Wave data recording program

Lucinda Region

1995 - 1996

Queensland Government

Environmental Protection Agency

Conservation data report No. W19.1

ISSN RE

Abstract

This report provides summaries of primary analysis of wave data recorded in water depths of approximately 9.7 metres relative to lowest astronomical tide, offshore from Lucinda Jetty Head in northern Queensland. Data was recorded using a Datawell 'Waverider' buoy, and covers the periods from 2 March 1995 to 13 May 1996. The data was divided into seasonal groupings for analysis. No estimations of wave direction data have been provided.

The Coastal Services Unit, Environmental & Technical Services Division of the Environmental Protection Agency, has prepared this report.

Wave data recording program
Lucinda Region 1995-1996

Disclaimer

While reasonable care and attention have been exercised in the collection, processing and compilation of the wave data included in this report, the Coastal Services Unit does not guarantee the accuracy and reliability of this information in any way. The Environmental Protection Agency accepts no responsibility for the use of this information in any way.

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1.0 Introduction

The Coastal Services Unit, as part of its long-term data collection program, has maintained a network of wave recording stations along Queensland's coast since 1968. This report summarises the primary analysis of wave data collected at the Lucinda station. In addition, brief details of the recording equipment, the methods of handling raw data and the type of analyses employed are provided. The Lucinda wave recording station was commissioned as a jointly funded project between the Ports Corporation of Queensland and the Environmental Protection Agency.

As an overview of the Environmental Protection Agency's coverage of data recording along the Queensland coastline, the network of wave recording stations have been grouped into three categories and are shown below. A new wave reporting has been introduced containing wave information on all sites for a given seasonal year, starting from 1997.

Permanent sites: These sites form part of long term data collection activities along the Queensland coast that collect wave statistics used for coastal management purposes. The stations are fully funded and operated by the Environmental Protection Agency.

Project sites: These sites are of limited duration, associated with some specific coastal activity, and are used to assess wave conditions for coastal investigation projects and/or to help monitor works such as beach nourishment. The stations are fully funded and operated by the Environmental Protection Agency as specific projects.

Joint project sites: The life of these sites will vary in duration, and they are associated with specific projects, to assess wave conditions, or to monitor works. These stations are operated in conjunction with (and jointly funded by) other agencies.

The 2001–2002 site groups are as follows: -

Current wave recording stations
for season 2001–2002

Permanent	Project		Joint project	Joint project partners
Brisbane	Woorim		Tweed Heads	TRESBP *
Mackay	Emu Park		Gold Coast Seaway	GCCC+
Townsville	Moreton Bay		Hay Point	PCQ #
Cairns	Mooloolaba		Weipa	PCQ #
	Dunk Island			
	Bar Cutting (Moreton Bay)			

* Tweed River Entrance Sand Bypassing Project (joint project of Qld and NSW governments with support of GCCC)

+ Gold Coast City Council

Ports Corporation of Queensland

2.0 Recording equipment configuration

The Coastal Services Unit's wave recording program utilises either of two systems to measure wave data: the Waverider buoy system or a wave pole. For the duration of this summary report the 'Waverider' system was utilised to measure the sea surface fluctuations at the Lucinda site.

Directional and non-directional Waverider buoys measure vertical acceleration by means of an accelerometer that is mounted on a gravity-stabilised platform suspended in a fluid filled plastic sphere located at the bottom of the buoy. This data is twice integrated to give displacement. The instantaneous water level and directional data (if present) are transmitted to the shore recording station as a frequency modulated high frequency radio signal. Both directional and non-directional buoy are in operation but only a non-directional buoy was used at Lucinda.

The Lucinda station was first installed on the 2 March 1995 and consisted of a shore station and Waverider buoy. The shore station used a personal computer (PC) system linked to the Datawell DIWAR Waverider receiver/digitiser. The changing water level was digitised at a rate of 0.39 second intervals (2.56Hz) and recorded in bursts of 4096 data points (approximately 26 minutes of data). Each record was stored on the hard disk of the PC. Proprietary software running on the PC controlled the timing of the data recordings and processed the data in 'near real time' to provide a set of standard sea-state parameters and spectra. Recorded data and analysis results were then accessed remotely via the public telephone network and downloaded daily to a central computer system in Brisbane for further checking, processing and archiving.

Further information on the operation of the Waverider buoy and the recording systems may be obtained from the sources listed in section 7.0 of this report.

3.0 Laboratory calibration checks

Waverider buoys used by the Coastal Services Unit are calibrated before deployment and also after recovery. Calibration is performed at the Queensland Government Hydraulics Laboratory using a buoy calibrator to simulate sinusoidal waves with amplitudes of either 1m or 1·4m depending on whether a 0·7m or 0·9m diameter buoy is being tested. The wheel is electrically controlled and the frequency may be varied from 0.016–0.25Hz. It is usual to check three frequencies during a calibration. The following characteristics of the buoy are also checked during the calibration procedure:

- phase and amplitude response
- accelerometer platform stability
- platform tilt
- battery capacity
- power output

Once removed from Lucinda, laboratory calibration checks for accelerometer error and platform tilt were performed on the buoy. The buoy was within the manufacturers specifications for results on calibration checks and no adjustments were made to the recorded data.

4.0 Wave recording and analysis procedures

Between 2 March 1995 to 13 May 1996, wave data were recorded 24 times daily, each of 26 minutes duration, with the timing of recordings set at hourly intervals (Australian Eastern Standard Time).

Recorded non-directional wave data are analysed in the time domain by the zero up-crossing method (see fig.10) and in the frequency domain by spectral analysis. Spectral analysis by the PC based system uses Fast Fourier Transform techniques to give 128 spectral estimates in bands of 0.01Hz.

Wave parameters resulting from this processing include the following:

S (f)	Energy density spectrum
Hsig	Significant wave height (time domain), the average of the highest third of the waves in the record
Hmax	The highest individual wave in the record (time domain)
Hrms	The root mean square of the wave heights in the record (time domain)
Tsig	Significant wave period (time domain), the average period of the highest third of waves in the record
Tz	The average period of all zero up-crossing waves in the record (time domain)
Tp	The wave period corresponding to the peak of the energy density spectrum (frequency domain)
Tc	The average period of all the waves in the record based on successive crests (time domain)

These parameters form the basis for the summary plots and tables attached to this report.

5.0 Data losses

Data losses can be divided into two categories: losses due to equipment failure and losses during data processing due to signal corruption. Common causes of data corruption include radio interference and a spurious low frequency component in the water level signal caused by a tilting accelerometer platform in the Waverider buoy.

Analysis of recorded data by the PC based systems includes some data rejection checks which may result in a small number of spurious data points being corrected by an interpolation procedure, otherwise the entire series is rejected. Details of data losses for the Lucinda wave recording station are included in section 9.0, 'Details of wave recorder installations'.

The wave climate data presented in this report are based on statistical analysis of the parameters obtained from the recorded wave data. Programs developed by the Coastal Services Unit provide statistical information on percentage of time occurrence and exceedance for wave heights and periods. The results of these analyses are presented in tables 4 to 9 and figures 4 and 5. In addition, similar analysis is carried out on the relationships between the various wave parameters and these are presented in figure 6.

As discussed above, the various sources of data loss can cause occasional gaps in the data record. Gaps may be relatively short caused by rejection of individual data records or much longer if caused by malfunction of the Waverider buoy or the recording equipment.

In the calculation of wave climate statistics, each record is assigned a total duration equal to half the recording interval on either side of that record. The duration on the side of records adjacent to gaps in the data are limited to a maximum value dependent on the nominal recording interval of that record. With the nominal recording interval set at 1 hour, the maximum allowable total duration of a record is equal to three hours. Each duration on either side of a record greater

than 90 minutes (half the maximum allowable total duration) is set to the maximum allowable of exactly 90 minutes, and a gap in the data is reported.

6.0 Data presentation

No attempt has been made to interpret the recorded data for design purposes or to apply corrections for refraction, diffraction and shoaling to obtain equivalent deepwater waves. Before any use is made of this data it is necessary to note the exact location of the buoy and the water depth in which the buoy was moored. This data is shown in section 9.0, 'Details of the wave recorder installations'. The non-directional Waverider recording system that is utilised by the Coastal Services Unit is designed to record vertical movements of the water surface only and any wave directions must be assigned to the individual wave records by other means.

Table 2, 'Queensland cyclones for 2 March 1995 – 13 May 1996', lists the names and dates of cyclones that occurred along the eastern seaboard of Queensland during the recording period of this report.

Table 3, 'Major meteorological events', provides a summary of meteorological events that occurred during the recording period of this report where the recorded Hsig value reached or exceeded one metre during the event. The wave parameters Hsig, Hmax, and Tp are listed for each event together with other relevant information. None of the cyclone events listed in table 2 contributed to the Hsig reaching one metre, but all have been plotted in figure 9.

Note that in figure 5, 'Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)', the bar columns begin at one second. This is because wave periods (Tp) for the Lucinda site were rarely below two seconds and because the Waverider system will not measure a wave period if it is outside the range of 1.6 to 20 seconds.

For the purposes of analysis, summer has been taken as the period from 1 November to 30 April of the following year and winter covers the period 1 May to 31 October in any one year.

