

Wave data recording program

Abbot Point Region

For the years 1977 to 1996

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For the years 1977 to 1996

Abstract

This report summarises the primary analyses of wave data recorded using a Datawell non-directional waverider buoy in water depths of approximately 12 metres, at offshore locations near Abbot Point in northern Queensland. Data were from 7 May 1977 to 9 August 1979 and from 8 November 1982 to 31 October 1996. 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.

Wave data recording program Abbot Point Region 1977–1996

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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 Abbot Point 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 utilises 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 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 Abbot Point station, for the period 7 May 1977 to 9 August 1979, 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 and provided a paper chart of the water level recordings and relayed an analogue signal to the ANMA analogue recorder.

Between 8 November 1982 and 10 November 1993, the recording station was upgraded to a WAREP Mark II waverider receiver and a DIMA digitiser/ recorder. The WAREP receiver controlled the timing of data recording and provided a paper chart of the water level signal. Wave data were recorded by the DIMA unit in 20 minute bursts and digitised at 0.5 second intervals (2.0Hz). The data were recorded on digital cassettes

and, along with the paper charts, transferred to the Brisbane office for processing.

On 11 November 1993, the Abbot Point wave recording station was re-established with a non-directional waverider buoy and the recording system upgraded to a personal computer (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 hard disk of the PC.

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.

Further information on the operation of the waverider buoy and the recording systems can be obtained from the sources listed in section 7 of this report.

2.4 Laboratory calibration checks

Waverider buoys used by the Authority are calibrated before deployment and also after recovery. Normally, a buoy is calibrated once every twelve months.

Calibration is performed at the Queensland Government Hydraulics Laboratory using a buoy calibrator (ferris wheel) to simulate sinusoidal waves with amplitudes of either 2m or 2.8m depending on whether a 0.7m or 0.9m 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 7 May 1977 to 9 August 1979, wave data were recorded twice daily, each of 20 minutes duration, with the timing of recordings set at 0300, and 1500 hours Australian Eastern Standard Time (AEST).

Over the period 8 November 1982 to 10 November 1993, 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.

Since 11 November 1993 through to the end of this report period of 31 October 1996, 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 2 metres, 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 autocorrelation method providing 50 lags at a spacing of 0.02Hz.

The PC based analysis uses Fast Fourier Transform techniques to give 128 spectral estimates in bands of 0.01Hz.

The zero upcrossing analysis is equivalent in both systems.

Wave parameters resulting from this processing include the following:

S(f)	Energy density spectrum,
Hsig	Significant wave height (time domain), the average of the highest one third of the waves in the record,
Hmax	The highest individual wave in the record,
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,
Tc	The average period of all the waves in the record based on successive crests.

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 Abbot Point wave recording station are included in appendix 1, 'Details of wave recorder installations'.

5 Wave climate

The wave climate data presented in this report are based on statistical analyses of the parameters obtained from the recorded wave data.

Programs developed by the Authority provide statistical information on percentage of time occurrence and exceedance for wave heights and periods. The results of these analyses are presented in tables 1 to 6 and figures 2, 3 and 4. In addition, similar analyses are carried out on the relationships between the various wave parameters and 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 (thirty 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 (thirty 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. This data is shown on appendix 1, 'Details of wave recorder installations'. The non-directional waverider recording system utilised by the Authority is designed to record vertical movements of the water

surface only and any wave directions must be assigned to the individual wave records by other means.

Appendix 2, 'Major meteorological events', provides a summary of meteorological events which occurred during the recording period of this report where the recorded Hsig value of 2 metres 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 2 metres 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 along the eastern seaboard of 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 Jun 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 Jul 1977
- * Wave data recording program, Burnett Heads Region (Report No. W05.1) 5 May 1976 to 5 Mar 1982
- * Wave data recording program, Burnett Heads Region (Report No. W05.2) 5 May 1976 to 13 Oct 1988
- * Wave data recording program, Abbot Point Region (Report No. W06.1) 6 May 1977 to 9 Aug 1979
- * Wave data recording program, Weipa Region (Report No. W07.1) 21 Dec 1978 to 7 Apr 1983
- * Wave data recording program, Gladstone Region (Report No. W08.1) 19 Dec 1979 to 16 May 1983
- * Wave data recording program, Brisbane Region (Report No. W09.1) 30 Oct 1976 to 30 Jun 1983
- * Wave data recording program, Brisbane Region (Report No. W09.2) 30 Oct 1976 to 30 Jun 1994
- * Wave data recording program, Brisbane Region (Report No. W09.3) 30 Oct 1976 to 28 Feb 1997
- * Wave data recording program, Bowen Region (Report No. W10.1) 14 Sept 1978 to 15 Nov 1984
- * Wave data recording program, Moreton Island Region

(Report No. W11.1) 15 Jun 1983 to 12 Apr 1985
 * Wave data recording program, Bramston Beach Region
 (Report No. W12.1) 16 Dec 1981 to 28 Oct 1985
 * Wave data recording program, Hay Point Region
 (Report No. W13.1) 22 Mar 1977 to 25 May 1987
 * Wave data recording program, Hay Point Region
 (Report No. W13.2) 22 Mar 1977 to 31 Oct 1996
 * Wave data recording program, Gold Coast Region
 (Report No. W14.1) 20 Feb 1987 to 30 Jun 1994
 * Wave data recording program, Gold Coast Region
 (Report No. W14.2) 20 Feb 1987 to 28 Feb 1997
 * Wave data recording program, Kirra
 (Report No. W15.1) 25 Aug 1988 to 30 Jun 1994
 * Wave data recording program, Kirra
 (Report No. W15.2) 25 Aug 1988 to 28 Feb 1997
 * Wave data recording program, Repulse Bay
 (Report No. W16.1) 2 Jun 1994 to 22 Oct 1995
 * Wave data recording program, Hayman Island
 (Report No. W17.1) 26 Oct 1995 to 14 Oct 1996
 * Wave data recording program, Tweed Region
 (Report No. W18.1) 15 Jan 1995 to 28 Feb 1997

See figure 1 for the locality plan of the waverider buoys and recording station for the period of this report.

Co-ordinates:- 148° 06' east, 19° 52' south
 Description:- 1.8 kilometers, south-east of the head of Abbot Point wharf.
 Buoy type:- Datawell non-directional waverider.
 Water depth at buoy:- 14 metres relative to Australian Height Datum.
 Period:- 7 May 1977– 9 August 1979

Co-ordinates:- 148° 05.8' east, 19° 51.9' south
 Description:- 300 meters, south-east of head of Abbot Point wharf.
 Buoy type:- Datawell non-directional waverider.
 Water depth at buoy:- 15 metres relative to Australian Height Datum.
 Period:- 8 November 1982–10 February 1985

Co-ordinates:- 148° 05.4' east, 19° 51.3' south
 Description:- 700 meters, northeast of head of Abbot Point wharf.
 Buoy type:- Datawell non-directional waverider.
 Water depth at buoy:- 18 metres relative to Australian Height Datum.
 Period:- 11 February 1985–19 February 1992

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

Appendix 1

Details of wave recorder installations

Buoy locations

Co-ordinates:- 148° 05.4' east, 19° 51.1' south
 Description:- 1.1 kilometers south southeast of Abbot Point wharf.
 Buoy type:- Datawell non-directional waverider.

