Wave data recording program
Weipa region
For the years 1978 - 1997

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Abstract

This report provides summaries of primary analyses of wave data recorded using a Datawell non-directional waverider buoy in water depths of approximately 5m, offshore near Weipa in the Gulf of Carpentaria, far northern Queensland. Recorded data covers the period from 21 December 1978 to 30 April 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.

RE276 August 1998

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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, *Operation 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 1975–3 Sept 1978.

Wave data recording program, Cairns Region
Report No. W01.2 — 2 May 1975–11 June 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.

Wave data recording program, Burnett Heads Region
Report No. W05.2 — 5 May 1976–13 Oct 1988.

Wave data recording program, Abbot Point Region
Report No. W06.1 — 6 May 1977–9 Aug 1979.

Wave data recording program, Abbot Point Region
Report No. W06.2 — 6 May 1977–31 Oct 1996.

Wave data recording program, Weipa Region
Report No. W07.1 — 21 Dec 1978–7 Apr 1983.

Wave data recording program, Gladstone Region
Report No. W08.1 — 19 Dec 1979–16 May 1983.

Wave data recording program, Brisbane Region
Report No. W09.1 — 30 Oct 1976–30 June 1983.

Wave data recording program, Brisbane Region
Report No. W09.2 — 30 Oct 1976–30 June 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 June 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, Hay Point Region
Report No. W13.2 — 22 Mar 1977–31 Oct 1996.

Wave data recording program, Gold Coast Region
Report No. W14.1 — 20 Feb 1987–30 June 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, Kirra
Report No. W15.2 — 25 Aug 1988–28 Feb 1997.

Wave data recording program, Repulse Bay
Report No. W16.1 — 2 June 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

Buoy locations

See figure 1 for the locality plan of the Waverider buoys and recording stations for the period of this report.

Co-ordinates: 141° 45·20' E, 12° 40·83' S
Description: 11 km west of Lorim Point
Buoy type: Datawell non-directional Waverider
Water depth at buoy: 6·8m relative to Australian Height Datum
Period: 21 December 1978–25 July 1990

Co-ordinates: 141° 45·02' E, 12° 40·25' S
Description: 11 km west of Lorim Point
Buoy type: Datawell non-directional Waverider
Water depth at buoy: 6·8m relative to Australian Height Datum
Period: 26 July 1990–17 November 1993

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

Co-ordinates: 141° 45·03' E, 12° 40·42' S
Description: 11 km west of Lorim Point
Buoy type: Datawell non-directional Waverider
Water depth at buoy: 6·8m relative to Australian Height Datum
Period: 18 November 1993–25 July 1994

Co-ordinates: 141° 45·20' E, 12° 40·41' S
Description: 11 km west of Lorim Point
Buoy type: Datawell non-directional waverider
Water depth at buoy: 5·3m relative to Australian Height Datum
Period: 26 July 1994–2 August 1995

Co-ordinates: 141° 45·10' E, 12° 40·60' S
Description: 11 km west of Lorim Point
Buoy type: Datawell non-directional Waverider
Water depth at buoy: 5·3m relative to Australian Height Datum
Period: 3 August 1995–13 September 1995

Co-ordinates: 141° 45·116' E, 12° 40·658' S
Description: 11 km west of Lorim Point
Buoy type: Datawell non-directional Waverider
Water depth at buoy: 5·3m relative to Australian Height Datum
Period: 6 Oct 1995–17 Sept 1996

Co-ordinates: 141° 45·124' E, 12° 40·646' S
Description: 11 km west of Lorim Point
Buoy type: Datawell non-directional Waverider
Water depth at buoy: 5·3m relative to Australian Height Datum
Period: 18 Sept 1996–30 Apr 1997

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

Location of recording station

Co-ordinates:141° 52·10' E, 12° 40·31' S
Description: Harbour Master's Office, Lorim Point
Period: 21 Dec 1978–2 Sept 1991

Co-ordinates: 141° 50·82' E, 12° 39·96' S
Description: Harbour Master's boat shed, Evans Landing
Period: 8 Sept 1991–30 Apr 1997

Recording intervals

Two, twenty minute records daily at 0300 and 1500 hours between 21 Dec 1978 and 2 Dec 1981.

Four, twenty minute records daily at 0300, 0900, 1500 and 2100 hours between 3 Dec 1981 and 2 Jan 1993.

Commencing on 20 Apr 1993, one hourly records, each of approximately 26 minutes have been 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:	40 668·00
Number of records used in analysis:	40 190·00
Number of days in recording period:	6 703·85
Number of days used in analysis:	4 983·51
Number of days lost:	1 720·34

Significant data gaps

10 April 1986–18 June 1986
14 March 1987–10 April 1987
14 February 1988–18 April 1988
27 March 1990–6 August 1990
23 December 1990–2 May 1991
28 August 1991–31 August 1991
8 October 1991–21 October 1991
23 October 1991–9 November 1991
31 January 1992–11 February 1992
3 July 1992–5 August 1992
31 November 1992–23 December 1992
2 January 1993–20 April 1993
17 September 1993–8 October 1993
30 June 1994–26 July 1994
14 September 1995–6 October 1995
24 August 1996–18 September 1996

Appendix 2

Meteorological event	Central pressure (hPa)	Date	Estimated position of cyclone relative to buoy (km)	Maximum Hsig recorded (m) See Notes(1)	Maximum Hmax recorded (m) See Notes (2)	Tp(s) See Notes (3)
Cyclone Peter	980	31-12-1978	150 S	3·09	4·46	10·67
Cyclone Greta	985	10-01-1979	150 SSW	2·97	4·46	11·62
Cyclone Stan		6-04-1979 to 15-04-1979	#	#	#	#
Cyclone Paul	996	6-01-1980	500 S	2·05	3·27	8·13
Low pressure system in southern Gulf of Carpentaria	998	15-01-1981		2·39	3·84	9·46
Cyclone Freda	996	26-02-1981	350 SE	2·12	3·09	8·21
Strong wind field associated with Cyclone Abigail		27-01-1982		2·22	3·11	8·10
Cyclone Dominic	950	7-04-1982	150 SSW	2·91	3·69	10·67
Cyclone Rebecca		20-02-1985 to 23-02-1985	#	#	#	#
Cyclone Sandy	953	23-03-1985	330 WSW	2·72	4·03	10·08
Low pressure system over north Queensland	1000	22-01-1986		2·27	4·95	8·11
Cyclone Jason	973	13-02-1987	540 SSW	2·05	3·75	9·46
Low pressure system in south-eastern Gulf of Carpentaria	1000	3-02-1989		2·15	3·58	9·17
Cyclone Ivor	984	21-03-1990	175 S	2·73	3·87	8·76
Cyclone Kelvin		24-02-1991 to 5-03-1991	#	#	#	#
Cyclone Mark	980	10-01-1992	110 SW	4·68	6·16	10·22
Low pressure system in south-eastern Gulf of Carpentaria	1000	27-02-1992		2·29	3·59	9·92
Cyclone Nina	970	24-12-1992	150 SSW	2·58	3·95	8·87
Series of low pressure systems across north -eastern Australia	1004	28-02-1994		2·11	3·65	8·83
Low pressure system in southern Gulf of Carpentaria	1004	12-02-1995		2·03	3·66	8·38
Cyclone Warren	985	5-03-1995	325 SW	2·87	5·10	9·55
Cyclone Ethel	1000	9-03-1996	200 SW	3·76	6·69	11·55
Trough associated with low pressure system over north-western Australia and cyclone	1004	8-03-1997		3·35	4·84	10·26
Justin in the Coral Sea	976					

# denotes that no data is available.

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 above table lists all events with a recorded Hsig value which reached the storm threshold of 2m during the recording period of this report.

Highest significant wave height (Hsig) recorded was 4·68m on 10 January 1992 during the passage of tropical cyclone Mark.

Highest maximum wave height (Hmax) recorded was 6·69m on 9 March 1996 during the passage of tropical cyclone Ethel.

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

Appendix 3
Tropical cyclones of the Gulf of Carpentaria region of Queensland 21 December 1978–30 April 1997

Cyclone Name	Year	Month
Peter	1978	12
Greta	1979	1
Stan	1979	4
Paul	1980	1
Eddie	1981	2
Dominic	1982	4
Jim	1984	3
Kathy	1984	3
Rebecca	1985	2
Vernon	1986	1
Irma	1987	1
Meena	1989	5
Felicity	1989	12
Greg	1990	3
Kelvin	1991	2
Mark	1992	1
Sadie	1994	1
Warren	1995	3
Barry	1996	1

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	665·70	178·21	112·58	11·23	0·96	3·31	2·53	0·31	974·84
0·20 - 0·39	1806·33	494·65	394.00	38·91	1·79	*	*	*	2735·68
0·40 - 0·59	199·03	188·48	266·42	67·51	0·46	*	*	*	721·90
0·60 - 0·79	4·21	35·57	132·5	58·39	1·92	*	*	*	232·60
0·80 - 0·99	0·25	6·54	42·78	68·91	0·88	*	*	*	119·36
1·00 - 1·19	*	0·83	18·96	45·57	1·42	*	*	*	66·78
1·20 - 1·39	0·25	0·26	3·72	39·55	2·17	*	*	*	45·94
1·40 - 1·59	*	0·33	3·08	26·25	2·29	*	*	*	31·96
1·60 - 1·79	*	0·04	*	17·35	2·97	*	*	*	20·35
1·80 - 1·99	*	*	*	8·57	3·16	*	*	*	11·73
2·00 - 2·19	*	*	*	5·14	3·06	*	*	*	8·20
2·20 - 2·39	*	*	*	2·09	3·65	*	*	*	5·73
2·40 - 2·59	*	*	*	1·43	0·85	0·25	*	*	2·54
2·60 - 2·79	*	*	*	0·35	2·31	*	*	*	2·66
2·80 - 2·99	*	*	*	0·25	1·34	0·25	*	*	1·84
3·00 - 3·19	*	*	*	*	0·42	*	*	*	0·42
3·20 - 3·39	*	*	*	*	0·05	*	*	*	0·05
3·40 - 3·59	*	*	*	*	0·06	*	*	*	0·06
3·60 - 3·79	*	*	*	*	0·04	0·32	*	*	0·36
3·80 - 3·99	*	*	*	*	*	*	*	*	0.00
4·00 - 4·19	*	*	*	*	*	*	*	*	0.00
4·20 - 4·39	*	*	*	*	*	0·25	*	*	0·25
4·40 - 4·59	*	*	*	*	*	*	*	*	0.00
4·60 - 4·79	*	*	*	*	0·25	*	*	*	0·25
4·80 - 4·99	*	*	*	*	*	*	*	*	0.00
Totals	2675·77	904·93	974·05	391·52	30·03	4·38	2·53	0·31	4983·51

* = 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	370·62	91·58	89·75	10·73	0·71	3·06	1·23	0·11	567·79
0·20 - 0·39	657·12	197·12	182·35	31·29	0·79	*	*	*	1068·67
0·40 - 0·59	61·25	89·12	154·79	59·89	0·46	*	*	*	365·51
0·60 - 0·79	1·67	14·52	107·77	57·97	1·67	*	*	*	183·60
0·80 - 0·99	*	3·83	40·20	67·91	0·88	*	*	*	112·81
1·00 - 1·19	*	0·33	17·54	45·57	1·42	*	*	*	64·87
1·20 - 1·39	*	0·26	3·72	39·55	2·17	*	*	*	45·70
1·40 - 1·59	*	0·33	3·08	26·25	2·29	*	*	*	31·96
1·60 - 1·79	*	0·04	*	17·35	2·97	*	*	*	20·35
1·80 - 1·99	*	*	*	8·57	3·16	*	*	*	11·73
2·00 - 2·19	*	*	*	5·14	3·06	*	*	*	8·20
2·20 - 2·39	*	*	*	2·09	3·65	*	*	*	5·73
2·40 - 2·59	*	*	*	1·43	0·85	0·25	*	*	2·54
2·60 - 2·79	*	*	*	0·35	2·31	*	*	*	2·66
2·80 - 2·99	*	*	*	0·25	1·34	0·25	*	*	1·84
3·00 - 3·19	*	*	*	*	0·42	*	*	*	0·42
3·20 - 3·39	*	*	*	*	0·05	*	*	*	0·05
3·40 - 3·59	*	*	*	*	0·06	*	*	*	0·06
3·60 - 3·79	*	*	*	*	0·04	0·32	*	*	0·36
3·80 - 3·99	*	*	*	*	*	*	*	*	0.00
4·00 - 4·19	*	*	*	*	*	*	*	*	0.00
4·20 - 4·39	*	*	*	*	*	0·25	*	*	0·25
4·40 - 4·59	*	*	*	*	*	*	*	*	0.00
4·60 - 4·79	*	*	*	*	0·25	*	*	*	0·25
4·80 - 4·99	*	*	*	*	*	*	*	*	0.00
Totals	1090·66	397·14	599·2	374·34	28·53	4·13	1·23	0·11	2495·34

* = 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	295·08	86·64	22·83	0·50	0·25	0·25	1·30	0·20	407·04
0·20 - 0·39	1149·21	297·53	211·66	7·62	1.00	*	*	*	1667·01
0·40 - 0·59	137·78	99·36	111·62	7·62	*	*	*	*	356·39
0·60 - 0·79	2·54	21·05	24·73	0·43	0·25	*	*	*	49.00
0·80 - 0·99	0·25	2·71	2·59	1.00	*	*	*	*	6·55
1·00 - 1·19	*	0·50	1·42	*	*	*	*	*	1·92
1·20 - 1·39	0·25	*	*	*	*	*	*	*	0·25
1·40 - 1·59	*	*	*	*	*	*	*	*	0.00
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
2·60 - 2·79	*	*	*	*	*	*	*	*	0.00
2·80 - 2·99	*	*	*	*	*	*	*	*	0.00
3·00 - 3·19	*	*	*	*	*	*	*	*	0.00
3·20 - 3·39	*	*	*	*	*	*	*	*	0.00
3·40 - 3·59	*	*	*	*	*	*	*	*	0.00
3·60 - 3·79	*	*	*	*	*	*	*	*	0.00
3·80 - 3·99	*	*	*	*	*	*	*	*	0.00
4·00 - 4·19	*	*	*	*	*	*	*	*	0.00
4·20 - 4·39	*	*	*	*	*	*	*	*	0.00
4·40 - 4·59	*	*	*	*	*	*	*	*	0.00
4·60 - 4·79	*	*	*	*	*	*	*	*	0.00
4·80 - 4·99	*	*	*	*	*	*	*	*	0.00
Totals	1585·11	507·79	374·85	17·17	1·50	0·25	1·30	0·20	2488·16

* = 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	13·36	3·58	2·26	0·23	0·02	0·07	0·05	0·01	19·56
0·20 - 0·39	36·25	9·93	7·91	0·78	0·04	*	*	*	54·89
0·40 - 0·59	3·99	3·78	5·35	1·35	0·01	*	*	*	14·49
0·60 - 0·79	0·08	0·71	2·66	1·17	0·04	*	*	*	4·67
0·80 - 0·99	0·01	0·13	0·86	1·38	0·02	*	*	*	2·40
1·00 - 1·19	*	0·02	0·38	0·91	0·03	*	*	*	1·34
1·20 - 1·39	*	0·01	0·07	0·79	0·04	*	*	*	0·92
1·40 - 1·59	*	0·01	0·06	0·53	0·05	*	*	*	0·64
1·60 - 1·79	*	*	*	0·35	0·06	*	*	*	0·41
1·80 - 1·99	*	*	*	0·17	0·06	*	*	*	0·24
2·00 - 2·19	*	*	*	0·10	0·06	*	*	*	0·16
2·20 - 2·39	*	*	*	0·04	0·07	*	*	*	0·12
2·40 - 2·59	*	*	*	0·03	0·02	0·01	*	*	0·05
2·60 - 2·79	*	*	*	0·01	0·05	*	*	*	0·05
2·80 - 2·99	*	*	*	0·01	0·03	0·01	*	*	0·04
3·00 - 3·19	*	*	*	*	0·01	*	*	*	0·01
3·20 - 3·39	*	*	*	*	*	*	*	*	0.00
3·40 - 3·59	*	*	*	*	*	*	*	*	0.00
3·60 - 3·79	*	*	*	*	*	0·01	*	*	0·01
3·80 - 3·99	*	*	*	*	*	*	*	*	0.00
4·00 - 4·19	*	*	*	*	*	*	*	*	0.00
4·20 - 4·39	*	*	*	*	*	0·01	*	*	0·01
4·40 - 4·59	*	*	*	*	*	*	*	*	0.00
4·60 - 4·79	*	*	*	*	0·01	*	*	*	0·01
4·80 - 4·99	*	*	*	*	*	*	*	*	0.00
Totals	53·69	18·16	19·55	7·86	0·60	0·09	0·05	0·01	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

