Wave data recording program
Repulse Bay
1994-1995

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Abstract
This report summarises primary analyses of wave data recorded in water depths of approximately 17m in Repulse Bay, off shore of Laguna Quays in north Queensland. Data were recorded using a Datawell non-directional waverider buoy, and cover the period from 2 June 1994 to 22 October 1995. 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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Contents

1 Introduction

As part of its long-term data collection program, the Beach Protection Authority (the Authority) has maintained a network of wave recording stations along Queensland's coast since 1968. This has been done using a series of wave recording stations. This report summarises the primary analyses of wave data collected at the Repulse Bay 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 Authority's 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 measure 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 vertical 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 north-south and east-west directions.

Instantaneous water levels and directional data are then transmitted to a 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 coaxial transmission line to the water. An enclosed circuit board housing containing an electronic oscillator is 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

The configuration of the Repulse Bay station comprises a Datawell non-directional waverider buoy and a recording station, consisting of 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), was 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 buoy operation and the recording system, refer to 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 the calibration procedure.

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, and
- power output.

The recorded wave data is not adjusted in light of the laboratory calibration results.

3 Wave recording and analysis procedures

From 2 June 1994 to 22 October 1995, the PC-based recording system generally recorded wave data at (nominally) hourly intervals.

Recorded non-directional wave data were analysed in the time domain by the zero upcrossing method and in the frequency domain by spectral analysis. The PC-based non-directional data analysis used Fast Fourier Transform techniques to give 128 spectral estimates in bands of 0·01Hz.

Wave parameters resulting from this processing include the following:

S(f)	energy density spectrum
Hsig	significant wave height (time domain), the average of the highest 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)
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 (frequency domain)
Tc	average period of all the waves in the record based on successive crests (time domain)

These parameters are the basis for the summary plots and tables in 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 the PC-based system included some data rejection checks. A small number of spurious data points may be corrected by an interpolation procedure. Otherwise, the entire series was rejected.

Details of data losses for the Repulse Bay wave recording station are included 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 for wave heights and periods. The results of these analyses are presented in tables 1 to 6 and figs.2 and 3. Similar analyses were carried out on the relationships between the various wave parameters and these are presented in fig.4.

5.1 Methodology

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

In calculating wave climate statistics, each record was assigned a total duration equal to half the recording interval on either side of that record. The maximum allowable total duration of a nominal hourly record is equal to three hours. Each duration on either side of a record greater than 90 minutes (half the maximum allowable total duration) was set to the maximum allowable of exactly 90 minutes, and a gap in the data was 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 is used, the exact location of the buoy and the water depth in which the buoy was moored should be noted. This information is presented in appendix 1. The non-directional waverider recording system records only vertical movements of the water surface, 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 covered by this report, where the recorded Hsig value reached the storm threshold of 1·5m 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 Hsig reaching the storm threshold of 1·5m are listed in appendix 2.

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

For 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

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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) 19 Sept 1975–31 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
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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, 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 Jun 1994
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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) 13 Jan 1995–28 Feb 1997

Appendix 1
Details of wave recorder installation
Repulse Bay

Location of buoys
See fig.1 for location of waverider buoy and recording station for the period covered by this report.

Location: 148° 51' 32" east, 20° 37' 41" south
Description: 1·6km south of South Repulse Island
Buoy type: Datawell non-directional waverider
Water depth at buoy: 17m LAT
Period: 2 June 1994–22 October 1995

Notes: The above buoy location was measured using GPS fixing procedures. Water depth is accurate to ± 1m.

Location of recording station
Laguna Quays Harbour Master's Office, Laguna Quays
Location: 148° 40' 44" east, 20° 36' 18" south
Period: 2 June 1994–22 October 1995

Recording interval
2 June 1994–22 October 1995: one hourly records each of approximately 26 minutes. This gives 4096 water surface elevation values for that period, from which seastate parameters are calculated and recorded.

Data collection and analysis:
Period: 2 June 1994–22 October 1995

Number of records collected:	10 814
Number of records used in analysis:	10 814
Number of days in recording period:	507.92
Number of days used in analysis:	482.58
Number of days lost:	25.34

Appendix 2
Major meteorological events
Repulse Bay

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]
High pressure system off New South Wales coast	1036	11-08-94		1·58	2·85	4·97
High pressure system over Tasman Sea	1024	05-12-94		1·73	3·84	6·51
High pressure system over Tasman Sea	1020	16-12-94		1·58	2·53	4·87
High pressure system over Tasman Sea	1028	28-04-95		1·50	2·91	5·38
High pressure system over Tasman Sea	1032	08-05-95		1·52	2·98	6·07
High pressure system off New South Wales coast	1024	10-10-95		1·60	2·83	5·49
High pressure system off New South Wales coast	1032	16-10-95		2·06	4·47	6·08

Notes: The above table includes all events with a recorded Hsig value that reached the storm threshold of 1·5m.
1, 2: Hsig 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 2·06m on 16 October 1995 coincident with a 1032hPa high pressure system off the New South Wales coast.

Highest maximum wave height (Hmax) recorded was 4·47m on 16 October 1995 coincident with a 1032hPa high pressure system off the New South Wales coast.

