S. DEAVES

Wave data recording program
Cairns region
For the years 1975 - 1997

QUEENSLAND GOVERNMENT
Department of
Environment and Heritage

Wave data recording program report No. 13 (WO1.3)

ISSN 0158-7757 RE275 August 1998

Wave data recording program
Cairns region
For the years 1975–1997

Abstract

This report provides summaries of primary analyses of wave data recorded using a Datawell non-directional waverider buoy in water depths of approximately 15m offshore near Cairns, far north Queensland. Recorded data covers the period from 2 May 1975 to 31 October 1997. The data were divided into seasonal groupings for analysis. No estimations of wave direction have been provided.

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

RE275 August 1998
Recycled paper saves energy and resources

Contents

1 Introduction

The Beach Protection Authority, as part of its long-term data collection program, has maintained a network of wave recording stations along the Queensland coast since 1968.

This report summarises the primary analyses of wave data collected at the Cairns 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 Beach Protection Authority's wave recording program utilises either of two systems to measure wave data — the waverider buoy or the wave pole system.

2.1 Waverider system

The waverider system manufactured by Datawell bv of the Netherlands uses a waverider buoy to measure the sea surface fluctuations at an offshore location. Both directional and non-directional buoys are presently in operation with the Beach Protection Authority.

Both the directional and non-directional waverider buoys measure vertical acceleration by means of an accelerometer, mounted on a gravity stabilised platform suspended in a fluid filled plastic sphere located at the bottom of the buoy. The vertical accelerations are then twice integrated to give vertical displacement.

The directional buoy also measures acceleration in the horizontal plane using two additional accelerometers fixed at perpendicular axes. After conversion of these accelerations to horizontal displacements, the direction of the buoy movement is derived by a transformation to north–south and east–west using a bearing from the on-board fluxgate compass.

The vertical buoy displacement, representing the instantaneous water level, and directional data (if present) are then transmitted to the recording 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, which acts as a coaxial 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 Cairns station, for the period 2 May 1975 to 17 March 1981, the installation comprised a waverider 6000 series non-directional buoy and a recording station consisting of a WAREP Mark II waverider receiver coupled to an ANMA analogue recorder. The WAREP receiver controlled the timing of data recording, provided a paper chart of the water level recordings and relayed an analogue signal to the ANMA analogue recorder.

Between 18 March 1981 and 20 January 1994, the recording station was upgraded by replacing the ANMA analogue recorder with 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, with the paper charts, transferred to the Brisbane office for processing.

On 21 January 1994, the Cairns wave recording station was further upgraded with a non-directional waverider buoy and the recording system upgraded to a PC-based system utilising 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 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 telephone network. Recorded data and analysis results are downloaded daily to a central computer system in Brisbane for checking, further 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 of this report.

2.4 Laboratory calibration checks

Waverider buoys used by the Beach Protection Authority are calibrated before deployment and after recovery. Normally, a buoy is calibrated once every twelve 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 0·6m 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

No adjustment to the recorded wave data in this report due to the laboratory calibration results is done in any way.

3 Wave recording and analysis procedures

From 2 May 1975 to 17 March 1981, wave data were recorded twice daily. Each record was of 20 minutes duration, with the timing of recordings set at 0300 and 1500 hours AEST (Australian Eastern Standard Time).

Over the period 18 March 1981 to 20 January 1994, wave data were recorded four times per day at 0300, 0900, 1500 and 2100 hours AEST. During storm events, the recording frequency may have been manually switched by the operator to record eight times per day.

From 21 January 1994 to 13 October 1997, the PC-based recording system 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) half-hourly 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 auto-correlation 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 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 one third of waves in the record

Tz The average period of all zero upcrossing 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.

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 Cairns wave recording station are included in Appendix 1 — Details of wave recorder installation.

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 Beach Protection 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 figures 2, 3 and 4. In addition, similar analyses are carried out on the relationships between the various wave parameters. These are presented in figure 5.

5.1 Methodology

As discussed above, the various sources of data losses can cause occasional gaps in the data record. Gaps may be relatively short caused by rejection of 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.

During the period when two records per day were taken, the nominal recording interval was 12 hours. The maximum allowable total duration of a record is equal to the nominal recording interval of 12 hours, with a small tolerance (30 minutes) to account for timing errors. Each duration on either side of a record greater than a nominal six hours (half the maximum allowable total duration), plus the tolerance, is set to the maximum allowable of exactly six hours, and a gap in the data is reported.

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, with a small tolerance (30 minutes) to account for timing errors. Each duration on either side of a record greater than a nominal three hours (half the maximum allowable total duration), plus the tolerance, 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 was 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. Before any use is made of this data, it is therefore necessary to note the exact location of the buoy and the water depth in which the buoy was moored. These data are shown in Appendix 1 — Details of the wave recorder installation. The non-directional waverider recording system that is used by the Beach Protection 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 — Major meteorological events, provides a summary of meteorological events which 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 which contributed to recorded Hsig values reaching the storm threshold of 2m are listed in Appendix 2 and figure 8.

Appendix 3 — Tropical cyclones of the east coast of Queensland, lists only the names and dates of all cyclones which occurred within the Gulf of Carpentaria in Queensland during the recording period of 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*

Datawell, Operation and Service Manual for the Non-directional Waverider, (1994)

Datawell, *Manual of Waverider Receiver type WAREP–mark II*, (1976)

Datawell, *Manual of the Digital Waverider Receiver type DIWAR*, (1990)

Datawell, *Manual for Analogue Magnetic Recorder (ANMA)*, (1973)

Datawell, *Manual of the Digital Magnetic Tape Recorder type DIMA–mark II*, (1979)

Datawell, *Operations and Service Manual for Directional Waverider from serial no. 30109*, (1991)

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

Bureau of Meteorology, *Monthly Weather Reviews*

8 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 June 1985

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, Sunshine Coast Region
Report No. W04.1 — 5 Apr 1974 to 5 July 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 June 1983.

Wave data recording program, Brisbane Region
Report No. W09.2 — 30 Oct 1976 to 30 June 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 June 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 June 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 June 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 June 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

Appendix 1
Details of wave recorder installation

Buoy locations
See figure 1 for the locality plan of the waverider buoys and recording station for the period of this report. All water depths are accurate to ± 1 metre.

Co-ordinates: 145° 42'E, 16° 42.55'S
Description: 10.2km, bearing 349° 36.05' from Yorkeys Knob recording station; 2.35km north-east of Double Island
Buoy type: Datawell non-directional waverider
Water depth at buoy: 18m relative to Australian Height Datum
Period: 2 May 1975–27 October 1985

Co-ordinates: 145° 42.05'E, 16° 42.75'S
Description: 9.8km, bearing 349° 31.85' from Yorkeys Knob recording station; 2.05km north-east of Double Island
Buoy type: Datawell non-directional waverider
Water depth at buoy: 18m relative to Australian Height Datum
Period: 28 October 1985–13 November 1987

Co-ordinates: 145° 42.05'E, 16° 43.07'S
Description: 9.26km, bearing 349° 56.10' from Yorkeys Knob recording station; 1.75km north-east of Double Island
Buoy type: Datawell non-directional waverider
Water depth at buoy: 15m relative to Australian Height Datum
Period: 14 November 1987–18 August 1988

Co-ordinates: 145° 42.20'E, 16° 43.07'S
Description: 9.21km, bearing 350° 44.55' from Yorkeys Knob recording station; 2.00km north-east of Double Island
Buoy type: Datawell non-directional waverider
Water depth at buoy: 15m relative to Australian Height Datum
Period: 19 August 1988–19 July 1991

Note: the above buoy locations were calculated using radar ranging and compass bearings to prominent landmarks.

Co-ordinates: 145° 42.33'E, 16° 43.51'S
Description: 8.4km, bearing 351° 28.51' from Yorkeys Knob recording station; 2.05km east of Double Island
Buoy type: Datawell non-directional waverider
Water depth at buoy: 15m relative to Australian Height Datum
Period: 20 July 1991–1 February 1993

Co-ordinates: 145° 43.33'E, 16° 43.51'S
Description: 8.3km, bearing 003° 43.67' from Yorkeys Knob recording station; 3.85 km east of Double Island
Buoy type: Datawell non-directional waverider
Water depth at buoy: 15m relative to Australian Height Datum
Period: 2 February 1993–18 January 1994

Co-ordinates: 145° 42.2'E, 16° 43.32'S
Description: 8.8km, bearing 350° 16.59' from Yorkeys Knob recording station; 1.85km east-northeast of Double Island
Buoy type: Datawell non-directional waverider
Water depth at buoy: 15m relative to Australian Height Datum
Period: 19 January 1994–30 January 1995

Co-ordinates: 145° 42.7'E, 16° 43.95'S
Description: 10.2km, bearing 355° 32.5' from Yorkeys Knob recording station; 2.80 km east-southeast of Double Island
Buoy type: Datawell non-directional waverider
Water depth at buoy: 15m relative to Australian Height Datum
Period: 31 January 1995–30 April 1997

Note: the above buoy locations were measured using GPS fixing procedures.

Location of recording station
Co-ordinates: 145° 43.00'E, 16° 48.00'S
Description: Yorkeys Knob — near water tank on Cairns City Council reserve
Period: 2 May 1975–20 January 1994

Co-ordinates: 145° 39.43'E, 16° 48.20'S
Description: Bureau of Meteorology station, Saddle Mountain
Period: 21 January 1994–30 April 1997

Recording intervals
Two, twenty minute records daily at 0300 and 1500 hours between 2 May 1975 and 17 March 1981.

Four, twenty minute records daily at 0300, 0900, 1500 and 2100 hours between 18 March 1981 and 20 January 1994.

Commencing on 21 January 1994, one hourly records, each of approximately 26 minutes were taken, giving 4096 water surface elevation measurements for that period. Sea state parameters are calculated and recorded from this data.

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

Data collection and analysis

Number of records collected	50 096.00
Number of records used in analysis	50 091.00
Number of days in recording period	8 218.00
Number of days used in analysis	6 728.29
Number of days lost	1 489.71

Appendix 2
Major meteorological events

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)
Cyclone Alan	994	1/02/1976	120 NNE	1.54	3.06	4.95
Cyclone Watorea	#	25/04/1976 to 29/04/1976	#	#	#	#
Cyclone Keith	993	31/01/1977	50 NE	1.91	3.21	5.44
Cyclone Peter	997	3/01/1979	140 NNW	1.80	3.32	5.30
Cyclone Ruth	#	11/02/1980 to 18/02/1980	#	#	#	#
Cyclone Winifred	#	27/01/1986 to 5/02/1986	#	#	#	#
Cyclone Ivor	996	19/03/1990	520 NE	1.92	3.03	5.19
Cyclone Joy	940	23/12/1990	130 NE	2.24	4.50	6.16
Cyclone Justin	#	7/03/1997 to 24/03/1997	#	#	#	#

# denotes data unavailable.

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.

The events listed in the above table include all events with a recorded Hsig value of 1.5m or greater, which occurred during the recording period of this report. The storm threshold for the Cairns buoy is set at 2m.

Highest Significant Wave Height (Hsig) recorded was 2.24m on 23 December 1990 during the passage of tropical cyclone Joy.

Highest Maximum Wave Height (Hmax) recorded was 4.5m on 23 December 1990 during the passage of tropical cyclone Joy.

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

Appendix 3

Tropical cyclones of the east coast of Queensland

2 May 1975 to 31 October 1997

Cyclone Name	Year	Month
David	1976	1
Alan	1976	1
Beth	1976	2
Colin	1976	2
Dawn-76	1976	3
Watorea	1976	4
June	1977	1
Keith	1977	1
Lily	1977	2
Miles	1977	2
Nancy-77	1977	2
Otto	1977	3
Tom	1977	11
Gwen	1978	2
Hal	1978	4
Peter	1978	1
Greta	1979	1
Gordon	1979	1
Rosa	1979	2
Kerry	1979	2
Stan	1979	4
Paul	1980	1
Ruth	1980	2
Simon	1980	2
Sina	1980	3
Eddie	1981	2
Cliff	1981	2
Freda	1981	2
Abigail	1982	1
Bernie	1982	4
Dominic	1982	4
Claudia	1982	5
Des	1983	1
Elinor	1983	2
Fritz	1983	12
Grace	1984	1
Harvey	1984	2
Ingrid	1984	2
Jim	1984	3
Kathy	1984	3
Lance	1984	4
Monica	1984	12
Nigel	1985	1
Odette	1985	1

Cyclone Name	Year	Month
Pierre	1985	2
Rebecca	1985	2
Tanya	1985	3
Vernon	1986	1
Winifred	1986	1
Alfred	1986	3
Manu	1986	4
Namu	1986	5
Jason	1987	2
Blanch	1987	5
Agi	1988	1
Charlie	1988	2
Delilah	1988	1
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
Ita	1997	2
Justin	1997	3

Table 1
Wave statistics
Wave period/wave height occurrences
All data, all directions

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	85.31	77.34	109.16	51.48	25.02	10.36	1.21	*	359.88
0.20 - 0.39	503.23	489.62	794.44	385.90	68.47	19.05	2.37	0.04	2263.12
0.40 - 0.59	157.60	958.49	458.71	371.81	51.80	8.28	1.46	*	2008.15
0.60 - 0.79	4.13	1031.87	71.53	167.75	30.17	2.58	0.25	*	1308.28
0.80 - 0.99	*	547.73	9.95	28.91	13.77	1.17	0.04	*	601.57
1.00 - 1.19	*	151.70	4.58	1.69	2.08	*	*	*	160.05
1.20 - 1.39	*	16.30	2.29	0.50	0.57	*	*	*	19.66
1.40 - 1.59	*	1.52	1.50	*	0.38	*	*	*	3.40
1.60 - 1.79	*	0.75	1.38	*	0.44	0.12	*	*	2.69
1.80 - 1.99	*	*	0.62	*	*	*	*	*	0.62
2.00 - 2.19	*	*	0.63	*	*	*	*	*	0.63
2.20 - 2.39	*	*	0.25	*	*	*	*	*	0.25
2.40 - 2.59	*	*	*	*	*	*	*	*	0.00
Totals	750.27	3275.32	1455.04	1008.04	192.70	41.56	5.33	0.04	6728.30

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

Table 2
Wave statistics
Wave period/wave height occurrences
Summer data, all directions

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	69.82	62.38	87.89	32.35	19.43	9.99	1.21	*	283.07
0.20 - 0.39	357.74	344.34	382.94	135.93	45.59	16.62	2.33	*	1285.49
0.40 - 0.59	105.73	532.89	168.42	77.69	24.77	7.51	1.46	*	918.47
0.60 - 0.79	3.29	470.98	26.59	28.06	8.04	2.42	0.25	*	539.63
0.80 - 0.99	*	208.95	5.92	4.96	1.68	1.08	*	*	222.59
1.00 - 1.19	*	65.32	3.54	1.35	0.71	*	*	*	70.92
1.20 - 1.39	*	9.18	2.29	0.25	0.57	*	*	*	12.29
1.40 - 1.59	*	1.27	1.50	*	0.38	*	*	*	3.15
1.60 - 1.79	*	0.75	1.38	*	0.44	0.12	*	*	2.69
1.80 - 1.99	*	*	0.62	*	*	*	*	*	0.62
2.00 - 2.19	*	*	0.63	*	*	*	*	*	0.63
2.20 - 2.39	*	*	0.25	*	*	*	*	*	0.25
2.40 - 2.59	*	*	*	*	*	*	*	*	0.00
Totals	536.58	1696.06	681.97	280.59	101.61	37.74	5.25	0.00	3339.80

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

Table 3
Wave statistics
Wave period/wave height occurrences
Winter data, all directions

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	15.48	14.96	21.27	19.13	5.59	0.37	*	*	76.80
0.20 - 0.39	145.48	145.28	411.50	249.96	22.88	2.43	0.04	0.04	977.61
0.40 - 0.59	51.87	425.61	290.29	294.12	27.03	0.77	*	*	1089.69
0.60 - 0.79	0.83	560.89	44.94	139.69	22.13	0.17	*	*	768.65
0.80 - 0.99	*	338.78	4.04	23.95	12.09	0.08	0.04	*	378.98
1.00 - 1.19	*	86.38	1.04	0.33	1.37	*	*	*	89.12
1.20 - 1.39	*	7.11	*	0.25	*	*	*	*	7.36
1.40 - 1.59	*	0.25	*	*	*	*	*	*	0.25
1.60 - 1.79	*	*	*	*	*	*	*	*	0.00
1.80 - 1.99	*	*	*	*	*	*	*	*	0.00
2.00 - 2.19	*	*	*	*	*	*	*	*	0.00
2.20 - 2.39	*	*	*	*	*	*	*	*	0.00
2.40 - 2.59	*	*	*	*	*	*	*	*	0.00
Totals	213.66	1579.26	773.08	727.43	91.09	3.82	0.08	0.04	3388.46

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

Table 4
Wave statistics
Wave period/wave height occurrences
All data, all directions

