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Wave data recording program
Kirra region
1988 - 1997

Department of Environment

QUEENSLAND GOVERNMENT

Conservation data report No.W15.2

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Abstract

This report summarises primary analyses of wave data recorded in water depths of approximately 16m, off shore from the Miles Street groyne and Kirra Point in southern Queensland. Data were recorded using a Datawell waverider buoy, and covers the period 25 August 1988 to 28 February 1997. The data were divided into seasonal groupings for analysis. No estimations of wave direction data have been provided.

This report has been prepared by the Coastal Management Branch, Division of Conservation, Department of Environment, on behalf of the Beach Protection Authority.

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Recycled paper saves energy and resources

1 Introduction

As part of its long-term collection program, the Beach Protection Authority (the Authority) has been recording wave characteristics along Queensland's coast since 1968. This has been done using a series of wave recording stations. The Kirra wave recording station has been jointly funded by the Queensland Government and the Gold Coast City Council as part of a series of beach nourishment projects in the southern Gold Coast area. This report summarises the primary analyses of wave data collected at the Kirra station. It also provides brief details of the recording equipment, the methods of handling raw data and the type of analyses employed.

2 Recording equipment

The wave recording program uses two systems to measure wave data: the waverider system and the wave pole system.

2.1 Waverider system

The waverider system, manufactured by Datawell bv of the Netherlands, uses a waverider buoy to determine the sea surface fluctuations at an offshore location. Directional and non-directional buoys are used.

In both types of buoys, vertical acceleration of the buoy is measured by an accelerometer, mounted on a stabilised platform suspended in a fluid-filled plastic sphere at the bottom of the buoy. This data is then twice integrated to give displacement.

The directional buoy also measures horizontal acceleration, using two fixed accelerometers and an onboard fluxgate compass to give the directional displacement in two horizontal axes. A transformation matrix is used to calculate these measured accelerations in the north-south and east-west directions.

The instantaneous water level and directional data are then transmitted to the shore station as a frequency modulated high frequency radio signal.

2.2 Wave pole system

The wave pole system, manufactured by the Queensland Government Hydraulics Laboratory, consists of a single, perforated metal pipe, surrounding an inner metal pipe that acts as a co-axial transmission line to the water, with an enclosed circuit board housing containing an electronic oscillator mounted on the top. This system is mounted vertically on a suitable offshore structure.

Relative wave height measurements are taken, based on the principle that a sharp change in the electrical impedance of the wave pole occurs at the fluctuating water surface and the period of oscillation is linearly proportional to the length of the wave pole that is not immersed in water.

Water surface elevations are recorded at the wave pole and are transferred via radio modem to a remote data recording computer.

2.3 Station configuration

In the original configuration of the Kirra station, first installed on 25 August 1988, the shore station consisted of a WAREP waverider receiver and a DIMA digitiser/recorder. The WAREP receiver controlled the timing of data recording and provided a paper chart of the water level signal. Wave data were recorded by the DIMA unit in 20 minute bursts and digitised at 0.5 second intervals (2.0Hz). The data were recorded on digital cassettes and, along with the paper charts, transferred to the Brisbane office for processing.

On 1 January 1991, the wave recording system was upgraded to a personal computer (PC) based system, using the Datawell DIWAR waverider receiver/digitiser. The water level data, digitised at 0.39 second intervals (2.56Hz), is recorded in bursts of 4096 points (approximately 26 minutes) and recorded on the PC's hard disk. The proprietary software running on the PC controls the timing of data recording and processes the data in 'near real time' to provide a set of standard sea-state parameters and spectra that may be accessed remotely via the public telephone network. Recorded data and analysis results are downloaded daily to a central computer system in Brisbane for checking, further processing and archiving.

For more information on the buoy operation and the recording systems, contact the sources listed in section 7.

2.4 Laboratory calibration checks

Waverider buoys are calibrated before deployment and also after recovery. Normally, a buoy is calibrated once every 12 months. Calibration is performed at the Queensland Government Hydraulics Laboratory using a buoy calibrator to simulate sinusoidal waves with amplitudes of either 2m or 2.8m, depending on whether a 0.7m or 0.9m diameter buoy is involved. The calibrator 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:

- compass (directional buoy),
- phase and amplitude response,
- accelerometer platform stability,
- platform tilt,
- battery capacity,
- power output.

The recorded wave data are not adjusted in any way in light of the laboratory calibration results.

3 Wave recording and analysis procedures

From 25 August 1988 to 31 December 1990, wave data were recorded four times per day at 0300, 0900, 1500 and 2100 hours (Australian Eastern Standard Time). During storm events, the recording frequency may have been manually switched by the operator to record eight times per day.

Since 1 January 1991, the PC based recording system has generally recorded data at (nominally) hourly intervals. During periods when the recorded significant wave height (Hsig) value reaches the storm threshold of 2m, recording frequency is increased to (nominally) 30 minute intervals.

Recorded non-directional wave data are analysed in the time domain by the zero upcrossing method and in the frequency domain by spectral analysis. Spectral analysis of the WAREP/DIMA data was performed by the autocorrelation method providing 50 lags at a spacing of 0.02Hz.

The PC based analysis uses Fast Fourier Transform techniques to give 128 spectral estimates in bands of 0.01Hz. The zero upcrossing analysis is equivalent in both systems.

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 one-third of the waves in the record
Hmax	highest individual wave in the record (time domain)
Hrms	root mean square of the wave heights in the record (time domain)

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Tsig	significant wave period (time domain), the average period of the highest one-third of waves in the record
Tz	average period of all zero upcrossing waves in the record (time domain)
Tp	wave period corresponding to the peak of the energy density spectrum
Tc	average period of all the waves in the record, based on successive crests

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

4 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 data recorded by both the WAREP/DIMA and the PC based systems includes some data rejection checks. In the case of the WAREP/DIMA data, the length of the record may be shortened to exclude corrupt data points. In the PC based analysis, a small number of spurious data points may be corrected by an interpolation procedure, otherwise the entire series is rejected.

Details of data losses for the Kirra wave recording station are in appendix 1.

5 Wave climate

The wave climate data presented in this report are based on statistical analyses of the parameters obtained from the recorded wave data. Programs developed by the Authority provide statistical information on percentage of time occurrence and exceedance for wave heights and periods. The results of these analyses are presented in tables 1 to 6 and figs.2, 3 and 4. Similar analyses are carried out on the relationships between the various wave parameters and these are presented in fig.5.

5.1 Methodology

As discused above, various data losses can cause occasional gaps in the data record. Rejection of data causes relatively short gaps, while buoy or recording equipment malfunctions cause much longer gaps.

In calculating 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.

During the period when four records per day were taken, the nominal recording interval was six hours. The maximum allowable total duration of a record is equal to the nominal recording interval of six hours. Each duration on either side of a record greater than nominal three hours (half the nominal recording interval) is set to the maximum allowable of exactly three hours, and a gap in the data is reported.

During the period when the nominal recording interval is one 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 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 deep-water waves. Therefore, before this data can be used, the exact location of the buoy and the water depth in which the buoy was moored should be noted. This information is in appendix 1. The non-directional waverider recording system that is used by the Authority 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.

Appendix 2 summarises meteorological events that occurred during the recording period of this report, where the recorded Hsig value of 2m was reached during the event. The wave parameters Hsig, Hmax, and Tp are listed for each event, together with other relevant information. Only the cyclone events that contributed to recorded Hsig values reaching the storm threshold of 2m are listed in appendix 2 and fig.8.

Appendix 3 lists only the names and dates of cyclones that occurred along the eastern seaboard of Queensland during the recording period covered by this report.

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

7 References

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

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

Datawell, *Manual of Waverider Receiver type WAREP — mark II.*

Datawell, *Manual of the Digital Waverider Receiver type DIWAR.*

Datawell, *Manual of the Digital Magnetic Tape Recorder type DIMA — mark II.*

Datawell, *Operations and Service Manual for Directional Waverider from serial no. 30109.*

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

Bureau of Meteorology, *Monthly Weather Review*, Melbourne.

8 Other reports in this series

Wave data recording program, Cairns Region (Report No.W01.1) 2 May 1975–3 Sept 1978

Wave data recording program, Cairns Region (Report No.W01.2) 2 May 1975–11 Jun 1985

Wave data recording program, Mackay Region (Report No.W02.1) 17 Sept 1975–5 Nov 1976

Wave data recording program, Mackay Region (Report No.W02.2) 17 Sept 1975–23 Aug 1985

Wave data recording program, Mackay Region (Report No.W02.3) 17 Sept 1975–30 Oct 1996

Wave data recording program, Townsville Region (Report No.W03.1) 16 July 1975–23 Feb 1979

Wave data recording program, Townsville Region (Report No.W03.2) 19 Nov 1975–29 Dec 1987

Wave data recording program, Sunshine Coast Region (Report No.W04.1) 5 Apr 1974–5 Jul 1977

Wave data recording program, Burnett Heads Region (Report No.W05.1) 5 May 1976–5 Mar 1982

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(Report No.W08.1) 19 Dec 1979–16 May 1983
Wave data recording program, Brisbane Region
(Report No.W09.1) 30 Oct 1976–30 Jun 1983
Wave data recording program, Brisbane Region
(Report No.W09.2) 30 Oct 1976–30 Jun 1994
Wave data recording program, Brisbane Region
(Report No.W09.3) 30 Oct 1976–28 Feb 1997
Wave data recording program, Bowen Region
(Report No.W10.1) 14 Sept 1978–15 Nov 1984
Wave data recording program, Moreton Island Region
(Report No.W11.1) 15 Jun 1983–12 Apr 1985
Wave data recording program, Bramston Beach Region
(Report No.W12.1) 16 Dec 1981–28 Oct 1985
Wave data recording program, Hay Point Region
(Report No.W13.1) 22 Mar 1977–25 May 1987
Wave data recording program, Gold Coast Region
(Report No.W14.1) 20 Feb 1987–30 Jun 1994
Wave data recording program, Gold Coast Region
(Report No.W14.2) 20 Feb 1987–28 Feb 1997
Wave data recording program, Kirra
(Report No.W15.1) 25 Aug 1988–30 Jun 1994
Wave data recording program, Repulse Bay
(Report No.W16.1) 2 Jun 1994–22 Oct 1995
Wave data recording program, Hayman Island
(Report No.W17.1) 26 Oct 1995–14 Oct 1996
Wave data recording program, Tweed Region
(Report No.W18.1) 15 Jan 1995–28 Feb 1997

Appendix 1

Details of wave recorder installations
Kirra Region

Location of buoys

See fig.1 for the locations of the waverider buoys and receiving station for the period of this report.

Location: 153°31.7' east, 28° 09.5' south
Description: 1.5km (off shore) from Kirra Point
Water depth at buoy: 16m relative to Australian Height Datum
Period: 25 August 1988 to 28 July 1991

Note: The above buoy location was calculated using radar ranging and compass bearings to prominent landmarks.

Location: 153° 31.76' east, 28° 09.43' south
Description: 1.5km off shore from Kirra Point
Water depth at buoy: 16m relative to Australian Height Datum
Period: 28 July 1991 to 28 February 1997

Note: The above buoy location was measured using GPS fixing procedures. All water depths are accurate to ± 1m.

Location of recording station

Air Sea Rescue Facility, Point Danger
Location: 153° 32.98' east, 28° 09.15' south
Period: 28 August 1988 to 28 February 1997

Normal recording interval

Four 20 minute records daily at 0300 hours, 0900 hours, 1500 hours and 2100 hours, from 25 August 1988 to 31 December 1990.

Commencing on 1 January 1991, one-hourly records, each of approximately 26 minutes, have been taken, giving 4096 water surface elevation measurements for that period, from which sea state parameters are calculated and recorded.

During storm events, where the recorded Hsig value reaches the storm threshold of 2m, the frequency of recording is increased to half hourly.