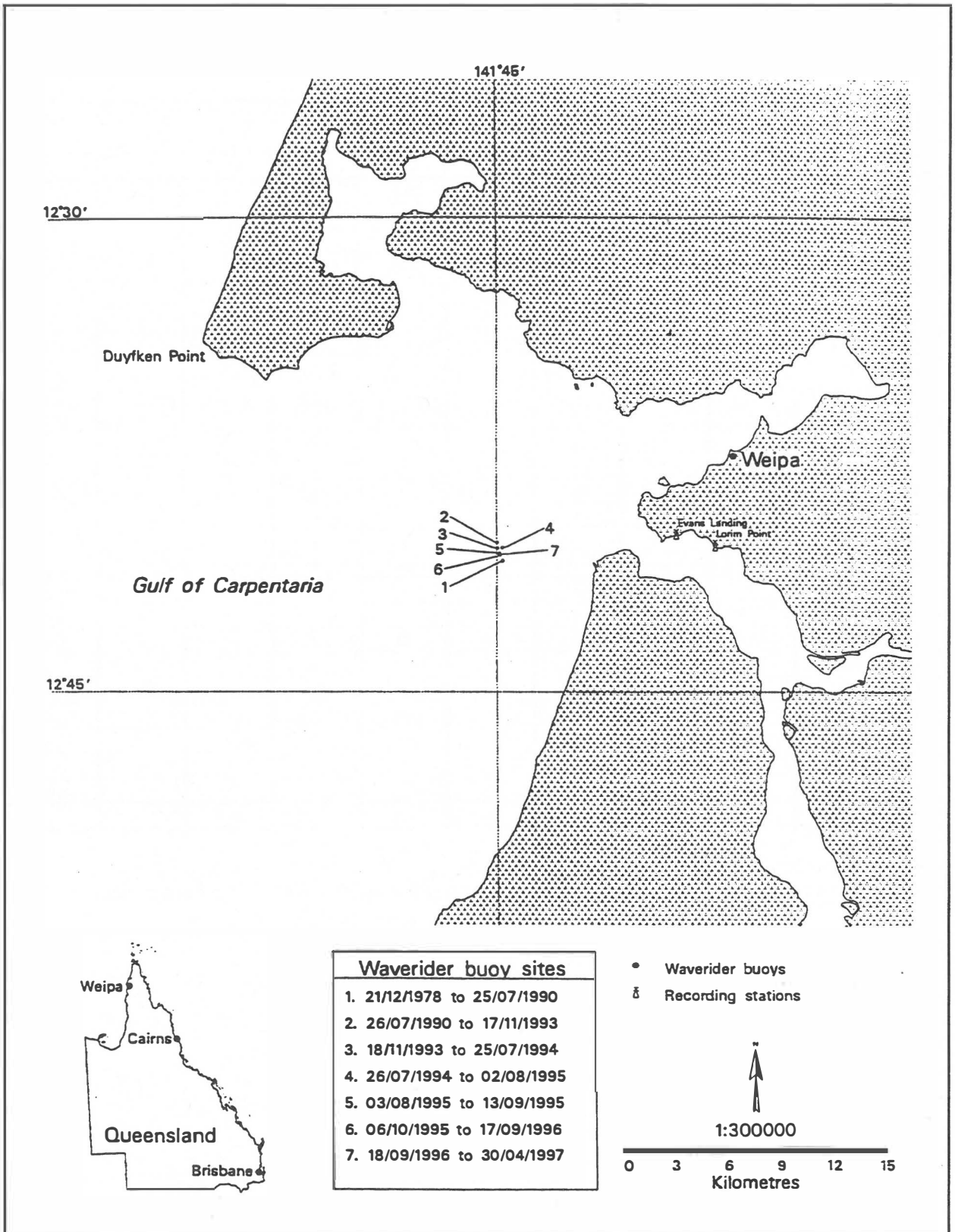
Significant wave height (Hsig) (metres)	Peak energy wave period (Tp) (seconds)								
	0-2·99	3-4·99	5-6·99	7-8·99	9-10·99	11-12·99	13-14·99	>14·99	Totals
0·00 - 0·19	14·85	3·67	3·60	0·43	0·03	0·12	0·05	*	22·75
0·20 - 0·39	26·33	7·90	7·31	1·25	0·03	*	*	*	42·83
0·40 - 0·59	2·45	3·57	6·20	2·40	0·02	*	*	*	14·65
0·60 - 0·79	0·07	0·58	4·32	2·32	0·07	*	*	*	7·36
0·80 - 0·99	*	0·15	1·61	2·72	0·04	*	*	*	4·52
1·00 - 1·19	*	0·01	0·70	1·83	0·06	*	*	*	2·60
1·20 - 1·39	*	0·01	0·15	1·58	0·09	*	*	*	1·83
1·40 - 1·59	*	0·01	0·12	1·05	0·09	*	*	*	1·28
1·60 - 1·79	*	*	*	0·70	0·12	*	*	*	0·82
1·80 - 1·99	*	*	*	0·34	0·13	*	*	*	0·47
2·00 - 2·19	*	*	*	0·21	0·12	*	*	*	0·33
2·20 - 2·39	*	*	*	0·08	0·15	*	*	*	0·23
2·40 - 2·59	*	*	*	0·06	0·03	0·01	*	*	0·10
2·60 - 2·79	*	*	*	0·01	0·09	*	*	*	0·11
2·80 - 2·99	*	*	*	0·01	0·05	0·01	*	*	0·07
3·00 - 3·19	*	*	*	*	0·02	*	*	*	0·02
3·20 - 3·39	*	*	*	*	*	*	*	*	0.00
3·40 - 3·59	*	*	*	*	*	*	*	*	0.00
3·60 - 3·79	*	*	*	*	*	0·01	*	*	0·01
3·80 - 3·99	*	*	*	*	*	*	*	*	0.00
4·00 - 4·19	*	*	*	*	*	*	*	*	0.00
4·20 - 4·39	*	*	*	*	*	0·01	*	*	0·01
4·40 - 4·59	*	*	*	*	*	*	*	*	0.00
4·60 - 4·79	*	*	*	*	0·01	*	*	*	0·01
4·80 - 4·99	*	*	*	*	*	*	*	*	0.00
Totals	43·71	15·92	24·01	15.00	1·14	0·17	0·05	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	11·86	3·48	0·92	0·02	0·01	0·01	0·05	0·01	16·36
0·20 - 0·39	46·19	11·96	8·51	0·31	0·04	*	*	*	67.00
0·40 - 0·59	5·54	3·99	4·49	0·31	*	*	*	*	14·32
0·60 - 0·79	0·10	0·85	0·99	0·02	0·01	*	*	*	1·97
0·80 - 0·99	0·01	0·11	0·10	0·04	*	*	*	*	0·26
1·00 - 1·19	*	0·02	0·06	*	*	*	*	*	0·08
1·20 - 1·39	0·01	*	*	*	*	*	*	*	0·01
1·40 - 1·59	*	*	*	*	*	*	*	*	0.00
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
2·60 - 2·79	*	*	*	*	*	*	*	*	0.00
2·80 - 2·99	*	*	*	*	*	*	*	*	0.00
3·00 - 3·19	*	*	*	*	*	*	*	*	0.00
3·20 - 3·39	*	*	*	*	*	*	*	*	0.00
3·40 - 3·59	*	*	*	*	*	*	*	*	0.00
3·60 - 3·79	*	*	*	*	*	*	*	*	0.00
3·80 - 3·99	*	*	*	*	*	*	*	*	0.00
4·00 - 4·19	*	*	*	*	*	*	*	*	0.00
4·20 - 4·39	*	*	*	*	*	*	*	*	0.00
4·40 - 4·59	*	*	*	*	*	*	*	*	0.00
4·60 - 4·79	*	*	*	*	*	*	*	*	0.00
4·80 - 4·99	*	*	*	*	*	*	*	*	0.00
Totals	63·71	20·41	15·07	0·69	0·06	0·01	0·05	0·01	100.00

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

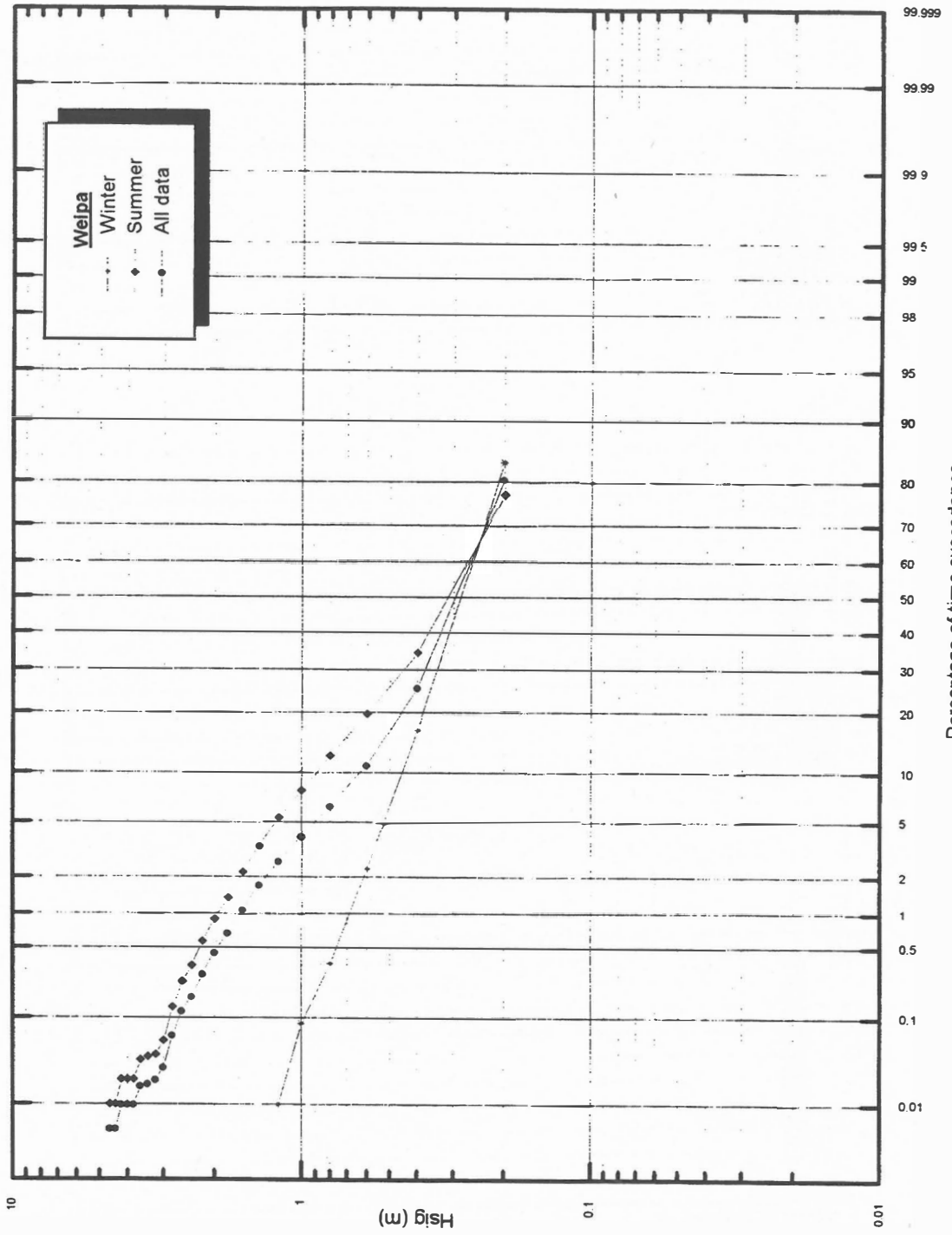


Locality Plan

Beach Protection Authority Queensland
Department of Environment and Heritage

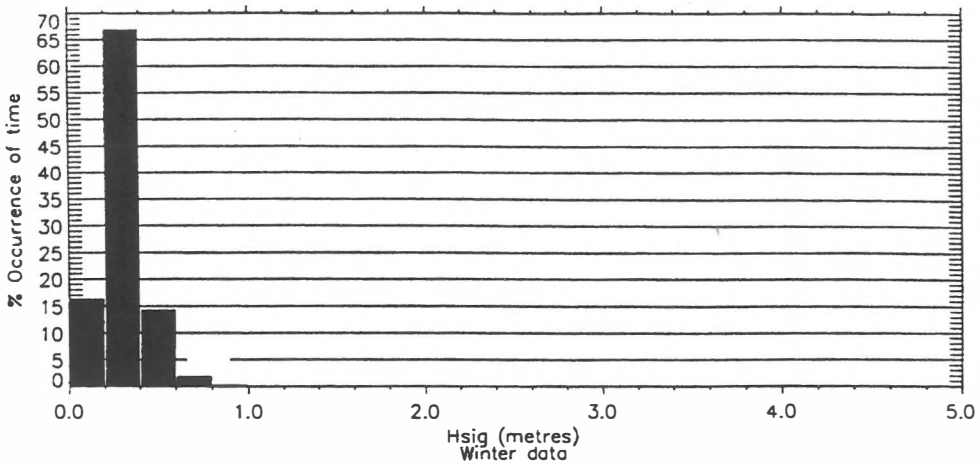
Wave data recording program
Weipa Region

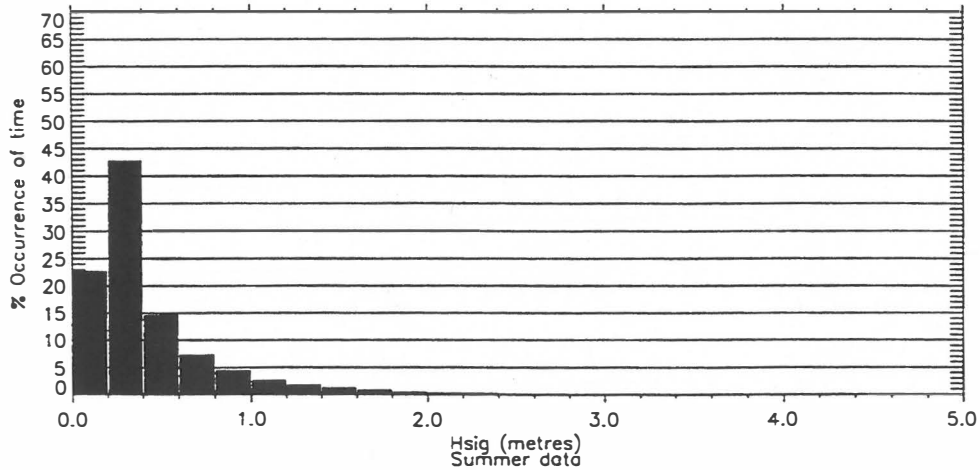
Figure 1

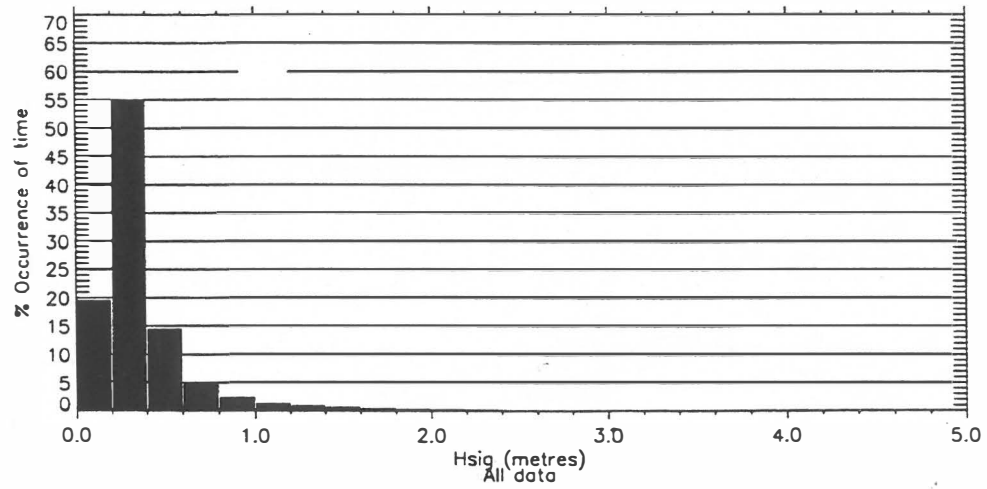


Percentage (of time) exceedance of wave heights (Hsig) for all periods (Tp)
21 December 1978 to 30 April 1997

