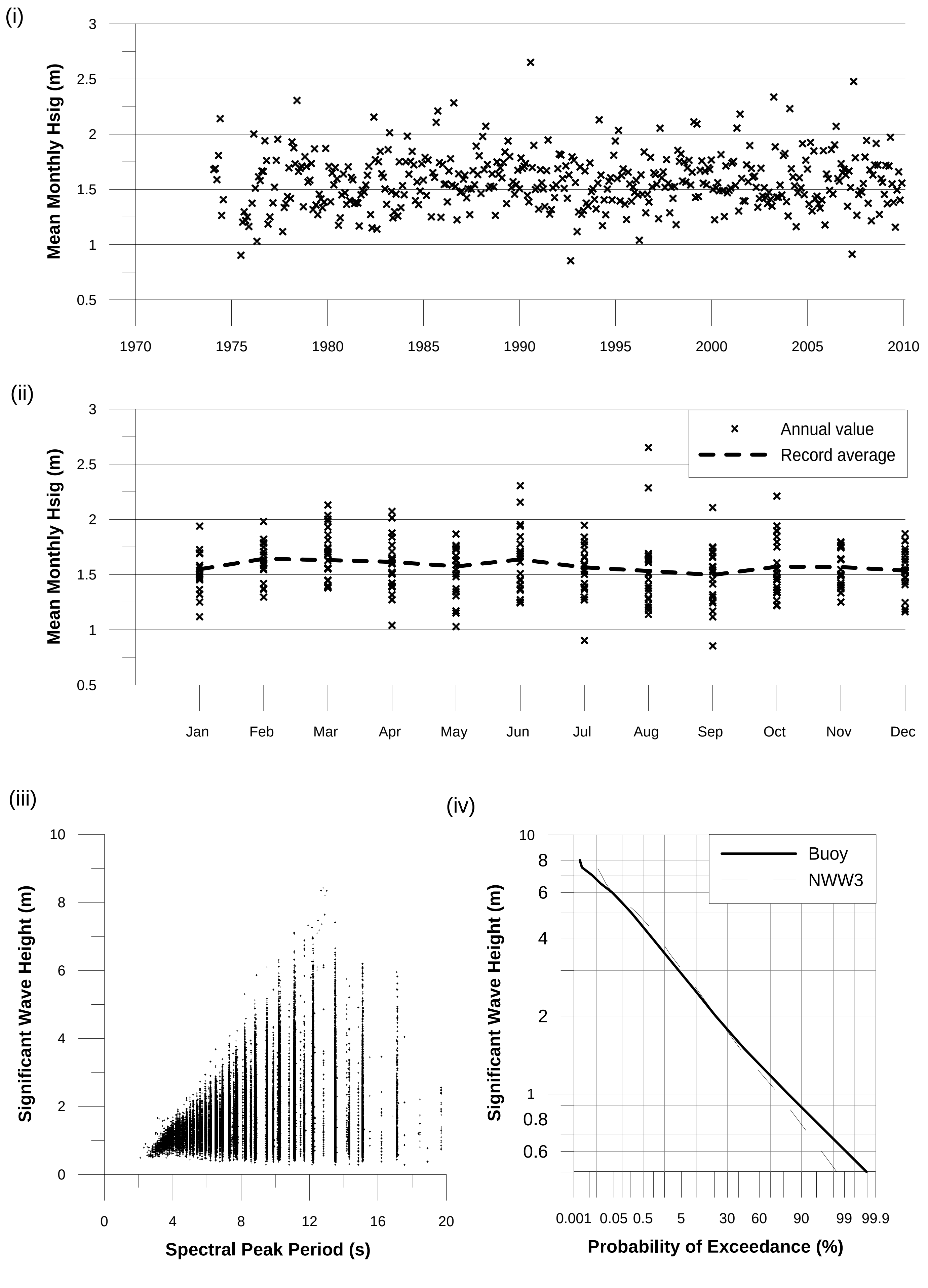
Figure C.5

filename.grf



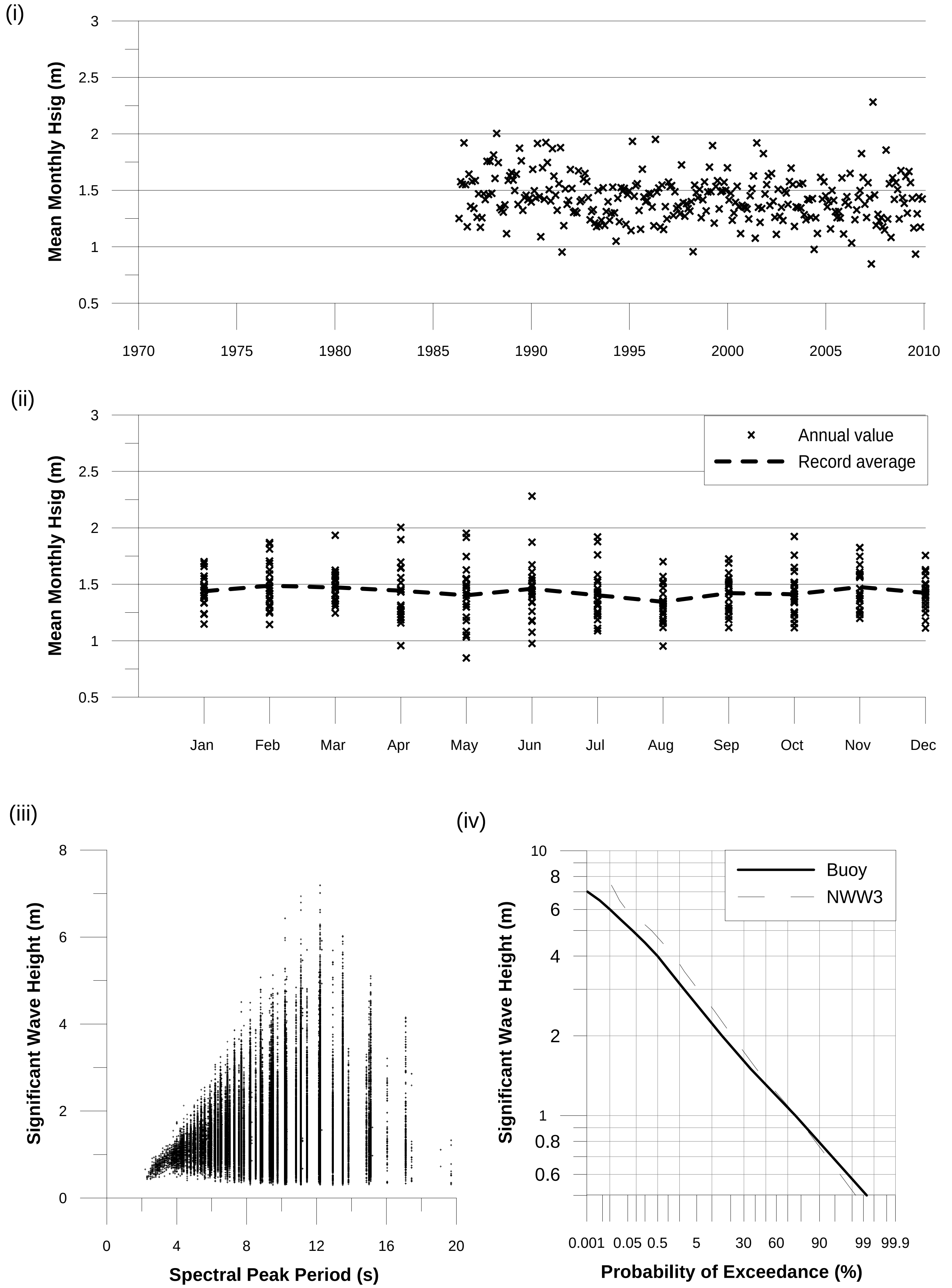
WRL Report No. 2010/16	BOTANY BAY WAVE RIDER BUOY STATISTICS	Figure C.6

filename.grf



WRL Report No. 2010/16	PORT KEMBLA WAVE BUOY STATISTICS	Figure C.7

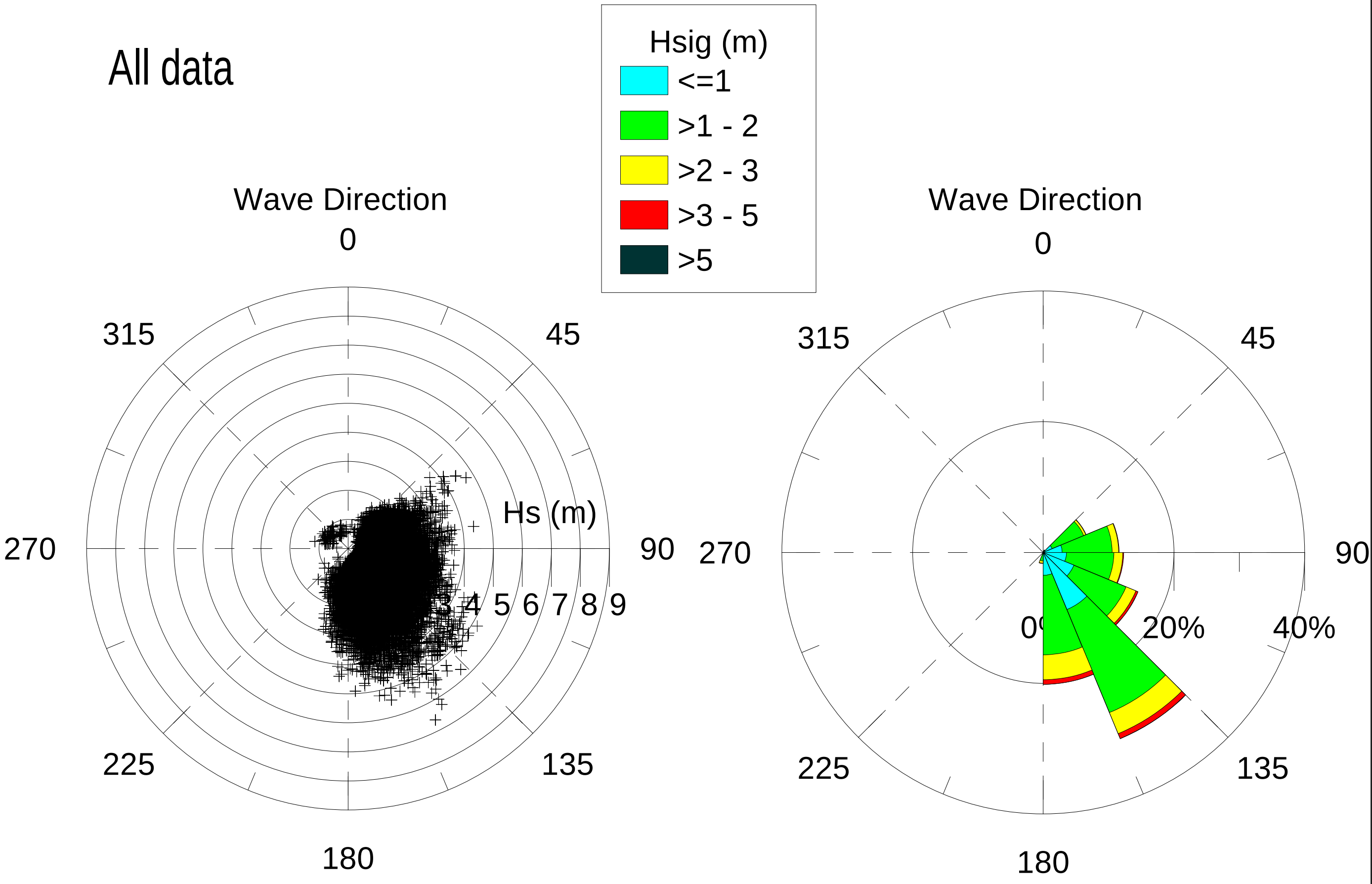
PKStats.grf



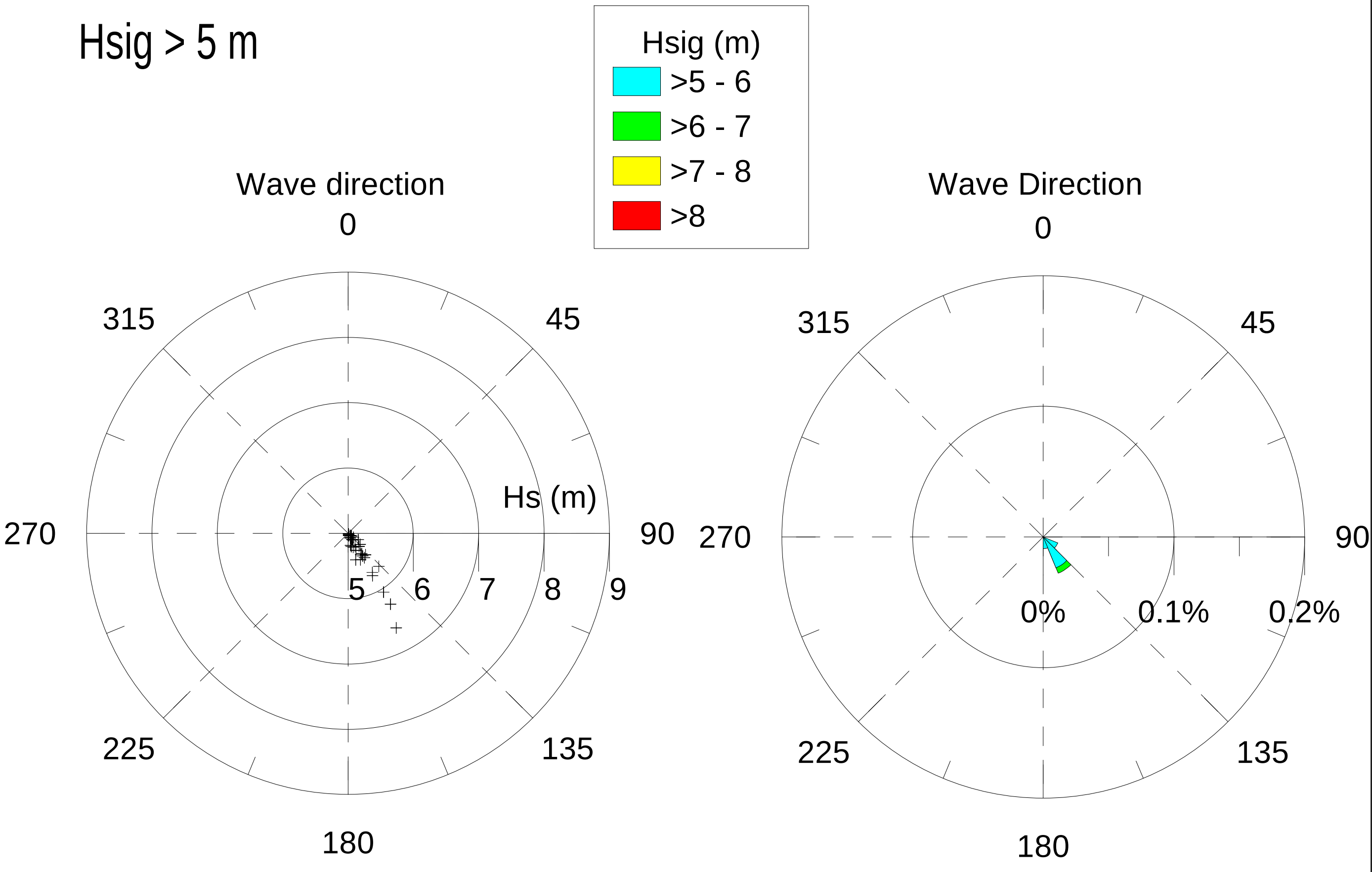
WRL Report No. 2010/16	BATEMANS BAY WAVE BUOY STATISTICS	Figure C.8

BateStats.grf

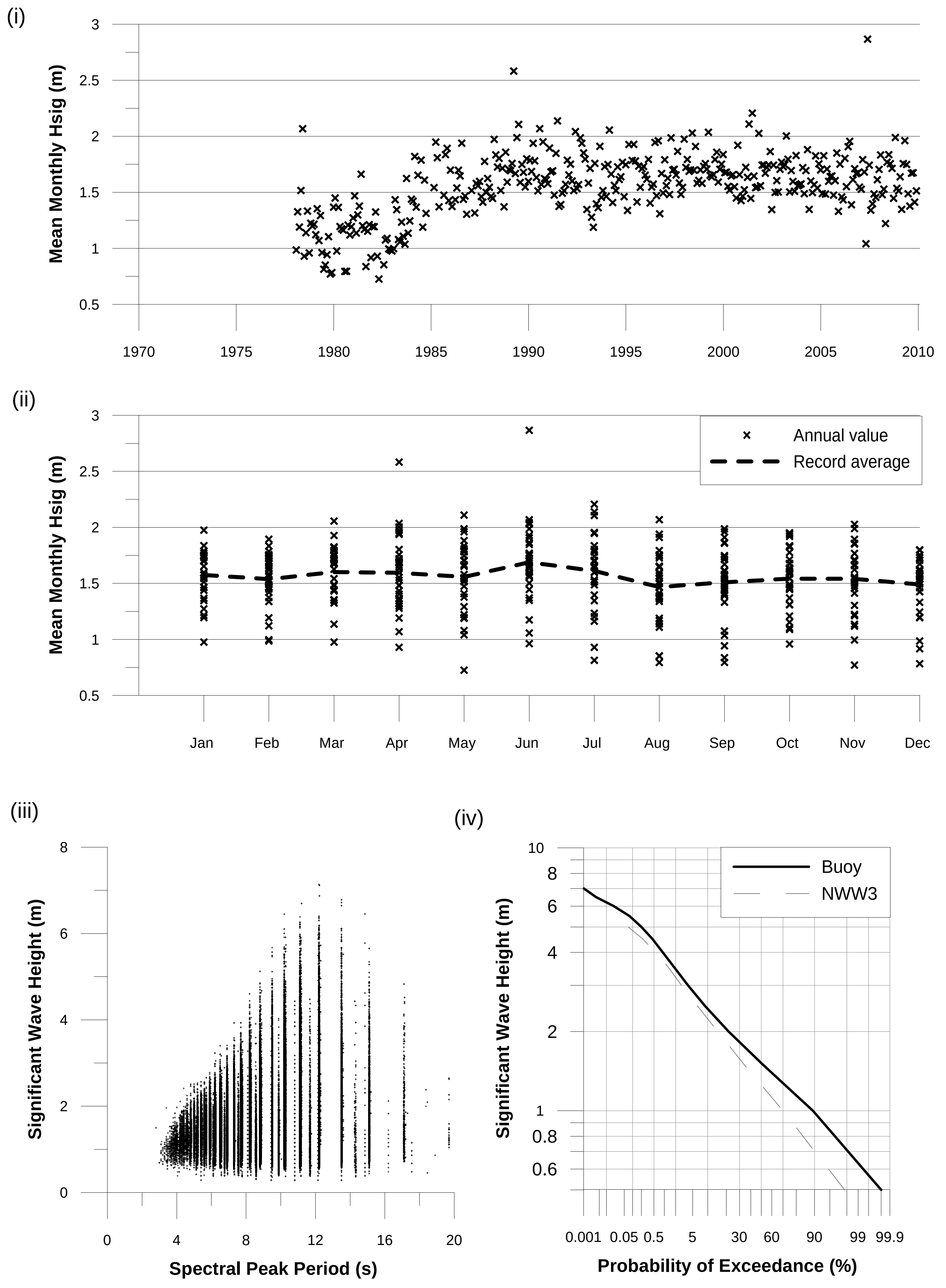
All data



Hsig > 5 m



WRL Report No. 2010/16	BATEMANS BAY DIRECTIONAL WAVE BUOY 2001 - 2009	Figure C.8 filename.grf



WRL Report No. 2010/16	EDEN WAVE BUOY STATISTICS	Figure C.9

filename.grf

APPENDIX D
STORM HISTORY TABLE

Glossary of Terms

Term		Description
Storm Index		Consecutive index counting individual storm events detected by one or more wave buoys along the NSW Coast
Storm Type[1]		Storm type classification as defined within Chapter Two of this report
Abbreviation	TC	Tropical Cyclone
	TL	Tropical Low
	ETL	Easterly Trough Low
	CL	Continental Low
	STL	Southern Tasman Low
	SSL	Southern Secondary Low
	ITL	Inland Trough Low
	AI	Anti-Cyclone Intensification
Buoy observing largest peak H_{sig} during storm		Values from that wave rider buoy which observed the largest peak significant wave height during the storm event
Date		Date at which storm H_{sig} peaked
Buoy		Buoy which observed the largest peak H_{sig} during the storm event
Abbreviation	BRI	Brisbane
	BYR	Byron Bay
	COF	Coffs Harbour
	CRO	Crowdy Head
	SYD	Sydney
	BOT	Botany Bay
	PK	Port Kembla
	BAT	Batemans Bay
	EDE	Eden
Peak H_{sig} (m)		Largest significant wave height observed during the storm event
Peak T_{p1} (s)		Peak period which occurred during the Peak H_{sig}
Mean H_{sig} (m)		Mean significant wave height over the entire storm event
Total Duration (hr)		Total length of time during which H_{sig} exceeded 2.0 m
Total Power (W/m)		Total wave power observed during the storm event
Storm rms H_{sig}		Measure of root mean square significant wave height during the storm event given by $\sqrt{1/N\left(\sum H^2\right)}$
Peak H_{sig} (m) during storm		Largest significant wave height observed during the storm event for individual wave rider buoys

[1]Storms detected at Botany Bay wave rider buoy only not classified during this study

Note: Blanks in this table may indicate that storm waves were not recorded on that buoy (but the buoy was operational at the time) or that the buoy was not operation at the time.

Storm History Table

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
1	NA	14/05/1971	BOT	4.4	12.2	3.2	66	-	3.3						4.4			
2	NA	22/05/1971	BOT	4.1	8.9	3.1	42	-	3.2						4.1			
3	NA	3/06/1971	BOT	2.8	8.4	2.3	96	-	2.3						2.8			
4	NA	15/06/1971	BOT	3.0	7.5	2.5	24	-	2.5						3.0			
5	NA	30/06/1971	BOT	3.7	-	2.9	54	-	3.0						3.7			
6	NA	25/07/1971	BOT	5.4	10.7	3.6	60	-	3.8						5.4			
7	NA	16/08/1971	BOT	3.4	8.4	2.7	60	-	2.7						3.4			
8	NA	15/11/1971	BOT	4.4	9.3	3.2	60	-	3.2						4.4			
9	NA	30/11/1971	BOT	3.7	8.4	2.8	42	-	2.8						3.7			
10	NA	16/12/1971	BOT	4.1	9.8	3.1	84	-	3.2						4.1			
11	NA	14/01/1972	BOT	4.7	-	4.2	54	-	4.3						4.7			
12	NA	19/01/1972	BOT	3.3	9.5	2.5	72	-	2.6						3.3			
13	NA	24/01/1972	BOT	3.4	13.1	2.7	66	-	2.7						3.4			
14	NA	9/02/1972	BOT	3.7	13.0	2.7	96	-	2.7						3.7			
15	NA	23/02/1972	BOT	3.4	9.6	2.7	24	-	2.8						3.4			
16	NA	9/03/1972	BOT	4.4	10.1	3.2	138	-	3.3						4.4			
17	NA	26/03/1972	BOT	5.2	-	3.2	144	-	3.3						5.2			
18	NA	4/04/1972	BOT	4.2	11.2	2.8	48	-	2.9						4.2			
19	NA	11/04/1972	BOT	3.7	9.6	2.7	78	-	2.7						3.7			
20	NA	13/05/1972	BOT	3.2	9.8	2.6	54	-	2.6						3.2			
21	NA	20/05/1972	BOT	4.2	10.2	3.0	84	-	3.0						4.2			
22	NA	27/05/1972	BOT	4.0	11.7	3.1	66	-	3.1						4.0			
23	NA	11/06/1972	BOT	3.6	9.9	2.5	102	-	2.5						3.6			
24	NA	28/07/1972	BOT	3.3	9.7	3.1	30	-	3.1						3.3			
25	NA	13/08/1972	BOT	4.0	14.5	3.2	72	-	3.2						4.0			
26	NA	25/10/1972	BOT	3.9	8.7	3.1	24	-	3.1						3.9			
27	NA	29/10/1972	BOT	4.6	9.2	2.8	60	-	2.9						4.6			
28	NA	3/11/1972	BOT	3.2	8.2	2.6	42	-	2.6						3.2			
29	NA	17/11/1972	BOT	3.1	11.5	2.6	18	-	2.7						3.1			
30	NA	21/11/1972	BOT	3.4	10.7	2.7	36	-	2.7						3.4			
31	NA	26/11/1972	BOT	3.8	10.2	2.9	84	-	2.9						3.8			
32	NA	3/12/1972	BOT	3.5	9.4	2.6	30	-	2.6						3.5			
33	NA	31/12/1972	BOT	3.4	8.2	2.6	24	-	2.6						3.4			
34	NA	7/02/1973	BOT	3.8	8.5	3.1	48	-	3.1						3.8			
35	NA	15/03/1973	BOT	4.4	12.2	3.0	66	-	3.1						4.4			
36	NA	23/03/1973	BOT	2.9	8.7	2.4	78	-	2.4						2.9			
37	NA	31/03/1973	BOT	3.2	10.1	2.7	30	-	2.7						3.2			
38	NA	17/05/1973	BOT	3.9	9.3	2.5	96	-	2.6						3.9			
39	NA	13/06/1973	BOT	3.7	9.0	2.9	42	-	3.0						3.7			
40	NA	16/06/1973	BOT	5.5	13.8	3.6	72	-	3.7						5.5			
41	NA	8/07/1973	BOT	3.0	-	2.4	114	-	2.4						3.0			
42	NA	6/08/1973	BOT	3.2	-	2.6	42	-	2.7						3.2			
43	NA	19/08/1973	BOT	3.8	-	2.8	102	-	2.9						3.8			
44	NA	29/08/1973	BOT	3.0	-	2.4	24	-	2.4						3.0			
45	NA	16/09/1973	BOT	3.2	-	2.8	30	-	2.8						3.2			
46	NA	24/09/1973	BOT	3.1	9.6	2.5	24	-	2.5						3.1			
47	NA	13/10/1973	BOT	3.1	7.4	2.5	42	-	2.5						3.1			
48	NA	6/11/1973	BOT	3.2	10.1	2.8	24	-	2.9						3.2			
49	NA	14/11/1973	BOT	3.5	11.5	2.7	36	-	2.8						3.5			
50	NA	28/11/1973	BOT	4.0	9.6	2.7	78	-	2.7						4.0			
51	NA	11/01/1974	BOT	3.1	-	2.5	114	-	2.5						3.1			
52	TC	7/02/1974	BOT	4.8	-	3.2	108	-	3.3						4.8	3.3		
53	IT	20/02/1974	BOT	5.2	-	4.0	12	-	4.2						5.2	4.2		
54	TC	11/03/1974	BOT	3.4	-	2.8	30	-	2.8						3.4	3.2		
55	NA	15/03/1974	BOT	4.0	-	2.6	96	-	2.7						4.0			
56	TC	25/03/1974	PK	3.0	12.2	2.6	66	-	2.6							3.0		
57	IT	14/04/1974	PK	3.8	14.2	3.0	66	-	3.1							3.8		
58	SSL	3/05/1974	PK	3.7	10.8	2.8	84	-	2.9							3.7		
59	SSL	26/05/1974	PK	6.2	12.8	4.1	96	-	4.4							6.2		
60	SSL	13/06/1974	PK	5.0	14.2	3.2	318	-	3.3							5.0		
61	NA	2/07/1974	BOT	4.0	-	2.9	48	-	2.9						4.0			
62	NA	28/07/1974	BOT	4.1	-	3.3	48	-	3.4						4.1			
63	STL	6/08/1974	BOT	6.4	-	3.9	90	-	4.1						6.4			
64	NA	28/08/1974	BOT	4.4	-	3.0	54	-	3.1						4.4			
65	NA	26/09/1974	BOT	5.4	-	3.5	54	-	3.7						5.4			
66	NA	11/10/1974	BOT	3.7	-	3.6	12	-	3.6						3.7			
67	NA	19/10/1974	BOT	3.7	-	3.0	102	-	3.1						3.7			
68	NA	3/11/1974	BOT	3.5	-	2.6	84	-	2.6						3.5			
69	NA	24/11/1974	BOT	3.2	-	2.5	72	-	2.5						3.2			

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
70	NA	27/11/1974	BOT	3.5	-	2.7	72	-	2.7						3.5			
71	NA	20/12/1974	BOT	3.7	-	3.0	84	-	3.0						3.7			
72	NA	27/01/1975	BOT	3.0	-	2.5	12	-	2.6						3.0			
73	NA	23/02/1975	BOT	3.3	-	2.7	72	-	2.7						3.3			
74	NA	1/03/1975	BOT	3.6	-	2.8	84	-	2.8						3.6			
75	NA	10/03/1975	BOT	2.8	-	2.3	102	-	2.4						2.8			
76	NA	21/04/1975	BOT	3.4	-	2.4	144	-	2.4						3.4			
77	NA	12/06/1975	BOT	5.3	-	3.2	138	-	3.3						5.3			
78	IT	21/06/1975	BOT	7.4	-	3.2	162	-	3.5						7.4			
79	NA	12/08/1975	BOT	4.7	-	3.5	78	-	3.6						4.7			
80	SSL	5/09/1975	BOT	3.7	-	2.8	54	-	2.9						3.7	3.2		
81	NA	3/10/1975	BOT	3.0	-	2.5	54	-	2.5						3.0			
82	NA	2/02/1976	BOT	3.2	-	2.7	12	-	2.8						3.2			
83	NA	6/02/1976	BOT	3.0	-	2.5	18	-	2.5						3.0			
84	TC	5/03/1976	PK	4.9	14.9	3.0	132	-	3.1						3.8	4.9		
85	ETL	26/03/1976	PK	3.7	12.2	2.9	84	-	2.9						3.3	3.7		
86	ETL	17/06/1976	BOT	5.3	-	3.0	180	-	3.1			5.1			5.3	4.1		
87	NA	1/07/1976	BOT	3.3	-	2.7	54	-	2.7						3.3			
88	SSL	15/07/1976	BOT	4.6	-	3.1	78	-	3.2			4.0			4.6	3.2		
89	NA	27/07/1976	BOT	3.2	-	2.5	54	-	2.5						3.2			
90	SSL	14/08/1976	BOT	4.5	-	3.3	186	-	3.4			3.9			4.5	4.1		
91	NA	25/08/1976	BOT	4.9	-	3.1	42	-	3.2						4.9			
92	SSL	7/09/1976	BOT	3.7	-	2.6	162	-	2.7						3.7	3.3		
93	STL	13/09/1976	BOT	3.3	-	2.5	90	-	2.6			2.9			3.3	2.6		
94	STL	24/09/1976	BOT	3.5	-	2.6	60	-	2.7						3.5	3.5		
95	CL	16/10/1976	BOT	3.3	-	2.8	42	-	2.8						3.3	3.2		
96	NA	19/10/1976	BOT	3.7	-	2.8	54	-	2.8						3.7			
97	IT	28/10/1976	BOT	3.4	-	2.5	96	-	2.6						3.4	3.1		
98	AI	4/01/1977	BOT	3.7	-	2.6	66	-	2.6						3.7			
99	CL	19/01/1977	BYR	3.9	10.8	2.8	42	-	2.8	2.7	3.9							
100	NA	2/02/1977	BOT	3.6	-	2.8	18	-	2.9						3.6			
101	AI	6/02/1977	BOT	3.1	-	2.4	30	-	2.4	2.5					3.1			
102	CL	22/02/1977	BYR	3.9	10.8	2.7	60	-	2.7		3.9				3.4			
103	AI	4/03/1977	BOT	3.9	-	2.7	96	-	2.8		3.1	3.2			3.9			
104	AI	16/03/1977	BYR	3.7	9.5	2.8	30	-	2.8		3.7	3.2						
105	SSL	9/04/1977	BOT	5.1	-	3.4	54	-	3.5	3.0	3.5	3.4			5.1	3.6		
106	STL	29/04/1977	BOT	3.9	-	2.5	108	-	2.5		3.4	3.5			3.9	3.6		
107	ETL	18/05/1977	BYR	5.6	12.2	3.3	108	-	3.4	4.4	5.6	5.5			4.5	4.4		
108	NA	29/05/1977	BOT	3.0	-	3.0	12	-	3.0						3.0			
109	STL	2/06/1977	BOT	4.5	-	2.7	60	-	2.8			3.3			4.5	3.6		
110	ETL	10/06/1977	BOT	5.0	-	3.1	60	-	3.3	3.6					5.0	3.5		
111	SSL	19/06/1977	BOT	4.4	-	3.1	54	-	3.2		3.5	3.3			4.4			
112	NA	26/06/1977	BOT	4.2	-	3.1	42	-	3.1						4.2			
113	NA	1/07/1977	BOT	4.4	-	3.3	42	-	3.4						4.4			
114	AI	8/07/1977	BRI	3.0	8.5	2.5	84	-	2.6	3.0								
115	NA	16/07/1977	BOT	3.9	-	2.6	72	-	2.6						3.9			
116	SSL	4/09/1977	BOT	4.1	-	2.9	60	-	2.9		4.0	3.4			4.1			
117	NA	15/09/1977	BOT	3.3	-	2.8	54	-	2.8						3.3			
118	NA	19/09/1977	BOT	3.4	-	2.8	24	-	2.9						3.4			
119	NA	24/09/1977	BOT	3.0	-	2.5	42	-	2.5						3.0			
120	STL	7/10/1977	BOT	3.3	-	2.7	30	-	2.8						3.3	3.2		
121	NA	15/11/1977	BOT	3.6	-	2.7	24	-	2.8						3.6			
122	STL	28/12/1977	BYR	4.0	10.8	3.3	30	-	3.3		4.0	3.8			3.7	3.2		
123	TC	11/01/1978	BOT	4.4	-	2.9	24	-	3.1		3.3	3.1			4.4			
124	IT	29/01/1978	BOT	5.2	-	3.2	72	-	3.3						5.2	5.0		
125	STL	1/03/1978	PK	3.9	10.8	3.2	24	-	3.2	2.6	2.7				3.3	3.9		
126	ETL	19/03/1978	PK	6.9	11.7	4.6	102	2098	4.9		3.9	3.9			6.5	6.9		4.4
127	SSL	4/04/1978	BOT	3.7	-	2.9	54	-	2.9						3.7	3.2		
128	ETL	17/04/1978	BYR	4.1	12.2	2.7	162	-	2.8	3.4	4.1				3.7	3.3		
129	STL	27/04/1978	BOT	3.2	-	2.8	24	-	2.8						3.2	3.1		
130	SSL	12/05/1978	BOT	3.1	-	2.7	66	-	2.7						3.1	3.0		
131	CL	20/05/1978	PK	6.3	12.2	3.5	132	-	3.7						4.1	6.3		6.0
132	ETL	1/06/1978	BOT	6.9	-	3.9	90	-	4.1						6.9	6.7		6.5
133	SSL	15/06/1978	BOT	6.6	-	3.3	144	-	3.4			3.5			6.6	3.7		4.6
134	SSL	25/06/1978	PK	4.1	11.7	3.4	66	763	3.4			3.2			3.9	4.1		
135	STL	5/07/1978	PK	3.3	14.3	3.0	42	412	3.0							3.3		
136	ETL	19/07/1978	BRI	3.3	12.6	2.8	84	-	2.8	3.3		3.2						
137	STL	25/07/1978	PK	3.1	9.9	2.9	18	123	3.0							3.1		
138	AI	5/08/1978	BRI	3.1	8.7	2.5	96	-	2.5	3.1	2.7							
139	SSL	13/08/1978	BOT	4.0	-	2.9	48	-	2.9		3.5				4.0	3.3		
140	CL	23/08/1978	PK	4.4	11.7	3.5	54	621	3.6	3.2		3.9			4.0	4.4		
141	SSL	27/08/1978	BOT	3.3	-	2.6	42	-	2.6						3.3	3.2		
142	NA	14/09/1978	BOT	3.1	-	2.4	42	-	2.5						3.1			