7.0 References

Permanent International Association of Navigation Congresses (1986), List of Sea State Parameters.

Datawell, Operation and Service Manual for the Waverider - series 6000.

Datawell, Manual of the Digital Waverider Receiver type DIWAR.

Lawson and Treloar Pty Ltd (1991), Real Time Wave Analysis Package.

Bureau of Meteorology, Monthly Weather Reviews : Queensland.

8.0 Other reports in this series

Wave data recording program, Cairns Region (Report No. W01.1)	2 May 1975 to 3 Sept 1978
Wave data recording program, Cairns Region (Report No. W01.2)	2 May 1975 to 11 Jun 1985
Wave data recording program, Cairns Region (Report No. W01.3)	2 May 1975 to 30 Apr 1997
Wave data recording program, Mackay Region (Report No. W02.1)	17 Sept 1975 to 5 Nov 1976
Wave data recording program, Mackay Region (Report No. W02.2)	17 Sept 1975 to 23 Aug 1985

Wave data recording program, Mackay Region (Report No. W02.3)	17 Sept 1975 to 30 Oct 1996
Wave data recording program, Townsville Region (Report No. W03.1)	16 July 1975 to 23 Feb 1979
Wave data recording program, Townsville Region (Report No. W03.2)	19 Nov 1975 to 29 Dec 1987
Wave data recording program, Townsville Region (Report No. W03.3)	19 Nov 1975 to 30 Apr 1997
Wave data recording program, Sunshine Coast Region (Report No. W04.1)	5 Apr 1974 to 5 Jul 1977
Wave data recording program, Burnett Heads Region (Report No. W05.1)	5 May 1976 to 5 Mar 1982
Wave data recording program, Burnett Heads Region (Report No. W05.2)	5 May 1976 to 13 Oct 1988
Wave data recording program, Abbot Point Region (Report No. W06.1)	6 May 1977 to 9 Aug 1979
Wave data recording program, Abbot Point Region (Report No. W06.2)	6 May 1977 to 31 Oct 1996
Wave data recording program, Weipa Region (Report No. W07.1)	21 Dec 1978 to 7 Apr 1983
Wave data recording program, Weipa Region (Report No. W07.2)	21 Dec 1978 to 30 Apr 1997
Wave data recording program, Gladstone Region (Report No. W08.1)	19 Dec 1979 to 16 May 1983
Wave data recording program, Brisbane Region (Report No. W09.1)	30 Oct 1976 to 30 Jun 1983
Wave data recording program, Brisbane Region (Report No. W09.2)	30 Oct 1976 to 30 Jun 1994
Wave data recording program, Brisbane Region (Report No. W09.3)	30 Oct 1976 to 28 Feb 1997
Wave data recording program, Bowen Region (Report No. W10.1)	14 Sept 1978 to 15 Nov 1984
Wave data recording program, Moreton Island Region (Report No. W11.1)	15 Jun 1983 to 12 Apr 1985
Wave data recording program, Bramston Beach Region (Report No. W12.1)	16 Dec 1981 to 28 Oct 1985
Wave data recording program, Hay Point Region (Report No. W13.1)	22 Mar 1977 to 25 May 1987
Wave data recording program, Hay Point Region (Report No. W13.2)	22 Mar 1977 to 31 Oct 1996
Wave data recording program, Gold Coast Region (Report No. W14.1)	20 Feb 1987 to 30 Jun 1994
Wave data recording program, Gold Coast Region (Report No. W14.2)	20 Feb 1987 to 28 Feb 1997
Wave data recording program, Kirra (Report No. W15.1)	25 Aug 1988 to 30 Jun 1994
Wave data recording program, Kirra (Report No. W15.2)	25 Aug 1988 to 28 Feb 1997
Wave data recording program, Repulse Bay (Report No. W16.1)	2 Jun 1994 to 22 Oct 1995
Wave data recording program, Hayman Island (Report No. W17.1)	26 Oct 1995 to 14 Oct 1996
Wave data recording program, Tweed Region (Report No. W18.1)	15 Jan 1995 to 28 Feb 1997

9.0 Details of wave recorder installations

Lucinda Region

Buoy locations:

See figure 1 for the locations of the Waverider buoy for the period of this report.

Co-ordinates:	146^{o} 23.00’ East, 18^{o} 30.94’ South
Description:	500 metres north of Lucinda Jetty Head
Water depth at buoy:	9.7 metres relative to Lowest Astronomical Tide.
Periods:	2 March 1995 to 29 September 1995 5 October 1995 to 13 May 1996

On the 29 September 1995, the buoy was removed on request of the Ports Corporation of Queensland because it had been placed in the path of vessels entering Lucinda port from the south. On crosschecking with the Townsville Harbour Master it was stated that the buoy was in “the most appropriate position” and was reinstalled on the 5 October 1995.

Note: - The above buoy location was measured using GPS fixing procedures.

- All water depths are accurate to ± 1 metre.

Location of recording stations:

Ports Corporation boat shed, Lucinda

Co-ordinates: 146° 19.80' East, 18° 31.53' South

Period: 28 February 1995 to 16 May 1996

Recording intervals:

Hourly records, each of approximately 26 minutes were taken, giving 4096 water surface elevation measurements per record, from which sea state parameters were calculated and recorded.

Normally during periods when the recorded Hsig value reaches the storm threshold of 2 metres, the recording frequency would be increased to 30 minute intervals. However, the protected nature of the Lucinda site, due to the surrounding islands near the buoy deployment area, meant that the buoy never received storm threshold wave heights, even in the presence of tropical cyclone Celeste.

Data collection and analysis:

Number of records collected: -	10,502	
Number of records used in analysis: -	10,316	
Number of days in recording period: -	437.58	
Number of days used in analysis: -	431.22	
Number of days lost: -	6.33	(of which approximately six days were from the removal requested by the Ports Corporation of

Table 1.

Wave climate program–summary of data capture
for 2 March 1995 – 13 May 1996

	Data capture [%] (Based on active periods)															
Station	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	**Total**
Lucinda	98.6	99.3	99.9	99.6	97.4	100.0	94.6	85.6	99.7	100.0	99.5	99.1	100.0	100.0	92.3	97.8

Table 2.

Queensland cyclones
for 2 March 1995 – 13 May 1996

Cyclone name	Month	Year
VIOLET	March	1995
WARREN	March	1995
AGNES	April	1995
BARRY	January	1996
CELESTE	January	1996
DENNIS	February	1996
ETHEL	March	1996

Cyclone tracks are shown in figure 9.

Table 3.

Major Meteorological Events

for 2 Mar 95 – 13 May 96

Meteorological event threshold value: 1m	Central pressure (hPa)	Date and time	Maximum Hsig recorded Notes (1) (m)	Maximum Hmax recorded Notes (2) (m)	Tp Notes (3) (s)
High over the Great Australian Bight	1024	13/03/1995 2000	1.00	1.90	3.97
High in the Tasman Sea	1028	28/04/1995 0200	1.07	2.07	4.96
High over the Bight and Tasman Sea	1032	08/05/1995 0600	1.10	1.79	6.21
High over Tasmania	1032	04/06/1995 0001	1.09	1.93	5.50
High over the Bight and low off the NSW coast	1032/1004	16/06/1995 2300	1.04	1.92	5.04
High over the Bight	1036	06/08/1995 1800	1.19	1.96	4.78
High over southern NSW	1036	12/08/1995 2000	1.12	1.75	4.35
High over the eastern Tasman Sea	1036	16/08/1995 0300	1.19	2.11	4.57
High over the central NSW coast	1028	29/08/1995 1800	1.04	1.85	5.28
High offshore from the NSW coast	1024	10/10/1995 0001	1.21	2.04	5.43
High offshore from the NSW coast	1032	16/10/1995 1600	1.17	2.21	4.74
Low over the Cape York Peninsular	1000	08/01/1996 0800	1.26	2.14	5.25
Low off the north QLD coast (developing T.C.Celeste)	1004	26/01/1996 2300	1.08	1.95	4.72
High south of Tasmania and in the Tasman Sea	1028	24/02/1996 2300	1.02	1.84	6.36
High in the Tasman Sea	1024	04/03/1996 1300	1.21	2.24	5.07
High in the Tasman Sea	1028	12/03/1996 1200	1.41	2.49	6.05
High in the Tasman Sea	1024	23/03/1996 1900	1.09	1.72	5.84
High in the Tasman Sea	1028	29/04/1996 1200	1.02	1.82	5.83

Notes: The Hsig values presented in column (1) and the Hmax values presented in column (2) are the maximum values recorded for each event and are not necessarily coincident in time.

The Tp values presented in column (3) and the Hsig values presented in Column (1) are coincident as a single event on the date shown.

Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of Forristall G.Z., Heideman J.C., Leggett I.M., Roskam B. and Vanderschuren L. (1996), "Effect of Sampling Variability on Hindcast and Measured Wave Heights", J. Waterway, Port, Costal and Ocean Engineering, Vol 122, No. 5, September/October 1996. Thus the un-smoothed data in tables 4 to 9 may be of a slightly larger value.