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	1.27	1.15	1.62	0.77	0.37	0.15	0.02	*	5.35
0.20 - 0.39	7.48	7.28	11.81	5.74	1.02	0.28	0.04	*	33.65
0.40 - 0.59	2.34	14.25	6.82	5.53	0.77	0.12	0.02	*	29.85
0.60 - 0.79	0.06	15.34	1.06	2.49	0.45	0.04	*	*	19.44
0.80 - 0.99	*	8.14	0.15	0.43	0.20	0.02	*	*	8.94
1.00 - 1.19	*	2.25	0.07	0.03	0.03	*	*	*	2.38
1.20 - 1.39	*	0.24	0.03	0.01	0.01	*	*	*	0.29
1.40 - 1.59	*	0.02	0.02	*	0.01	*	*	*	0.05
1.60 - 1.79	*	0.01	0.02	*	0.01	*	*	*	0.04
1.80 - 1.99	*	*	0.01	*	*	*	*	*	0.01
2.00 - 2.19	*	*	0.01	*	*	*	*	*	0.01
2.20 - 2.39	*	*	*	*	*	*	*	*	0.00
2.40 - 2.59	*	*	*	*	*	*	*	*	0.00
Totals	11.15	48.68	21.62	15.00	2.87	0.61	0.08	0.00	100.00

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

Table 5
Wave statistics
Wave period/wave height occurrences
Summer data, all directions

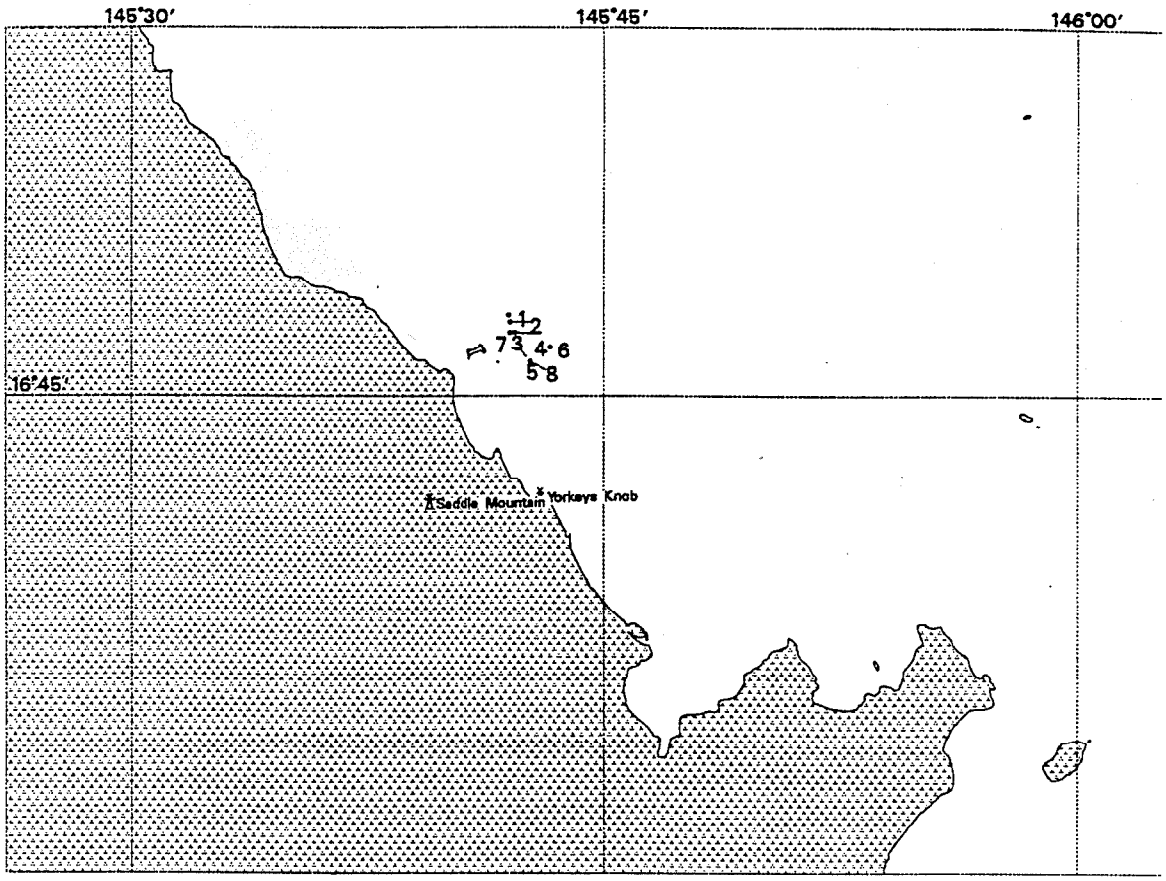
Significant wave height (Hsig) (metres)	Peak energy wave period (Tp) (seconds)								
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	Totals
0.00 - 0.19	2.09	1.87	2.63	0.97	0.58	0.30	0.04	*	8.48
0.20 - 0.39	10.71	10.31	11.47	4.07	1.37	0.50	0.07	*	38.50
0.40 - 0.59	3.17	15.96	5.04	2.33	0.74	0.22	0.04	*	27.50
0.60 - 0.79	0.10	14.10	0.80	0.84	0.24	0.07	0.01	*	16.16
0.80 - 0.99	*	6.26	0.18	0.15	0.05	0.03	*	*	6.67
1.00 - 1.19	*	1.96	0.11	0.04	0.02	*	*	*	2.13
1.20 - 1.39	*	0.27	0.07	0.01	0.02	*	*	*	0.37
1.40 - 1.59	*	0.04	0.04	*	0.01	*	*	*	0.09
1.60 - 1.79	*	0.02	0.04	*	0.01	*	*	*	0.07
1.80 - 1.99	*	*	0.02	*	*	*	*	*	0.02
2.00 - 2.19	*	*	0.02	*	*	*	*	*	0.02
2.20 - 2.39	*	*	0.01	*	*	*	*	*	0.01
2.40 - 2.59	*	*	*	*	*	*	*	*	0.00
Totals	16.07	50.79	20.43	8.41	3.04	1.12	0.16	0.00	100.00

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

Table 6
Wave statistics
Wave period/wave height occurrences
Winter data, all directions

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	0.44	0.63	0.56	0.17	0.01	*	*	2.27
0.20 - 0.39	4.29	4.29	12.14	7.38	0.68	0.07	*	*	28.85
0.40 - 0.59	1.53	12.56	8.57	8.68	0.80	0.02	*	*	32.16
0.60 - 0.79	0.02	16.55	1.33	4.12	0.65	*	*	*	22.67
0.80 - 0.99	*	10.00	0.12	0.71	0.36	*	*	*	11.19
1.00 - 1.19	*	2.55	0.03	0.01	0.04	*	*	*	2.63
1.20 - 1.39	*	0.21	*	0.01	*	*	*	*	0.22
1.40 - 1.59	*	0.01	*	*	*	*	*	*	0.01
1.60 - 1.79	*	*	*	*	*	*	*	*	0.00
1.80 - 1.99	*	*	*	*	*	*	*	*	0.00
2.00 - 2.19	*	*	*	*	*	*	*	*	0.00
2.20 - 2.39	*	*	*	*	*	*	*	*	0.00
2.40 - 2.59	*	*	*	*	*	*	*	*	0.00
Totals	6.30	46.61	22.82	21.47	2.70	0.10	0.00	0.00	100.00

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



Waverider buoy sites	
1.	02-05-1975 to 27-10-1985
2.	28-10-1985 to 13-11-1987
3.	14-11-1987 to 18-08-1988
4.	19-08-1988 to 19-07-1991
5.	20-07-1991 to 01-02-1993
6.	02-02-1993 to 18-01-1994
7.	19-01-1994 to 30-01-1995
8.	31-01-1995 to 31-10-1997

- Waverider buoys
- Recording stations

1:400000

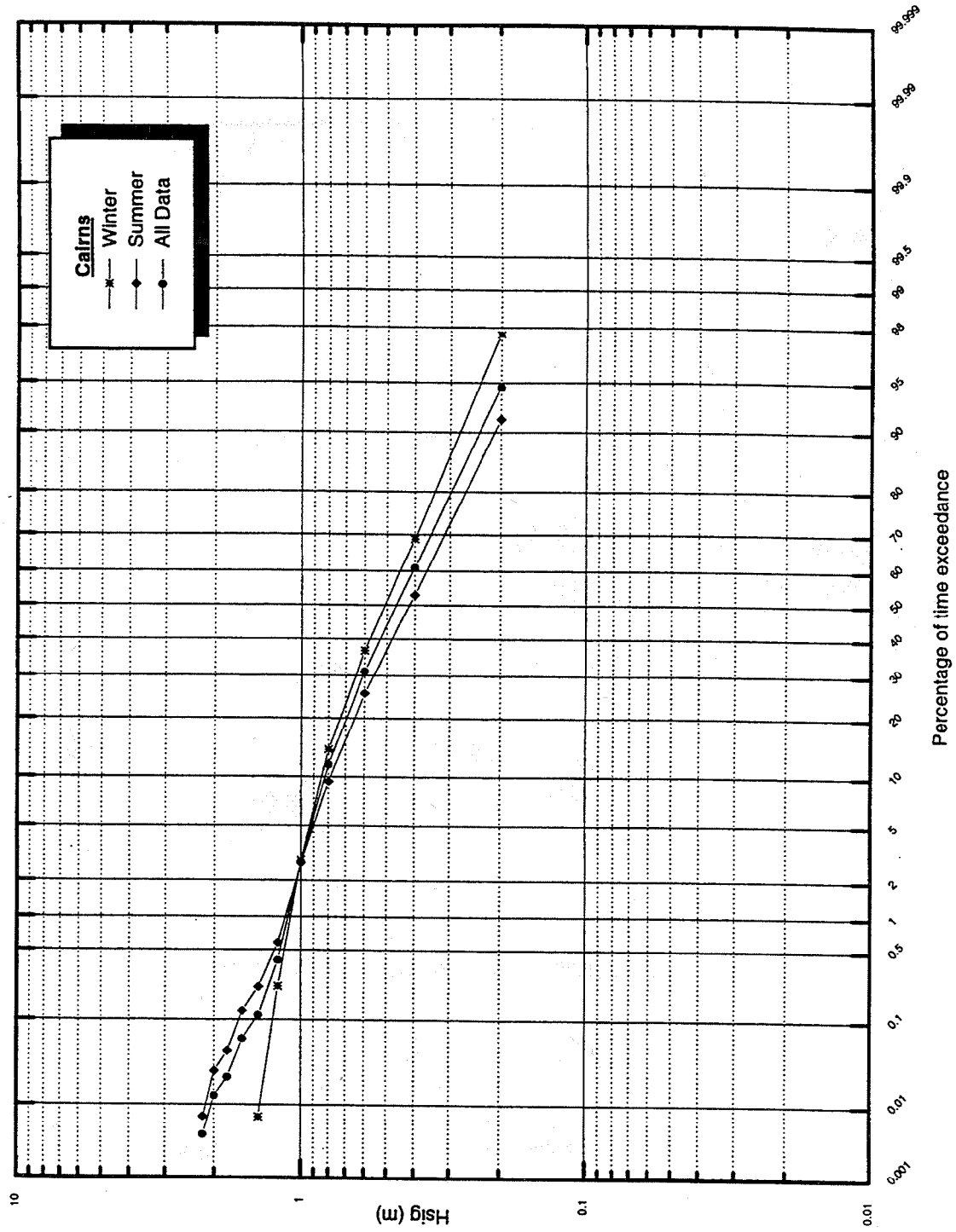
0 4 8 12 16 20
kilometres

Locality Plan

Beach Protection Authority Queensland
Department of Environment and Heritage

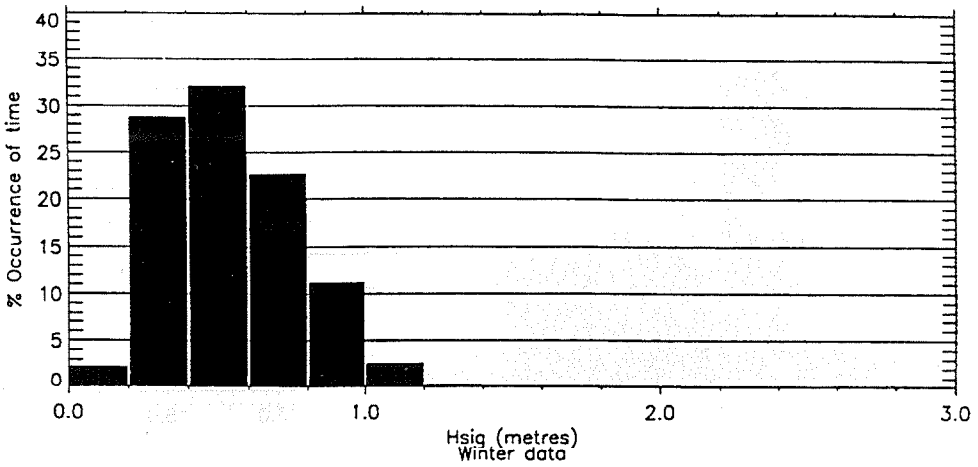
Wave data recording program
Cairns Region

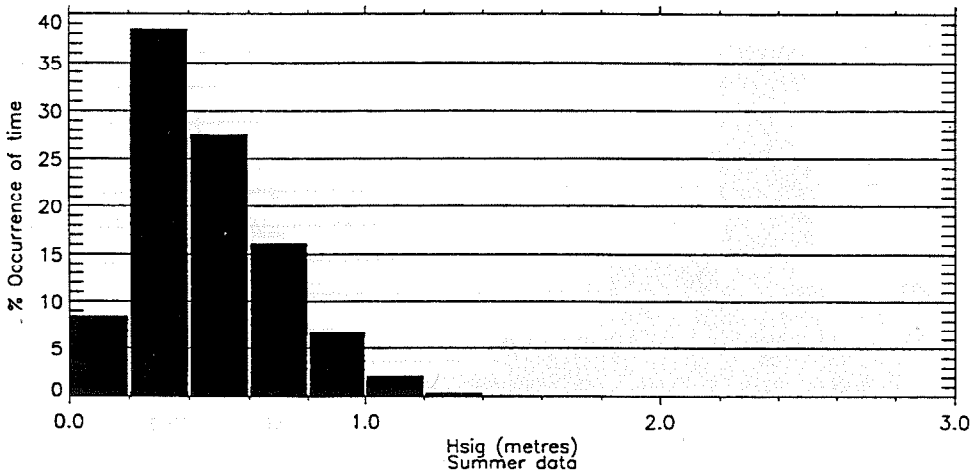
Figure 1

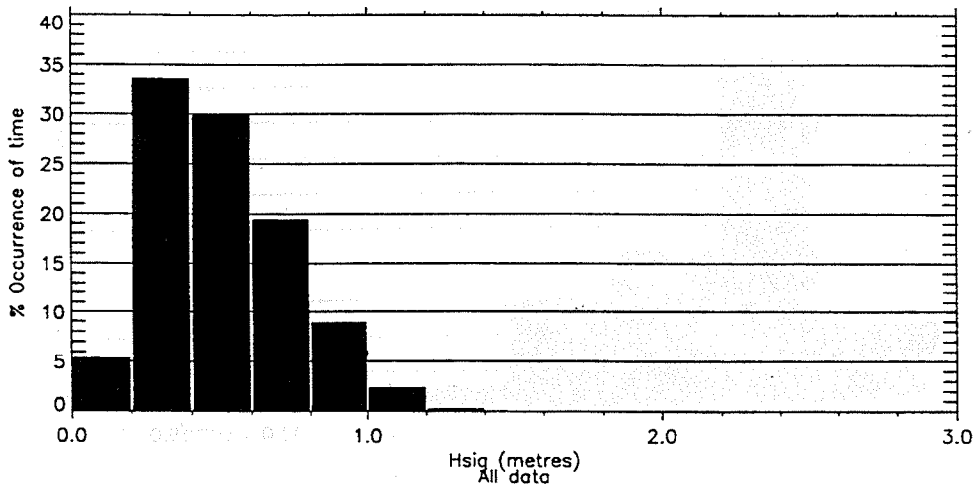


Percentage (of time) exceedance of wave heights (Hsig) for all periods
2 May 1975 to 31 October 1997