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
143	NA	24/09/1978	BOT	3.2	-	2.9	30	-	2.9						3.2			
144	SSL	27/09/1978	EDE	3.9	9.5	2.6	36	-	2.6		3.5							3.9
145	NA	19/10/1978	BOT	4.0	-	3.0	48	-	3.0						4.0			
146	IT	1/11/1978	BOT	3.6	-	2.6	36	-	2.6						3.6	3.1		
147	IT	12/11/1978	BOT	4.1	-	2.7	54	-	2.8			3.4			4.1	3.5		
148	NA	7/12/1978	BOT	4.2	-	3.1	42	-	3.2						4.2			
149	NA	15/12/1978	BOT	3.4	-	2.8	36	-	2.8						3.4			
150	STL	20/12/1978	BOT	3.7	-	2.5	42	-	2.6						3.7	3.4		
151	AI	30/12/1978	BYR	3.2	8.6	2.6	54	266	2.7		3.2							
152	ETL	22/01/1979	BOT	3.8	-	3.0	36	-	3.1			3.5			3.8			
153	AI	28/01/1979	BYR	3.3	9.9	2.7	48	260	2.7		3.3	3.1						
154	TC	5/02/1979	COF	4.0	13.5	3.1	12	24	3.3	3.6	3.4	4.0			3.7	3.7		
155	STL	17/02/1979	BOT	4.0	-	2.8	42	-	2.8						4.0	3.5		
156	TC	21/02/1979	BRI	2.9	8.3	2.6	72	-	2.6	2.9								
157	IT	4/03/1979	BOT	4.6	-	3.0	72	-	3.1						4.6	4.3		
158	IT	16/03/1979	EDE	3.7	10.8	2.8	60	-	2.8						2.9	2.5		3.7
159	SSL	25/03/1979	BYR	3.9	11.7	2.7	48	304	2.8		3.9				3.4	3.3		
160	AI	30/03/1979	BYR	3.0	9.9	2.3	72	307	2.3		3.0							
161	AI	11/04/1979	BYR	3.1	8.6	2.2	60	266	2.2	2.5	3.1							
162	ETL	30/04/1979	BYR	3.2	9.9	2.6	66	360	2.6		3.2	3.1						
163	SSL	6/05/1979	COF	3.5	9.9	2.5	102	537	2.6			3.5			3.4	3.2		
164	ETL	22/05/1979	COF	3.4	11.7	2.4	84	436	2.5	2.9	3.1	3.4						
165	SSL	1/06/1979	BOT	4.2	-	2.9	90	-	3.0		3.9	3.9			4.2	3.4		
166	ETL	22/06/1979	BOT	3.7	-	2.7	66	-	2.8			3.0			3.7			
167	ETL	30/07/1979	BRI	4.7	11.0	3.9	36	-	4.0	4.7		3.5						
168	STL	14/08/1979	BOT	3.7	-	2.8	42	-	2.8						3.7	3.2		
169	SSL	21/08/1979	BOT	3.6	-	3.1	18	-	3.2						3.6	3.3		
170	NA	23/08/1979	BOT	3.4	-	2.6	18	-	2.7						3.4			
171	NA	29/08/1979	BOT	3.3	-	2.7	18	-	2.8						3.3			
172	SSL	1/09/1979	BYR	3.5	10.8	2.6	48	-	2.7		3.5				3.4	3.1		
173	SSL	24/09/1979	BYR	4.4	9.9	3.2	60	545	3.3		4.4				3.6	3.1		
174	IT	29/10/1979	BYR	3.2	7.6	2.8	24	134	2.8		3.2							
175	NA	5/01/1980	BOT	3.1	-	2.7	18	-	2.8						3.1			
176	TC	10/01/1980	BOT	4.5	-	2.5	90	-	2.6	4.3					4.5			4.4
177	STL	16/01/1980	BOT	4.1	-	3.0	42	-	3.0			3.1			4.1			
178	NA	6/02/1980	BOT	3.2	-	2.7	24	-	2.7						3.2			
179	NA	10/02/1980	BOT	3.1	-	2.7	36	-	2.7						3.1			
180	TC	14/02/1980	BRI	4.0	9.8	2.8	132	-	2.8	4.0	3.7	3.9			3.3	3.3		3.3
181	TC	25/02/1980	BOT	3.7	-	2.7	30	-	2.7	3.2	3.3				3.7			
182	TC	10/03/1980	BYR	3.9	10.8	3.0	36	-	3.1	3.7	3.9	3.7			3.8	3.2		
183	AI	6/04/1980	BOT	2.8	-	2.5	72	-	2.5	2.6					2.8			
184	ETL	21/04/1980	COF	3.2	14.3	2.6	30	217	2.7		3.1	3.2						
185	STL	27/04/1980	BOT	4.1	-	2.9	60	-	2.9						4.1	3.3		
186	ETL	8/05/1980	BYR	5.8	10.8	3.2	144	-	3.4	5.2	5.8	4.7			5.4	5.2		3.9
187	SSL	7/06/1980	COF	4.4	12.2	2.7	54	-	2.8	2.9	3.7	4.4			3.8	3.8		
188	SSL	18/06/1980	BOT	4.5	9.7	3.0	70	-	3.1		3.3	2.9			4.5	3.2		
189	SSL	5/07/1980	BOT	3.1	11.0	2.4	33	-	2.5			3.1			3.1	3.0		
190	STL	10/07/1980	BOT	3.8	10.1	3.0	55	-	3.0			3.2			3.8	3.5		
191	STL	23/07/1980	BOT	3.3	9.3	2.6	61	-	2.7			3.1			3.3			
192	SSL	4/08/1980	BYR	3.1	9.5	2.6	12	-	2.7		3.1							
193	STL	15/08/1980	BOT	3.4	9.2	2.5	41	-	2.5						3.4	3.1		
194	CL	11/10/1980	EDE	3.3	8.1	2.6	24	-	2.6						3.1			3.3
195	NA	24/10/1980	BOT	3.3	8.8	2.5	40	-	2.6						3.3			
196	SSL	3/11/1980	BOT	4.6	10.0	2.7	55	-	2.8		4.0	3.1			4.6	3.5		
197	SSL	23/11/1980	BYR	3.1	10.8	2.4	18	-	2.4		3.1					3.0		
198	IT	30/12/1980	BOT	3.8	8.5	2.9	33	-	2.9						3.8	3.1		
199	ETL	2/02/1981	BRI	3.1	9.4	2.5	72	-	2.6	3.1		2.5						
200	TC	15/02/1981	BRI	4.4	9.6	3.1	60	-	3.2	4.4		4.3						
201	TC	7/03/1981	BYR	3.2	10.8	2.5	42	-	2.5		3.2							
202	ETL	4/04/1981	BOT	3.9	10.2	2.9	90	-	3.0						3.9	3.8		3.5
203	SSL	11/04/1981	BYR	4.0	10.8	2.7	108	-	2.8		4.0				3.5	3.2		
204	NA	14/04/1981	BOT	3.3	12.0	2.5	41	-	2.5						3.3			
205	NA	29/04/1981	BOT	3.1	9.7	2.6	44	-	2.6						3.1			
206	ETL	6/05/1981	COF	3.1	13.5	2.4	48	-	2.4			3.1						
207	AI	14/05/1981	BRI	2.9	8.2	2.6	84	-	2.6	2.9								
208	IT	22/05/1981	COF	4.0	10.8	2.5	108	-	2.5	3.8		4.0			3.9	3.8		3.2
209	SSL	6/06/1981	EDE	3.5	9.9	2.5	60	326	2.5									3.5
210	NA	13/06/1981	BOT	3.4	12.2	2.6	37	-	2.6						3.4			
211	STL	10/07/1981	BOT	5.9	13.0	3.2	113	-	3.4			3.1			5.9	4.3		
212	IT	31/07/1981	BYR	3.2	9.5	2.5	48	-	2.5		3.2					2.7		
213	SSL	10/08/1981	BOT	3.7	9.6	2.4	53	-	2.4			3.2			3.7	2.7		
214	NA	28/09/1981	BOT	3.5	11.2	2.6	31	-	2.6						3.5			
215	NA	19/10/1981	BOT	3.3	8.6	2.4	75	-	2.4						3.3			

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
216	IT	23/10/1981	BOT	3.3	8.4	2.6	27	-	2.6			3.2			3.3			
217	CL	14/12/1981	BOT	4.1	9.2	3.0	61	-	3.1		3.1				4.1			
218	NA	7/01/1982	BOT	3.6	9.4	2.8	18	-	2.9						3.6			
219	TC	27/01/1982	BRI	4.0	9.7	3.3	24	-	3.4	4.0					3.5	3.6		
220	AI	6/02/1982	BRI	3.0	10.2	2.6	48	-	2.7	3.0								
221	IT	26/02/1982	BOT	3.1	7.9	2.8	18	-	2.8						3.1	3.0		
222	IT	9/03/1982	BOT	4.7	8.7	2.9	35	-	3.0						4.7	3.4		
223	ETL	13/03/1982	BYR	3.5	9.9	2.6	108	625	2.7		3.5	3.4				2.6		
224	NA	30/03/1982	BOT	3.5	9.1	2.6	27	-	2.7						3.5			
225	TC	8/04/1982	BYR	3.9	14.3	3.2	84	818	3.2	3.0	3.9	3.5						
226	NA	30/04/1982	BOT	3.1	12.0	2.6	55	-	2.6						3.1			
227	NA	21/05/1982	BOT	3.2	11.2	2.3	41	-	2.3						3.2			
228	SSL	3/06/1982	BOT	4.9	11.7	3.3	144	-	3.4		3.3				4.9	3.7		
229	AI	5/06/1982	BYR	4.1	14.3	2.7	96	676	2.8		4.1	3.1						
230	ETL	17/06/1982	BYR	3.5	11.7	2.8	84	694	2.8		3.5					3.2		
231	STL	23/06/1982	BOT	4.0	11.5	2.9	116	-	2.9		3.1				4.0	3.9		
232	NA	4/07/1982	BOT	3.0	10.1	2.4	84	-	2.4						3.0			
233	AI	16/07/1982	BOT	3.0	7.7	2.5	97	-	2.5						3.0	2.6		
234	SSL	20/07/1982	BOT	4.4	10.0	3.1	50	-	3.2	2.9		3.9			4.4	4.3		
235	NA	11/09/1982	BOT	3.0	8.6	2.5	38	-	2.5						3.0			
236	ETL	22/09/1982	BYR	4.0	10.8	3.0	54	-	3.1	3.6	4.0	3.5			3.7	3.5		
237	SSL	30/09/1982	BOT	6.2	11.4	2.8	82	-	3.0		3.6	3.8			6.2	3.7		
238	SSL	5/10/1982	BOT	3.8	10.1	2.7	48	-	2.8		3.7				3.8			
239	IT	10/10/1982	COF	4.8	11.7	2.8	42	274	3.0	3.2		4.8			3.9	3.5		
240	ETL	14/10/1982	BOT	3.6	10.5	2.7	43	-	2.8						3.6			
241	NA	23/10/1982	BOT	3.1	9.6	2.4	81	-	2.4						3.1			
242	NA	11/11/1982	BOT	3.7	10.2	2.8	17	-	2.8						3.7			
243	STL	2/12/1982	PK	3.3	9.9	2.7	42	238	2.8							3.3		
244	STL	21/12/1982	BOT	4.2	10.6	2.9	15	-	3.0						4.2	3.4		
245	TC	19/01/1983	BRI	3.2	8.8	2.5	66	-	2.5	3.2	3.1	3.2						
246	STL	17/02/1983	PK	3.6	10.8	2.9	30	-	3.0						3.5	3.6		
247	STL	10/03/1983	BOT	4.1	9.7	2.6	52	-	2.6	3.6					4.1	3.2		
248	IT	21/03/1983	PK	4.6	11.7	3.3	54	560	3.5						4.2	4.6		4.4
249	ETL	15/04/1983	BOT	5.0	10.3	3.3	168	-	3.4	3.7		3.5			5.0	4.8		
250	NA	26/04/1983	BOT	4.9	10.3	2.9	43	-	3.0						4.9			
251	IT	3/05/1983	EDE	3.9	9.5	2.7	72	-	2.8						3.2	3.1		3.9
252	ETL	4/06/1983	BRI	5.3	11.0	3.5	132	-	3.7	5.3	4.8	4.8			3.7			3.4
253	ETL	22/06/1983	BRI	5.1	9.7	2.9	132	-	3.0	5.1	4.2							
254	SSL	9/07/1983	BOT	5.5	12.3	4.0	76	-	4.1		3.5	4.3			5.5			4.6
255	ETL	25/07/1983	COF	3.6	10.8	2.9	30	-	2.9	3.0		3.6						
256	SSL	3/08/1983	PK	4.5	11.7	3.4	66	725	3.5		3.7				4.3	4.5		
257	IT	26/08/1983	EDE	3.5	9.9	2.8	48	312	2.8						3.4	3.0		3.5
258	NA	10/09/1983	BOT	3.1	9.8	2.6	33	-	2.7						3.1			
259	SSL	25/09/1983	BOT	4.1	10.6	2.8	39	-	2.9	3.0	3.2	3.2			4.1			
260	IT	8/10/1983	COF	4.5	14.9	3.4	108	-	3.5		3.9	4.5			4.3	4.0		4.5
261	IT	17/10/1983	EDE	3.2	9.9	2.4	90	417	2.4									3.2
262	AI	21/11/1983	BRI	3.6	8.3	2.6	48	-	2.6	3.6								
263	IT	7/12/1983	PK	3.3	12.2	2.7	60	-	2.7	3.0						3.3		
264	AI	5/01/1984	BRI	3.2	9.1	2.7	48	-	2.8	3.2								
265	STL	16/01/1984	EDE	3.8	11.7	3.0	42	313	3.1			3.0						3.8
266	STL	31/01/1984	PK	3.8	11.7	2.8	108	817	2.9							3.8		
267	SSL	10/02/1984	BOT	3.6	10.4	2.6	40	-	2.7		3.5				3.6			
268	TC	1/03/1984	PK	3.9	8.6	2.9	114	841	3.0	3.1	2.9	3.2			3.8	3.9		3.9
269	SSL	20/03/1984	BOT	4.4	9.0	2.9	129	-	3.0						4.4	3.3		3.7
270	NA	28/03/1984	BOT	3.1	9.7	2.5	30	-	2.5						3.1			
271	TC	9/04/1984	COF	6.2	11.7	3.8	96	1416	3.9	5.2		6.2			4.0	3.6		
272	SSL	7/05/1984	BOT	5.2	9.9	3.3	148	-	3.4						5.2	4.2		4.3
273	TL	20/05/1984	BYR	4.4	12.2	3.2	108	-	3.3	4.1	4.4					3.1		
274	ETL	20/06/1984	BOT	5.0	10.1	3.4	74	-	3.5	3.4	3.6				5.0	4.8		
275	ETL	30/06/1984	BOT	5.2	11.6	3.3	109	-	3.4		4.1	3.8			5.2	4.8		
276	SSL	5/07/1984	BOT	6.5	11.9	4.0	67	-	4.2		3.6	3.6			6.5	5.6		
277	ETL	27/07/1984	BOT	4.2	9.9	2.8	65	-	2.9		3.7	3.8			4.2	3.9		3.9
278	STL	15/08/1984	BOT	3.9	12.2	2.7	60	-	2.7		2.8				3.9	3.7		
279	SSL	1/09/1984	BYR	3.3	12.2	2.4	75	2309	2.4		3.3							
280	SSL	20/09/1984	EDE	3.8	11.7	2.9	132	1042	3.0							3.7		3.8
281	STL	30/09/1984	BYR	5.1	13.5	3.5	61	4540	3.6	3.3	5.1	4.0			4.5	4.3		
282	ETL	22/10/1984	BYR	2.6	8.2	2.2	100	2298	2.2		2.6							
283	ETL	31/10/1984	COF	4.3	11.1	3.0	46	1864	3.1		4.0	4.3			3.7			
284	IT	7/11/1984	PK	5.5	11.1	3.4	64	3788	3.6						5.0	5.5		
285	AI	16/11/1984	BYR	3.3	8.8	2.5	47	1300	2.5		3.3							
286	TC	31/12/1984	PK	4.4	13.5	2.9	176	7846	2.9	3.5		4.1			4.3	4.4		
287	NA	11/01/1985	BOT	3.7	10.1	2.5	58	-	2.6						3.7			
288	IT	18/01/1985	COF	3.1	10.2	2.6	33	942	2.6			3.1			3.0			

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
289	IT	9/02/1985	COF	3.8	12.2	2.9	41	1764	2.9	3.0		3.8				3.2		
290	IT	22/02/1985	COF	3.3	11.1	2.6	135	4342	2.6	3.0		3.3			3.1	3.1		
291	TC	5/03/1985	BOT	3.7	9.8	2.6	31	-	2.6	3.0		3.6			3.7			
292	IT	25/03/1985	PK	3.4	10.2	2.6	35	911	2.6							3.4		
293	ETL	14/04/1985	PK	3.8	12.2	2.8	62	2874	2.9			3.1			3.5	3.8		3.8
294	ETL	2/05/1985	COF	4.4	12.2	2.8	201	12395	2.8	3.5		4.4			2.6			3.3
295	SSL	20/05/1985	BOT	6.1	11.1	3.8	54	-	4.0	2.8		4.7			6.1			3.3
296	SSL	24/05/1985	BOT	3.5	9.8	2.6	36	-	2.6	3.4					3.5			3.0
297	SSL	6/06/1985	BOT	6.3	12.2	3.7	50	-	3.9	2.8		3.5			6.3			4.7
298	SSL	21/06/1985	BOT	3.3	8.0	2.5	62	-	2.5						3.3	3.2		
299	ETL	9/07/1985	COF	6.6	11.1	4.0	25	2312	4.2	3.9		6.6			5.1	5.1		
300	NA	19/07/1985	BOT	3.1	7.9	2.5	27	-	2.5						3.1			
301	SSL	23/07/1985	BOT	3.1	9.2	2.6	34	-	2.6						3.1	3.0		
302	SSL	27/07/1985	BOT	3.6	9.8	2.8	33	-	2.9						3.6	3.5		
303	STL	1/08/1985	BOT	4.2	11.5	3.2	65	-	3.3						4.2	3.8		
304	NA	19/08/1985	BOT	3.3	11.4	2.5	71	-	2.5						3.3			
305	SSL	3/09/1985	BOT	5.9	13.0	3.7	110	-	3.9	3.4	4.3	3.7			5.9	4.5		
306	IT	20/09/1985	BOT	4.6	10.1	2.6	104	-	2.7						4.6	4.4		
307	NA	26/09/1985	BOT	3.2	10.1	2.5	51	-	2.6						3.2			
308	IT	13/10/1985	BOT	3.8	9.3	2.8	85	-	2.9						3.8			3.3
309	IT	21/10/1985	EDE	3.8	12.2	2.9	34	1613	2.9		3.0		3.1		3.5			3.8
310	IT	25/10/1985	BOT	7.0	11.3	5.3	14	-	5.4	3.9	4.7	4.9	4.5		7.0			6.1
311	IT	8/11/1985	EDE	3.2	11.1	2.5	67	2232	2.6									3.2
312	AI	12/11/1985	BYR	4.3	8.9	3.0	51	2126	3.0		4.3							3.1
313	SSL	19/11/1985	BYR	4.4	11.1	3.1	66	3412	3.2		4.4	4.3	3.2		3.7	4.2		3.0
314	IT	27/11/1985	EDE	5.5	9.5	3.1	70	3307	3.2			4.0	3.0		3.5			5.5
315	AI	1/12/1985	BRI	3.4	8.1	2.4	30	-	2.5	3.4								
316	IT	18/01/1986	EDE	5.4	10.2	3.3	26	1455	3.4						3.7	3.8		5.4
317	TC	24/01/1986	COF	5.3	10.2	2.9	75	3042	3.0	3.8	4.5	5.3	4.1		4.1	4.0		
318	IT	3/02/1986	BOT	3.2	9.6	2.4	79	-	2.5						3.2	3.2		
319	NA	23/02/1986	BOT	3.1	7.5	2.6	14	-	2.6						3.1			
320	TC	13/03/1986	BOT	3.6	11.7	2.7	81	-	2.7	3.1					3.6	3.5		
321	AI	23/03/1986	BRI	2.7	9.6	2.3	78	-	2.3	2.7								
322	STL	6/04/1986	PK	5.2	11.1	2.8	33	1415	2.9	3.1		3.3			4.4	5.2		
323	AI	17/04/1986	EDE	3.1	10.2	2.5	62	1604	2.5	2.6								3.1
324	SSL	30/04/1986	BOT	3.3	8.3	2.6	33	-	2.6						3.3	3.3		
325	ETL	12/05/1986	COF	5.3	10.2	3.2	58	2848	3.3			5.3	5.1					4.0
326	CL	21/05/1986	PK	3.7	13.5	2.4	51	1717	2.5						3.1	3.7		
327	SSL	26/05/1986	BYR	3.2	11.1	2.5	40	1266	2.6		3.2					3.1		
328	NA	31/05/1986	BOT	3.0	10.1	2.5	47	-	2.5						3.0			
329	NA	10/06/1986	BOT	3.1	9.9	2.4	21	-	2.5						3.1			
330	ETL	17/06/1986	BYR	4.8	12.2	2.7	105	4657	2.8	4.0	4.8		4.5		3.0	3.0		
331	STL	1/07/1986	CRO	3.7	13.5	2.6	59	2608	2.7		3.0	3.5	3.7		3.0	3.1	3.4	3.6
332	STL	11/07/1986	COF	3.9	12.2	2.9	85	4428	2.9		3.7	3.9	3.8		3.6		3.7	
333	AI	20/07/1986	BYR	3.2	13.5	2.5	59	2174	2.5		3.2							
334	STL	26/07/1986	BOT	4.9	11.8	3.0	51	-	3.1		3.7	4.2	3.7		4.9	4.4	4.2	3.2
335	ETL	5/08/1986	BOT	6.8	10.8	4.5	134	-	4.7	3.3	5.0	6.4	5.9		6.8	6.8	5.6	5.0
336	IT	15/09/1986	BOT	4.1	11.8	2.7	82	-	2.7		4.0	3.5			4.1	3.7	3.5	
337	STL	22/10/1986	EDE	3.4	8.2	2.5	20	527	2.5				3.0					3.4
338	STL	26/10/1986	PK	3.1	12.2	2.5	34	1245	2.5							3.1		
339	IT	9/11/1986	BYR	3.0	8.8	2.3	19	415	2.3		3.0							
340	IT	15/11/1986	BRI	3.1	8.8	2.4	48	-	2.4	3.1								
341	IT	20/11/1986	BOT	6.3	12.1	3.8	98	-	4.0	3.2		3.9	4.2		6.3	4.9	6.0	
342	SSL	29/11/1986	BAT	4.2	12.2	2.9	27	1374	3.0		3.0		3.4			3.6	4.2	
343	SSL	9/12/1986	CRO	3.8	12.2	2.7	13	459	2.8		3.2		3.8			3.1	3.3	
344	TC	19/12/1986	COF	3.5	13.5	2.4	99	2995	2.5		3.4	3.5						
345	TL	5/01/1987	BAT	3.0	10.2	2.4	82	2488	2.4			2.9			2.8	2.9	3.0	
346	STL	22/01/1987	PK	3.1	10.2	2.3	24	597	2.3							3.1		
347	AI	5/02/1987	BYR	3.7	8.8	2.4	104	2865	2.5		3.7							
348	ETL	5/03/1987	BYR	4.9	10.2	3.1	125	5776	3.2	4.7	4.9					3.3	3.0	
349	STL	9/03/1987	BYR	4.4	11.1	2.7	75	2973	2.8	3.0	4.4							
350	IT	17/03/1987	BYR	4.0	10.2	2.8	43	1646	2.9		4.0		3.3					
351	AI	1/04/1987	CRO	4.0	12.2	2.6	65	2917	2.7		3.3	3.2	4.0					
352	SSL	9/04/1987	BYR	5.0	11.1	3.1	84	4538	3.2	3.9	5.0	4.4	4.5		3.6	3.6	3.0	
353	AI	21/04/1987	BYR	3.0	8.8	2.4	185	4892	2.4	2.8	3.0	3.0	3.0					
354	STL	3/05/1987	EDE	3.4	10.2	2.7	39	1262	2.7								3.1	3.4
355	AI	10/05/1987	BYR	4.2	9.5	2.8	134	4792	2.9	3.6	4.2	3.0						
356	SSL	18/05/1987	PK	4.1	11.1	2.7	60	2483	2.8		3.5		3.8		3.7	4.1	4.0	
357	SSL	29/05/1987	BYR	3.5	11.1	2.9	57	2415	2.9		3.5		3.5					
358	AI	5/06/1987	BYR	3.1	9.5	2.4	130	3422	2.4	2.9	3.1							
359	AI	16/06/1987	BYR	2.9	7.7	2.3	73	1765	2.3		2.9							
360	NA	30/06/1987	BOT	2.7	10.6	2.3	74	-	2.3						2.7			
361	AI	8/07/1987	BYR	2.7	8.2	2.3	72	1548	2.3		2.7							

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
362	SSL	13/07/1987	COF	4.4	11.1	3.2	28	1664	3.3		3.0	4.4	3.3		4.0	3.8		3.3
363	SSL	3/08/1987	PK	6.1	12.2	3.9	32	2852	4.0			4.0	3.5	5.7	5.6	6.1		
364	AI	12/08/1987	BYR	3.5	8.8	2.5	85	2524	2.5	3.1	3.5							
365	ETL	19/08/1987	BOT	4.3	9.3	2.9	68	-	2.9		3.2	3.3	3.3	4.2	4.3	3.8	3.6	
366	STL	2/09/1987	CRO	4.8	15.1	3.5	39	3324	3.5		4.6	3.0	4.8	4.2	4.1	3.9	4.7	3.8
367	STL	11/09/1987	BYR	4.2	13.5	2.9	45	2308	2.9		4.2	4.0			3.0			
368	SSL	23/09/1987	BYR	3.1	10.2	2.5	36	1156	2.5		3.1							
369	SSL	1/10/1987	SYD	4.3	10.2	2.9	39	1572	2.9	3.6	3.8	3.9	3.8	4.3	4.0	4.0	3.5	3.3
370	SSL	5/10/1987	CRO	4.3	11.1	3.1	25	1447	3.2		3.9	3.7	4.3	3.7	3.5	3.8		
371	SSL	12/10/1987	COF	4.6	10.2	2.7	72	2455	2.7	3.2	3.7	4.6		3.4	3.0			4.2
372	IT	20/10/1987	PK	4.3	8.8	2.9	173	6247	2.9		3.4	3.9	3.8	4.3	3.5	4.3	3.2	3.4
373	IT	27/10/1987	BOT	3.4	9.5	2.9	36	-	2.9				3.1		3.4		3.0	
374	IT	12/11/1987	SYD	6.8	11.1	3.9	78	6099	4.1		5.5	4.9	5.9	6.8	5.7	5.2		3.3
375	STL	24/11/1987	BAT	3.7	9.5	2.8	16	534	2.8							3.4	3.7	
376	CL	3/12/1987	BAT	3.8	12.2	2.8	87	3640	2.8				3.1		3.7	3.6	3.8	3.7
377	IT	22/12/1987	PK	3.7	10.2	2.6	105	3246	2.6				2.9	3.5	3.5	3.7	3.2	3.1
378	TC	15/01/1988	BRI	4.3	10.4	3.0	84	-	3.1	4.3		3.8	3.3	3.4	3.5	3.0		3.4
379	IT	1/02/1988	PK	4.1	9.5	2.6	44	1398	2.7	3.2	3.9			3.9	3.4	4.1	3.3	3.3
380	IT	9/02/1988	CRO	6.5	15.1	3.7	93	8480	3.9	3.9	5.3	6.4	6.5	5.3	5.7	5.4	4.5	
381	IT	15/02/1988	COF	4.6	11.1	3.1	99	5296	3.2	3.9	4.6	4.6	4.2	4.1	4.2	3.9	3.3	
382	TL	6/03/1988	COF	4.2	15.1	2.8	130	6240	2.8	4.0	4.1	4.2	3.3	3.3	3.3	3.8	3.7	
383	STL	14/03/1988	BOT	3.2	11.9	2.5	32	-	2.5						3.2		3.0	
384	AI	24/03/1988	BYR	2.8	9.5	2.3	98	2200	2.3		2.8							
385	ETL	9/04/1988	EDE	5.7	12.2	3.3	94	5940	3.5	4.1	4.1	5.2	5.0	5.0	4.9	4.6	4.5	5.7
386	TC	16/04/1988	BAT	3.4	8.2	2.8	12	376	2.8				3.0	3.1	3.1		3.4	
387	ETL	30/04/1988	PK	6.1	12.2	3.6	117	8784	3.7	3.1		3.2	4.3	5.6	5.5	6.1	4.4	4.7
388	STL	11/05/1988	COF	3.4	8.8	2.5	46	1369	2.6			3.4				3.0		
389	SSL	24/05/1988	EDE	5.5	10.2	3.0	75	3879	3.2			3.2	4.1	5.5	5.3	5.5	4.5	5.5
390	AI	5/06/1988	BRI	4.5	9.7	3.0	150	-	3.0	4.5	3.6	4.4	3.6					
391	STL	5/06/1988	EDE	4.1	10.2	2.8	92	3768	2.9					3.4		3.1		4.1
392	SSL	17/06/1988	CRO	4.8	11.1	3.0	69	3481	3.1	3.5	4.8	4.4	4.8	3.8	3.2	3.2	3.1	3.2
393	AI	23/06/1988	BYR	3.8	10.2	2.6	60	1725	2.7	3.4	3.8							
394	AI	1/07/1988	EDE	3.1	11.2	2.3	41	1131	2.3					3.0				3.1
395	IT	6/07/1988	EDE	5.9	11.1	3.5	71	4781	3.7	4.0	4.3	3.9	4.8	4.1	4.4	4.7	4.8	5.9
396	AI	12/07/1988	BRI	4.5	9.2	3.1	72	-	3.2	4.5	3.6			3.0		3.1		
397	STL	28/07/1988	BYR	4.2	12.2	2.8	40	1764	2.8		4.2	3.4		3.2				
398	SSL	8/08/1988	SYD	5.4	11.1	3.5	133	9410	3.6	2.4	3.2	4.0	4.8	5.4		5.0	4.2	4.2
399	IT	24/08/1988	CRO	5.0	11.1	3.3	34	1981	3.4		4.5	3.9	5.0	4.4	4.1	3.7		
400	ETL	15/09/1988	BYR	6.0	11.1	3.3	90	5314	3.5	4.6	6.0	4.9	4.1	5.0	4.4	4.2	3.3	3.6
401	ETL	20/09/1988	SYD	3.6	11.1	2.6	65	2269	2.7		3.0			3.6		3.5		
402	STL	13/10/1988	PK	3.4	9.5	2.7	14	477	2.7						3.1	3.4		
403	IT	25/10/1988	PK	3.2	10.2	2.7	13	459	2.7			3.2				3.2		
404	AI	6/11/1988	BRI	4.2	9.5	4.0	18	-	4.0	4.2		3.5	3.3	3.5	3.8	3.7	3.5	3.5
405	IT	17/11/1988	EDE	5.4	10.2	2.8	140	5172	2.9	3.2				3.8	3.7	3.5	3.3	5.4
406	IT	28/11/1988	COF	3.1	7.7	2.5	11	258	2.5			3.1						
407	TL	18/12/1988	BRI	5.0	10.3	3.3	180	-	3.4	5.0		4.1	3.5	3.0				
408	TC	27/12/1988	BOT	4.4	9.7	2.7	102	-	2.8	3.1		4.2	3.6		4.4			
409	TC	3/01/1989	CRO	2.7	8.8	2.3	132	3461	2.3			2.6	2.7					
410	AI	23/01/1989	BOT	3.6	11.6	2.5	45	-	2.5	3.0	3.3	3.0		2.9	3.6	3.1		
411	TL	5/02/1989	EDE	3.4	13.5	2.7	42	1767	2.8	3.2		3.2	2.8	3.3				3.4
412	TC	21/02/1989	CRO	4.5	11.1	3.0	59	2940	3.0	3.4	4.3	4.3	4.5	4.5	4.2	3.9	3.0	
413	AI	28/02/1989	COF	2.6	8.8	2.2	96	2005	2.2			2.6						
414	IT	11/03/1989	EDE	3.3	11.1	2.7	23	1231	2.8									3.3
415	IT	16/03/1989	BYR	4.4	8.8	2.7	64	2329	2.8	3.5	4.4		4.0	3.4	3.8	3.5	3.4	
416	IT	26/03/1989	COF	4.0	9.5	2.6	70	2115	2.6	3.1	3.0	4.0		2.7	3.2	3.1		
417	AI	1/04/1989	EDE	4.2	9.5	2.9	143	5430	2.9	3.9	3.7	3.4	3.0	3.3	2.9	3.1		4.2
418	IT	11/04/1989	EDE	3.7	8.2	2.8	48	2889	2.8					3.0				3.7
419	ETL	25/04/1989	BRI	6.1	10.6	3.5	126	-	3.7	6.1	5.9	5.6	5.3	4.4		3.7	2.7	3.8
420	SSL	10/05/1989	EDE	3.5	8.2	2.7	21	1028	2.7									3.5
421	ETL	21/05/1989	BYR	3.7	9.5	2.7	44	1471	2.8	3.4	3.7	3.6						
422	AI	29/05/1989	BRI	4.8	10.3	3.2	108	-	3.3	4.8	3.6							
423	SSL	1/06/1989	CRO	4.9	13.5	3.1	64	3989	3.2		4.8	4.5	4.9	4.6		4.2	4.3	3.8
424	SSL	11/06/1989	EDE	4.1	8.3	2.7	33	1133	2.8		3.1						3.4	4.1
425	ETL	22/06/1989	COF	7.4	11.1	3.3	299	18662	3.5	3.6	4.6	7.4	5.8	4.4			3.8	3.7
426	AI	1/07/1989	BYR	3.2	10.2	2.5	109	3269	2.5	3.2	3.2							
427	SSL	11/07/1989	EDE	6.7	11.2	3.8	100	9044	4.0		3.6	3.2	3.9	4.3	3.8	3.8	4.8	6.7
428	SSL	18/07/1989	EDE	3.7	8.8	2.5	31	799	2.5		3.4			3.1	3.1			3.7
429	SSL	25/07/1989	BOT	5.4	10.2	3.2	96	-	3.3	3.3	3.7	4.2		5.1	5.4	4.9	4.9	5.0
430	STL	6/08/1989	EDE	3.4	10.2	2.5	22	658	2.6					3.1				3.4
431	SSL	12/08/1989	SYD	4.8	13.5	3.4	75	4551	3.4	3.3			4.7	4.8	4.5	4.5	3.7	4.0
432	ETL	19/08/1989	BRI	4.7	10.0	3.0	126	-	3.1	4.7			3.0					
433	SSL	7/09/1989	BYR	4.3	11.1	2.7	84	2844	2.7	4.1	4.3		3.9	3.5		3.3	3.3	3.6
434	SSL	28/09/1989	CRO	5.8	12.2	3.8	65	5678	3.9		3.8	4.2	5.8	3.9	4.5	4.1	3.3	