The highest smoothed Significant Wave Height (Hsig) recorded for the period was 1.41 metres, recorded at 1200 on 12 March 1996 during the presence of a high in the Tasman Sea. The corresponding un-smoothed value recorded at this time was 1.52 metres.

Highest Maximum Wave Height (Hmax) recorded for the period was 2.49 metres, recorded on 12 March 1996 during the presence of a high in the Tasman Sea.

Meteorological information was obtained from the 'Monthly Weather Review' published by the Bureau of Meteorology.

Table 4.

Wave statistics
Wave period/wave height occurrences
All data, all directions

* = 0.00
(Table values are number of days for the recording period, rounded to the second decimal place)

Significant wave height **Hsig** (metres)	Peak energy wave period (Tp) (seconds)								
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	Totals
0.00 - 0.09	1.10	2.15	0.58	0.25	0.31	*	*	*	4.39
0.10 - 0.19	15.11	15.00	21.33	7.79	1.40	*	*	*	60.63
0.20 - 0.29	25.54	28.13	21.69	5.71	0.38	*	*	*	81.45
0.30 - 0.39	20.75	36.02	13.71	2.25	0.75	0.04	*	*	73.52
0.40 - 0.49	10.37	35.75	8.98	0.50	0.33	*	*	*	55.93
0.50 - 0.59	3.12	30.44	7.60	0.29	0.12	*	*	*	41.57
0.60 - 0.69	0.83	27.06	8.81	0.04	0.08	*	*	*	36.82
0.70 - 0.79	0.12	21.58	9.54	0.13	0.04	*	*	*	31.41
0.80 - 0.89	*	12.75	7.92	0.08	*	*	*	*	20.75
0.90 - 0.99	*	7.92	5.29	0.17	*	*	*	*	13.38
1.00 - 1.09	*	3.71	2.92	0.38	*	*	*	*	7.01
1.10 - 1.19	*	1.63	0.83	0.08	*	*	*	*	2.54
1.20 - 1.29	*	0.63	0.54	0.08	*	*	*	*	1.25
1.30 - 1.39	*	0.29	0.12	0.12	*	*	*	*	0.53
1.40 - 1.49	*	*	*	*	*	*	*	*	0.00
1.50 - 1.59	*	0.04	*	*	*	*	*	*	0.04
1.60 - 1.69	*	*	*	*	*	*	*	*	0.00
Totals	76.94	223.10	109.86	17.87	3.41	0.04	0.00	0.00	431.22

Table 5.

Wave statistics
Wave period/wave height occurrences
Summer data, all directions

* = 0.00
(Table values are number of days for the recording period, rounded to the second decimal place)

Significant wave height **Hsig** (metres)	Peak energy wave period (Tp) (seconds)								
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	Totals
0.00 - 0.09	0.71	1.54	0.58	0.17	0.27	*	*	*	3.27
0.10 - 0.19	11.61	9.96	8.62	1.17	0.08	*	*	*	31.44
0.20 - 0.29	17.79	16.75	11.52	2.58	0.04	*	*	*	48.68
0.30 - 0.39	15.63	21.85	7.92	1.29	0.50	*	*	*	47.19
0.40 - 0.49	7.33	22.06	5.50	0.17	0.21	*	*	*	35.27
0.50 - 0.59	1.58	18.98	3.83	0.17	0.08	*	*	*	24.64
0.60 - 0.69	0.62	14.15	3.60	*	*	*	*	*	18.37
0.70 - 0.79	0.08	10.04	3.12	*	*	*	*	*	13.24
0.80 - 0.89	*	5.71	2.75	*	*	*	*	*	8.46
0.90 - 0.99	*	3.46	2.33	0.08	*	*	*	*	5.87
1.00 - 1.09	*	1.29	0.92	0.08	*	*	*	*	2.29
1.10 - 1.19	*	0.92	0.54	0.04	*	*	*	*	1.50
1.20 - 1.29	*	0.33	0.33	0.08	*	*	*	*	0.74
1.30 - 1.39	*	0.25	0.08	0.12	*	*	*	*	0.45
1.40 - 1.49	*	*	*	*	*	*	*	*	0.00
1.50 - 1.59	*	0.04	*	*	*	*	*	*	0.04
1.60 - 1.69	*	*	*	*	*	*	*	*	0.00
Totals	55.35	127.33	51.64	5.95	1.18	0.00	0.00	0.00	241.45

Table 6.

Wave statistics
Wave period/wave height occurrences
Winter data, all directions

* = 0.00
(Table values are number of days for the recording period, rounded to the second decimal place)

Significant wave height **Hsig** (metres)	Peak energy wave period (Tp) (seconds)								
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	Totals
0.00 - 0.09	0.40	0.60	*	0.08	0.04	*	*	*	1.12
0.10 - 0.19	3.50	5.04	12.71	6.62	1.31	*	*	*	29.18
0.20 - 0.29	7.75	11.38	10.17	3.12	0.33	*	*	*	32.75
0.30 - 0.39	5.12	14.17	5.79	0.96	0.25	0.04	*	*	26.33
0.40 - 0.49	3.04	13.69	3.48	0.33	0.12	*	*	*	20.66
0.50 - 0.59	1.54	11.46	3.77	0.12	0.04	*	*	*	16.93
0.60 - 0.69	0.21	12.92	5.21	0.04	0.08	*	*	*	18.46
0.70 - 0.79	0.04	11.54	6.42	0.13	0.04	*	*	*	18.17
0.80 - 0.89	*	7.04	5.17	0.08	*	*	*	*	12.29
0.90 - 0.99	*	4.46	2.96	0.08	*	*	*	*	7.50
1.00 - 1.09	*	2.42	2.00	0.29	*	*	*	*	4.71
1.10 - 1.19	*	0.71	0.29	0.04	*	*	*	*	1.04
1.20 - 1.29	*	0.29	0.21	*	*	*	*	*	0.50
1.30 - 1.39	*	0.04	0.04	*	*	*	*	*	0.08
1.40 - 1.49	*	*	*	*	*	*	*	*	0.00
1.50 - 1.59	*	*	*	*	*	*	*	*	0.00
1.60 - 1.69	*	*	*	*	*	*	*	*	0.00
Totals	21.60	95.76	58.22	11.89	2.21	0.04	0.00	0.00	189.72

Table 7.

Wave statistics
Wave period/wave height occurrences
All data, all directions

* = 0.00
(Table values are percentage occurrences for the recording period, rounded to the second decimal place)

Significant wave height **Hsig** (metres)	Peak energy wave period (Tp) (seconds)								
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	Totals
0.00 - 0.09	0.26	0.50	0.14	0.06	0.07	*	*	*	1.02
0.10 - 0.19	3.50	3.48	4.95	1.81	0.32	*	*	*	14.06
0.20 - 0.29	5.92	6.52	5.03	1.32	0.09	*	*	*	18.88
0.30 - 0.39	4.81	8.35	3.18	0.52	0.17	0.01	*	*	17.05
0.40 - 0.49	2.41	8.29	2.08	0.12	0.08	*	*	*	12.97
0.50 - 0.59	0.72	7.06	1.76	0.07	0.03	*	*	*	9.64
0.60 - 0.69	0.19	6.28	2.04	0.01	0.02	*	*	*	8.54
0.70 - 0.79	0.03	5.00	2.21	0.03	0.01	*	*	*	7.28
0.80 - 0.89	*	2.96	1.84	0.02	*	*	*	*	4.81
0.90 - 0.99	*	1.84	1.23	0.04	*	*	*	*	3.10
1.00 - 1.09	*	0.86	0.68	0.09	*	*	*	*	1.62
1.10 - 1.19	*	0.38	0.19	0.02	*	*	*	*	0.59
1.20 - 1.29	*	0.14	0.13	0.02	*	*	*	*	0.29
1.30 - 1.39	*	0.07	0.03	0.03	*	*	*	*	0.13
1.40 - 1.49	*	*	*	*	*	*	*	*	0.00
1.50 - 1.59	*	0.01	*	*	*	*	*	*	0.01
1.60 - 1.69	*	*	*	*	*	*	*	*	0.00
Totals	17.85	51.73	25.48	4.14	0.79	0.01	0.00	0.00	100

Table 8.