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

Appendix 3
Tropical cyclones of the east coast of Queensland
2 June 1994–22 October 1995

Cyclone name	Year	Month
Violet	1995	3
Agnes-95	1995	4

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	43·25	24·33	12·52	8·50	7·96	3·19	0·67	0·06	100·47
0·20–0·39	61·00	57·99	13·92	1·52	1·02	0·37	0·04	*	135·86
0·40–0·59	5·77	69·27	11·42	0·23	*	*	*	*	86·69
0·60–0·79	0·08	53·09	15·23	0·21	*	*	*	*	68·60
0·80–0·99	*	35·96	15·77	0·04	*	*	*	*	51·77
1·00–1·19	*	14·09	13·23	*	*	*	*	*	27·31
1·20–1·39	*	1·83	6·06	*	*	*	*	*	7·90
1·40–1·59	*	0·35	2·58	*	*	*	*	*	2·94
1·60–1·79	*	*	0·83	*	*	*	*	*	0·83
1·80–1·99	*	*	0·17	*	*	*	*	*	0·17
2·00–2·19	*	*	0·04	*	*	*	*	*	0·04
2·20–2·39	*	*	*	*	*	*	*	*	0·00
Totals	110·10	256·90	91·77	10·50	8·98	3·56	0·71	0·06	482·58

* = 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	16·10	11·04	2·94	3·19	4·90	1·23	0·21	*	39·60
0·20–0·39	27·09	24·79	7·21	0·69	0·94	0·08	*	*	60·80
0·40–0·59	2·33	22·46	4·92	0·17	*	*	*	*	29·87
0·60–0·79	*	12·31	3·46	0·21	*	*	*	*	15·98
0·80–0·99	*	6·33	3·42	0·04	*	*	*	*	9·79
1·00–1·19	*	2·23	2·15	*	*	*	*	*	4·37
1·20–1·39	*	0·17	1·33	*	*	*	*	*	1·50
1·40–1·59	*	0·08	0·71	*	*	*	*	*	0·79
1·60–1·79	*	*	0·21	*	*	*	*	*	0·21
1·80–1·99	*	*	*	*	*	*	*	*	0·00
2·00–2·19	*	*	*	*	*	*	*	*	0·00
2·20–2·39	*	*	*	*	*	*	*	*	0·00
Totals	45·52	79·42	26·33	4·29	5·83	1·31	0·21	0·00	162·92

* = 0·00
(Table values are numbers of days for the recording period, rounded to the second decimal place.)

Table 3.

Wave statistic
— wave period (Tp)/wave height (Hsig) occurrences
— winter 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	27·15	13·29	9·58	5·31	3·06	1·96	0·46	0·06	60·87
0·20–0·39	33·91	33·19	6·71	0·83	0·08	0·29	0·04	*	75·07
0·40–0·59	3·44	46·81	6·50	0·06	*	*	*	*	56·81
0·60–0·79	0·08	40·77	11·77	*	*	*	*	*	52·62
0·80–0·99	*	29·62	12·35	*	*	*	*	*	41·98
1·00–1·19	*	11·86	11·08	*	*	*	*	*	22·94
1·20–1·39	*	1·67	4·73	*	*	*	*	*	6·40
1·40–1·59	*	0·27	1·88	*	*	*	*	*	2·15
1·60–1·79	*	*	0·62	*	*	*	*	*	0·62
1·80–1·99	*	*	0·17	*	*	*	*	*	0·17
2·00–2·19	*	*	0·04	*	*	*	*	*	0·04
2·20–2·39	*	*	*	*	*	*	*	*	0·00
Totals	64·58	177·48	65·44	6·21	3·15	2·25	0·50	0·06	319·67

* = 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	8·96	5·04	2·59	1·76	1·65	0·66	0·14	0·01	20·82
0·20–0·39	12·64	12·02	2·88	0·31	0·21	0·08	0·01	*	28·15
0·40–0·59	1·20	14·35	2·37	0·05	*	*	*	*	17·96
0·60–0·79	0·02	11·00	3·16	0·04	*	*	*	*	14·22
0·80–0·99	*	7·45	3·27	0·01	*	*	*	*	10·73
1·00–1·19	*	2·92	2·74	*	*	*	*	*	5·66
1·20–1·39	*	0·38	1·26	*	*	*	*	*	1·64
1·40–1·59	*	0·07	0·54	*	*	*	*	*	0·61
1·60–1·79	*	*	0·17	*	*	*	*	*	0·17
1·80–1·99	*	*	0·03	*	*	*	*	*	0·03
2·00–2·19	*	*	0·01	*	*	*	*	*	0·01
2·20–2·39	*	*	*	*	*	*	*	*	0·00
Totals	22·82	53·23	19·02	2·18	1·86	0·74	0·15	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 (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	9·88	6·78	1·80	1·96	3·01	0·75	0·13	*	24·31
0·20–0·39	16·63	15·22	4·42	0·42	0·58	0·05	*	*	37·32
0·40–0·59	1·43	13·79	3·02	0·10	*	*	*	*	18·34
0·60–0·79	*	7·56	2·12	0·13	*	*	*	*	9·81
0·80–0·99	*	3·89	2·10	0·03	*	*	*	*	6·01
1·00–1·19	*	1·37	1·32	*	*	*	*	*	2·68
1·20–1·39	*	0·10	0·82	*	*	*	*	*	0·92
1·40–1·59	*	0·05	0·43	*	*	*	*	*	0·49
1·60–1·79	*	*	0·13	*	*	*	*	*	0·13
1·80–1·99	*	*	*	*	*	*	*	*	0·00
2·00–2·19	*	*	*	*	*	*	*	*	0·00
2·20–2·39	*	*	*	*	*	*	*	*	0·00
Totals	27·94	48·75	16·16	2·63	3·58	0·81	0·13	0·00	100·00