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Cairns Region	**Figure 2**

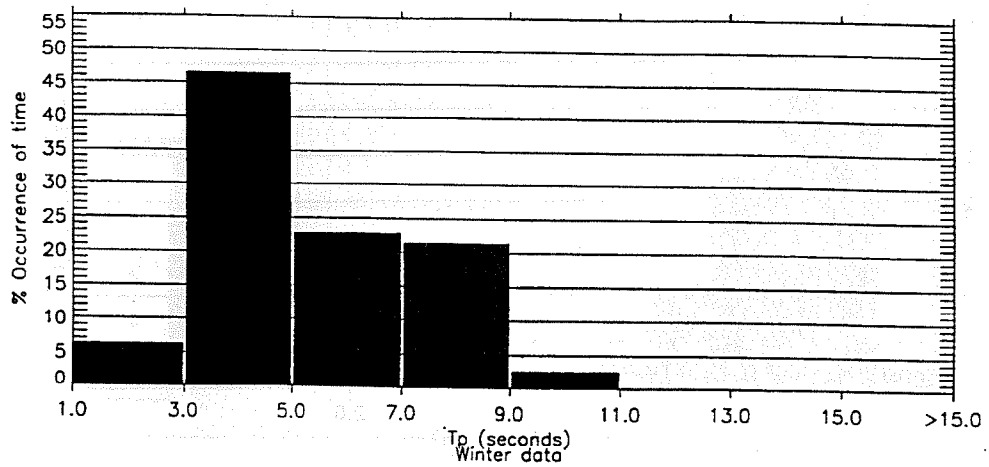


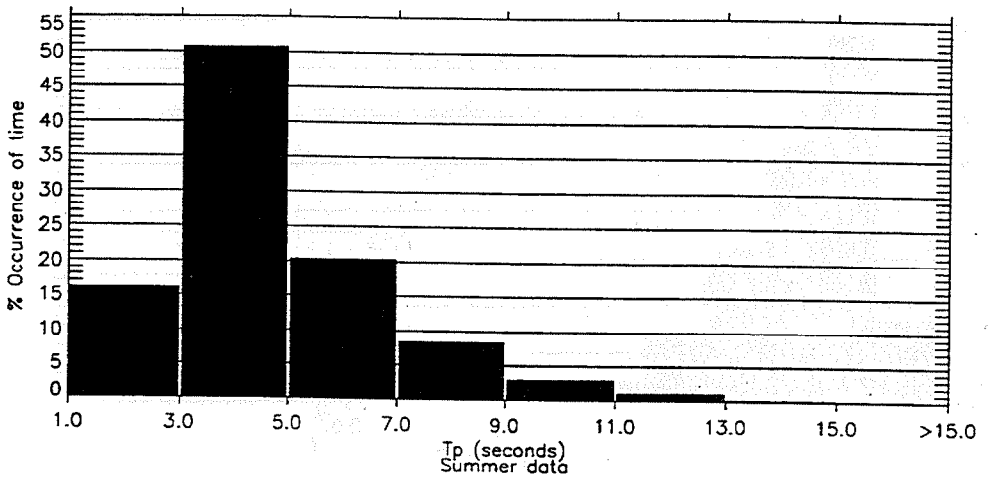


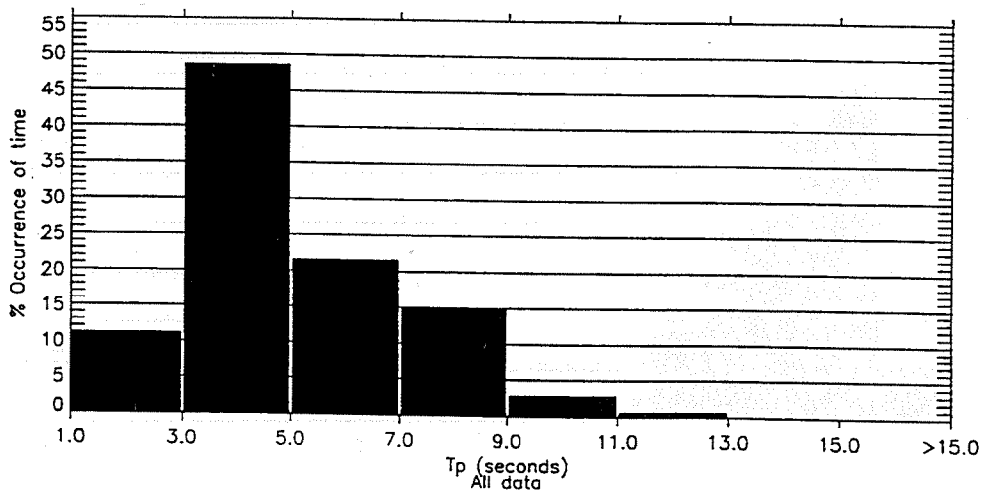


Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Cairns Region	**Figure 3**

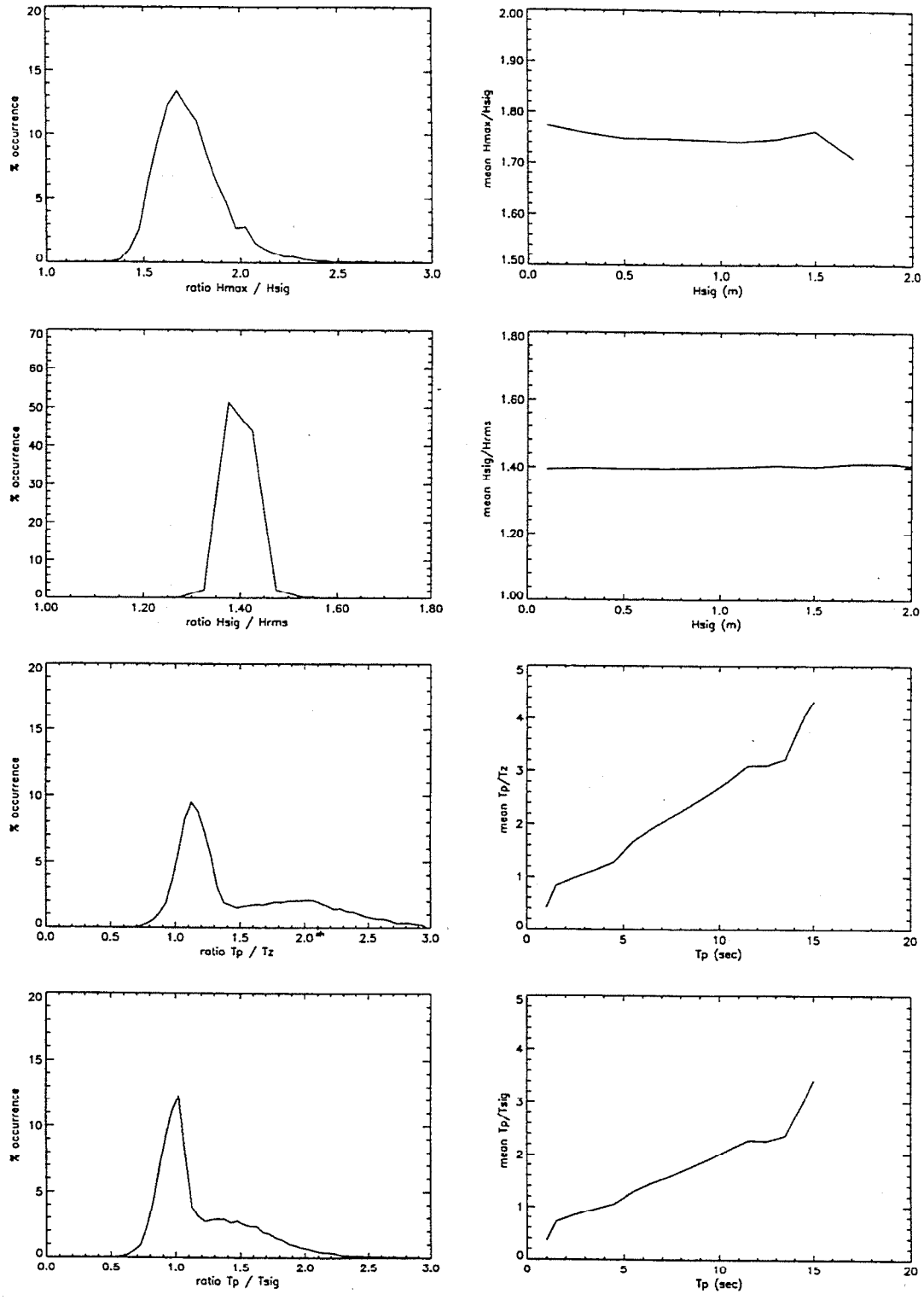






Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Cairns Region	**Figure 4**

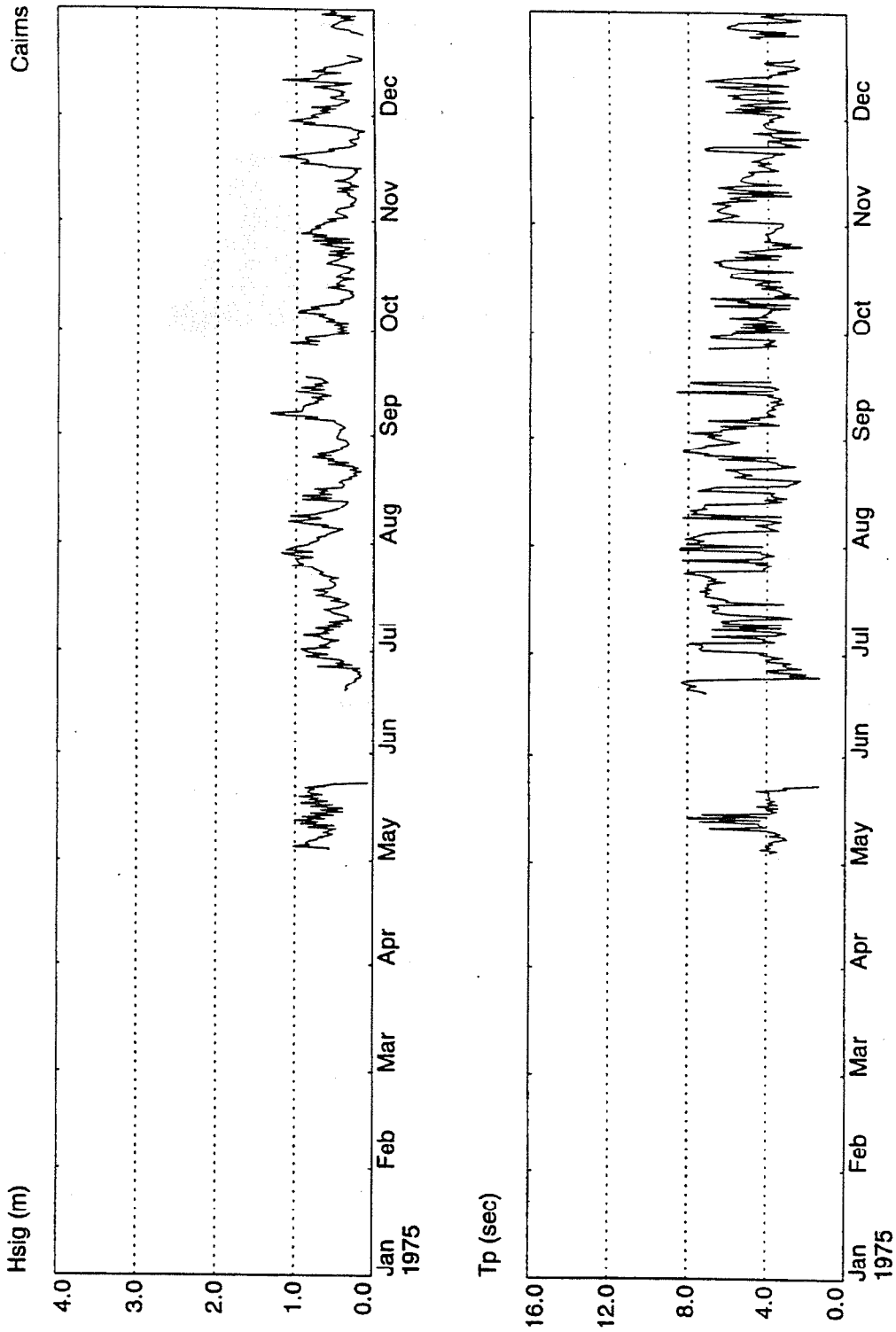


Wave parameter relationships
2 May 1975 to 31 October 1997

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 5

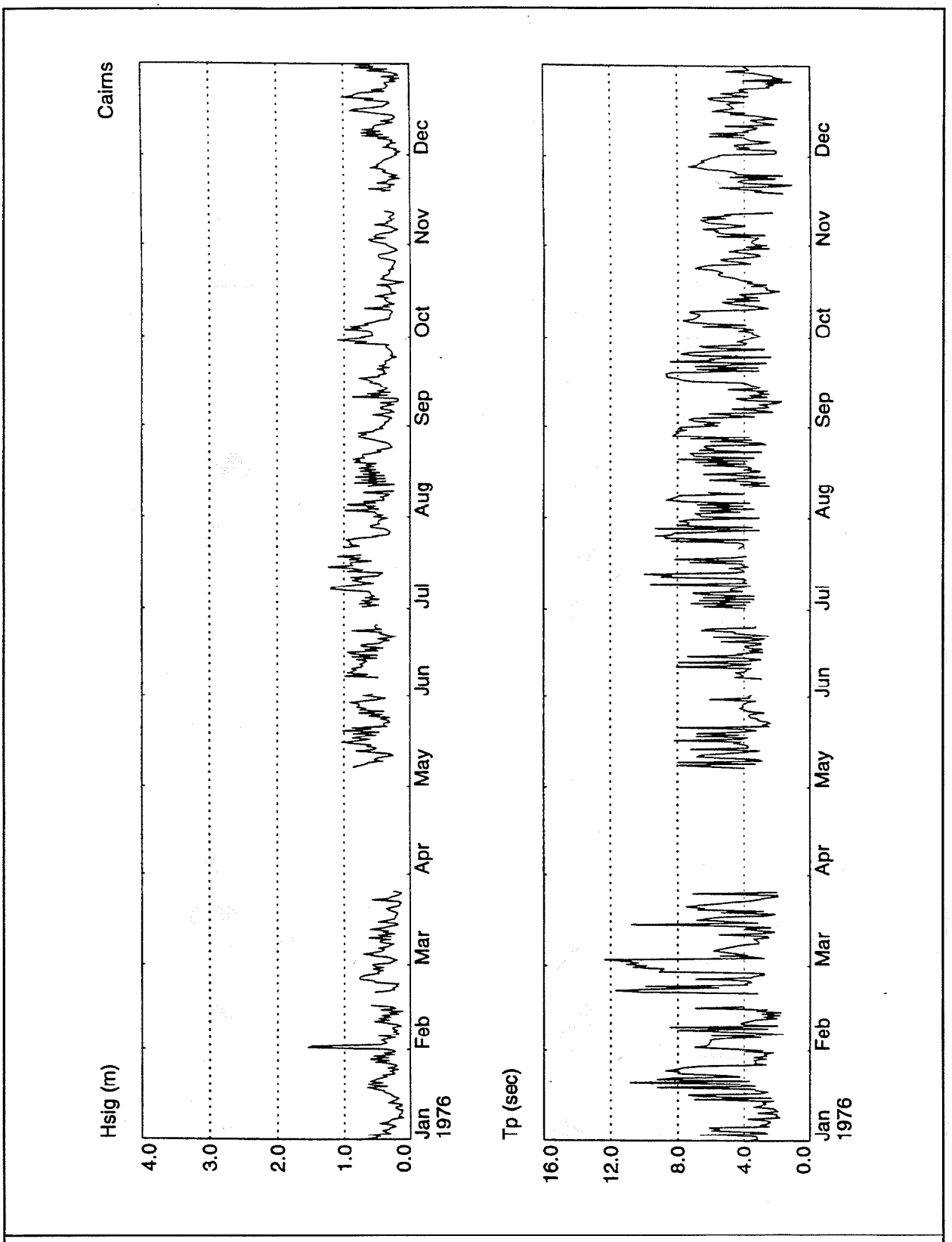


Daily wave recordings
2 May 1975 to 31 December 1975

Beach Protection Authority Queensland
Department of Environment and Heritage

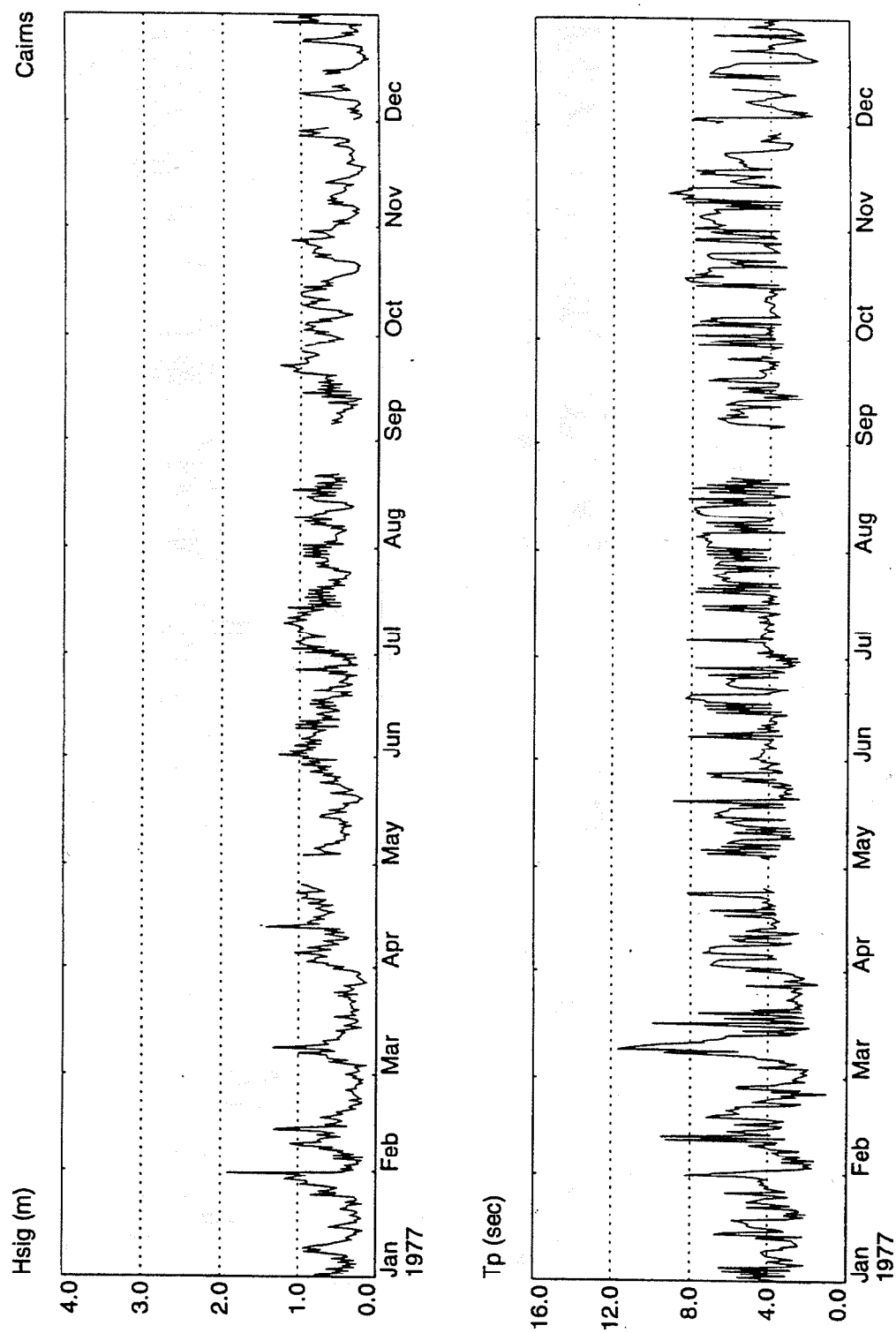
Wave data recording program
Cairns Region