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
435	STL	3/10/1989	SYD	3.7	13.5	2.6	71	2565	2.7			3.1		3.7	3.5	3.4	3.2	3.3
436	STL	21/10/1989	CRO	4.4	12.2	2.8	25	1018	2.9				4.4	3.8	3.7	3.2		3.0
437	STL	28/10/1989	BAT	3.8	12.2	2.8	30	1377	2.9		3.0		3.7	3.5	3.2		3.8	3.4
438	CL	8/11/1989	SYD	3.3	10.2	2.5	54	1663	2.6					3.3				
439	AI	21/11/1989	BYR	3.3	8.8	2.6	18	554	2.6		3.3		3.1	3.1				
440	IT	7/12/1989	BOT	3.2	9.5	2.7	51	-	2.7		3.0		3.0		3.2			2.7
441	IT	14/12/1989	BOT	4.4	8.8	3.6	20	-	3.7				3.3	3.9	4.4	3.3	3.3	3.4
442	STL	20/12/1989	BOT	3.2	7.2	2.6	15	-	2.6						3.2	3.2		
443	STL	4/01/1990	BAT	3.3	7.7	2.6	15	409	2.7					3.2	3.0		3.3	
444	STL	16/01/1990	CRO	3.2	8.2	2.5	35	1009	2.6				3.2					
445	TC	26/01/1990	BRI	3.7	11.3	3.0	96	-	3.1	3.7		3.2	3.6			3.4	3.2	3.6
446	TC	6/02/1990	EDE	5.5	12.2	3.8	47	4497	3.9			4.2	4.6	3.7	3.7	3.3	3.7	5.5
447	IT	11/02/1990	SYD	5.0	9.5	3.0	72	3061	3.1		3.1	3.0		5.0	4.7	4.3	3.4	
448	AI	27/02/1990	BYR	2.9	7.3	2.3	127	2681	2.3	2.8	2.9							
449	TC	7/03/1990	CRO	6.3	12.2	3.9	84	7963	4.1	3.3	5.7		6.3	4.7	5.0	4.8	3.3	3.1
450	TC	19/03/1990	SYD	3.6	7.7	2.8	23	725	2.8				3.2	3.6	3.4	3.2		
451	AI	5/04/1990	PK	3.5	10.2	2.6	49	1550	2.7		3.2		2.9	3.3	3.5	3.5	3.3	3.3
452	IT	21/04/1990	EDE	5.5	9.5	2.8	129	5782	3.0		3.8	3.1						5.5
453	SSL	27/04/1990	PK	5.6	12.2	3.6	48	3633	3.7			3.3	4.0	4.4		5.6		4.0
454	NA	3/05/1990	BOT	3.3	9.5	2.7	20	-	2.8						3.3			
455	STL	15/05/1990	EDE	4.8	17.1	2.7	178	7938	2.8		3.9	3.4		3.5	3.4	3.6	4.2	4.8
456	SSL	20/05/1990	BOT	3.9	9.7	2.7	78	-	2.7		3.4			3.6	3.9	3.3		
457	ETL	29/05/1990	CRO	6.7	12.2	3.4	70	4632	3.6		4.7	5.5	6.7	3.3	3.3	3.7	3.6	2.9
458	AI	9/06/1990	BRI	4.5	10.3	3.3	162	-	3.4	4.5	3.8		3.0					
459	SSL	18/06/1990	BYR	4.0	10.2	2.9	73	2786	3.0	3.1	4.0		3.1	3.3			3.1	3.2
460	SSL	19/07/1990	SYD	3.4	11.1	2.8	32	1291	2.8					3.4				3.1
461	ETL	3/08/1990	SYD	7.2	10.2	2.9	157	7234	3.0	2.8	3.4		3.2	7.2	5.9	6.1	5.1	5.0
462	STL	7/08/1990	SYD	3.7	11.1	2.9	51	2503	2.9				3.3	3.7	3.4			
463	SSL	16/08/1990	SYD	4.2	11.1	2.9	88	3723	3.0		3.2	3.1	3.9	4.2	3.7		3.0	3.0
464	NA	24/08/1990	BOT	3.6	11.0	3.0	4	-	3.1						3.6			
465	SSL	26/08/1990	PK	6.7	13.5	3.6	140	11602	3.7	3.1	5.2	3.8	5.0	6.3	4.3	6.7	4.4	5.8
466	STL	4/09/1990	CRO	3.7	12.2	2.8	28	1168	2.9		3.4		3.7	3.4		3.5		
467	SSL	14/09/1990	BOT	5.5	10.0	2.9	82	-	3.1	3.2	3.2	3.3	4.3	5.0	5.5	5.2	4.2	3.6
468	IT	27/09/1990	COF	3.2	8.8	2.5	28	779	2.5	3.1		3.2		3.1		3.0		
469	SSL	3/10/1990	PK	3.5	11.1	2.9	30	1278	2.9					3.1		3.5	3.0	3.1
470	CL	13/10/1990	PK	6.5	13.5	3.9	66	6534	4.1	3.4	3.7	4.2	6.4	5.3	6.2	6.5	6.0	6.4
471	SSL	22/10/1990	CRO	4.8	11.1	3.2	104	5059	3.3		4.1	3.2	4.8	4.3	4.5	4.6		3.3
472	IT	11/11/1990	BYR	4.4	9.5	2.9	156	6884	3.0	4.0	4.4	3.7	3.6	3.1	3.5			3.1
473	IT	19/11/1990	SYD	4.0	12.2	2.6	104	3694	2.7		3.7	3.3	3.4	4.0	3.5	4.0	3.8	3.9
474	STL	11/12/1990	EDE	4.9	9.5	3.2	40	2030	3.3		3.5		4.4	3.8	3.9	4.1	4.1	4.9
475	STL	27/12/1990	EDE	3.2	7.7	2.7	12	343	2.7									3.2
476	STL	7/01/1991	BYR	3.6	12.2	2.5	47	1642	2.5		3.6				3.2	3.0	3.3	
477	IT	16/01/1991	BAT	3.2	7.7	2.6	8	212	2.6								3.2	
478	STL	2/02/1991	BOT	3.4	10.0	2.6	30	-	2.6					3.4	3.4			
479	IT	6/02/1991	BOT	3.2	9.1	2.5	16	-	2.5						3.2	3.0		
480	IT	18/02/1991	BAT	5.1	15.1	3.4	123	9536	3.5		3.4			3.6	3.5	4.3	5.1	4.5
481	IT	1/03/1991	PK	4.0	10.2	3.1	30	1278	3.1		3.4	3.0	3.7	3.6		4.0	3.8	3.1
482	IT	11/03/1991	BAT	3.6	7.3	2.5	16	388	2.5					3.5	3.1	3.1	3.6	
483	IT	24/03/1991	EDE	5.5	12.2	3.4	82	5477	3.5		3.4			3.9		3.9	4.1	5.5
484	AI	9/04/1991	BYR	3.2	8.8	2.5	58	1857	2.5		3.2							
485	STL	22/04/1991	COF	3.9	8.8	2.7	65	2821	2.7		3.4	3.9	3.4	3.7	3.1	3.7	3.3	
486	SSL	27/04/1991	EDE	4.6	10.2	2.7	156	5765	2.8		3.5	3.4	3.6	4.0	4.0	3.6	4.6	4.6
487	IT	10/05/1991	CRO	3.6	9.5	2.5	190	7115	2.6	2.8		3.1	3.6	3.2	3.1			
488	ETL	9/06/1991	BYR	5.6	11.1	2.8	125	4921	2.9		5.6	4.9	5.0	4.0	4.3	4.1	3.9	4.9
489	SSL	14/06/1991	BYR	4.9	10.2	3.1	43	2298	3.2		4.9							3.1
490	SSL	23/06/1991	BYR	3.7	10.2	3.0	30	1458	3.1		3.7		3.2		3.2			
491	SSL	2/07/1991	BYR	3.0	13.5	2.4	77	2218	2.4		3.0							
492	SSL	11/07/1991	EDE	5.6	12.2	3.1	214	11506	3.2			4.1	3.6	4.4	4.7	4.6	4.6	5.6
493	STL	23/07/1991	PK	4.5	15.1	3.0	97	6258	3.0			3.9	3.9	3.3	3.6	4.5	4.1	3.7
494	STL	9/08/1991	CRO	3.1	12.2	2.4	30	890	2.4				3.1					
495	STL	17/08/1991	CRO	3.3	12.2	2.6	61	2302	2.6		3.0	3.0	3.3					
496	SSL	25/08/1991	CRO	4.2	11.1	2.7	40	1712	2.8				4.2			3.0		
497	STL	1/09/1991	CRO	3.3	12.2	2.6	43	1484	2.6				3.3					
498	SSL	12/09/1991	BOT	4.4	9.3	3.0	49	-	3.1		3.1	3.6		4.1	4.4	3.9		
499	STL	17/10/1991	CRO	4.0	12.2	2.7	35	1304	2.8		3.6		4.0	3.5			3.4	
500	IT	28/10/1991	BYR	3.7	11.1	2.9	48	2154	2.9		3.7		3.4	3.2	3.2	3.5	3.6	3.2
501	IT	31/10/1991	SYD	3.2	8.8	2.5	25	621	2.5				3.1	3.2				
502	IT	30/11/1991	BOT	4.5	8.8	2.7	249	-	2.7	3.1	3.5			3.3	4.5	3.1	3.1	
503	IT	5/12/1991	SYD	3.3	11.1	2.5	36	1095	2.6			3.2		3.3				
504	IT	13/12/1991	COF	5.0	10.3	2.9	46	1913	3.1		3.3	5.0	4.0		4.4	3.8	3.5	3.9
505	IT	29/12/1991	EDE	3.0	12.2	2.3	75	1821	2.3		3.0				2.7			3.0
506	IT	7/01/1992	EDE	3.6	12.2	2.8	70	2765	2.8			3.1	3.3		3.0	2.8	2.8	3.6
507	TC	13/01/1992	BRI	4.4	9.5	3.4	112	-	3.4	4.4	3.8	2.8	3.1		3.1			3.2

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
508	STL	28/01/1992	BAT	3.8	9.5	2.9	21	750	2.9							3.0	3.8	
509	IT	10/02/1992	PK	4.9	9.5	2.9	111	4147	3.0					4.5	4.8	4.9	4.5	4.0
510	TC	19/02/1992	COF	4.6	9.5	2.7	82	3629	2.8	4.3	4.4	4.6	4.0	3.9	3.2	3.1	3.2	4.1
511	IT	26/02/1992	BRI	4.9	10.2	2.8	184	-	1.7	4.9	4.2	3.4	3.5	3.2	3.1			
512	TC	17/03/1992	BRI	5.1	9.7	3.0	300	-	1.3	5.1	3.3	3.4						3.2
513	STL	19/03/1992	BOT	3.8	10.9	2.5	162	-	2.5		3.2		3.7	3.0	3.8	3.6		3.8
514	STL	8/04/1992	PK	4.8	11.1	3.0	33	1481	3.1	3.9	3.1	3.4	4.4	4.0	4.6	4.8		
515	IT	28/04/1992	EDE	4.0	11.1	2.8	46	1783	2.8	3.1						3.1		4.0
516	ETL	23/05/1992	BOT	4.3	9.4	2.8	73	-	2.8		3.1	3.6	3.8	4.1	4.3	3.7	3.4	
517	STL	18/06/1992	EDE	4.4	15.1	2.6	158	6568	2.7			3.1				3.0		4.4
518	SSL	27/06/1992	EDE	4.4	11.1	2.9	138	5747	2.9	3.1	3.2	3.0	3.3	3.9	3.7	3.8	3.7	4.4
519	SSL	10/07/1992	PK	3.6	10.2	2.7	71	2437	2.7		3.0			3.1		3.6	3.3	
520	SSL	21/07/1992	BOT	4.6	9.4	3.1	38	-	3.2	3.4	4.1	3.9	3.3	4.5	4.6	3.8	3.3	3.1
521	AI	26/07/1992	SYD	4.5	12.5	3.1	30	1889	3.2	3.2	3.4	3.8	3.7	4.5	3.8	3.3		
522	SSL	9/08/1992	COF	3.5	10.2	2.6	35	1162	2.7			3.5		3.4		3.1		
523	SSL	24/08/1992	SYD	4.6	10.0	2.6	105	4141	2.7	3.9	3.2	4.1	3.6	4.6	4.5	4.6	3.9	4.0
524	SSL	17/09/1992	CRO	3.9	12.2	2.8	26	1068	2.9				3.9	3.3			3.1	3.7
525	IT	25/09/1992	BAT	4.7	10.2	3.1	51	2500	3.2	3.4	4.1	3.2		3.7	3.7		4.7	4.7
526	SSL	1/10/1992	BYR	4.5	12.2	2.5	55	2052	2.5	3.2	4.5	3.4		3.1				
527	SSL	9/10/1992	EDE	3.7	10.2	3.0	44	1725	3.1		3.2	3.0						3.7
528	IT	21/10/1992	BOT	5.3	10.3	3.3	122	-	3.4	3.8	4.0	5.0	4.0	4.7	5.3	5.2	4.5	4.7
529	IT	31/10/1992	EDE	3.3	9.5	2.8	29	957	2.8									3.3
530	IT	7/11/1992	BYR	4.5	12.2	3.1	39	2012	3.2	3.3	4.5	4.3	3.9	3.3	4.1		3.0	
531	SSL	13/11/1992	EDE	5.4	12.2	3.7	78	5812	3.8		4.2	3.6	4.3	3.8	3.9	4.3	3.9	5.4
532	AI	21/11/1992	EDE	3.7	8.8	2.8	87	2887	2.9									3.7
533	IT	1/12/1992	COF	5.8	12.2	3.5	60	4186	3.7	4.3	5.2	5.8	5.2	4.3	4.1	3.7	3.3	
534	IT	6/12/1992	EDE	4.6	10.2	3.1	134	5826	3.2				3.1		3.3	3.4	4.1	4.6
535	IT	9/12/1992	CRO	3.9	10.2	2.8	112	4164	2.8	3.1	3.0		3.9		3.1			
536	NA	21/01/1993	BOT	3.1	7.6	2.6	16	-	2.6						3.1			
537	IT	25/01/1993	BAT	3.9	9.5	2.5	28	805	2.6			3.0		3.5	3.8		3.9	3.4
538	AI	7/02/1993	CRO	4.0	15.1	3.1	39	2668	3.1	3.9			4.0					3.8
539	IT	10/02/1993	EDE	3.1	9.5	2.4	37	860	2.4									3.1
540	TC	4/03/1993	COF	3.7	12.2	2.5	36	1180	2.5	3.4		3.7			3.2			
541	TC	17/03/1993	BRI	7.4	12.3	3.5	319	-	3.8	7.4	5.5	4.3	3.7		3.1	3.1		
542	SSL	30/03/1993	BOT	4.8	11.4	3.0	47	-	3.1		3.0		3.9	4.0	4.8	4.5	3.0	3.9
543	AI	15/04/1993	BYR	3.8	8.8	2.6	71	2072	2.7	3.1	3.8							
544	SSL	4/05/1993	PK	4.4	11.1	3.0	29	1405	3.1		3.4			3.9	4.4	4.4		
545	STL	15/05/1993	BYR	4.8	12.2	2.9	139	6122	3.0	3.3	4.8	3.8	3.7	4.3	4.0		3.1	
546	STL	8/06/1993	BOT	3.7	14.1	2.5	59	-	2.6		3.0				3.7	3.2		
547	STL	13/06/1993	EDE	5.3	15.1	3.1	86	5873	3.2	3.2	4.2		4.0	4.8	4.4	4.3	4.7	5.3
548	STL	24/06/1993	SYD	3.5	13.3	2.6	34	1563	2.7	2.9		2.8	2.6	3.5		2.7		3.4
549	ETL	13/07/1993	BYR	3.3	7.7	2.8	27	974	2.8	3.3	3.3	3.3						
550	ETL	30/07/1993	BRI	3.6	10.5	2.6	36	-	2.6	3.6	3.1							
551	ETL	6/08/1993	BYR	4.2	11.1	3.0	66	3279	3.1	3.6	4.2	4.1	4.1	3.6	4.0	3.4	3.3	
552	SSL	11/08/1993	CRO	4.1	11.1	2.9	29	1229	2.9				4.1					
553	STL	4/09/1993	CRO	4.8	12.2	3.1	56	3183	3.2	3.3	3.8	3.9	4.8	3.5	3.8	3.9	3.6	3.7
554	IT	16/09/1993	EDE	3.7	10.2	2.6	138	4288	2.6	3.2			3.0	3.0		3.3		3.7
555	SSL	5/10/1993	PK	4.1	9.5	3.0	26	1093	3.0		3.8		3.0	4.0	3.7	4.1	3.3	3.2
556	IT	11/10/1993	BRI	4.2	10.4	2.9	55	-	3.0	4.2	3.3	3.1		4.2				
557	SSL	27/10/1993	SYD	3.5	10.5	2.6	18	577	2.7	3.2		3.1		3.5	3.4	3.2		3.4
558	AI	31/10/1993	BRI	4.4	8.8	2.9	81	-	3.0	4.4								
559	SSL	9/11/1993	SYD	3.7	11.8	2.7	33	1306	2.7				3.1	3.7	3.4	3.4	3.5	
560	STL	23/11/1993	PK	3.8	11.1	2.9	18	764	3.0			3.3		3.1	3.0	3.8		
561	AI	5/12/1993	BOT	3.3	9.9	2.7	19	-	2.7	3.0	3.3	3.1		3.2	3.3		3.0	3.0
562	SSL	24/12/1993	CRO	3.4	11.1	2.6	25	890	2.7				3.4	3.1	3.1	3.0		3.0
563	STL	28/12/1993	EDE	4.5	12.2	3.0	50	2300	3.1									4.5
564	AI	14/01/1994	BOT	4.3	9.6	3.2	35	-	3.2		3.2	3.2			4.3			
565	TC	21/01/1994	PK	3.4	7.7	2.8	18	534	2.8	3.2	2.9	3.1	3.2	3.0	3.4	3.4	3.3	
566	AI	20/02/1994	BRI	3.6	8.7	2.5	34	-	2.6	3.6		3.1	3.3	3.2		3.3		
567	STL	28/02/1994	PK	4.8	10.2	3.2	40	2034	3.3					4.8		4.8	3.1	3.5
568	IT	3/03/1994	BRI	4.6	10.4	2.6	74	-	2.7	4.6	3.5	4.1						
569	IT	13/03/1994	EDE	6.7	13.5	3.5	209	16030	3.7	3.6	4.3	4.9	5.3	5.0	5.1	6.2	4.2	6.7
570	AI	26/03/1994	BRI	4.0	10.5	2.8	302	-	2.8	4.0	3.2				3.5	3.5		
571	AI	31/03/1994	COF	3.2	12.2	2.4	204	5789	2.4			3.2	2.9					
572	SSL	14/04/1994	SYD	5.7	11.1	3.3	80	4872	3.4	4.6	4.9	4.1	3.7	5.7	5.3	5.1	3.3	4.7
573	AI	4/05/1994	COF	3.1	8.8	2.4	57	1556	2.4	3.1		3.1						
574	AI	8/05/1994	EDE	3.4	8.8	2.6	34	1014	2.6			3.2	3.3		3.1	3.1		3.4
575	STL	20/05/1994	CRO	3.7	12.2	2.6	36	1479	2.6				3.7					
576	SSL	10/06/1994	SYD	5.4	12.5	3.1	98	5684	3.2	3.2		2.9	4.7	5.4	4.5	4.6	4.3	4.4
577	SSL	28/06/1994	CRO	3.9	8.8	2.8	49	1755	2.8		3.2	3.8	3.9	3.0	3.3	3.0	3.2	
578	SSL	15/07/1994	BYR	3.7	11.1	2.5	57	2024	2.6	3.3	3.7	3.4	3.1	3.3				
579	AI	23/07/1994	BRI	3.7	8.8	3.3	15	-	3.3	3.7	3.5	3.3		3.6	3.7		3.0	3.6
580	AI	9/08/1994	BAT	4.9	15.1	3.1	60	4068	3.2		3.3	4.4	3.5	4.2	3.3	3.3	4.9	3.3

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
581	STL	13/08/1994	BAT	3.1	8.8	2.5	9	249	2.6				2.9				3.1	
582	STL	7/09/1994	CRO	5.0	12.2	3.0	94	5352	3.1			4.0	5.0	4.2	3.6	3.6	4.0	
583	STL	21/09/1994	BRI	5.1	11.5	2.8	68	-	2.9	5.1	4.5	4.8		3.7	3.8	3.3	3.2	3.7
584	STL	26/09/1994	BOT	3.8	12.2	2.5	42	-	2.6			3.0		3.5	3.8	3.6		3.0
585	STL	12/10/1994	PK	3.6	9.5	2.7	43	1687	2.8						3.4	3.6	3.0	3.3
586	SSL	18/10/1994	BAT	3.5	9.5	2.6	14	420	2.6								3.5	
587	IT	20/10/1994	BOT	5.2	9.9	2.9	51	-	3.1	3.6	3.3	3.1		3.7	5.2	4.5	4.0	
588	SSL	31/10/1994	EDE	3.1	7.7	2.4	31	712	2.4									3.1
589	AI	16/11/1994	BRI	3.1	8.5	2.6	23	-	2.7	3.1								
590	AI	3/12/1994	BRI	4.4	10.1	2.9	122	-	2.9	4.4	3.4	4.1	3.1	3.4	3.3	3.3		
591	IT	8/12/1994	BOT	3.3	8.4	2.6	55	-	2.6		3.2			3.0	3.3			3.1
592	IT	26/12/1994	COF	3.8	11.1	2.6	37	1256	2.7	3.3		3.8			2.9	3.0		
593	IT	29/12/1994	BOT	3.9	9.2	2.8	20	-	2.8			3.7			3.9	3.5		
594	AI	2/01/1995	SYD	3.5	8.3	2.7	33	969	2.7					3.5	3.1	3.4		2.4
595	IT	8/01/1995	BYR	3.4	8.8	2.5	52	1409	2.5	3.2	3.4	3.0				3.1		
596	IT	21/01/1995	BOT	5.0	10.2	3.0	115	-	3.1	4.5	4.2		3.6	4.5	5.0	4.7	4.3	3.9
597	STL	31/01/1995	PK	3.7	8.8	2.8	23	814	2.9	3.2	3.4			3.4	3.5	3.7		
598	AI	7/02/1995	BRI	5.1	10.4	3.1	41	-	3.3	5.1		3.2						
599	TL	15/02/1995	BRI	6.4	11.2	3.1	226	-	3.2	6.4	5.8	4.0	4.0	3.6	3.4	3.7		
600	AI	24/02/1995	BRI	3.5	8.4	2.4	58	-	2.4	3.5								
601	TC	4/03/1995	CRO	7.4	13.5	3.7	206	17786	3.9	4.5	5.8	6.2	7.4	5.1	5.1	5.3	4.4	3.9
602	STL	12/03/1995	BAT	4.1	8.2	3.0	13	492	3.1								4.1	
603	TL	13/03/1995	SYD	4.5	12.5	3.8	5	401	3.8	4.4	4.1	3.2	4.1	4.5	3.9	3.4		
604	STL	24/03/1995	BAT	3.4	9.5	2.9	8	294	2.9								3.4	
605	STL	31/03/1995	PK	3.7	9.5	2.5	18	604	2.6						3.3	3.7	3.2	
606	STL	11/04/1995	CRO	4.6	15.1	2.7	68	3115	2.8	3.5		3.5	4.6	3.9	3.7	3.8	4.3	
607	STL	24/04/1995	BAT	3.2	7.7	2.5	15	356	2.5								3.2	
608	SSL	6/05/1995	BOT	5.4	-	3.6	234	-	3.7	3.0	3.6			3.5	5.4	3.7	3.1	
609	IT	18/05/1995	BOT	4.7	9.2	2.8	180	-	2.9				3.2	3.4	4.7	4.3	4.3	3.1
610	IT	17/06/1995	COF	5.1	12.2	3.1	147	7479	3.2	4.1	4.2	5.1		5.1	4.8	4.8	4.3	4.5
611	AI	8/07/1995	EDE	3.7	13.5	2.6	77	3147	2.7									3.7
612	STL	16/07/1995	BRI	3.1	10.4	2.5	40	-	2.5	3.1								
613	STL	22/07/1995	EDE	3.8	15.1	2.6	109	4682	2.7	3.1	3.2		3.2		3.0	3.3	3.3	3.8
614	STL	8/08/1995	EDE	4.4	11.1	3.0	84	3727	3.1			4.0	3.5	4.3	3.5	3.2	3.7	4.4
615	AI	16/08/1995	BRI	3.2	8.5	2.4	50	-	2.4	3.2								
616	AI	27/08/1995	BOT	3.5	9.6	2.5	29	-	2.5					3.1	3.5	3.0		
617	STL	6/09/1995	CRO	5.1	12.2	3.5	76	5617	3.6	3.1	4.7	4.4	5.1	4.4	5.0	4.2	3.3	
618	SSL	25/09/1995	BOT	7.2	11.7	3.6	133	-	3.9	4.7	4.3	4.1	5.4	5.8	7.2	6.6	5.2	4.4
619	AI	9/10/1995	BRI	4.4	8.8	3.0	34	-	3.1	4.4	3.4							
620	STL	14/10/1995	EDE	3.8	11.1	2.5	32	1074	2.6					3.3	3.6	3.3	3.2	3.8
621	AI	14/10/1995	COF	3.4	8.2	2.5	41	1172	2.5		3.3	3.4		3.2				
622	IT	24/10/1995	BOT	4.7	9.4	3.2	33	-	3.3		3.6			4.3	4.7	4.2	3.4	3.7
623	STL	30/10/1995	BAT	3.2	7.7	2.6	6	152	2.6								3.2	
624	CL	5/11/1995	EDE	4.3	8.2	3.0	68	2831	3.1									4.3
625	AI	13/11/1995	BRI	3.5	10.2	2.7	54	-	2.7	3.5	3.0	3.0						
626	IT	23/11/1995	SYD	3.8	10.5	2.5	32	1024	2.6	3.2			3.3	3.8				3.4
627	IT	12/12/1995	COF	3.7	8.8	2.5	35	946	2.6			3.7	3.4					3.4
628	STL	21/12/1995	EDE	4.8	12.2	2.9	103	4522	3.0	4.6		3.9	3.6	4.5	4.2	4.1	3.7	4.8
629	TC	11/01/1996	BYR	3.2	8.8	2.3	100	2534	2.4		3.2	2.6						
630	TC	15/02/1996	BRI	6.2	12.9	3.2	123	-	3.3	6.2	5.4		4.7	4.9	3.5	3.5	3.5	4.3
631	AI	22/02/1996	BRI	4.4	9.5	3.0	140	-	3.1	4.4	3.5							
632	AI	9/03/1996	BRI	3.5	10.3	2.4	221	-	2.5	3.5	3.2		3.1		3.1			
633	STL	18/03/1996	BOT	4.0	14.9	2.9	38	-	3.0		3.1	3.3		3.9	4.0			
634	TC	29/03/1996	BRI	3.6	12.1	2.6	221	-	2.6	3.6	2.8							
635	SSL	12/04/1996	BAT	3.9	8.2	2.7	45	1483	2.8						3.2		3.9	3.2
636	ETL	28/04/1996	BYR	4.0	11.1	3.0	29	1219	3.0		4.0	3.5		3.1				
637	ETL	2/05/1996	BRI	6.9	11.9	3.5	263	-	3.8	6.9	4.7	5.2		3.7		3.4	3.0	3.5
638	ETL	17/05/1996	BRI	4.8	10.3	3.1	166	-	3.2	4.8	4.4	3.9		4.1		4.1		4.4
639	ETL	21/05/1996	SYD	3.1	9.5	2.7	51	1726	2.7					3.1	3.1			
640	ETL	16/06/1996	BYR	3.1	9.5	2.3	45	1113	2.4	3.0	3.1							2.9
641	STL	24/06/1996	BOT	3.8	10.2	3.2	4	-	3.2					3.6	3.8	3.1		
642	STL	9/07/1996	PK	3.6	12.2	2.9	63	2803	3.0		3.1				3.1	3.6		3.1
643	SSL	16/07/1996	CRO	4.4	11.1	3.0	123	6325	3.1	3.2			4.4	3.7	3.8	4.1	3.3	4.4
644	CL	29/07/1996	PK	4.3	11.1	2.9	51	2258	3.0			3.1	3.1	3.4	3.4	4.3		4.1
645	STL	9/08/1996	CRO	4.0	12.2	2.5	67	2219	2.6				4.0		3.4		3.8	3.5
646	SSL	19/08/1996	BOT	6.3	10.1	3.4	54	-	3.6	3.9	4.0	4.4	5.8	5.2	6.3	4.7		
647	IT	31/08/1996	PK	7.4	13.5	3.2	119	7397	3.5					6.1	6.5	7.4	7.2	6.8
648	SSL	11/09/1996	EDE	3.7	8.2	2.8	28	1021	2.8									3.7
649	SSL	22/09/1996	BYR	4.5	10.2	3.0	39	1705	3.1	3.5	4.5	3.4	3.1		3.2			3.4
650	STL	29/09/1996	PK	3.2	8.2	2.4	26	600	2.4							3.2		
651	AI	8/10/1996	BRI	3.7	9.4	2.7	38	-	2.7	3.7								
652	SSL	20/10/1996	COF	3.5	7.7	2.3	59	1415	2.3	3.4	3.4	3.5		3.1	3.1		3.0	
653	IT	7/11/1996	BYR	4.4	12.2	3.0	68	3211	3.1		4.4			4.1	4.0	3.9	3.3	3.4

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
654	CL	19/11/1996	PK	6.1	13.5	3.2	93	6187	3.4		3.7	4.3	4.3	4.9	5.5	6.1		4.6
655	STL	7/12/1996	EDE	3.6	11.1	2.6	23	691	2.6				3.0	3.0		3.1		3.6
656	IT	13/12/1996	BYR	4.1	11.1	3.0	19	827	3.1	3.3	4.1	3.3	3.7	3.4	3.3	3.1		
657	TC	26/12/1996	SYD	3.4	8.3	2.4	48	1068	2.4		3.2		3.1	3.4	3.3			3.0
658	TC	8/01/1997	SYD	4.5	13.3	3.0	59	3043	3.1	3.3	4.4	3.4	3.3	4.5	4.3	4.1	3.8	3.5
659	IT	2/02/1997	BRI	4.0	7.9	2.7	204	-	2.7	4.0			3.7		3.2	3.2		
660	IT	12/02/1997	BOT	3.4	9.1	2.4	62	-	2.4					3.1	3.4	3.3		
661	TC	20/02/1997	BRI	3.1	8.5	2.5	92	-	2.5	3.1								
662	TL	28/02/1997	BYR	3.2	12.2	2.6	39	1430	2.6	3.1	3.2							
663	IT	2/03/1997	EDE	3.8	8.8	2.8	38	1382	2.9					3.2	3.2		3.2	3.8
664	TC	10/03/1997	BRI	4.2	9.1	2.7	199	-	2.7	4.2	3.6		3.1	3.0		3.1	3.3	
665	STL	13/03/1997	BAT	3.2	8.2	2.5	16	477	2.5								3.2	
666	SSL	24/03/1997	CRO	3.2	10.2	2.4	36	968	2.4		3.1		3.2					3.0
667	IT	1/04/1997	EDE	3.1	10.2	2.4	28	727	2.5									3.1
668	SSL	7/04/1997	COF	5.2	13.5	3.2	54	3256	3.3	4.4	5.0	5.2	3.8	3.5	4.6	4.3	4.0	3.4
669	STL	18/04/1997	BAT	3.4	8.2	2.5	23	696	2.5					3.3	3.3		3.4	
670	AI	27/04/1997	BRI	3.7	8.6	2.7	37	-	2.8	3.7								
671	ETL	10/05/1997	BOT	8.9	13.1	3.3	275	-	3.7	4.3	6.0	5.6	6.3	8.4	8.9	8.4		5.9
672	IT	17/05/1997	BRI	4.0	9.6	2.5	49	-	2.6	4.0	3.8	3.1	3.1			3.4		
673	AI	1/06/1997	BYR	3.2	9.5	2.6	63	1787	2.6		3.2				3.0			
674	ETL	16/06/1997	CRO	4.6	12.2	2.9	118	5012	3.0	4.0	3.1	4.2	4.6	3.7	3.6	3.3	3.2	3.2
675	ETL	26/06/1997	PK	5.2	11.1	2.9	206	8535	2.9	3.2	4.5	4.1	3.2	3.9	4.4	5.2	3.1	5.1
676	STL	10/07/1997	CRO	4.3	11.1	2.8	40	1768	2.9		3.1		4.3					3.5
677	AI	22/07/1997	BOT	3.7	11.0	2.8	33	-	2.8				3.1	3.3	3.7	3.6		
678	AI	3/08/1997	BYR	3.7	12.2	2.7	82	3106	2.8	3.1	3.7		3.0	3.4	3.3	3.1		
679	STL	12/08/1997	BOT	3.2	10.2	2.3	34	-	2.4					3.2	3.2			
680	AI	20/08/1997	EDE	3.1	12.2	2.5	21	726	2.5									3.1
681	STL	25/08/1997	EDE	3.4	11.1	2.4	46	1402	2.5									3.4
682	SSL	6/09/1997	EDE	3.8	10.2	2.6	116	3582	2.6					3.1	3.3	3.3	3.4	3.8
683	CL	17/09/1997	SYD	3.8	13.3	2.8	36	1604	2.8					3.8	3.6	3.4	3.3	3.2
684	IT	25/09/1997	PK	3.7	10.2	2.5	95	2584	2.5		3.0		3.0	2.8	3.0	3.7	3.6	
685	SSL	29/09/1997	BYR	3.2	9.5	2.5	44	1255	2.5		3.2	3.1			3.1			
686	IT	8/10/1997	EDE	4.7	8.8	2.8	42	1636	2.9		3.5	3.7	3.4	3.9	3.7	4.0		4.7
687	STL	13/10/1997	COF	3.1	10.2	2.5	29	888	2.5		3.1	3.1						
688	STL	21/10/1997	BOT	3.7	9.1	2.7	47	-	2.7				3.7	3.7	3.7	3.4		
689	STL	1/11/1997	EDE	3.4	10.2	2.8	27	931	2.8						3.2	3.2		3.4
690	IT	3/12/1997	BRI	3.4	8.2	2.7	21	-	2.7	3.4								
691	IT	10/12/1997	BRI	4.4	9.8	3.2	59	-	3.2	4.4			3.5	3.9	4.4	4.3		3.0
692	AI	15/01/1998	BOT	3.1	8.9	2.4	18	-	2.4	2.7					3.1			
693	IT	9/02/1998	COF	4.3	9.5	2.7	36	1200	2.7		3.8	4.3			3.2	3.3		
694	IT	17/02/1998	BOT	3.6	9.8	2.8	27	-	2.8					3.3	3.6	3.5		
695	STL	23/02/1998	BOT	4.2	10.1	3.0	31	-	3.1	3.6	3.4	3.5		3.6	4.2	3.8		
696	STL	28/02/1998	PK	3.3	10.2	2.6	19	573	2.6						3.0	3.3		
697	SSL	7/03/1998	SYD	5.7	11.8	3.4	80	5394	3.5	3.7	5.1	5.5		5.7	4.5		3.3	5.3
698	SSL	9/03/1998	BAT	3.3	11.1	2.9	16	665	2.9						3.0		3.3	
699	TC	26/03/1998	BRI	6.0	13.1	3.6	67	-	3.8	6.0	5.1	4.2	3.5	3.4	3.2		4.3	
700	AI	2/04/1998	BYR	3.6	8.8	2.7	22	904	2.7	3.4	3.6							
701	AI	15/04/1998	BRI	3.0	9.0	2.4	111	-	2.4	3.0	3.0							
702	IT	27/04/1998	EDE	4.1	10.2	2.9	36	1502	2.9					3.3	3.0			4.1
703	ETL	6/05/1998	EDE	6.0	12.2	3.6	47	3558	3.8		3.6	3.2	3.5	3.8	3.9		3.8	6.0
704	ETL	19/05/1998	PK	5.0	10.2	2.9	101	4552	3.0		3.1		3.5	4.9	4.9	5.0	3.6	3.7
705	SSL	25/05/1998	SYD	3.8	10.0	2.9	44	1797	2.9		3.6			3.8	3.7	3.5	3.0	3.2
706	ETL	5/06/1998	SYD	4.4	12.5	2.9	88	4102	3.0		3.8	3.0	3.2	4.4	4.2	3.5		
707	STL	8/06/1998	SYD	4.8	12.5	2.8	76	3271	2.9				4.6	4.8	4.4	4.2	3.5	4.2
708	AI	17/06/1998	PK	3.7	9.5	2.8	39	1315	2.8		3.6			3.1	3.1	3.7		3.3
709	SSL	23/06/1998	EDE	6.4	10.2	3.6	96	7014	3.8		3.2			4.1	3.8	3.6	3.6	6.4
710	SSL	2/07/1998	BYR	5.2	13.5	3.3	37	2780	3.5	5.2	5.2	4.2	4.5	4.8	4.6			4.4
711	SSL	10/07/1998	BOT	4.2	10.7	3.2	26	-	3.3				3.0	3.8	4.2	3.6		
712	ETL	15/07/1998	SYD	4.0	10.0	2.8	67	2669	2.9		3.0	3.0	3.7	4.0		3.7		
713	STL	28/07/1998	EDE	3.3	8.8	2.5	87	2387	2.5									3.3
714	IT	7/08/1998	BOT	6.0	9.8	4.0	103	-	4.1	3.4	4.7	4.2	4.6	5.0	6.0	3.7	4.5	5.6
715	IT	17/08/1998	PK	4.2	8.8	3.0	62	2404	3.0	4.1	3.6	4.2	3.8	3.7	3.8	4.2	3.3	3.4
716	IT	27/08/1998	CRO	4.1	13.5	2.8	57	2711	2.9	3.9	3.5	3.7	4.1	3.7	3.6	3.5		3.2
717	STL	5/09/1998	BOT	3.2	7.9	2.5	14	-	2.5	3.0	3.1			3.1	3.2			
718	AI	16/09/1998	PK	3.4	10.2	2.6	28	982	2.6		3.0					3.4		
719	STL	25/09/1998	BOT	4.0	8.6	2.8	39	-	2.9					3.6	4.0	3.3		3.4
720	STL	8/10/1998	BOT	3.5	12.4	2.6	81	-	2.6		3.4		3.4	3.3	3.5	3.2		3.3
721	STL	21/10/1998	BYR	3.7	11.1	2.9	32	1348	2.9	3.6	3.7	3.5				3.5		
722	SSL	28/10/1998	EDE	3.3	10.2	2.5	58	1858	2.6				3.0			3.1		3.3
723	SSL	1/11/1998	BOT	4.9	9.7	3.3	89	-	3.4	3.9		4.1	3.5	4.6	4.9	4.1	4.2	3.7
724	ETL	19/11/1998	COF	5.7	12.2	3.2	80	4705	3.4	4.8		5.7	3.8	4.0	3.9	3.6	3.0	
725	IT	26/11/1998	BRI	4.1	9.8	2.4	91	-	2.5	4.1	3.1	3.1	3.3		3.1	3.4	3.3	
726	IT	15/12/1998	EDE	3.5	10.2	2.7	64	2055	2.7	3.0	3.2				3.3			3.5