Water depth at buoy:- 12 metres relative to
Australian Height Datum.
Period:- 20 February 1992–31 October 1996

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

Location of recording station

Co-ordinates:- 148° 14' east, 20° 00.4' south
Description:- Bowen Hills, Bowen
Period:- 7 May 1977–9 August 1979

Co-ordinates:- 148° 05' east, 19° 53' south
Description:- On-site First Aid Office,
Abbot Point coal loading wharf.
Period:- 9 November 1982–31 October 1996

Recording intervals

Two twenty minute records daily at 0300 hours and
1500 hours between 7 May 1977 and 9 August 1979.

Four twenty minute records daily at 0300 hours, 0900
hours, 1500 hours and 2100 hours between
8 November 1982 and 10 November 1993.

The Abbot Point waverider buoy and recording station
were decommissioned on 9 August 1979 and the site
remained inactive until recommissioning on 8 November
1982.

From 11 November 1993, one hourly records, each of
approximately twenty-six (26) minute have been taken,
giving 4096 water surface elevation measurements for
that period, from which sea state parameters are
calculated and recorded.

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

Data collection and analysis

Number of records collected:-	40257
Number of records used in analysis:-	40255
Number of days in recording period:-	7117.88
Number of days used in analysis:-	4990.11
Number of days lost (total):-	2127.77
Number of days between 9 August 1979 and 8 November 1982 when station was decommissioned:-	1186.63
Number of days lost (actual):-	941.14

Appendix 2

Major meteorological events

Meteorological Event	Central Pressure (hPa)	Date	Estimated position of cyclone relative to buoy (km)	Maximum Hsig recorded (1) (m)	Maximum Hmax recorded (2) (m)	Tp (3) (secs)
Cyclone Kerry	955	2-03-1979	50 S	2.22	3.40	7.40
Cyclone Charlie	993	1-03-1988	130 SSW	3.14	5.61	7.60
Cyclone Aivu	935	4-04-1989	240 NNE	3.79	5.96	8.81
Cyclone Joy	990	26-12-1990	130 N	3.43	5.54	7.70
Cyclone Celeste	965	27-01-1996	80 SE	2.77	5.30	6.57

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 2 metres, which occurred during the recording period of this report.

Highest Significant Wave Height (Hsig) recorded was 3.79 metres on 4 April 1989 during the passage of tropical cyclone Aivu *.

Highest Maximum Wave Height (Hmax) recorded was 5.96 metres on 4 April 1989 during the passage of tropical cyclone Aivu *.

* At this time the station ceased recording due to the loss of the waverider buoy. Therefore, larger waves may have occurred during tropical cyclone Aivu.

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

Appendix 3

Tropical cyclones of the east coast of Queensland

7 May 1977–9 August 1979 and 9 November 1982–31 October 1996

Cyclone Name	Year	Month
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
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
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

Cyclone Name	Year	Month
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

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

Significant wave height (Hsig) (metres)	Peak energy wave period (Tp) (seconds)								Totals
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	
0.00 - 0.19	191.54	85.85	48.16	29.47	4.71	*	0.25	*	359.98
0.20 - 0.39	485.22	810.50	41.56	16.15	1.67	0.67	*	*	1355.76
0.40 - 0.59	46.18	1262.19	33.39	4.33	0.25	0.25	*	*	1346.60
0.60 - 0.79	0.33	945.20	116.91	0.67	0.50	*	*	*	1063.61
0.80 - 0.99	*	400.37	200.77	0.50	*	*	*	*	601.64
1.00 - 1.19	*	78.06	118.99	0.04	*	*	*	*	197.09
1.20 - 1.39	*	6.27	42.49	*	*	*	*	*	48.76
1.40 - 1.59	*	0.37	9.63	*	0.25	*	*	*	10.25
1.60 - 1.79	*	*	2.29	0.04	*	*	*	*	2.33
1.80 - 1.99	*	*	1.34	0.41	*	*	*	*	1.75
2.00 - 2.19	*	*	0.42	0.37	*	*	*	*	0.79
2.20 - 2.39	*	*	0.02	0.37	*	*	*	*	0.39
2.40 - 2.59	*	*	0.13	0.04	*	*	*	*	0.17
2.60 - 2.79	*	*	0.29	*	*	*	*	*	0.29
2.80 - 2.99	*	*	*	0.13	*	*	*	*	0.13
3.00 - 3.19	*	*	*	0.13	*	*	*	*	0.13
3.20 - 3.39	*	*	*	*	*	*	*	*	0.00
3.40 - 3.59	*	*	*	0.25	*	*	*	*	0.25
3.60 - 3.79	*	*	*	0.19	*	*	*	*	0.19
3.80 - 3.99	*	*	*	*	*	*	*	*	0.00
Totals	723.28	3588.82	616.39	53.09	7.38	0.92	0.25	0.00	4990.11

* = 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)								Totals
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	
0.00 - 0.19	59.21	23.39	8.53	2.78	0.25	*	*	*	94.17
0.20 - 0.39	215.90	353.38	17.21	8.46	1.46	0.67	*	*	597.08
0.40 - 0.59	27.89	592.84	10.16	3.58	0.25	*	*	*	634.72
0.60 - 0.79	0.29	467.70	51.80	0.58	0.50	*	*	*	520.87
0.80 - 0.99	*	228.95	109.51	0.42	*	*	*	*	338.88
1.00 - 1.19	*	50.68	75.22	*	*	*	*	*	125.91
1.20 - 1.39	*	5.19	31.04	*	*	*	*	*	36.23
1.40 - 1.59	*	0.33	7.88	*	*	*	*	*	8.21
1.60 - 1.79	*	*	2.29	0.04	*	*	*	*	2.33
1.80 - 1.99	*	*	1.34	0.41	*	*	*	*	1.75
2.00 - 2.19	*	*	0.42	0.37	*	*	*	*	0.79
2.20 - 2.39	*	*	0.02	0.37	*	*	*	*	0.39
2.40 - 2.59	*	*	0.13	0.04	*	*	*	*	0.17
2.60 - 2.79	*	*	0.29	*	*	*	*	*	0.29
2.80 - 2.99	*	*	*	0.13	*	*	*	*	0.13
3.00 - 3.19	*	*	*	0.13	*	*	*	*	0.13
3.20 - 3.39	*	*	*	*	*	*	*	*	0.00
3.40 - 3.59	*	*	*	0.25	*	*	*	*	0.25
3.60 - 3.79	*	*	*	0.19	*	*	*	*	0.19
3.80 - 3.99	*	*	*	*	*	*	*	*	0.00
Totals	303.29	1722.47	315.85	17.76	2.46	0.67	0.00	0.00	2362.49

* = 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)								Totals
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	
0.00 - 0.19	132.33	62.46	39.63	26.68	4.46	*	0.25	*	265.81
0.20 - 0.39	269.32	457.12	24.34	7.69	0.21	*	*	*	758.68
0.40 - 0.59	18.30	669.36	23.23	0.75	*	0.25	*	*	711.88
0.60 - 0.79	0.04	477.50	65.11	0.08	*	*	*	*	542.73
0.80 - 0.99	*	171.42	91.26	0.08	*	*	*	*	262.76
1.00 - 1.19	*	27.37	43.77	0.04	*	*	*	*	71.19
1.20 - 1.39	*	1.08	11.45	*	*	*	*	*	12.54
1.40 - 1.59	*	0.04	1.75	*	0.25	*	*	*	2.04
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
Totals	419.99	1866.35	300.54	35.33	4.92	0.25	0.25	0.00	2627.63