Figure 6.01



Daily wave recordings
1 January 1976 to 31 December 1976

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Cairns Region	**Figure 6.02**

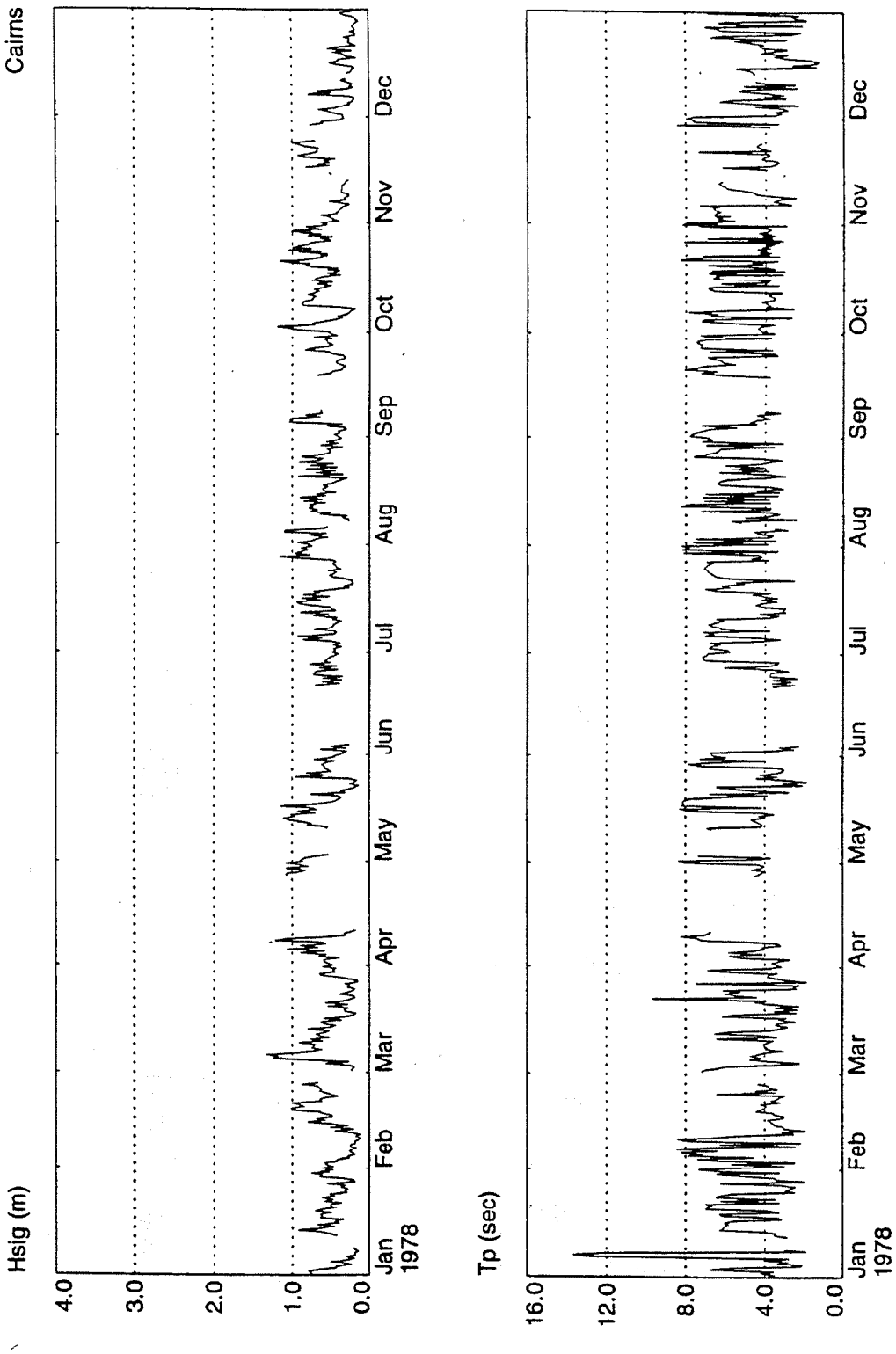


Daily wave recordings
1 January 1977 to 31 December 1977

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 6.03

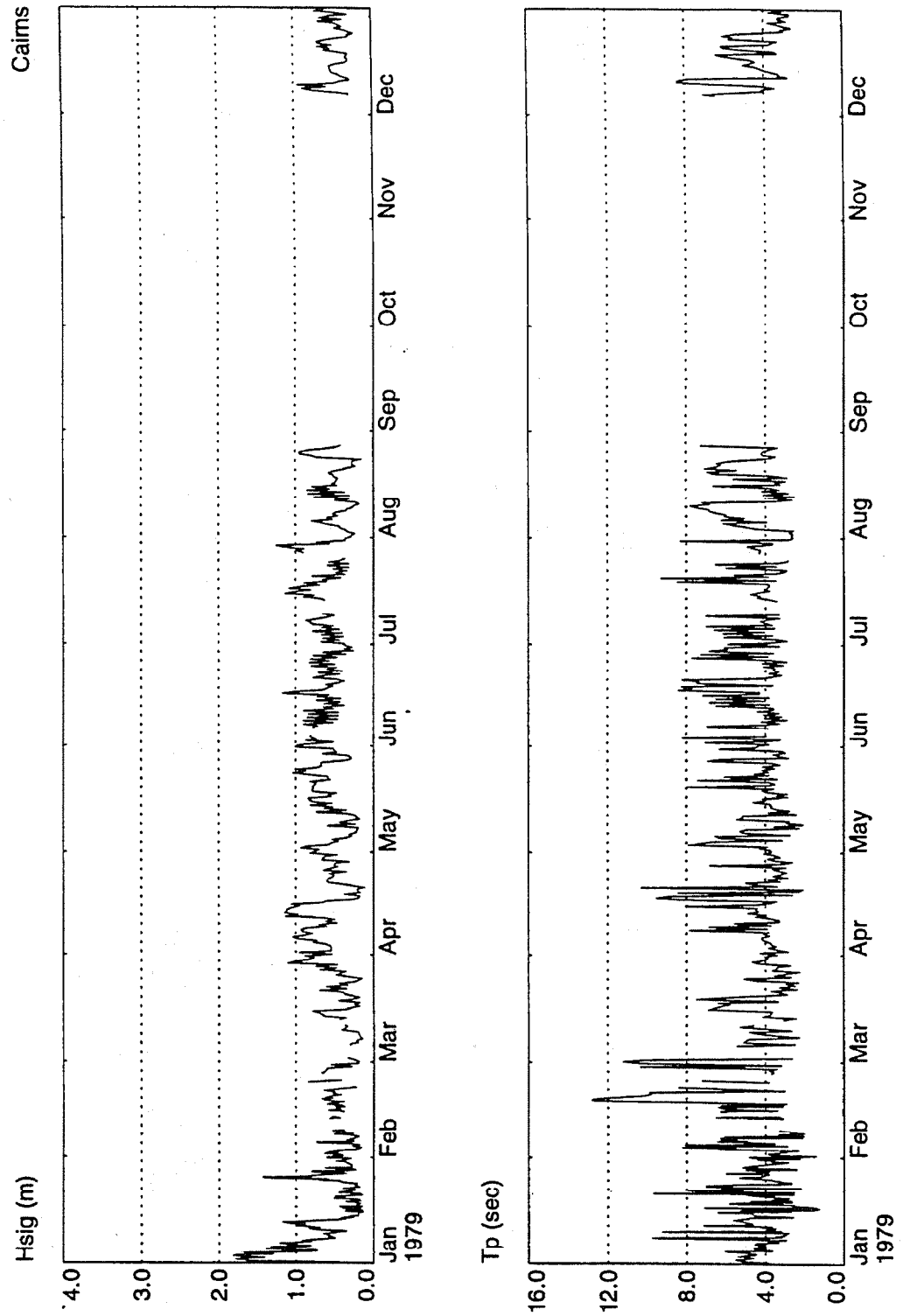


Daily wave recordings
1 January 1978 to 31 December 1978

Beach Protection Authority Queensland
Department of Environment and Heritage

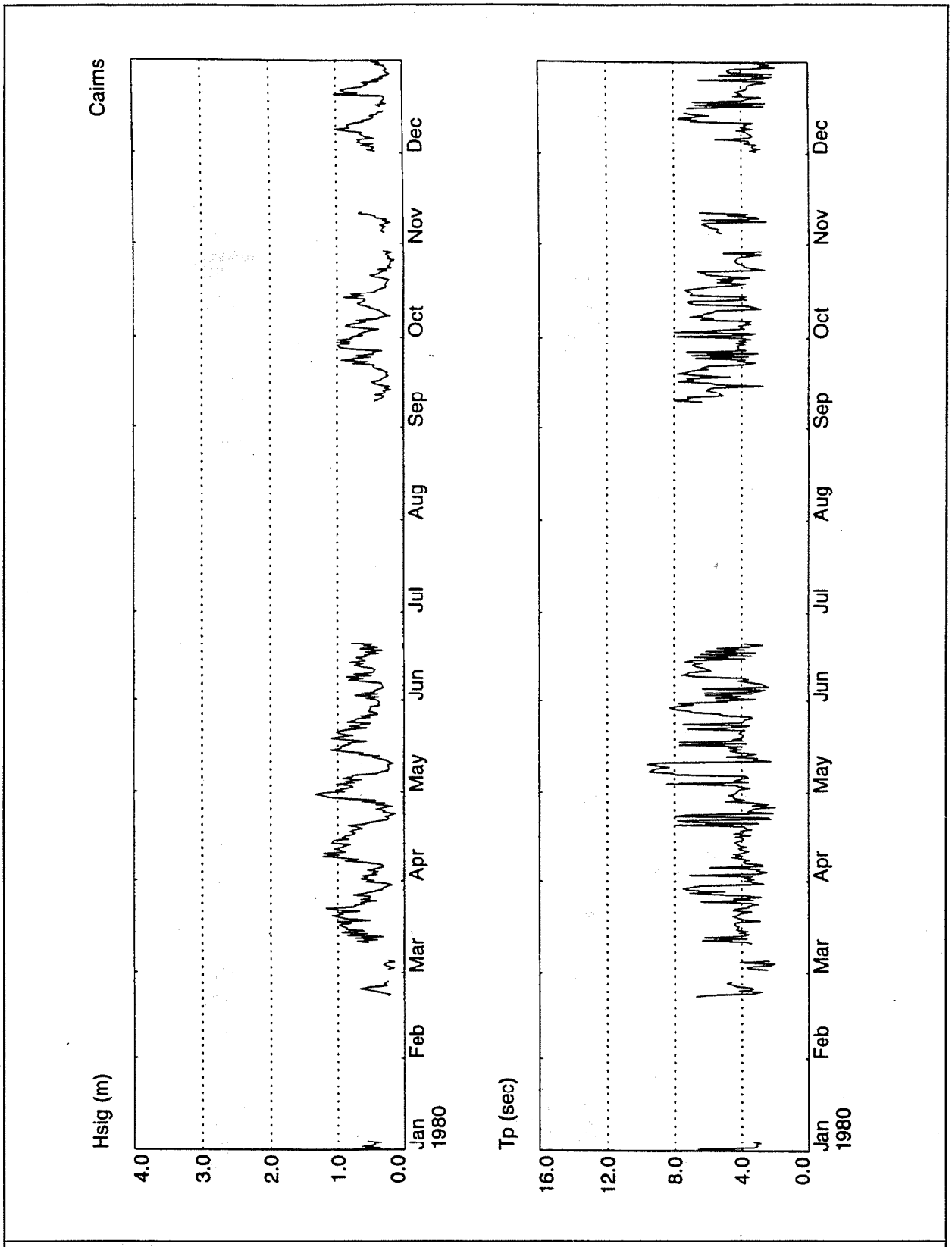
Wave data recording program
Cairns Region

Figure 6.04



Daily wave recordings
1 January 1979 to 31 December 1979

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Cairns Region	**Figure 6.05**