Data collection and analysis

Number of records collected:	53 206.00
Number of records used in analysis:	53 206.00
Number of days in recording period:	3108.33
Number of days used in analysis:	2778.22
Number of days lost:	330.12

Appendix 2
Major meteorological events — Kirra Region

Meteorological event	Central pressure (hPa)	Date	Estimated position of cyclone relative to buoy (km)	Maximum Hsig recorded (m)[1]	Maximum Hmax recorded (m)[2]	Tp (secs)[3]
Low pressure system off New South Wales coast	996	17-09-88		2.03	3.54	7.12
Low pressure system off Queensland coast	1004	9-11-88		2.09	3.32	11.35
Low pressure system over Fraser Island	996	18-12-88		3.25	4.60	10.43
Low pressure system off southern Queensland coast	1000	20-02-89		2.41	3.97	12.16
Cyclone Aivu	955	5-04-89	800 NNE	2.70	4.59	10.52
High pressure system off southern central New South Wales and low pressure system off south-east Queensland	1028 1000	26-04-89		5.13	7.29	11.99
Low pressure system off south-east Queensland	1004	28-05-89		3.04	4.76	10.27
Low pressure system off south-east Queensland	1004	19-08-89		2.93	4.86	10.06
Low pressure system off southern Queensland coast	996	25-01-90		2.01	3.18	10.22
High pressure system over Tasman Sea	1032	27-03-90		2.40	3.65	9.55
High pressure system over Tasman Sea	1032	5-04-90		2.41	4.17	8.37
Low pressure system over central Queensland coast	1008	20-04-90		2.67	4.66	6.89
High pressure system over New South Wales	1028	10-06-90		3.07	5.04	13.00
High pressure system over Tasman Sea and low pressure system in Coral Sea	1024 1000	8-03-91		2.00	3.60	9.62
High pressure system over Tasmania	1036	9-06-91		2.38	3.71	11.28
Low pressure system over central Queensland coast	1004	12-12-91		3.39	6.31	8.35
Cyclone Betsy	978	13-01-92	740 NE	2.74	4.94	12.97
Cyclone Daman	998	18-02-92	410 E	3.49	5.32	14.93
Cyclone Fran	980	14-03-92	360 N	3.02	5.38	10.19
High pressure system over Tasman Sea	1028	5-04-92		2.36	4.06	10.21
High pressure system over central Australia	1016	13-05-92		2.18	3.60	7.88
Local thunderstorms		25-11-92		2.19	4.51	7.10
Cyclone Roger	992	17-03-93	450 NE	4.85	8.51	13.35
High pressure system over Tasman Sea	1028	14-09-93		2.20	3.97	8.13
High pressure system over Tasman Sea and low pressure system over New South Wales	1020 1004	4-10-93		2.31	4.29	7.41
Cyclone Rewa	992	21-01-94	320 ENE	2.38	4.27	10.38
High pressure system over Tasman Sea	1032	30-03-94		2.56	4.84	13.01
Low pressure system over northern New South Wales	1012	20-10-94		2.01	3.40	7.28
Low pressure system over central New South Wales	988	20-01-95		2.09	4.22	6.42
Low pressure system over Fraser Island	1004	5-02-95		3.97	7.96	10.95

Meteorological event	Central pressure (hPa)	Date	Estimated position of cyclone relative to buoy (km)	Maximum Hsig recorded (m)[1]	Maximum Hmax recorded (m)[2]	Tp (secs)[3]
Low pressure system over Fraser Island and low pressure system over northern New South Wales coast	1000 996	7-03-95		2.32	4.14	11.80
High pressure system over Tasman Sea	1036	16-08-95		2.18	4.12	8.23
Low pressure system over Tasmania with a trough through south-east Queensland	984	19-12-95		2.02	3.58	6.90
Low pressure system off southern Queensland coast	1000	15-02-96		2.02	3.35	12.65
High pressure system over Tasman Sea	1024	29-03-96		2.68	5.09	12.65
Low pressure system over Fraser Island	1004	2-05-96		5.71	10.54	13.25
High pressure system over Tasman Sea	1032	17-05-96		2.50	4.76	11.26
High pressure system over Tasman Sea	1024	28-07-96		2.64	5.59	8.75
High pressure system over Tasman Sea	1020	20-09-96		2.06	3.93	8.31
Low pressure system over Tasmania with trough through south-east Queensland	976	30-09-96		2.57	4.76	6.94

Note: The above table includes all events with a recorded Hsig value that reached the storm threshold of 2m.

1, 2: Hisg values and Hmax values are the maximum values recorded for each event and are not necessarily coincident in time.

1, 3: Tp values and Hsig values presented are coincident as a single event on the date shown.

Highest significant wave height (Hsig) recorded was 5.71m on 2 May 1996 due to a low pressure system over Fraser Island off the southern Queensland coast.

Highest maximum wave height (Hmax) recorded was 10.54m on 2 May 1996 due to a low pressure system over Fraser Island off the southern Queensland coast.

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

Appendix 3
Tropical cyclones of the east coast of Queensland
25 August 1988 to 28 February 1997

Cyclone Name	Year	Month
Harry	1989	2
Aivu	1989	4
Meena	1989	5
Ernie	1989	5
Felicity	1989	12
Nancy-90	1990	1
Hilda	1990	3
Ivor	1990	3
Joy	1990	12
Kelvin	1991	2
Lisa	1991	5
Mark	1992	1
Betsy	1992	1
Daman	1992	2
Esau	1992	2
Fran	1992	3
Nina	1992	1
Oliver	1993	2
Polly	1993	2
Roger	1993	3
Rewa	1993	1
Sadie	1994	1
Theodore	1994	2
Violet	1995	3
Agnes-95	1995	4
Barry	1996	1
Celeste	1996	1
Dennis	1996	2
Ethel	1996	3
Fergus	1996	12
Gillian	1997	2
Harold	1997	2

Table 1.

Wave statistics
— Wave period (Tp)/wave height (Hsig) occurrences
— All data, all directions, measured in days.

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
0·00–0·19	*	*	*	0·46	0·29	0·08	0·46	0·04	1·34
0·20–0·39	1·48	5·13	19·83	33·40	82·46	52·83	29·28	8·98	233·39
0·40–0·59	3·76	44·17	101·79	123·40	198·68	134·99	58·86	17·11	682·76
0·60–0·79	0·88	67·23	130·03	169·47	168·36	76·97	35·11	14·02	662·07
0·80–0·99	1·08	52·02	108·55	185·91	107·61	43·04	16·37	3·17	517·74
1·00–1·19	0·50	22·85	58·39	127·72	76·74	20·54	7·04	1·33	315·11
1·20–1·39	*	6·62	29·35	62·27	44·69	13·62	3·09	0·46	160·10
1·40–1·59	*	0·67	12·53	27·51	31·01	8·15	1·96	0·33	82·16
1·60–1·79	*	*	4·33	14·33	21·01	8·05	1·59	0·21	49·51
1·80–1·99	*	*	1·37	5·98	9·44	5·16	1·20	*	23·16
2·00–2·19	*	*	0·75	3·69	7·65	4·95	0·48	*	17·53
2·20–2·39	*	*	0·02	1·36	7·04	1·43	0·33	0·08	10·26
2·40–2·59	*	*	0·04	0·99	3·55	2·35	0·21	*	7·13
2·60–2·79	*	*	0·25	0·29	3·27	0·73	0·04	0·04	4·63
2·80–2·99	*	*	*	0·08	2·13	0·79	0·34	*	3·33
3·00–3·19	*	*	*	0·08	1·13	0·46	0·25	*	1·92
3·20–3·39	*	*	*	0·13	0·43	0·85	0·04	*	1·45
3·40–3·59	*	*	*	*	0·39	0·69	0·06	*	1·14
3·60–3·79	*	*	*	*	0·06	0·38	0·17	*	0·60
3·80–3·99	*	*	*	*	0·29	0·35	0·06	*	0·71
4·00–4·19	*	*	*	*	0·02	0·21	0·13	*	0·35
4·20–4·39	*	*	*	*	*	0·07	0·04	*	0·11
4·40–4·59	*	*	*	*	0·02	0·04	0·23	*	0·29
4·60–4·79	*	*	*	*	0·02	0·35	0·08	*	0·45
4·80–4·99	*	*	*	*	*	0·12	0·11	*	0·24
5·00–5·19	*	*	*	*	*	0·45	*	*	0·45
5·20–5·39	*	*	*	*	*	0·06	0·05	*	0·11
5·40–5·59	*	*	*	*	*	0·02	0·08	*	0·10
5·60–5·79	*	*	*	*	*	*	0·05	*	0·05
5·80–5·99	*	*	*	*	*	*	*	*	0·00
Totals	7·69	198·69	467·24	757·07	766·30	377·73	157·72	45·78	2778·22

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

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Table 2.

Wave statistics
— Wave period (Tp)/wave height (Hsig) occurrences
— Summer data, all directions, measured in days.

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
0·00–0·19	*	*	*	*	*	*	*	*	0·00
0·20–0·39	*	1·58	8·98	12·19	17·89	6·56	2·79	0·75	50·74
0·40–0·59	0·69	20·42	52·11	65·27	80·12	31·23	14·08	4·96	268·88
0·60–0·79	0·04	33·79	75·82	106·75	94·98	30·84	12·23	3·92	358·38
0·80–0·99	*	27·52	64·54	128·06	73·69	23·82	7·42	0·83	325·88
1·00–1·19	*	14·24	29·99	85·63	56·60	14·62	4·02	0·08	205·19
1·20–1·39	*	4·28	14·55	42·77	33·81	10·02	2·17	0·04	107·64
1·40–1·59	*	0·46	5·38	18·92	24·93	5·32	1·21	0·21	56·42
1·60–1·79	*	*	2·21	9·62	15·37	6·42	0·50	0·12	34·25
1·80–1·99	*	*	0·71	3·53	5·89	4·11	1·08	*	15·31
2·00–2·19	*	*	0·46	1·87	5·38	3·20	0·48	*	11·40
2·20–2·39	*	*	*	0·50	4·14	1·32	0·33	0·08	6·38
2·40–2·59	*	*	*	0·63	2·80	1·81	0·21	*	5·44
2·60–2·79	*	*	0·25	0·21	1·92	0·33	0·04	0·04	2·80
2·80–2·99	*	*	*	0·08	1·47	0·21	0·08	*	1·84
3·00–3·19	*	*	*	0·08	0·71	0·29	*	*	1·08
3·20–3·39	*	*	*	0·13	0·37	0·41	0·04	*	0·95
3·40–3·59	*	*	*	*	0·33	0·33	0·04	*	0·70
3·60–3·79	*	*	*	*	0·04	0·08	0·08	*	0·21
3·80–3·99	*	*	*	*	0·29	0·17	*	*	0·46
4·00–4·19	*	*	*	*	*	0·17	0·08	*	0·25
4·20–4·39	*	*	*	*	*	0·04	*	*	0·04
4·40–4·59	*	*	*	*	*	0·04	0·12	*	0·17
4·60–4·79	*	*	*	*	*	0·30	*	*	0·30
4·80–4·99	*	*	*	*	*	*	0·04	*	0·04
5·00–5·19	*	*	*	*	*	0·25	*	*	0·25
5·20–5·39	*	*	*	*	*	*	*	*	0·00
5·40–5·59	*	*	*	*	*	*	*	*	0·00
5·60–5·79	*	*	*	*	*	*	*	*	0·00
5·80–5·99	*	*	*	*	*	*	*	*	0·00
Totals	0·73	102·31	255·02	476·24	420·72	141·89	47·05	11·04	1455·00

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

Table 2.

Wave statistics
— Wave period (Tp)/wave height (Hsig) occurrences
— Summer data, all directions, measured in days.

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
0·00–0·19	*	*	*	0·46	0·29	0·08	0·46	0·04	1·34
0·20–0·39	1·48	3·55	10·85	21·21	64·57	46·27	26·49	8·23	182·65
0·40–0·59	3·07	23·75	49·67	58·13	118·56	103·76	44·78	12·15	413·88
0·60–0·79	0·83	33·44	54·21	62·71	73·38	46·13	22·88	10·10	303·69
0·80–0·99	1·08	24·49	44·01	57·86	33·92	19·22	8·95	2·33	191·87
1·00–1·19	0·50	8·61	28·40	42·09	20·14	5·92	3·02	1·25	109·92
1·20–1·39	*	2·33	14·80	19·50	10·89	3·60	0·92	0·42	52·46
1·40–1·59	*	0·21	7·15	8·59	6·08	2·83	0·75	0·13	25·74
1·60–1·79	*	*	2·11	4·71	5·64	1·62	1·09	0·08	15·26
1·80–1·99	*	*	0·67	2·44	3·55	1·06	0·13	*	7·84
2·00–2·19	*	*	0·29	1·82	2·27	1·75	*	*	6·13
2·20–2·39	*	*	0·02	0·87	2·89	0·10	*	*	3·89
2·40–2·59	*	*	0·04	0·36	0·75	0·54	*	*	1·69
2·60–2·79	*	*	*	0·08	1·35	0·40	*	*	1·83
2·80–2·99	*	*	*	*	0·66	0·58	0·25	*	1·49
3·00–3·19	*	*	*	*	0·42	0·17	0·25	*	0·84
3·20–3·39	*	*	*	*	0·06	0·44	*	*	0·50
3·40–3·59	*	*	*	*	0·06	0·35	0·02	*	0·44
3·60–3·79	*	*	*	*	0·02	0·29	0·08	*	0·40
3·80–3·99	*	*	*	*	*	0·19	0·06	*	0·25
4·00–4·19	*	*	*	*	0·02	0·04	0·04	*	0·10
4·20–4·39	*	*	*	*	*	0·03	0·04	*	0·07
4·40–4·59	*	*	*	*	0·02	*	0·10	*	0·12
4·60–4·79	*	*	*	*	0·02	0·05	0·08	*	0·16
4·80–4·99	*	*	*	*	*	0·12	0·07	*	0·20
5·00–5·19	*	*	*	*	*	0·20	*	*	0·20
5·20–5·39	*	*	*	*	*	0·06	0·05	*	0·11
5·40–5·59	*	*	*	*	*	0·02	0·08	*	0·10
5·60–5·79	*	*	*	*	*	*	0·05	*	0·05
5·80–5·99	*	*	*	*	*	*	*	*	0·00
Totals	6·96	96·37	212·22	280·83	345·58	235·84	110·67	34·74	1323·21

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

Table 4.

Wave statistics
— Wave period (Tp)/wave height (Hsig) occurrences
— All data, all directions, measured in percentage occurrences.