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

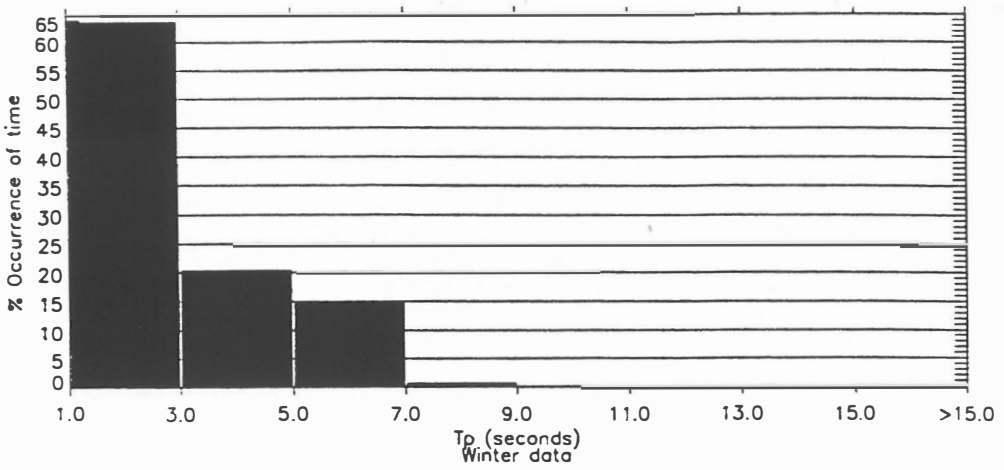


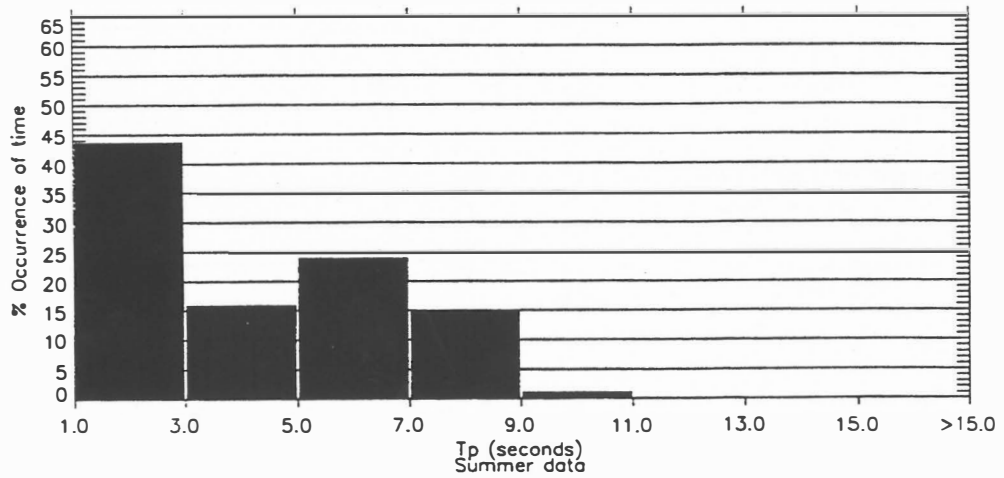


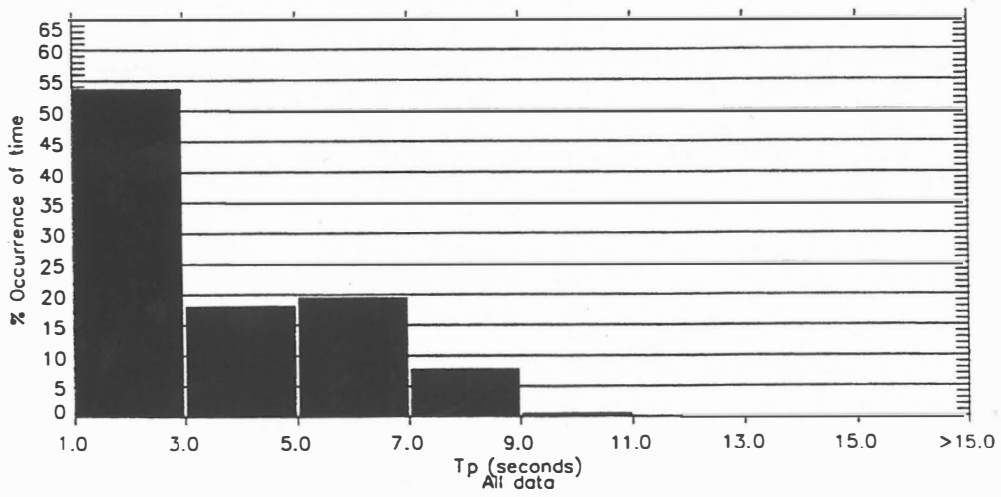


Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

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

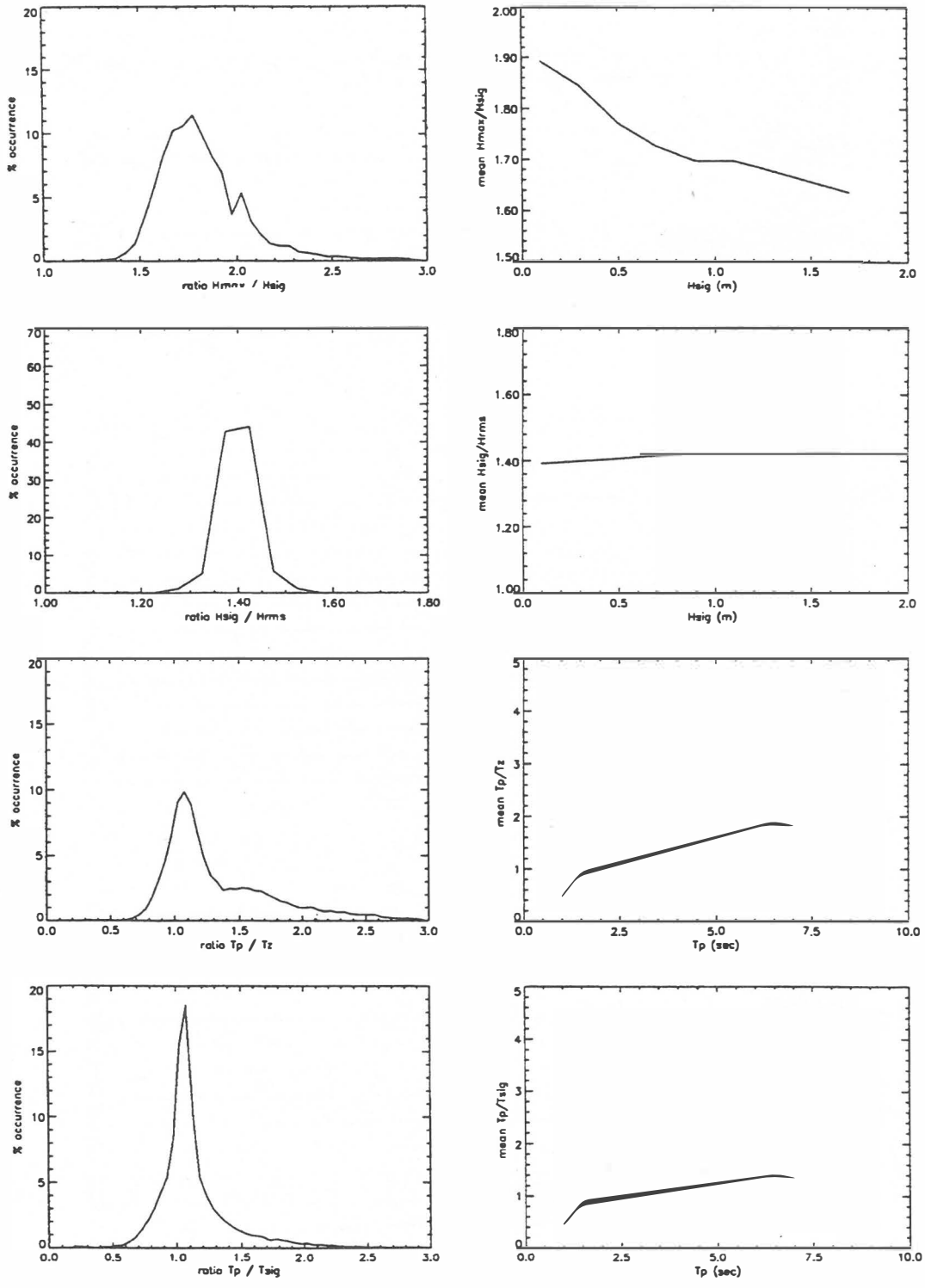






Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

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

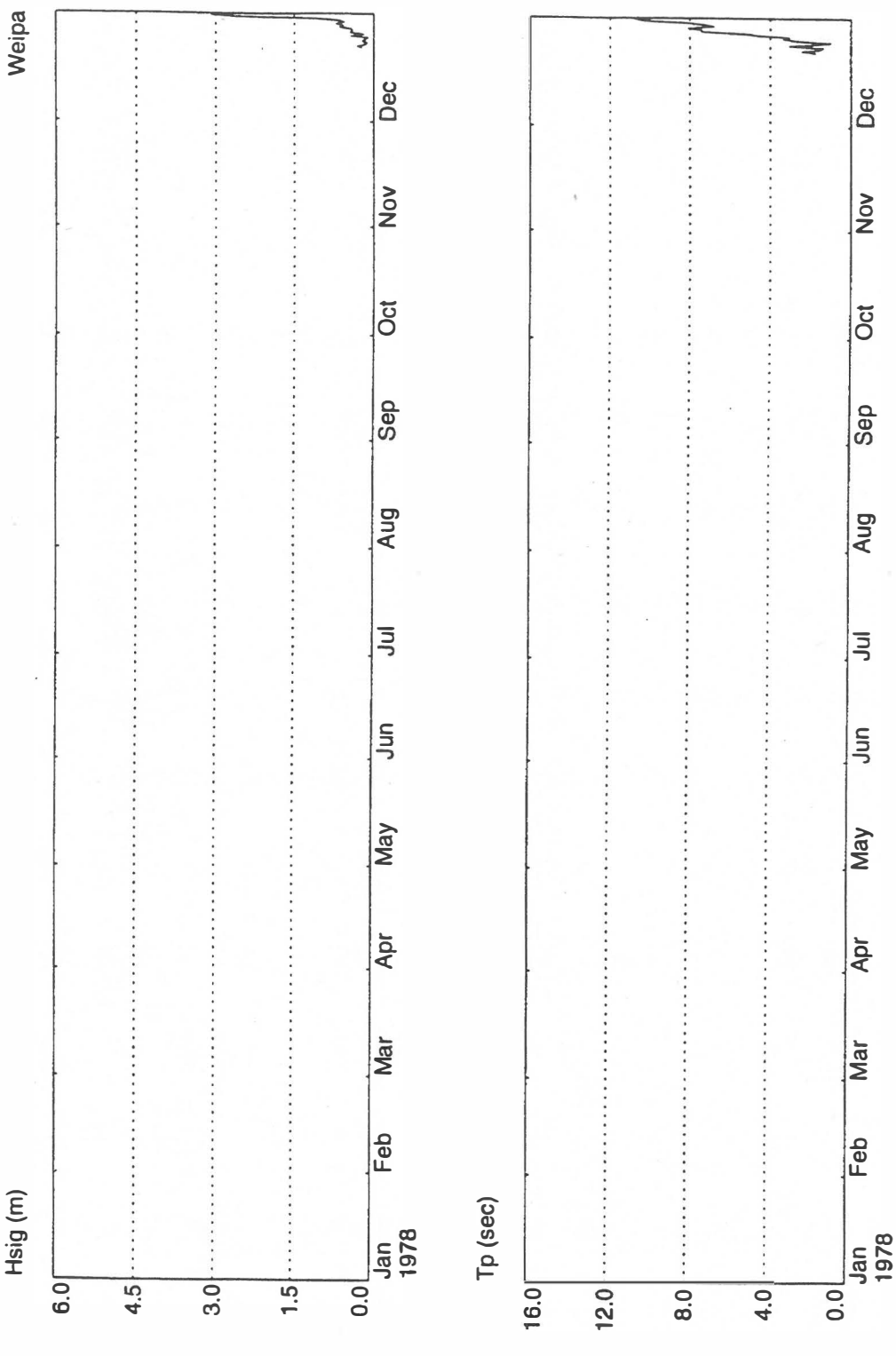


Wave parameter relationships
21 December 1978 to 30 April 1997

Beach Protection Authority Queensland
Department of Environment and Heritage

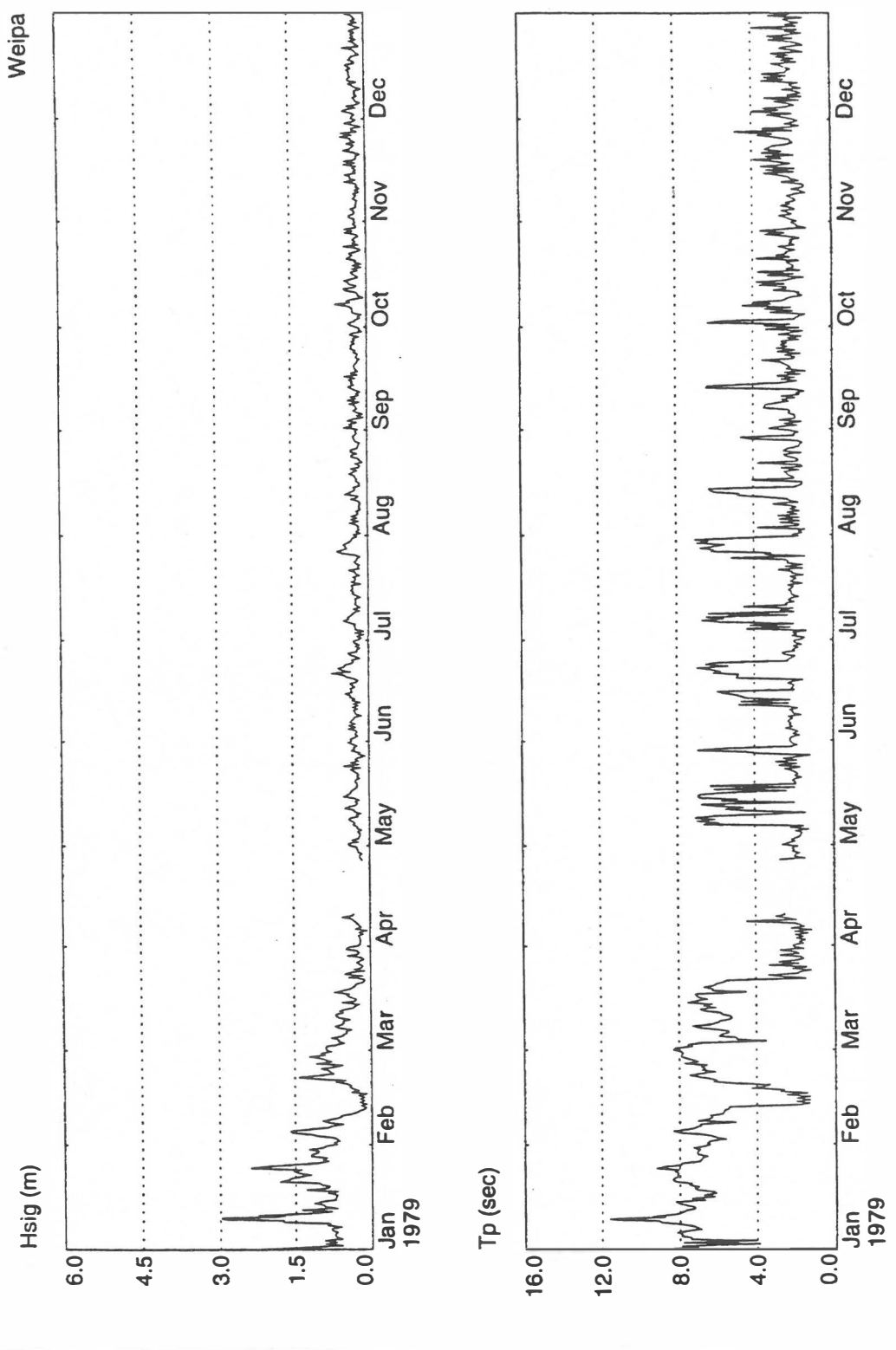
Wave data recording program
Weipa Region