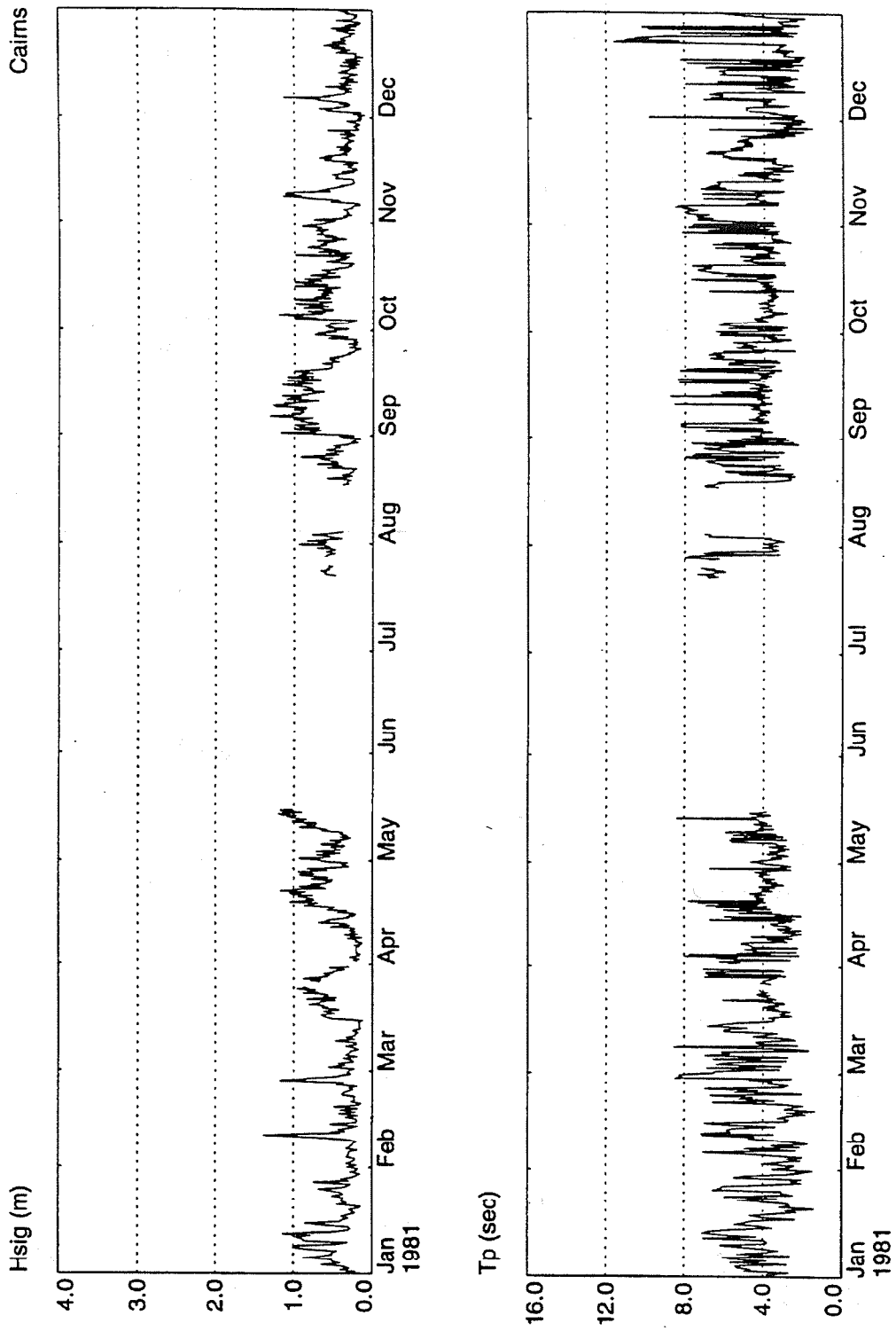


Daily wave recordings
1 January 1980 to 31 December 1980

Beach Protection Authority Queensland
Department of Environment and Heritage

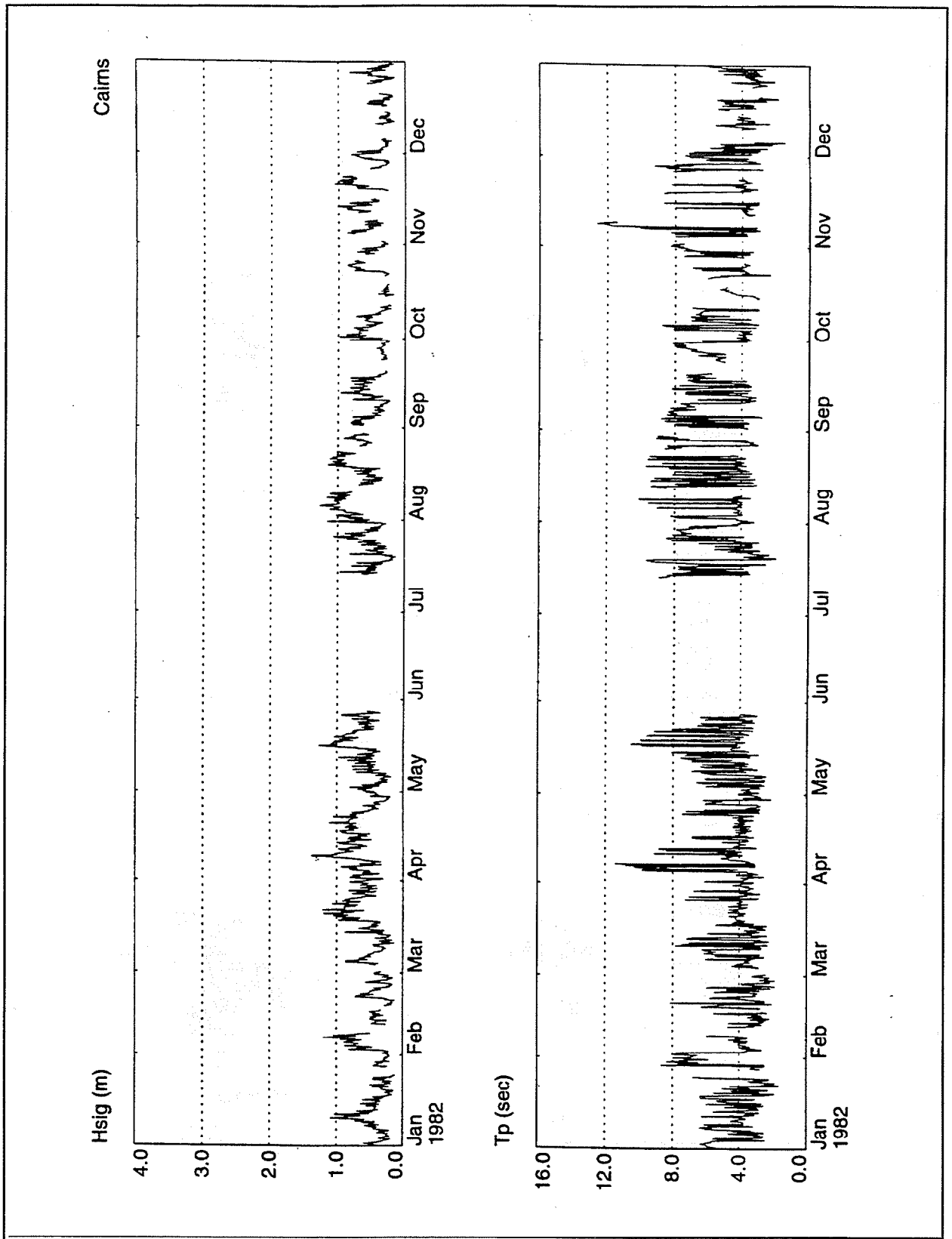
Wave data recording program
Cairns Region

Figure 6.06



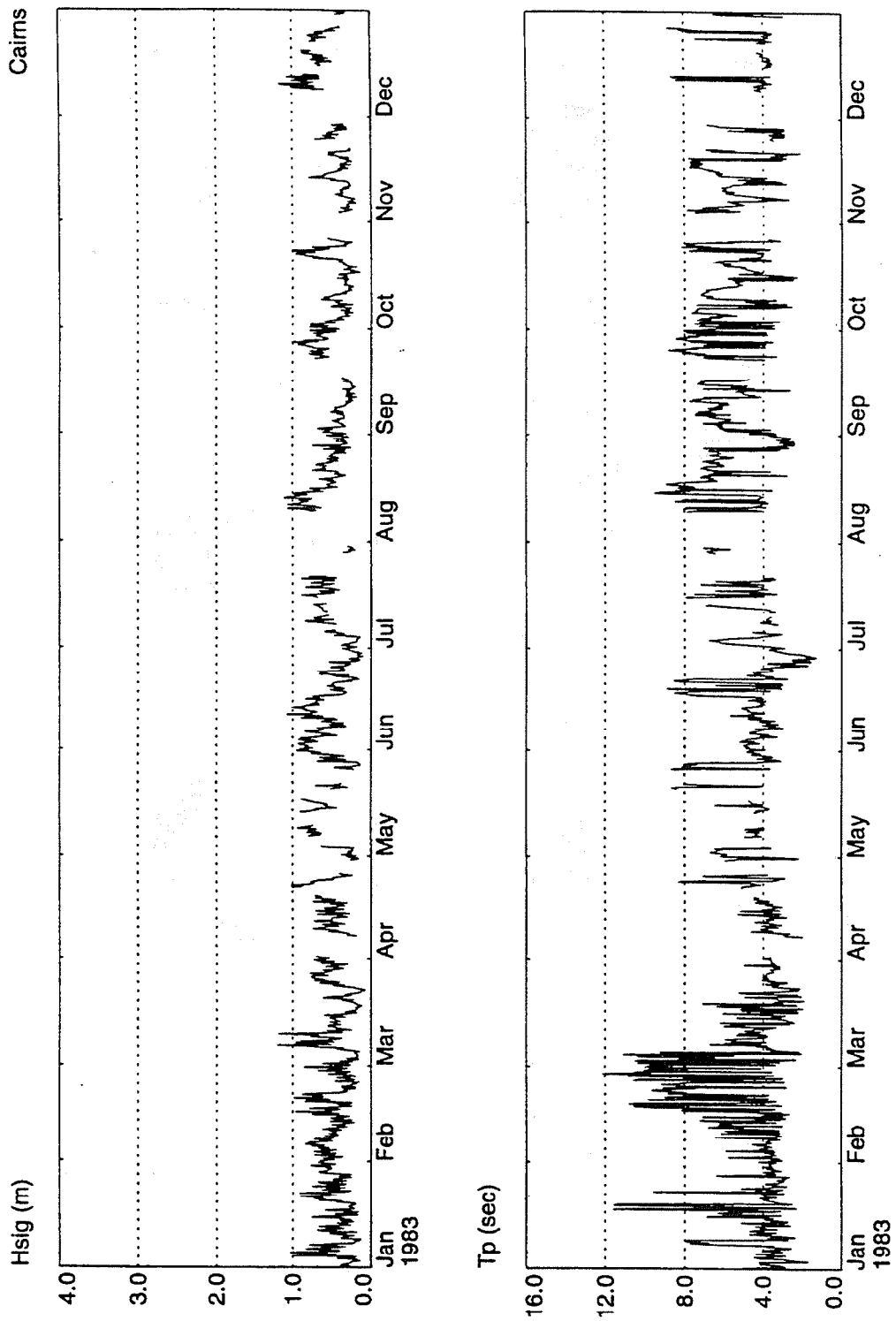
Daily wave recordings
1 January 1981 to 31 December 1981

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Cairns Region	**Figure 6.07**



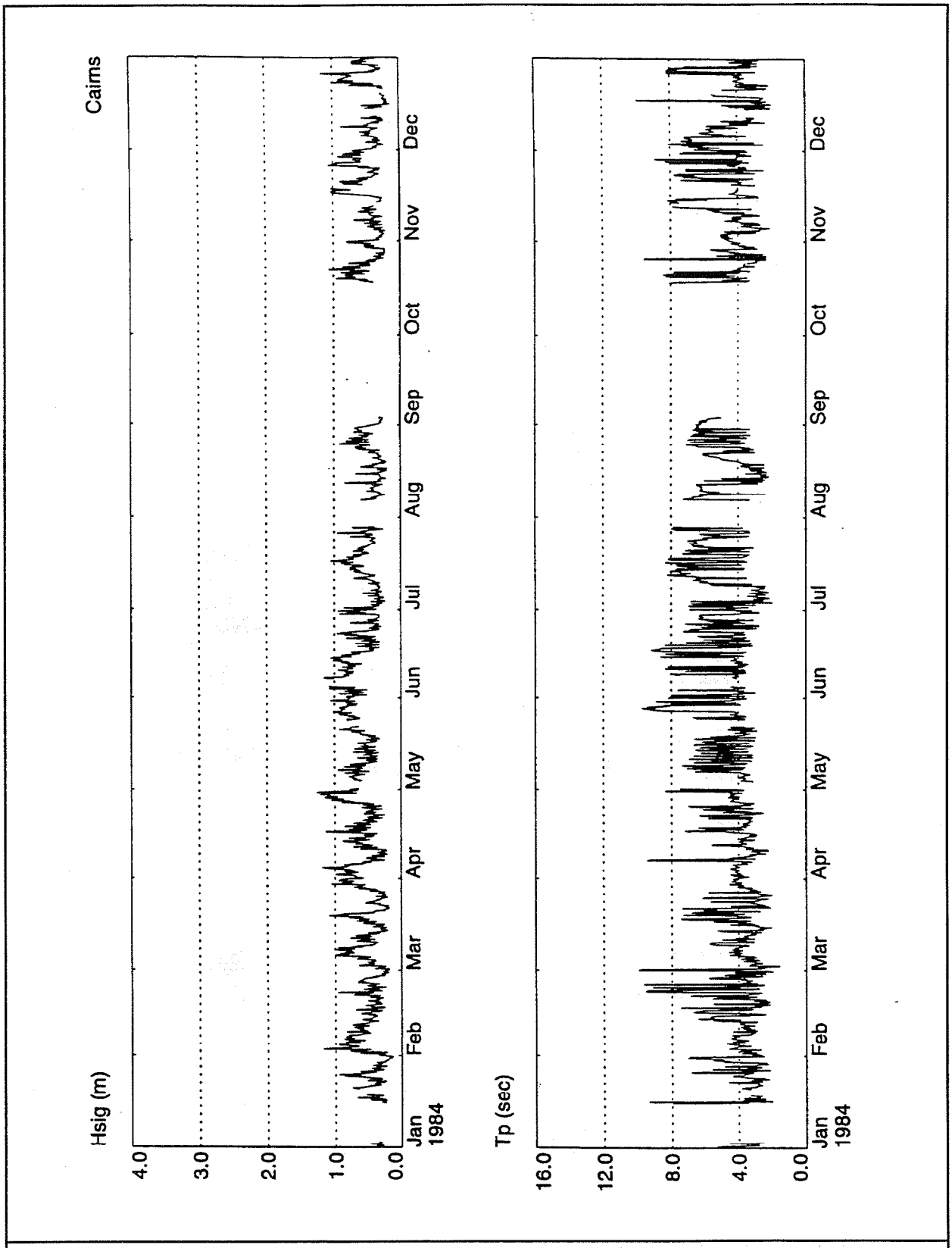
Daily wave recordings
1 January 1982 to 31 December 1982

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Cairns Region	**Figure 6.08**



Daily wave recordings
1 January 1983 to 31 December 1983

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Cairns Region	**Figure 6.09**

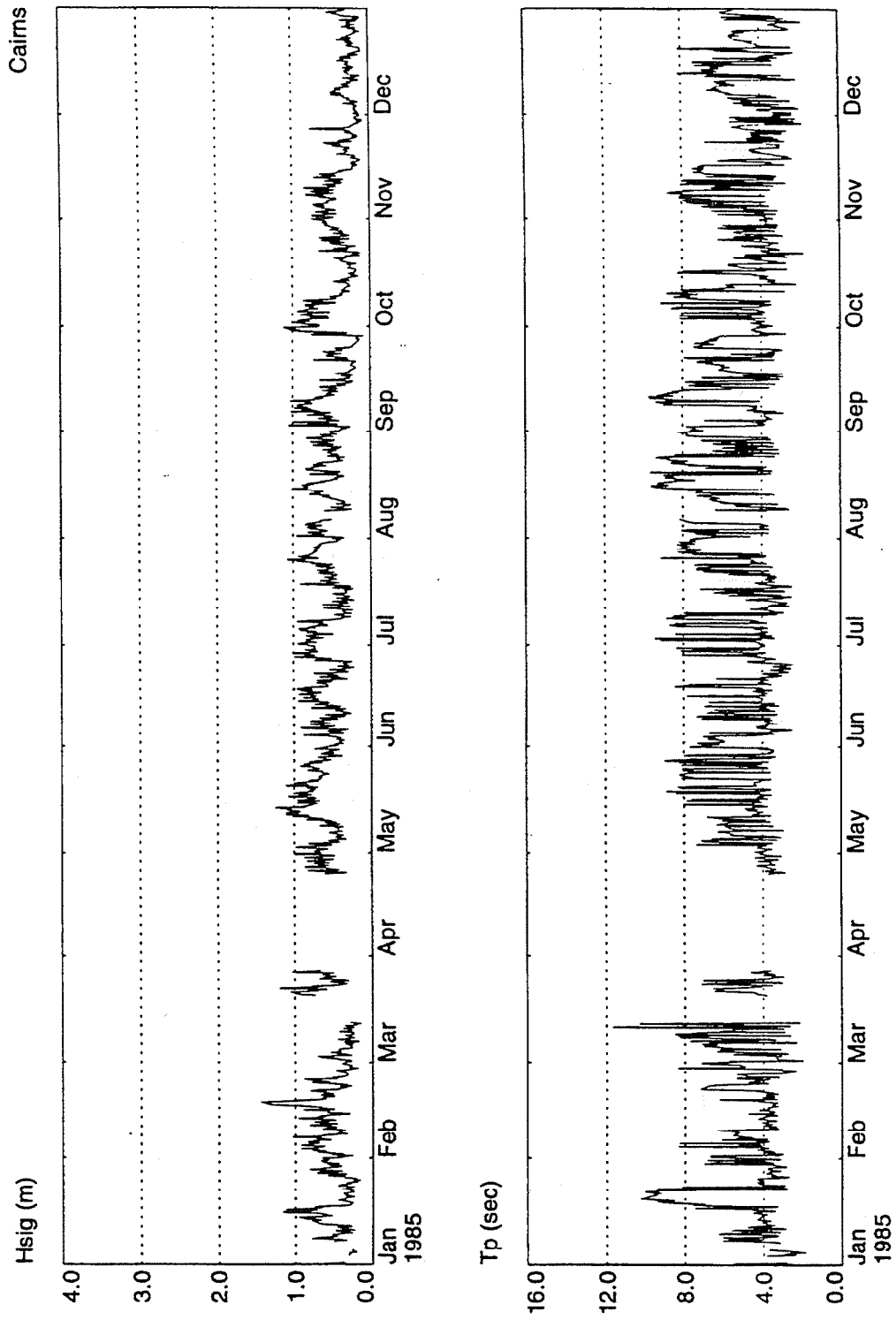


Daily wave recordings
1 January 1984 to 31 December 1984

Beach Protection Authority Queensland
Department of Environment and Heritage

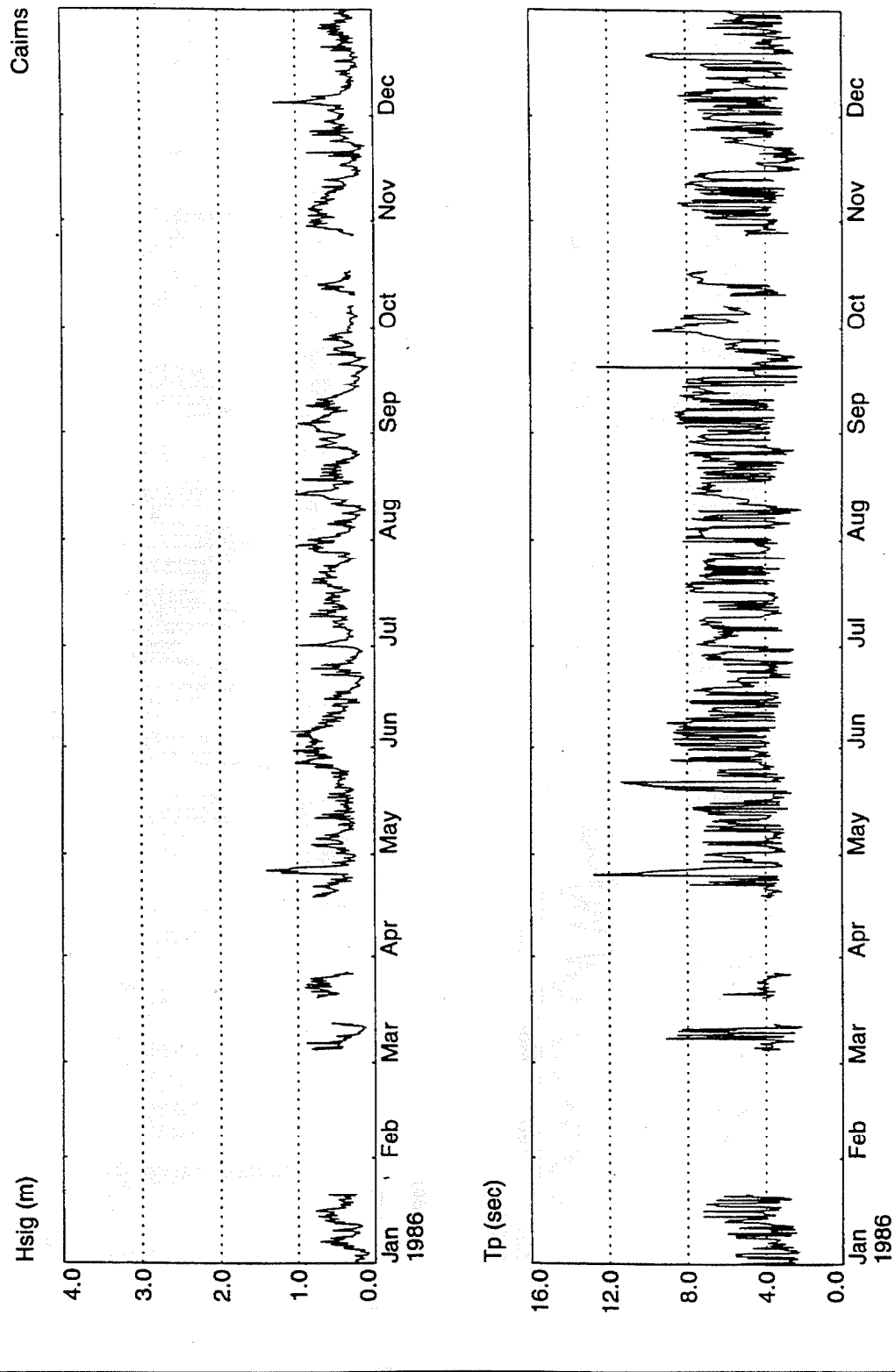
Wave data recording program
Cairns Region