Wave Statistics
Wave period/wave height occurrences
Summer data, all directions

* = 0.00
(Table values are percentage occurrences for the recording period, rounded to the second decimal place)

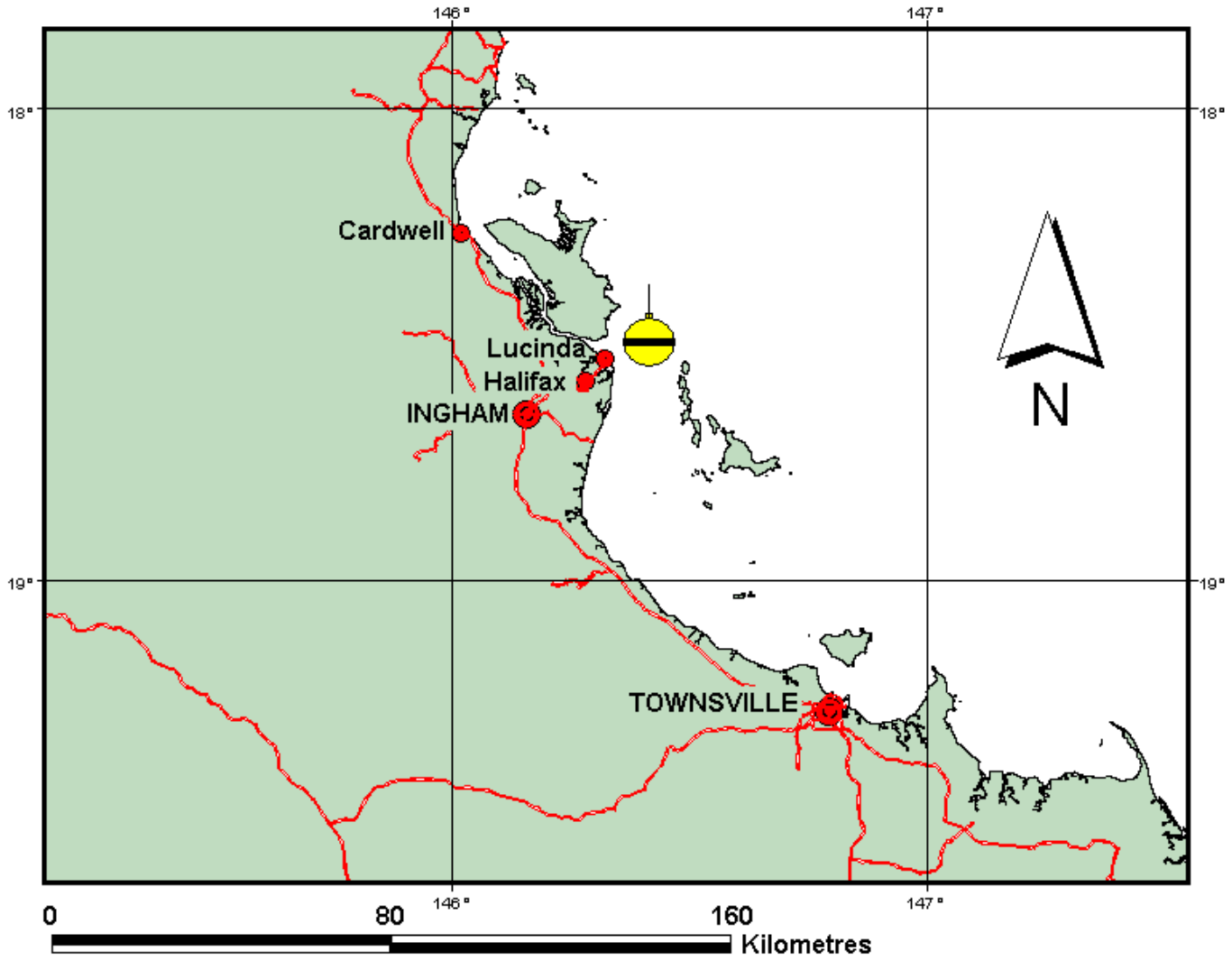
Significant wave height **Hsig** (metres)	Peak energy wave period (Tp) (seconds)								
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	Totals
0.00 - 0.09	0.29	0.64	0.24	0.07	0.11	*	*	*	1.35
0.10 - 0.19	4.81	4.12	3.57	0.48	0.03	*	*	*	13.02
0.20 - 0.29	7.37	6.94	4.77	1.07	0.02	*	*	*	20.16
0.30 - 0.39	6.47	9.05	3.28	0.53	0.21	*	*	*	19.54
0.40 - 0.49	3.04	9.14	2.28	0.07	0.09	*	*	*	14.61
0.50 - 0.59	0.66	7.86	1.59	0.07	0.03	*	*	*	10.21
0.60 - 0.69	0.26	5.86	1.49	*	*	*	*	*	7.61
0.70 - 0.79	0.03	4.16	1.29	*	*	*	*	*	5.49
0.80 - 0.89	*	2.36	1.14	*	*	*	*	*	3.50
0.90 - 0.99	*	1.43	0.97	0.03	*	*	*	*	2.43
1.00 - 1.09	*	0.53	0.38	0.03	*	*	*	*	0.95
1.10 - 1.19	*	0.38	0.22	0.02	*	*	*	*	0.62
1.20 - 1.29	*	0.14	0.14	0.03	*	*	*	*	0.31
1.30 - 1.39	*	0.10	0.03	0.05	*	*	*	*	0.19
1.40 - 1.49	*	*	*	*	*	*	*	*	0.00
1.50 - 1.59	*	0.02	*	*	*	*	*	*	0.02
1.60 - 1.69	*	*	*	*	*	*	*	*	0.00
Totals	22.92	52.73	21.39	2.47	0.49	0.00	0.00	0.00	100

Table 9.

Wave statistics
Wave period/wave height occurrences
Winter data, all directions

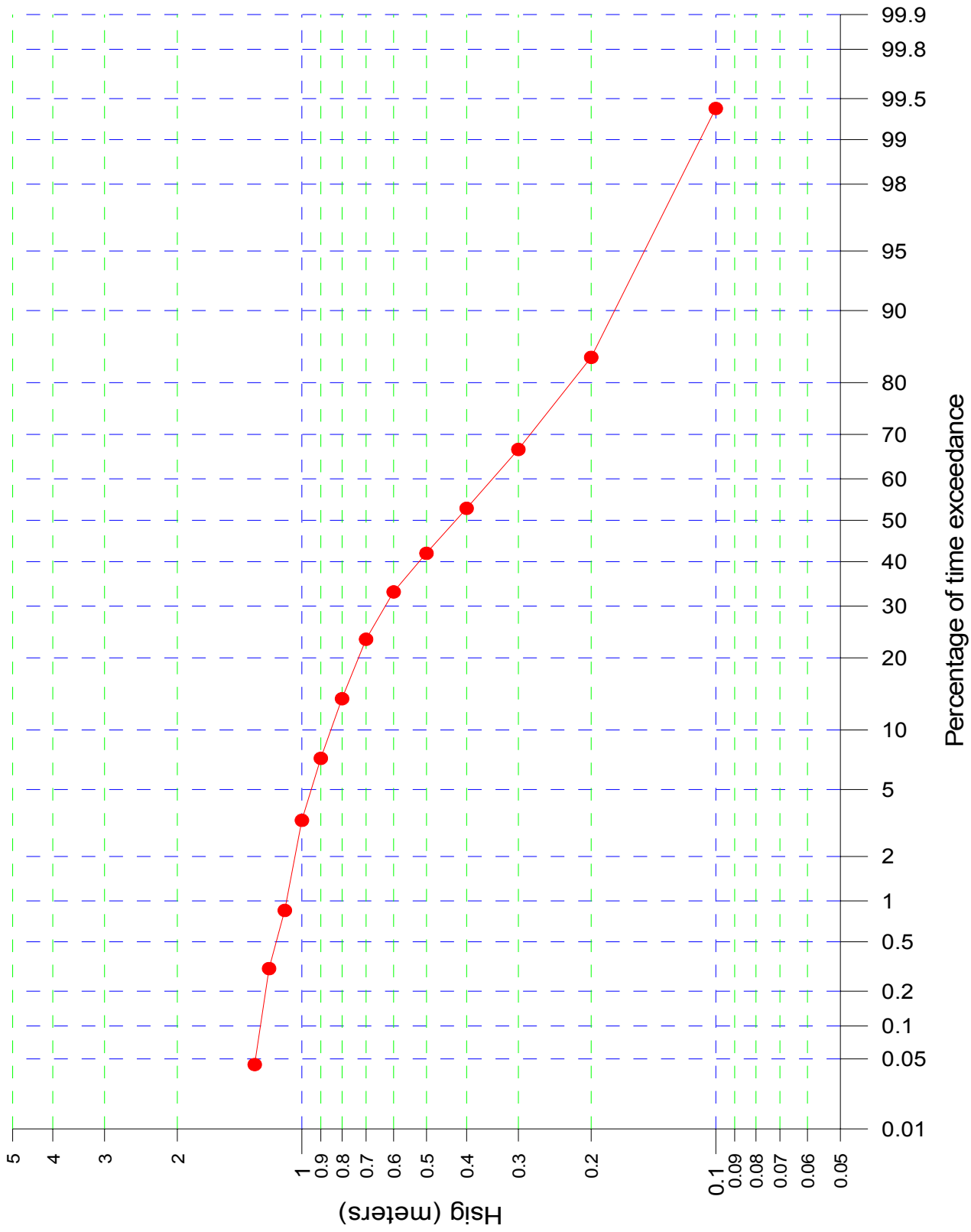
* = 0.00
(Table values are percentage occurrences for the recording period, rounded to the second decimal place)