* = 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)								Totals
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	
0.00 - 0.19	3.84	1.72	0.97	0.59	0.09	*	*	*	7.21
0.20 - 0.39	9.72	16.24	0.83	0.32	0.03	0.01	*	*	27.17
0.40 - 0.59	0.93	25.29	0.67	0.09	0.01	0.01	*	*	26.99
0.60 - 0.79	0.01	18.94	2.34	0.01	0.01	*	*	*	21.31
0.80 - 0.99	*	8.02	4.02	0.01	*	*	*	*	12.06
1.00 - 1.19	*	1.56	2.38	*	*	*	*	*	3.95
1.20 - 1.39	*	0.13	0.85	*	*	*	*	*	0.98
1.40 - 1.59	*	0.01	0.19	*	*	*	*	*	0.21
1.60 - 1.79	*	*	0.05	*	*	*	*	*	0.05
1.80 - 1.99	*	*	0.03	0.01	*	*	*	*	0.04
2.00 - 2.19	*	*	0.01	0.01	*	*	*	*	0.02
2.20 - 2.39	*	*	*	0.01	*	*	*	*	0.01
2.40 - 2.59	*	*	*	*	*	*	*	*	0.00
2.60 - 2.79	*	*	0.01	*	*	*	*	*	0.01
2.80 - 2.99	*	*	*	*	*	*	*	*	0.00
3.00 - 3.19	*	*	*	*	*	*	*	*	0.00
3.20 - 3.39	*	*	*	*	*	*	*	*	0.00
3.40 - 3.59	*	*	*	0.01	*	*	*	*	0.01
3.60 - 3.79	*	*	*	*	*	*	*	*	0.00
3.80 - 3.99	*	*	*	*	*	*	*	*	0.00
Totals	14.49	71.92	12.35	1.06	0.15	0.02	0.00	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)								Totals
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	
0.00 - 0.19	2.51	0.99	0.36	0.12	0.01	*	*	*	3.99
0.20 - 0.39	9.14	14.96	0.73	0.36	0.06	0.03	*	*	25.27
0.40 - 0.59	1.18	25.09	0.43	0.15	0.01	*	*	*	26.87
0.60 - 0.79	0.01	19.80	2.19	0.02	0.02	*	*	*	22.05
0.80 - 0.99	*	9.69	4.64	0.02	*	*	*	*	14.34
1.00 - 1.19	*	2.15	3.18	*	*	*	*	*	5.33
1.20 - 1.39	*	0.22	1.31	*	*	*	*	*	1.53
1.40 - 1.59	*	0.01	0.33	*	*	*	*	*	0.35
1.60 - 1.79	*	*	0.10	*	*	*	*	*	0.10
1.80 - 1.99	*	*	0.06	0.02	*	*	*	*	0.07
2.00 - 2.19	*	*	0.02	0.02	*	*	*	*	0.03
2.20 - 2.39	*	*	*	0.02	*	*	*	*	0.02
2.40 - 2.59	*	*	0.01	*	*	*	*	*	0.01
2.60 - 2.79	*	*	0.01	*	*	*	*	*	0.01
2.80 - 2.99	*	*	*	0.01	*	*	*	*	0.01
3.00 - 3.19	*	*	*	0.01	*	*	*	*	0.01
3.20 - 3.39	*	*	*	*	*	*	*	*	0.00
3.40 - 3.59	*	*	*	0.01	*	*	*	*	0.01
3.60 - 3.79	*	*	*	0.01	*	*	*	*	0.01
3.80 - 3.99	*	*	*	*	*	*	*	*	0.00
Totals	12.84	72.91	13.37	0.75	0.10	0.03	0.00	0.00	100.00

* = 0.00

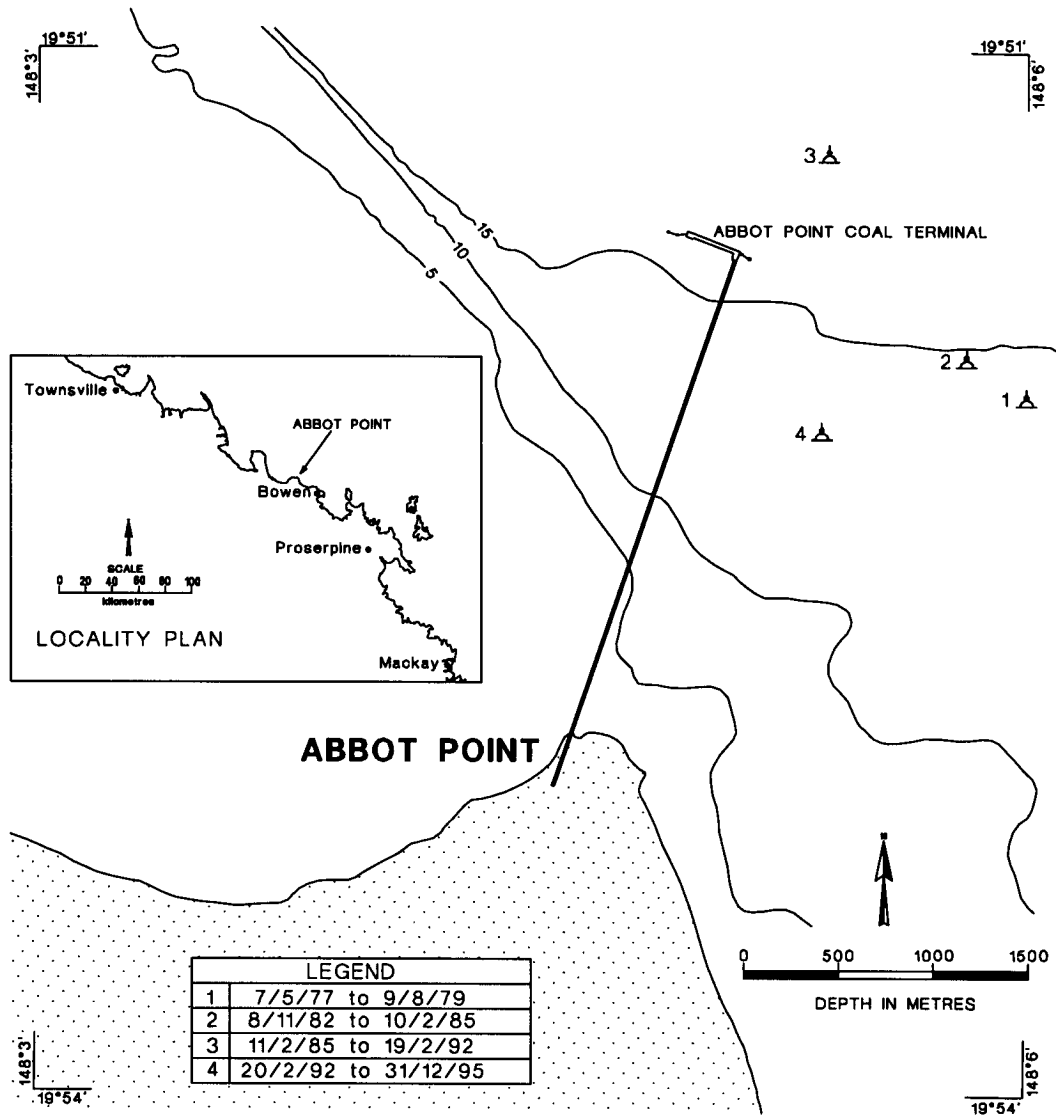
(Table values are percentage occurrences for the recording period, rounded to the second decimal place)