Figure 6.10



Daily wave recordings
1 January 1985 to 31 December 1985

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Cairns Region	**Figure 6.11**

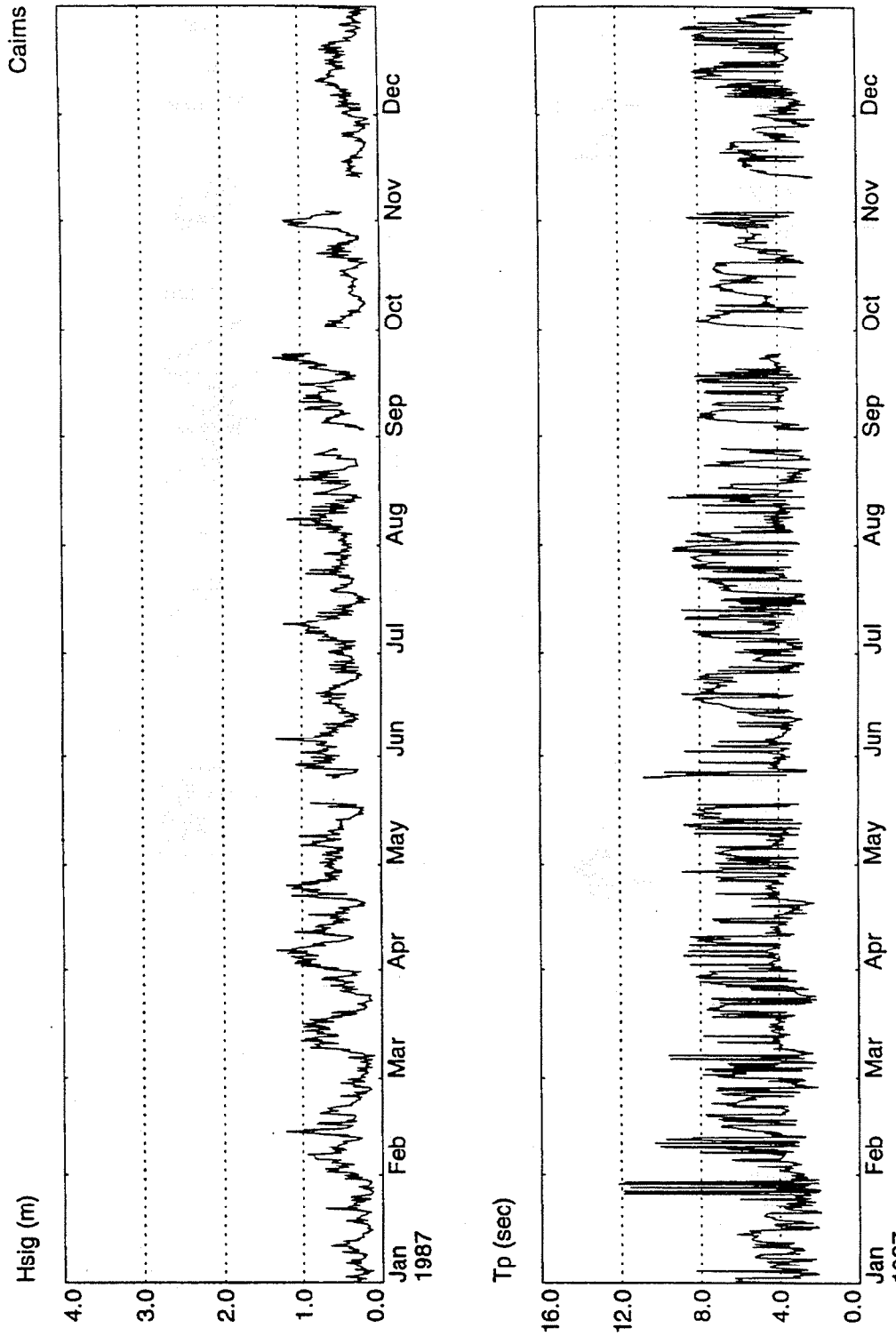


Daily wave recordings
1 January 1986 to 31 December 1986

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 6.12

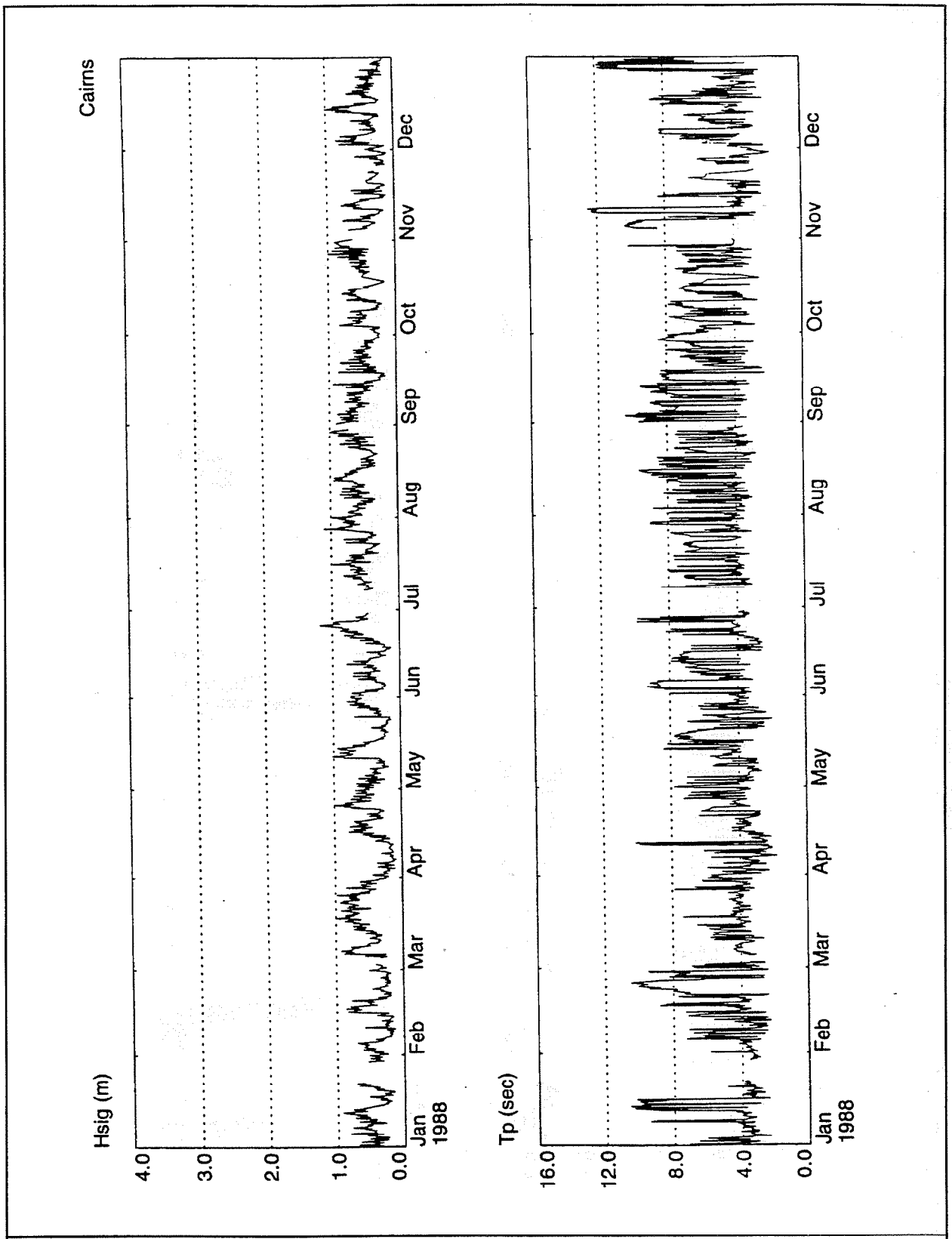


Daily wave recordings
1 January 1987 to 31 December 1987

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 6.13

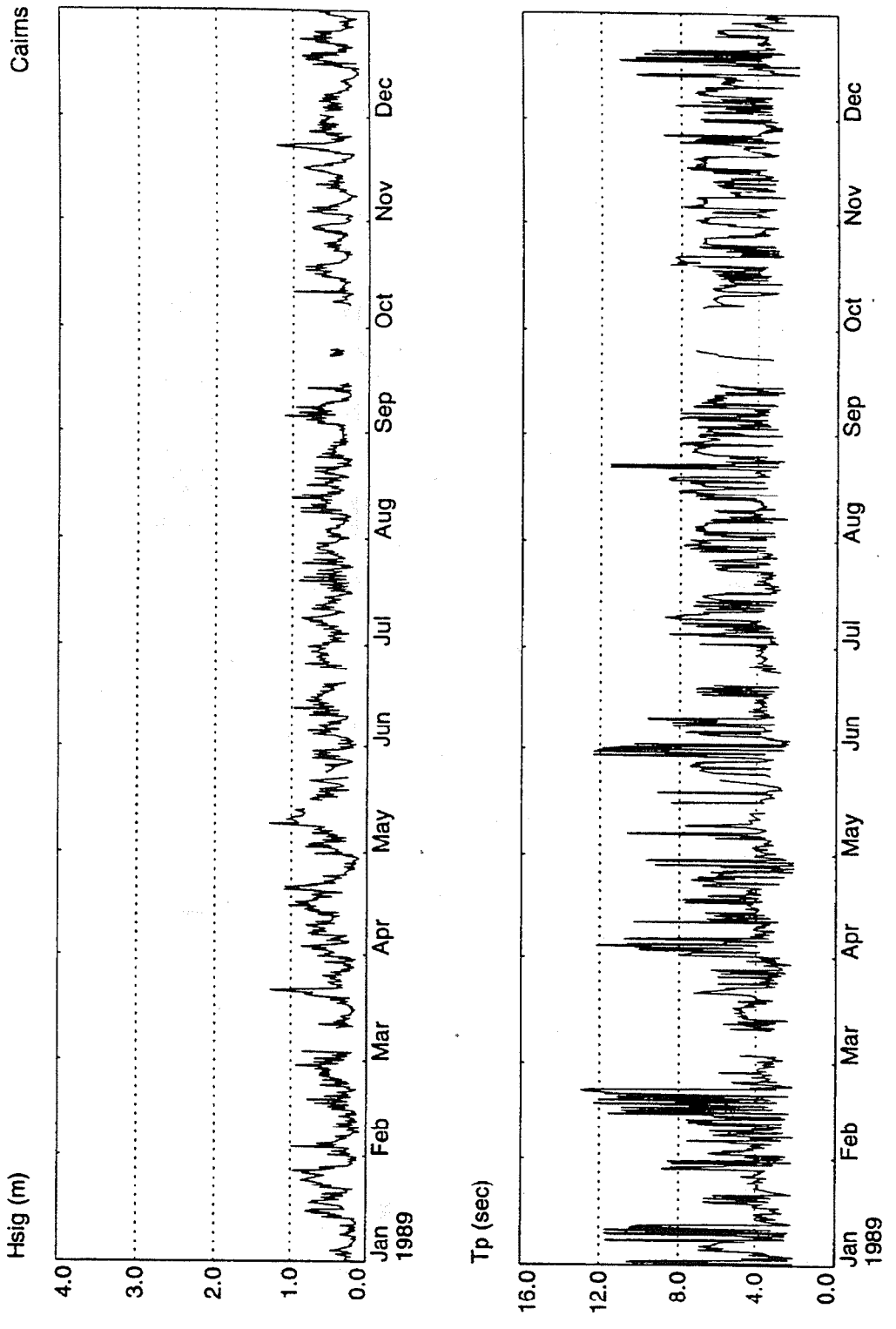


Daily wave recordings
1 January 1988 to 31 December 1988

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 6.14

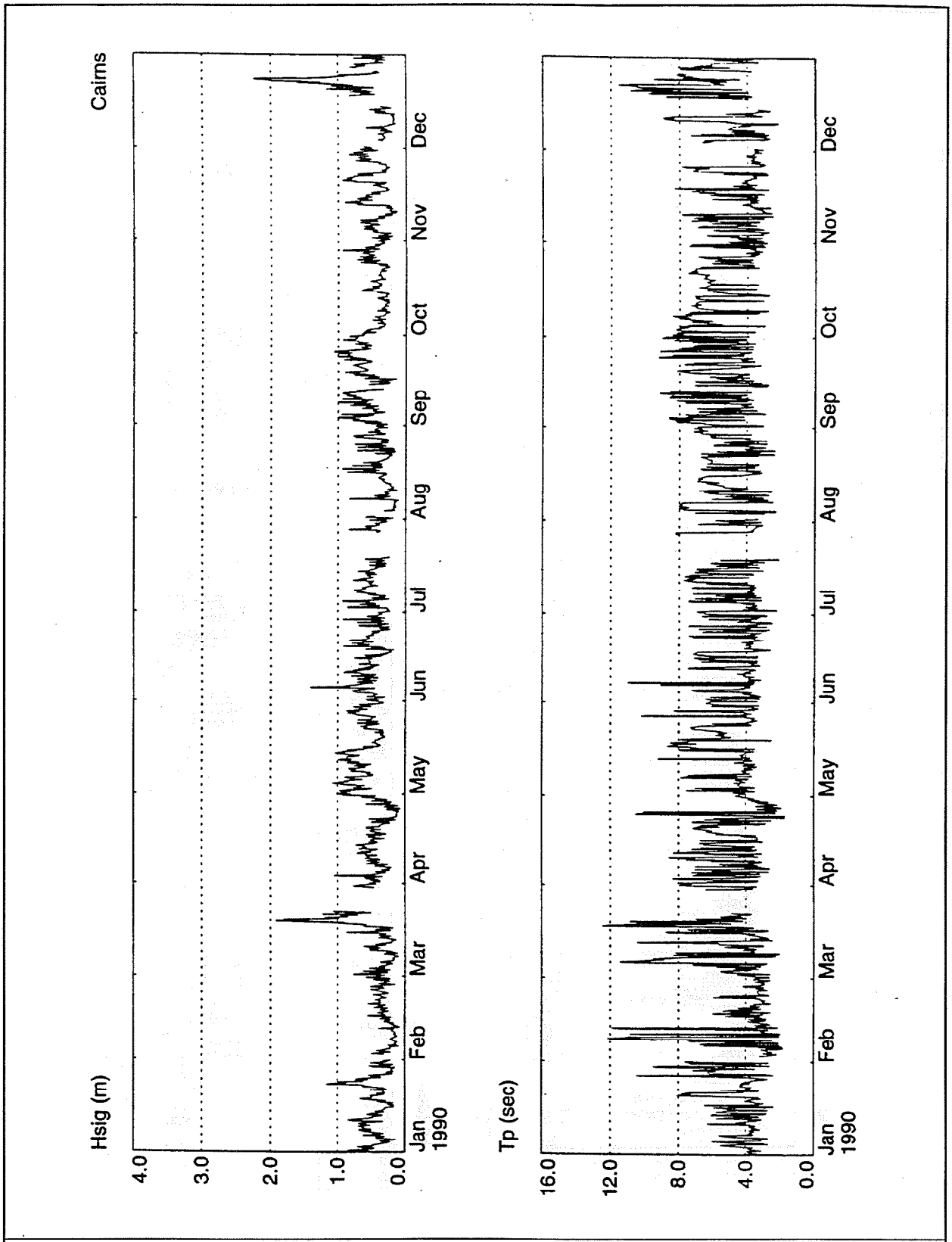


Daily wave recordings
1 January 1989 to 31 December 1989

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 6.15

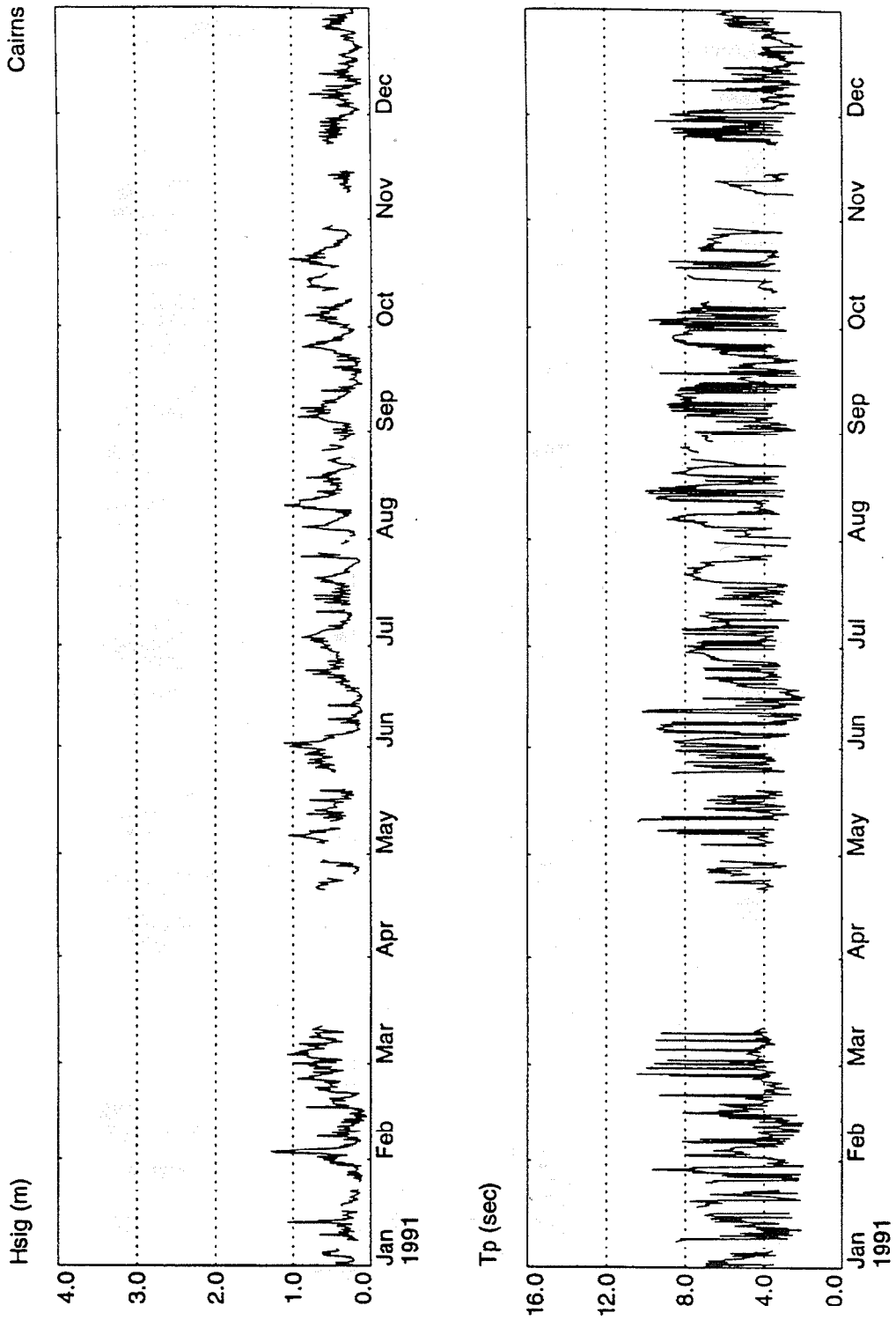


Daily wave recordings
1 January 1990 to 31 December 1990

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 6.16

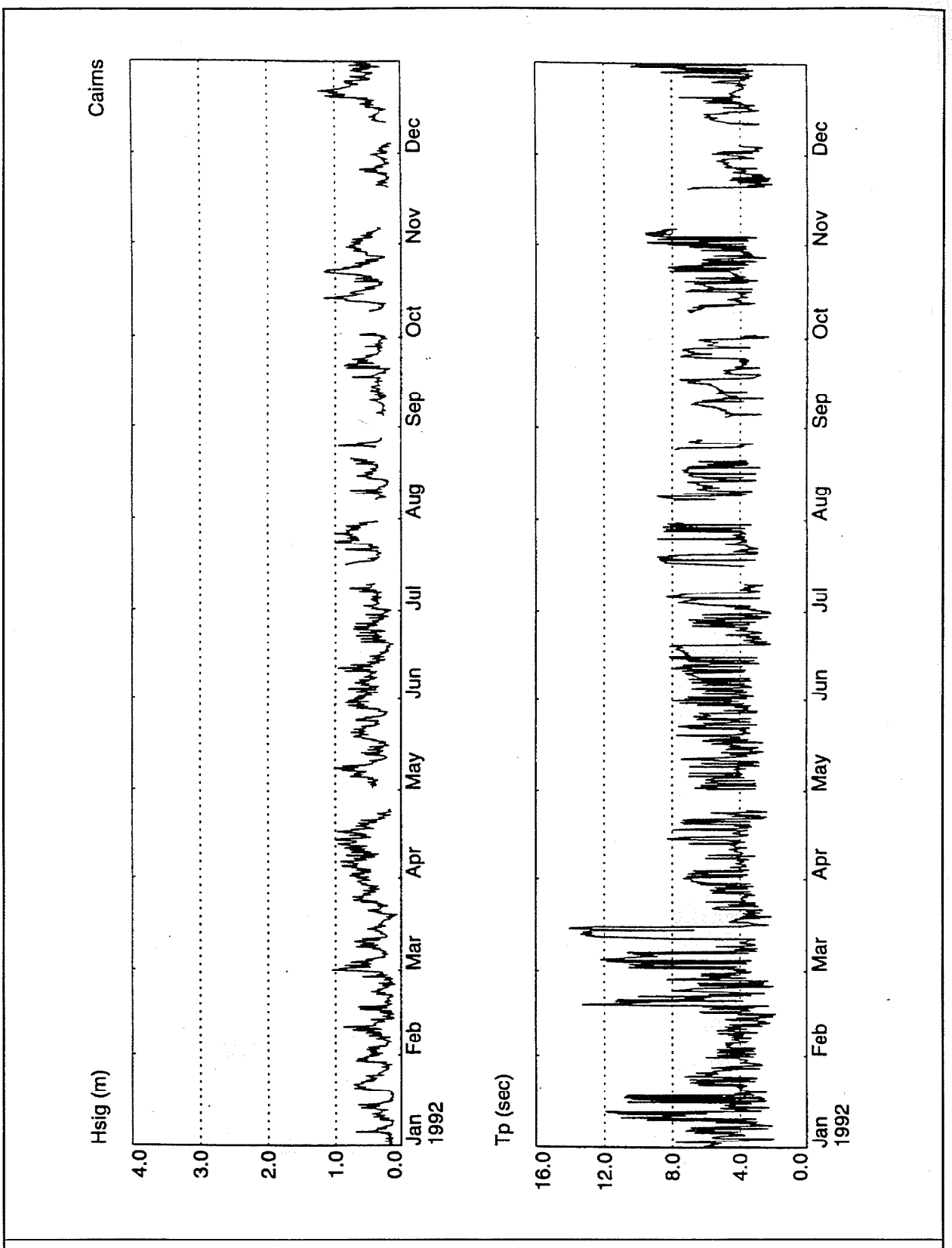


Daily wave recordings
1 January 1991 to 31 December 1991

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region .