Significant wave height **Hsig** (metres)	Peak energy wave period (Tp) (seconds)								
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	Totals
0.00 - 0.09	0.21	0.32	*	0.04	0.02	*	*	*	0.59
0.10 - 0.19	1.84	2.66	6.70	3.49	0.69	*	*	*	15.38
0.20 - 0.29	4.08	6.00	5.36	1.65	0.18	*	*	*	17.26
0.30 - 0.39	2.70	7.47	3.05	0.51	0.13	0.02	*	*	13.88
0.40 - 0.49	1.60	7.21	1.83	0.18	0.07	*	*	*	10.89
0.50 - 0.59	0.81	6.04	1.99	0.07	0.02	*	*	*	8.93
0.60 - 0.69	0.11	6.81	2.75	0.02	0.04	*	*	*	9.73
0.70 - 0.79	0.02	6.08	3.38	0.07	0.02	*	*	*	9.57
0.80 - 0.89	*	3.71	2.72	0.04	*	*	*	*	6.48
0.90 - 0.99	*	2.35	1.56	0.04	*	*	*	*	3.95
1.00 - 1.09	*	1.27	1.05	0.15	*	*	*	*	2.48
1.10 - 1.19	*	0.37	0.15	0.02	*	*	*	*	0.55
1.20 - 1.29	*	0.15	0.11	*	*	*	*	*	0.26
1.30 - 1.39	*	0.02	0.02	*	*	*	*	*	0.04
1.40 - 1.49	*	*	*	*	*	*	*	*	0.00
1.50 - 1.59	*	*	*	*	*	*	*	*	0.00
1.60 - 1.69	*	*	*	*	*	*	*	*	0.00
Totals	11.38	50.46	30.68	6.28	1.18	0.02	0.00	0.00	100



Location	Latitude	Longitude	Water depth (m)	Deployment date	Removal date
1	-18.52	146.38	9.7	2 March 1995	29 September 1995
2	-18.52	146.38	9.7	5 October 1995	13 May 1996

Queensland Government Environmental Protection Agency	Location history	
	Wave data recording program Lucinda region	Figure 1

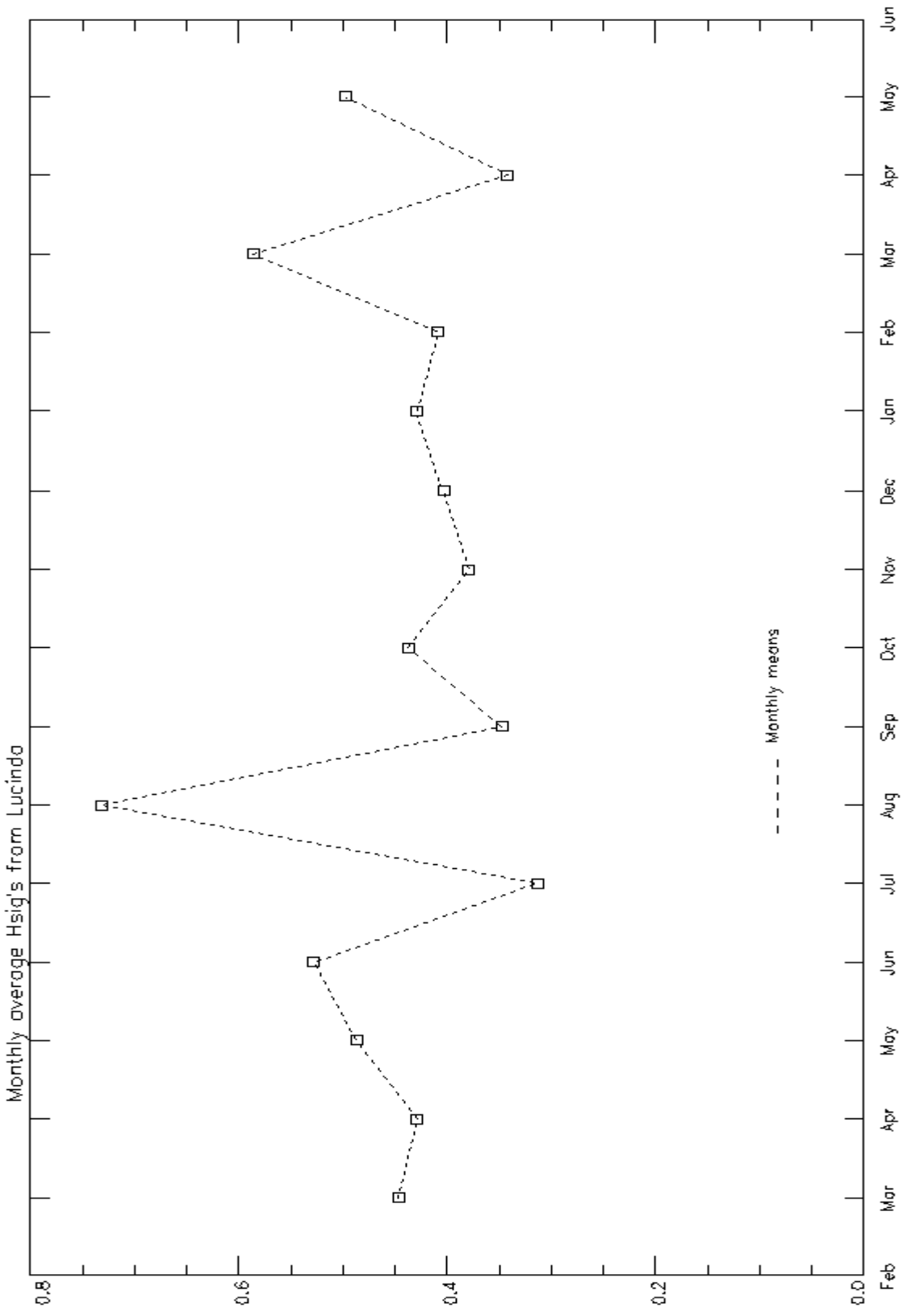


Queensland Government
Environmental Protection Agency

Percentage (of time) exceedance of wave heights (Hsig) for all wave periods (Tp)
2 March 1995 to 13 May 1996

Wave data recording program
Lucinda region

Figure 2

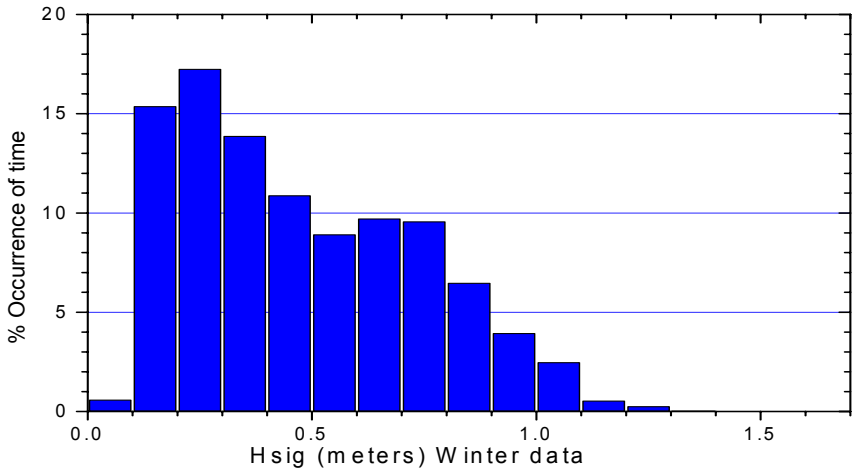


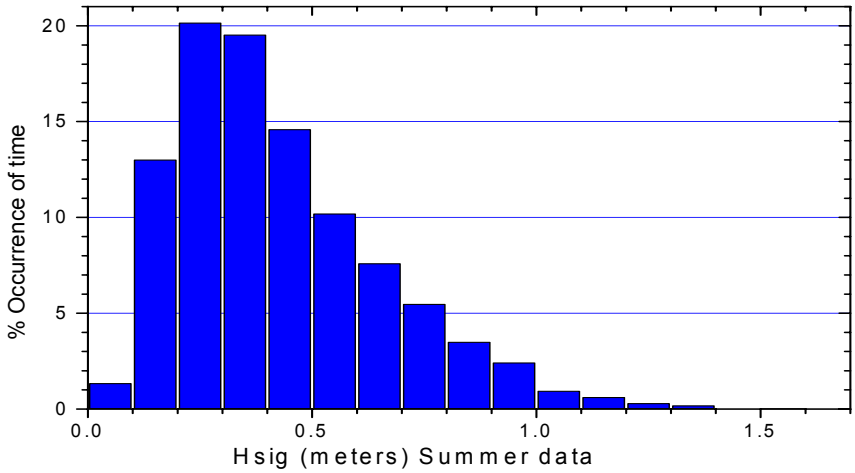
Queensland Government
Environmental Protection Agency

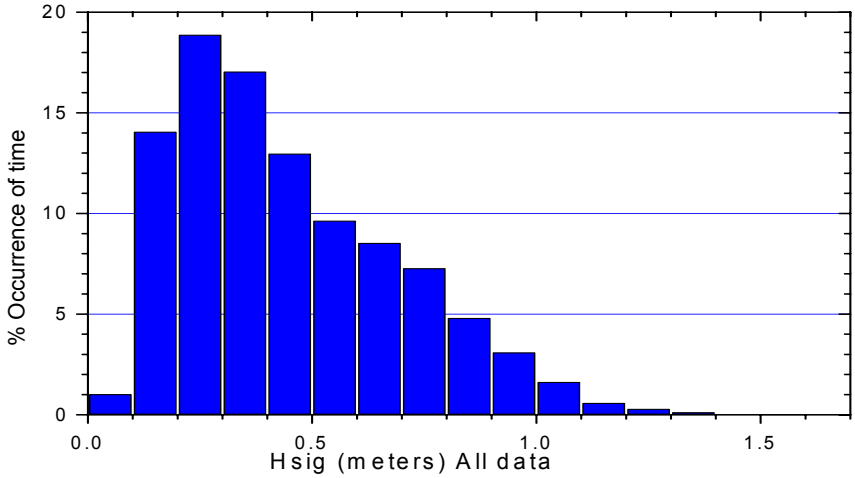
Plot of monthly averages for all data for wave height (Hsig)