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

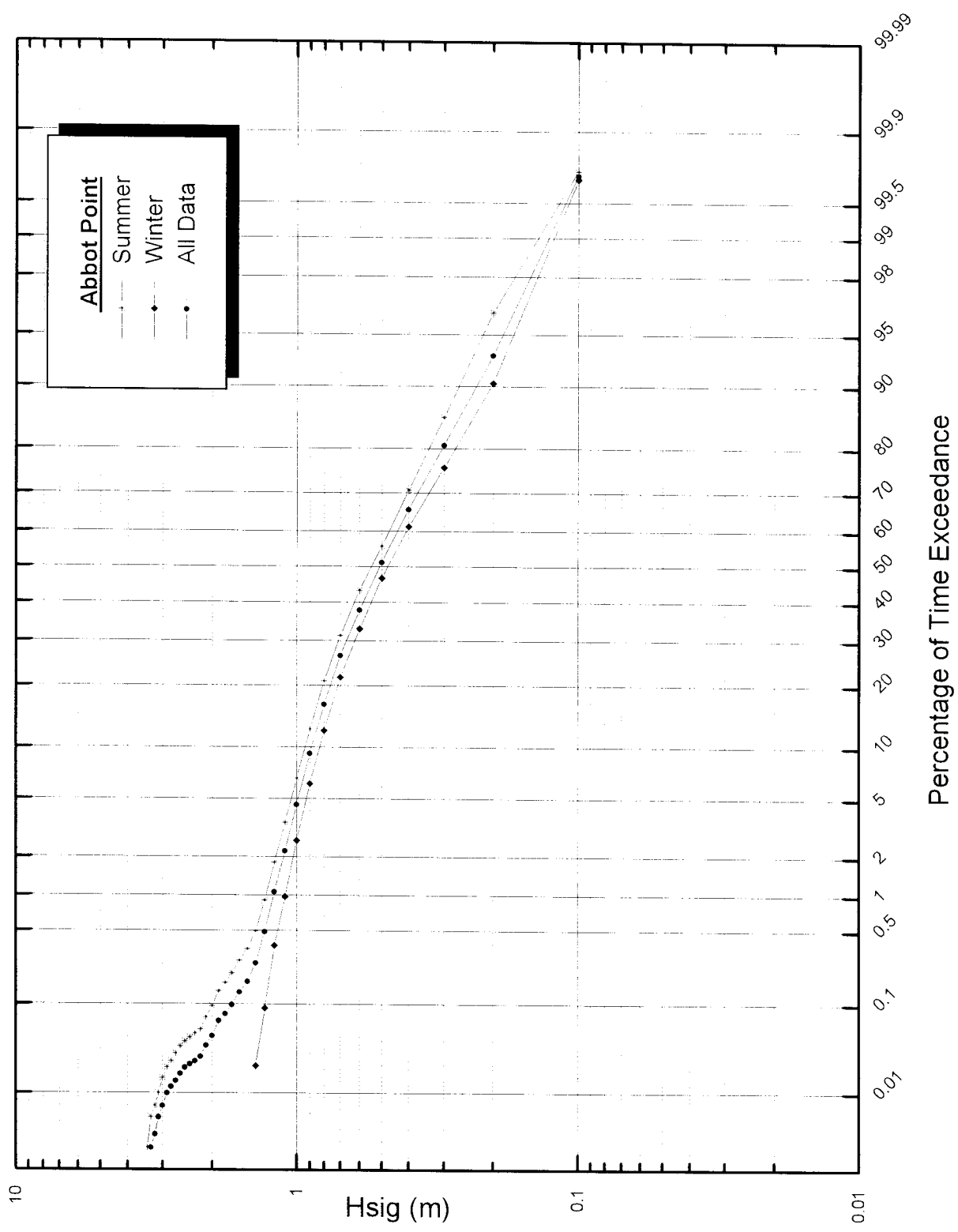
Significant wave height (Hsig) (metres)	Peak energy wave period (Tp) (seconds)								Totals
	0-2.99	3-4.99	5-6.99	7-8.99	9-10.99	11-12.99	13-14.99	>14.99	
0.00 - 0.19	5.04	2.38	1.51	1.02	0.17	*	0.01	*	10.12
0.20 - 0.39	10.25	17.40	0.93	0.29	0.01	*	*	*	28.87
0.40 - 0.59	0.70	25.47	0.88	0.03	*	0.01	*	*	27.09
0.60 - 0.79	*	18.17	2.48	*	*	*	*	*	20.65
0.80 - 0.99	*	6.52	3.47	*	*	*	*	*	10.00
1.00 - 1.19	*	1.04	1.67	*	*	*	*	*	2.71
1.20 - 1.39	*	0.04	0.44	*	*	*	*	*	0.48
1.40 - 1.59	*	*	0.07	*	0.01	*	*	*	0.08
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
Totals	15.98	71.03	11.44	1.34	0.19	0.01	0.01	0.00	100.00