Figure 5



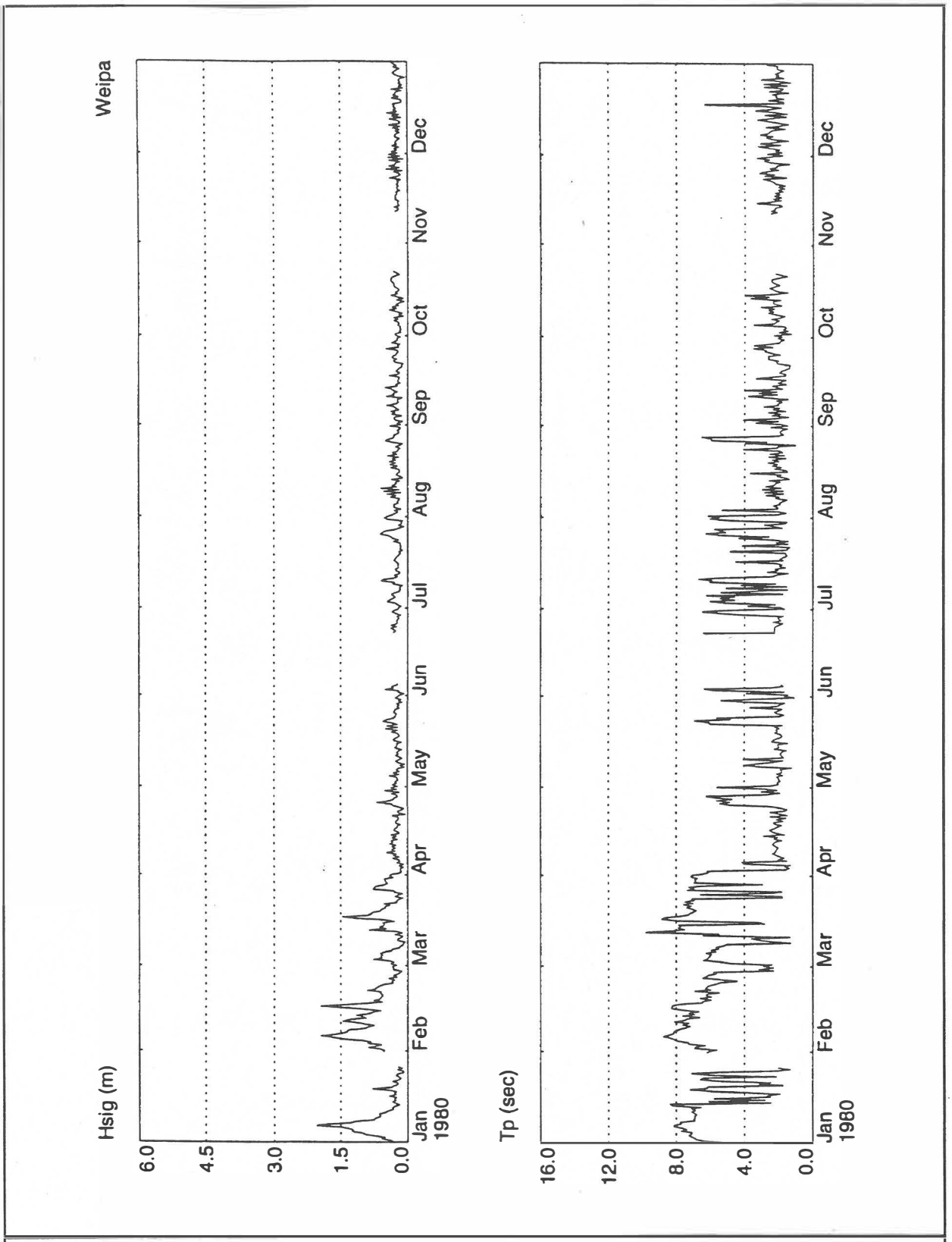
Daily wave recordings
1 January 1978 to 31 December 1978

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.01**



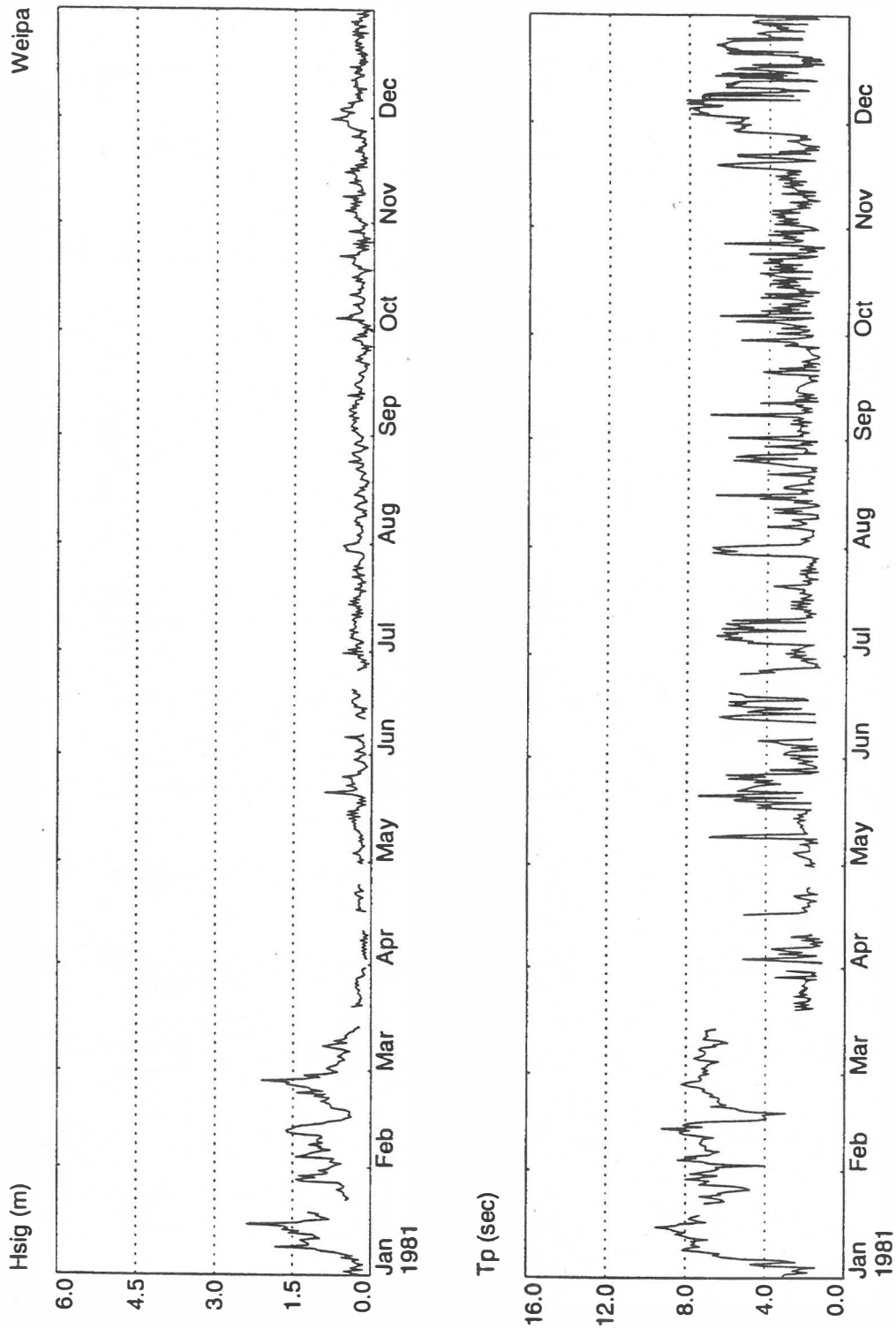
Daily wave recordings
1 January 1979 to 31 December 1979

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



Daily wave recordings
1 January 1980 to 31 December 1980

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.03**

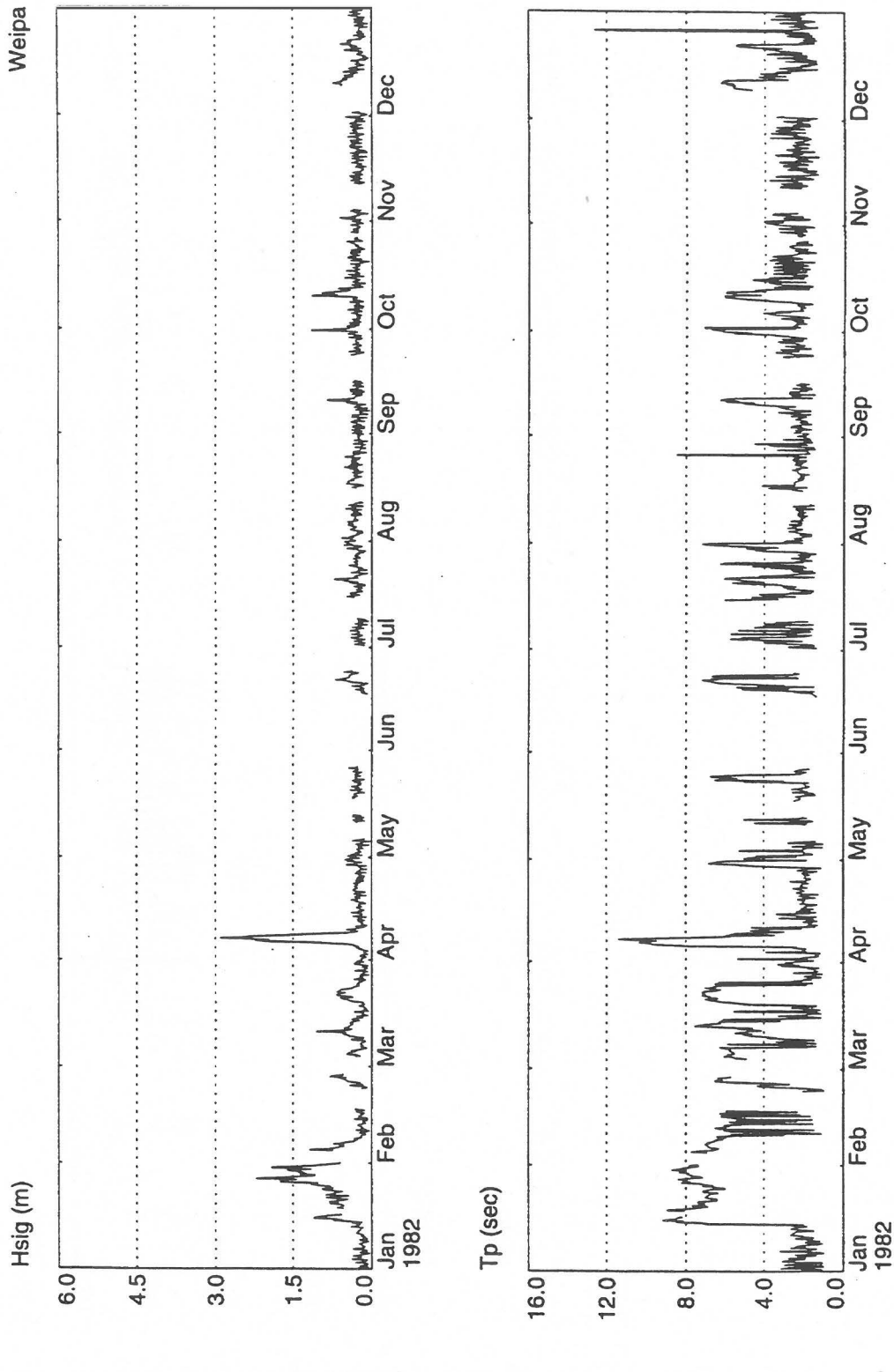


Daily wave recordings
1 January 1981 to 31 December 1981

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Weipa Region

Figure 6.04

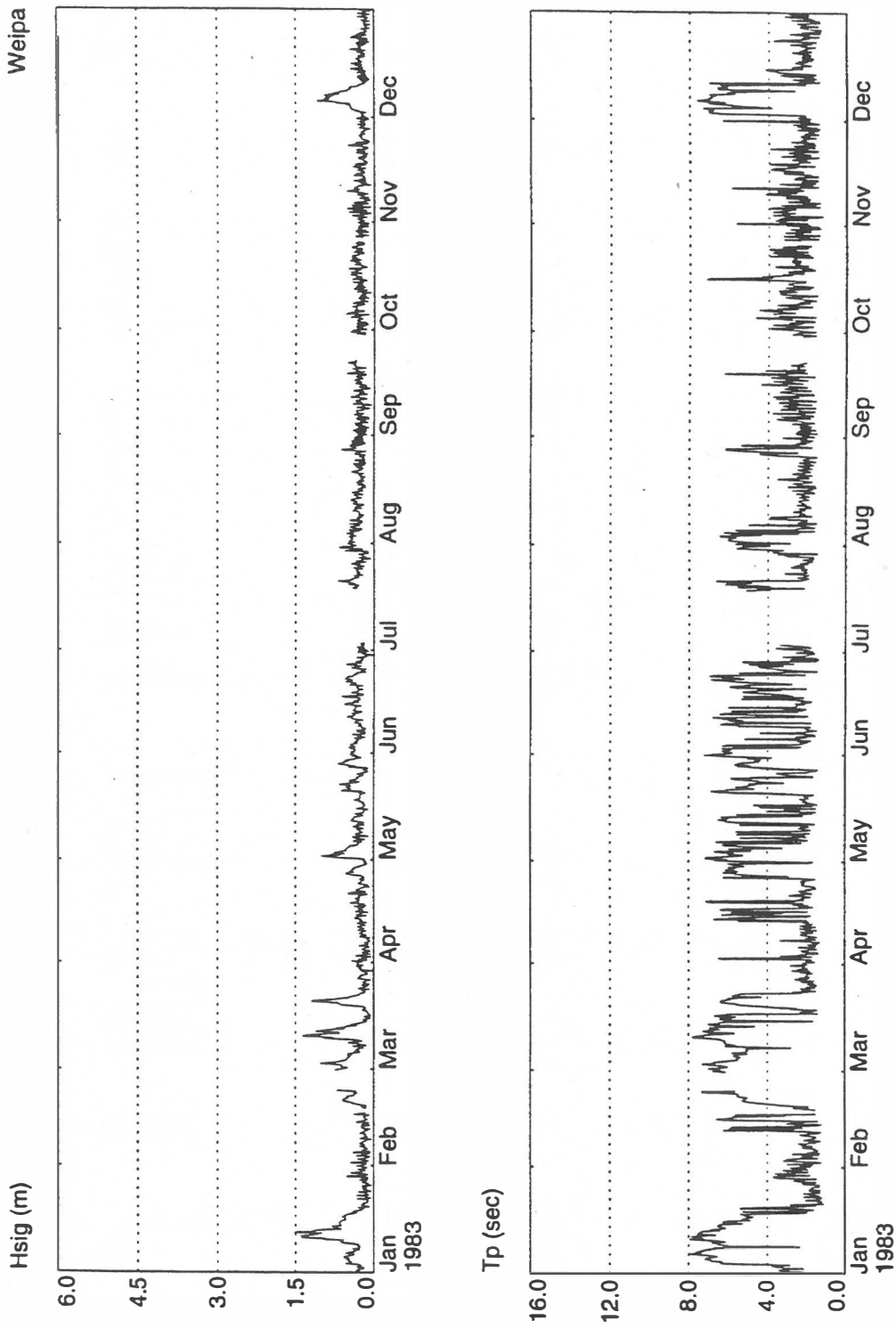


Daily wave recordings
1 January 1982 to 31 December 1982

Beach Protection Authority Queensland
Department of Environment and Heritage

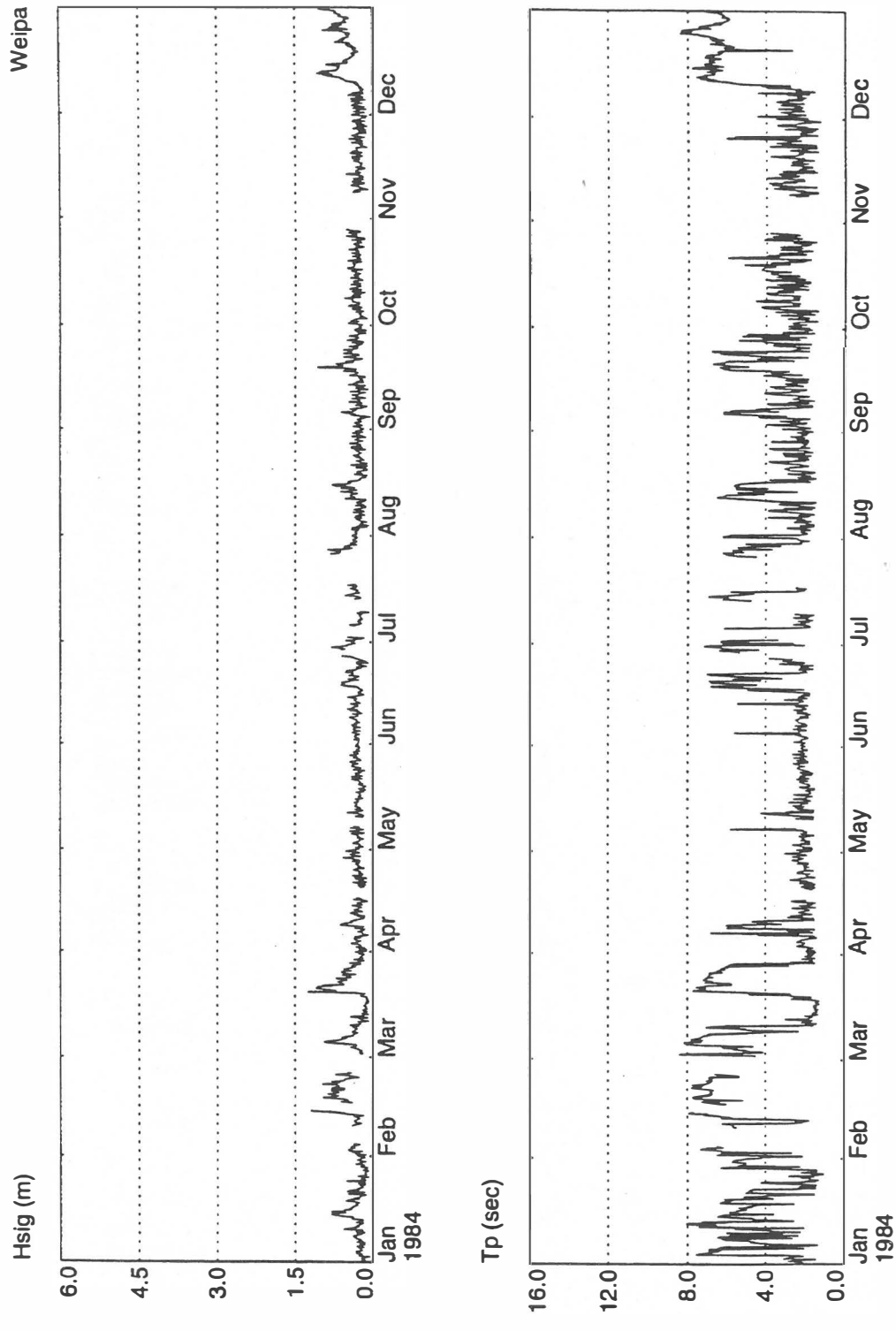
Wave data recording program
Weipa Region