Wave data recording program
Lucinda region

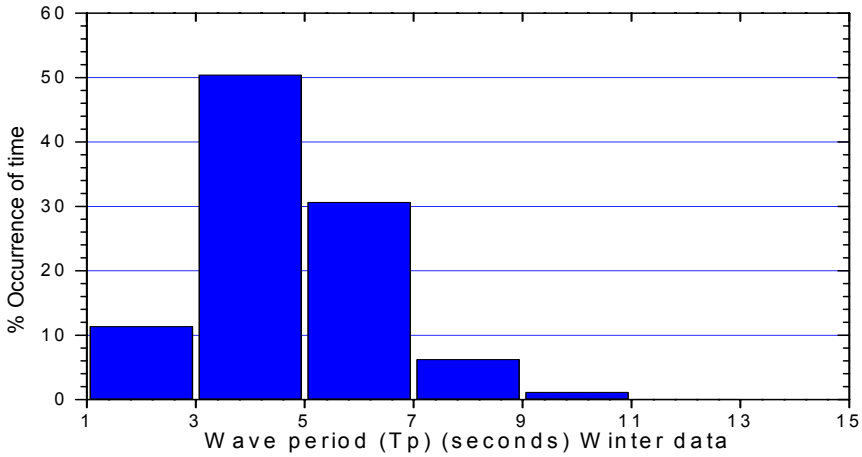
Figure 3

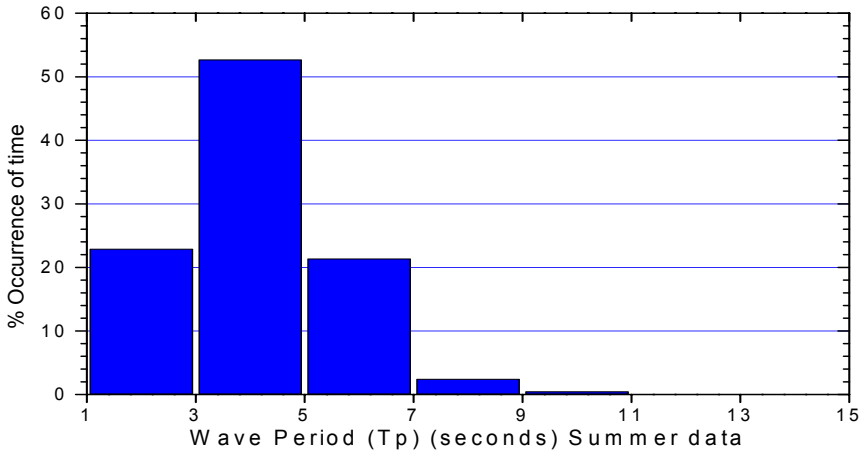


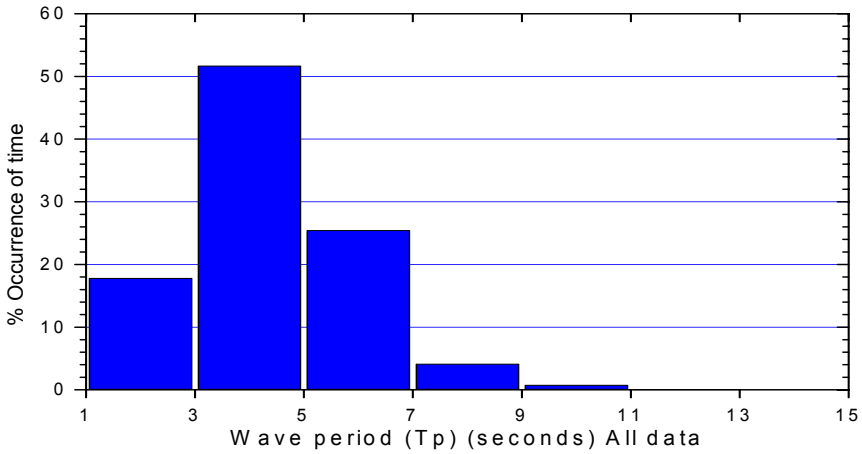




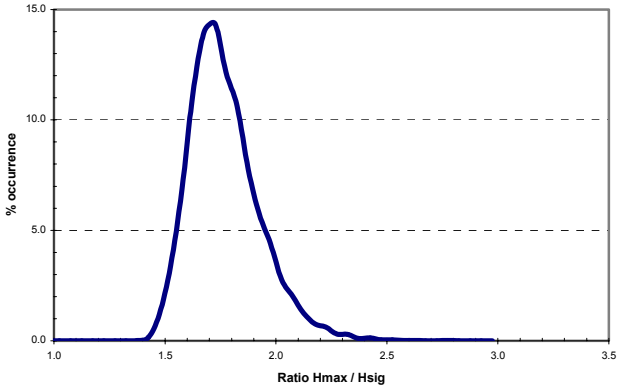
Queensland Government Environmental Protection Agency	Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)	
	Wave data recording program Lucinda region	Figure 4

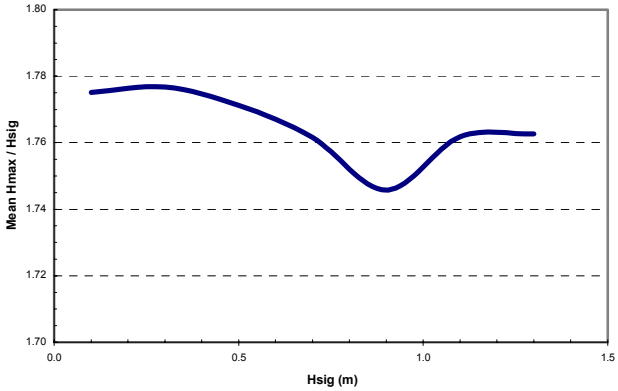


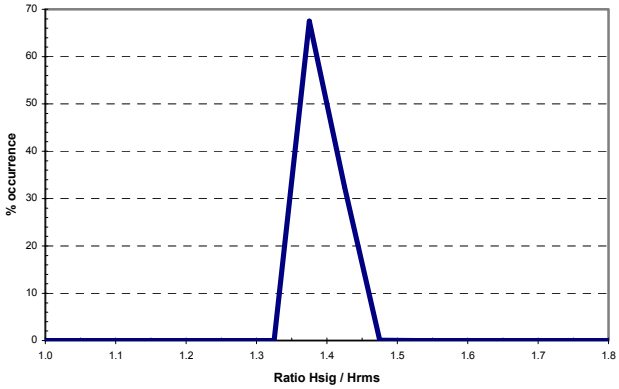


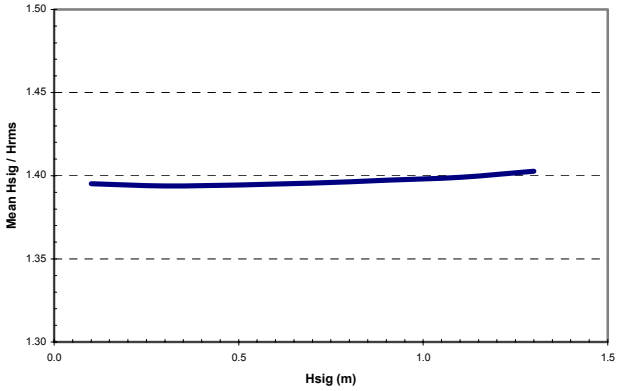


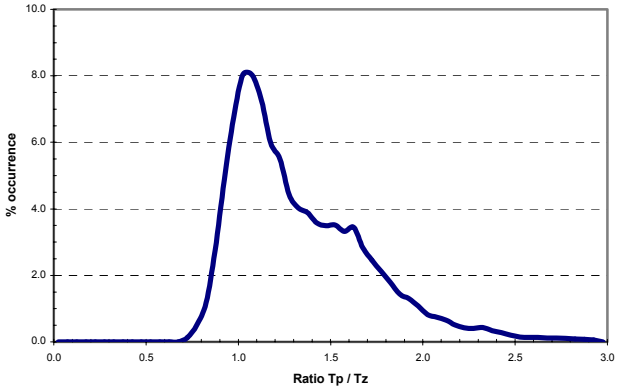
Queensland Government Environmental Protection Agency	Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)	
	Wave data recording program Lucinda region	Figure 5