* = 0.00

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



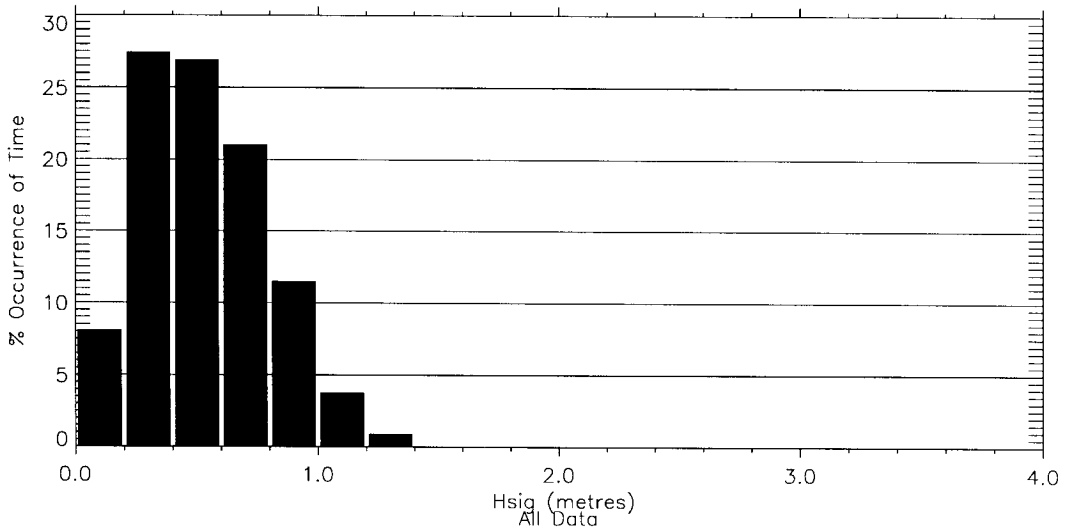
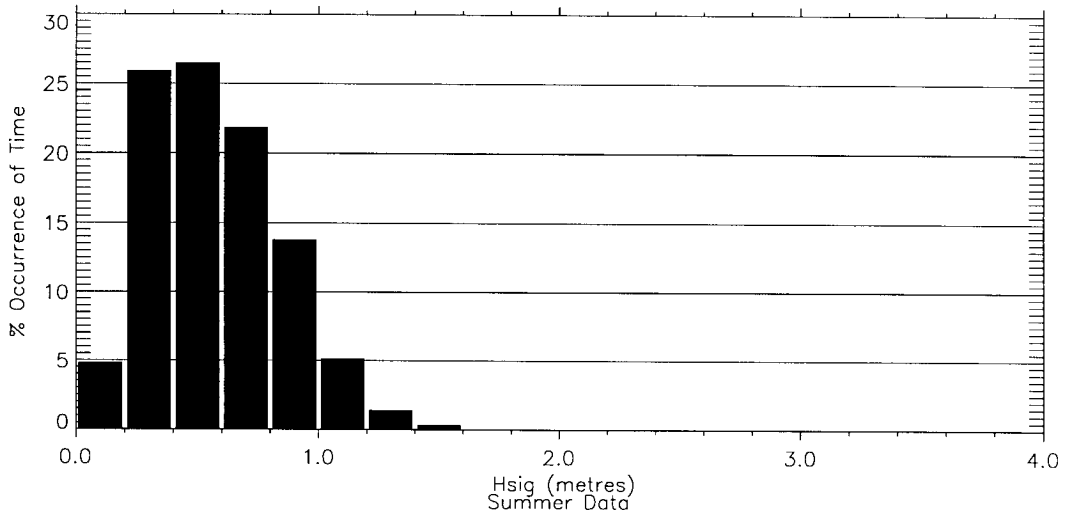
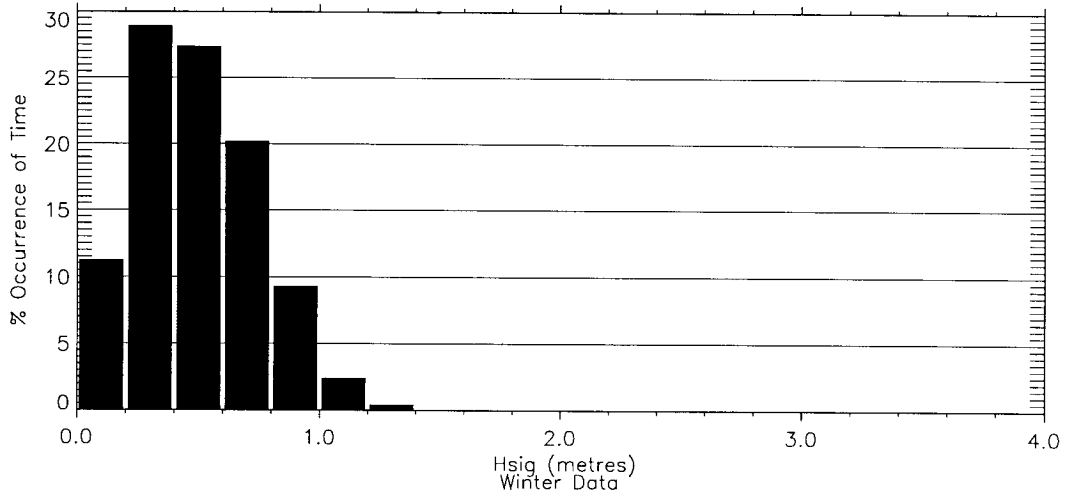
Locality Map



PERCENTAGE (of time) EXCEEDANCE
 OF WAVE HEIGHTS (Hsig) FOR ALL WAVE PERIODS
 7 May 1977 to 30 April 1996

Wave Data Recording Program
 ABBOT POINT REGION

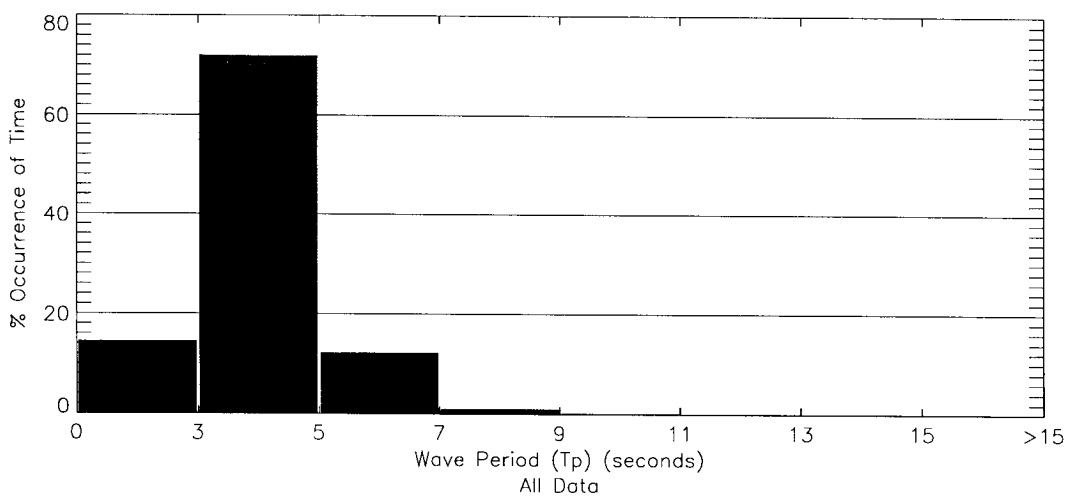
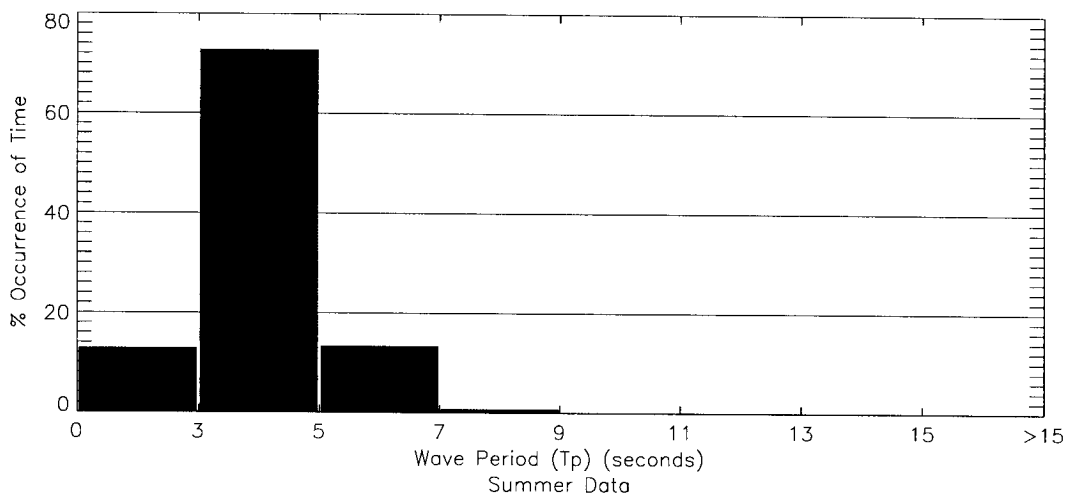
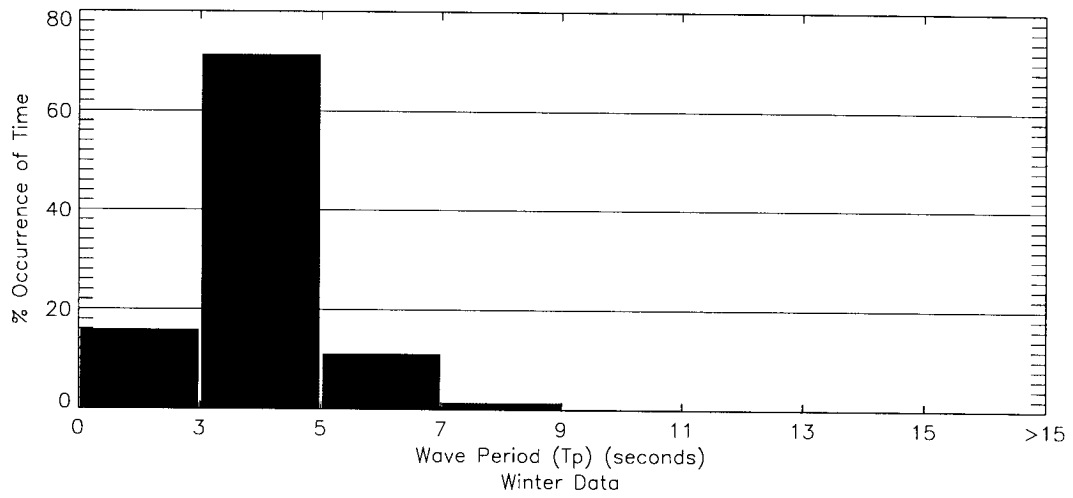
Figure: 2