Figure 6.05



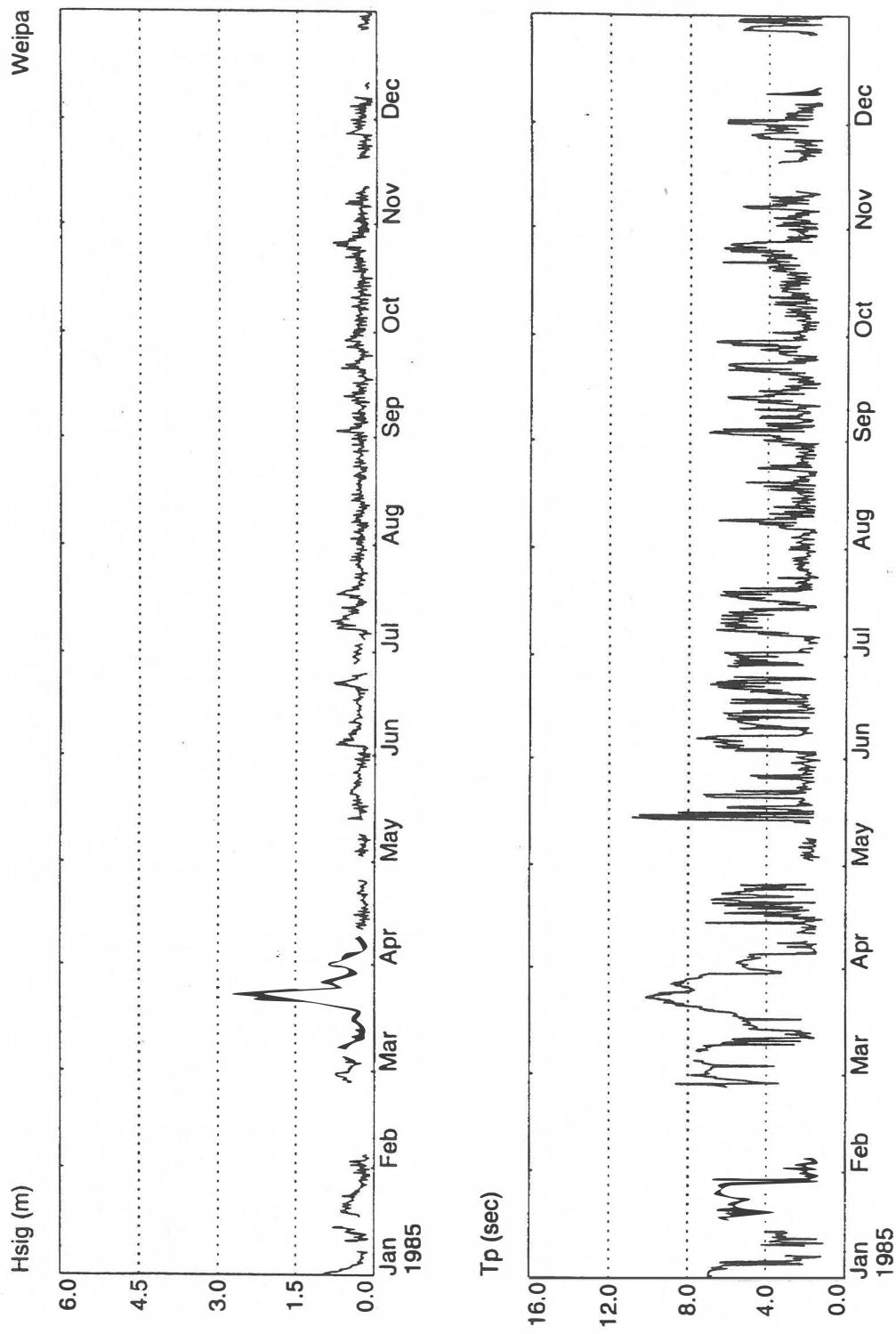
Daily wave recordings
1 January 1983 to 31 December 1983

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.06**



Daily wave recordings
1 January 1984 to 31 December 1984

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

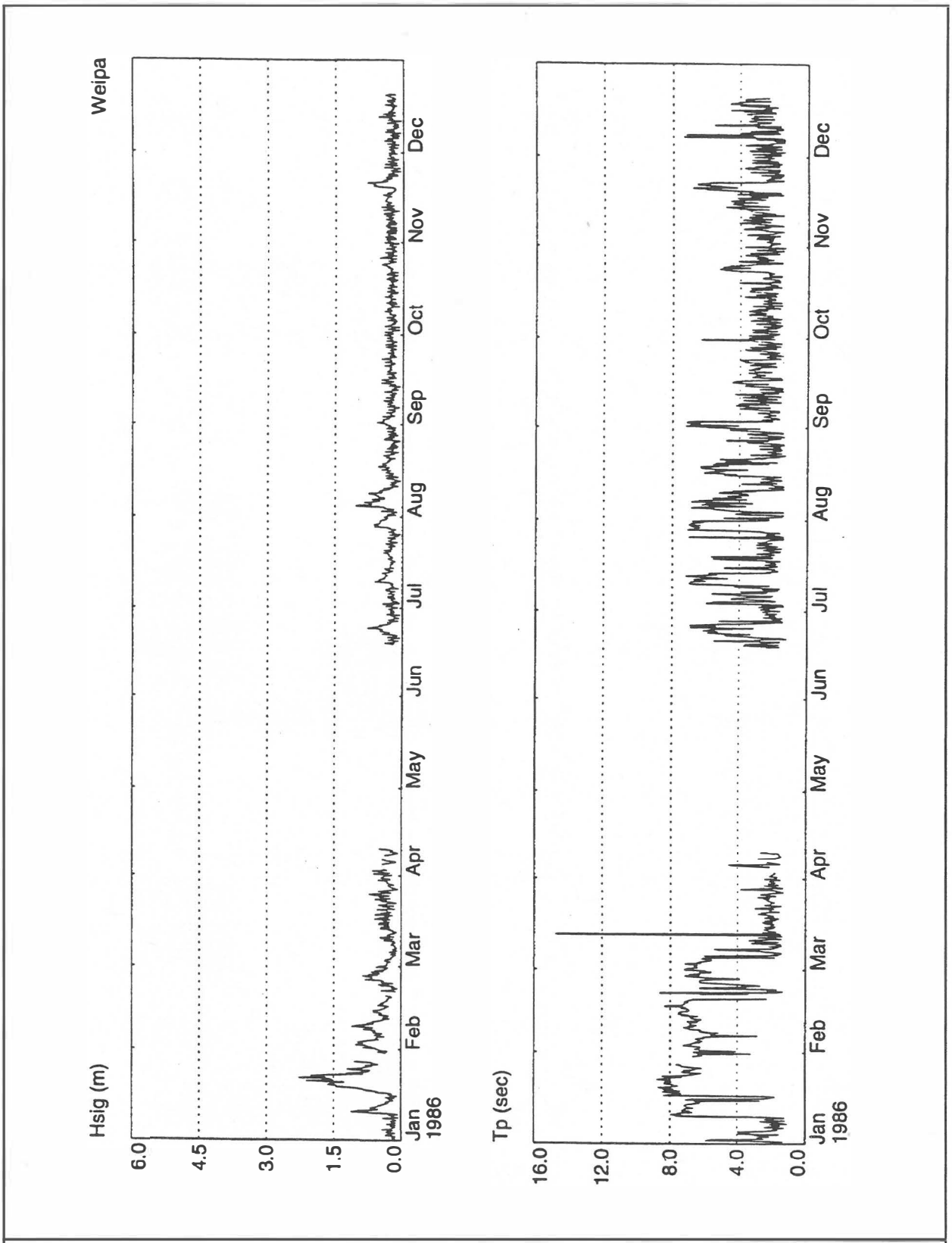


Daily wave recordings
1 January 1985 to 31 December 1985

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Weipa Region

Figure 6.08

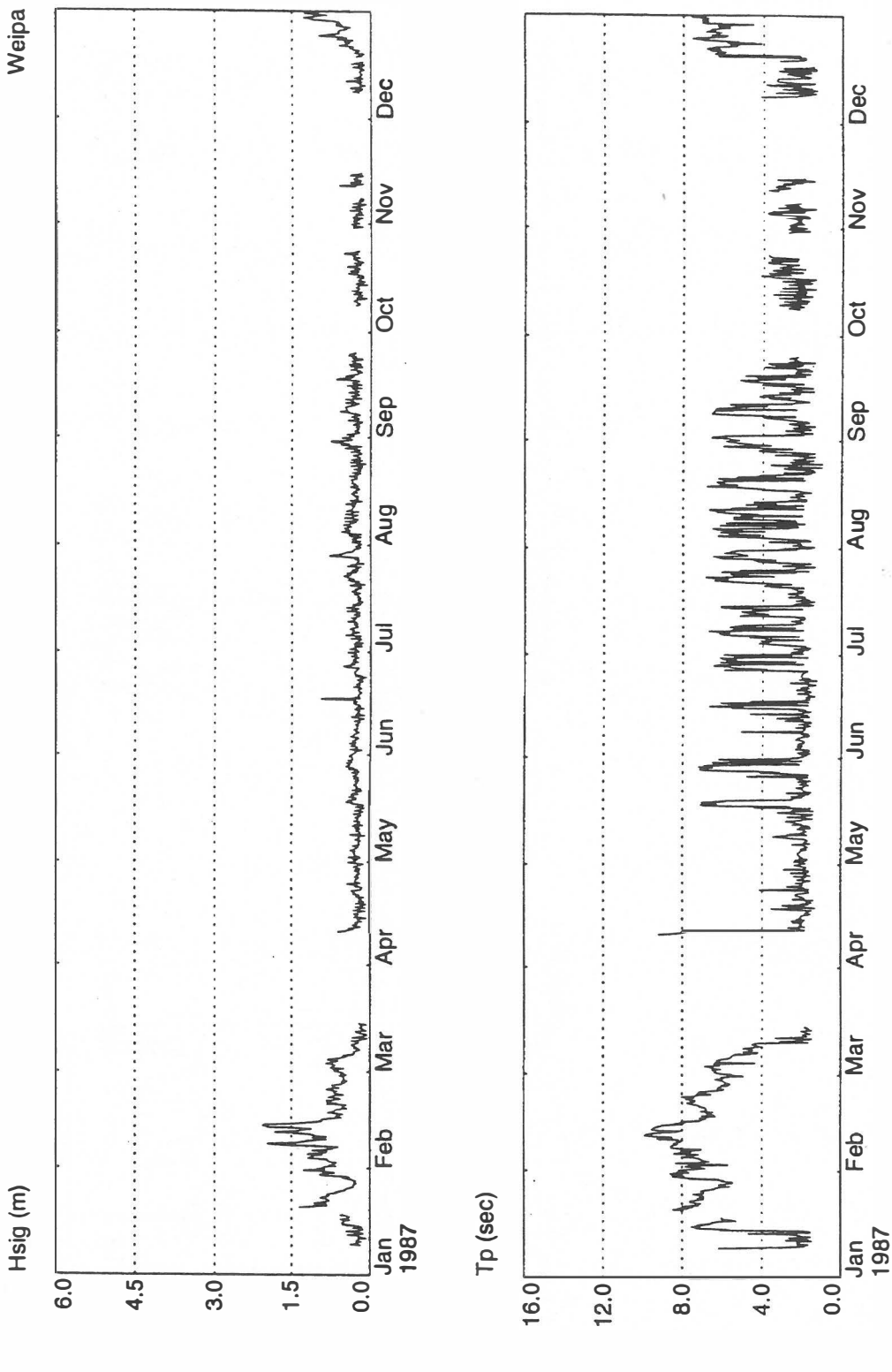


Daily wave recordings
1 January 1986 to 31 December 1986

Beach Protection Authority Queensland
Department of Environment and Heritage

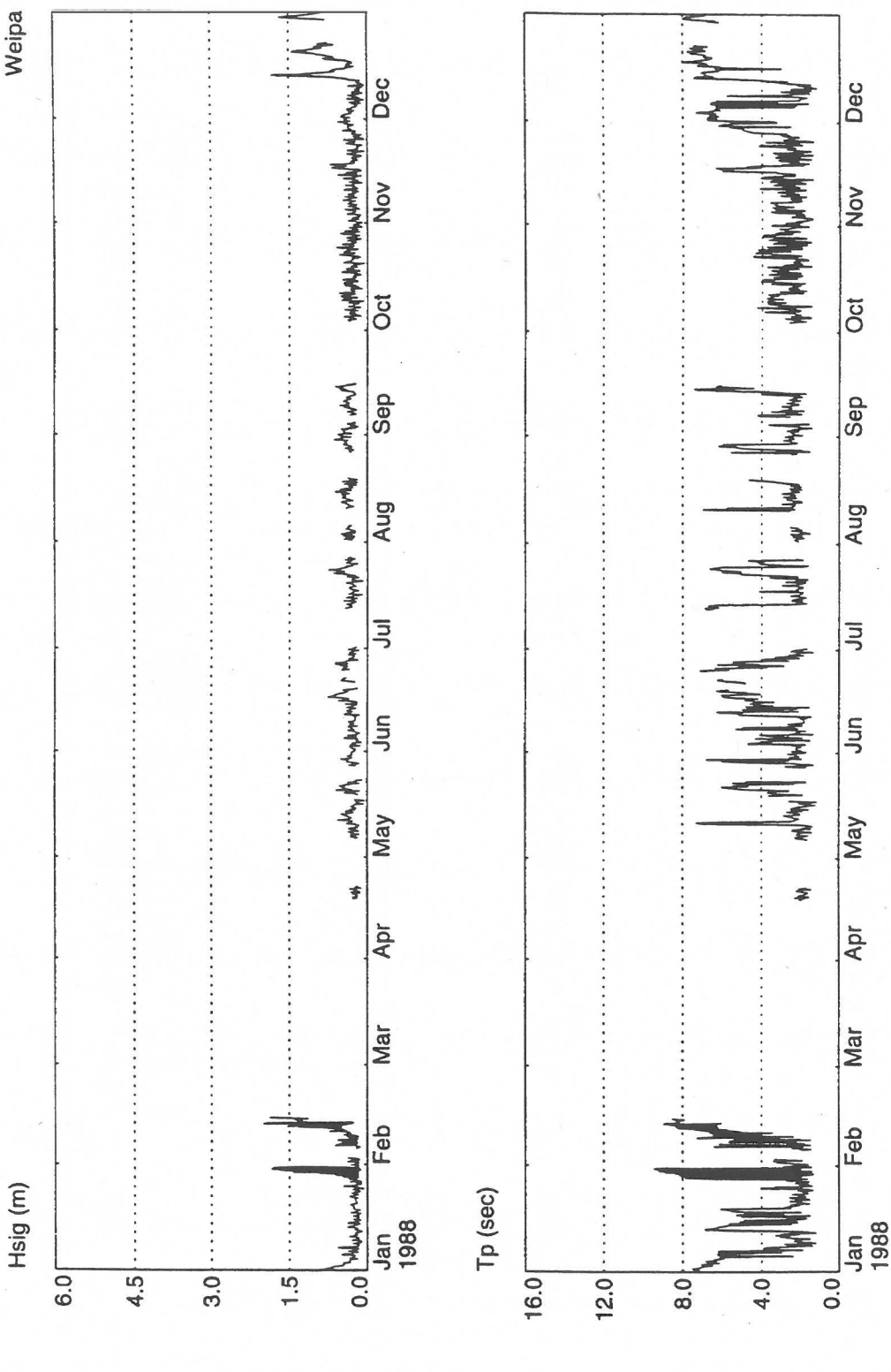
Wave data recording program
Weipa Region