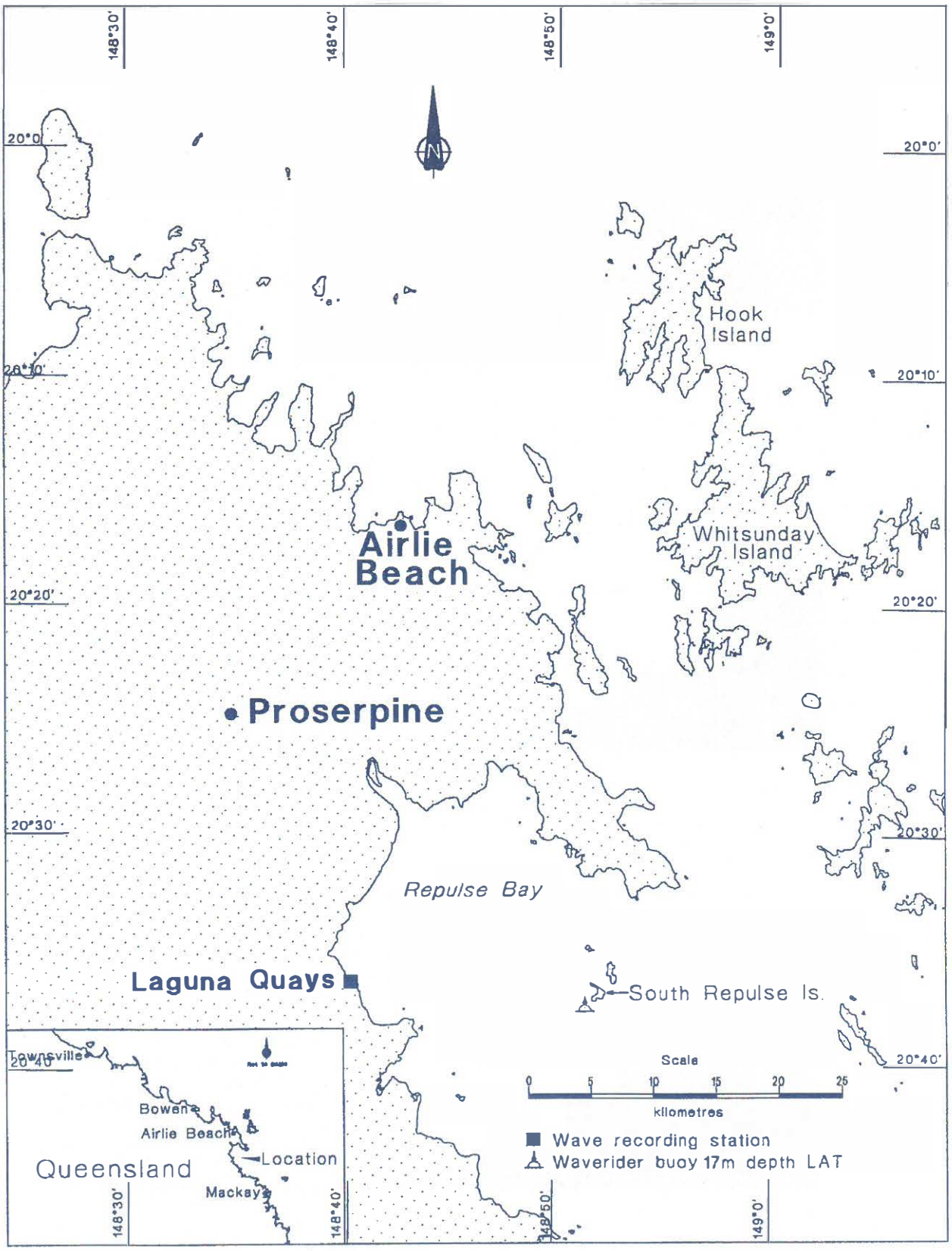
* = 0·00
(Table values are percentage occurrences for the recording period, rounded to the second decimal place.)

Table 6.

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

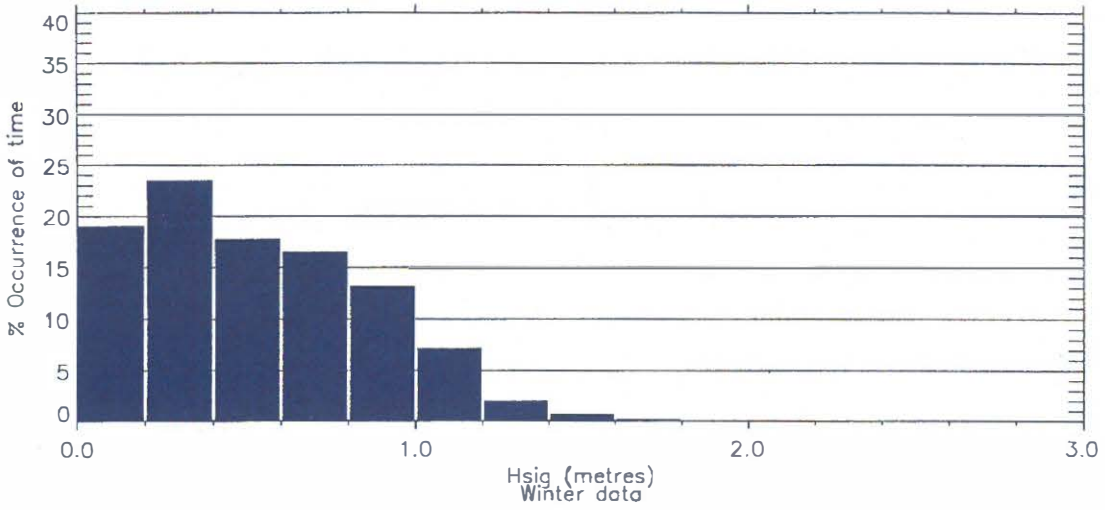
Significant wave height (Hsig) (metres)	Peak energy wave period (Tp) (seconds)								
	0-2·99	3-4·99	5-6·99	7-8·99	9-10·99	11-12·99	13-14·99	>14·99	Totals
0·00–0·19	8·49	4·16	3·00	1·66	0·96	0·61	0·14	0·02	19·04
0·20–0·39	10·61	10·38	2·10	0·26	0·03	0·09	0·01	*	23·48
0·40–0·59	1·07	14·64	2·03	0·02	*	*	*	*	17·77
0·60–0·79	0·03	12·75	3·68	*	*	*	*	*	16·46
0·80–0·99	*	9·27	3·86	*	*	*	*	*	13·13
1·00–1·19	*	3·71	3·47	*	*	*	*	*	7·18
1·20–1·39	*	0·52	1·48	*	*	*	*	*	2·00
1·40–1·59	*	0·08	0·59	*	*	*	*	*	0·67
1·60–1·79	*	*	0·20	*	*	*	*	*	0·20
1·80–1·99	*	*	0·05	*	*	*	*	*	0·05
2·00–2·19	*	*	0·01	*	*	*	*	*	0·01
2·20–2·39	*	*	*	*	*	*	*	*	0·00
Totals	20·20	55·52	20·47	1·94	0·98	0·70	0·16	0·02	100·00