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
0·00–0·19	*	*	*	0·02	0·01	*	0·02	*	0·05
0·20–0·39	0·05	0·18	0·71	1·20	2·97	1·90	1·05	0·32	8·40
0·40–0·59	0·14	1·59	3·66	4·44	7·15	4·86	2·12	0·62	24·58
0·60–0·79	0·03	2·42	4·68	6·10	6·06	2·77	1·26	0·50	23·83
0·80–0·99	0·04	1·87	3·91	6·69	3·87	1·55	0·59	0·11	18·64
1·00–1·19	0·02	0·82	2·10	4·60	2·76	0·74	0·25	0·05	11·34
1·20–1·39	*	0·24	1·06	2·24	1·61	0·49	0·11	0·02	5·76
1·40–1·59	*	0·02	0·45	0·99	1·12	0·29	0·07	0·01	2·96
1·60–1·79	*	*	0·16	0·52	0·76	0·29	0·06	0·01	1·78
1·80–1·99	*	*	0·05	0·22	0·34	0·19	0·04	*	0·83
2·00–2·19	*	*	0·03	0·13	0·28	0·18	0·02	*	0·63
2·20–2·39	*	*	*	0·05	0·25	0·05	0·01	*	0·37
2·40–2·59	*	*	*	0·04	0·13	0·08	0·01	*	0·26
2·60–2·79	*	*	0·01	0·01	0·12	0·03	*	*	0·17
2·80–2·99	*	*	*	*	0·08	0·03	0·01	*	0·12
3·00–3·19	*	*	*	*	0·04	0·02	0·01	*	0·07
3·20–3·39	*	*	*	*	0·02	0·03	*	*	0·05
3·40–3·59	*	*	*	*	0·01	0·02	*	*	0·04
3·60–3·79	*	*	*	*	*	0·01	0·01	*	0·02
3·80–3·99	*	*	*	*	0·01	0·01	*	*	0·03
4·00–4·19	*	*	*	*	*	0·01	*	*	0·01
4·20–4·39	*	*	*	*	*	*	*	*	0·00
4·40–4·59	*	*	*	*	*	*	0·01	*	0·01
4·60–4·79	*	*	*	*	*	0·01	*	*	0·02
4·80–4·99	*	*	*	*	*	*	*	*	0·01
5·00–5·19	*	*	*	*	*	0·02	*	*	0·02
5·20–5·39	*	*	*	*	*	*	*	*	0·00
5·40–5·59	*	*	*	*	*	*	*	*	0·00
5·60–5·79	*	*	*	*	*	*	*	*	0·00
5·80–5·99	*	*	*	*	*	*	*	*	0·00
Totals	0·28	7·15	16·82	27·25	27·58	13·60	5·68	1·65	100·00

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

Table 5.

Wave statistics
— Wave period (Tp)/wave height (Hsig) occurrences
— Summer data, all directions, measured in percentage occurrences.

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
0·00–0·19	*	*	*	*	*	*	*	*	0·00
0·20–0·39	*	0·11	0·62	0·84	1·23	0·45	0·19	0·05	3·49
0·40–0·59	0·05	1·40	3·58	4·49	5·51	2·15	0·97	0·34	18·48
0·60–0·79	*	2·32	5·21	7·34	6·53	2·12	0·84	0·27	24·63
0·80–0·99	*	1·89	4·44	8·80	5·06	1·64	0·51	0·06	22·40
1·00–1·19	*	0·98	2·06	5·89	3·89	1·00	0·28	0·01	14·10
1·20–1·39	*	0·29	1·00	2·94	2·32	0·69	0·15	*	7·40
1·40–1·59	*	0·03	0·37	1·30	1·71	0·37	0·08	0·01	3·88
1·60–1·79	*	*	0·15	0·66	1·06	0·44	0·03	0·01	2·35
1·80–1·99	*	*	0·05	0·24	0·40	0·28	0·07	*	1·05
2·00–2·19	*	*	0·03	0·13	0·37	0·22	0·03	*	0·78
2·20–2·39	*	*	*	0·03	0·28	0·09	0·02	0·01	0·44
2·40–2·59	*	*	*	0·04	0·19	0·12	0·01	*	0·37
2·60–2·79	*	*	0·02	0·01	0·13	0·02	*	*	0·19
2·80–2·99	*	*	*	0·01	0·10	0·01	0·01	*	0·13
3·00–3·19	*	*	*	0·01	0·05	0·02	*	*	0·07
3·20–3·39	*	*	*	0·01	0·03	0·03	*	*	0·07
3·40–3·59	*	*	*	*	0·02	0·02	*	*	0·05
3·60–3·79	*	*	*	*	*	0·01	0·01	*	0·01
3·80–3·99	*	*	*	*	0·02	0·01	*	*	0·03
4·00–4·19	*	*	*	*	*	0·01	0·01	*	0·02
4·20–4·39	*	*	*	*	*	*	*	*	0·00
4·40–4·59	*	*	*	*	*	*	0·01	*	0·01
4·60–4·79	*	*	*	*	*	0·02	*	*	0·02
4·80–4·99	*	*	*	*	*	*	*	*	0·00
5·00–5·19	*	*	*	*	*	0·02	*	*	0·02
5·20–5·39	*	*	*	*	*	*	*	*	0·00
5·40–5·59	*	*	*	*	*	*	*	*	0·00
5·60–5·79	*	*	*	*	*	*	*	*	0·00
5·80–5·99	*	*	*	*	*	*	*	*	0·00
Totals	0·05	7·03	17·53	32·73	28·92	9·75	3·23	0·76	100·00

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

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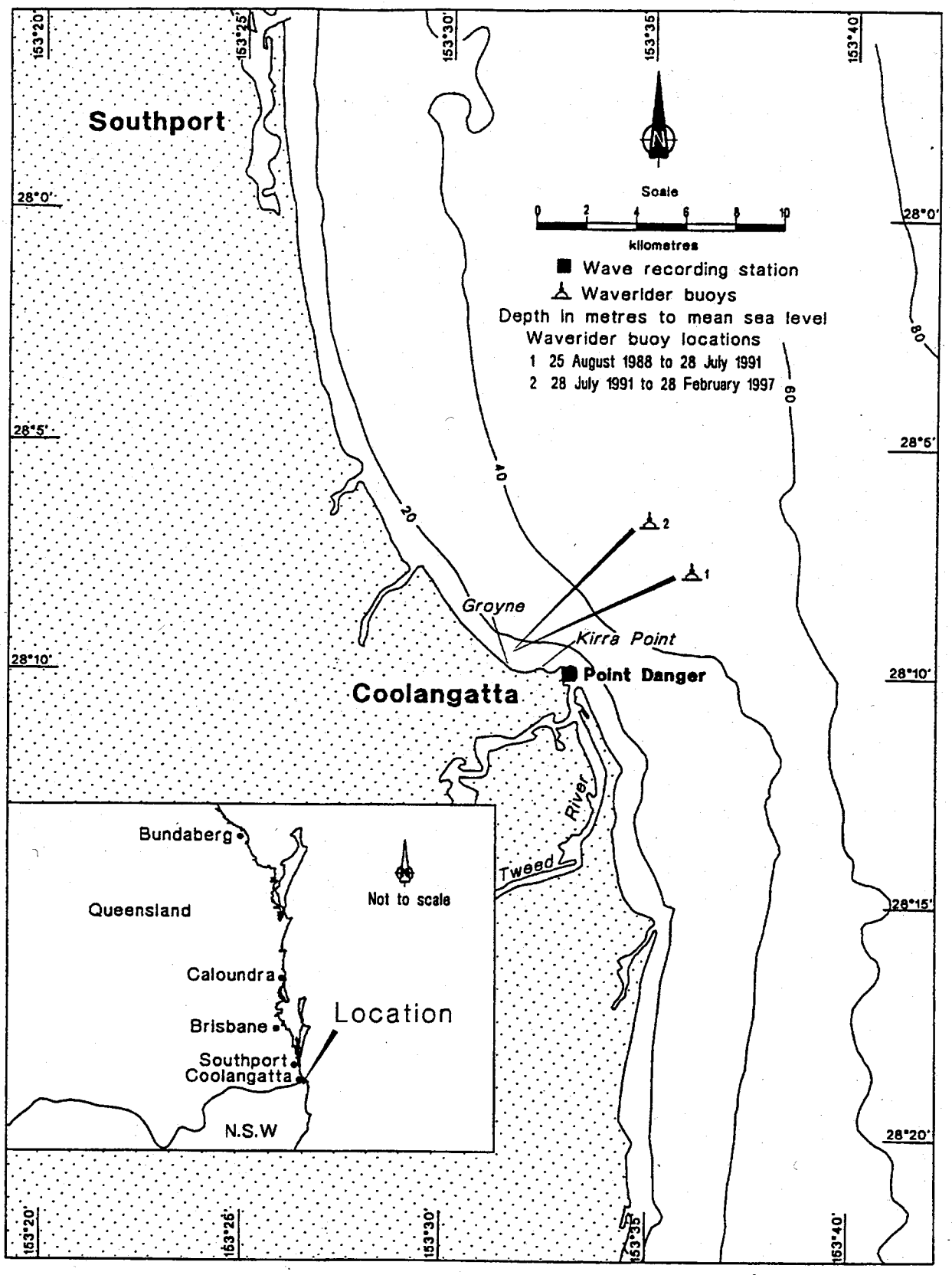
Table 6.

Wave statistics
— Wave period (Tp)/wave height (Hsig) occurrences
— Winter data, all directions, measured in percentage occurrences.

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
0·00–0·19	*	*	*	0·03	0·02	0·01	0·03	*	0·10
0·20–0·39	0·11	0·27	0·82	1·60	4·88	3·50	2·00	0·62	13·80
0·40–0·59	0·23	1·79	3·75	4·39	8·96	7·84	3·38	0·92	31·28
0·60–0·79	0·06	2·53	4·10	4·74	5·55	3·49	1·73	0·76	22·95
0·80–0·99	0·08	1·85	3·33	4·37	2·56	1·45	0·68	0·18	14·50
1·00–1·19	0·04	0·65	2·15	3·18	1·52	0·45	0·23	0·09	8·31
1·20–1·39	*	0·18	1·12	1·47	0·82	0·27	0·07	0·03	3·96
1·40–1·59	*	0·02	0·54	0·65	0·46	0·21	0·06	0·01	1·95
1·60–1·79	*	*	0·16	0·36	0·43	0·12	0·08	0·01	1·15
1·80–1·99	*	*	0·05	0·18	0·27	0·08	0·01	*	0·59
2·00–2·19	*	*	0·02	0·14	0·17	0·13	*	*	0·46
2·20–2·39	*	*	*	0·07	0·22	0·01	*	*	0·29
2·40–2·59	*	*	*	0·03	0·06	0·04	*	*	0·13
2·60–2·79	*	*	*	0·01	0·10	0·03	*	*	0·14
2·80–2·99	*	*	*	*	0·05	0·04	0·02	*	0·11
3·00–3·19	*	*	*	*	0·03	0·01	0·02	*	0·06
3·20–3·39	*	*	*	*	*	0·03	*	*	0·04
3·40–3·59	*	*	*	*	*	0·03	*	*	0·03
3·60–3·79	*	*	*	*	*	0·02	0·01	*	0·03
3·80–3·99	*	*	*	*	*	0·01	*	*	0·02
4·00–4·19	*	*	*	*	*	*	*	*	0·01
4·20–4·39	*	*	*	*	*	*	*	*	0·01
4·40–4·59	*	*	*	*	*	*	0·01	*	0·01
4·60–4·79	*	*	*	*	*	*	0·01	*	0·01
4·80–4·99	*	*	*	*	*	0·01	0·01	*	0·01
5·00–5·19	*	*	*	*	*	0·01	*	*	0·01
5·20–5·39	*	*	*	*	*	*	*	*	0·01
5·40–5·59	*	*	*	*	*	*	0·01	*	0·01
5·60–5·79	*	*	*	*	*	*	*	*	0·00
5·80–5·99	*	*	*	*	*	*	*	*	0·00
Totals	0·53	7·28	16·04	21·22	26·12	17·82	8·36	2·63	100·00

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



Locality plan

Beach Protection Authority Queensland Department of Environment	Wave data recording program Kirra Region	**Figure 1**