Figure 6.09



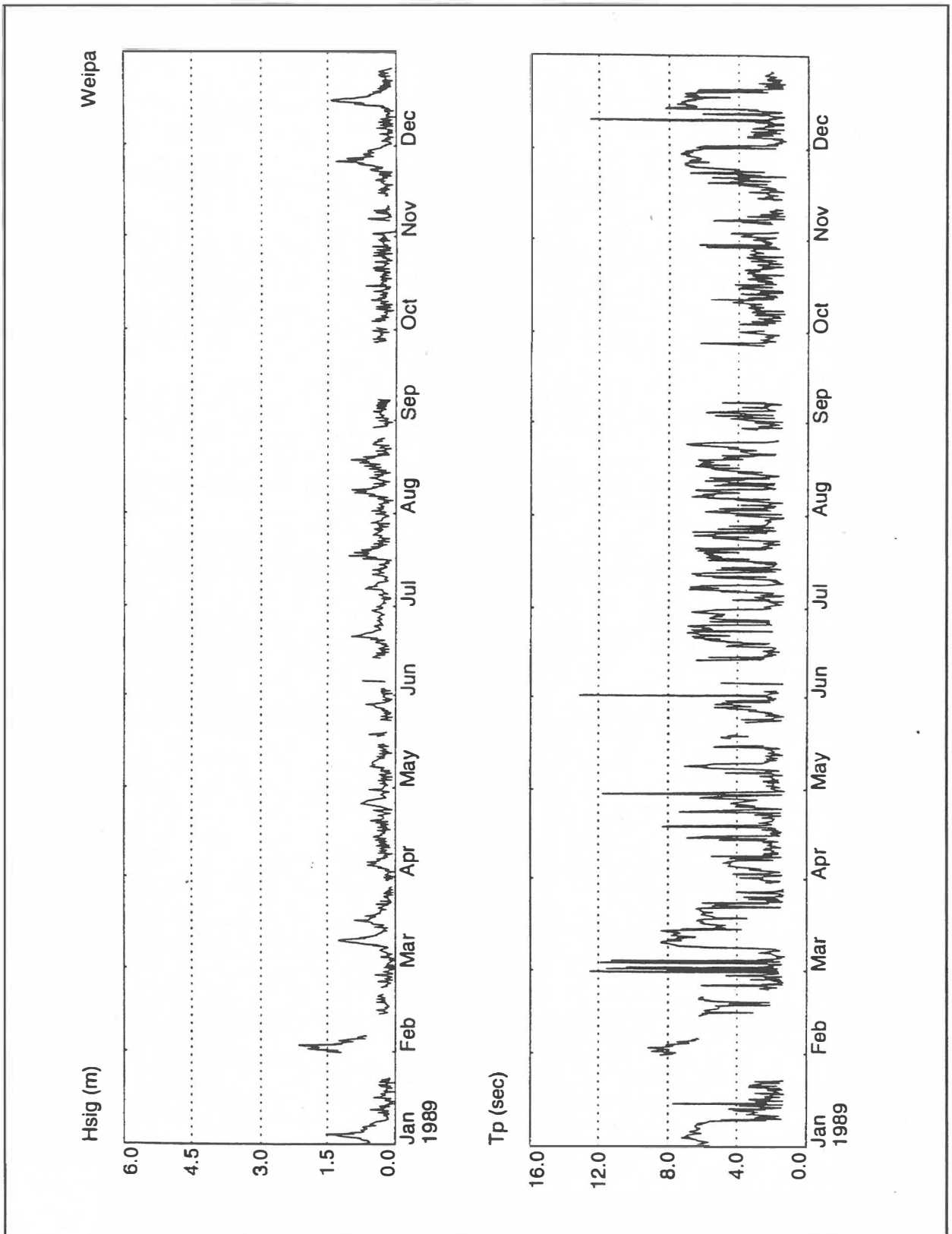
Daily wave recordings
1 January 1987 to 31 December 1987

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.10**



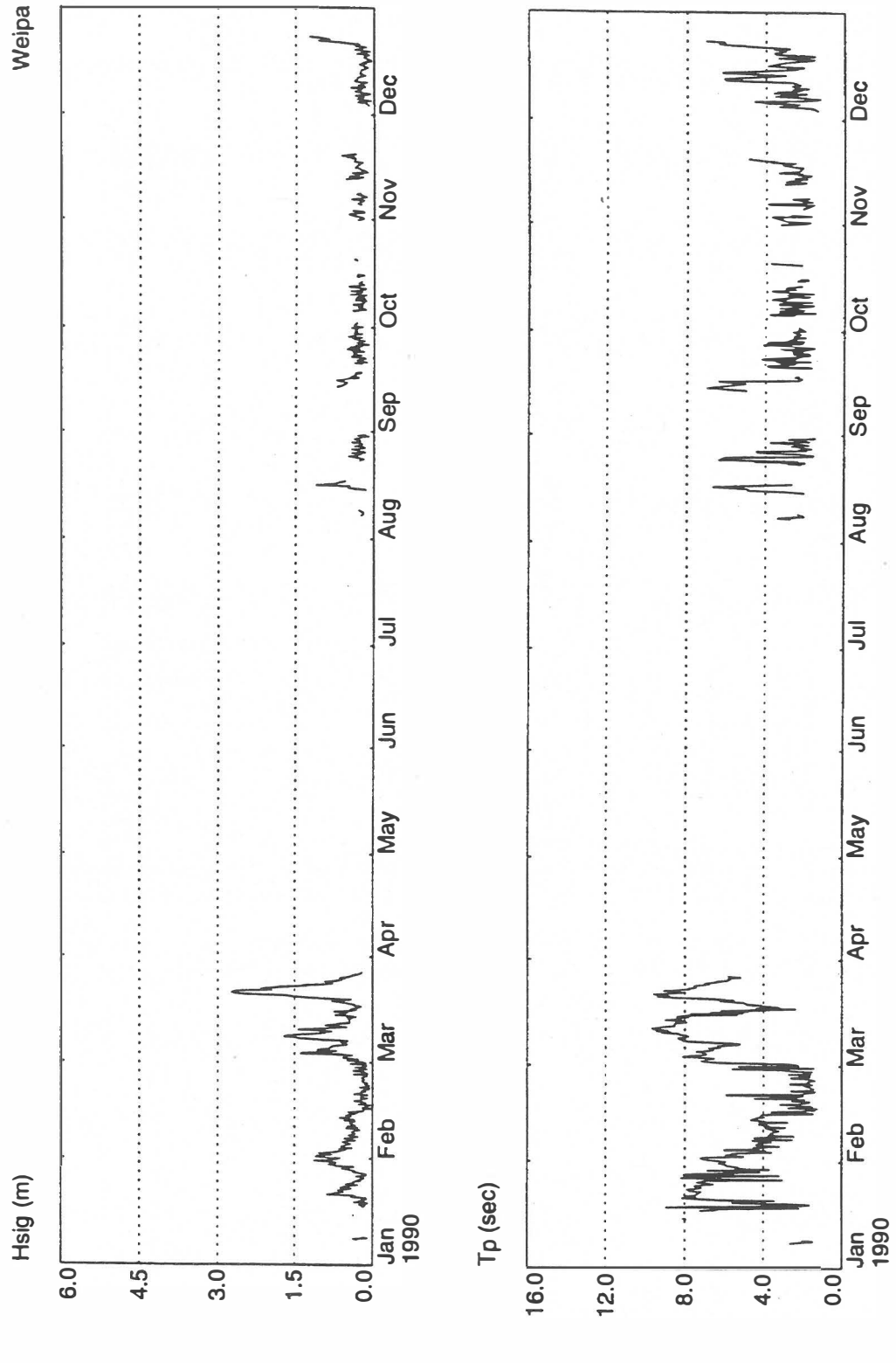
Daily wave recordings
1 January 1988 to 31 December 1988

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



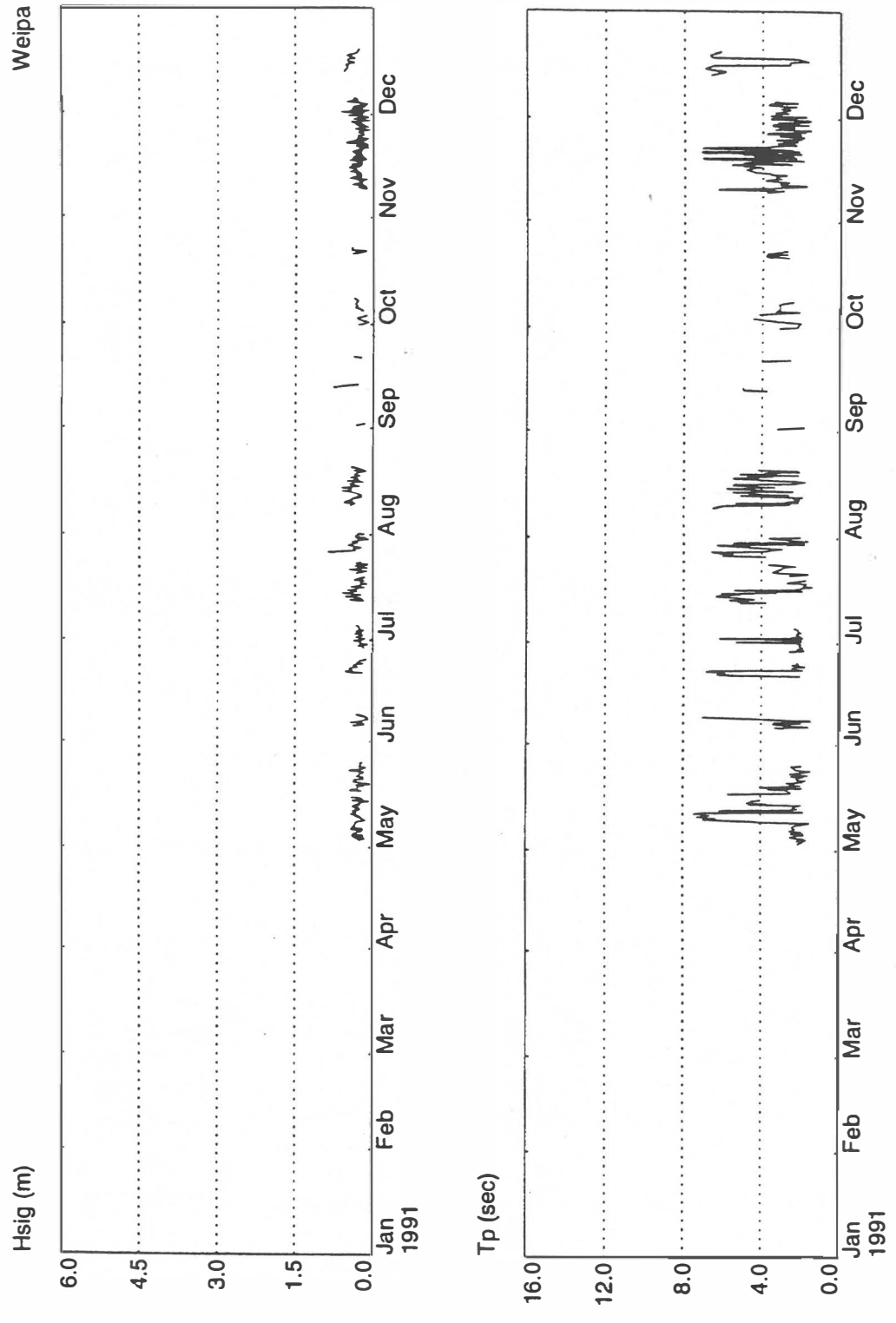
Daily wave recordings
1 January 1989 to 31 December 1989

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.12**



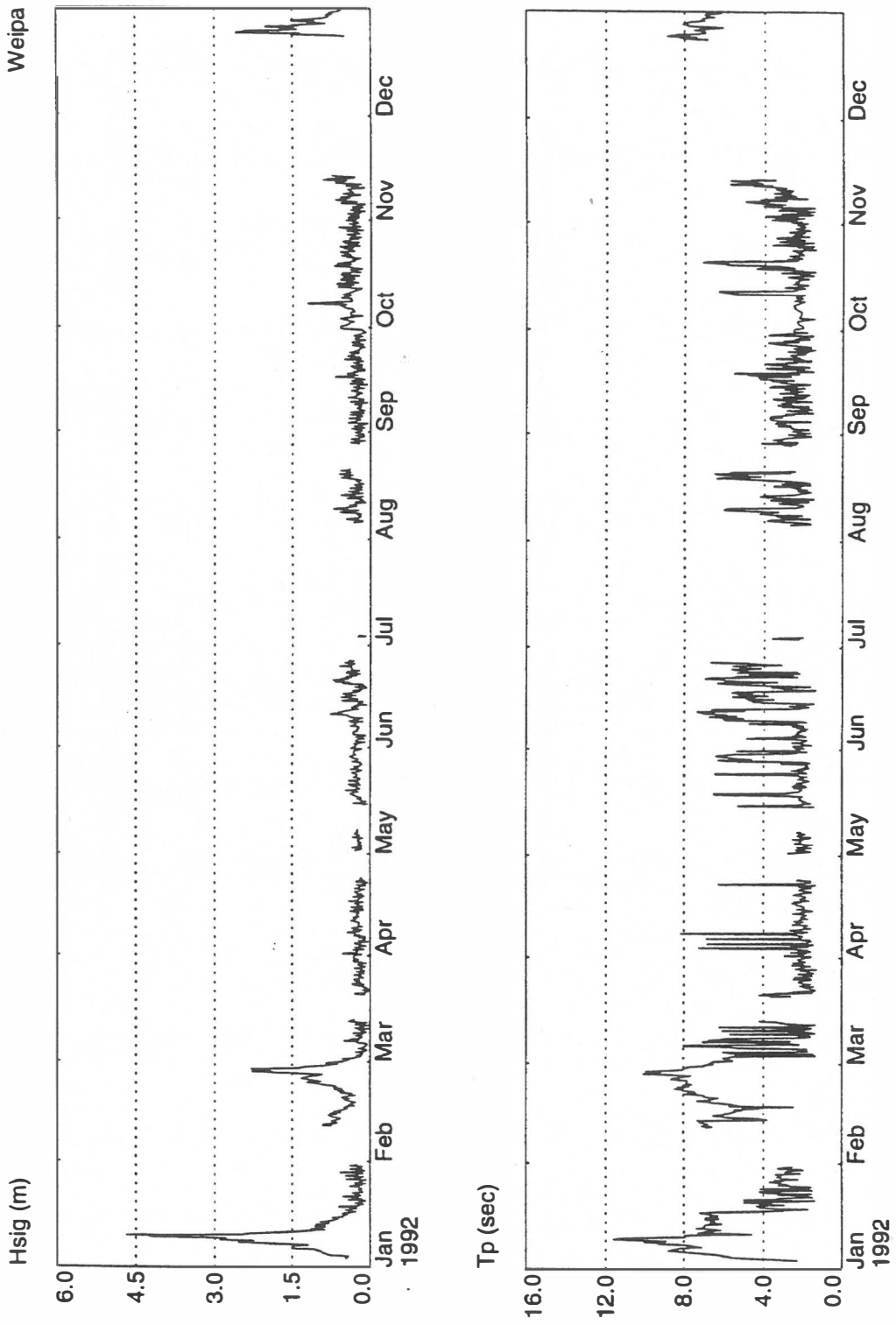
Daily wave recordings
1 January 1990 to 31 December 1990