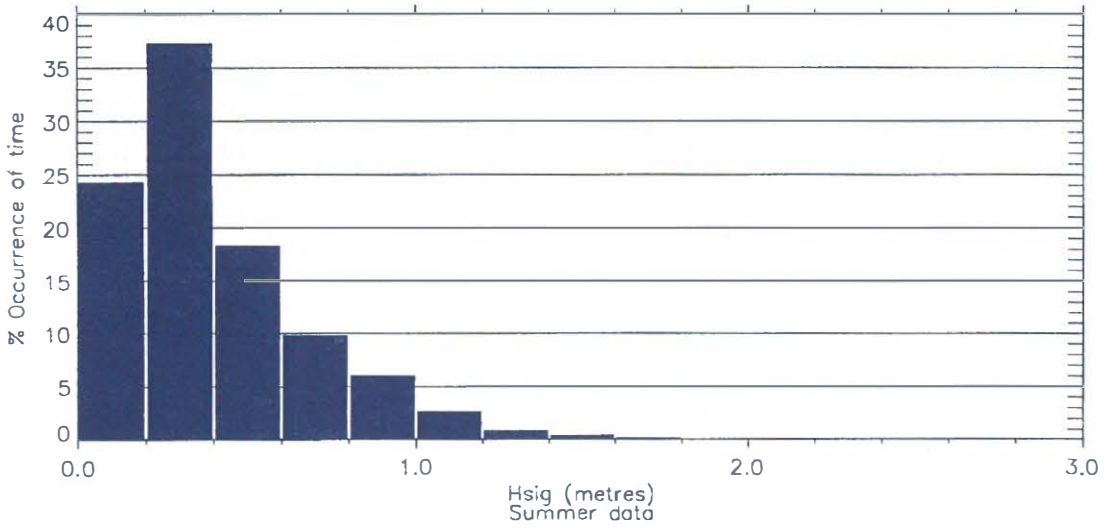
* = 0·00
(Table values are percentage occurrences for the recording period, rounded to the second decimal place.)

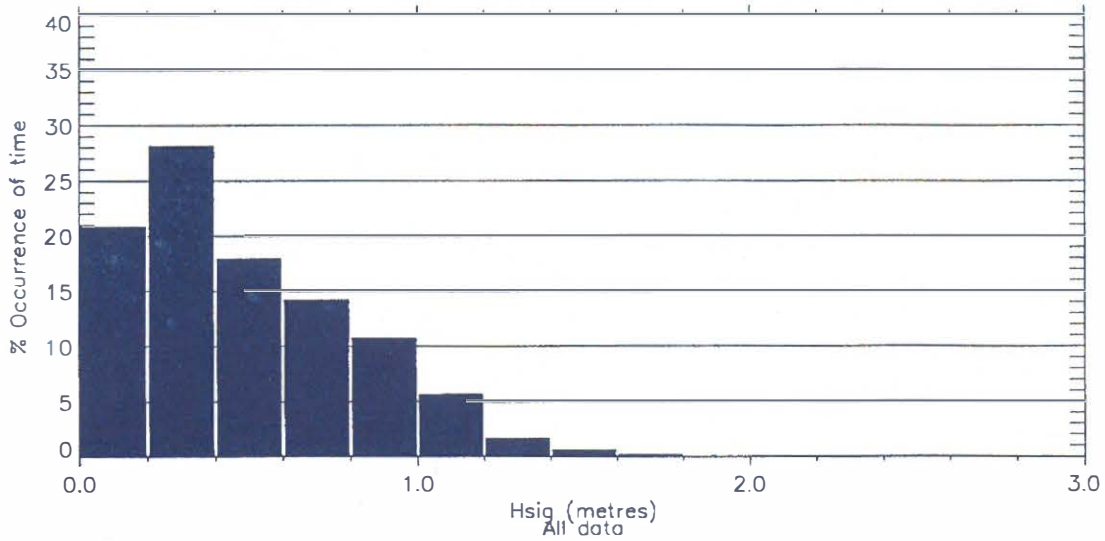


Locality plan

Beach Protection Authority Queensland Department of Environment	Wave data recording program Repulse Bay	**Figure 1**