HISTOGRAM PERCENTAGE (of time), OCCURRENCE OF WAVE HEIGHTS (Hsig)
 FOR ALL WAVE PERIODS (Tp)
 7 May 1977 to 30 April 1996

Wave Data Recording Program
 ABBOT POINT REGION

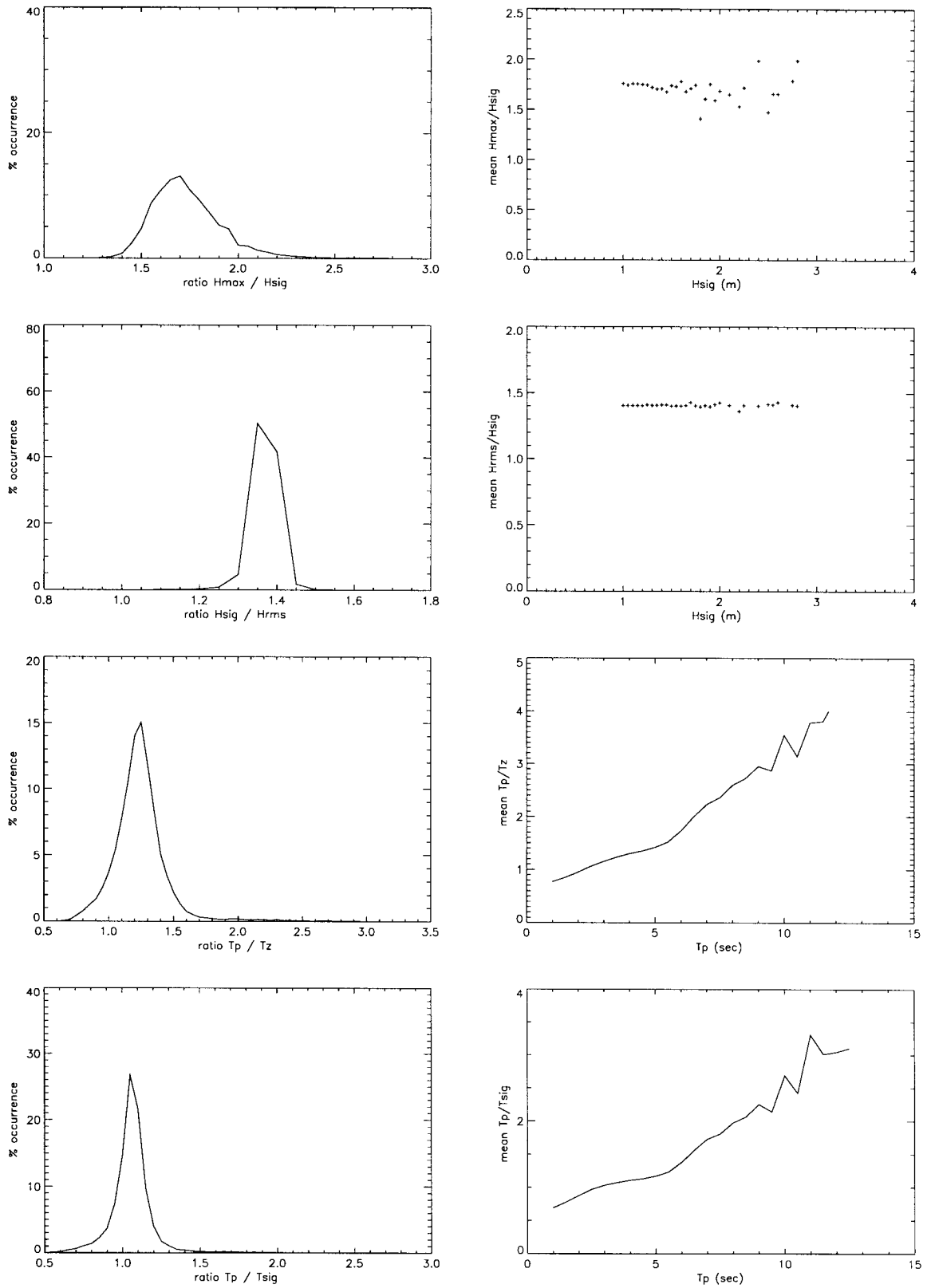
Figure: 3



HISTOGRAM PERCENTAGE (of time), OCCURRENCE OF WAVE PERIODS (T_p)
 FOR ALL WAVE HEIGHTS (H_{sig})
 7May 1977 to 30 April 1996