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
727	IT	14/01/1999	BAT	3.6	8.8	2.8	15	498	2.8						3.1		3.6	3.6
728	TC	20/01/1999	BOT	3.3	7.9	2.3	102	-	2.4		2.9				3.3	2.8		3.2
729	ETL	5/02/1999	COF	5.3	13.5	3.0	88	4835	3.2	3.3	5.0	5.3	5.3	3.4	3.5	4.5		3.2
730	TC	10/02/1999	COF	3.6	11.1	2.8	152	5952	2.8	3.1		3.6				3.4		2.6
731	STL	19/02/1999	BOT	4.3	9.8	2.9	27	-	3.0				3.0		4.3	3.3		
732	TC	23/02/1999	COF	3.7	12.2	2.4	88	2837	2.5			3.7	3.3		3.6	3.7	3.4	
733	AI	9/03/1999	BRI	3.4	9.4	2.7	46	-	2.7	3.4		3.0	3.1		3.2			
734	AI	23/03/1999	BRI	3.9	9.0	2.6	77	-	2.7	3.9	3.5	3.5	3.6			3.7	3.2	3.7
735	SSL	29/03/1999	EDE	3.7	10.2	2.4	35	936	2.5		3.3		3.3				3.2	3.7
736	SSL	6/04/1999	BOT	4.6	9.9	2.6	36	-	2.7		4.0	3.1	3.1	4.4	4.6	4.5	3.5	3.5
737	AI	11/04/1999	BRI	4.0	10.4	2.6	300	-	2.6	4.0		3.6						
738	STL	21/04/1999	PK	4.2	9.5	3.2	18	796	3.2					3.2		4.2		
739	SSL	23/04/1999	CRO	6.5	15.1	3.7	110	10434	3.9	4.4	4.4	4.9	6.5	6.2		4.8	4.8	4.0
740	STL	28/04/1999	BOT	6.7	11.8	3.4	254	-	3.6		3.5		4.0		6.7	4.6	4.9	4.8
741	ETL	11/05/1999	BYR	3.7	9.5	2.6	48	1521	2.6	3.4	3.7	3.3						
742	ETL	24/05/1999	BRI	5.4	14.7	3.3	214	-	3.4	5.4	5.0	5.3	4.4	4.5	3.7	4.1	4.0	5.0
743	AI	2/06/1999	BRI	3.8	10.5	2.8	48	-	2.8	3.8	3.7	3.3	3.3		3.0	3.2		
744	SSL	12/06/1999	BOT	4.6	12.3	3.6	35	-	3.7	3.0	3.3		4.0	4.6	4.6	4.4	4.3	4.4
745	AI	28/06/1999	BRI	4.0	9.4	2.7	247	-	2.7	4.0		3.3	3.2			3.0		
746	SSL	2/07/1999	SYD	4.5	9.1	3.2	41	2019	3.2		4.0	3.6	3.8	4.5	3.4	3.2		
747	ETL	14/07/1999	COF	6.8	12.2	3.7	107	9182	3.9	4.1	4.7	6.8	6.8	6.1	5.6	5.1	4.5	3.9
748	AI	26/07/1999	BYR	4.8	11.1	2.9	142	5864	3.0	4.6	4.8	3.6	3.4		3.0			
749	SSL	1/08/1999	SYD	3.8	9.1	3.0	34	1379	3.0				3.4	3.8	3.6	3.6		
750	STL	6/08/1999	BRI	3.2	10.3	2.4	42	-	2.4	3.2								3.1
751	STL	15/08/1999	SYD	4.9	12.5	3.5	42	3106	3.6		3.3			4.9	4.2			4.0
752	STL	21/08/1999	PK	4.1	10.2	2.4	34	1130	2.5						3.3	4.1		
753	AI	30/08/1999	BRI	4.1	12.1	3.0	89	-	3.0	4.1	3.6	3.1						3.0
754	STL	4/09/1999	EDE	3.2	8.2	2.7	36	1274	2.7									3.2
755	IT	12/09/1999	SYD	4.5	13.3	3.1	102	5742	3.2	3.1	3.0	2.9	3.0	4.5	4.4	4.0	3.9	4.1
756	STL	20/09/1999	EDE	3.3	11.1	2.3	56	1498	2.3	3.1								3.3
757	IT	9/10/1999	BRI	3.2	10.7	2.4	78	-	2.4	3.2	2.8							
758	IT	19/10/1999	SYD	3.6	8.3	2.6	26	704	2.6					3.6	3.4			
759	IT	24/10/1999	BAT	6.6	12.2	3.8	62	5338	4.1				3.3	4.0	4.1	5.1	6.6	5.2
760	IT	1/11/1999	BRI	4.8	11.3	3.0	103	-	3.1	4.8	4.3	3.6	3.2	2.6	2.8			3.5
761	IT	11/11/1999	BYR	5.7	15.0	3.5	101	9155	3.6	4.3	5.7	4.3	5.0	5.0	4.3	4.4	4.5	4.3
762	IT	17/11/1999	BRI	3.1	7.7	2.4	21	-	2.4	3.1								
763	AI	27/11/1999	CRO	3.3	9.5	2.6	28	785	2.6	3.1	3.0	3.0	3.3					
764	STL	12/12/1999	BOT	3.8	9.9	2.6	61	-	2.6					3.3	3.8	3.5		
765	STL	19/12/1999	PK	3.9	12.2	2.7	72	2969	2.8					3.2	3.9	3.9	3.0	3.3
766	IT	29/12/1999	SYD	5.5	13.5	3.6	84	5948	3.7	3.5			3.0	5.5	4.1	3.4	4.3	4.4
767	IT	5/01/2000	EDE	5.4	13.5	3.3	57	3368	3.4		4.0	4.7		4.8	4.2	4.3	4.8	5.4
768	AI	13/01/2000	BRI	4.4	10.8	2.7	98	-	2.8	4.4		4.1	3.7		2.9	3.3		
769	AI	24/01/2000	BRI	3.3	9.5	2.6	39	-	2.6	3.3				3.1				
770	IT	29/01/2000	BOT	4.1	8.9	2.8	79	-	2.8	3.0	3.2			3.5	4.1	3.5		3.0
771	SSL	14/02/2000	BYR	4.5	10.2	3.0	76	3848	3.1	4.3	4.5	4.0	3.3	4.1	4.1		3.4	2.9
772	IT	9/03/2000	EDE	5.0	10.2	2.7	73	2639	2.7				4.6	4.7	4.5		3.1	5.0
773	AI	15/03/2000	BYR	3.2	13.5	2.6	33	1606	2.6		3.2							
774	IT	25/03/2000	BRI	4.4	9.7	2.6	117	-	2.6	4.4	3.5	3.1	3.4	3.7	3.4		3.7	
775	IT	6/04/2000	BOT	5.9	10.4	3.7	36	-	3.8	3.9	4.3	3.8		5.0	5.9	5.8	3.8	4.1
776	AI	2/05/2000	BRI	4.8	12.1	2.9	437	-	3.0	4.8	4.1	3.6	3.6	4.4	3.7	4.3	3.7	4.5
777	ETL	7/05/2000	BYR	4.4	13.5	2.9	56	2568	3.0		4.4							
778	STL	21/05/2000	CRO	3.3	9.5	2.5	31	1063	2.5				3.3					
779	STL	1/06/2000	EDE	5.9	13.5	3.4	93	6485	3.6		4.3	4.7		5.0	5.2	5.6	3.9	5.9
780	SSL	7/06/2000	COF	3.3	11.1	2.6	36	1181	2.6			3.3						
781	AI	11/06/2000	BYR	4.1	9.4	2.7	121	4204	2.8	3.4	4.1	3.9		3.6	3.5	3.1		3.4
782	SSL	30/06/2000	SYD	6.1	11.1	3.2	157	9996	3.4	3.6		3.7	4.6	6.1	5.9	5.8	5.3	4.6
783	SSL	17/07/2000	BYR	5.2	12.2	2.8	163	7478	2.9	3.8	5.2	4.2	4.7	4.2	4.2		3.4	3.1
784	STL	12/08/2000	PK	3.3	10.2	2.5	34	1233	2.5			3.0	3.1			3.3		
785	SSL	17/08/2000	CRO	4.7	12.2	2.7	109	4666	2.8		3.6	4.1	4.7	3.9	4.0	3.8	3.0	
786	SSL	2/09/2000	COF	3.6	11.1	2.8	11	474	2.9			3.6						
787	AI	26/09/2000	PK	4.7	11.1	3.0	31	1372	3.1				3.5		3.9	4.7	4.4	3.5
788	STL	11/10/2000	BOT	3.9	10.8	2.9	14	-	3.0				3.8	3.2	3.9	3.6		3.8
789	IT	31/10/2000	BRI	5.2	9.6	2.8	114	-	2.9	5.2	3.3	3.2				3.1		3.7
790	IT	14/11/2000	PK	3.2	8.2	2.6	30	860	2.6						3.0	3.2		
791	STL	1/12/2000	SYD	3.2	8.2	2.7	15	460	2.7					3.2	3.2	3.2	3.0	
792	AI	16/12/2000	BRI	3.1	8.5	2.4	8	-	2.4	3.1								
793	STL	30/12/2000	BAT	3.1	9.5	2.4	58	1592	2.4	3.0						2.7	3.1	
794	TL	9/01/2001	BYR	3.7	11.1	2.8	43	1579	2.8	3.1	3.7			3.1	3.1	3.3	3.0	3.2
795	IT	19/01/2001	BRI	4.7	9.8	3.1	58	-	3.2	4.7	3.3	3.3		3.6	3.6	4.1	4.7	3.3
796	IT	1/02/2001	BRI	5.4	10.0	3.6	88	-	3.8	5.4			4.1	3.1	2.9	2.7		
797	TL	16/02/2001	BYR	3.7	10.2	2.5	105	3078	2.5	3.7	3.7	2.8						
798	ETL	5/03/2001	BYR	5.1	10.2	3.8	119	9146	3.9	4.9	5.1	5.1	4.4	4.5			3.2	3.9
799	SSL	17/03/2001	EDE	3.6	9.5	2.9	18	656	2.9							3.4		3.6

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
800	TL	28/03/2001	BOT	4.2	10.1	2.5	37	-	2.6	2.8	3.2		3.1	3.4	4.2	4.1	3.1	
801	TC	12/04/2001	BYR	5.0	12.2	2.8	141	6875	2.9	5.0	5.0		4.5	4.3	3.8	4.0	4.3	3.4
802	IT	21/04/2001	EDE	4.6	9.5	2.8	71	2974	2.9									4.6
803	TL	30/04/2001	BRI	2.7	10.3	2.2	98	-	2.2	2.7					2.7			
804	ETL	11/05/2001	EDE	4.5	11.1	2.6	217	5636	2.7			2.8	3.6	4.3	4.3	4.1	3.0	4.5
805	ETL	18/05/2001	BOT	4.0	8.4	2.8	37	-	2.9	3.7	3.3	3.2		3.2	4.0	3.6		3.3
806	SSL	29/05/2001	SYD	3.8	8.8	2.6	51	1583	2.6	3.5	3.3	3.2	3.1	3.8	3.7	3.7		
807	STL	10/06/2001	EDE	3.2	8.8	2.4	23	590	2.4									3.2
808	SSL	16/06/2001	PK	4.5	12.2	3.0	81	4080	3.0	3.9		3.8	3.6	3.7	4.0	4.5	3.3	4.1
809	AI	28/06/2001	BRI	3.1	8.2	2.3	64	-	2.3	3.1						3.0		
810	SSL	8/07/2001	EDE	5.9	11.1	3.4	149	8093	3.5	4.3	4.8	3.3	3.5	3.2	3.3	3.4	3.7	5.9
811	STL	19/07/2001	SYD	4.0	11.1	3.0	115	5664	3.0			2.8	3.2	4.0	3.5	3.5	2.9	3.0
812	ETL	28/07/2001	BOT	8.1	12.5	4.4	99	-	4.7	3.1		3.8	6.3	7.0	8.1	6.3	5.4	4.5
813	STL	19/08/2001	COF	3.9	13.5	2.5	51	1859	2.5			3.9				3.4		
814	SSL	23/08/2001	BOT	4.0	11.2	2.7	52	-	2.8				3.2		4.0	3.9	3.7	3.7
815	STL	8/09/2001	EDE	3.1	7.7	2.5	21	482	2.5									3.1
816	SSL	26/09/2001	COF	4.1	12.2	2.8	62	2448	2.9	3.2	3.9	4.1	3.0	3.9	4.0	3.4	3.2	3.1
817	SSL	8/10/2001	PK	4.9	12.2	3.6	35	2498	3.7			4.1	3.6	4.8	4.4	4.9	4.6	4.0
818	STL	14/10/2001	BAT	3.0	8.8	2.5	9	254	2.6								3.0	
819	SSL	20/10/2001	COF	4.0	8.8	2.8	43	1635	2.9			4.0		3.4	3.2	3.3	3.1	
820	IT	7/11/2001	BOT	3.5	8.0	2.6	34	-	2.6						3.5	3.2		3.1
821	IT	14/11/2001	SYD	3.9	12.2	3.0	38	1872	3.1	3.4			3.5	3.9	3.5	3.3	3.6	3.5
822	CL	21/11/2001	SYD	6.2	11.1	4.2	108	10688	4.3	4.3	4.7	5.2	4.5	6.2	5.9	4.9	4.8	5.3
823	ETL	28/11/2001	BYR	3.6	9.4	2.8	33	1172	2.9	3.2	3.6							
824	CL	3/12/2001	EDE	4.2	10.2	2.6	141	4738	2.7				3.0	3.5	3.3	4.2	3.6	4.2
825	STL	12/12/2001	BOT	3.5	11.0	2.7	35	-	2.7					3.4	3.5	3.2		
826	SSL	10/01/2002	EDE	3.5	11.1	2.5	177	4996	2.5				2.7		3.3	3.1	3.1	3.5
827	TL	26/01/2002	BRI	3.8	10.5	2.8	209	-	2.8	3.8	3.7	3.5						
828	AI	5/02/2002	SYD	4.1	8.8	2.4	133	3538	2.5	3.5	3.0	3.7	2.9	4.1	3.5	3.2		
829	IT	10/02/2002	EDE	6.0	11.1	3.6	63	4570	3.8	3.2	3.5	3.2		3.7	3.6	3.1	3.5	6.0
830	TC	8/03/2002	BOT	3.4	8.7	2.4	21	-	2.5	2.5				2.7	3.4			
831	IT	11/03/2002	COF	3.5	12.2	2.4	67	1998	2.5	3.0	3.1	3.5						
832	AI	23/03/2002	BRI	3.8	10.2	2.8	58	-	2.9	3.8		3.4		3.0				
833	IT	31/03/2002	BYR	5.0	11.1	2.9	72	3176	3.0	4.8	5.0	3.6		3.8	3.7	4.0		3.1
834	STL	4/04/2002	SYD	3.5	9.4	2.9	17	637	2.9	3.3				3.5	3.1	3.2		
835	ETL	22/04/2002	SYD	4.3	9.4	2.5	97	3022	2.6			3.0		4.3	4.2	3.8	4.3	
836	AI	1/05/2002	BRI	2.8	12.2	2.3	182	-	2.3	2.8	2.8							
837	SSL	11/05/2002	SYD	3.8	9.4	2.7	24	761	2.7	3.2	3.5		3.4	3.8				
838	STL	20/05/2002	EDE	4.2	10.3	2.7	194	7898	2.8						3.4		3.8	4.2
839	ETL	29/05/2002	SYD	4.6	17.1	2.7	186	8505	2.7		3.0	3.6	3.9	4.6	3.8	3.7		
840	AI	3/06/2002	BRI	3.9	9.3	2.6	193	-	2.6	3.9	3.0							
841	STL	18/06/2002	EDE	5.9	13.5	3.4	99	6927	3.6	5.1	3.1	5.3		5.0	4.5	4.2	4.7	5.9
842	SSL	29/06/2002	EDE	7.1	12.2	3.5	78	6072	3.8	4.7	4.2	5.7	6.3	6.2	5.5	5.2	4.5	7.1
843	SSL	10/07/2002	CRO	4.3	12.2	2.9	40	1917	3.0	4.1	3.6	3.9	4.3	3.7	3.5			
844	SSL	22/07/2002	BRI	3.7	9.8	2.8	36	-	2.9	3.7	3.2		3.4					
845	SSL	25/07/2002	CRO	4.6	11.1	3.3	38	2491	3.5	2.8	3.6		4.6	4.4	4.3	3.3		3.9
846	SSL	5/08/2002	CRO	3.6	12.2	2.9	29	1316	2.9	3.3			3.6	3.4	3.2	3.1		
847	STL	16/08/2002	SYD	5.8	12.2	3.9	98	9545	4.0		4.2	3.6	4.8	5.8	5.4	4.6	4.6	4.9
848	STL	23/08/2002	BOT	4.0	9.8	3.0	53	-	3.1	3.6	3.7	3.4	3.4	4.0	4.0	3.6		
849	STL	3/09/2002	EDE	3.7	8.8	2.8	16	494	2.8		3.2	3.6						3.7
850	AI	11/09/2002	BRI	3.5	9.7	2.5	52	-	2.6	3.5	3.2	3.2				3.4		
851	STL	20/09/2002	SYD	3.7	12.2	2.9	49	2458	2.9					3.7	3.1			3.6
852	STL	8/10/2002	EDE	3.9	11.1	2.9	42	1824	2.9	3.3					3.2	3.1	3.1	3.9
853	STL	26/10/2002	SYD	3.7	9.4	2.6	66	2095	2.7	3.5	3.1	3.4	3.0	3.7	3.2	3.1		3.3
854	AI	16/11/2002	BRI	4.5	9.9	2.8	49	-	2.9	4.5	3.5					3.1		3.7
855	IT	1/12/2002	BAT	3.3	8.8	2.5	23	598	2.6						3.2		3.3	
856	STL	7/12/2002	SYD	3.8	8.8	2.5	48	1601	2.6			3.1		3.8	3.3			
857	IT	11/12/2002	SYD	5.2	8.8	3.1	81	3857	3.2	4.1	4.5	3.4	4.4	5.2	4.5	3.2		
858	STL	25/12/2002	BAT	3.3	8.2	2.3	22	600	2.4	2.8				3.2			3.3	
859	AI	5/01/2003	BRI	3.5	9.3	2.6	73	-	2.7	3.5								
860	IT	9/01/2003	SYD	4.9	12.2	2.7	101	3868	2.8	3.8	3.6	4.0	3.3	4.9	4.5	3.7	4.0	3.2
861	TC	2/02/2003	BRI	4.9	9.7	3.1	123	-	3.2	4.9	4.4	3.1						
862	IT	24/02/2003	COF	4.0	9.5	2.7	71	2436	2.8	3.5		4.0		3.0	3.0	3.2		3.8
863	TC	2/03/2003	CRO	3.9	10.2	2.7	105	4001	2.7	3.3			3.9				3.1	3.8
864	STL	20/03/2003	EDE	4.3	9.5	2.6	114	3568	2.7									4.3
865	IT	3/04/2003	BOT	4.5	10.1	2.8	96	-	2.9	3.5			4.2	3.9	4.5	3.5	3.3	3.8
866	SSL	18/04/2003	SYD	4.8	13.5	3.1	145	7797	3.2	3.3		4.6	3.9	4.8	4.4	4.2	3.5	3.3
867	AI	26/04/2003	BRI	3.3	9.3	2.5	78	-	2.5	3.3								
868	SSL	4/05/2003	SYD	5.7	11.1	3.5	83	6328	3.6	4.8		5.7	4.8	5.7	5.4	3.6		4.4
869	SSL	11/05/2003	SYD	3.3	11.1	2.6	22	710	2.6					3.3	3.1	3.1		
870	ETL	15/05/2003	CRO	4.7	9.5	2.6	115	3695	2.6	3.7		3.7	4.7	4.0	4.1	3.8	3.7	4.1
871	AI	28/05/2003	BRI	4.3	10.9	3.0	63	-	3.1	4.3		3.1	3.5			3.1		
872	ETL	27/06/2003	COF	5.4	12.2	3.7	31	2524	3.8	4.4	3.9	5.4	4.6	5.0	4.2	4.6	4.4	3.7

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
873	ETL	3/07/2003	BRI	4.2	12.1	2.9	110	-	2.9	4.2		3.3	3.8		3.1	3.0	3.6	
874	STL	11/07/2003	EDE	3.4	7.7	2.7	23	635	2.7	3.0								3.4
875	AI	17/07/2003	BRI	3.1	12.2	2.6	101	-	2.6	3.1								
876	STL	24/07/2003	EDE	4.2	8.2	2.8	29	920	2.8					3.5	3.1			4.2
877	SSL	31/07/2003	SYD	5.3	13.5	3.7	71	6116	3.8			3.3	3.9	5.3	4.3	3.8	4.1	4.8
878	SSL	10/08/2003	PK	4.2	11.1	3.1	31	1750	3.2					4.1		4.2		
879	STL	14/08/2003	PK	4.0	11.1	2.8	53	2516	2.9					3.8		4.0		3.1
880	STL	24/08/2003	EDE	4.4	8.8	2.7	36	1210	2.8				3.5	4.0		3.8		4.4
881	STL	4/09/2003	BYR	5.9	13.5	3.5	38	3685	3.7	3.9	5.9	3.6	4.8	4.9	4.8	5.4	3.9	3.1
882	SSL	9/09/2003	BRI	3.8	12.1	2.8	61	-	2.8	3.8	3.6		3.3	3.4	3.2	3.4	3.2	
883	SSL	28/09/2003	BYR	4.3	12.2	2.7	54	2196	2.7		4.3	3.9						
884	CL	3/10/2003	PK	4.3	10.2	2.9	53	2272	2.9		3.4	3.9	3.8		4.0	4.3		3.9
885	SSL	11/10/2003	SYD	5.0	12.2	3.6	76	5336	3.7	3.2	4.6	4.2	3.7	5.0	4.6	3.7		4.6
886	IT	27/10/2003	PK	4.2	12.2	2.6	71	2776	2.7					3.6	3.6	4.2		3.2
887	IT	3/11/2003	BRI	3.9	8.9	2.8	46	-	2.8	3.9		3.2				3.9		
888	AI	13/11/2003	BRI	3.1	8.4	2.5	35	-	2.5	3.1								
889	IT	17/11/2003	SYD	3.5	10.2	2.7	55	1950	2.8	3.2		3.2	3.4	3.5	3.1	3.4	3.3	3.5
890	IT	24/11/2003	CRO	4.3	8.8	2.9	108	4379	2.9	3.3	3.4	3.2	4.3	3.3	3.5	2.9	2.5	
891	IT	6/12/2003	BRI	4.8	10.9	3.3	57	-	3.4	4.8	4.4	3.7	4.3	3.4	3.6	3.3	3.6	
892	IT	28/12/2003	BRI	3.0	9.8	2.5	149	-	2.5	3.0								
893	IT	9/01/2004	BRI	3.2	7.7	2.8	20	-	2.8	3.2								
894	AI	19/01/2004	BRI	4.2	9.0	3.0	54	-	3.1	4.2	3.3							3.0
895	IT	31/01/2004	EDE	3.0	7.3	2.4	49	1256	2.5									3.0
896	STL	16/02/2004	BAT	3.6	9.4	2.7	10	314	2.7							3.0	3.6	3.1
897	IT	25/02/2004	COF	6.5	11.1	3.1	182	10113	3.3	3.7		6.5		5.5	4.7	5.1	3.5	3.9
898	ETL	5/03/2004	BRI	7.0	12.1	3.2	154	-	3.4	7.0		4.1		3.1	3.1			
899	STL	10/03/2004	SYD	3.7	11.1	2.6	36	1251	2.7			3.1		3.7	3.6	3.5	3.4	
900	TC	24/03/2004	BRI	4.8	10.8	3.0	208	-	3.1	4.8	4.5	3.8	3.7	3.0		3.0		3.5
901	SSL	8/04/2004	COF	3.5	9.5	2.7	43	1540	2.7	2.6	3.3	3.5		3.3		3.2		3.0
902	STL	19/04/2004	EDE	3.2	11.1	2.5	34	1091	2.5							3.1		3.2
903	STL	2/05/2004	EDE	3.7	11.1	2.3	77	2211	2.3				3.3					3.7
904	STL	3/05/2004	CRO	3.8	13.5	2.6	31	1213	2.6				3.8					3.5
905	ETL	11/05/2004	EDE	5.3	12.2	3.3	134	7490	3.4	3.2	3.4		3.3	3.7		4.2	3.8	5.3
906	STL	29/05/2004	BAT	3.1	11.1	2.5	32	1041	2.5								3.1	
907	SSL	11/06/2004	BOT	3.1	7.4	2.4	22	-	2.4		3.0				3.1			
908	SSL	10/07/2004	BOT	4.5	11.5	2.7	56	-	2.7	3.4	3.4	3.1	3.4	3.5	4.5	3.6		2.7
909	SSL	18/07/2004	SYD	6.7	12.2	4.0	66	6170	4.1	4.0	3.4	4.0	5.3	6.7	6.4	5.8	4.7	4.9
910	STL	15/08/2004	SYD	4.9	11.1	2.9	82	3918	3.0	3.1	3.2	3.3	3.7	4.9	4.2	4.6	3.9	
911	STL	2/09/2004	EDE	3.5	13.5	2.5	80	2827	2.6		3.0		3.0		3.1	3.1		3.5
912	STL	8/09/2004	EDE	3.6	10.2	2.6	33	1138	2.6									3.6
913	STL	13/09/2004	BRI	4.1	10.9	3.0	39	-	3.1	4.1	3.2	3.3	3.0					
914	IT	2/10/2004	BOT	5.0	10.5	3.3	51	-	3.4	3.2	3.1		3.1	4.9	5.0	4.4		3.7
915	SSL	9/10/2004	SYD	3.3	12.2	2.6	29	1012	2.6					3.3				
916	IT	19/10/2004	COF	5.2	9.5	3.5	27	1517	3.6	3.7	3.9	5.2	5.2	4.9	4.7	4.4	3.7	4.0
917	CL	28/10/2004	PK	6.2	15.1	3.8	48	5533	4.1		4.3	4.3	5.3	5.8	5.7	6.2	3.9	6.1
918	CL	12/11/2004	EDE	3.5	7.7	2.5	23	527	2.6									3.5
919	AI	23/11/2004	BRI	4.2	9.5	3.1	106	-	3.1	4.2		3.5	3.6	3.1	3.0	3.2	3.4	
920	STL	2/12/2004	CRO	3.3	8.2	2.6	28	827	2.6	3.2	3.0	3.2	3.3			3.2		
921	CL	8/12/2004	EDE	3.6	9.5	2.6	35	994	2.6								3.2	3.6
922	CL	15/12/2004	BOT	4.4	11.3	2.7	44	-	2.8				3.0	3.8	4.4	3.9		
923	STL	20/12/2004	PK	3.6	10.2	2.4	41	1045	2.4					3.5	3.5	3.6		
924	IT	29/12/2004	BOT	4.7	12.1	3.2	78	-	3.2	3.1	4.6	3.5	3.2	4.4	4.7	4.5	3.7	4.0
925	TC	17/01/2005	COF	3.9	9.5	2.7	28	854	2.7	3.1		3.9	3.6					
926	IT	3/02/2005	EDE	3.7	10.2	2.5	160	4784	2.5	3.4		3.0	3.1					3.7
927	STL	12/02/2005	BAT	3.6	8.8	2.8	10	341	2.9								3.6	
928	IT	6/03/2005	COF	3.6	12.2	2.8	37	1536	2.8	3.3		3.6				3.0		
929	IT	23/03/2005	BOT	6.9	12.1	2.8	266	-	3.0		4.9			6.6	6.9	6.1		4.0
930	STL	4/04/2005	BOT	4.3	10.4	2.9	40	-	3.0	3.0	3.0			4.0	4.3	3.8		
931	AI	21/04/2005	BRI	3.7	8.5	2.6	103	-	2.6	3.7	2.9							3.1
932	AI	3/05/2005	BRI	3.6	8.1	2.6	161	-	2.6	3.6	3.0							
933	ETL	14/05/2005	CRO	6.0	10.2	3.4	176	11548	3.5	5.1	4.7	5.3	6.0	4.1	3.7	3.8	3.2	3.4
934	STL	26/05/2005	CRO	4.7	13.5	3.0	199	11951	3.1	3.6			4.7	3.5	3.9	3.3		
935	SSL	29/05/2005	BOT	4.3	13.1	2.7	90	-	2.7	3.5		3.8		3.5	4.3	3.7	3.1	3.6
936	TL	14/06/2005	BYR	3.0	14.3	2.5	46	2476	2.5		3.0							
937	SSL	24/06/2005	SYD	5.6	11.1	3.0	48	2440	3.2			3.7	3.5	5.6	4.9	4.5	5.4	4.8
938	STL	30/06/2005	BYR	5.4	10.5	2.9	159	5060	2.9	4.4	5.4	4.7	4.6	4.5	4.6	4.4	4.7	4.8
939	IT	10/07/2005	BOT	6.6	12.6	3.7	68	-	4.0	5.0	5.5	3.7	5.0	6.2	6.6	6.1	5.2	6.3
940	SSL	20/07/2005	BYR	3.8	11.8	2.8	104	3300	2.8	3.6	3.8			3.4				
941	SSL	5/08/2005	COF	3.7	12.2	2.6	48	1655	2.6	3.5		3.7						
942	ETL	13/08/2005	BRI	3.8	9.8	2.8	33	-	2.9	3.8								3.4
943	AI	27/08/2005	BRI	3.7	9.1	2.6	173	-	2.6	3.7		3.0	2.7				3.3	3.3
944	SSL	17/09/2005	CRO	3.7	10.2	2.6	35	1042	2.7	3.2			3.7				3.3	3.3
945	STL	29/09/2005	EDE	3.9	9.5	2.8	24	772	2.8						3.1			3.9