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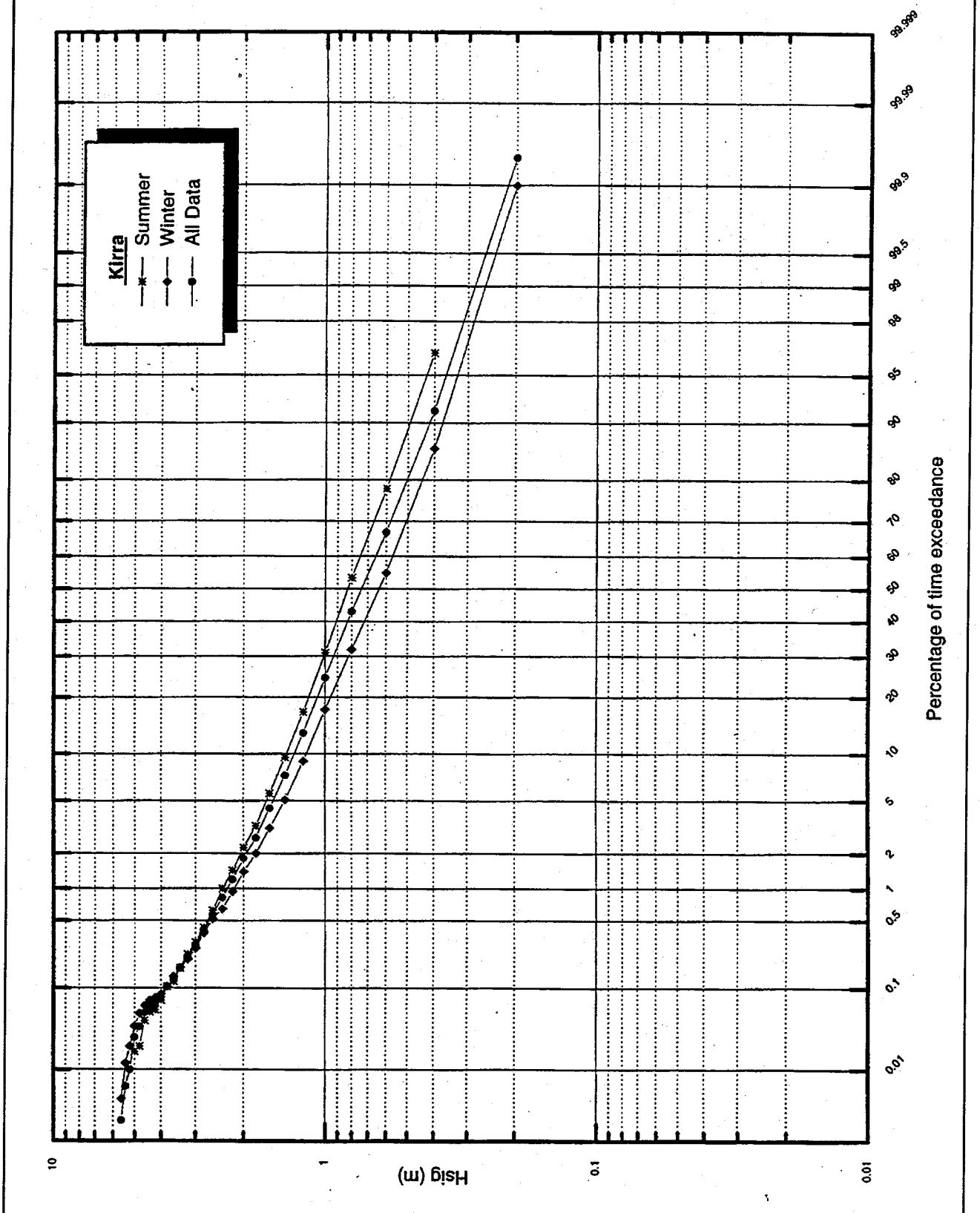
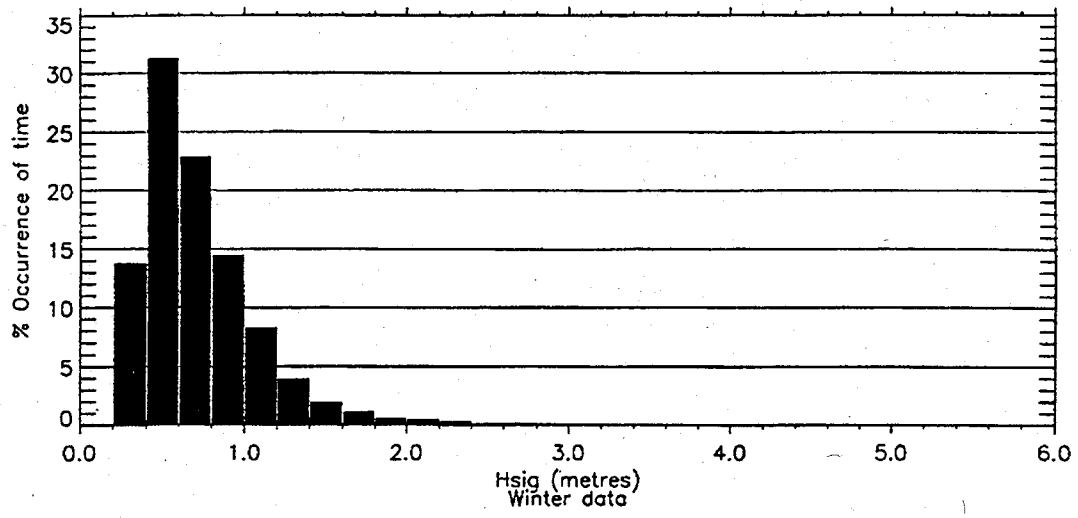
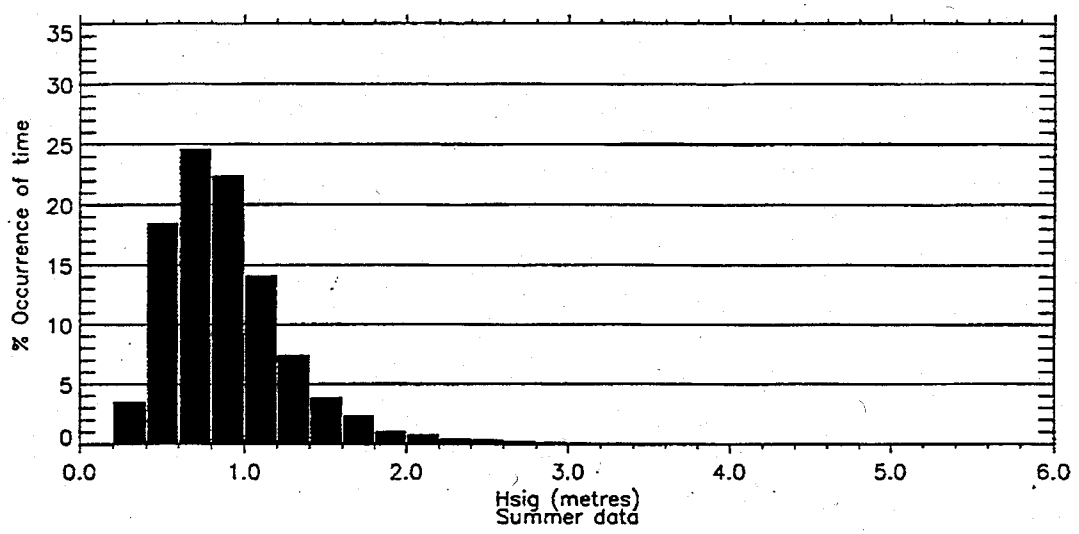
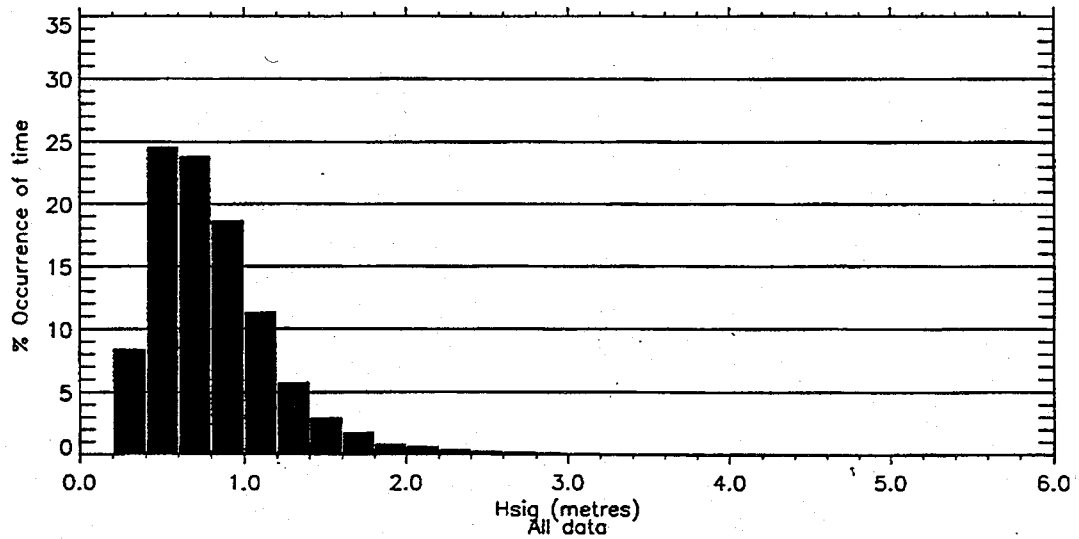


Percentage (of time) exceedance of wave heights (Hsig) for all periods 25 August 1988 to February 1997

Beach Protection Authority Queensland Department of Environment	Wave data recording program Kirra Region	**Figure 2**

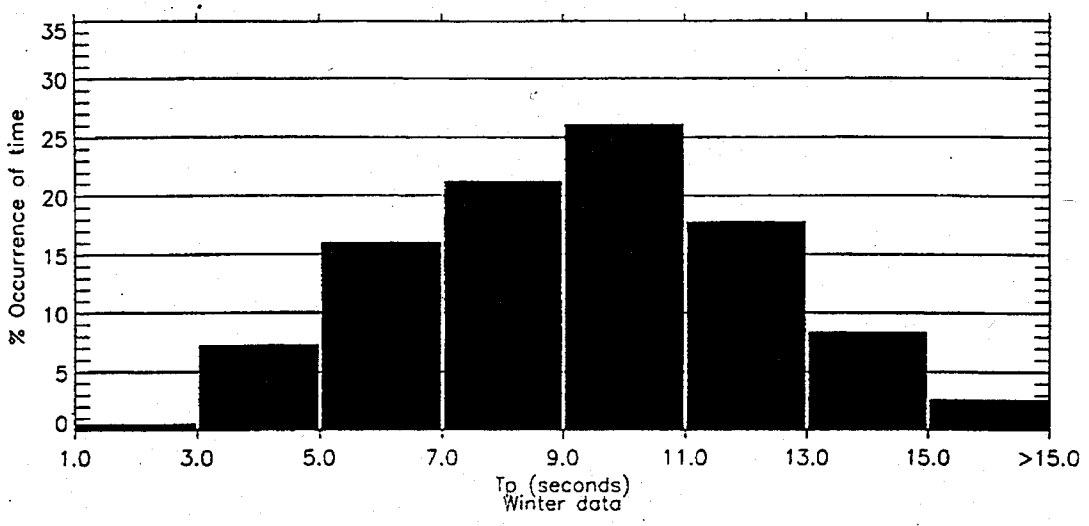


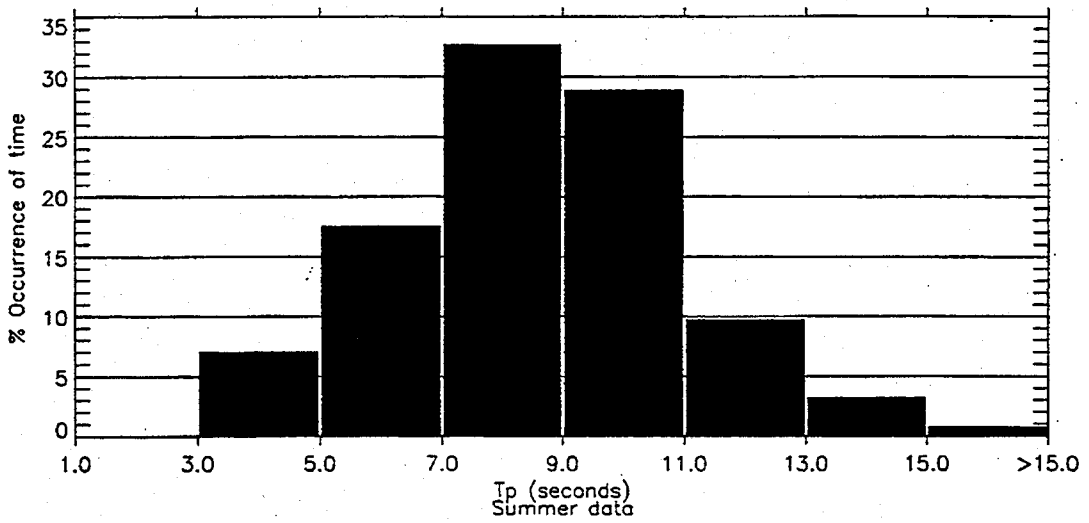


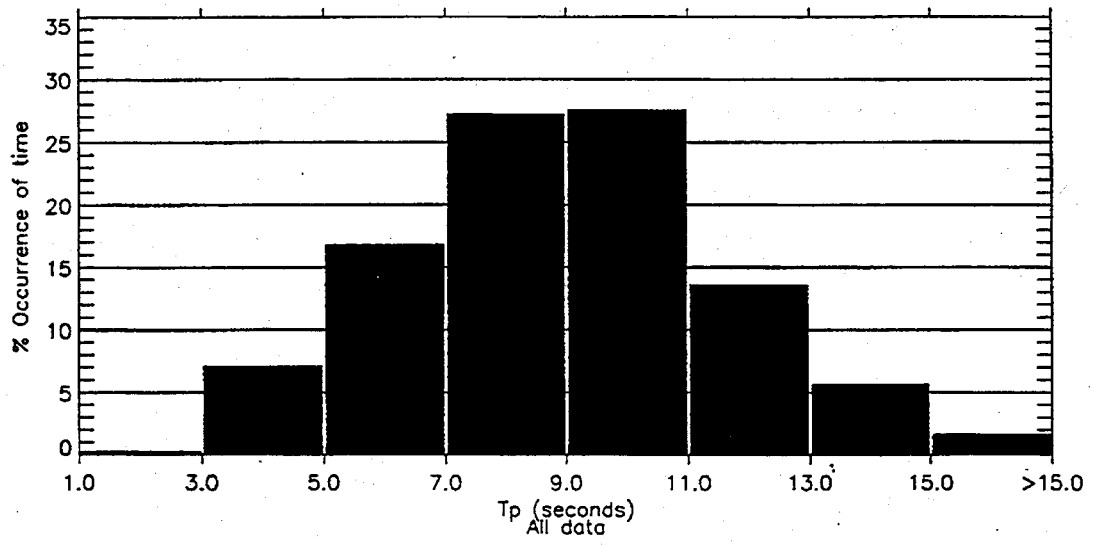


Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

Beach Protection Authority Queensland Department of Environment	Wave data recording program Kirra Region	**Figure 3**