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.13**



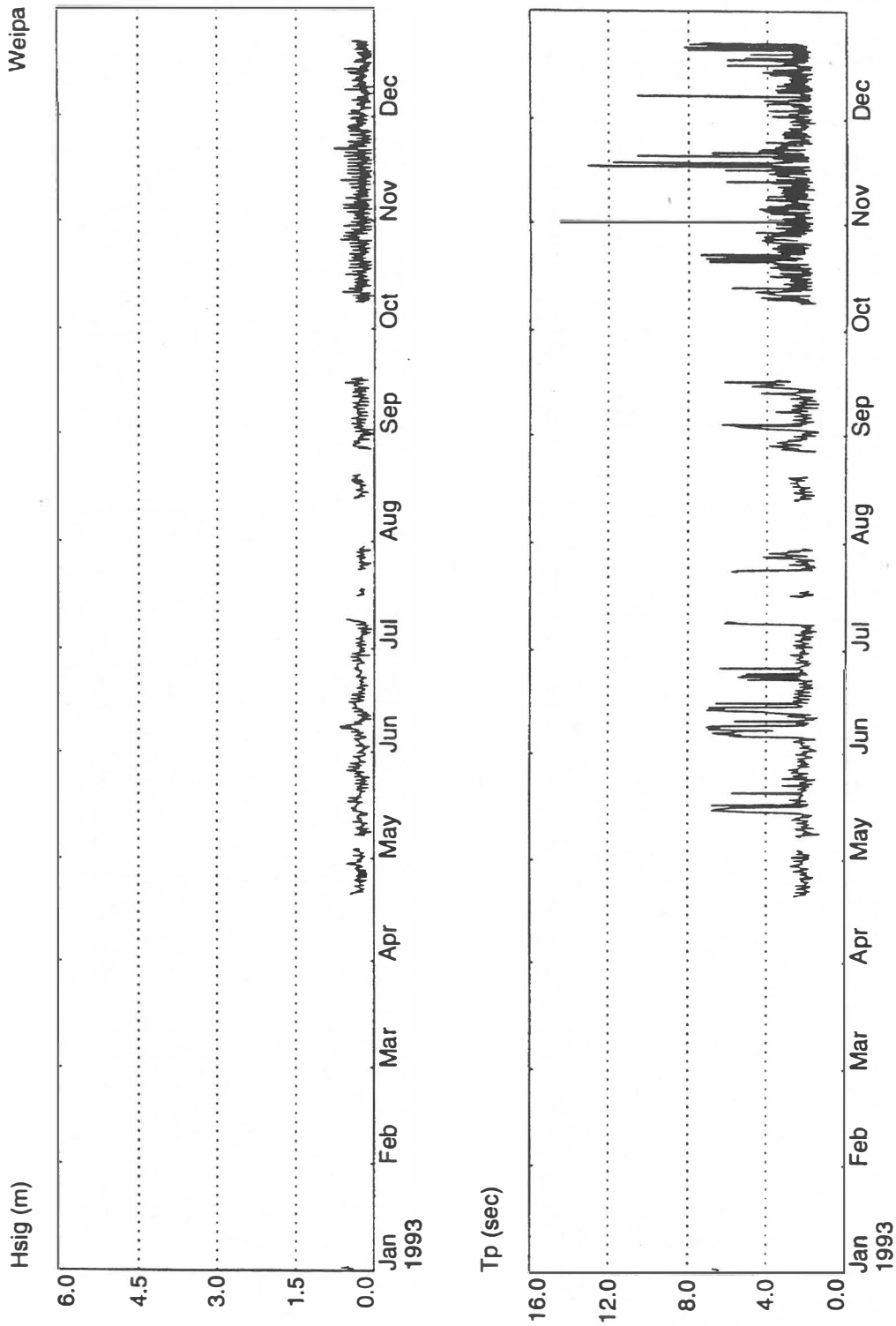
Daily wave recordings
1 January 1991 to 31 December 1991

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.14**



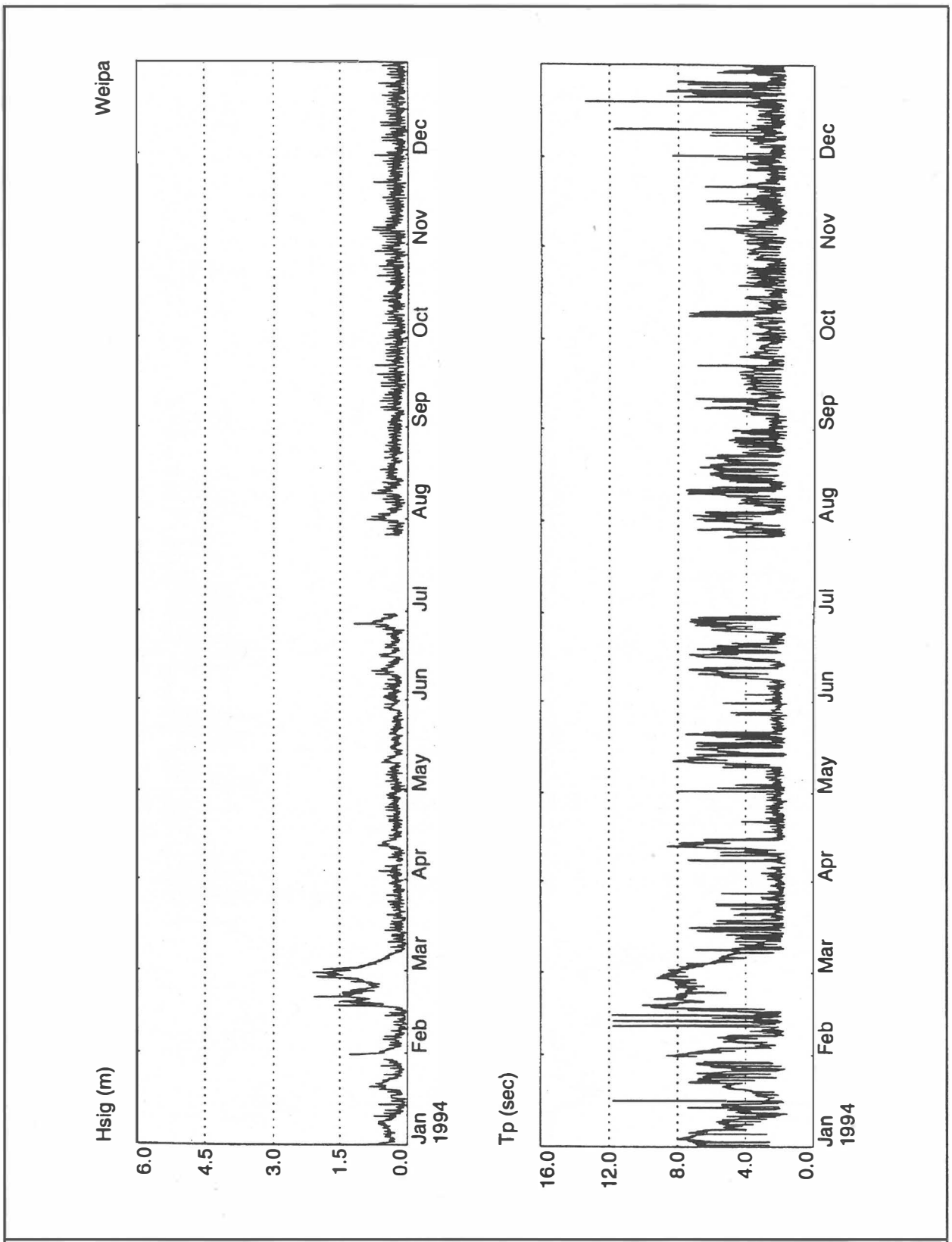
Daily wave recordings
1 January 1992 to 31 December 1992

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.15**



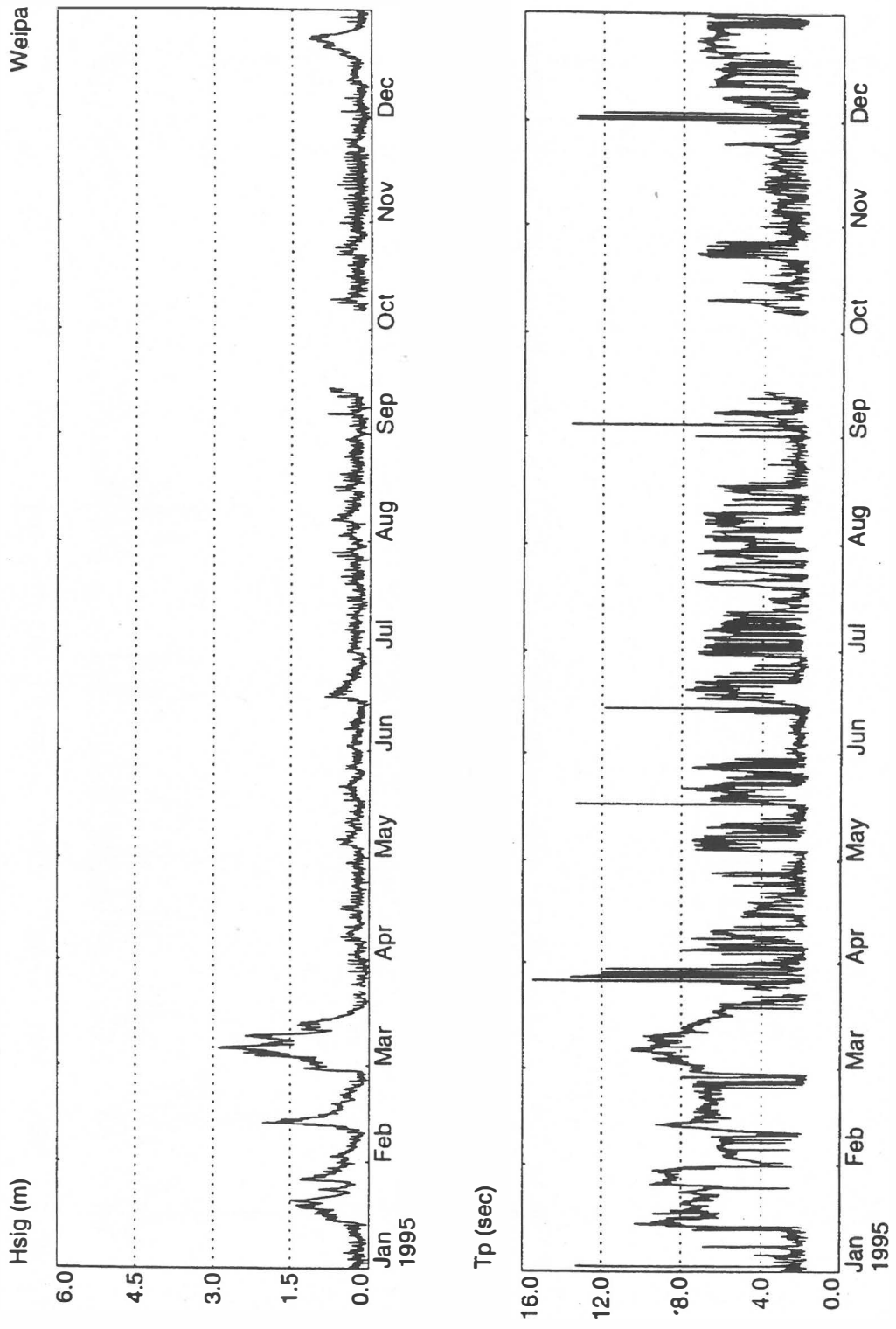
Daily wave recordings
1 January 1993 to 31 December 1993

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.16**



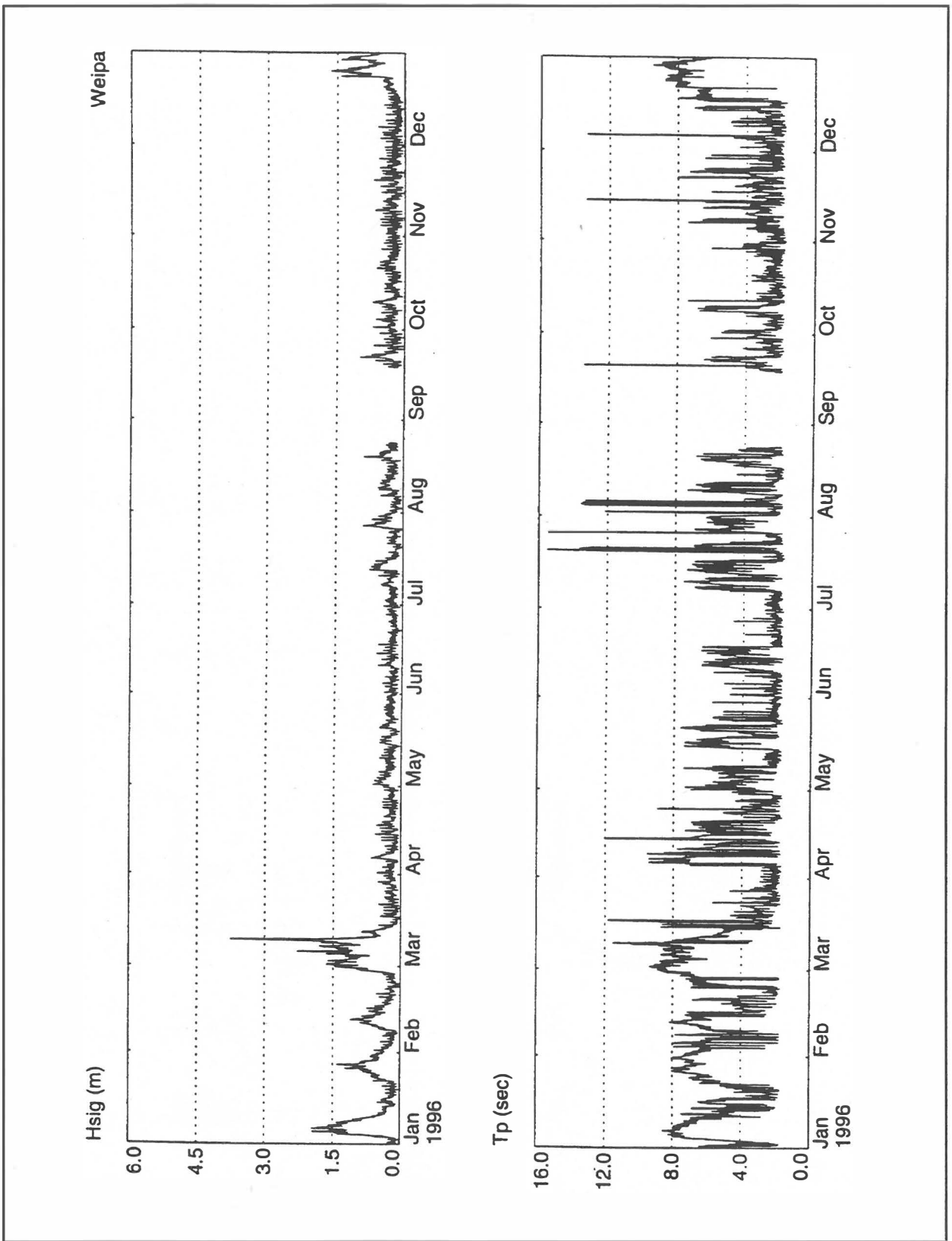
Daily wave recordings
1 January 1994 to 31 December 1994