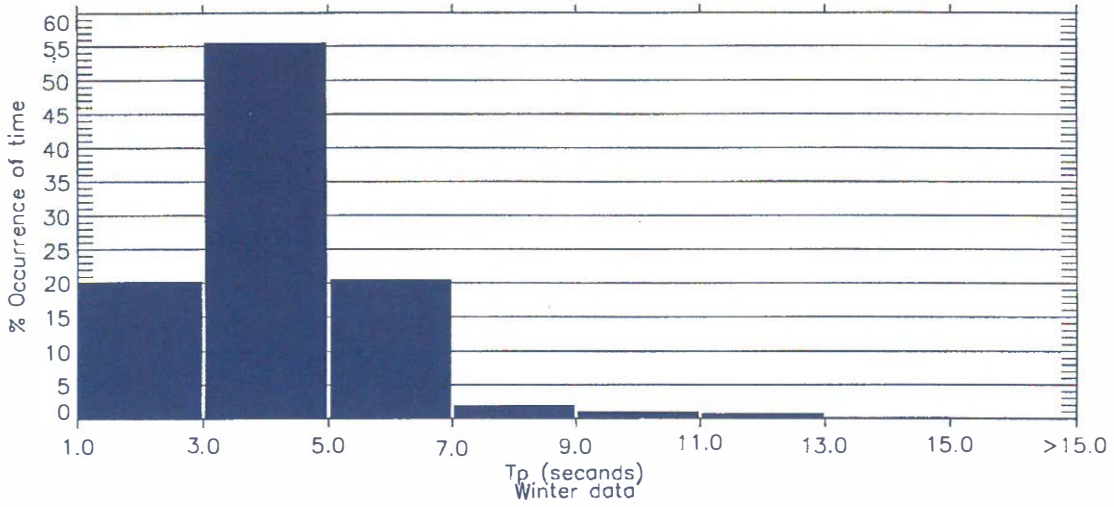


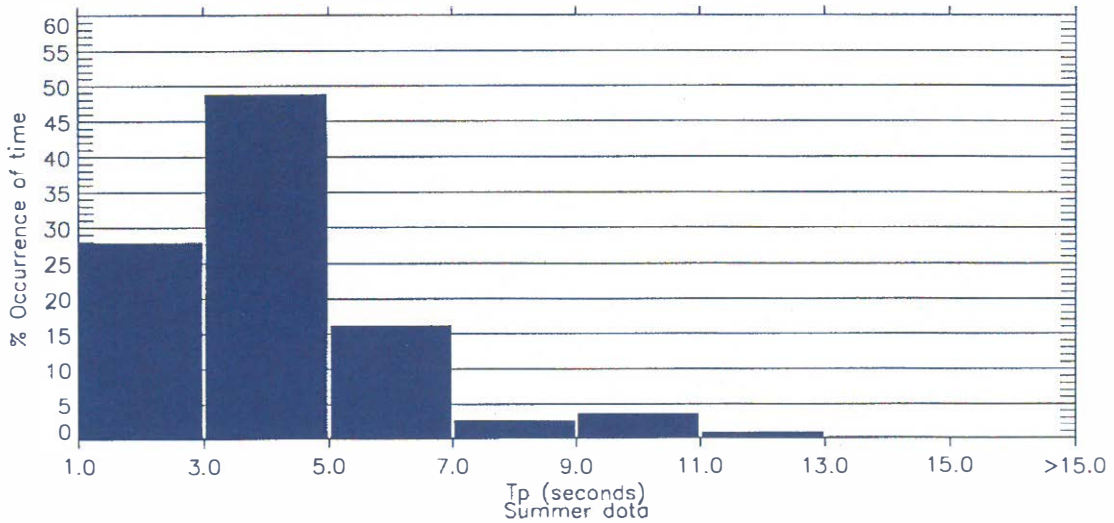


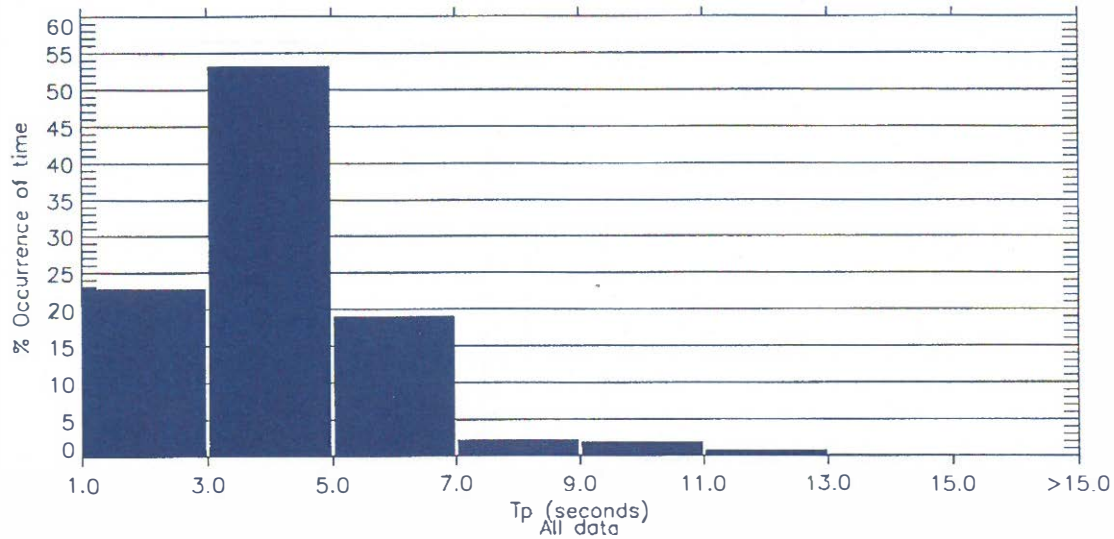


Histogram percentage (of time), occurrence of wave heights (Hsig) for all wave periods (Tp)
2 June 1994 – 22 October 1995