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
946	ETL	18/10/2005	COF	4.8	12.2	3.2	47	2633	3.3	3.1		4.8	4.3					3.0
947	IT	16/11/2005	COF	6.0	13.5	3.7	64	4971	3.8	4.8	4.1	6.0	5.4	5.8	6.0		4.9	3.5
948	STL	21/11/2005	EDE	3.1	15.1	2.6	17	802	2.6					3.1				3.1
949	IT	28/11/2005	BAT	6.6	12.2	3.2	79	4874	3.4	4.0	4.1			5.5	5.0	4.3	6.6	5.7
950	STL	19/12/2005	CRO	3.2	11.1	2.4	44	1237	2.4				3.2					
951	IT	8/01/2006	BYR	4.0	10.0	2.6	129	3631	2.7	3.8	4.0	3.4	3.5	3.2	3.2	3.2		
952	TC	19/01/2006	BYR	3.5	9.1	2.5	72	1420	2.5	3.4	3.5				3.0			
953	STL	31/01/2006	BOT	3.3	10.5	2.6	11	-	2.6					3.1	3.3			
954	STL	7/02/2006	SYD	5.3	11.1	3.5	22	1351	3.6	3.8	4.3	3.7	3.4	5.3	4.9	4.7	4.2	3.3
955	STL	10/02/2006	BOT	3.7	8.8	2.3	41	-	2.4					3.2	3.7	3.1		
956	AI	24/02/2006	BRI	2.5	7.5	2.2	81	-	2.2	2.5								
957	ETL	4/03/2006	BRI	7.2	12.2	4.1	144	-	4.4	7.2		4.1	3.1					
958	STL	8/03/2006	SYD	3.1	11.1	2.5	42	1435	2.5					3.1	3.1			
959	TC	25/03/2006	BRI	4.8	12.2	2.9	201	-	3.0	4.8		3.7	3.0	4.0	4.1	3.1	3.1	3.8
960	STL	2/04/2006	SYD	4.0	12.2	3.0	66	3466	3.0				3.6	4.0	3.8	3.3	3.8	3.3
961	STL	9/04/2006	PK	5.2	17.1	3.5	87	8412	3.6				3.8	4.9	4.6	5.2	3.2	4.6
962	STL	16/04/2006	BAT	4.5	15.0	3.1	52	3467	3.1	3.4			3.3		3.3	3.9	4.5	3.8
963	SSL	22/04/2006	PK	3.2	8.9	2.6	17	514	2.6							3.2		
964	SSL	28/04/2006	EDE	3.7	13.5	2.7	56	2582	2.8	2.8		3.2		3.5	3.3	3.3		3.7
965	ETL	23/05/2006	EDE	5.0	11.2	2.7	104	3838	2.8					2.8	2.8	2.9		5.0
966	SSL	3/06/2006	SYD	6.5	13.5	3.7	89	8056	4.0	3.4		3.2	4.1	6.5	6.0	4.4		4.1
967	STL	11/06/2006	SYD	6.2	12.2	3.5	68	5371	3.7	3.1	4.8		3.3	6.2	5.7	5.1		5.3
968	STL	16/06/2006	SYD	4.1	13.5	2.8	77	4161	2.9	3.0	3.4		3.3	4.1	3.8	3.3		4.1
969	STL	8/07/2006	PK	3.7	13.5	2.6	63	2936	2.6		3.2				3.2	3.7		
970	SSL	14/07/2006	PK	4.6	13.5	2.9	99	5588	3.0		3.0			4.1	4.4	4.6		4.0
971	IT	19/07/2006	SYD	4.9	10.2	3.1	121	6516	3.2	3.9	4.2	3.9		4.9	4.5	4.5		3.7
972	AI	27/07/2006	BYR	4.2	11.1	2.9	101	3402	2.9	3.9	4.2		3.3	3.5				
973	ETL	7/08/2006	BRI	4.9	11.5	3.6	124	-	3.7	4.9	4.8	4.0	4.4	4.0	3.8	3.4		3.0
974	STL	17/08/2006	EDE	3.1	8.3	2.4	19	416	2.4									3.1
975	SSL	25/08/2006	BOT	3.5	8.6	2.5	19	-	2.6	3.1	3.1	3.4		3.3	3.5	3.1		
976	CL	7/09/2006	BOT	5.8	10.5	5.0	21	-	5.0	4.3	4.8	4.5	4.0	5.1	5.8	4.6	4.3	3.6
977	STL	8/10/2006	BOT	4.7	12.0	2.8	58	-	2.9	4.1	3.8	3.4		4.5	4.7	4.0	4.0	
978	STL	16/10/2006	PK	3.3	9.5	2.4	46	1323	2.4						3.2	3.3		
979	STL	21/10/2006	BOT	4.4	9.9	3.0	37	-	3.0	3.5				3.9	4.4	4.0	4.1	
980	STL	26/10/2006	BOT	3.7	9.7	2.9	16	-	2.9					3.4	3.7	3.1		
981	STL	28/10/2006	SYD	4.6	10.2	3.4	44	2916	3.5	3.6	4.0			4.6	4.6	3.9	3.2	4.2
982	IT	5/11/2006	BOT	3.9	9.5	2.6	92	-	2.7		3.1			3.8	3.9	3.8		
983	STL	9/11/2006	BYR	4.1	12.5	2.9	41	1996	2.9	3.3	4.1	3.6				3.5	3.5	3.7
984	SSL	16/11/2006	COF	5.0	12.2	2.9	43	1932	3.0		4.9	5.0		3.6	3.9	3.6		
985	STL	29/11/2006	BOT	5.1	10.5	3.3	25	-	3.4	3.0		3.4		4.8	5.1	4.3	3.4	4.2
986	IT	3/12/2006	COF	4.3	12.2	2.7	33	1201	2.7			4.3			3.1			
987	STL	11/12/2006	EDE	3.6	9.5	2.5	46	1208	2.6					3.3	3.2	3.1		3.6
988	STL	27/12/2006	BOT	3.2	12.3	2.5	37	-	2.6					3.2	3.2			
989	CL	8/01/2007	EDE	4.8	13.5	3.0	62	3209	3.1	2.9				3.8	4.1			4.8
990	STL	27/01/2007	BOT	4.0	11.7	2.9	29	-	3.0	3.2		3.1		3.5	4.0		3.6	3.2
991	TC	11/02/2007	EDE	3.4	8.3	2.5	47	1319	2.5					3.2	3.3		3.1	3.4
992	TC	6/03/2007	COF	3.6	9.5	2.7	42	1518	2.8	3.2		3.6	3.4		3.0			3.2
993	STL	25/03/2007	BOT	4.2	9.1	2.9	64	-	2.9			4.2	3.3	4.0	4.2	3.9	3.6	3.0
994	STL	1/04/2007	BOT	3.2	10.6	2.5	34	-	2.5				3.1		3.2			
995	SSL	7/04/2007	CRO	3.8	10.3	2.7	61	2147	2.8	3.2	3.1		3.8	3.6	3.7	3.3		3.7
996	CL	29/04/2007	EDE	3.4	10.3	2.4	53	1399	2.4									3.4
997	STL	10/05/2007	COF	3.6	8.9	2.4	46	1287	2.5			3.6						
998	ETL	9/06/2007	SYD	6.9	10.8	3.2	491	29540	3.3		3.2	3.7	4.6	6.9	6.2	6.1	4.8	4.3
999	ETL	17/06/2007	CRO	3.7	9.5	2.6	60	1997	2.7		3.3		3.7					
1000	ETL	20/06/2007	PK	6.1	12.2	2.8	252	10766	2.9				3.9			6.1	5.7	6.0
1001	ETL	28/06/2007	EDE	7.1	12.2	4.0	84	8437	4.2	3.1	3.2	3.3				4.9	5.4	7.1
1002	SSL	6/07/2007	SYD	4.9	12.9	3.3	26	1768	3.4					4.9	4.8	4.0	3.2	4.2
1003	SSL	10/07/2007	CRO	5.0	11.2	2.9	115	5429	3.0	3.5	4.0		5.0	4.4	4.9	4.7	4.0	3.8
1004	SSL	19/07/2007	SYD	6.5	12.9	3.8	73	6864	4.0	3.3	4.1		4.6	6.5	4.8			4.7
1005	AI	26/07/2007	BYR	4.5	10.0	2.9	102	3471	2.9		4.5							
1006	STL	8/08/2007	BYR	4.9	11.8	3.2	170	8859	3.3		4.9							
1007	ETL	21/08/2007	BRI	5.5	10.3	3.3	192	-	3.5	5.5		4.2	4.7	3.2				
1008	ETL	25/08/2007	COF	3.3	11.2	2.6	100	3447	2.6			3.3						
1009	STL	31/08/2007	BYR	3.2	9.1	2.5	82	1415	2.5		3.2							
1010	TL	4/09/2007	SYD	3.1	9.3	2.4	62	1614	2.5				3.1	3.1				
1011	STL	11/09/2007	BYR	4.8	10.5	3.2	140	6693	3.2	4.5	4.8	3.5						
1012	SSL	18/09/2007	SYD	3.8	9.8	3.2	15	719	3.2	3.5		3.2	3.0	3.8	3.5	3.0		
1013	STL	22/09/2007	BOT	3.7	9.0	2.7	44	-	2.7	3.3				3.5	3.7	3.0		
1014	IT	9/10/2007	BYR	3.4	9.1	2.8	41	1042	2.8		3.4			3.2	3.2	3.2		
1015	STL	18/10/2007	BYR	4.2	10.5	2.6	65	1928	2.7	3.1	4.2	3.7	3.2	3.4	3.1	3.6		3.2
1016	CL	5/11/2007	BOT	5.2	11.7	3.0	72	-	3.2	3.0	4.4	4.5	4.1	5.2	5.2	4.8	4.6	4.8
1017	IT	23/11/2007	BOT	3.3	8.8	2.6	29	-	2.6					3.1	3.3	3.1		
1018	STL	22/12/2007	EDE	4.1	8.9	2.6	56	1803	2.7					3.2	3.1			4.1

Storm Index	Storm Type	Buoy observing largest peak H_{sig} during storm								Peak Hsig (m) during storm								
		Peak Date	Buoy	Peak H_{sig} (m)	Peak T_{p1} (s)	Mean H_{sig} (m)	Total Dur (hr)	Total Power (kW/m)	Storm rms Hsig	BRI	BYR	COF	CRO	SYD	BOT	PK	BAT	EDE
1019	TL	31/12/2007	BRI	6.3	13.4	3.8	233	-	3.9	6.3	4.7	5.0	4.5	3.9	4.1	3.8		3.3
1020	TC	22/01/2008	BRI	4.4	11.2	2.8	117	-	2.9	4.4	3.3	3.4	3.4	4.0	4.1	3.5		3.0
1021	IT	8/02/2008	PK	4.0	11.2	2.5	125	4148	2.6	2.9			3.2	3.7	3.9	4.0	3.6	3.2
1022	IT	13/02/2008	BYR	3.5	9.3	2.5	278	8570	2.5		3.5	3.0		3.2	3.3	3.0	3.1	
1023	STL	20/02/2008	BRI	3.9	11.3	2.5	330	-	1.6	3.9		3.7			3.1	3.3	2.9	
1024	STL	29/02/2008	BOT	4.5	8.8	2.8	109	-	2.9	4.2	4.0	3.3	3.0	4.1	4.5	4.2	3.5	3.9
1025	AI	9/03/2008	BRI	3.2	7.6	2.6	97	-	2.6	3.2								
1026	STL	21/03/2008	BAT	3.5	8.9	2.8	13	434	2.9					3.2	3.2		3.5	
1027	TL	4/04/2008	BYR	2.9	8.9	2.2	111	2245	2.2	2.7	2.9							
1028	ETL	25/04/2008	CRO	3.7	10.3	2.8	60	2200	2.8	3.6	3.4	3.6	3.7	3.4	3.5	2.9		
1029	STL	29/04/2008	CRO	3.2	11.2	2.7	34	1298	2.7	3.1			3.2	3.1				
1030	SSL	19/05/2008	SYD	3.9	10.3	2.8	33	1280	2.8		3.4	3.3		3.9	3.8			
1031	ETL	2/06/2008	BRI	4.6	9.8	3.2	146	-	3.2	4.6	4.0	3.4					3.0	
1032	ETL	6/06/2008	SYD	4.5	10.3	3.0	121	5607	3.1	3.1			3.9	4.5	4.3			
1033	SSL	15/06/2008	BOT	5.3	12.5	3.5	85	-	3.6	4.1	5.3	5.3	5.0	5.3	5.3		3.4	3.0
1034	STL	23/06/2008	COF	3.6	12.2	2.6	102	3963	2.6	3.4	3.4	3.6		3.4				3.4
1035	STL	4/07/2008	EDE	3.6	13.5	2.5	34	1344	2.5									3.6
1036	STL	22/07/2008	PK	5.9	15.1	3.4	96	8145	3.6	5.0	3.6	4.5	5.5	4.0	4.7	5.9	3.0	
1037	SSL	29/07/2008	BOT	4.4	10.3	3.0	49	-	3.0	3.8	3.0	3.1	3.7	4.1	4.4	4.3	3.9	3.9
1038	STL	2/08/2008	PK	3.3	11.2	2.5	30	981	2.5							3.3		
1039	SSL	8/08/2008	PK	3.7	8.9	2.7	27	870	2.7					3.1	3.2	3.7		
1040	STL	17/08/2008	PK	4.5	12.2	3.0	85	4651	3.0	2.9	3.6	4.2	3.4	4.0	3.9	4.5	3.7	4.2
1041	SSL	23/08/2008	BRI	6.4	11.5	3.4	67	-	3.6	6.4	5.0	5.1	4.8	6.1	5.6	5.1	3.5	3.3
1042	ETL	5/09/2008	CRO	5.3	11.2	3.1	169	9139	3.1	4.1	4.4	4.9	5.3	5.1	4.9	4.7	3.7	3.9
1043	IT	24/09/2008	BRI	4.3	9.8	3.0	42	-	3.1	4.3	3.3							
1044	IT	16/10/2008	BRI	3.4	8.9	2.8	28	-	2.8	3.4								
1045	SSL	22/10/2008	BOT	4.9	9.6	2.8	76	-	2.9	3.7	3.6	3.5	3.3	4.7	4.9			3.4
1046	STL	4/11/2008	SYD	3.6	9.3	2.6	62	2208	2.6	3.0				3.6	3.6	3.3	3.1	3.6
1047	IT	10/11/2008	BRI	3.9	8.9	2.8	119	-	2.9	3.9	3.5							
1048	IT	24/11/2008	EDE	5.1	12.2	2.7	166	6550	2.8	3.5			3.0	4.3	3.8		3.4	5.1
1049	CL	15/12/2008	PK	5.6	12.2	3.6	45	3591	3.7						5.1	5.6	3.8	5.6
1050	IT	20/12/2008	BOT	3.8	9.6	2.9	27	-	2.9	3.4			3.6		3.8	3.5		
1051	TL	3/01/2009	BRI	3.8	9.4	2.6	65	-	2.6	3.8	3.1							
1052	STL	17/01/2009	PK	3.3	9.5	2.5	22	606	2.6			3.1	3.1			3.3		
1053	STL	24/01/2009	BAT	3.0	8.9	2.6	12	318	2.6						3.0		3.0	
1054	IT	14/02/2009	BYR	6.6	10.9	2.8	107	4566	2.9	3.9	6.6	5.3	4.0	4.2	3.9	3.6	3.8	
1055	TC	11/03/2009	BRI	4.7	9.7	3.1	130	-	3.2	4.7	3.6				3.4	3.3		
1056	TC	1/04/2009	CRO	6.2	12.2	3.1	158	9308	3.4	5.1	4.9	5.5	6.2	5.9	5.3	4.0	3.3	3.1
1057	ETL	20/04/2009	CRO	5.7	12.2	3.5	156	11073	3.6	4.7	5.0	5.4	5.7	3.8	4.2	3.8	3.4	2.8
1058	STL	30/04/2009	EDE	3.8	13.5	2.5	118	4526	2.5					3.2			3.2	3.8
1059	STL	11/05/2009	COF	3.7	13.5	2.6	132	5218	2.7			3.7	3.5		3.1	3.1		3.1
1060	ETL	21/05/2009	BYR	7.6	13.0	4.0	186	18225	4.2	5.6	7.6	6.5	6.2	3.6	4.8	4.3	3.2	4.0
1061	ETL	24/05/2009	SYD	3.4	12.1	2.6	31	1240	2.6					3.4				
1062	SSL	29/05/2009	EDE	4.0	9.5	2.4	105	2613	2.4					3.1	3.0	3.4		3.0
1063	STL	11/06/2009	COF	4.5	13.5	3.1	44	2665	3.1			4.5	3.7	4.1			3.4	4.1
1064	AI	21/06/2009	EDE	4.0	8.9	2.6	86	2700	2.6	3.5	3.4	3.1	2.9	3.6		3.2		3.4
1065	ETL	10/07/2009	BRI	4.1	9.8	3.0	140	-	3.1	4.1	3.3	2.8	2.9		2.9	2.9		3.4
1066	NA	17/07/2009	BOT	3.2	8.3	2.7	25	-	2.8						3.2			
1067	STL	24/07/2009	SYD	3.5	8.9	2.6	26	827	2.7					3.5	3.3			
1068	SSL	9/08/2009	CRO	3.3	9.5	2.5	50	1516	2.5	3.2			3.3					
1069	STL	9/09/2009	EDE	4.0	10.3	2.5	50	1600	2.5									3.8
1070	SSL	28/09/2009	EDE	4.0	9.5	2.7	31	1107	2.7		3.4	3.1						3.3
1071	CL	4/10/2009	EDE	4.0	13.5	2.6	31	1169	2.6			3.1		3.7	3.9	3.5		3.0
1072	SSL	8/10/2009	BOT	6.6	11.1	3.6	91	-	3.9	5.7	4.4	3.2	5.2	6.2	6.6	5.3	4.4	4.9
1073	STL	26/10/2009	BOT	3.6	8.8	2.7	35	-	2.8				3.6	3.5	3.6	3.4		
1074	STL	4/11/2009	BOT	3.0	10.9	2.3	27	-	2.3						3.0	3.0		
1075	SSL	17/11/2009	BOT	4.1	10.0	2.9	46	-	3.0				3.2	3.1	4.1	4.0		
1076	STL	24/11/2009	CRO	3.5	10.3	2.6	31	980	2.7				3.5		3.2	3.3		
1077	STL	1/12/2009	CRO	5.0	13.5	3.1	70	4030	3.2	3.2			5.0	4.0	4.4	4.0		5.0
1078	STL	17/12/2009	BAT	4.0	6.8	2.4	35	883	2.4								3.1	