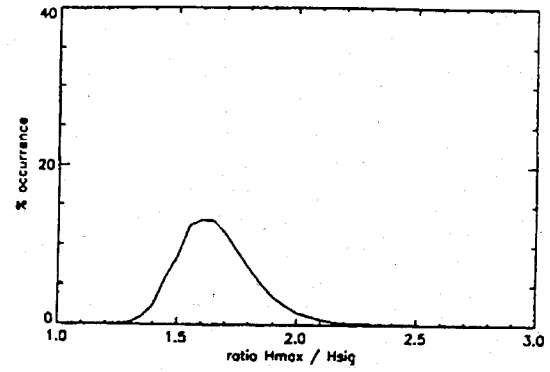


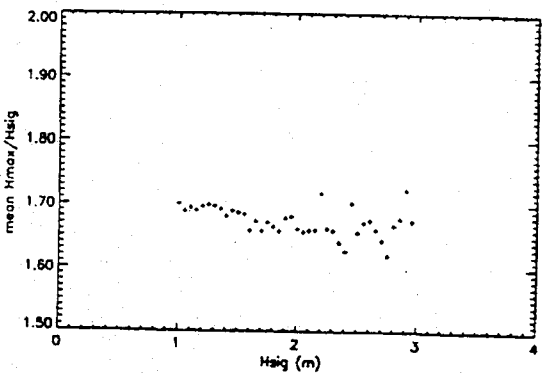


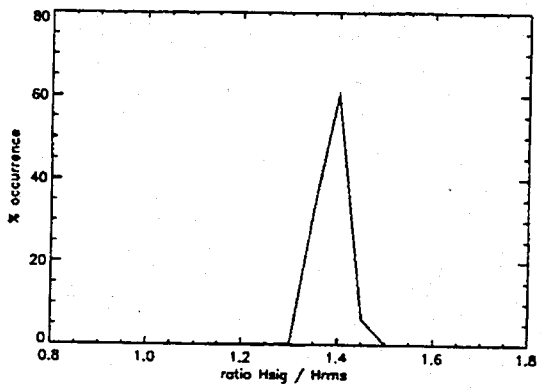


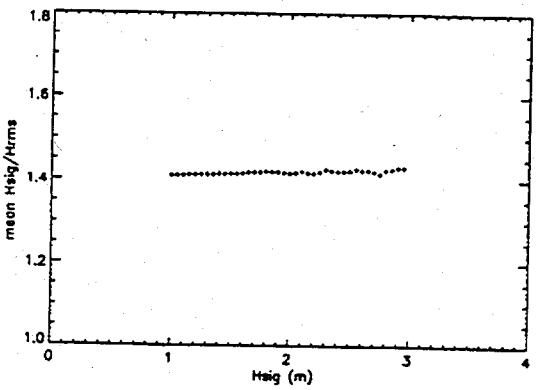
Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

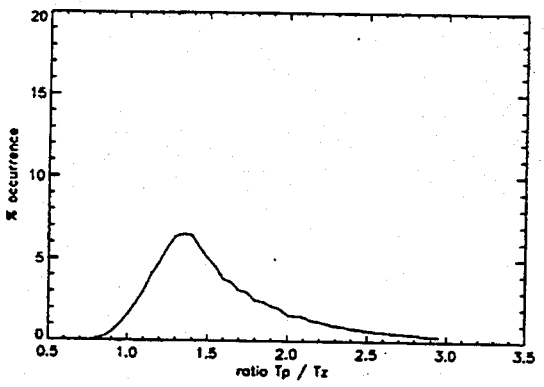
Beach Protection Authority Queensland Department of Environment	Wave data recording program Kirra Region	**Figure 4**

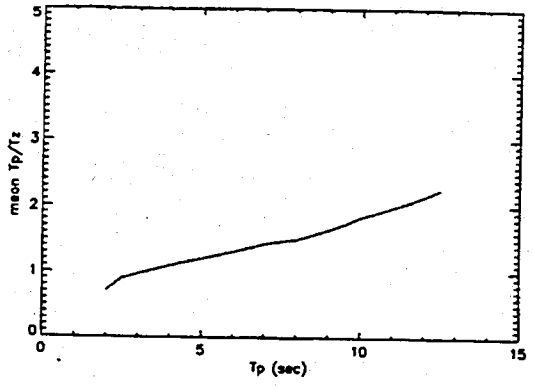


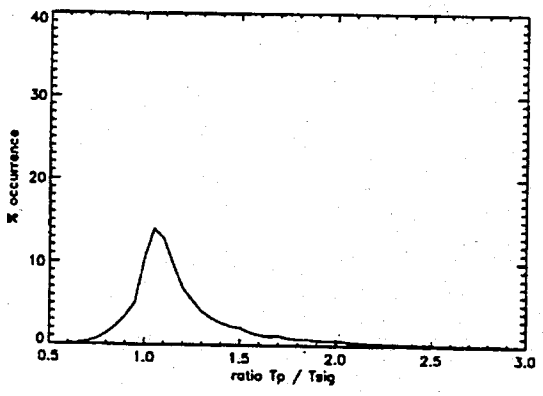


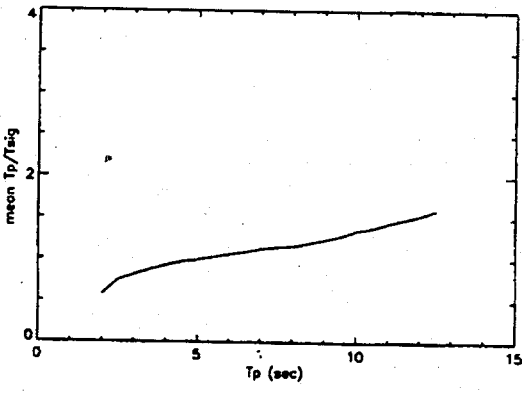










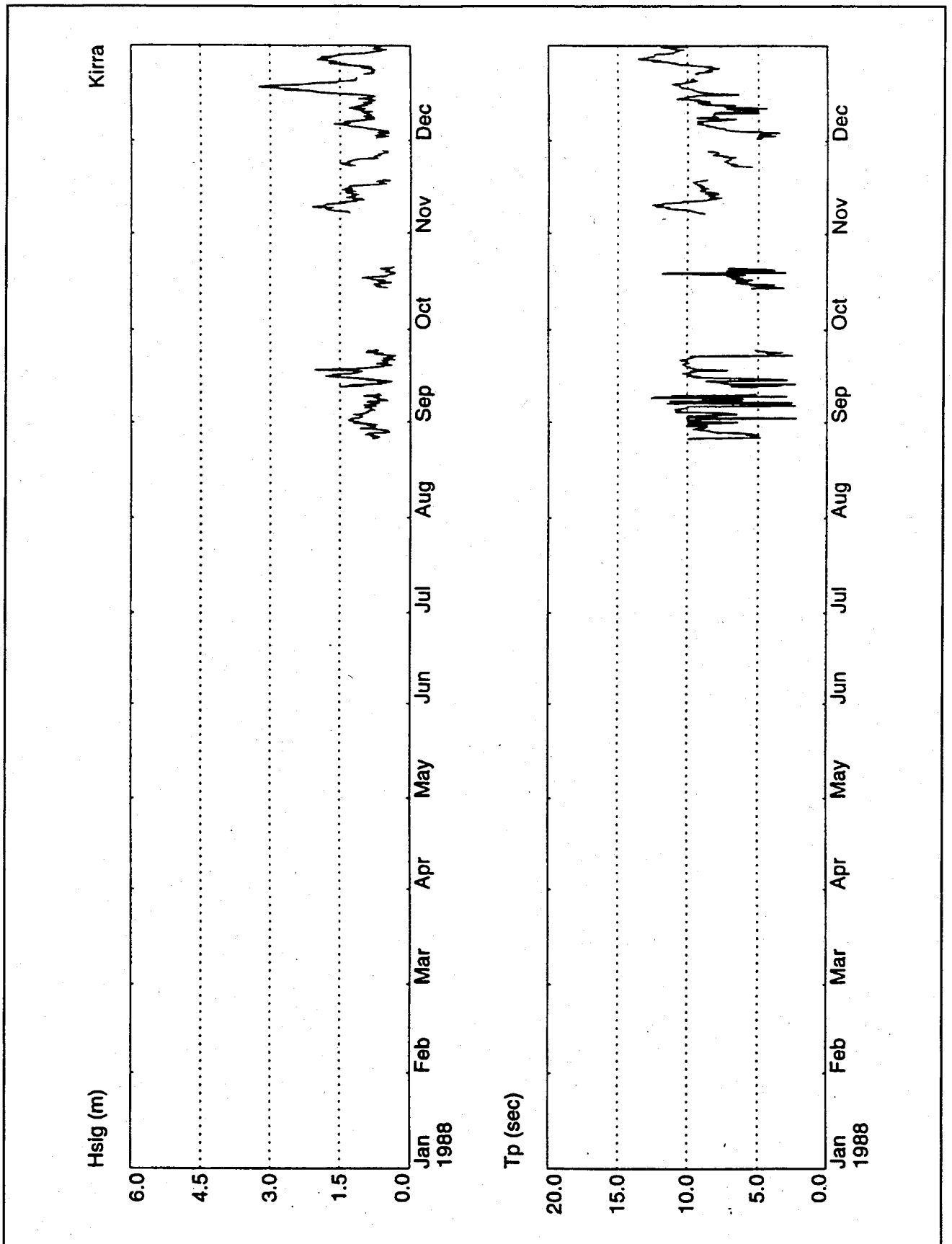


Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

Beach Protection Authority Queensland
Department of Environment

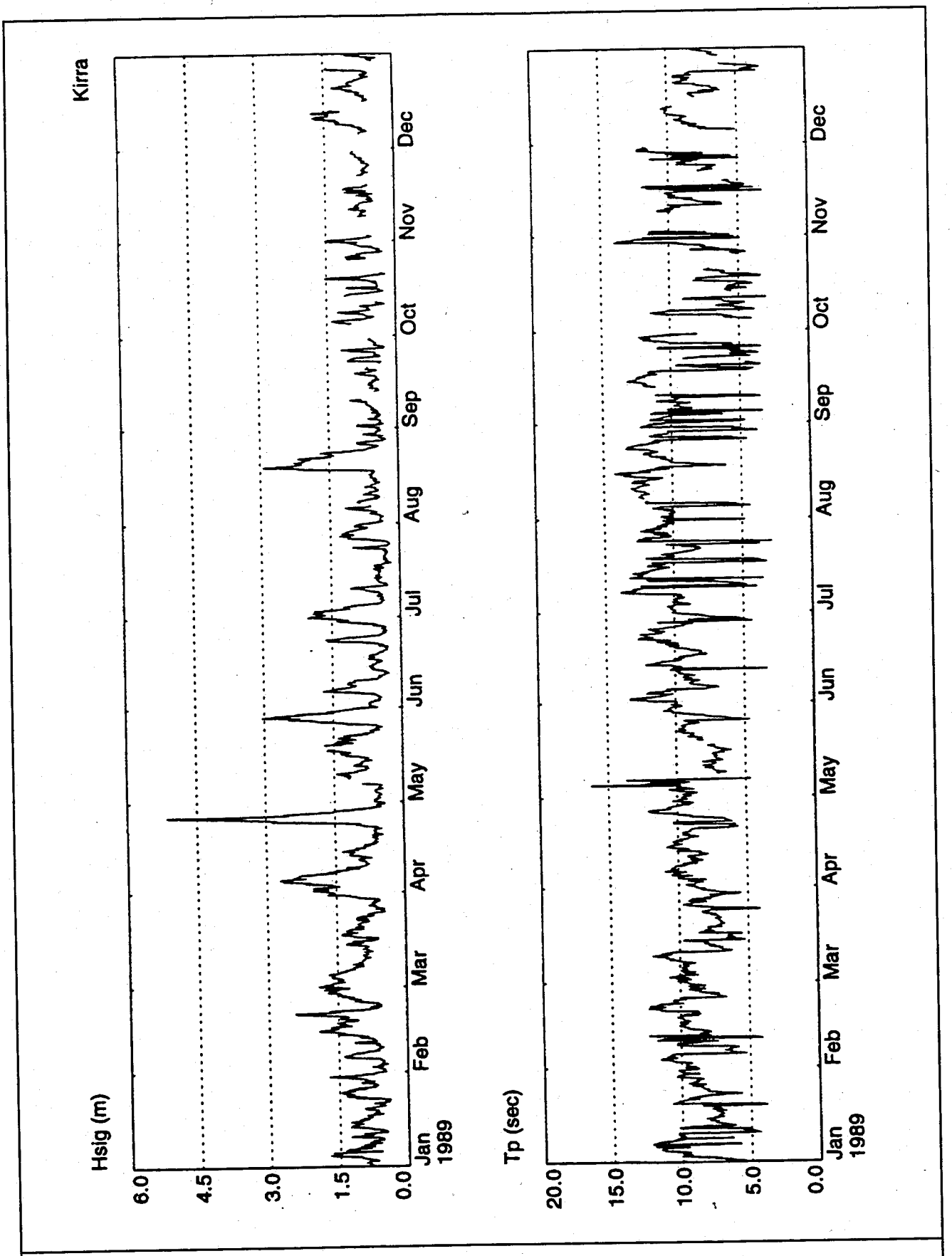
Wave data recording program
Kirra Region