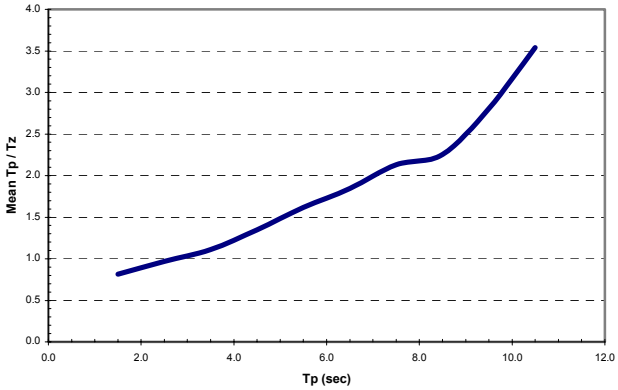


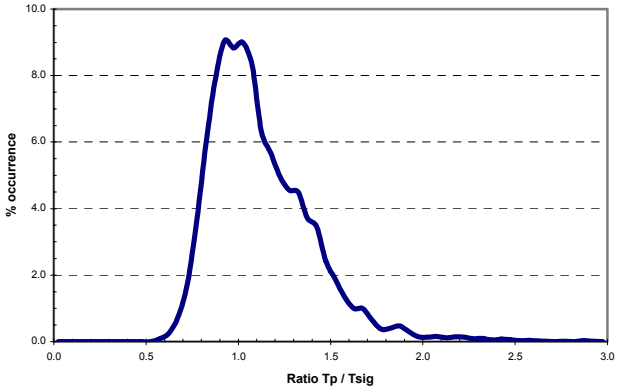


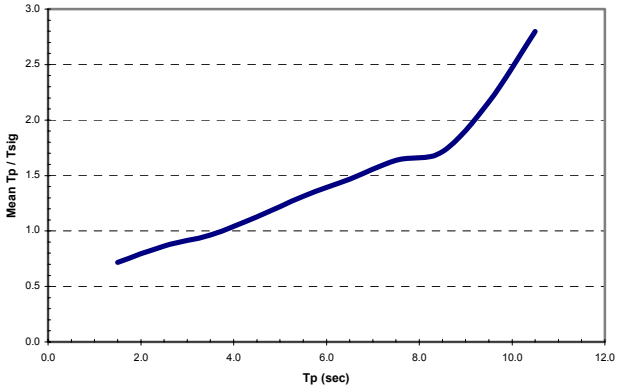










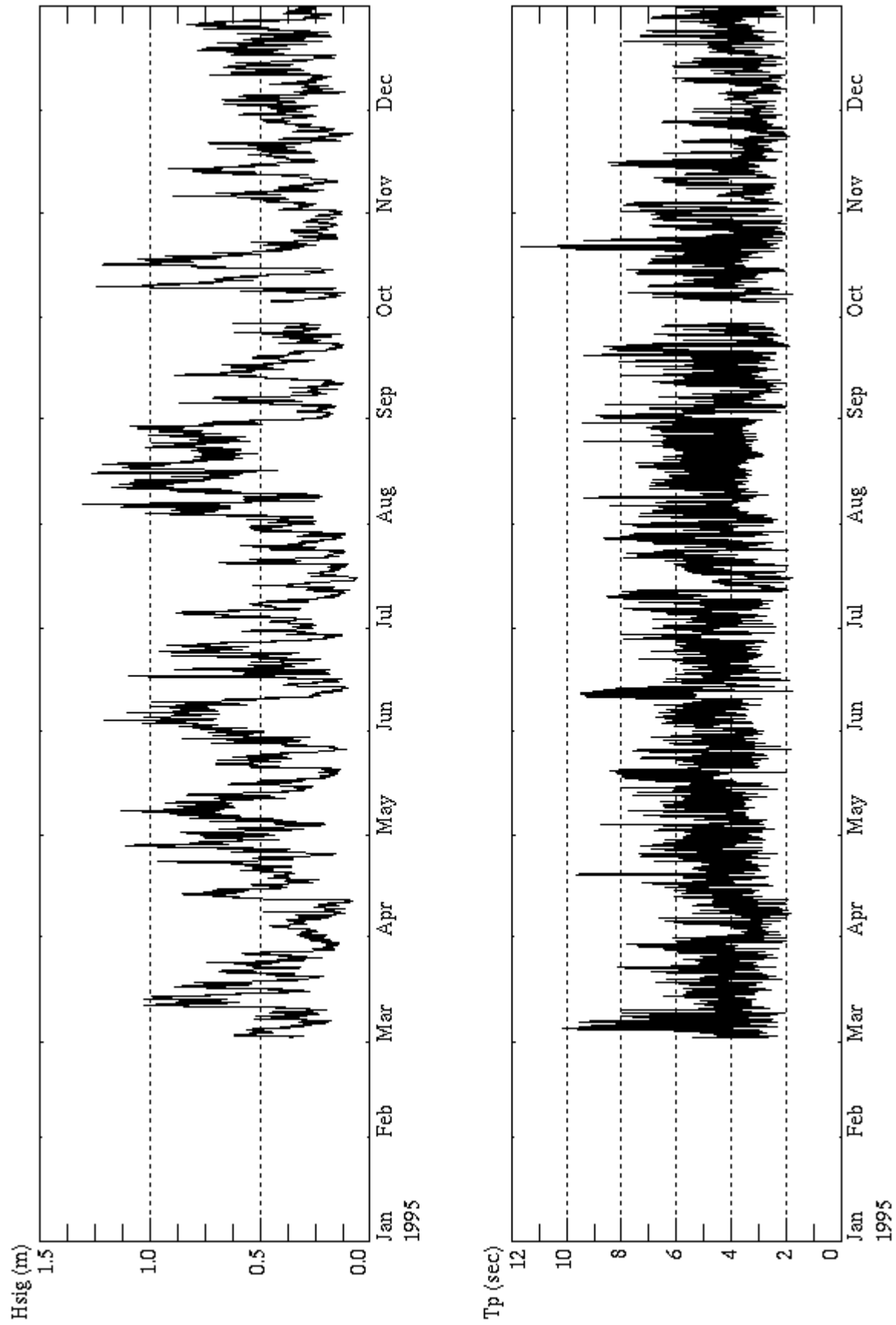


Queensland Government
Environmental Protection Agency

Wave parameter relationships
2 March 1995 to 13 May 1996

Wave data recording program
Lucinda region

Figure 6

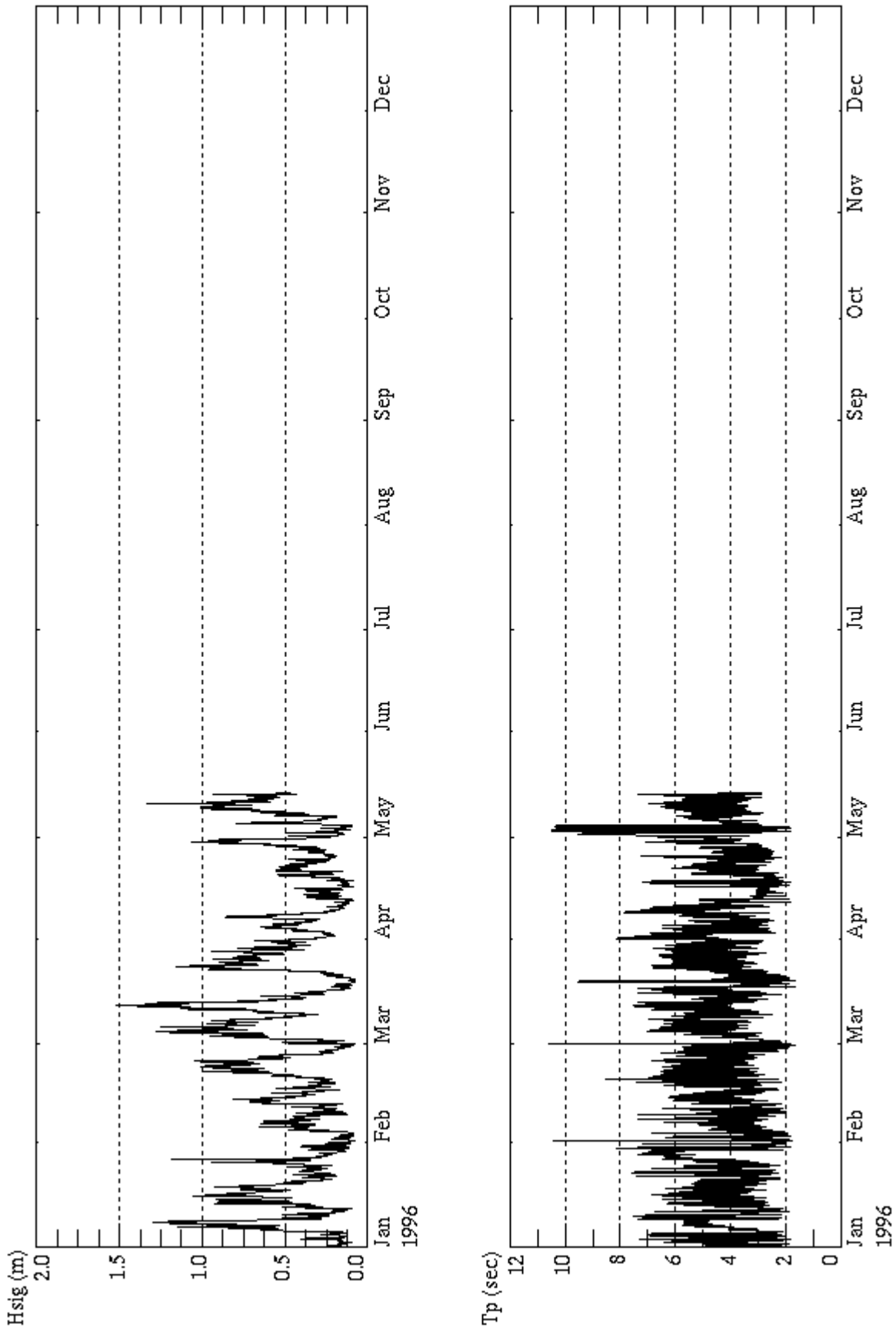


Queensland Government
Environmental Protection Agency

Daily wave recordings
2 March 1995 to 31 December 1995

Wave data recording program
Lucinda region

Figure 7

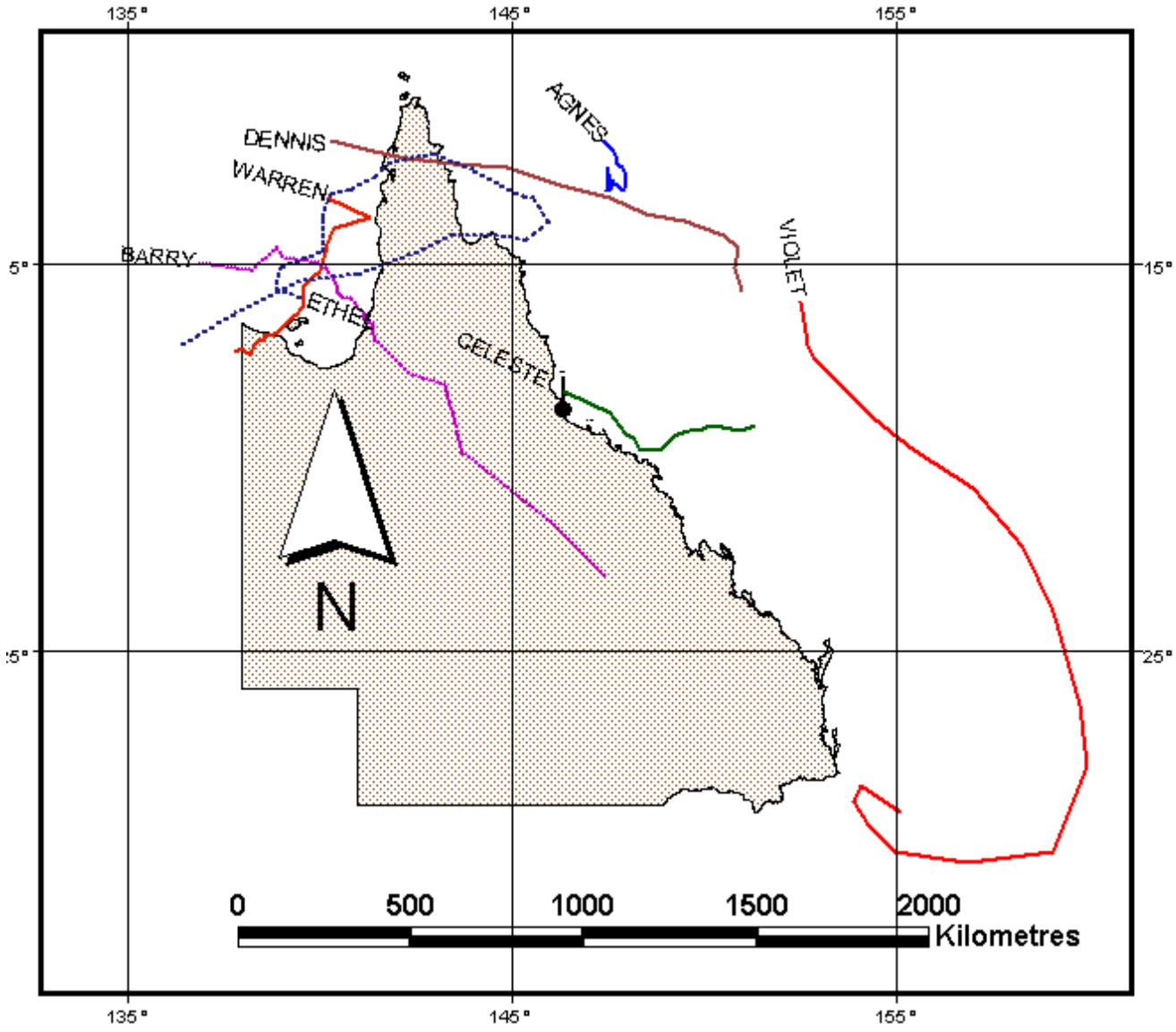


Queensland Government
Environmental Protection Agency

Daily wave recordings
1 January 1996 to 13 May 1996

Wave data recording program
Lucinda region

Figure 8

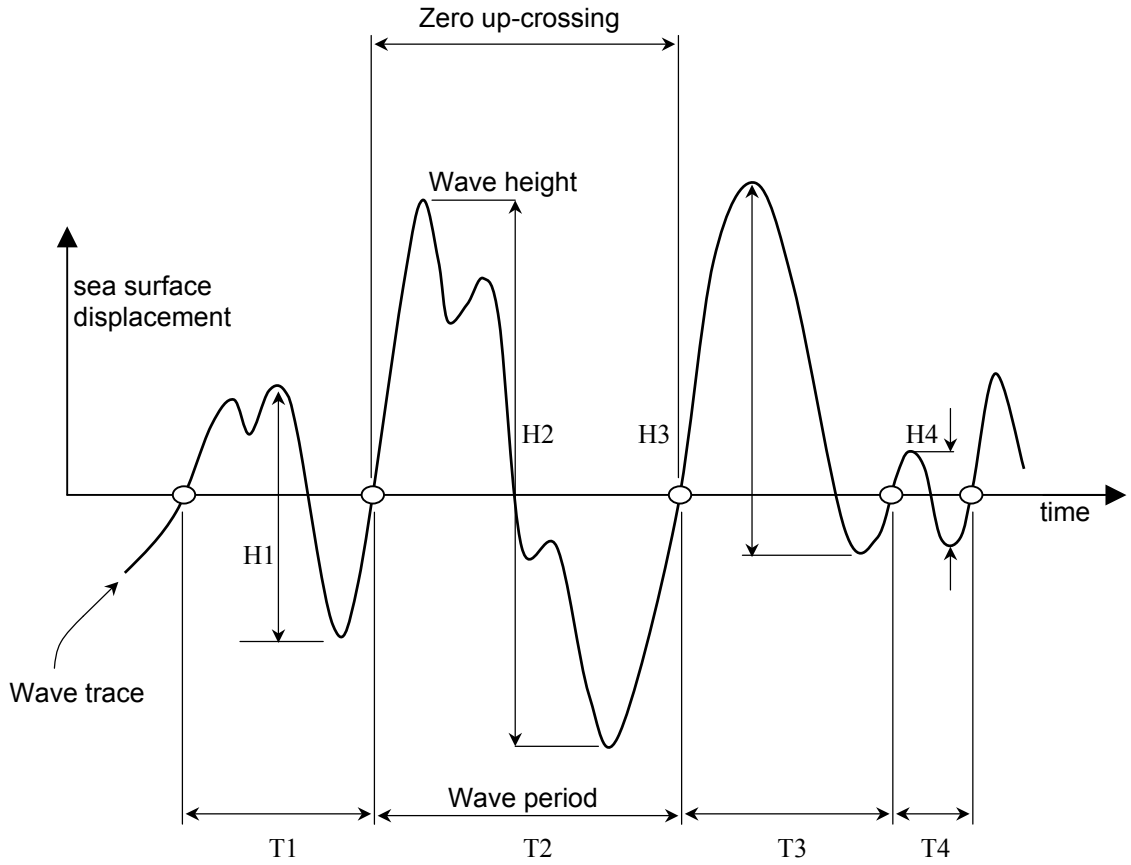


Queensland Government Environmental Protection Agency	Cyclone tracks 2 March 1995 to 13 May 1996	
	Wave data recording program Lucinda region	Figure 9

Zero up-crossing analysis

A direct, repeatable and widely accepted method to extract representative statistics from wave traces recorded by a waverider buoy is the zero crossing method. For the zero up-crossing method, the method employed by the Environmental Protection Agency, a wave is defined as the portion of the record between two successive zero up-crossings. The waves are ranked, with their corresponding periods, and statistical wave parameters computed.

An explanation of wave parameters is presented in the Glossary of terms.



Queensland Government Environmental Protection Agency	Zero up-crossing analysis	
	Wave data recording program Lucinda region	Figure 10

Appendix A

Glossary of terms

Glossary of terms

Hsig	Significant wave height defined as the average of the highest one-third of zero up-crossing wave heights.
Thsig	The average period of the highest one-third of zero up-crossing wave heights in the record.
Hrms	Root mean square wave height in the record, from the time domain.
Hmax	The maximum zero up-crossing wave height in a record.
Tz	The average period of all zero crossing waves in the record, from the time domain.
Tp	The period at the peak spectral energy, $1/f_p$.
f_p	Spectral peak frequency (wave frequency delivering the most energy).

Note : All heights in metres, all periods in seconds.