Figure 6.17

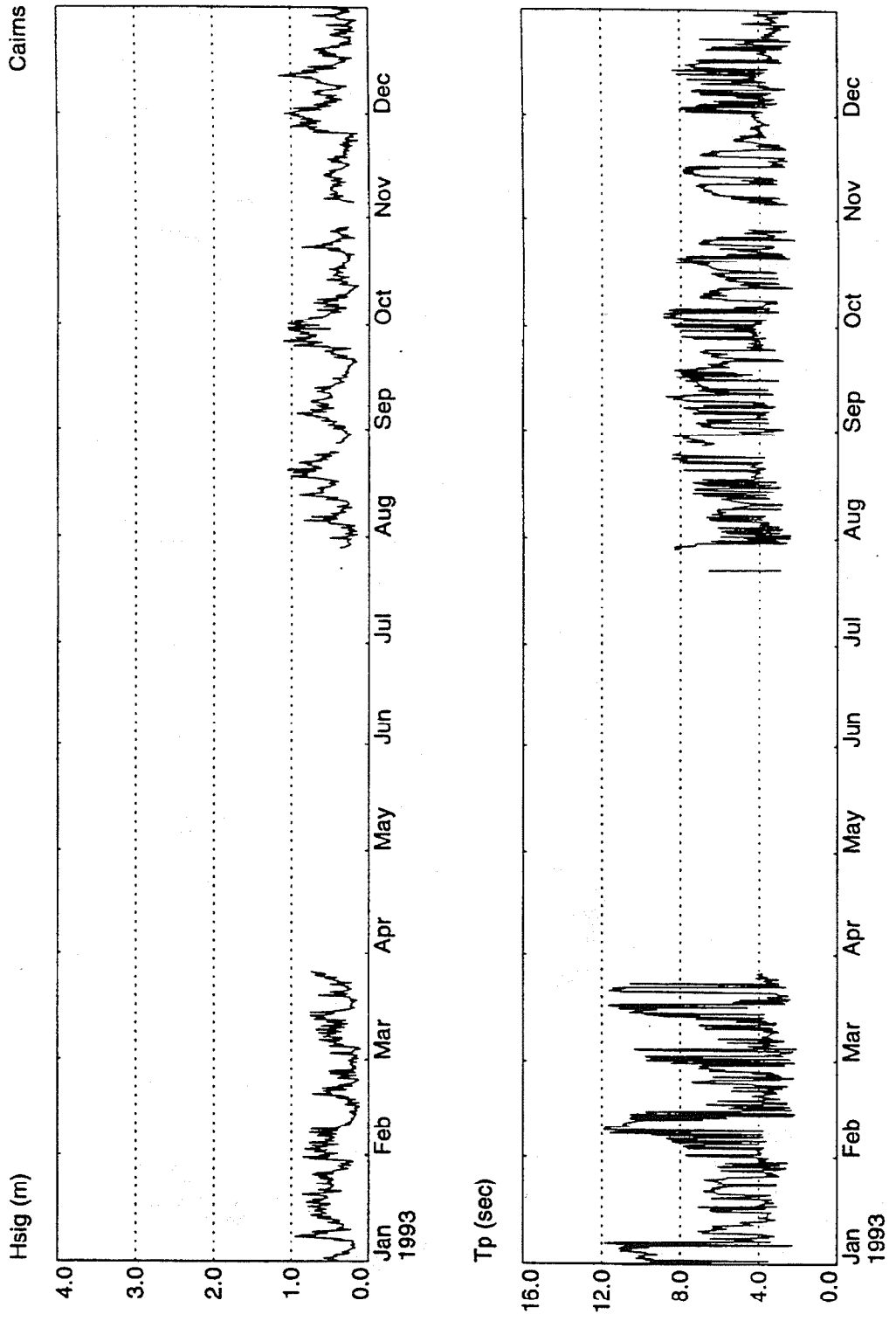


Daily wave recordings
1 January 1992 to 31 December 1992

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 6.18

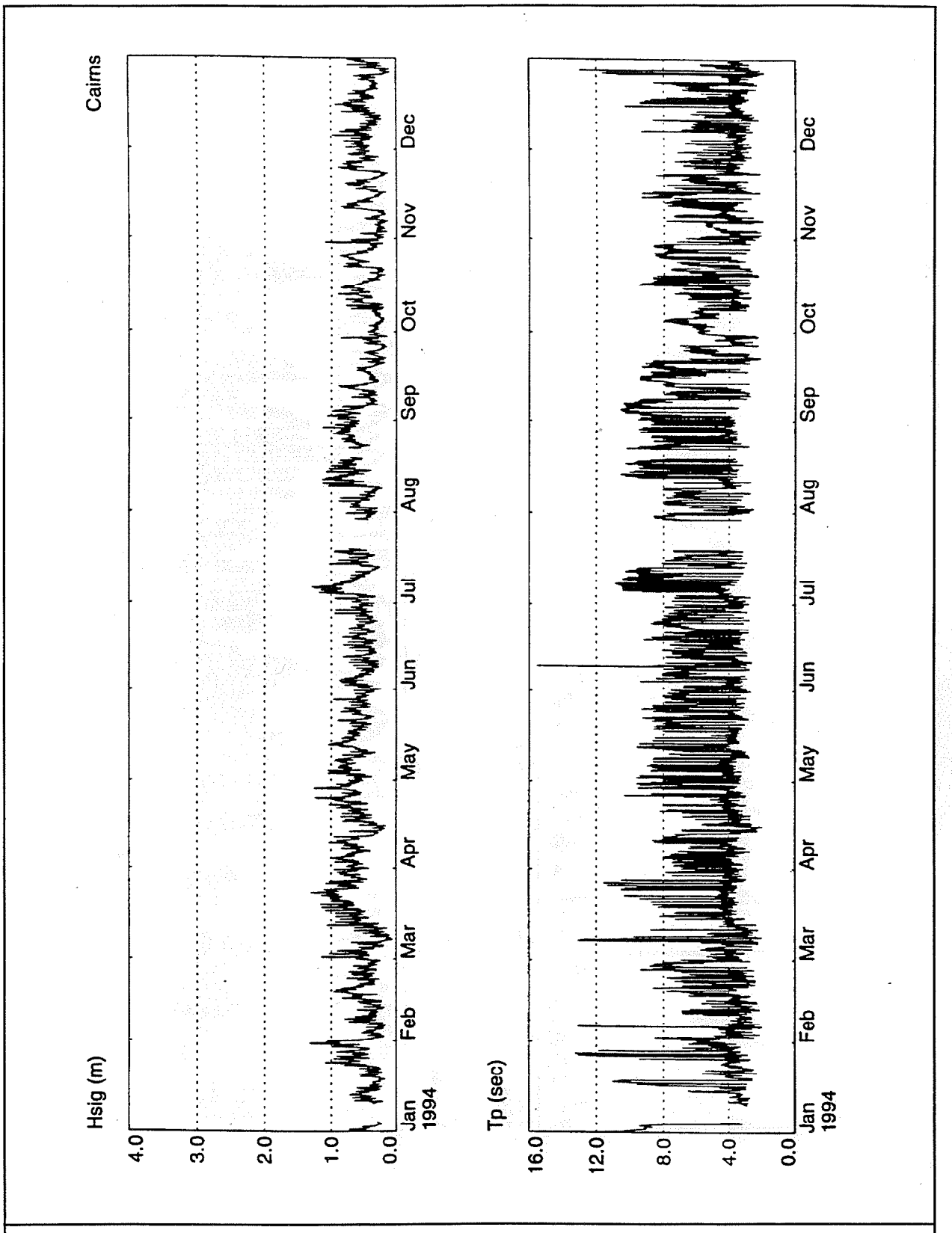


Daily wave recordings
1 January 1993 to 31 December 1993

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 6.19

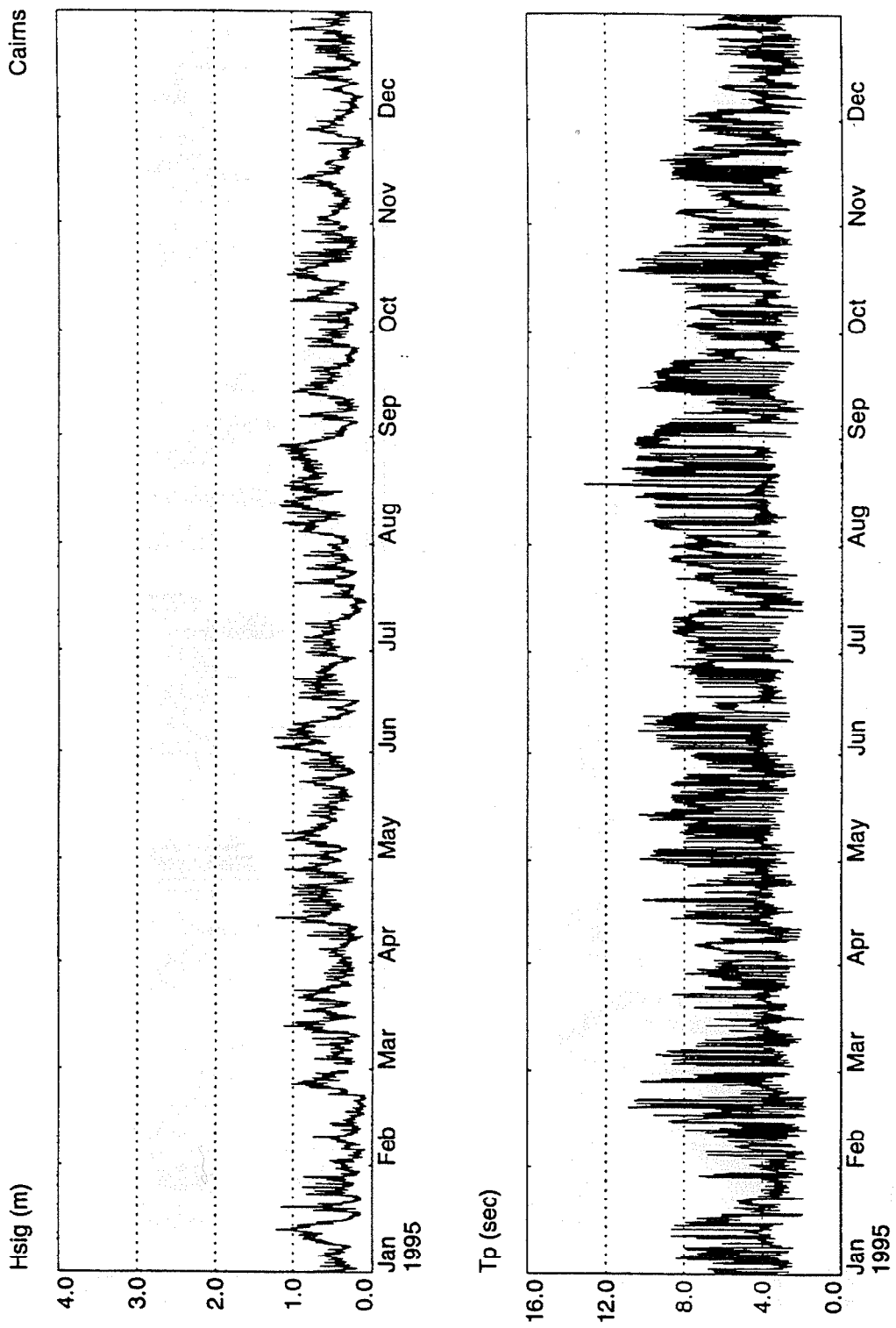


Daily wave recordings
1 January 1994 to 31 December 1994

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 6.20

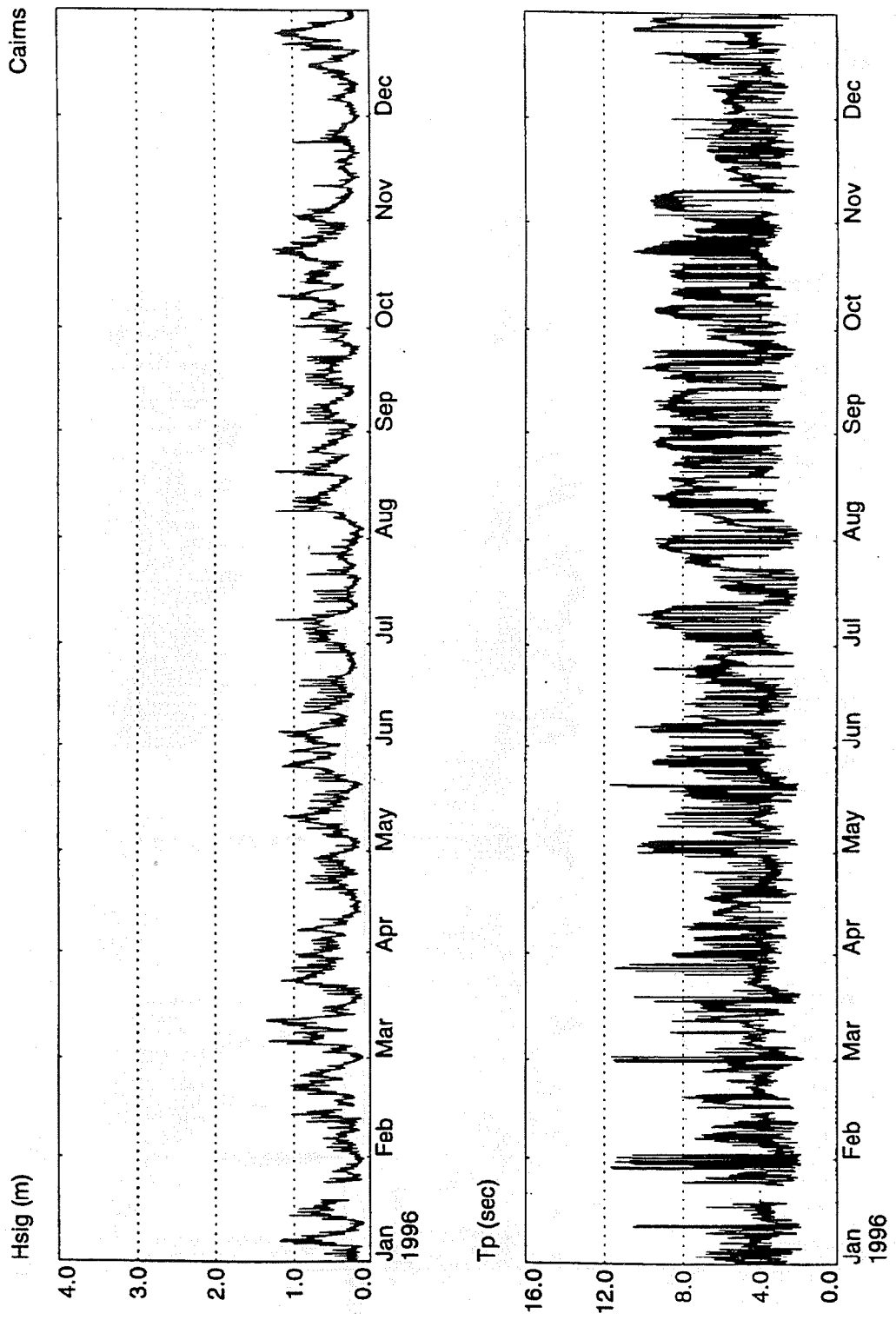


Daily wave recordings
1 January 1995 to 31 December 1995

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 6.21

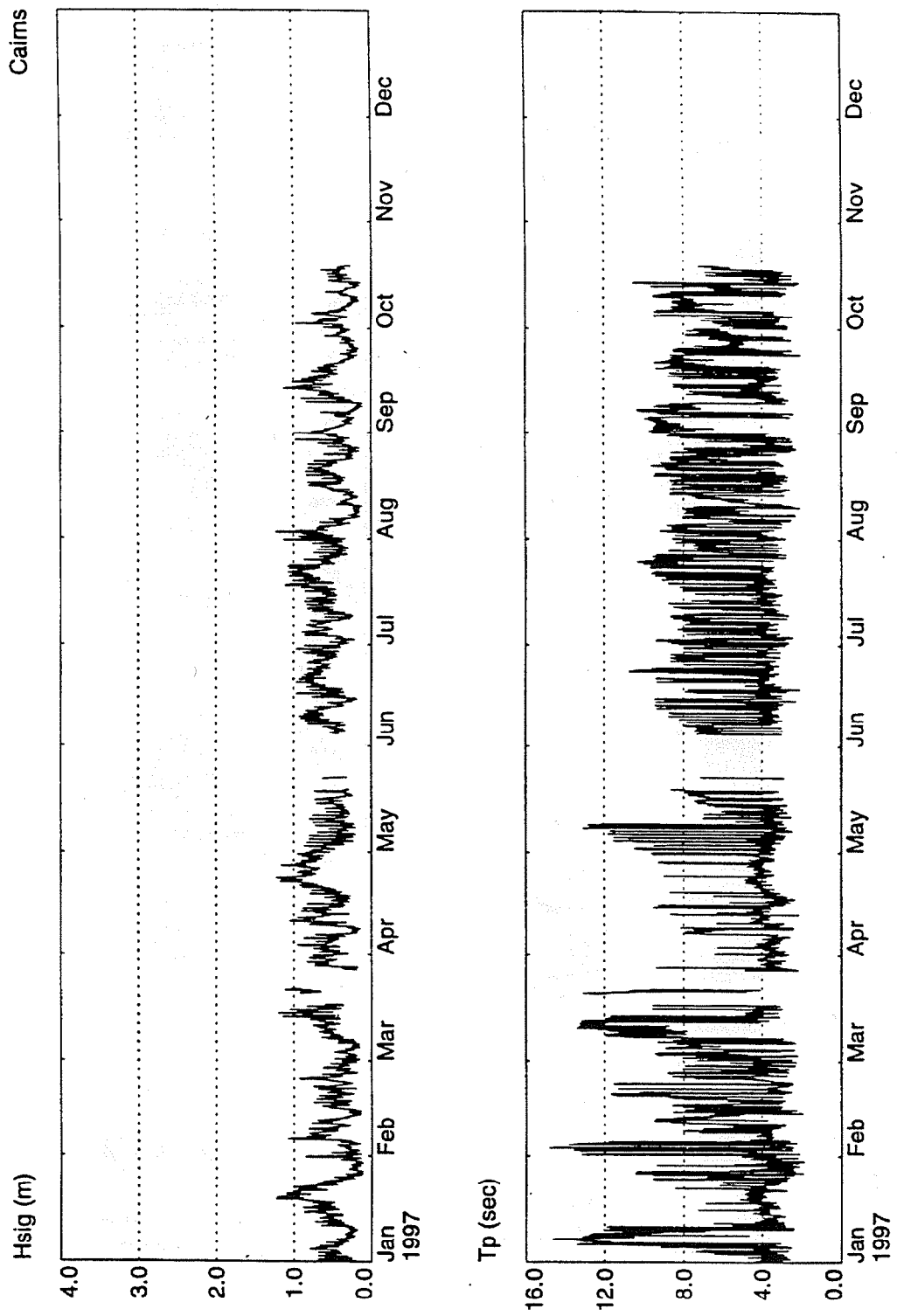