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.17**



Daily wave recordings
1 January 1995 to 31 December 1995

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.18**

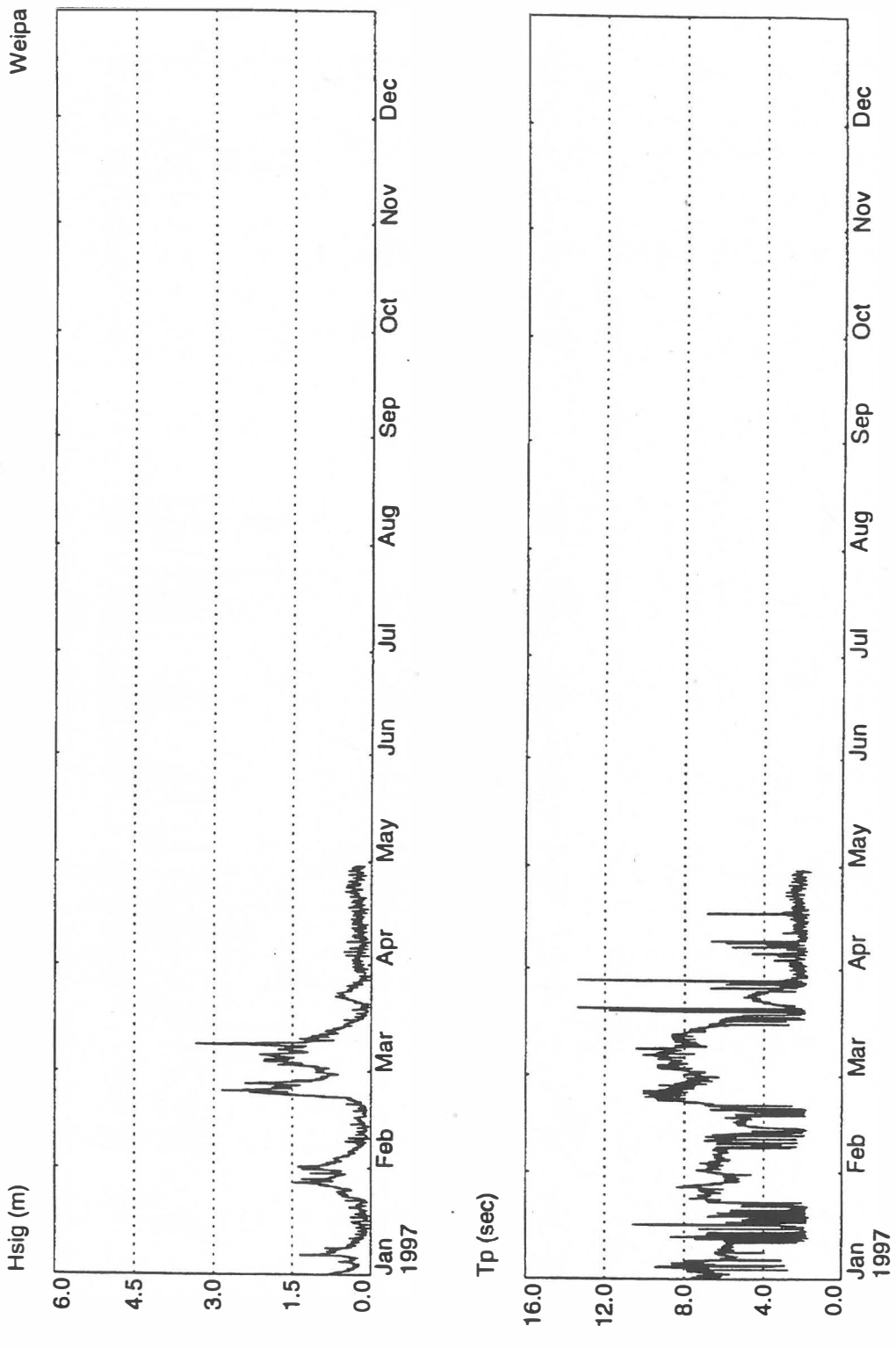


Daily wave recordings
1 January 1996 to 31 December 1996

Beach Protection Authority Queensland
Department of Environment and Heritage

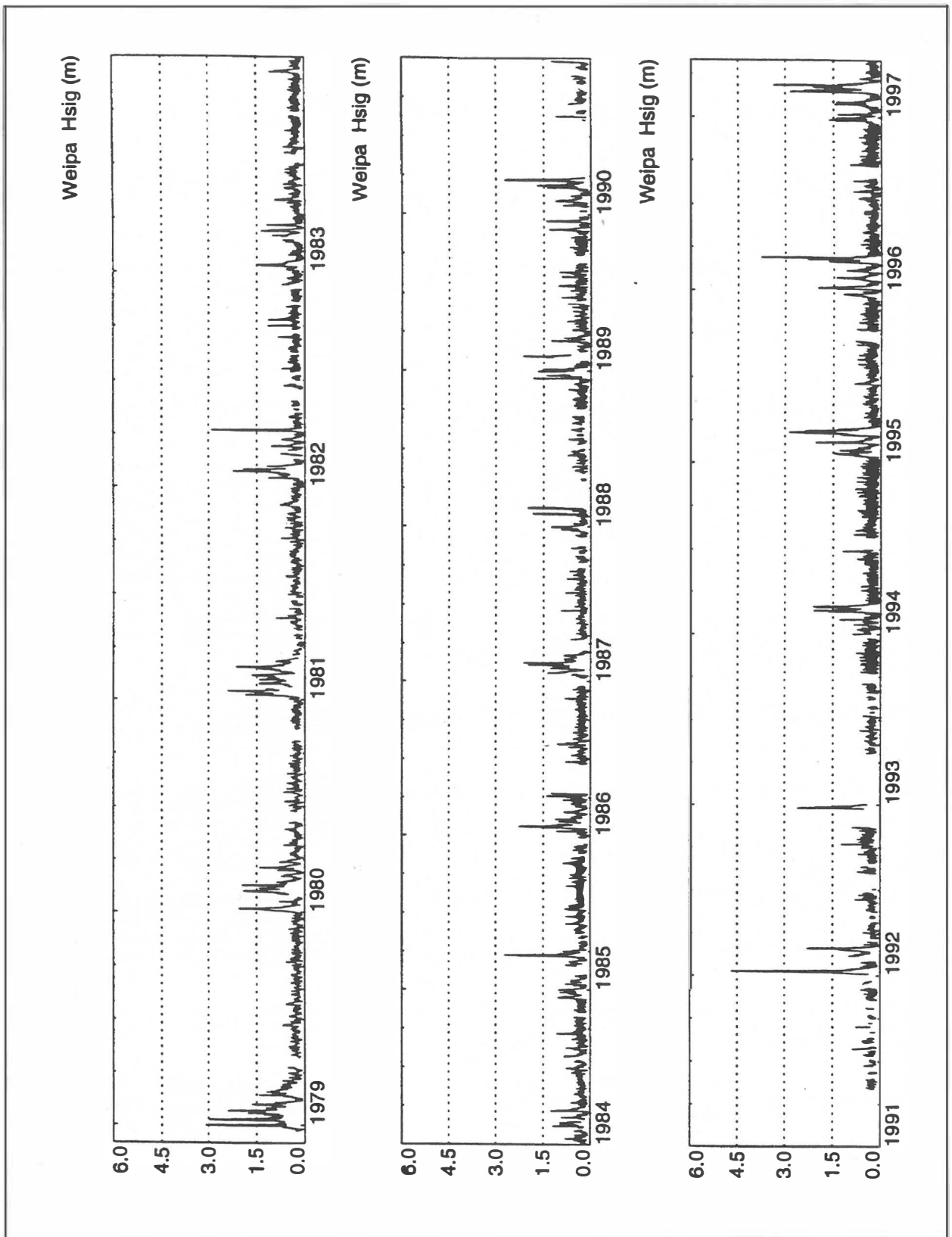
Wave data recording program
Weipa Region

Figure 6.19



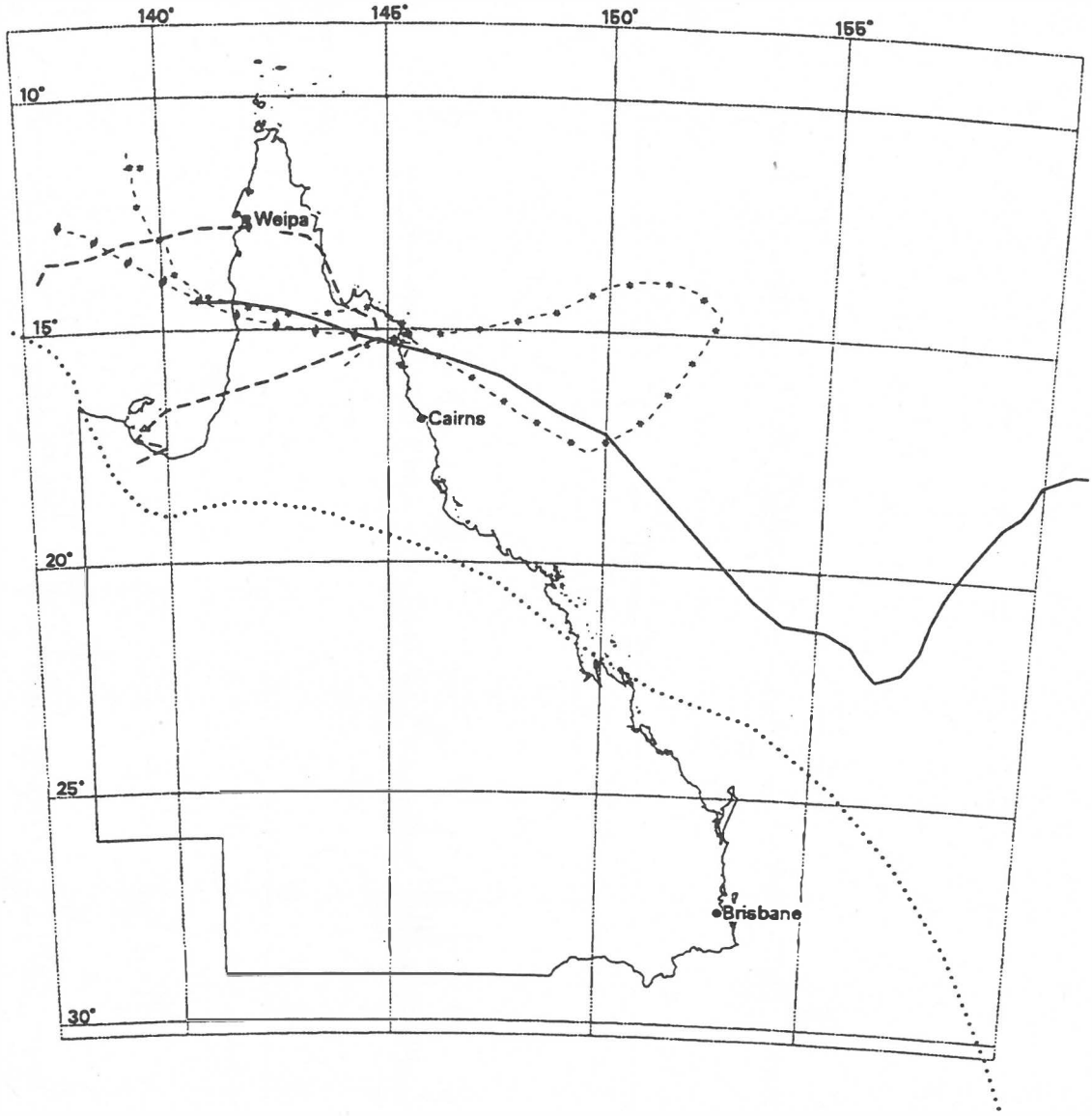
Daily wave recordings
1 January 1997 to 31 December 1997

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 6.20**



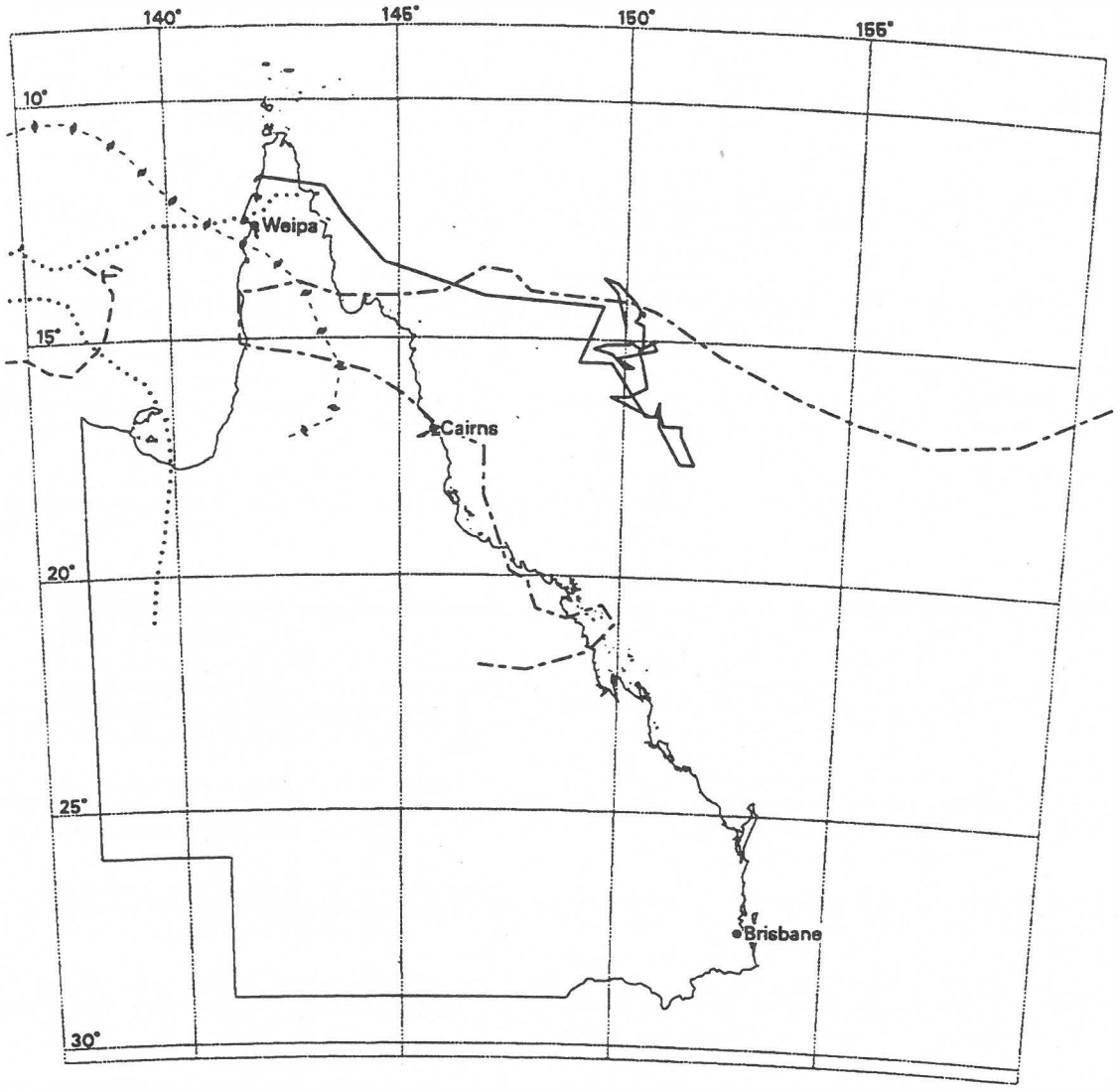
Whole recording period wave heights (Hsig)

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



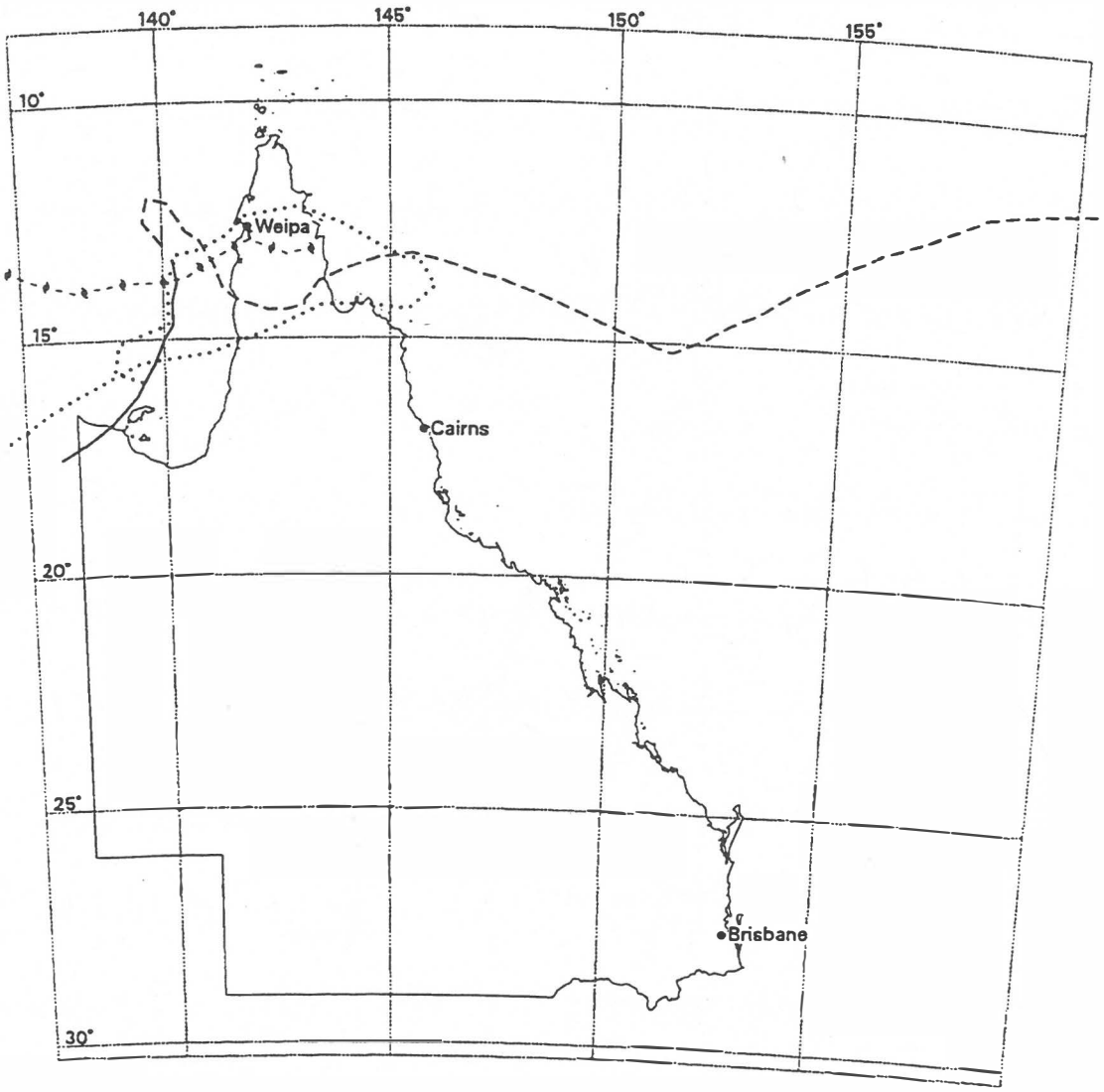
Cyclone Tracks
1978-1982

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 8.01**



Cyclone Tracks
1983-1991

Beach Protection Authority Queensland Department of Environment and Heritage	Wave data recording program Weipa Region	**Figure 8.02**



Key to cyclones

Mark — Nina

Warren — Ethel

1:16000000

0 160 320 480 640 800

kilometres

Cyclone Tracks
1992-1997

Beach Protection Authority Queensland
Department of Environment and Heritage

Wave data recording program
Weipa Region

Figure 8.03