APPENDIX E
TIME SERIES OF STORM TYPE AND MAGNITUDE

WRL
Report No. 2010/16

BRISBANE WAVERIDER BUOY
STORM TYPE AND PEAK SIGNIFICANT WAVE HEIGHT

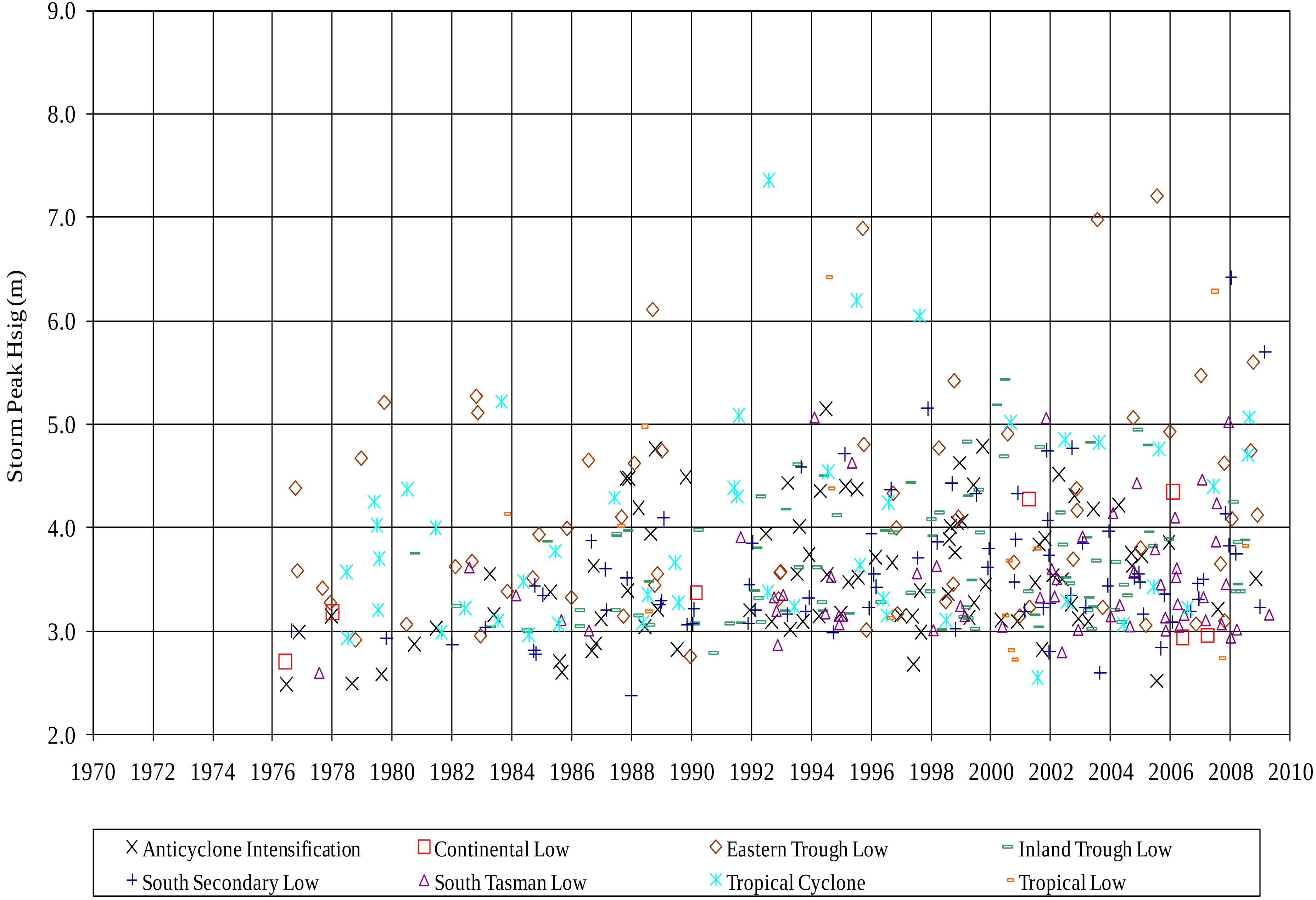


Figure E.1

WRL
Report No. 2010/16

BYRON BAY WAVERIDER BUOY
STORM TYPE AND PEAK SIGNIFICANT WAVE HEIGHT

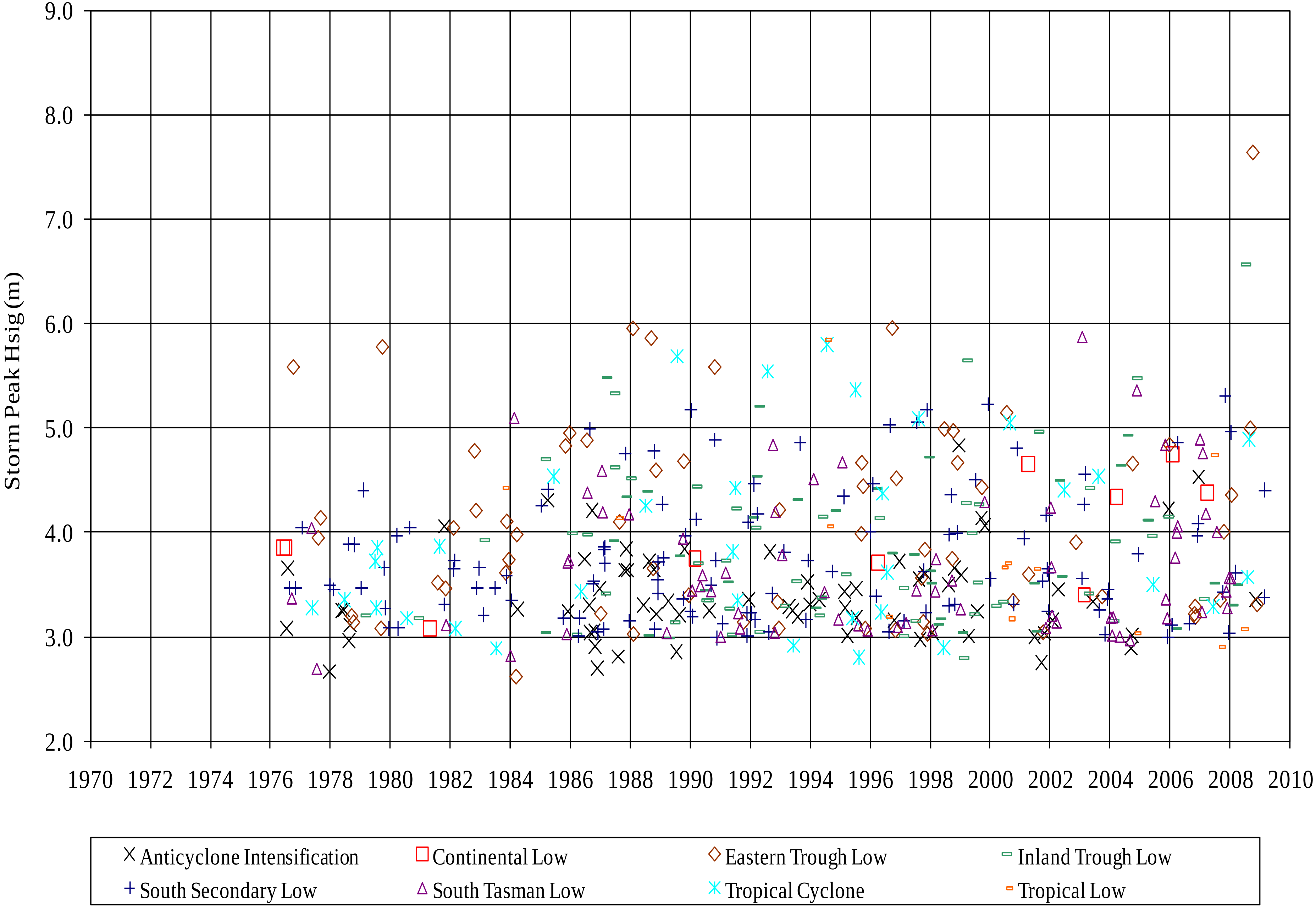


Figure
E.2

WRL
Report No. 2010/16

COFFS HARBOUR WAVERIDER BUOY
STORM TYPE AND PEAK SIGNIFICANT WAVE HEIGHT

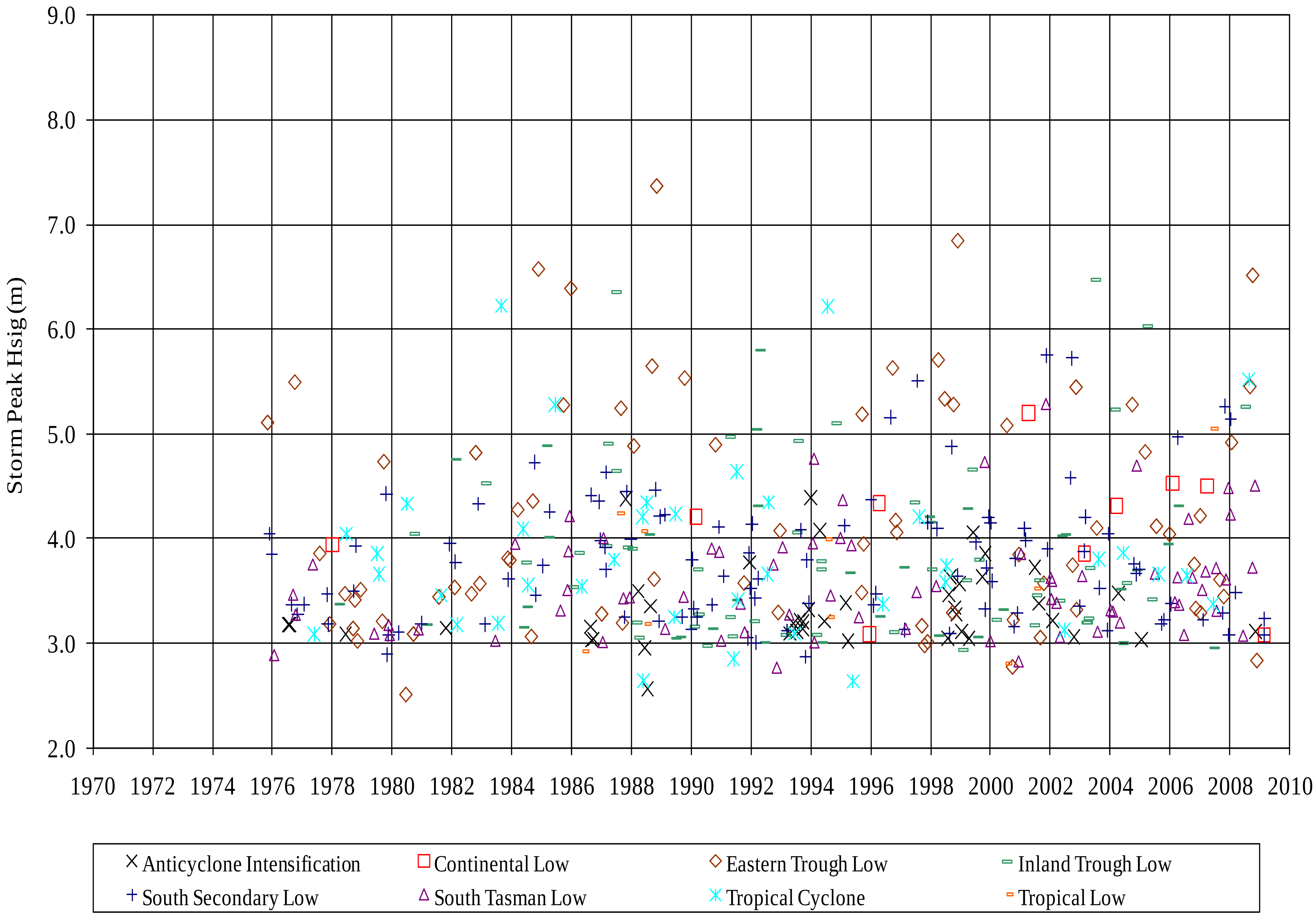


Figure
E.3

WRL
Report No. 2010/16

CROWDY HEAD WAVERIDER BUOY
STORM TYPE AND PEAK SIGNIFICANT WAVE HEIGHT

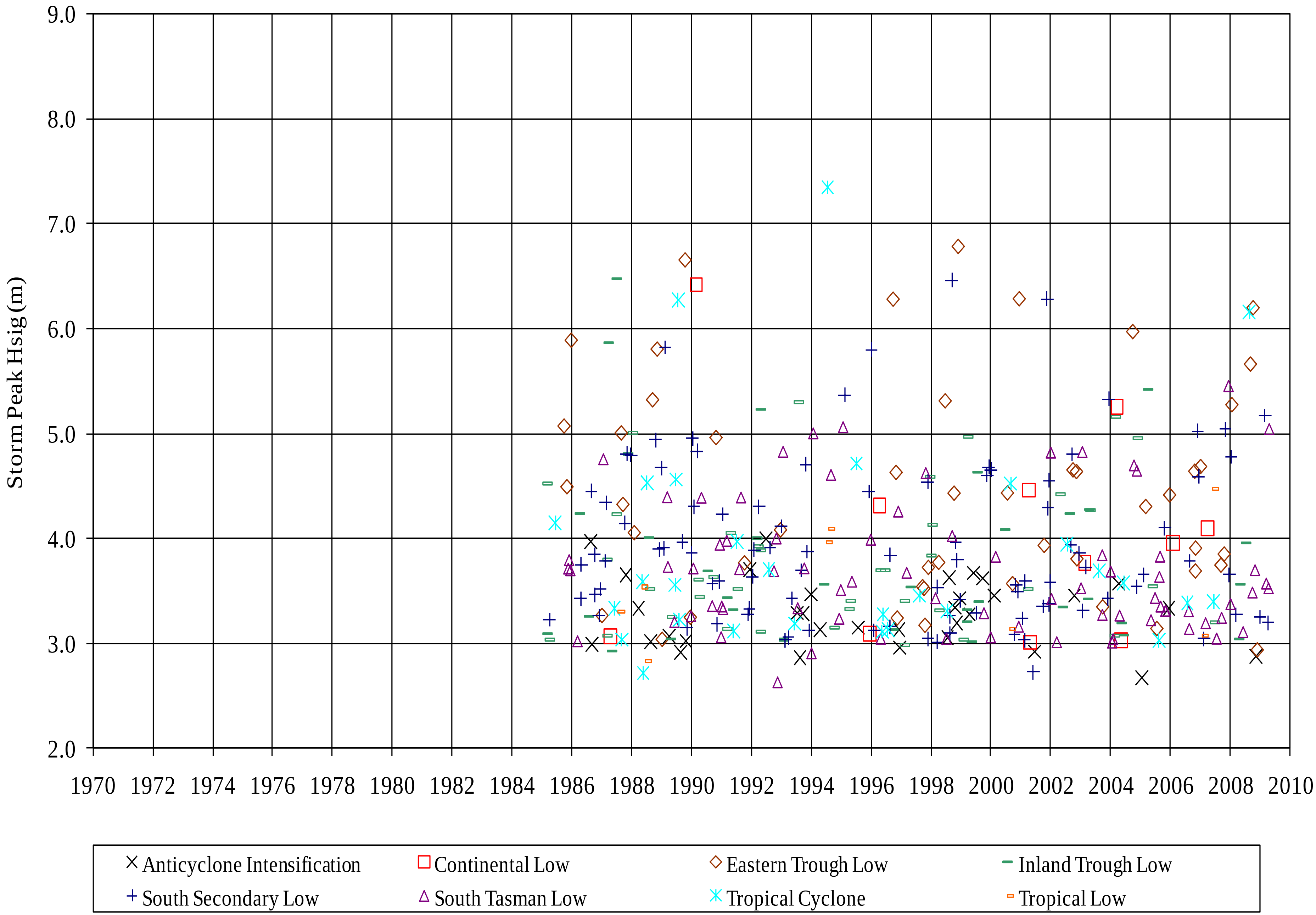


Figure
E.4

WRL
Report No. 2010/16

SYDNEY WAVERIDER BUOY
STORM TYPE AND PEAK SIGNIFICANT WAVE HEIGHT

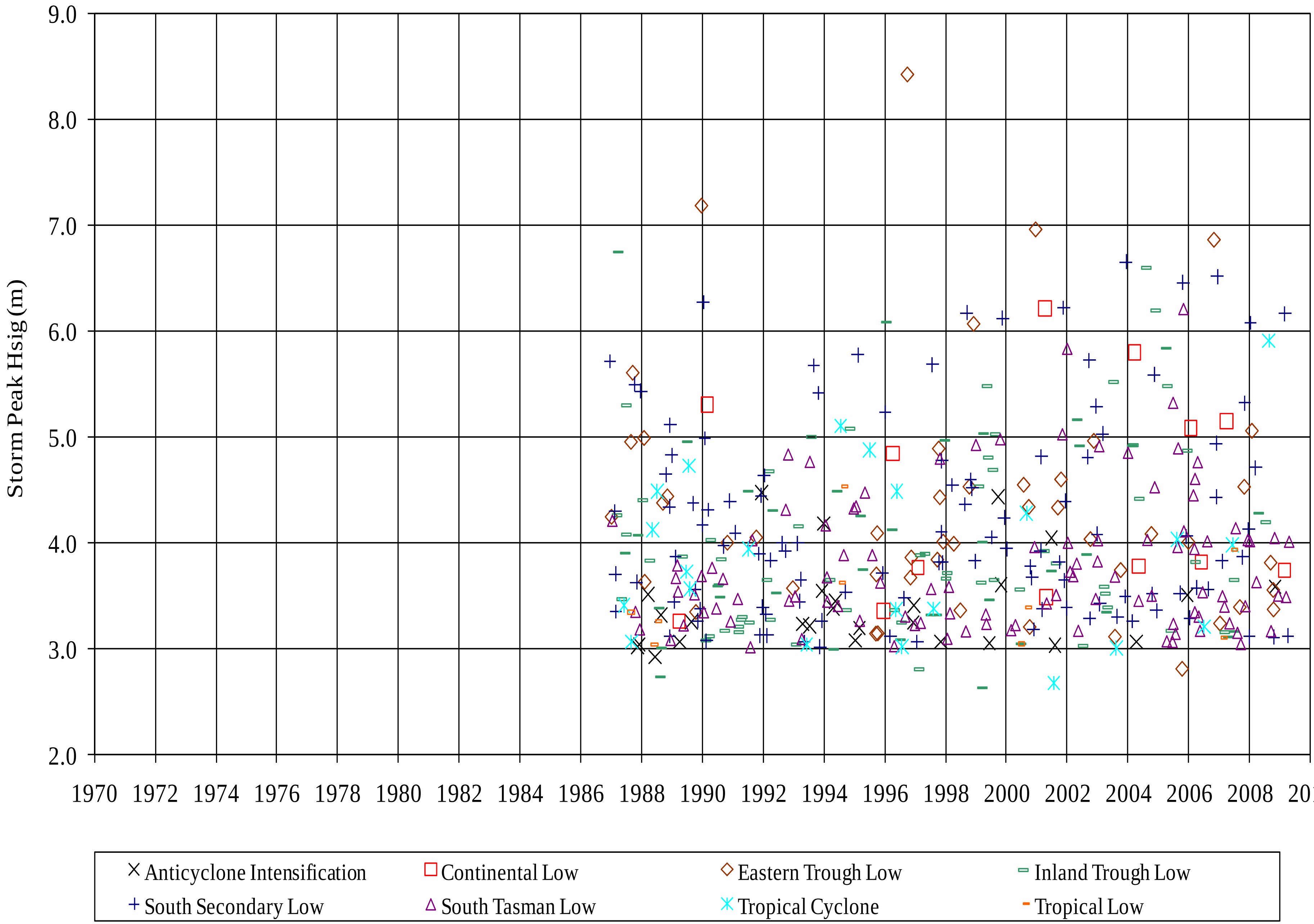


Figure E.5

WRL

Report No. 2010/16

BOTANY BAY WAVERIDER BUOY

STORM TYPE AND PEAK SIGNIFICANT WAVE HEIGHT

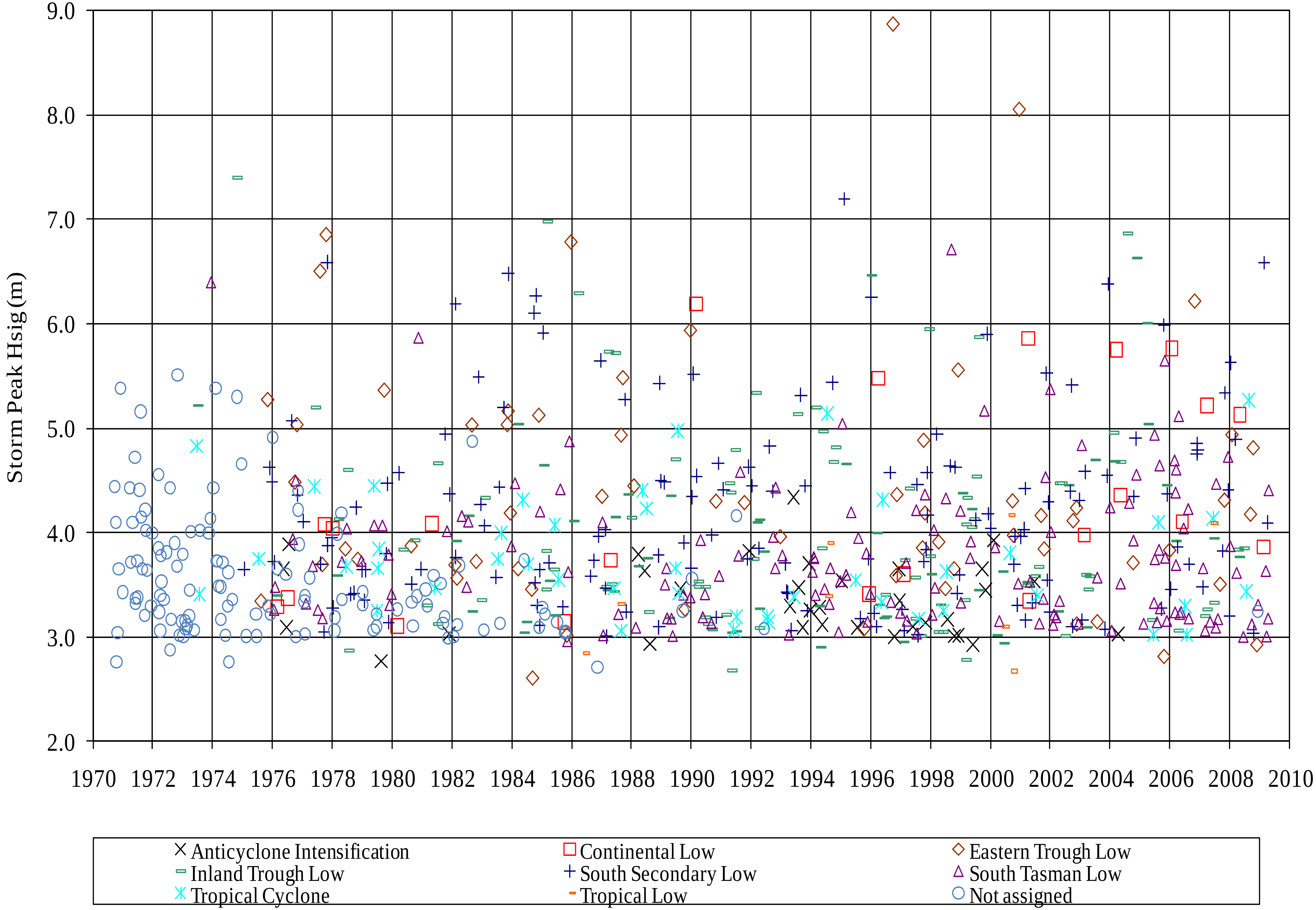


Figure E.6

WRL
Report No. 2010/16

PORT KEMBLA WAVERIDER BUOY
STORM TYPE AND PEAK SIGNIFICANT WAVE HEIGHT

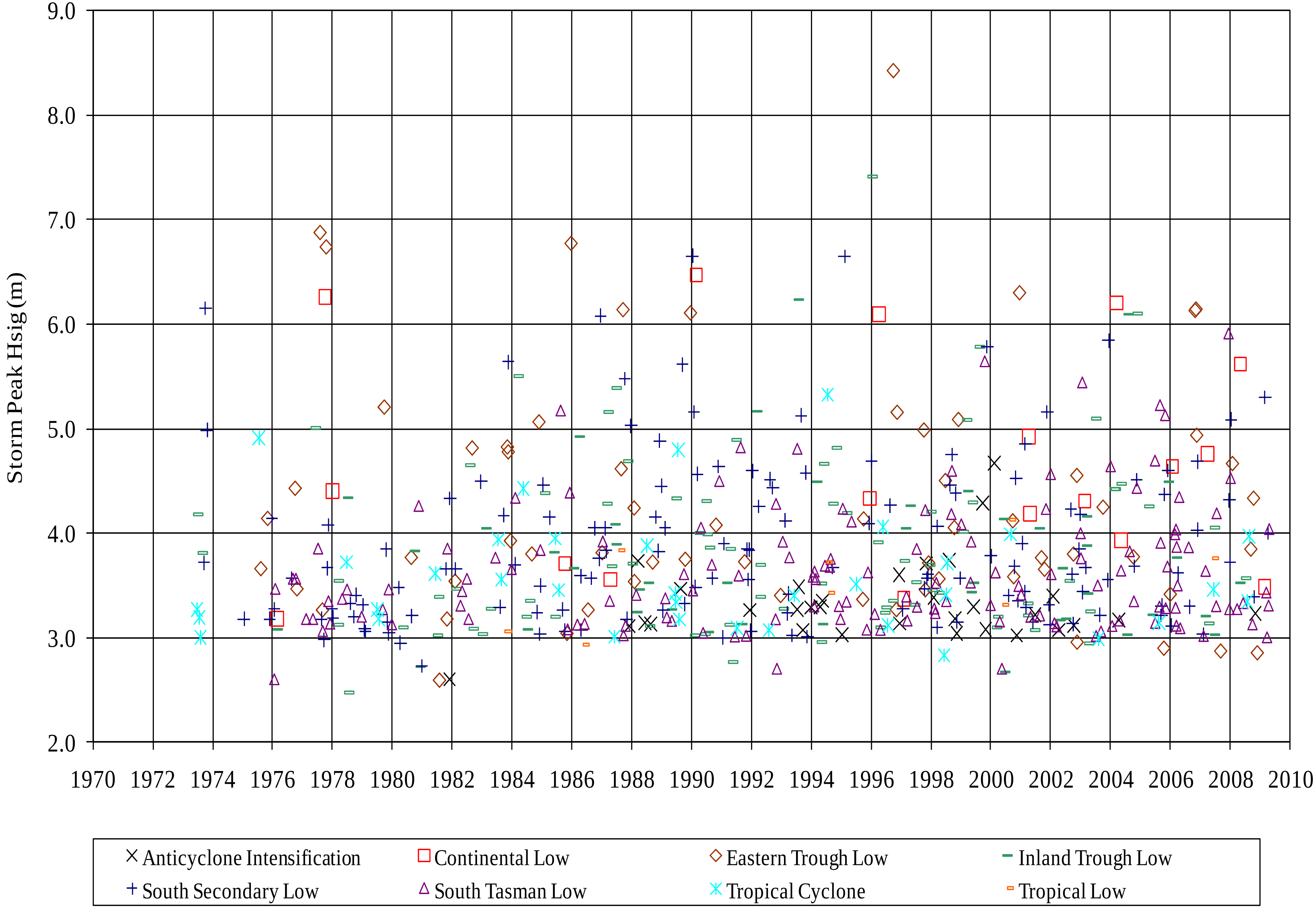


Figure
E.7

WRL
Report No. 2010/16

BATEMANS BAY WAVERIDER BUOY
STORM TYPE AND PEAK SIGNIFICANT WAVE HEIGHT

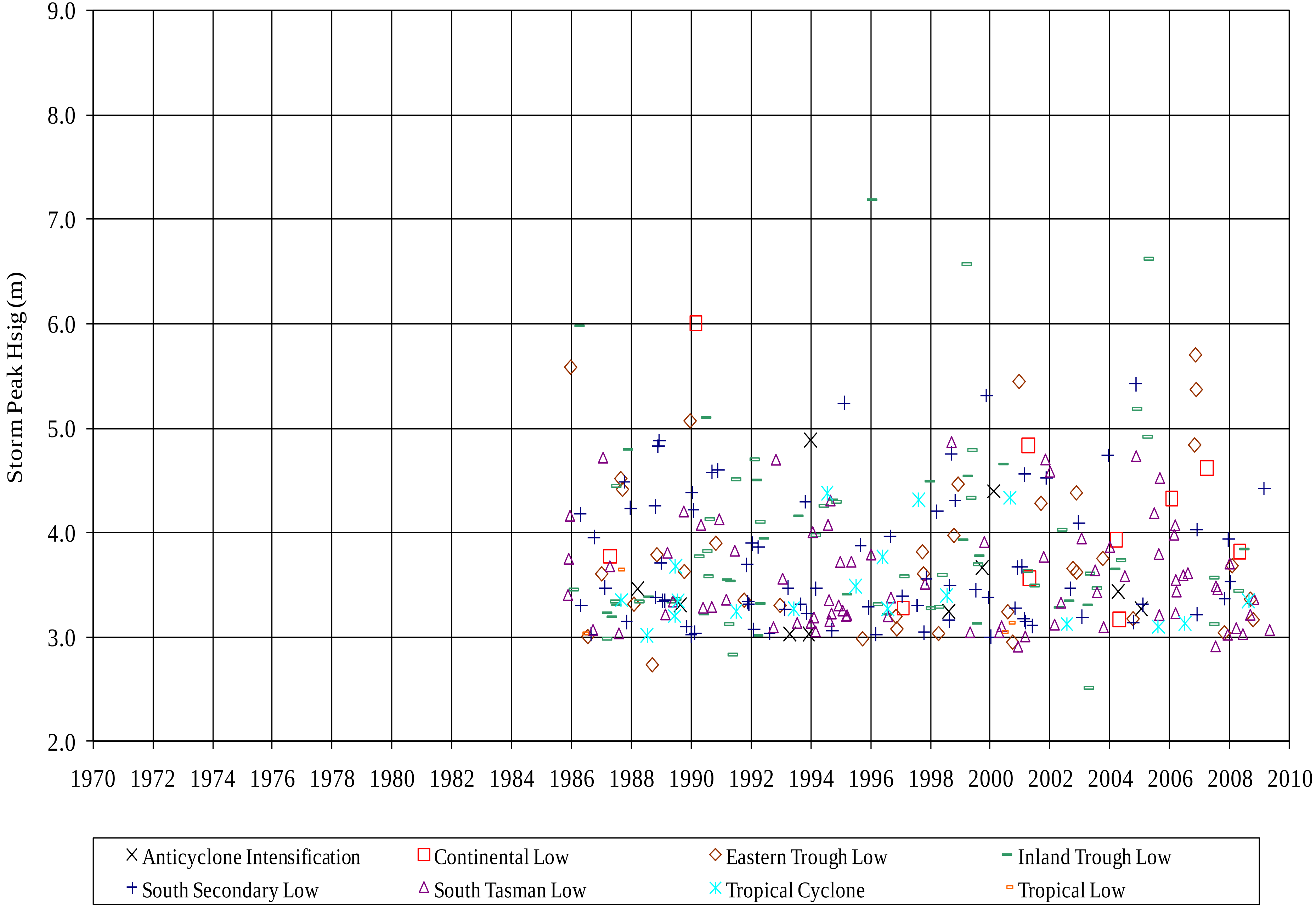


Figure
E.8

WRL
Report No. 2010/16

EDEN WAVERIDER BUOY
STORM TYPE AND PEAK SIGNIFICANT WAVE HEIGHT

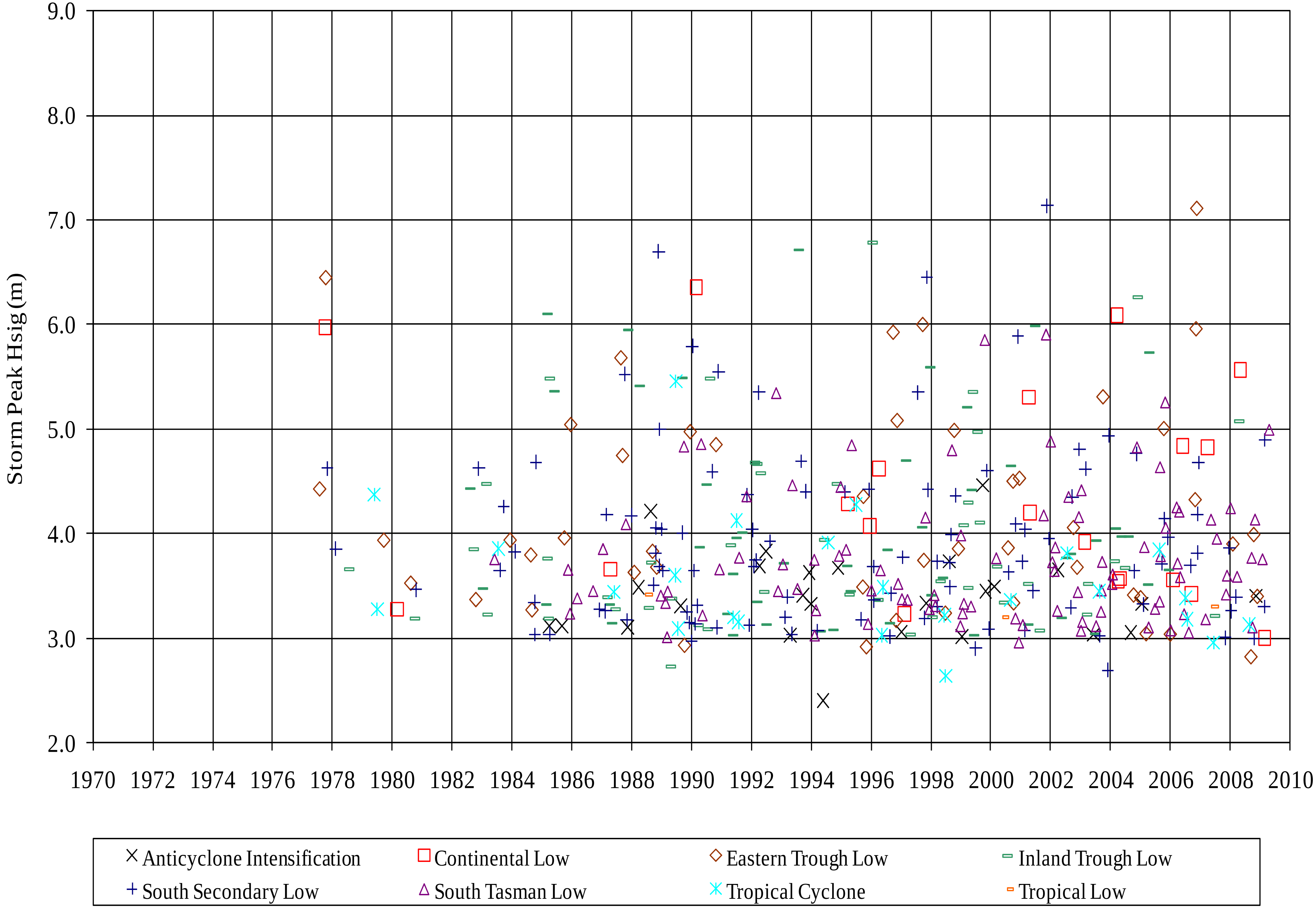
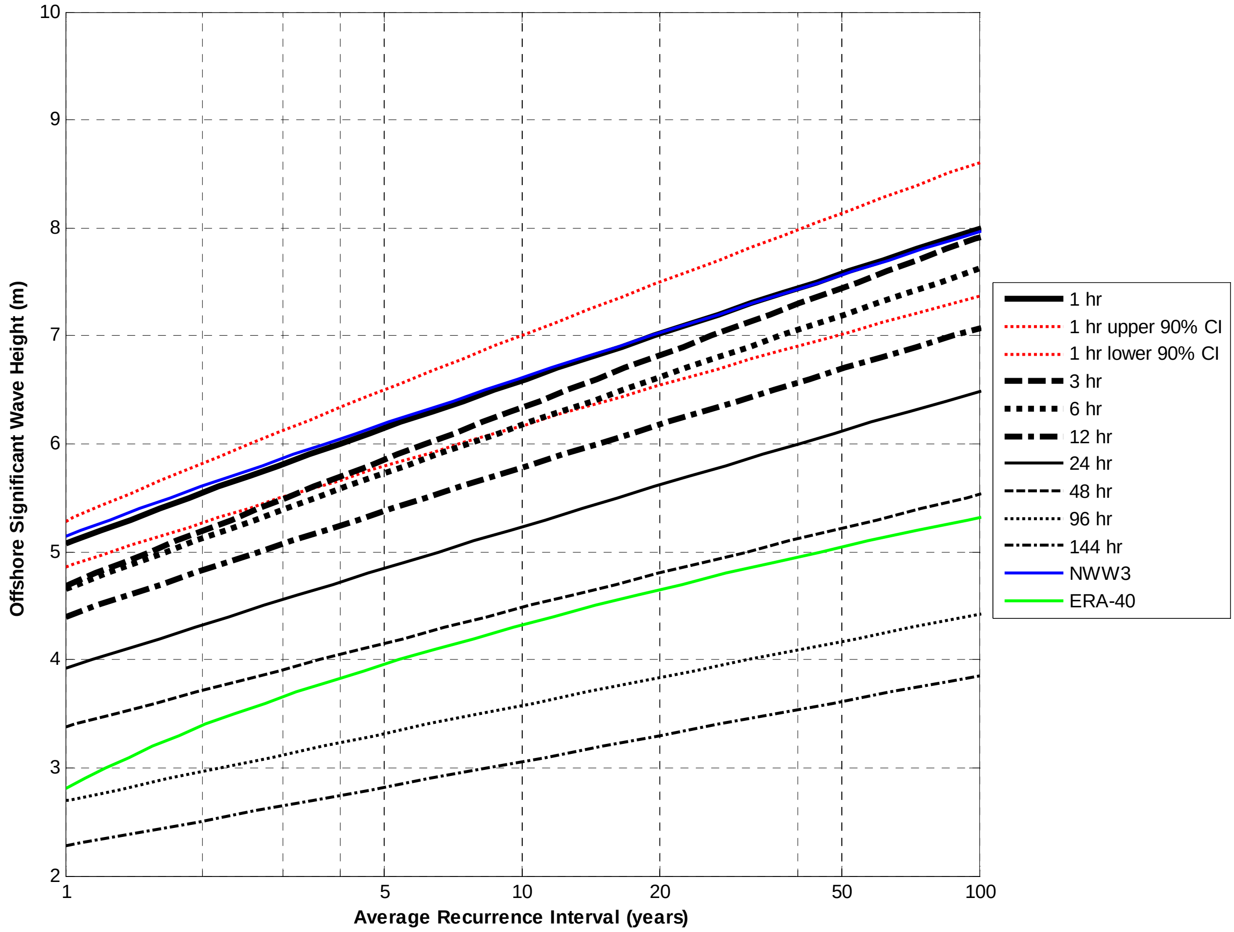


Figure
E.9

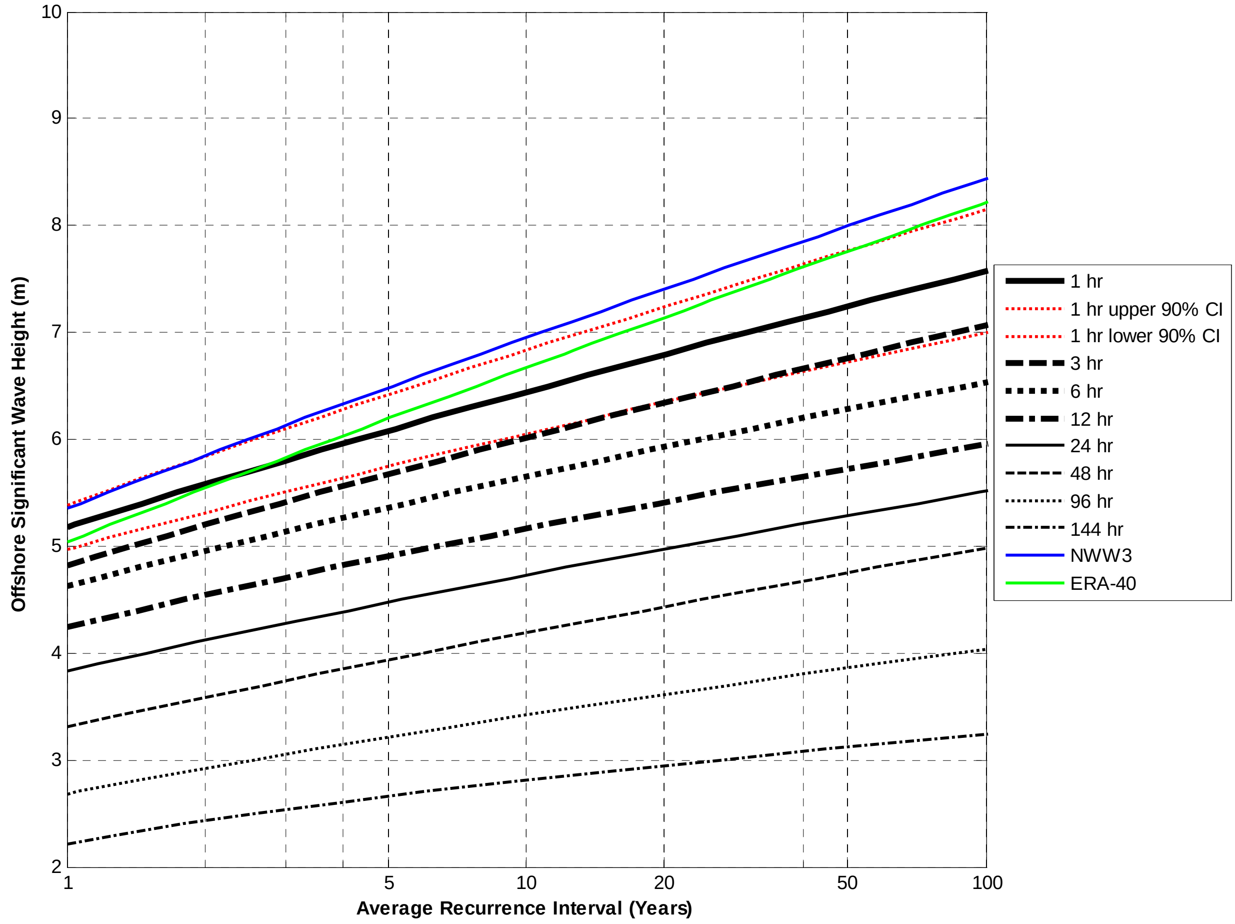
APPENDIX F
EXTREME WAVE HEIGHTS FOR VARYING ARI AND DURATION



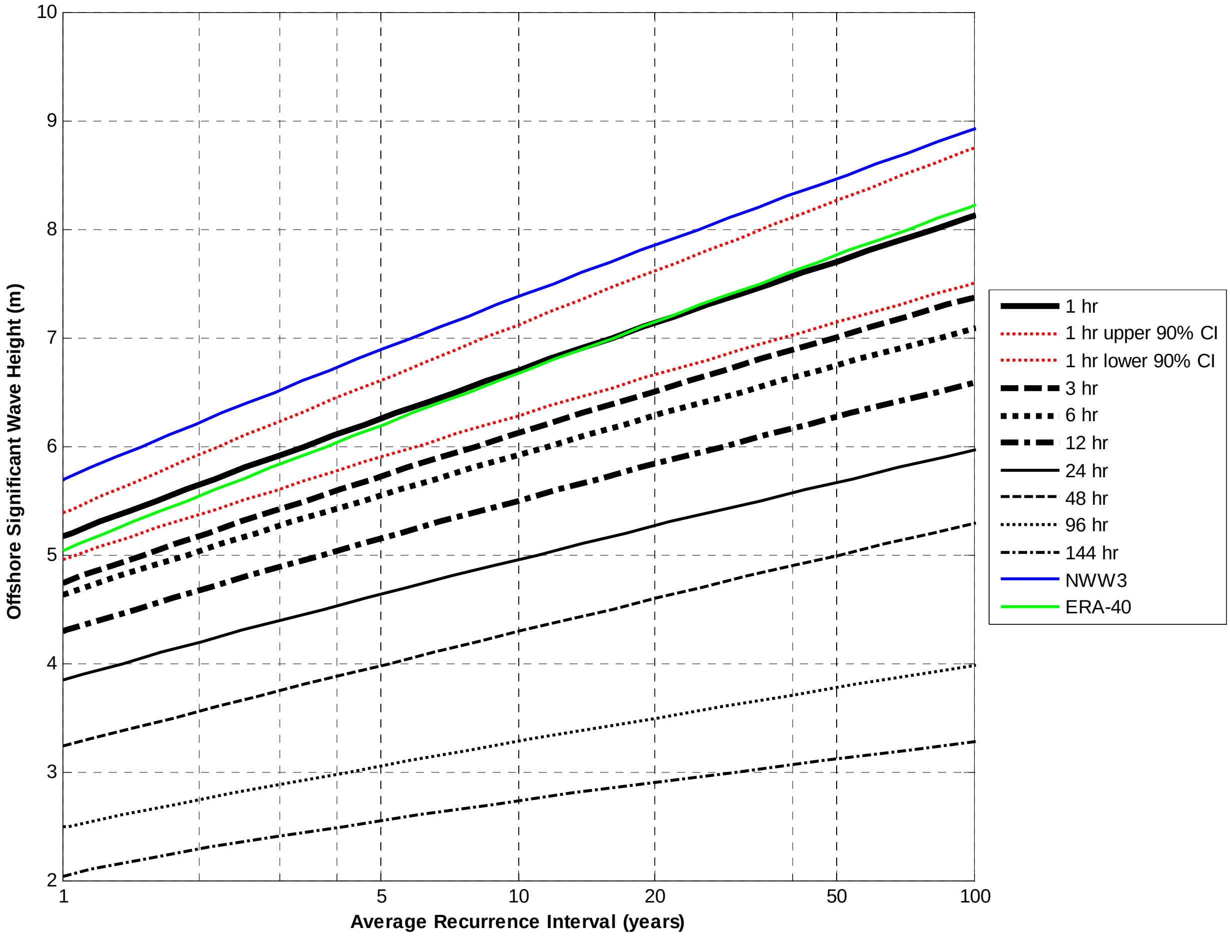
Brisbane Wave Buoy		ARI (years)						
		1	2	5	10	20	50	100
1 hour	Hs (m)	5.1	5.5	6.1	6.6	7.0	7.6	8.0
	90% CI (± m)	0.2	0.2	0.3	0.3	0.3	0.4	0.4
3 hours	Hs (m)	4.7	5.2	5.9	6.3	6.8	7.4	7.9
	90% CI (± m)	0.2	0.3	0.3	0.4	0.4	0.5	0.6
6 hours	Hs (m)	4.7	5.1	5.7	6.2	6.6	7.2	7.6
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.4	0.5
12 hours	Hs (m)	4.4	4.8	5.4	5.8	6.2	6.7	7.1
	90% CI (± m)	0.2	0.2	0.3	0.3	0.3	0.4	0.4
24 hours	Hs (m)	3.9	4.3	4.8	5.2	5.6	6.1	6.5
	90% CI (± m)	0.2	0.2	0.2	0.3	0.3	0.4	0.4
48 hours	Hs (m)	3.4	3.7	4.2	4.5	4.8	5.2	5.5
	90% CI (± m)	0.1	0.2	0.2	0.3	0.3	0.3	0.4
96 hours	Hs (m)	2.7	3.0	3.3	3.6	3.8	4.2	4.4
	90% CI (± m)	0.1	0.1	0.2	0.3	0.3	0.4	0.4
144 hours	Hs (m)	2.3	2.5	2.8	3.1	3.3	3.6	3.9
	90% CI (± m)	0.1	0.1	0.2	0.3	0.4	0.5	0.5
NWW3	Hs (m)	5.1	5.6	6.2	6.6	7.0	7.6	8.0
	90% CI (± m)	0.3	0.3	0.4	0.5	0.6	0.7	0.8
ERA-40	Hs (m)	2.8	3.4	4.0	4.3	4.7	5.0	5.3
	90% CI (± m)	0.1	0.2	0.3	0.3	0.4	0.4	0.5

EXTREME VALUES FOR BRISBANE

Figure F-1



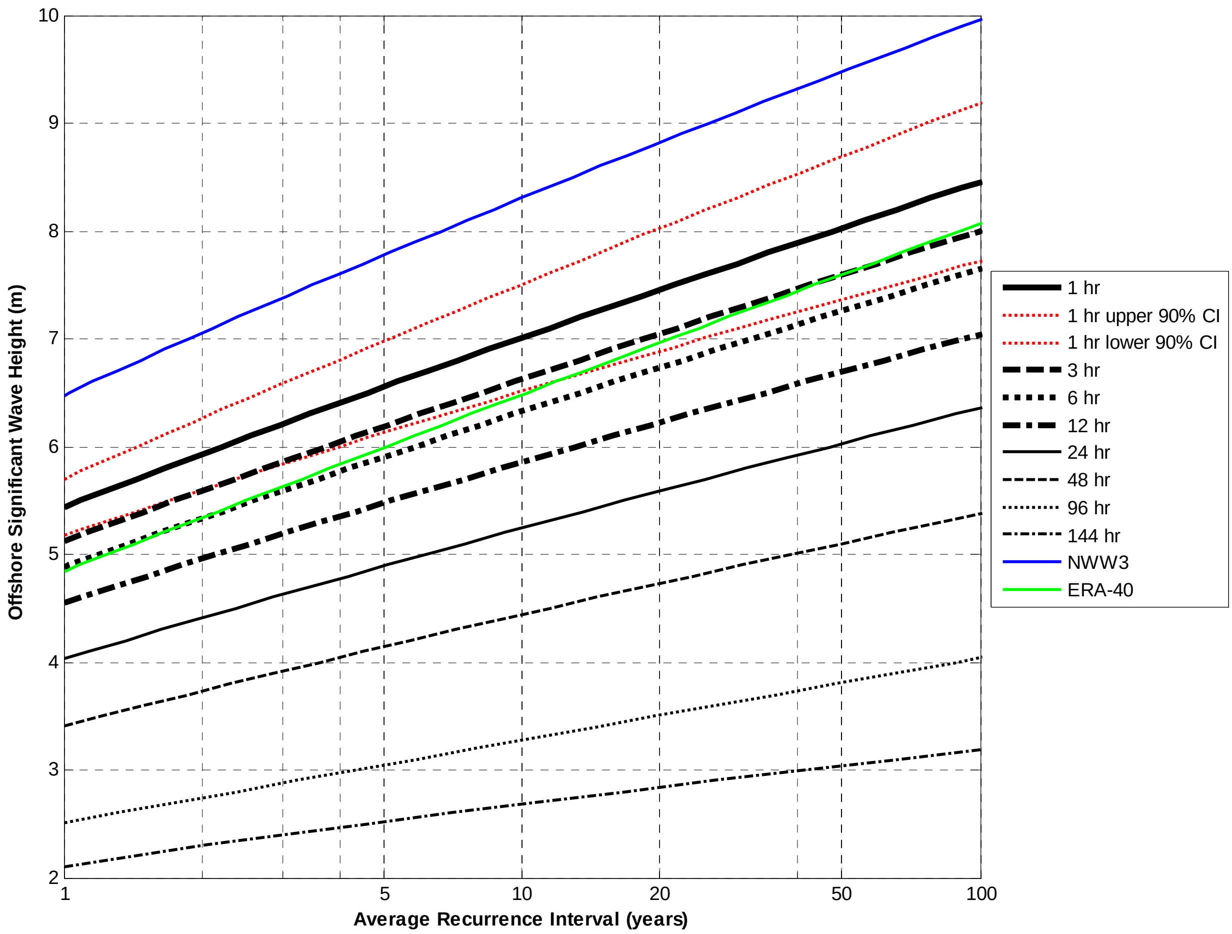
Byron Bay Wave Buoy		ARI (years)						
		1	2	5	10	20	50	100
1 hour	Hs (m)	5.2	5.6	6.1	6.4	6.8	7.2	7.6
	90% CI (± m)	0.2	0.2	0.2	0.2	0.3	0.3	0.3
3 hours	Hs (m)	4.8	5.2	5.7	6.0	6.3	6.8	7.1
	90% CI (± m)	0.1	0.2	0.2	0.2	0.3	0.3	0.3
6 hours	Hs (m)	4.6	5.0	5.4	5.7	5.9	6.3	6.5
	90% CI (± m)	0.1	0.1	0.2	0.2	0.2	0.2	0.3
12 hours	Hs (m)	4.2	4.5	4.9	5.2	5.4	5.7	6.0
	90% CI (± m)	0.1	0.1	0.2	0.2	0.2	0.2	0.2
24 hours	Hs (m)	3.8	4.1	4.5	4.7	5.0	5.3	5.5
	90% CI (± m)	0.1	0.1	0.2	0.2	0.2	0.2	0.2
48 hours	Hs (m)	3.3	3.6	3.9	4.2	4.4	4.8	5.0
	90% CI (± m)	0.1	0.1	0.2	0.2	0.2	0.3	0.3
96 hours	Hs (m)	2.7	2.9	3.2	3.4	3.6	3.9	4.0
	90% CI (± m)	0.1	0.1	0.2	0.2	0.2	0.3	0.3
144 hours	Hs (m)	2.2	2.4	2.7	2.8	2.9	3.1	3.2
	90% CI (± m)	0.1	0.1	0.1	0.2	0.2	0.2	0.3
NWW3	Hs (m)	5.3	5.8	6.5	7.0	7.4	8.0	8.4
	90% CI (± m)	0.3	0.4	0.5	0.6	0.6	0.7	0.8
ERA-40	Hs (m)	5.0	5.5	6.2	6.7	7.1	7.8	8.2
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.4	0.5