Beach Protection Authority Queensland Department of Environment	Wave data recording program Repulse Bay	**Figure 2**

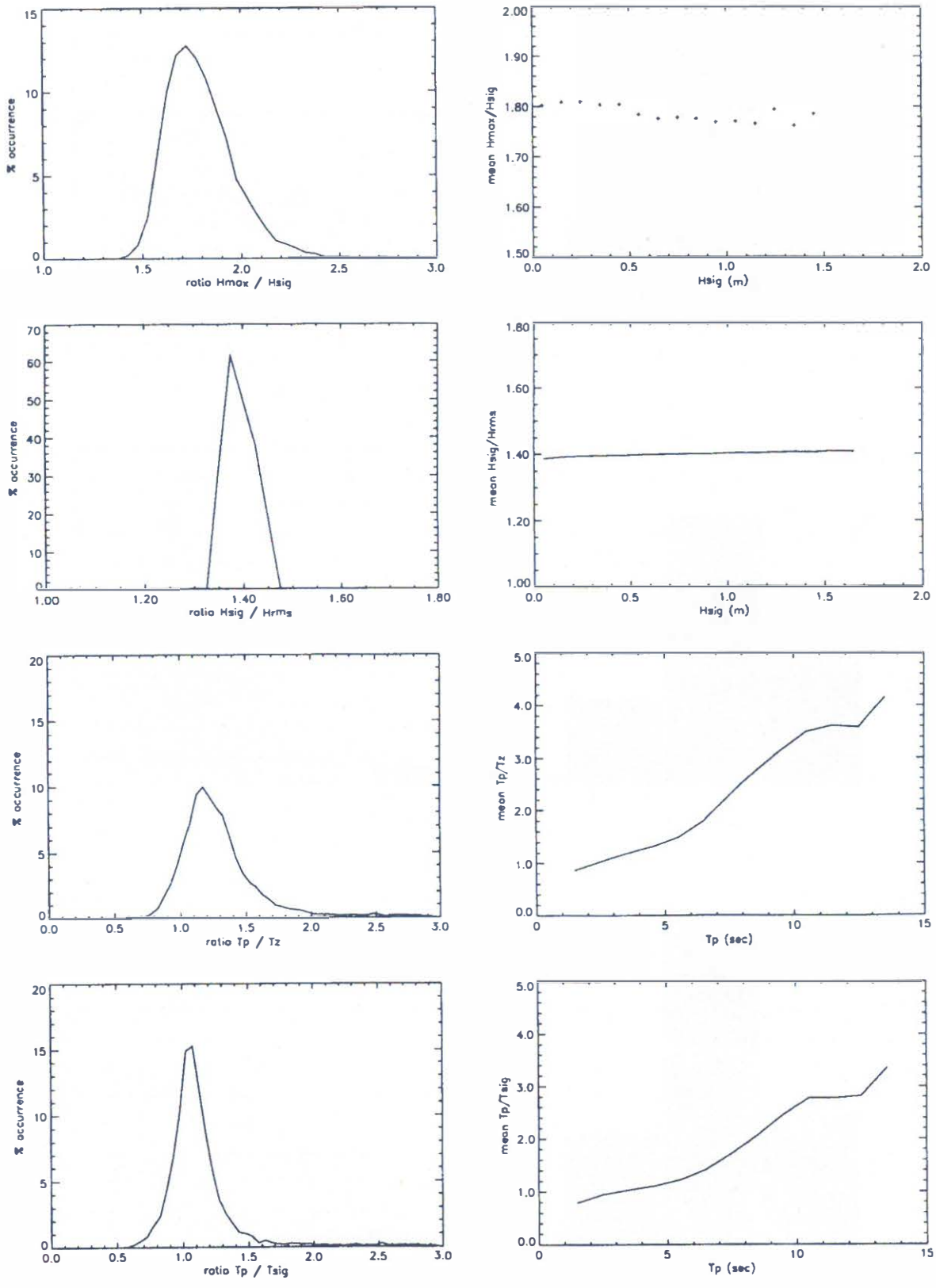






Histogram percentage (of time), occurrence of wave periods (Tp) for all wave heights (Hsig)
2 June 1994 – 22 October 1995

Beach Protection Authority Queensland Department of Environment	Wave data recording program Repulse Bay	**Figure 3**