Figure 5



Daily wave recordings
25 August 1988 to 31 December 1988

Beach Protection Authority Queensland Department of Environment	Wave data recording program Kirra Region	**Figure 6.01**



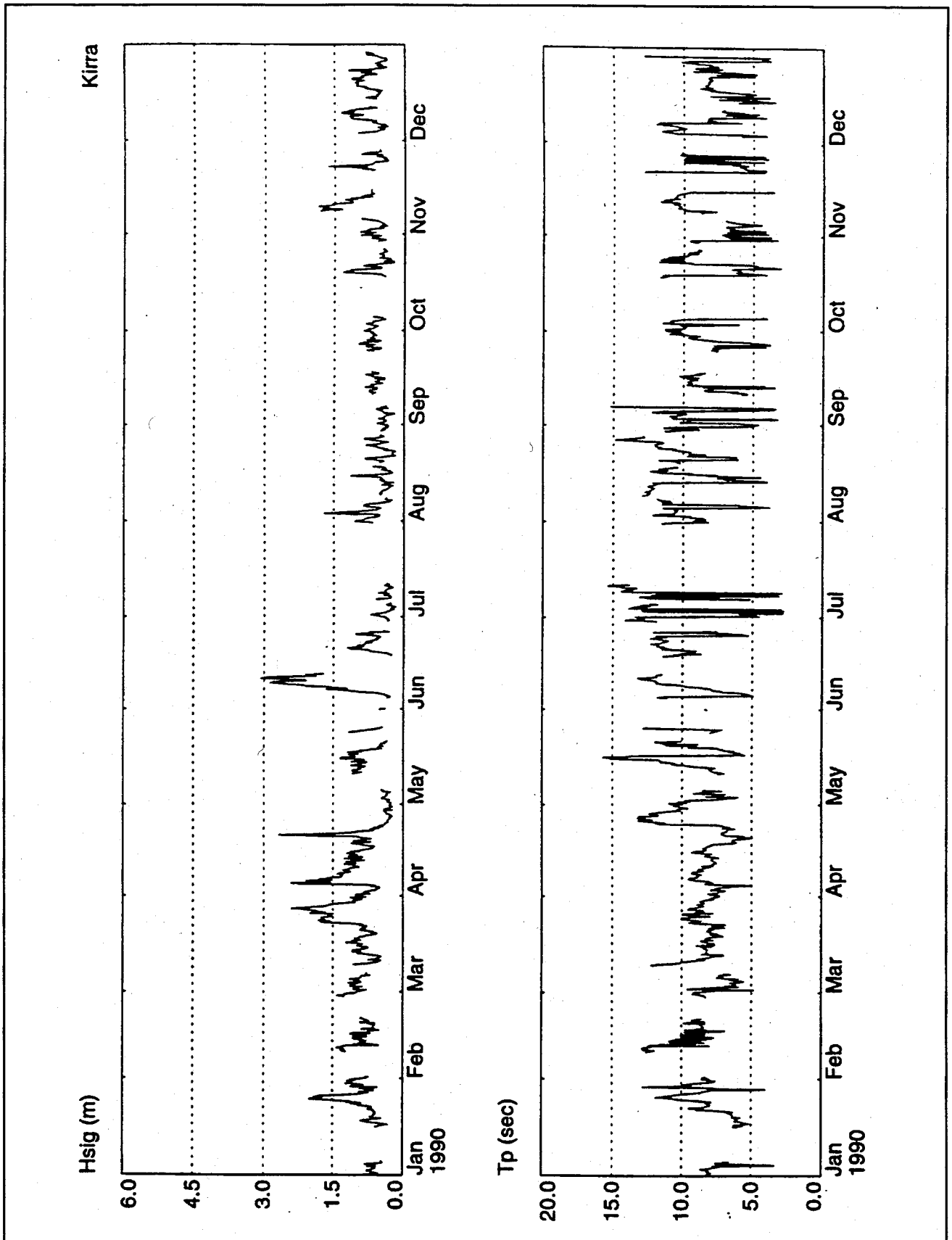
Daily wave recordings
1 January 1989 to 31 December 1989

Beach Protection Authority Queensland
Department of Environment

Wave data recording program
Kirra Region

Figure 6.02

Wave data recording program, Kirra — 1988-1997 • October 1997 • ISSN 0158-7757

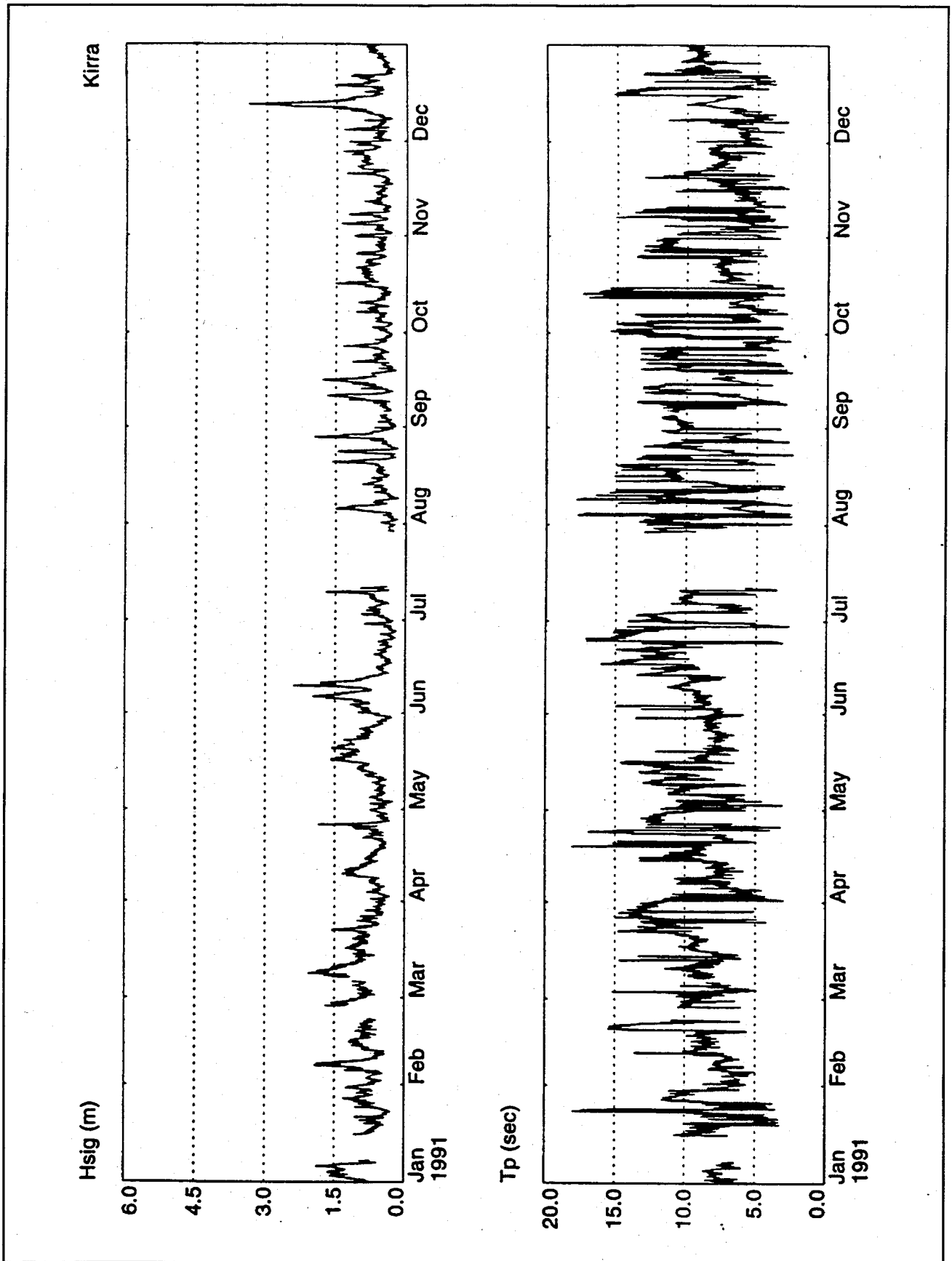


Daily wave recordings
1 January 1990 to 31 December 1990

Beach Protection Authority Queensland
Department of Environment

Wave data recording program
Kirra Region

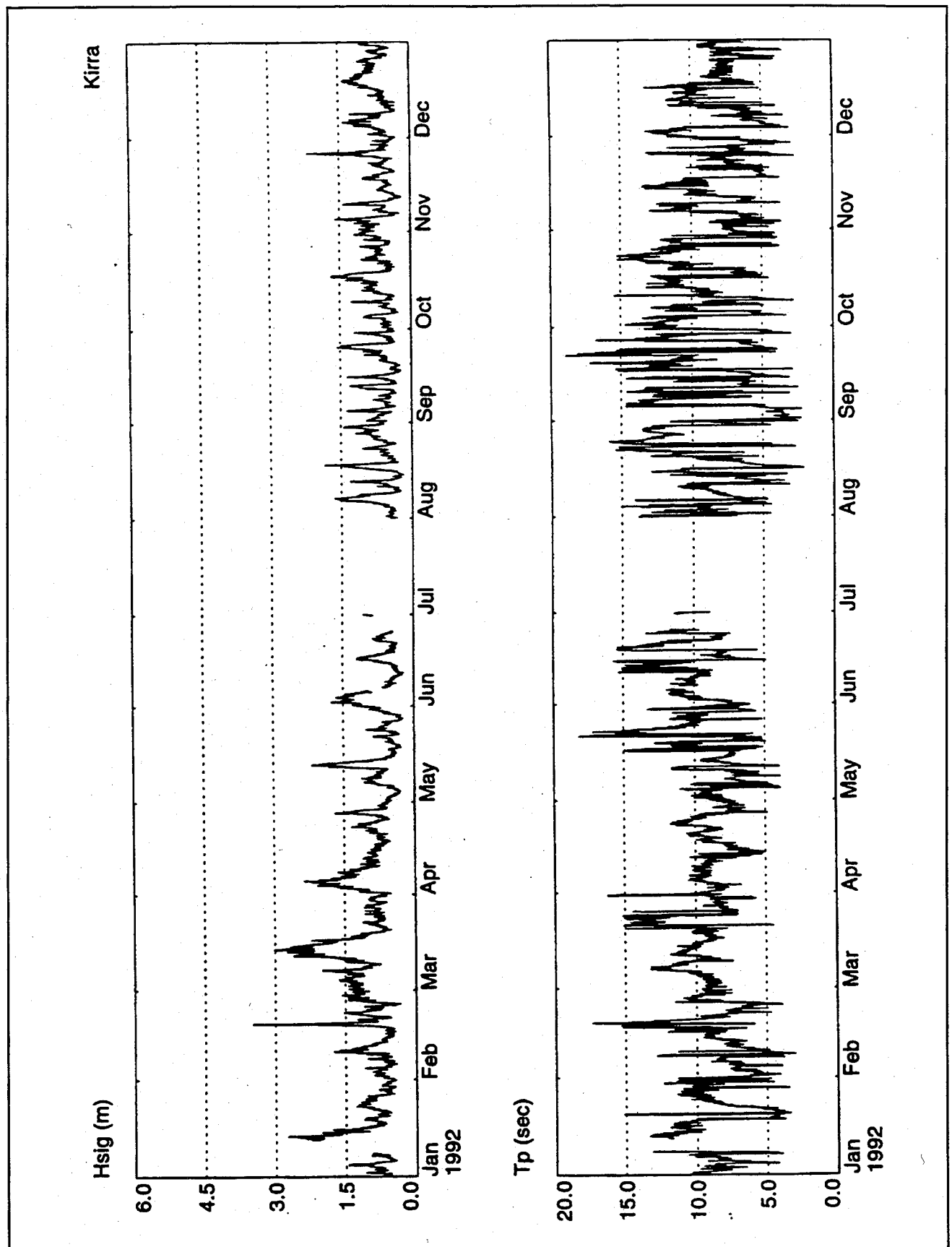
Figure 6.03



Daily wave recordings
1 January 1991 to 31 December 1991

Beach Protection Authority Queensland Department of Environment	Wave data recording program Kirra Region	**Figure 6.04**