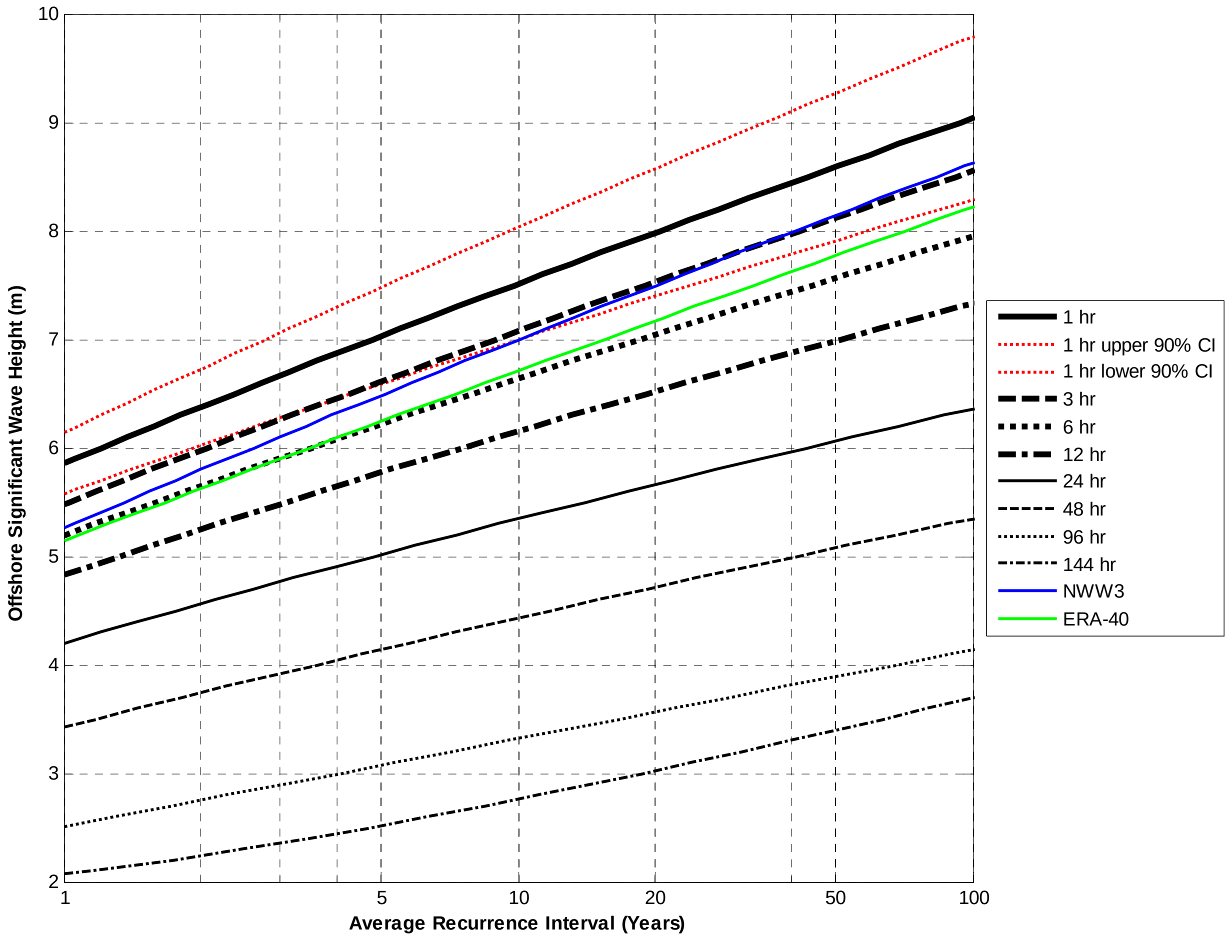
Coffs Harbour Wave Buoy		ARI (years)						
		1	2	5	10	20	50	100
1 hour	Hs (m)	5.2	5.6	6.3	6.7	7.1	7.7	8.1
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.4	0.4
3 hours	Hs (m)	4.7	5.2	5.7	6.1	6.5	7.0	7.4
	90% CI (± m)	0.2	0.2	0.3	0.3	0.3	0.4	0.4
6 hours	Hs (m)	4.6	5.0	5.5	5.9	6.3	6.7	7.1
	90% CI (± m)	0.2	0.2	0.2	0.3	0.3	0.3	0.4
12 hours	Hs (m)	4.3	4.7	5.2	5.5	5.8	6.3	6.6
	90% CI (± m)	0.1	0.2	0.2	0.2	0.3	0.3	0.3
24 hours	Hs (m)	3.8	4.2	4.6	5.0	5.3	5.7	6.0
	90% CI (± m)	0.1	0.2	0.2	0.2	0.3	0.3	0.3
48 hours	Hs (m)	3.2	3.6	4.0	4.3	4.6	5.0	5.3
	90% CI (± m)	0.1	0.2	0.2	0.3	0.3	0.3	0.4
96 hours	Hs (m)	2.5	2.7	3.1	3.3	3.5	3.8	4.0
	90% CI (± m)	0.1	0.1	0.2	0.2	0.3	0.3	0.4
144 hours	Hs (m)	2.0	2.3	2.6	2.7	2.9	3.1	3.3
	90% CI (± m)	0.1	0.1	0.2	0.2	0.3	0.3	0.4
NWW3	Hs (m)	5.7	6.2	6.9	7.4	7.9	8.5	8.9
	90% CI (± m)	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ERA-40	Hs (m)	5.0	5.5	6.2	6.7	7.1	7.8	8.2
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.4	0.5

EXTREME VALUES FOR COFFS HARBOUR

Figure F-3



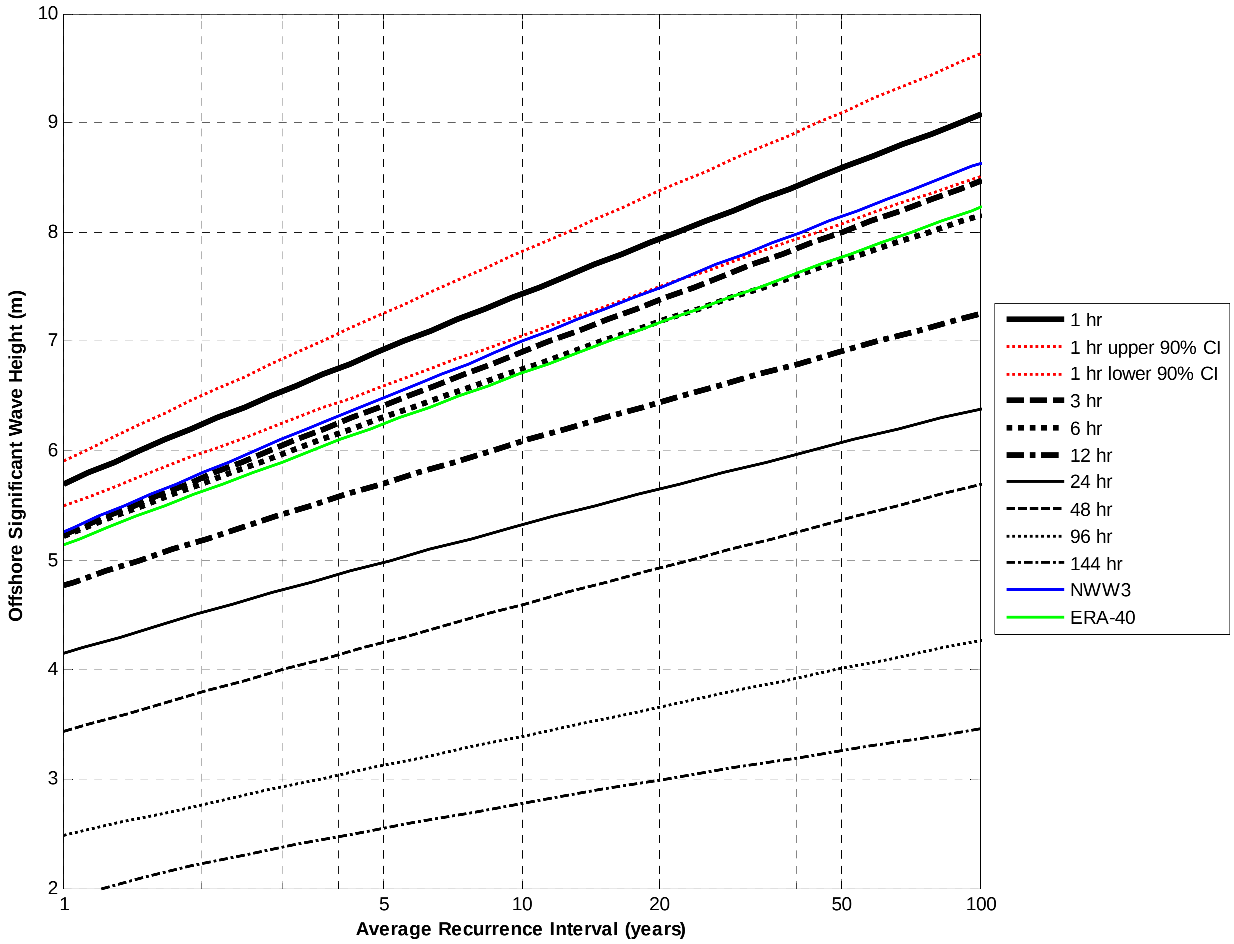
Crowdy Head Wave Buoy		ARI (years)						
		1	2	5	10	20	50	100
1 hour	Hs (m)	5.4	5.9	6.6	7.0	7.5	8.0	8.5
	90% CI (± m)	0.2	0.3	0.3	0.4	0.4	0.5	0.5
3 hours	Hs (m)	5.1	5.6	6.2	6.6	7.0	7.6	8.0
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.4	0.5
6 hours	Hs (m)	4.9	5.3	5.9	6.3	6.7	7.3	7.6
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.4	0.5
12 hours	Hs (m)	4.5	5.0	5.5	5.9	6.2	6.7	7.0
	90% CI (± m)	0.2	0.2	0.3	0.3	0.3	0.4	0.4
24 hours	Hs (m)	4.0	4.4	4.9	5.2	5.6	6.0	6.4
	90% CI (± m)	0.2	0.2	0.2	0.3	0.3	0.4	0.4
48 hours	Hs (m)	3.4	3.7	4.1	4.4	4.7	5.1	5.4
	90% CI (± m)	0.1	0.2	0.2	0.3	0.3	0.3	0.4
96 hours	Hs (m)	2.5	2.7	3.0	3.3	3.5	3.8	4.0
	90% CI (± m)	0.1	0.2	0.2	0.3	0.3	0.4	0.5
144 hours	Hs (m)	2.1	2.3	2.5	2.7	2.8	3.0	3.2
	90% CI (± m)	0.1	0.1	0.2	0.2	0.3	0.3	0.4
NWW3	Hs (m)	6.5	7.1	7.8	8.3	8.8	9.5	10.0
	90% CI (± m)	0.4	0.5	0.7	0.8	0.9	1.0	1.2
ERA-40	Hs (m)	4.8	5.3	6.0	6.5	7.0	7.6	8.1
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.4	0.5



Sydney Wave Buoy		ARI (years)						
		1	**2**	**5**	**10**	**20**	**50**	**100**
1 hour	**Hs (m)**	5.9	6.4	7.0	7.5	8.0	8.6	9.0
	90% CI (± m)	0.2	0.3	0.3	0.4	0.4	0.5	0.5
3 hours	**Hs (m)**	5.5	6.0	6.6	7.1	7.5	8.1	8.6
	90% CI (± m)	0.2	0.3	0.3	0.4	0.4	0.4	0.5
6 hours	**Hs (m)**	5.2	5.6	6.2	6.6	7.0	7.6	8.0
	90% CI (± m)	0.2	0.2	0.3	0.3	0.3	0.4	0.4
12 hours	**Hs (m)**	4.8	5.2	5.8	6.2	6.5	7.0	7.3
	90% CI (± m)	0.2	0.2	0.3	0.3	0.3	0.3	0.4
24 hours	**Hs (m)**	4.2	4.6	5.0	5.3	5.7	6.1	6.4
	90% CI (± m)	0.2	0.2	0.2	0.3	0.3	0.3	0.3
48 hours	**Hs (m)**	3.4	3.7	4.1	4.4	4.7	5.1	5.3
	90% CI (± m)	0.1	0.2	0.2	0.3	0.3	0.3	0.4
96 hours	**Hs (m)**	2.5	2.8	3.1	3.3	3.6	3.9	4.1
	90% CI (± m)	0.1	0.2	0.3	0.3	0.4	0.5	0.6
144 hours	**Hs (m)**	2.1	2.2	2.5	2.8	3.0	3.4	3.7
	90% CI (± m)	0.1	0.1	0.3	0.5	0.7	0.9	1.2
NWW3	**Hs (m)**	5.3	5.8	6.5	7.0	7.5	8.1	8.6
	90% CI (± m)	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ERA-40	**Hs (m)**	5.1	5.6	6.2	6.7	7.2	7.8	8.2
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.5	0.5

EXTREME VALUES FOR SYDNEY

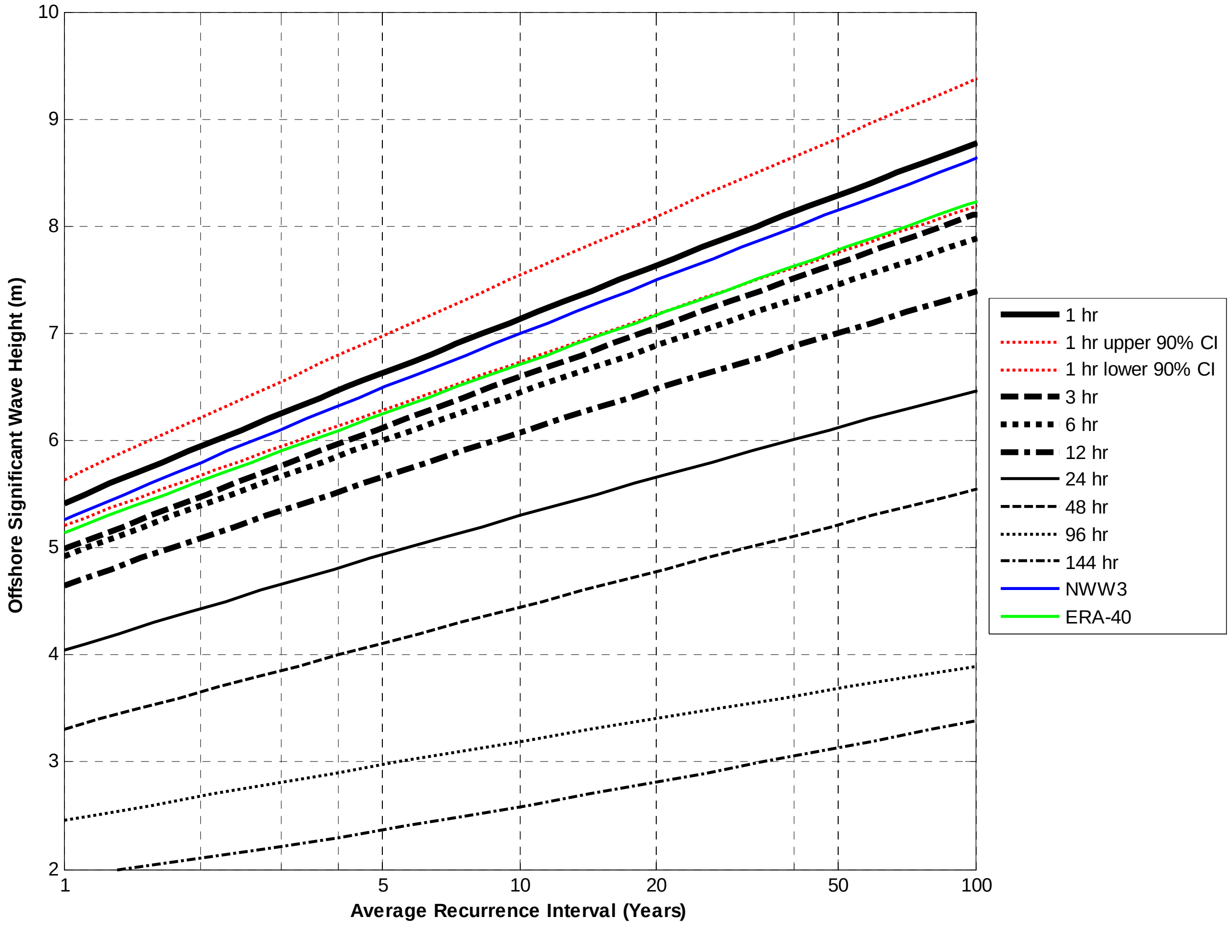
Figure F-5



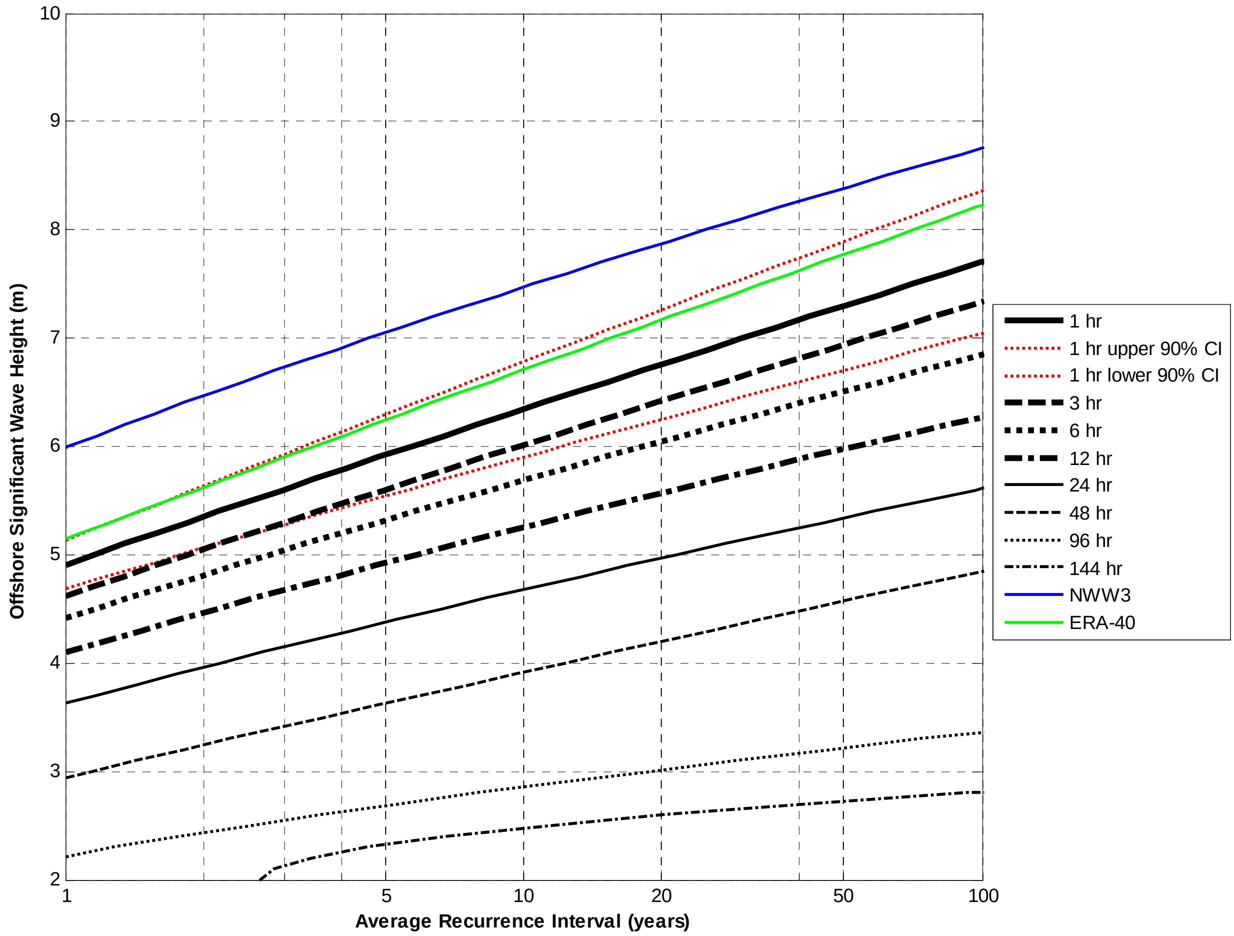
Botany Bay Wave Buoy		ARI (years)						
		1	**2**	**5**	**10**	**20**	**50**	**100**
1 hour	**Hs (m)**	5.7	6.2	6.9	7.4	7.9	8.6	9.1
	90% CI (± m)	0.2	0.2	0.3	0.3	0.3	0.4	0.4
3 hours	**Hs (m)**	5.2	5.7	6.4	6.9	7.4	8.0	8.5
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.4	0.4
6 hours	**Hs (m)**	5.2	5.7	6.3	6.7	7.2	7.7	8.2
	90% CI (± m)	0.2	0.2	0.2	0.3	0.3	0.3	0.4
12 hours	**Hs (m)**	4.8	5.2	5.7	6.1	6.4	6.9	7.3
	90% CI (± m)	0.1	0.2	0.2	0.2	0.2	0.3	0.3
24 hours	**Hs (m)**	4.1	4.5	5.0	5.3	5.7	6.1	6.4
	90% CI (± m)	0.1	0.1	0.2	0.2	0.2	0.3	0.3
48 hours	**Hs (m)**	3.4	3.8	4.3	4.6	4.9	5.4	5.7
	90% CI (± m)	0.1	0.2	0.2	0.2	0.3	0.3	0.4
96 hours	**Hs (m)**	2.5	2.8	3.1	3.4	3.7	4.0	4.3
	90% CI (± m)	0.1	0.1	0.2	0.3	0.3	0.4	0.5
144 hours	**Hs (m)**	1.9	2.2	2.5	2.8	3.0	3.3	3.5
	90% CI (± m)	0.1	0.1	0.2	0.2	0.3	0.4	0.5
NWW3	**Hs (m)**	5.3	5.8	6.5	7.0	7.5	8.1	8.6
	90% CI (± m)	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ERA-40	**Hs (m)**	5.1	5.6	6.2	6.7	7.2	7.8	8.2
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.5	0.5

EXTREME VALUES FOR BOTANY BAY

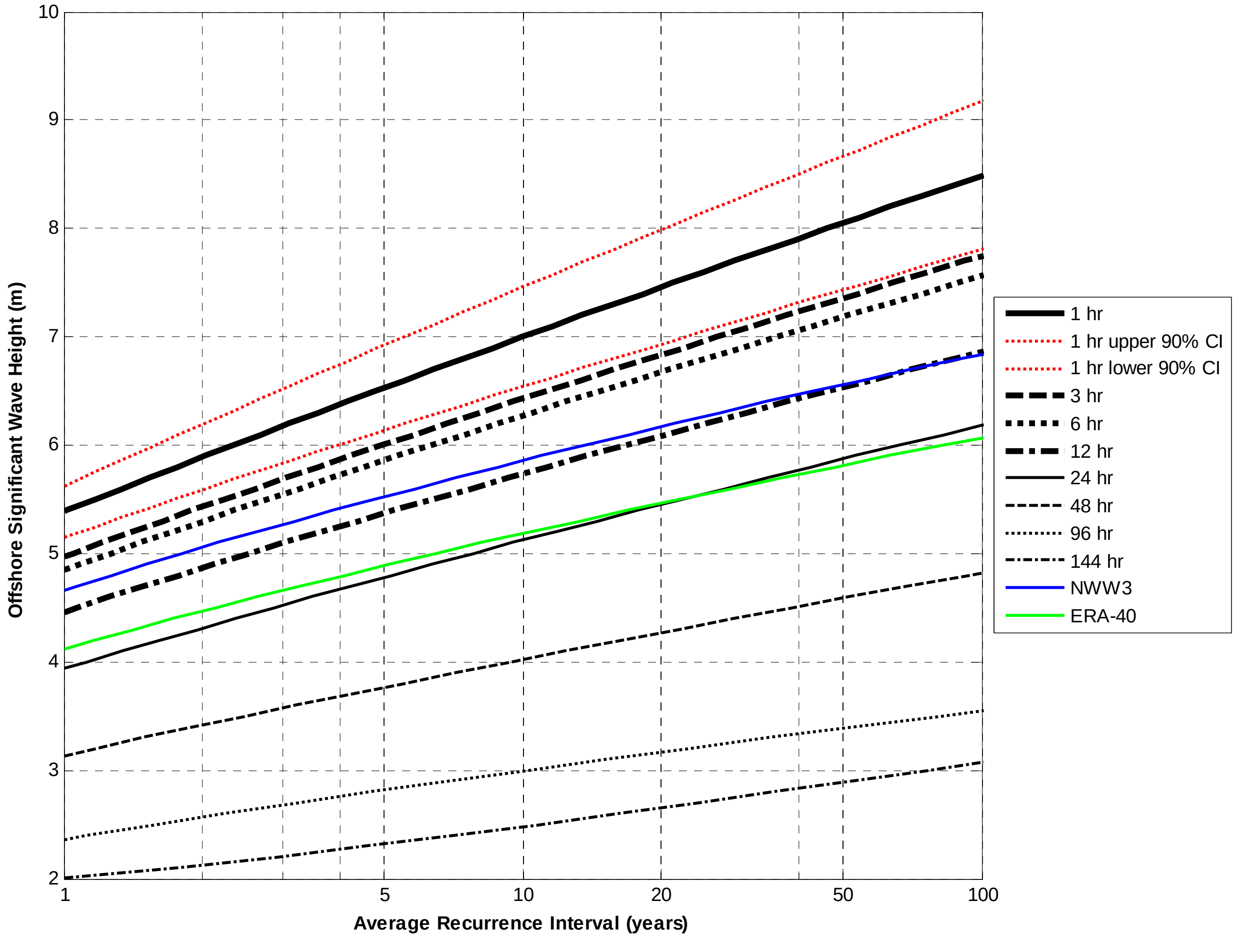
Figure
F-6



Port Kembla Wave Buoy		ARI (years)						
		1	2	5	10	20	50	100
1 hour	Hs (m)	5.4	5.9	6.6	7.1	7.6	8.3	8.8
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.4	0.5
3 hours	Hs (m)	5.0	5.5	6.1	6.6	7.1	7.7	8.1
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.4	0.5
6 hours	Hs (m)	4.9	5.4	6.0	6.4	6.9	7.5	7.9
	90% CI (± m)	0.2	0.2	0.3	0.3	0.3	0.4	0.4
12 hours	Hs (m)	4.6	5.1	5.7	6.1	6.5	7.0	7.4
	90% CI (± m)	0.2	0.2	0.2	0.3	0.3	0.3	0.4
24 hours	Hs (m)	4.0	4.4	4.9	5.3	5.7	6.1	6.5
	90% CI (± m)	0.1	0.2	0.2	0.2	0.3	0.3	0.3
48 hours	Hs (m)	3.3	3.7	4.1	4.4	4.8	5.2	5.5
	90% CI (± m)	0.1	0.2	0.2	0.3	0.3	0.4	0.4
96 hours	Hs (m)	2.5	2.7	3.0	3.2	3.4	3.7	3.9
	90% CI (± m)	0.1	0.1	0.2	0.2	0.3	0.3	0.4
144 hours	Hs (m)	2.0	2.1	2.4	2.6	2.8	3.1	3.4
	90% CI (± m)	0.1	0.1	0.2	0.3	0.4	0.6	0.8
NWW3	Hs (m)	5.3	5.8	6.5	7.0	7.5	8.1	8.6
	90% CI (± m)	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ERA-40	Hs (m)	5.1	5.6	6.2	6.7	7.2	7.8	8.2
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.5	0.5



Batemans Bay Wave Buoy		ARI (years)						
		1	2	5	10	20	50	100
1 hour	Hs (m)	4.9	5.3	5.9	6.3	6.8	7.3	7.7
	90% CI (± m)	0.2	0.2	0.3	0.4	0.4	0.5	0.5
3 hours	Hs (m)	4.6	5.0	5.6	6.0	6.4	6.9	7.3
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.5	0.5
6 hours	Hs (m)	4.4	4.8	5.3	5.7	6.0	6.5	6.8
	90% CI (± m)	0.2	0.2	0.3	0.3	0.3	0.4	0.4
12 hours	Hs (m)	4.1	4.5	4.9	5.3	5.6	6.0	6.3
	90% CI (± m)	0.2	0.2	0.2	0.3	0.3	0.3	0.4
24 hours	Hs (m)	3.6	4.0	4.4	4.7	5.0	5.3	5.6
	90% CI (± m)	0.1	0.2	0.2	0.3	0.3	0.3	0.4
48 hours	Hs (m)	2.9	3.2	3.6	3.9	4.2	4.6	4.9
	90% CI (± m)	0.1	0.2	0.2	0.3	0.3	0.4	0.5
96 hours	Hs (m)	2.2	2.4	2.7	2.9	3.0	3.2	3.4
	90% CI (± m)	0.1	0.1	0.2	0.2	0.3	0.3	0.4
144 hours	Hs (m)	2.0	2.0	2.3	2.5	2.6	2.7	2.8
	90% CI (± m)	0.1	0.2	0.1	0.2	0.3	0.3	0.4
NWW3	Hs (m)	6.0	6.5	7.1	7.5	7.9	8.4	8.8
	90% CI (± m)	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ERA-40	Hs (m)	5.1	5.6	6.2	6.7	7.2	7.8	8.2
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.5	0.5



Eden Wave Buoy		ARI (years)						
		1	2	5	10	20	50	100
1 hour	Hs (m)	5.4	5.9	6.5	7.0	7.5	8.1	8.5
	90% CI (± m)	0.2	0.2	0.3	0.3	0.4	0.4	0.5
3 hours	Hs (m)	5.0	5.4	6.0	6.4	6.8	7.4	7.7
	90% CI (± m)	0.2	0.2	0.3	0.3	0.3	0.4	0.4
6 hours	Hs (m)	4.8	5.3	5.9	6.3	6.7	7.2	7.6
	90% CI (± m)	0.2	0.2	0.3	0.3	0.3	0.4	0.4
12 hours	Hs (m)	4.5	4.9	5.4	5.7	6.1	6.5	6.9
	90% CI (± m)	0.2	0.2	0.2	0.3	0.3	0.3	0.3
24 hours	Hs (m)	3.9	4.3	4.8	5.1	5.5	5.9	6.2
	90% CI (± m)	0.1	0.2	0.2	0.2	0.3	0.3	0.3
48 hours	Hs (m)	3.1	3.4	3.8	4.0	4.3	4.6	4.8
	90% CI (± m)	0.1	0.1	0.2	0.2	0.2	0.3	0.3
96 hours	Hs (m)	2.4	2.6	2.8	3.0	3.2	3.4	3.5
	90% CI (± m)	0.1	0.1	0.2	0.2	0.2	0.3	0.3
144 hours	Hs (m)	2.0	2.1	2.3	2.5	2.7	2.9	3.1
	90% CI (± m)	0.1	0.1	0.2	0.3	0.4	0.5	0.6
NWW3	Hs (m)	4.7	5.1	5.5	5.9	6.2	6.6	6.8
	90% CI (± m)	0.2	0.3	0.3	0.4	0.4	0.5	0.5
ERA-40	Hs (m)	4.1	4.5	4.9	5.2	5.5	5.8	6.1
	90% CI (± m)	0.1	0.1	0.2	0.2	0.2	0.2	0.2

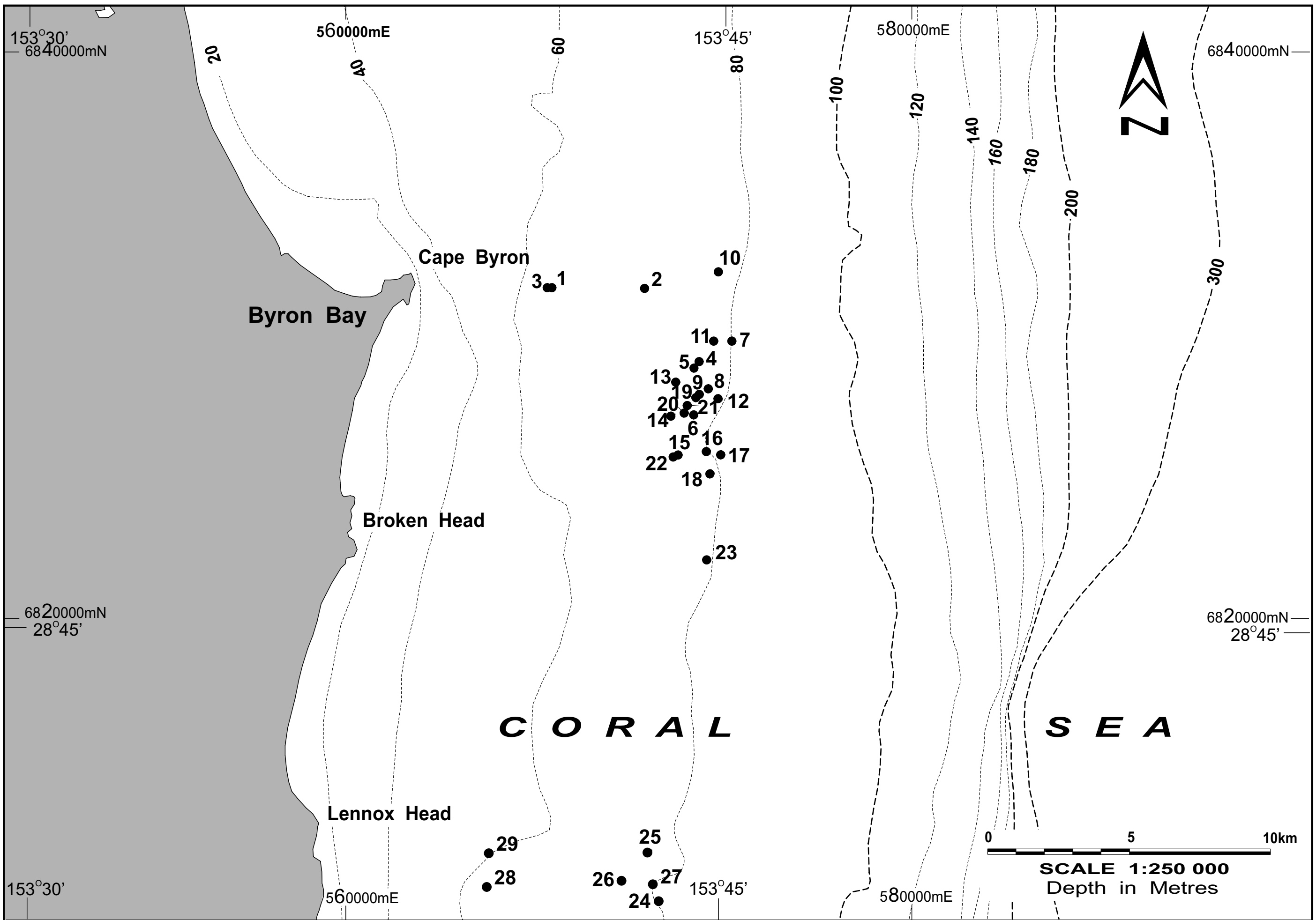
EXTREME VALUES FOR EDEN

APPENDIX G
MHL WAVE BUOY LOCATIONAL HISTORY

G-1 Byron Bay
G-2 Coffs Harbour
G-3 Crowdy Head
G-4 Sydney
G-5 Port Kembla
G-6 Batemans Bay
G-7 Eden