Wave parameter relationships
2 June 1994 – 22 October 1995

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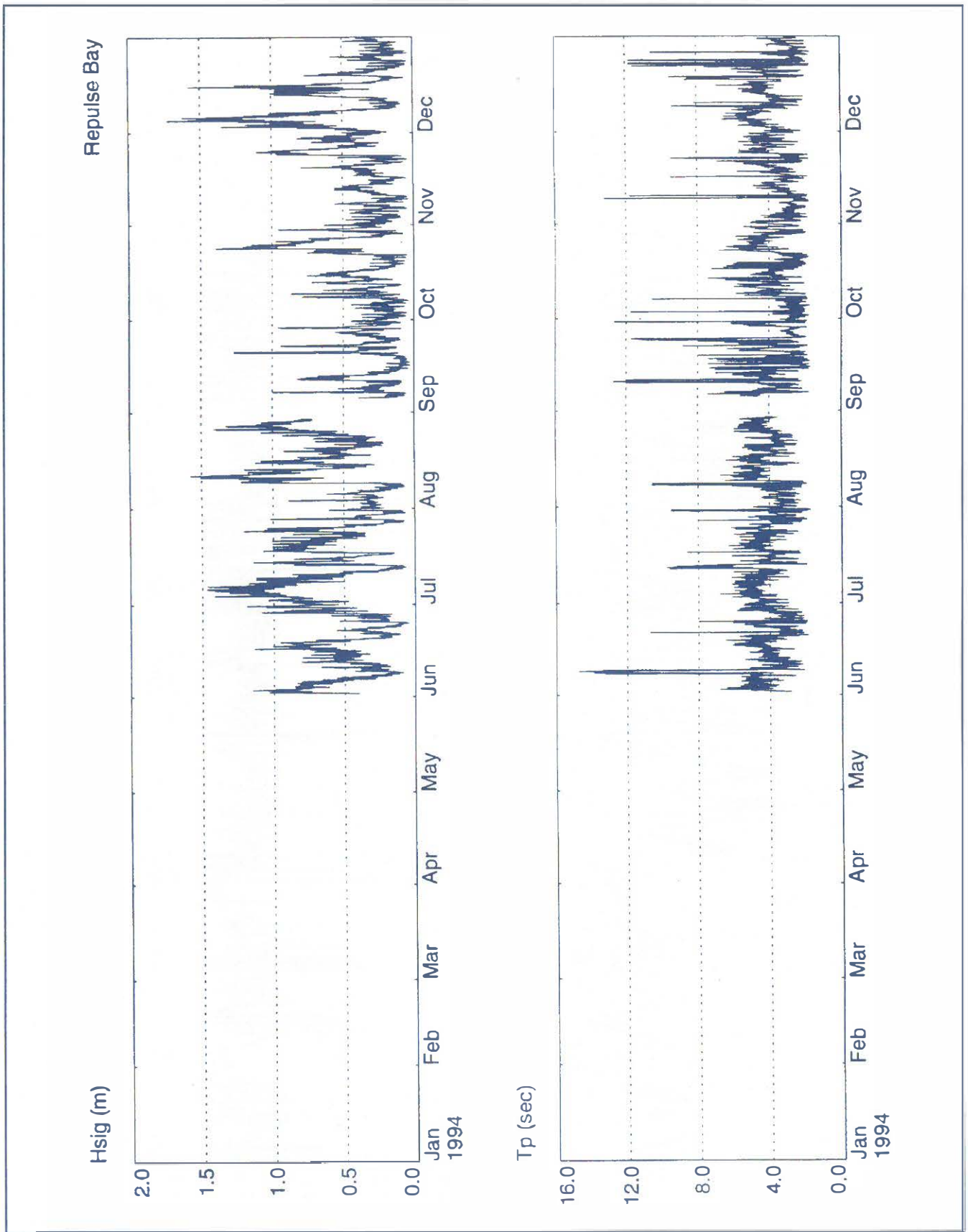
Department of Environment