Daily wave recordings
1 January 1996 to 31 December 1996

Beach Protection Authority Queensland
Department of Environment and Heritage

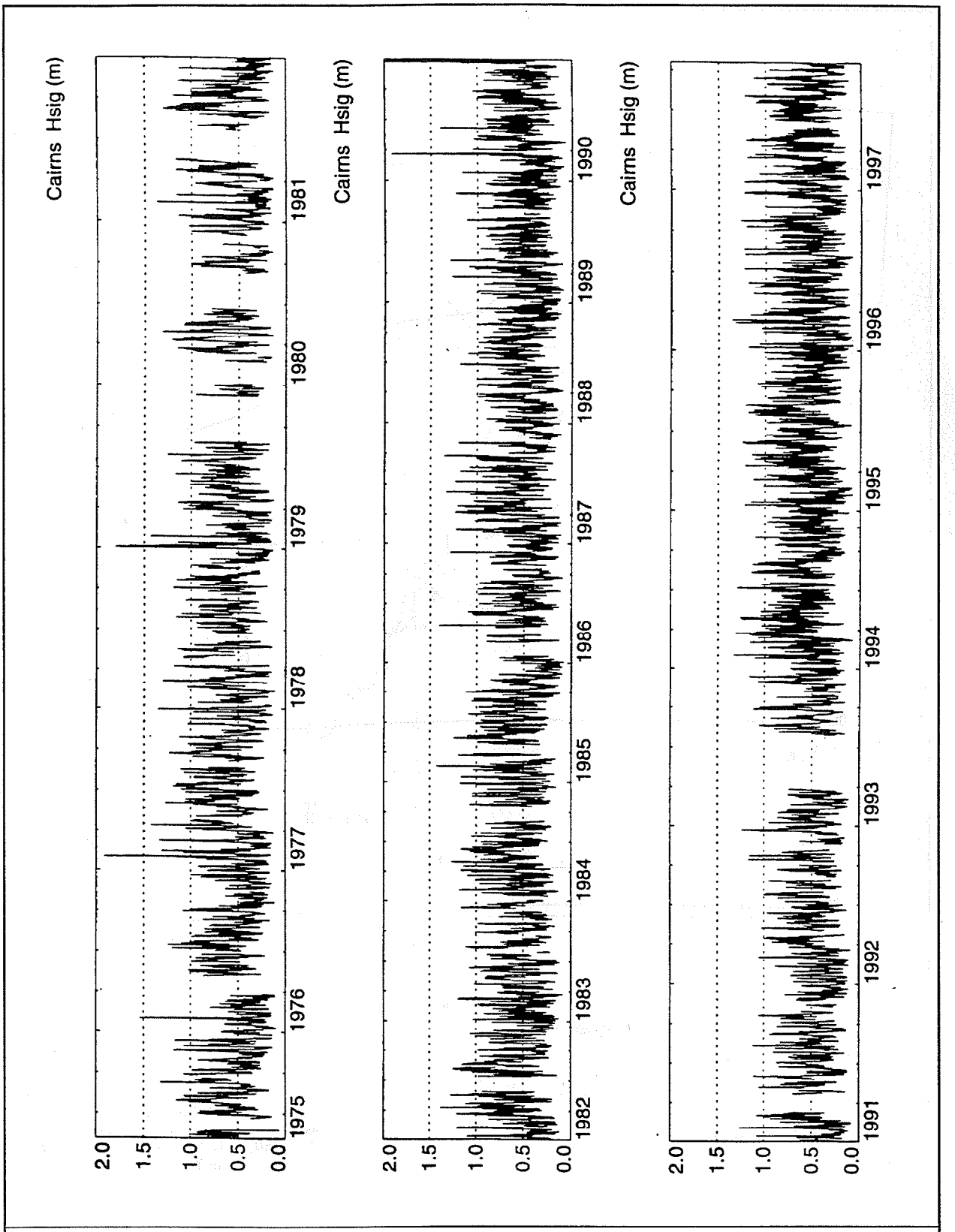
Wave data recording program
Cairns Region

Figure 6.22



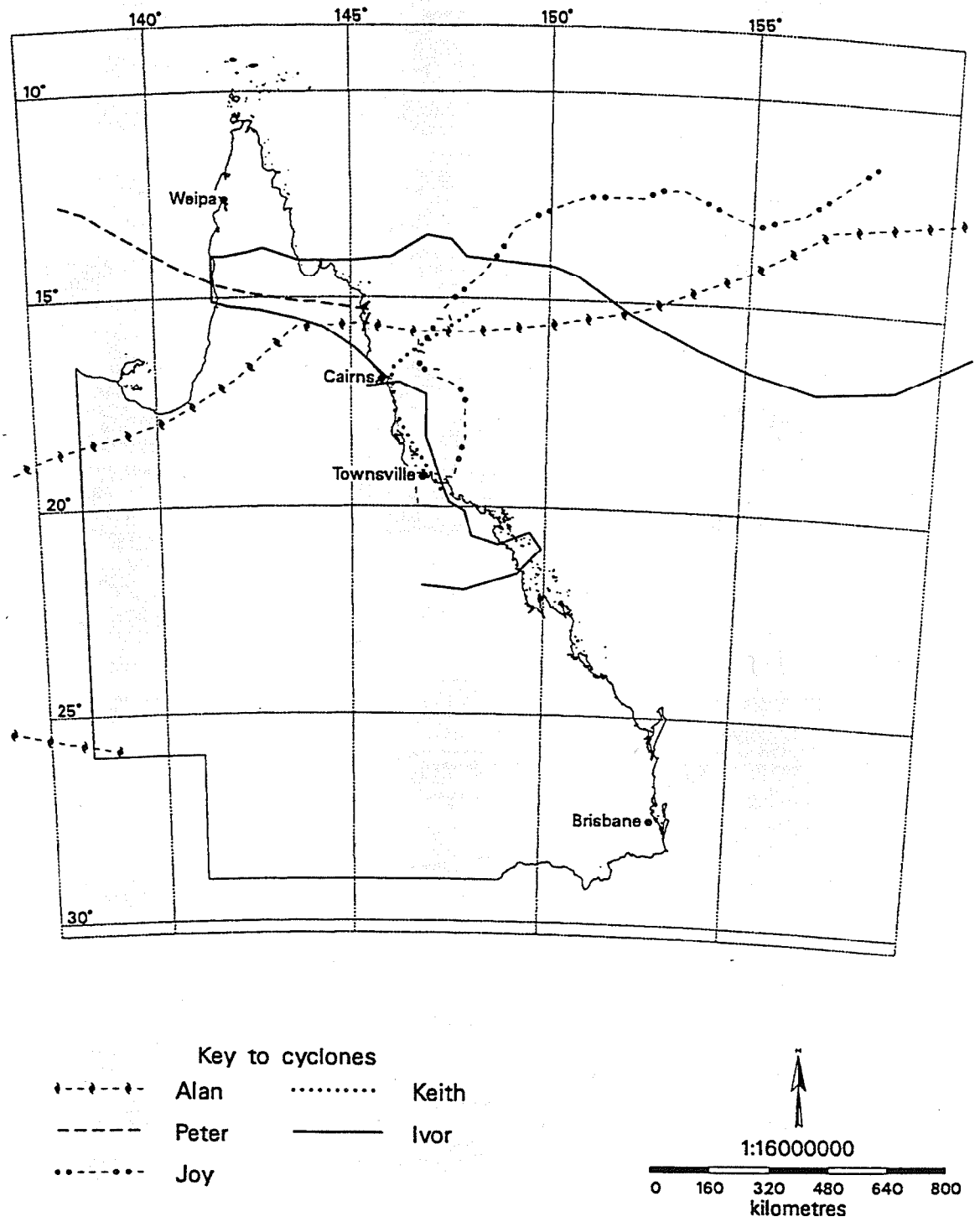
Daily wave recordings
1 January 1997 to 31 December 1997

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Cairns Region	**Figure 6.23**



Whole recording period wave heights (Hsig)
2 May 1975 to 31 October 1997

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Cairns Region	**Figure 7**



Cyclone Tracks
1975-1997

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Cairns Region

Figure 8