Wave data recording program, Kirra — 1988-1997 • October 1997 • ISSN 0158-7757



Daily wave recordings
1 January 1992 to 31 December 1992

Beach Protection Authority Queensland
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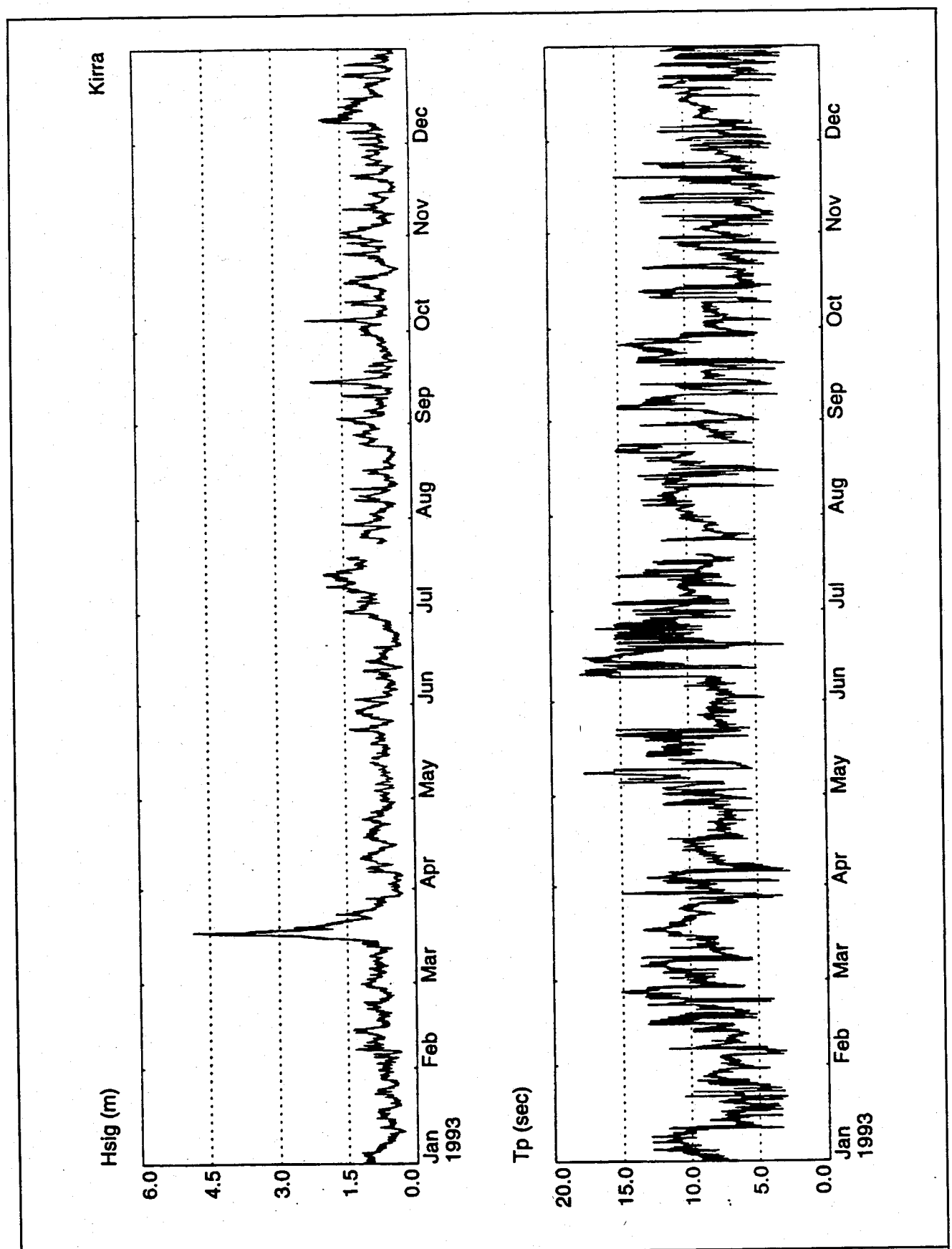
Wave data recording program
Kirra Region

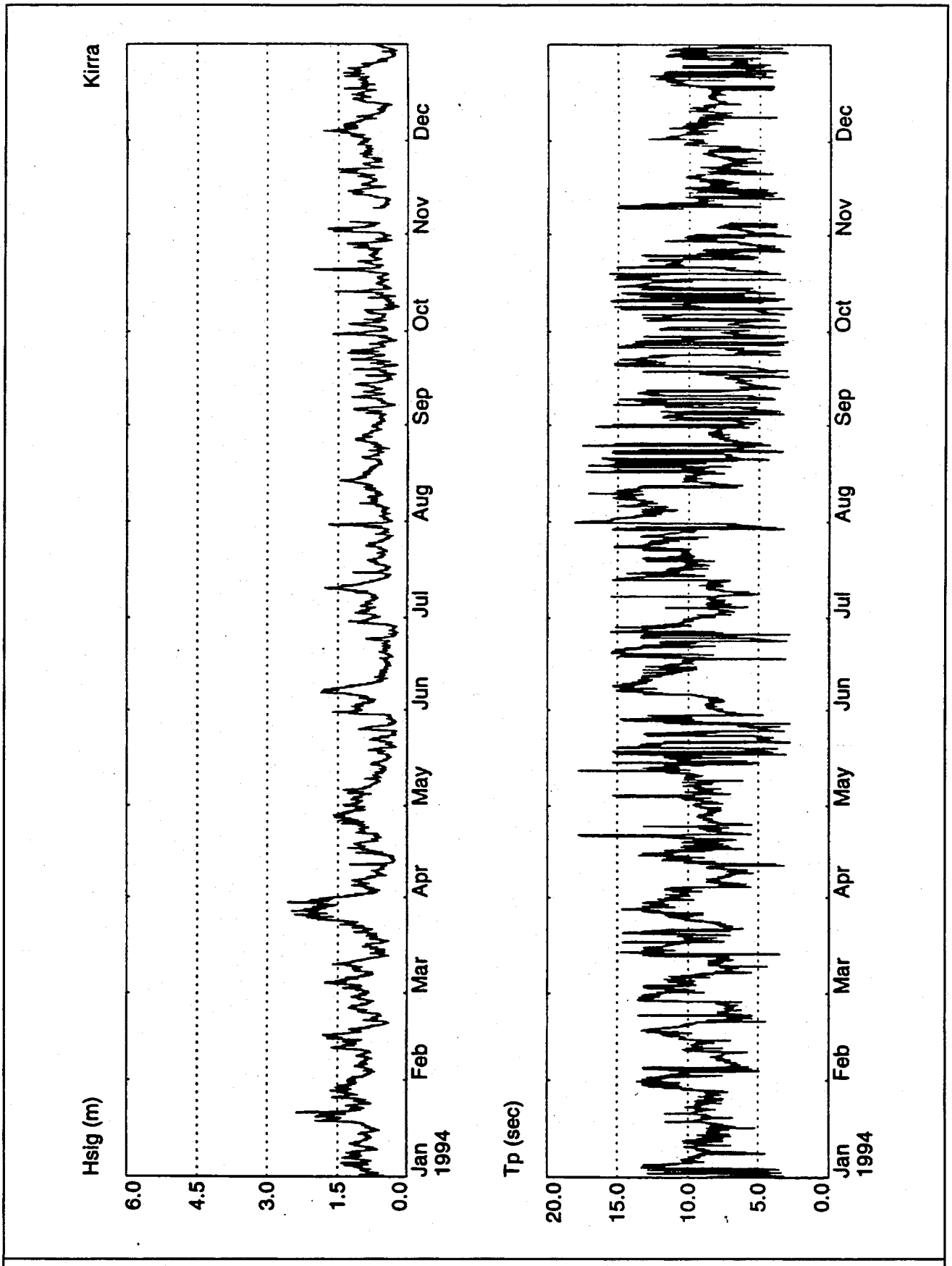
Figure 6.05



Daily wave recordings
1 January 1993 to 31 December 1993

Beach Protection Authority Queensland Department of Environment	Wave data recording program Kirra Region	**Figure 6.06**