Public Works
Manly Hydraulics Laboratory

BYRON BAY WAVERIDER BUOY LOCATION HISTORY



DEPLOYMENT LOCATION	LOCATION DETAILS Latitude (S)	Longitude (E)	GDA (Zone 56) Easting	Northing	WATER DEPTH (m)	DEPLOYMENT PERIOD First Date	Last Date
1	28°38'24"	153°41'18"	567280	6831690	64	14-Oct-1976	07-Jun-1978
2	28°38'24"	153°43'18"	570530	6831670	70	03-Aug-1978	13-Jun-1979
3	28°38'24"	153°41'12"	567110	6831690	62	08-Aug-1979	09-Aug-1983
4	28°39'48"	153°44'30"	572470	6829080	77	09-Aug-1983	13-Dec-1983
5	28°39'54"	153°44'24"	572310	6828890	77	07-Feb-1984	25-Sep-1984
6	28°40'48"	153°44'24"	572300	6827230	73	25-Sep-1984	30-Jun-1985
7	28°39'24"	153°45'12"	573620	6829810	80	27-Aug-1985	22-Nov-1985
8	28°40'18"	153°44'42"	572790	6828140	78	12-Dec-1985	24-Mar-1987
9	28°40'25"	153°44'31"	572480	6827950	78	24-Mar-1987	19-Nov-1987
10	28°38'05"	153°44'54"	573150	6832250	77	03-Dec-1987	07-Apr-1988
11	28°39'24"	153°44'49"	572980	6829800	77	18-May-1988	07-Nov-1988
12	28°40'30"	153°44'55"	573130	6827780	82	06-Dec-1988	08-Dec-1988
13	28°40'12"	153°44'00"	571650	6828350	72	10-Jan-1989	05-Aug-1989
14	28°40'49"	153°43'55"	571500	6827200	71	29-Aug-1989	14-Dec-1989
15	28°41'35"	153°44'03"	571730	6825790	74	07-Feb-1990	06-Dec-1990
16	28°41'30"	153°44'40"	572730	6825950	73	06-Dec-1990	09-May-1991
17	28°41'33"	153°44'59"	573240	6825840	78	29-May-1991	14-May-1992
18	28°41'55"	153°44'46"	572880	6825170	73	14-May-1992	18-Jun-1993
19	28°40'28"	153°44'26"	572360	6827850	73	23-Jun-1993	21-Jul-1993
20	28°40'46"	153°44'12"	571970	6827300	72	21-Jul-1993	11-Nov-1993
21	28°40'37"	153°44'15"	572060	6827570	72	01-Dec-1993	20-Jul-1994
22	28°41'36"	153°43'57"	571560	6825760	72	20-Jul-1994	05-Feb-1996
23	28°43'32"	153°44'40"	572700	6822180	72	05-Feb-1996	28-Nov-2001
24	28°50'09"	153°43'43"	571080	6809970	71	29-Nov-2000	23-Jan-2001
25	28°49'14"	153°43'38"	570950	6811670	71	10-Feb-2001	29-Aug-2003
26	28°49'44"	153°43'08"	570030	6810570	71	29-Aug-2003	12-Aug-2004
27	28°50'02"	153°43'24"	570570	6810200	71	12-Aug-2004	01-Jan-2005
28	28°49'36"	153°39'48"	564720	6811040	62	04-Feb-2005	11-Dec-2007
29	28°49'21"	153°39'56"	564940	6811500	62	11-Dec-2007	Present

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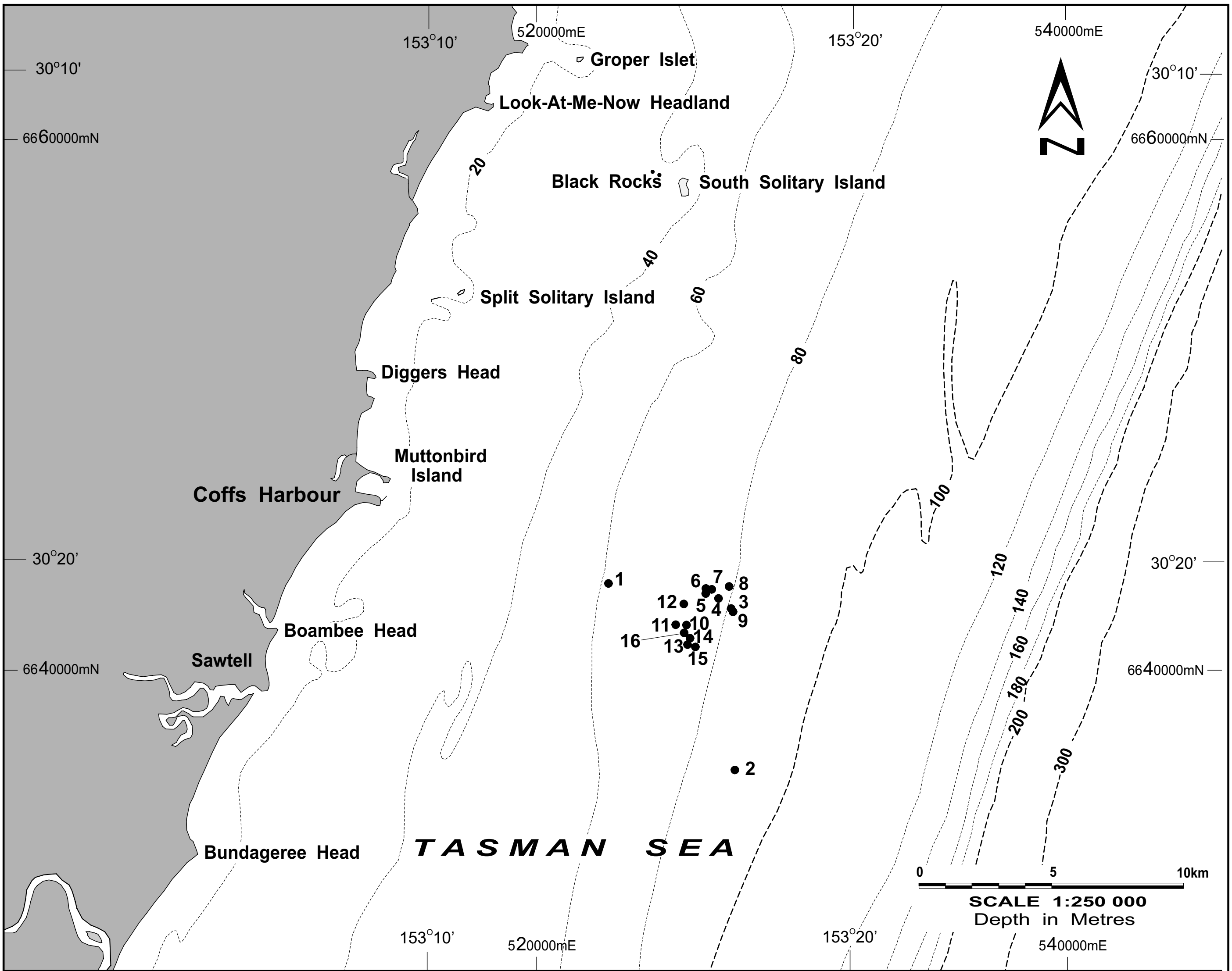
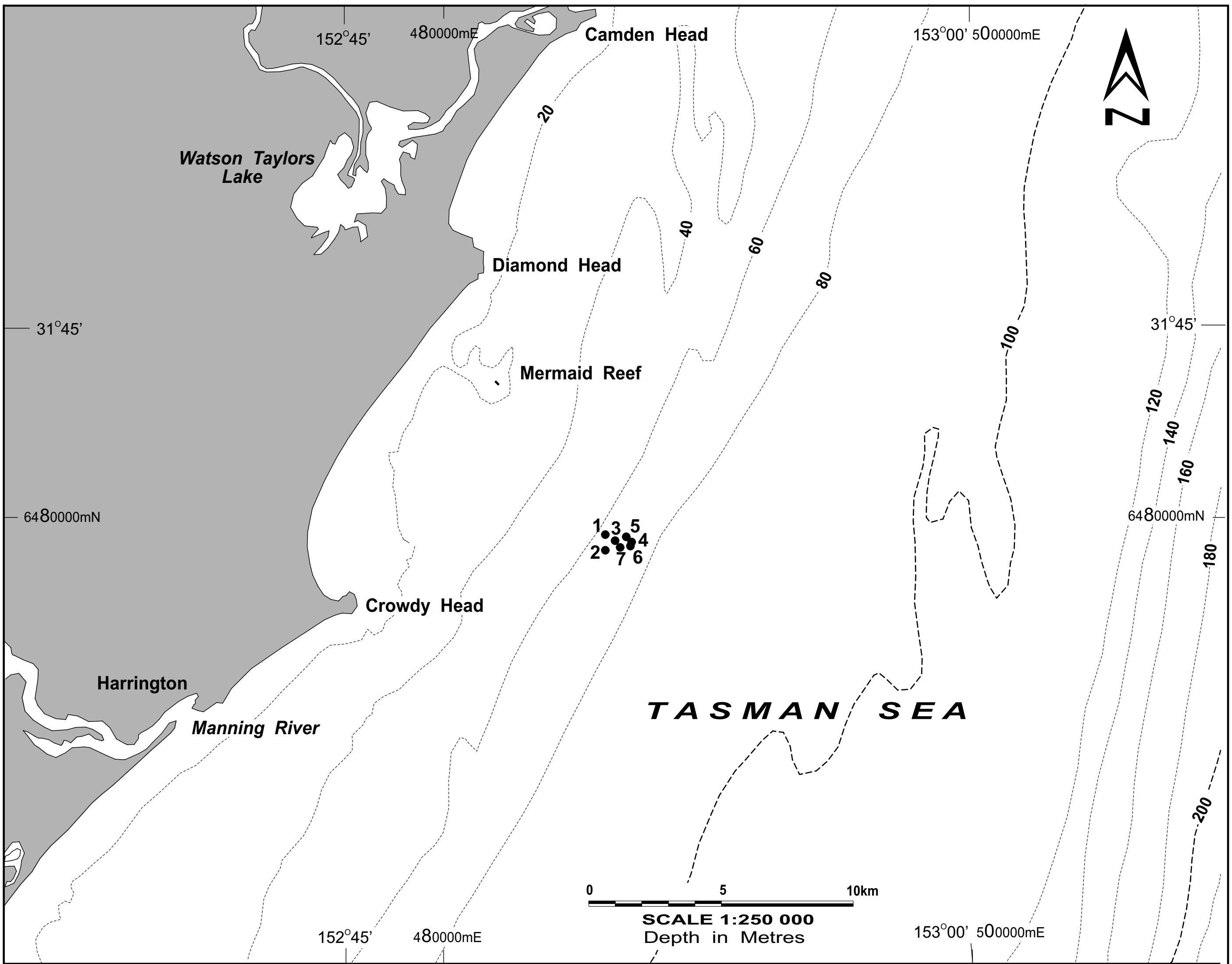
COFFS HARBOUR WAVERIDER BUOY LOCATION HISTORY



DEPLOYMENT LOCATION	LOCATION DETAILS Latitude (S)	Longitude (E)	GDA (Zone 56) Easting	Northing	WATER DEPTH (m)	DEPLOYMENT PERIOD First Date	Last Date
1	30°20'30"	153°14'12"	522750	6643320	60	26-May-1976	18-Aug-1983
2	30°24'18"	153°17'12"	527540	6636290	80	18-Aug-1983	20-Dec-1983
3	30°21'00"	153°17'06"	527390	6642380	80	20-Dec-1983	07-Mar-1984
4	30°20'48"	153°16'48"	526910	6642760	79	07-Mar-1984	21-Mar-1985
5	30°20'42"	153°16'30"	526430	6642940	77	12-Apr-1985	09-Jul-1985
6	30°20'36"	153°16'30"	526430	6643130	77	13-Aug-1985	29-Oct-1985
7	30°20'37"	153°16'38"	526640	6643100	77	05-Nov-1985	08-Oct-1987
8	30°20'34"	153°17'03"	527300	6643200	80	08-Oct-1987	25-Sep-1989
9	30°21'04"	153°17'08"	527450	6642250	82	25-Sep-1989	06-Dec-1989
10	30°21'21"	153°16'03"	525700	6641750	71	19-Dec-1989	11-Apr-1990
11	30°21'20"	153°15'48"	525300	6641770	73	11-Apr-1990	22-Feb-1991
12	30°20'55"	153°15'59"	525600	6642550	73	22-Feb-1991	02-Jul-1996
13	30°21'46"	153°16'04"	525730	6640970	74	26-Jul-1996	06-Dec-1997
14	30°21'37"	153°16'09"	525870	6641250	72	18-Jan-1998	07-Nov-2002
15	30°21'36"	153°16'22"	526210	6641280	72	23-Nov-2002	11-Mar-2005
16	30°21'25"	153°16'07"	525920	6641810	72	01-Apr-2005	Present

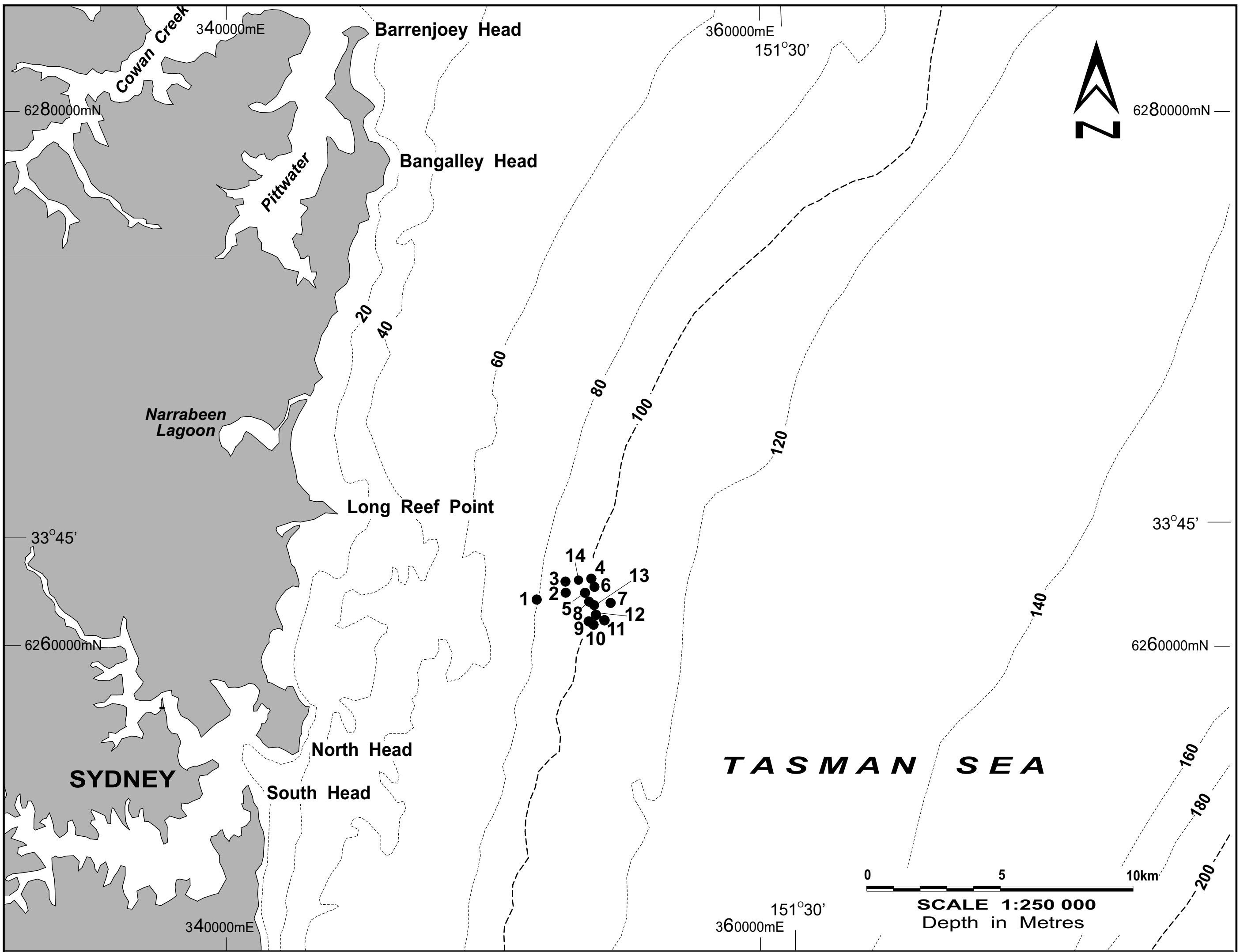
December 2009

CROWDY HEAD WAVERIDER BUOY LOCATION HISTORY



DEPLOYMENT LOCATION	LOCATION DETAILS Latitude (S)	Longitude (E)	GDA (Zone 56) Easting	Northing	WATER DEPTH (m)	DEPLOYMENT PERIOD First Date	Last Date
1	31°49'37"	152°51'12"	486110	6478730	77	10-Oct-1985	11-Nov-1986
2	31°49'17"	152°51'12"	486110	6479330	77	11-Nov-1986	20-Oct-1987
3	31°49'25"	152°51'26"	486480	6479100	80	20-Oct-1987	08-Aug-1989
4	31°49'26"	152°51'49"	487100	6479050	79	08-Aug-1989	17-Jul-1990
5	31°49'20"	152°51'42"	486900	6479250	77	17-Jul-1990	20-Apr-1993
6	31°49'31"	152°51'47"	487050	6478900	79	20-Apr-1993	21-Nov-1997
7	31°49'31"	152°51'35"	486720	6478910	79	21-Nov-1997	Present

SYDNEY DIRECTIONAL WAVERIDER BUOY LOCATION HISTORY



DEPLOYMENT LOCATION	LOCATION DETAILS: Latitude (S)	Longitude (E)	GDA (Zone 56) Easting	Northing	WATER DEPTH (m)	DEPLOYMENT PERIOD: First Date	Last Date
1	33°46'26"	151°23'52"	351650	6261750	82	03-Mar-1992	05-Apr-1993
2	33°46'18"	151°24'35"	352740	6262010	85	22-Jun-1993	17-Nov-1993
3	33°46'04"	151°24'36"	352760	6262440	85	17-Nov-1993	01-Dec-1993
4	33°46'02"	151°25'13"	353710	6262520	85	18-Dec-1993	16-Feb-1994
5	33°46'17"	151°25'03"	353460	6262050	85	22-Mar-1994	25-Feb-1995
6	33°46'11"	151°25'18"	353840	6262230	87	25-Feb-1995	11-Feb-1998
7	33°46'31"	151°25'39"	354400	6261640	87	11-Feb-1998	01-Oct-1998
8	33°46'29"	151°25'07"	353570	6261680	85	01-Oct-1998	07-Feb-1999
9	33°46'53"	151°25'09"	353630	6260940	85	26-Mar-1999	23-Nov-1999
10	33°46'57"	151°25'17"	353830	6260840	85	23-Nov-1999	20-Jul-2001
11	33°46'54"	151°25'29"	354160	6260930	85	11-Sep-2001	18-May-2004
12	33°46'45"	151°25'15"	354160	6260930	85	18-May-2004	15-Jan-2005
13	33°46'31"	151°25'04"	353490	6261620	85	15-Feb-2005	13-Mar-2008
14	33°46'18"	151°24'59"	353360	6262020	92	13-Mar-2008	Present

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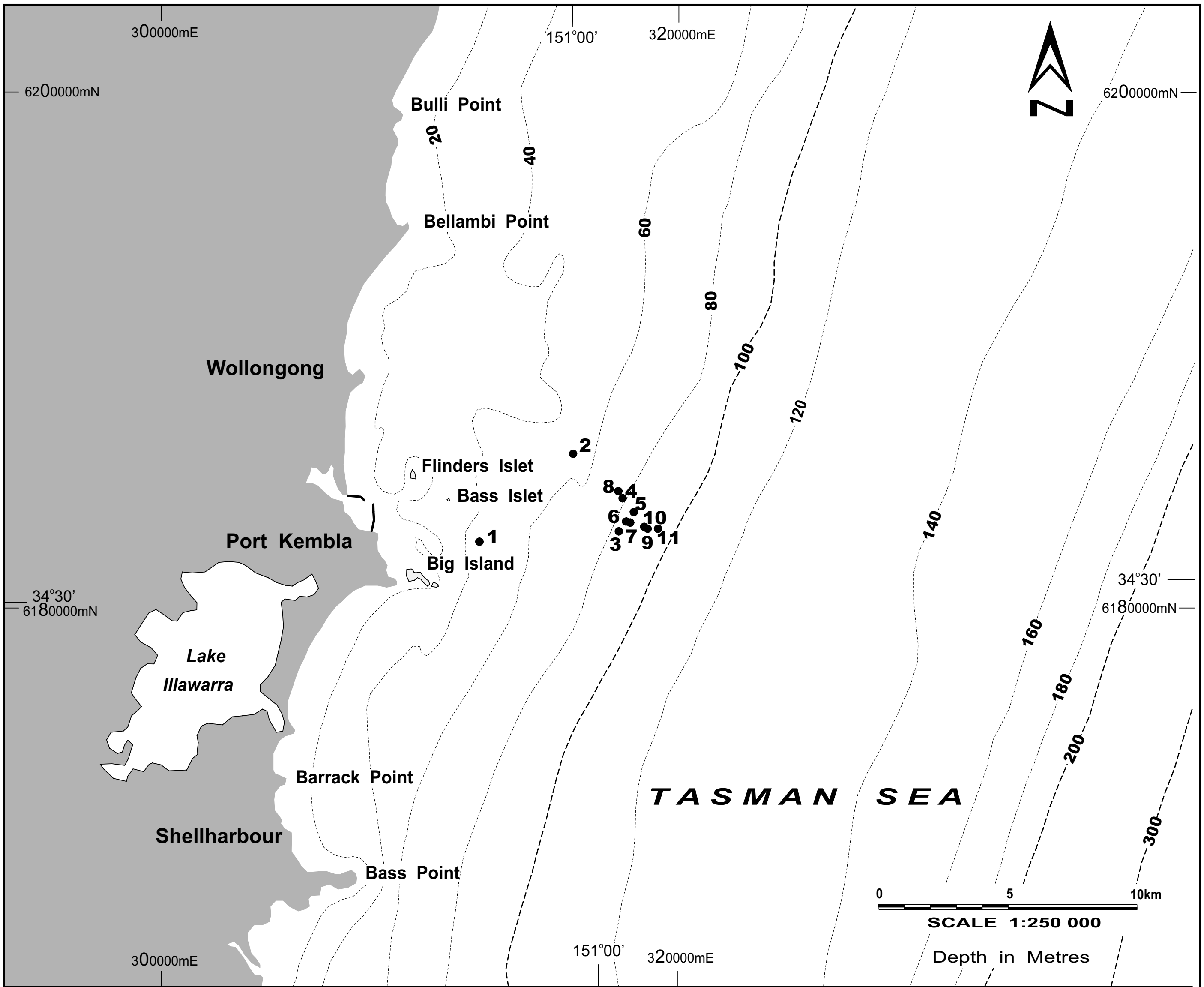
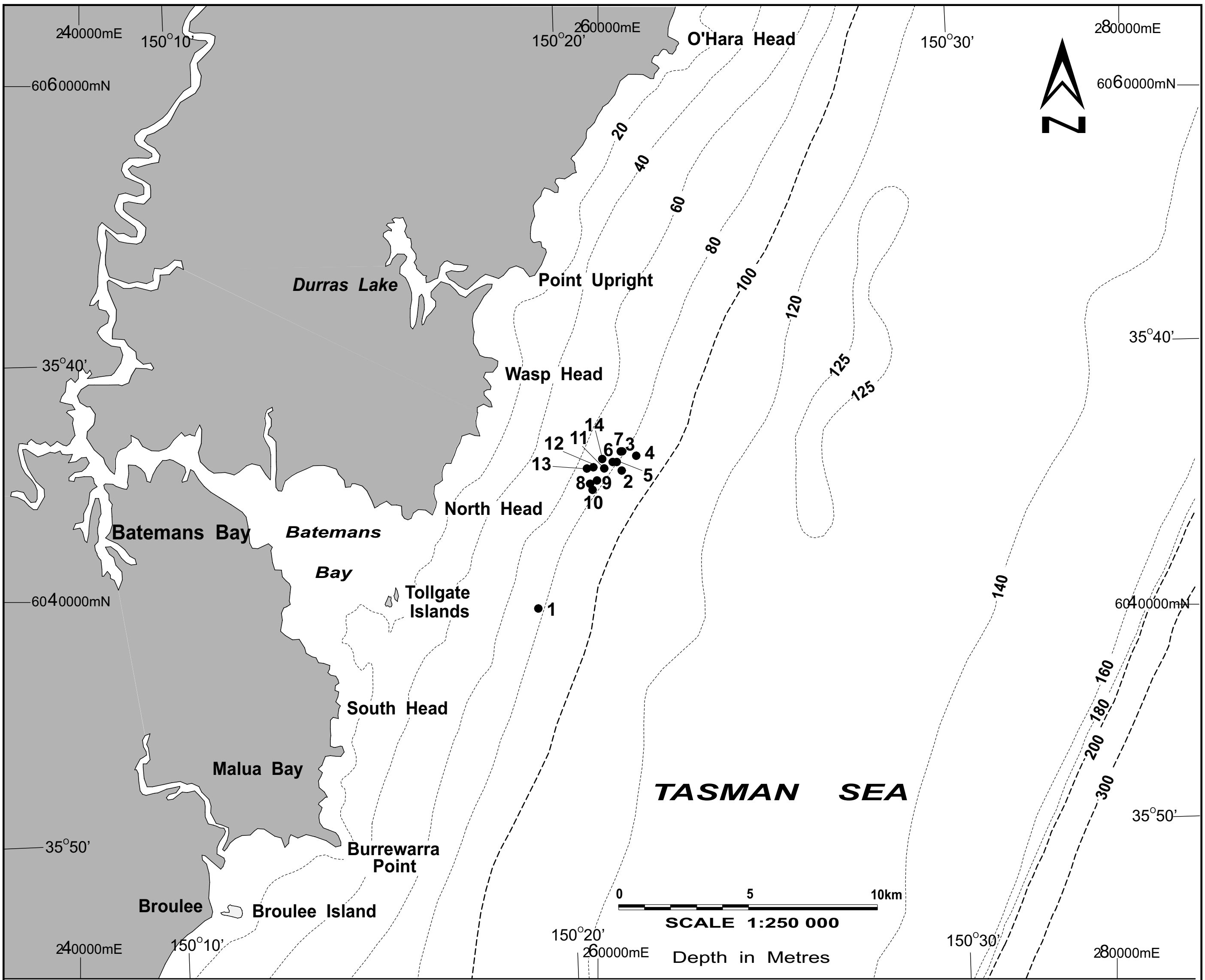
PORT KEMBLA WAVERIDER BUOY LOCATION HISTORY



DEPLOYMENT LOCATION	LOCATION DETAILS Latitude (S)	Longitude (E)	GDA (Zone 56) Easting	Northing	WATER DEPTH (m)	DEPLOYMENT PERIOD First Date	Last Date
1	34°28'52"	150°57'22"	312310	6182590	40	07-Feb-1974	25-Oct-1976
2	34°27'04"	150°59'47"	315940	6185990	50	25-Oct-1976	16-Nov-1983
3	34°28'42"	151°00'54"	317710	6183000	82	16-Nov-1983	14-Jun-1984
4	34°28'01"	151°01'00"	317850	6184280	76	14-Jun-1984	27-May-1988
5	34°28'18"	151°01'18"	318300	6183750	73	01-Jun-1988	19-Dec-1988
6	34°28'30"	151°01'06"	318000	6183380	73	19-Jan-1989	25-Jan-1990
7	34°28'32"	151°01'12"	318150	6183330	77	25-Jan-1990	24-Oct-1991
8	34°27'52"	151°00'55"	317700	6184550	82	24-Oct-1991	24-Jun-1992
9	34°28'24"	151°01'23"	318820	6183090	77	24-Jun-1992	28-Jul-1994
10	34°28'38"	151°01'31"	318650	6183150	78	28-Jul-1994	10-Jun-2003
11	34°28'28"	151°01'34"	318720	6183460	80	25-Jun-2003	Present

BATEMANS BAY WAVERIDER BUOY LOCATION HISTORY



DEPLOYMENT LOCATION	LOCATION DETAILS Latitude (S)	Longitude (E)	GDA (Zone 56) Easting	Northing	WATER DEPTH (m)	DEPLOYMENT PERIOD First Date	Last Date
1	35°45'19"	150°19'11"	257650	6039860	79	27-May-1986	02-Jun-1986
2	35°42'29"	150°21'25"	260880	6045200	75	02-Jun-1986	30-Sep-1987
3	35°42'05"	150°21'24"	260850	6045950	75	01-Oct-1987	29-Jun-1988
4	35°42'12"	150°21'47"	261430	6045750	84	30-Jun-1988	07-Feb-1989
5	35°42'18"	150°21'18"	260700	6045530	80	07-Feb-1989	19-Mar-1989
6	35°42'18"	150°21'12"	260550	6045530	73	11-Apr-1989	24-Oct-1989
7	35°42'05"	150°21'26"	260900	6045950	75	25-Oct-1989	09-Nov-1989
8	35°42'44"	150°20'35"	259650	6044700	73	22-Nov-1989	26-Apr-1990
9	35°42'40"	150°20'47"	259950	6044830	73	09-May-1990	19-Oct-1990
10	35°42'52"	150°20'39"	259750	6044450	73	13-Nov-1990	05-Jan-1997
11	35°42'26"	150°20'58"	260200	6045270	75	05-Jan-1997	28-Mar-1998
12	35°42'24"	150°20'41"	259780	6045320	73	29-Apr-1998	30-Jul-2004
13	35°42'26"	150°20'55"	260030	6045090	73	30-Jul-2004	18-Dec-2008
14	35°42'11"	150°20'38"	259680	6045740	73	25-Jan-2008	Present

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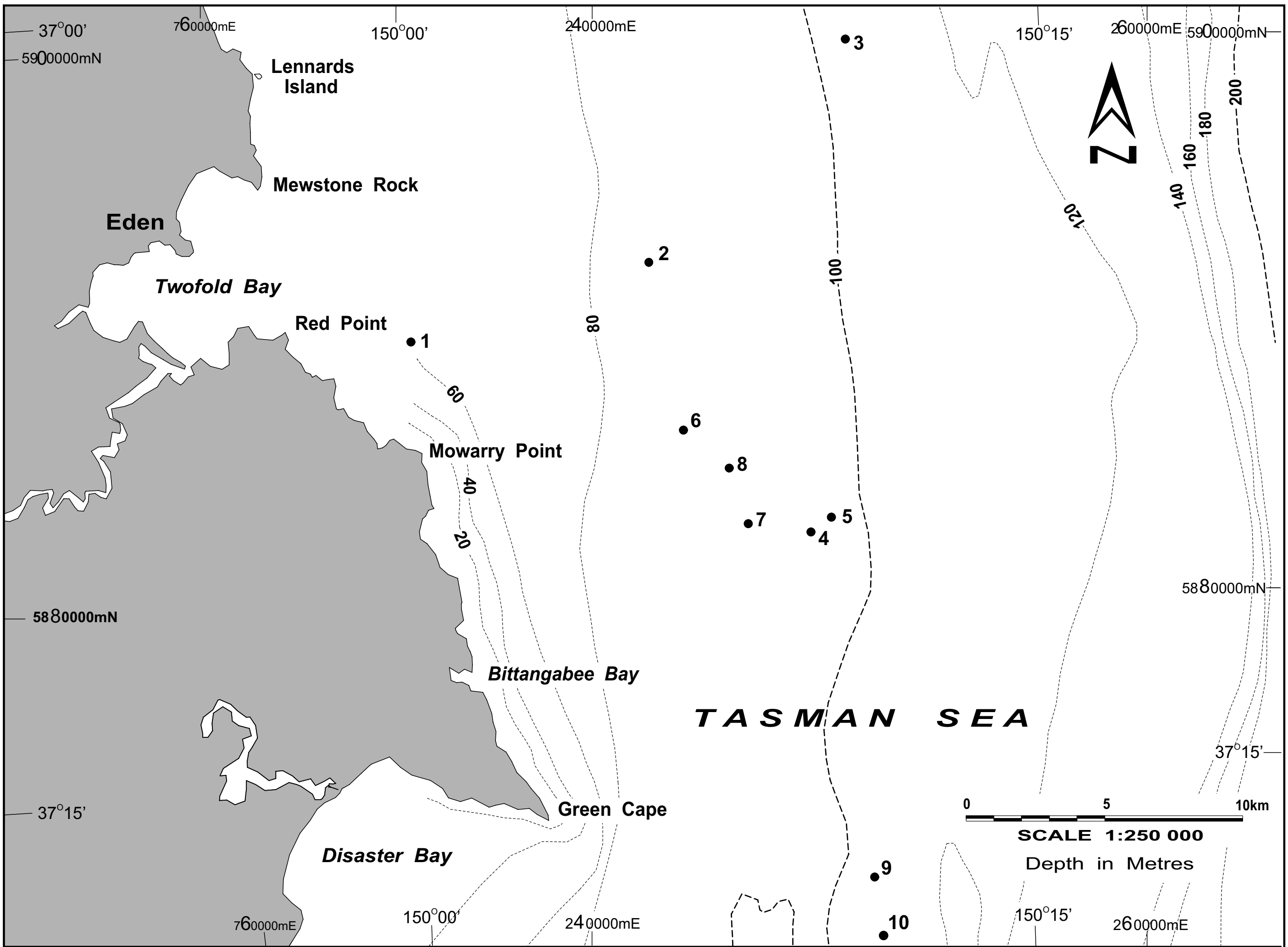
EDEN WAVERIDER BUOY LOCATION HISTORY



DEPLOYMENT LOCATION	LOCATION DETAILS				WATER DEPTH (m)	DEPLOYMENT PERIOD	
	Latitude (S)	Longitude (E)	GDA (Zone 56) Easting	GDA (Zone 56) Northing		First Date	Last Date
1	37°06'36"	150°00'00"	233420	5888700	55	08-Feb-1978	21-Sep-1983
2	37°05'12"	150°05'48"	241930	5891550	79	21-Sep-1983	22-Sep-1984
3	37°01'00"	150°10'42"	248960	5899540	104	10-Oct-1984	23-Oct-1984
4	37°10'30"	150°09'30"	247710	5881920	86	21-Mar-1985	15-Oct-1986
5	37°10'13"	150°10'01"	248450	5882450	95	15-Oct-1986	04-Feb-1987
6	37°08'28"	150°06'30"	243150	5885550	80	04-Feb-1987	10-Feb-1987
7	37°10'18"	150°08'00"	245480	5882220	90	23-Apr-1987	04-Feb-1988
8	37°09'12"	150°07'35"	244800	5884200	90	04-Feb-1988	07-Mar-1989
9	37°17'12"	150°10'48"	250000	5869580	110	07-Mar-1989	14-Sep-2000
10	37°18'06"	150°11'06"	250500	5866890	100	14-Sep-2000	Present