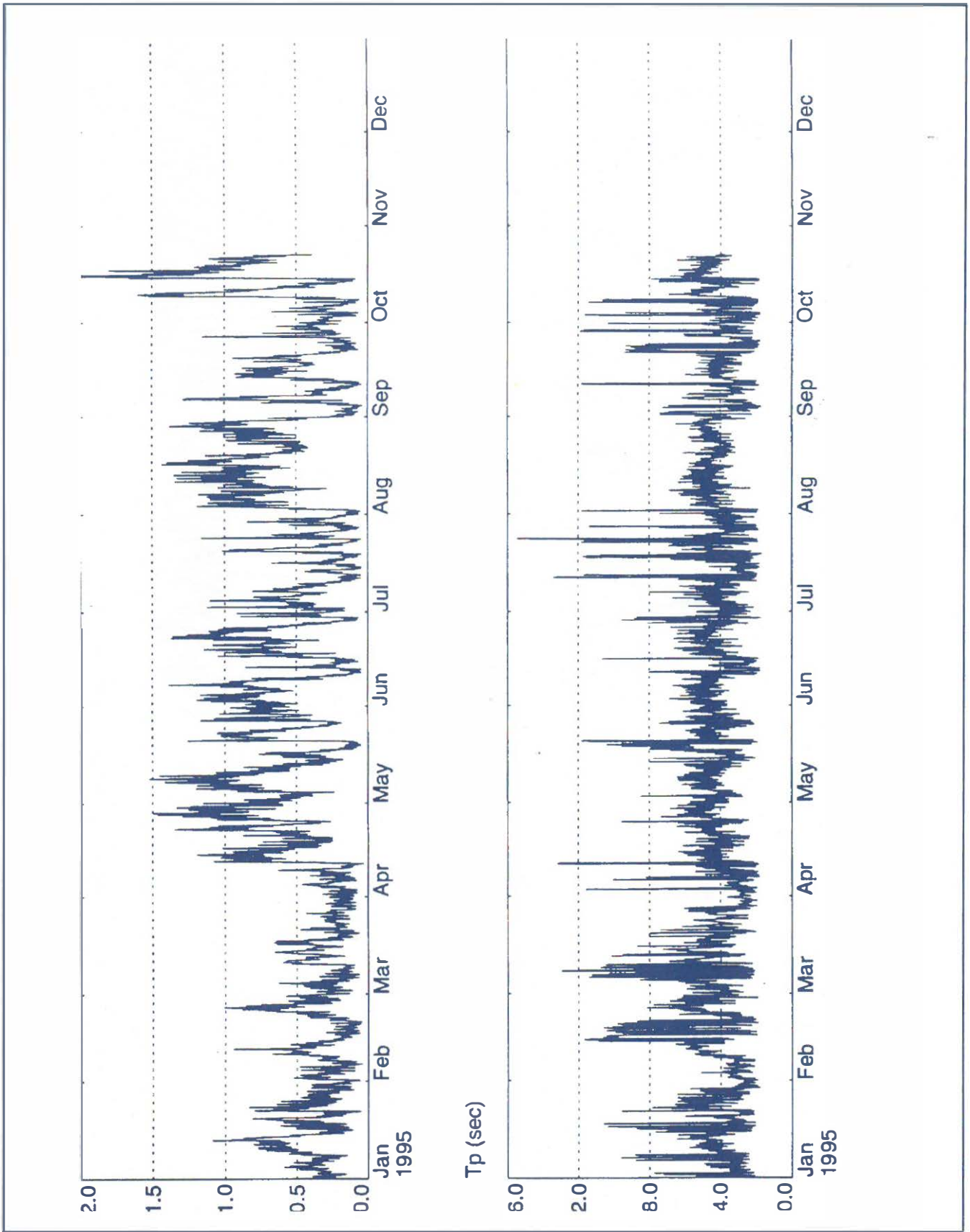
Wave data recording program
Repulse Bay

Figure 4



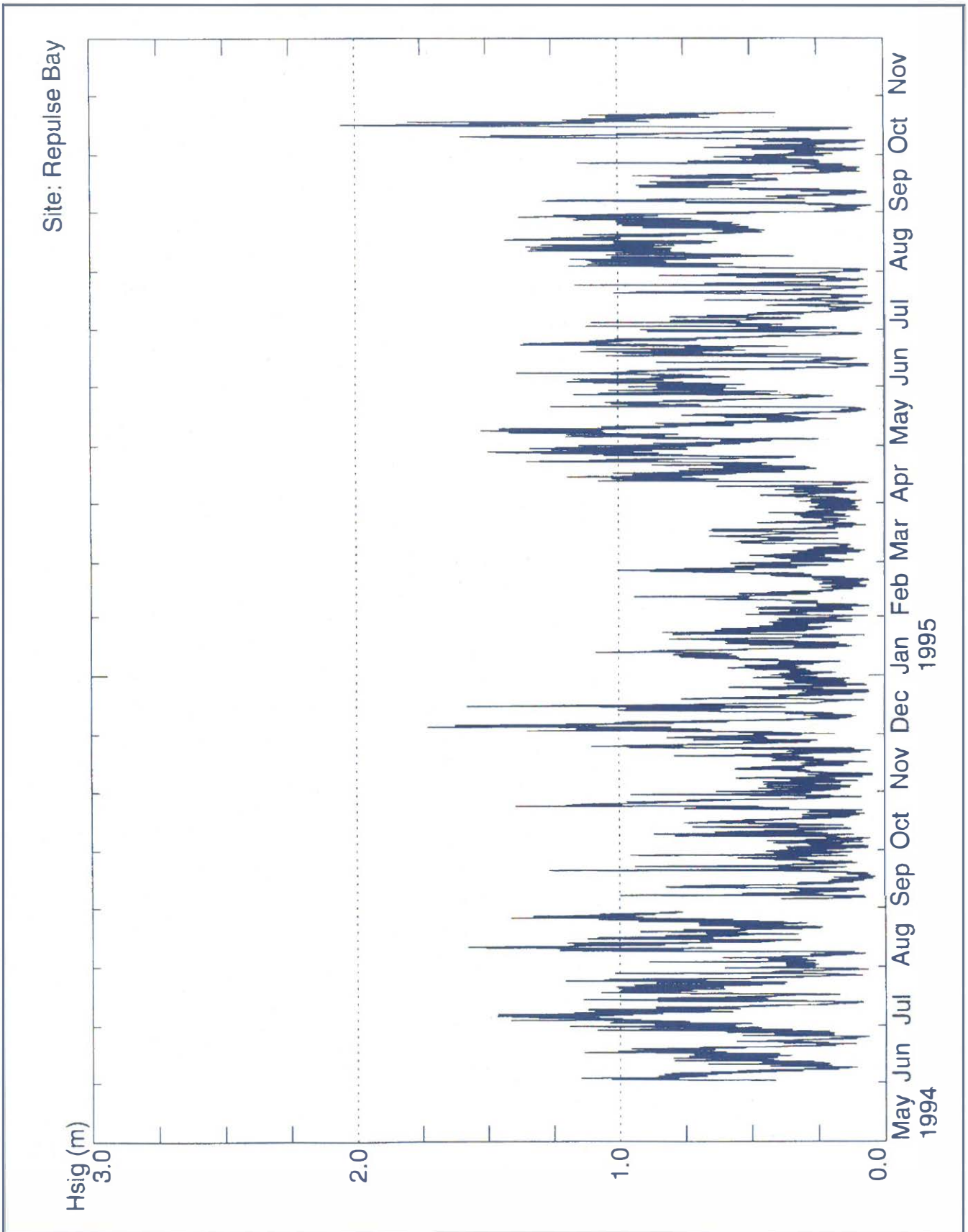
Daily wave recordings
1 January 1994 – 31 December 1994

Beach Protection Authority Queensland Department of Environment	Wave data recording program Repulse Bay	**Figure 5.01**



Daily wave recordings
1 January 1995 – 31 December 1995

Beach Protection Authority Queensland Department of Environment	Wave data recording program Repulse Bay	**Figure 5.02**



Whole recording period wave heights (Hsig)

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Wave data recording program
Repulse Bay

Figure 6