Wave data recording program, Kirra — 1988-1997 • October 1997 • ISSN 0158-7757

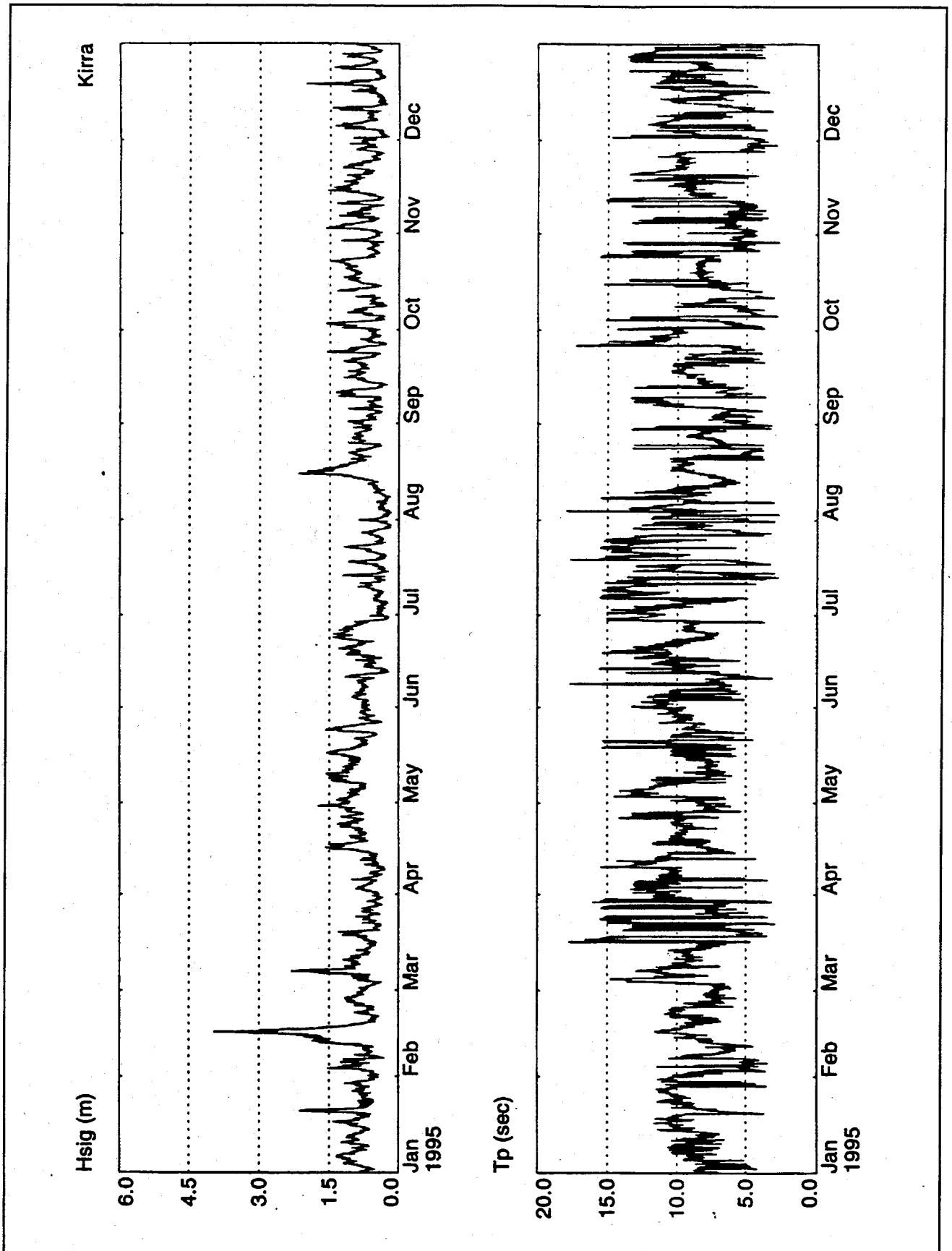


Daily wave recordings
1 January 1994 to 31 December 1994

Beach Protection Authority Queensland
Department of Environment

Wave data recording program
Kirra Region

Figure 6.07

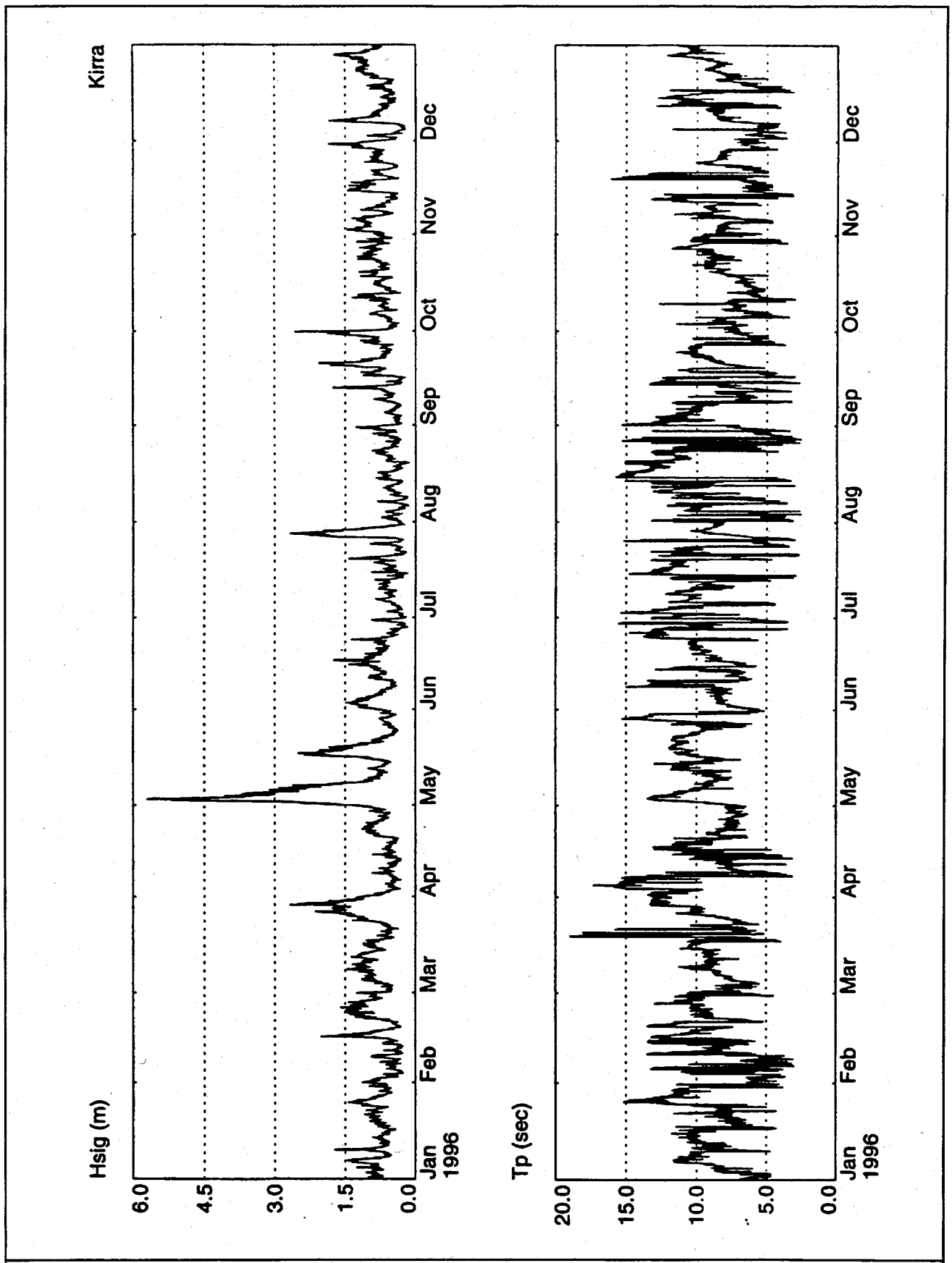


Daily wave recordings
1 January 1995 to 31 December 1995

Beach Protection Authority Queensland
Department of Environment

Wave data recording program
Kirra Region

Figure 6.08

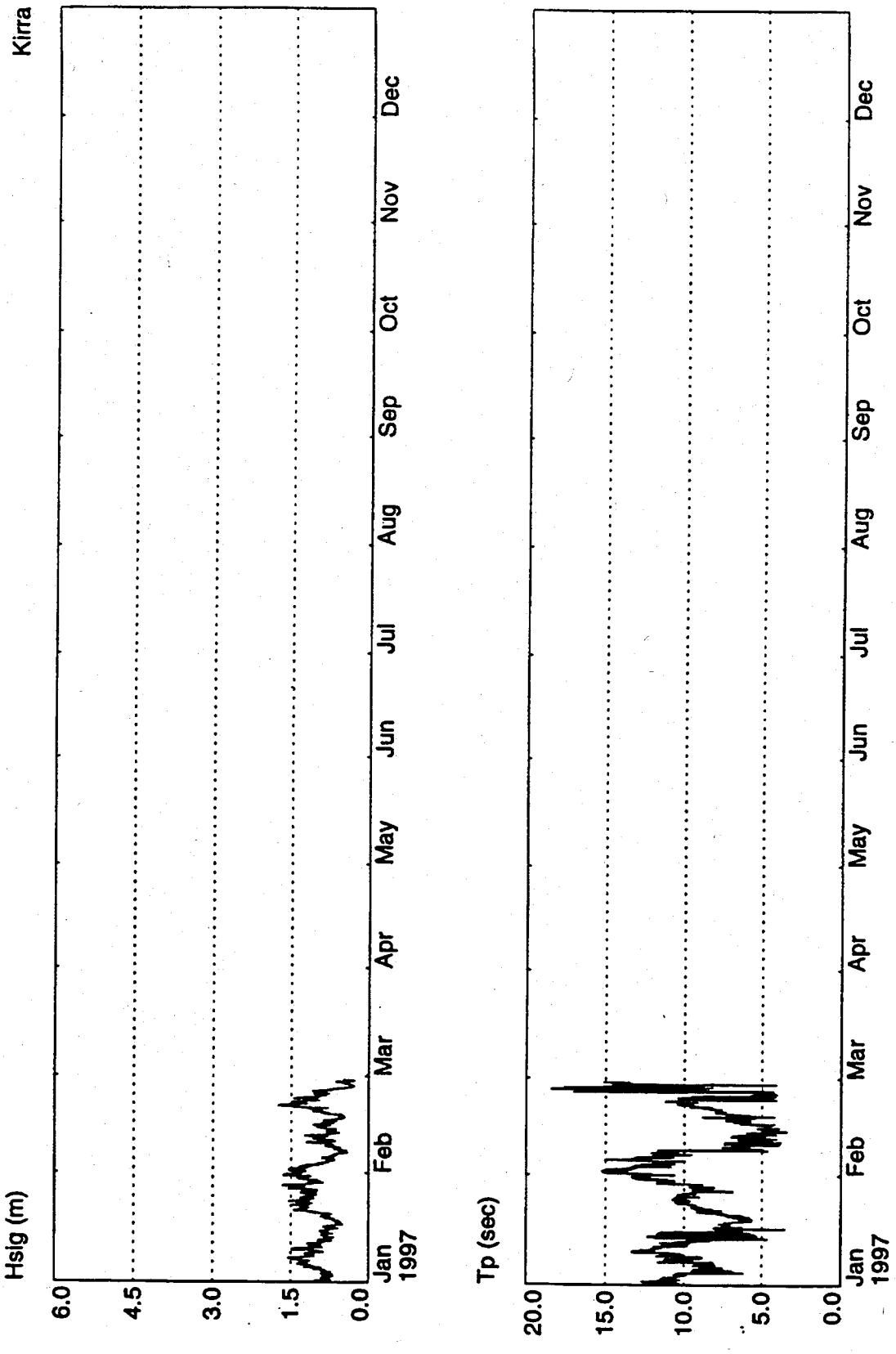


Daily wave recordings
1 January 1996 to 31 December 1996

Beach Protection Authority Queensland
Department of Environment

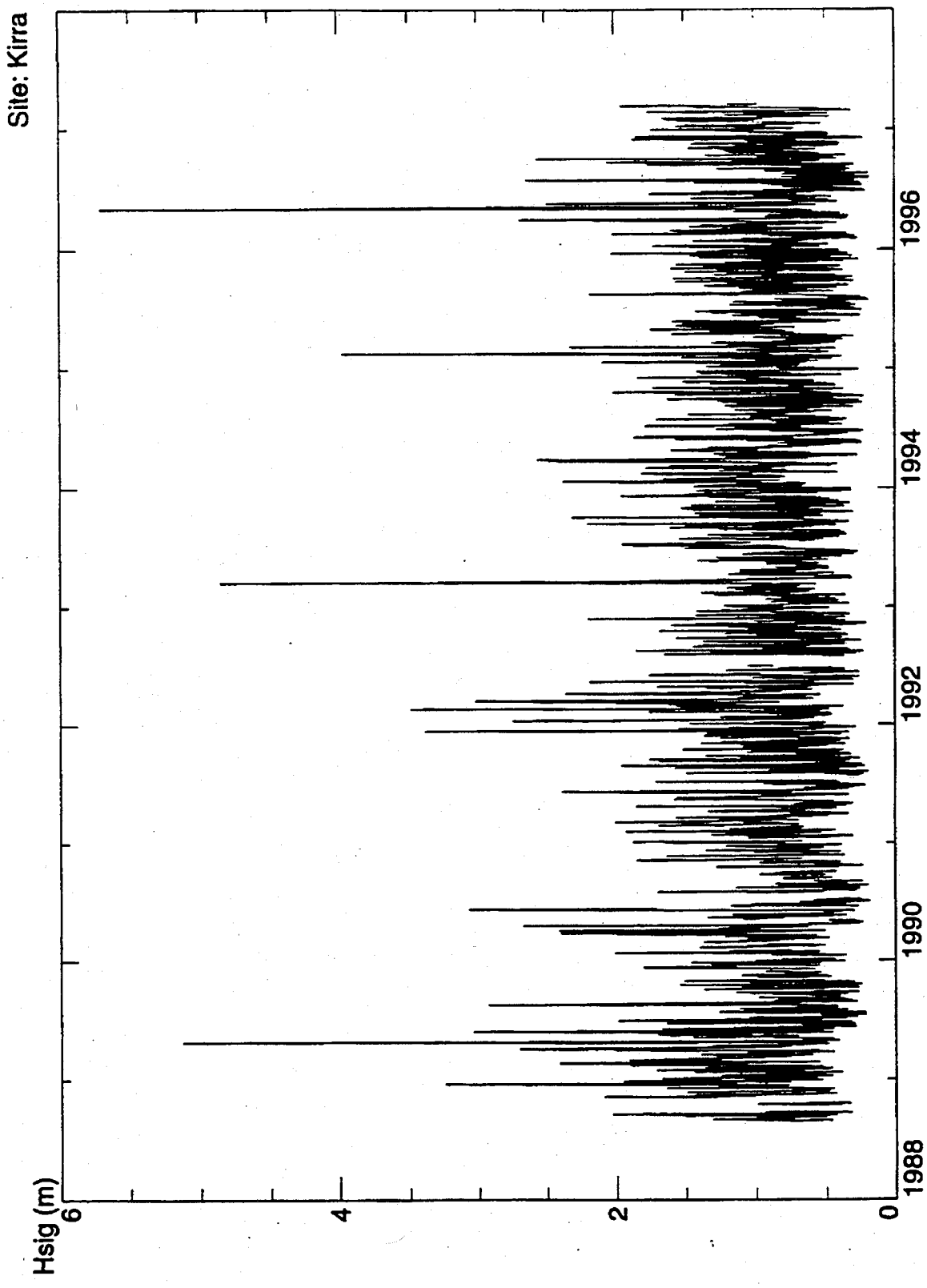
Wave data recording program
Kirra Region

Figure 6.09



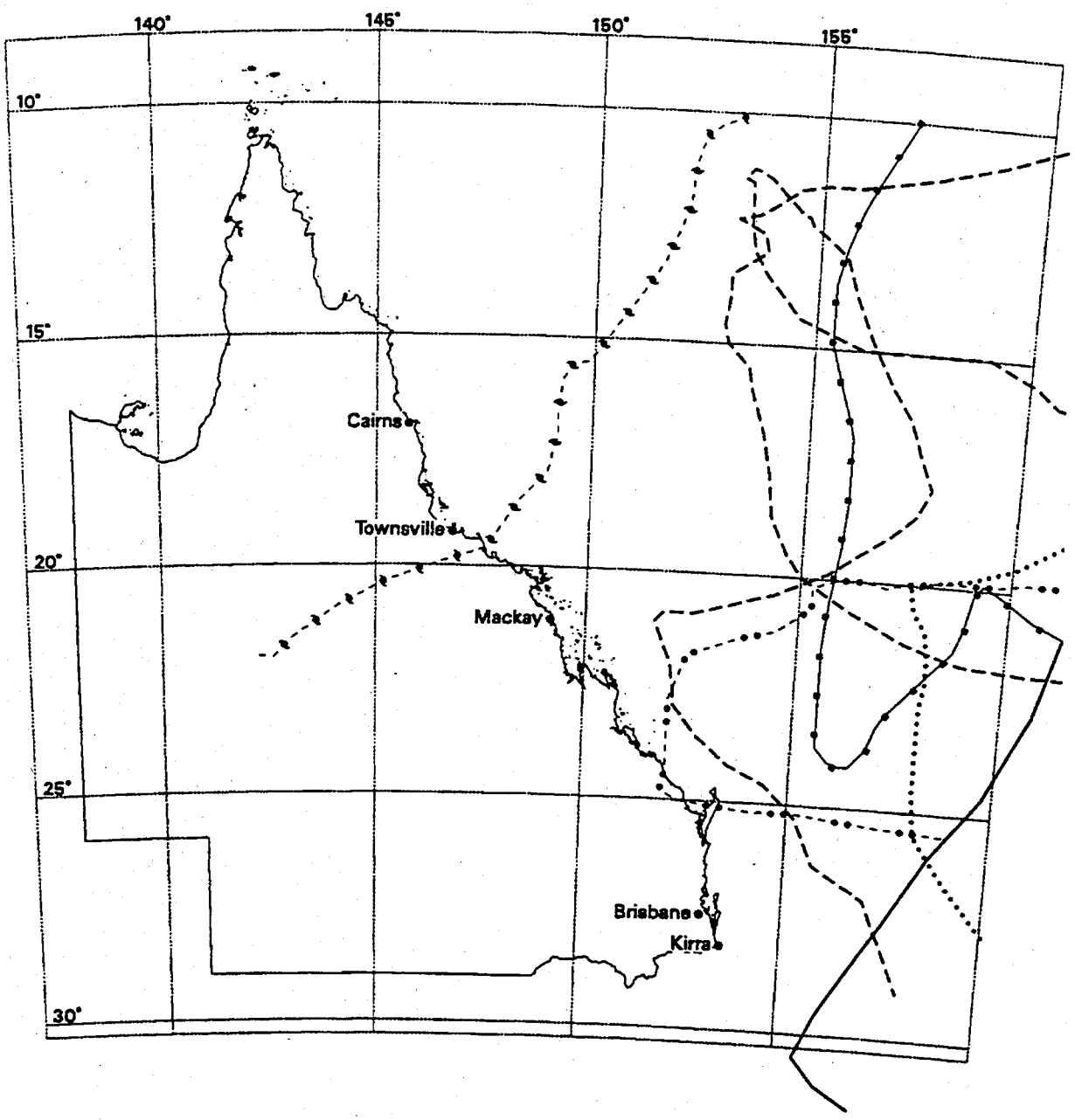
Daily wave recordings
1 January 1996 to 28 February 1997

Beach Protection Authority Queensland Department of Environment	Wave data recording program Kirra Region	**Figure 6.10**



Whole recording period single plot of wave heights (Hsig)

Beach Protection Authority Queensland Department of Environment	Wave data recording program Kirra Region	**Figure 7**



Key to cyclones

- Aivu
- Betsy
- Daman
- Fran
- Roger
- Rewa

1:16000000

0 160 320 480 640 800

Kilometres

Cyclone tracks
1988 to 1997

Beach Protection Authority Queensland
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Wave data recording program
Kirra Region

Figure 8

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