Wave Data Recording Program
 ABBOT POINT REGION

Figure: 4

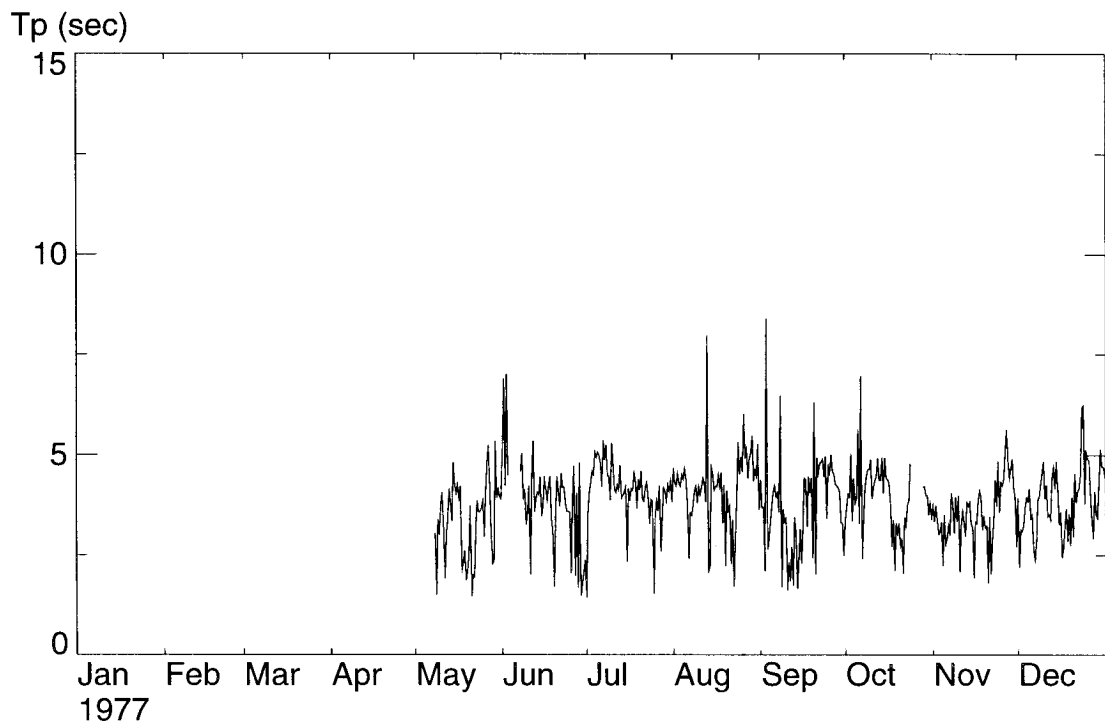
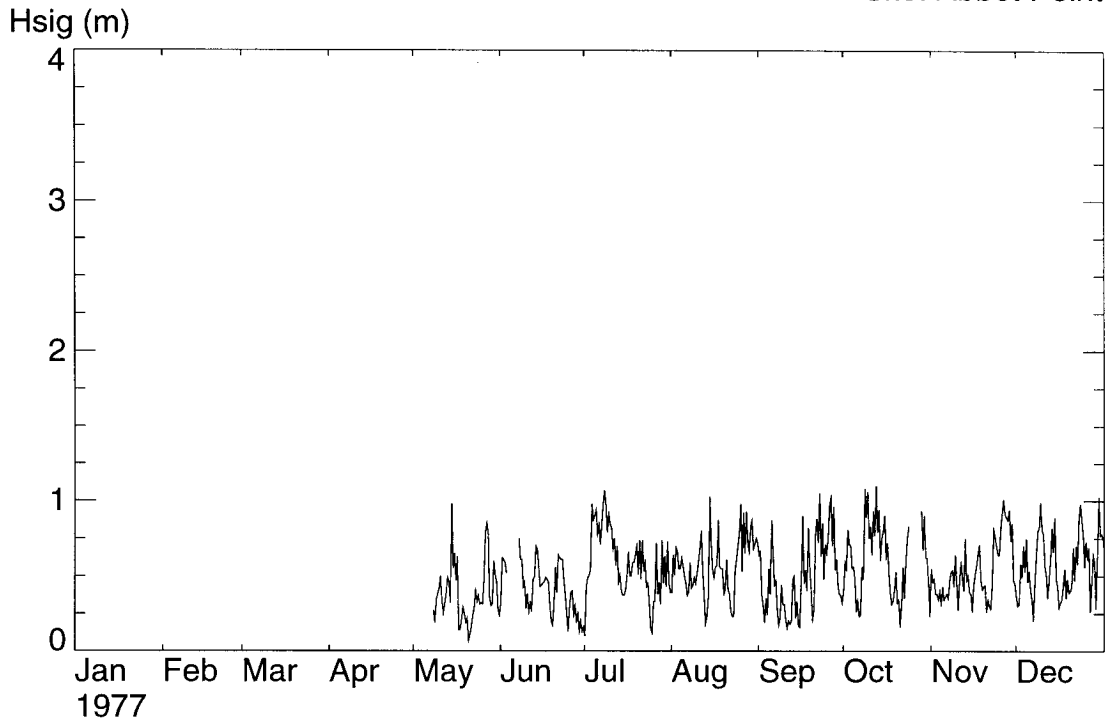


Wave Parameter Relationships
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT

Figure: 5

Site: Abbot Point

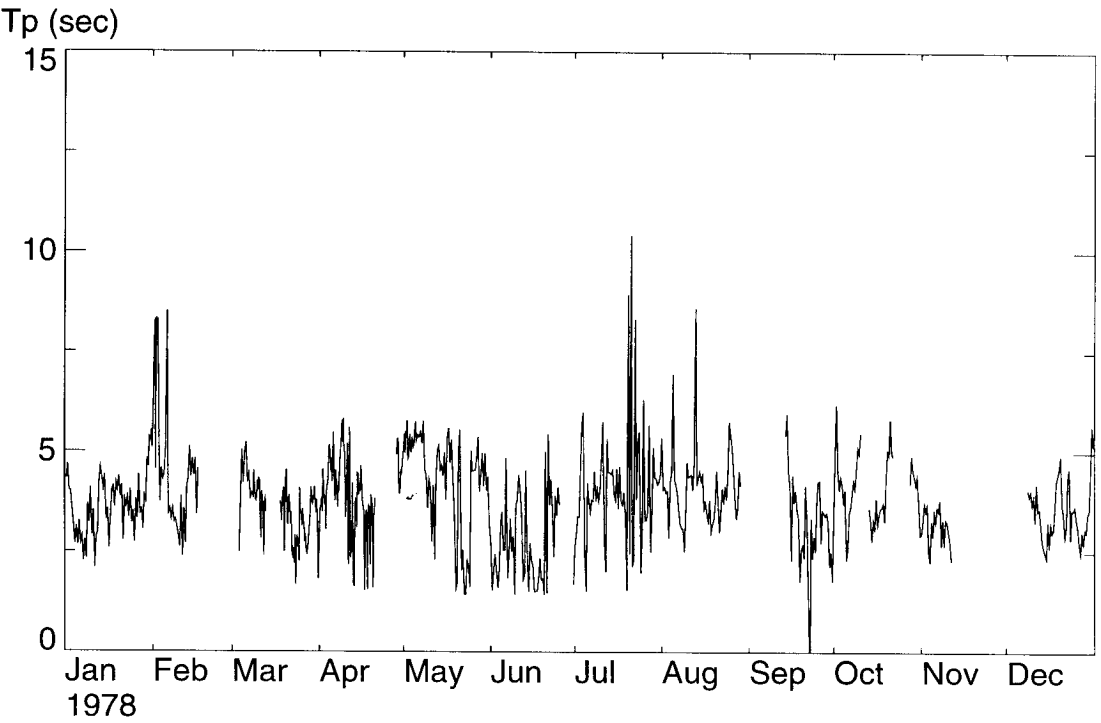
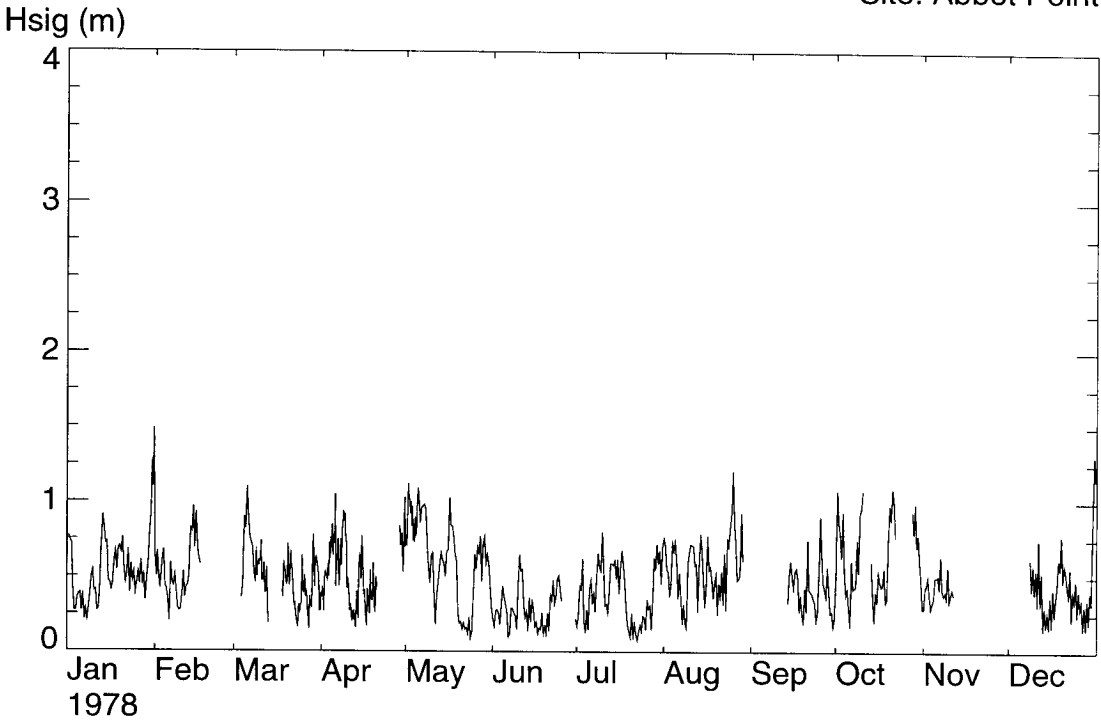


DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.01

Site: Abbot Point

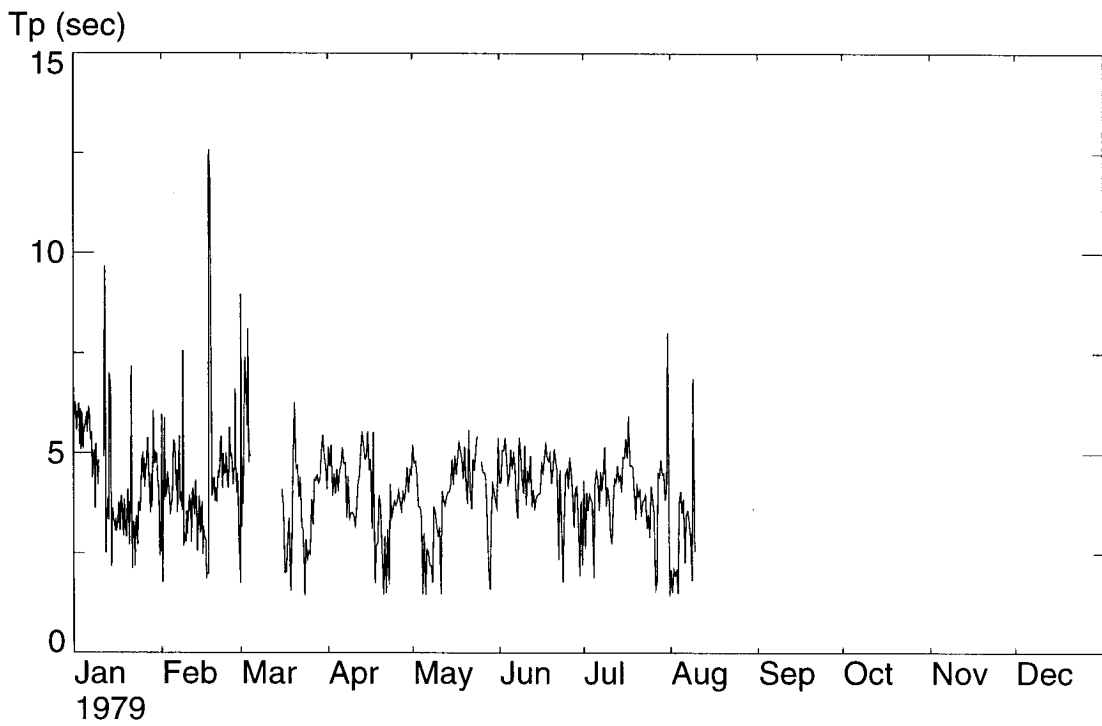
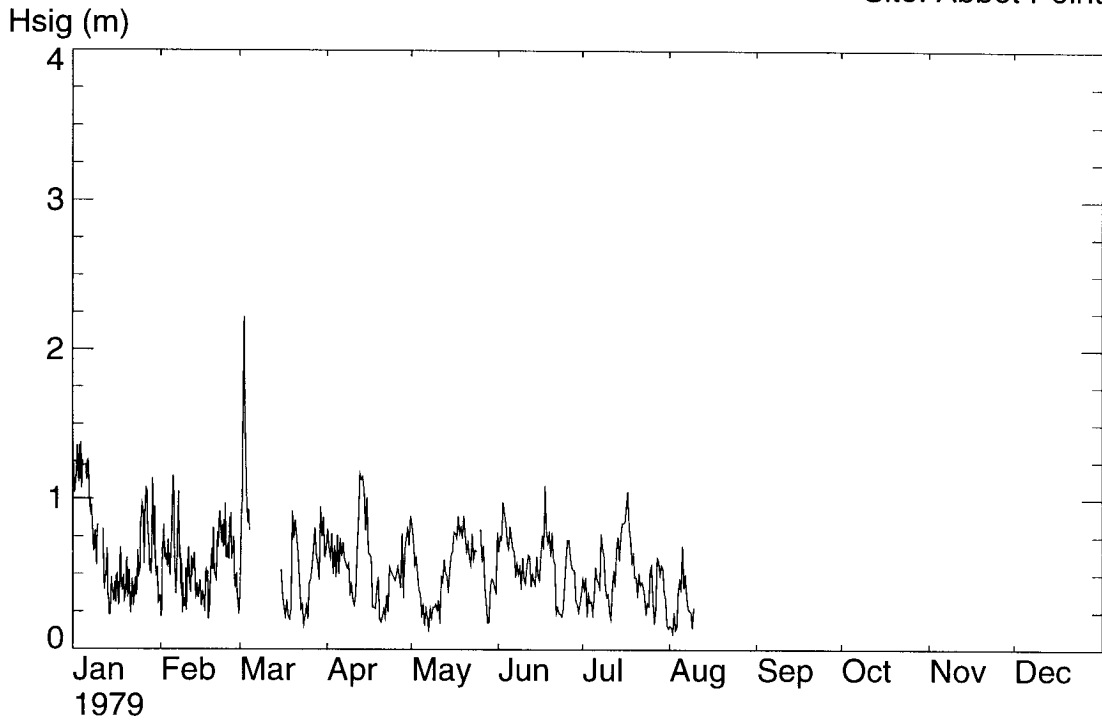


DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.02

Site: Abbot Point

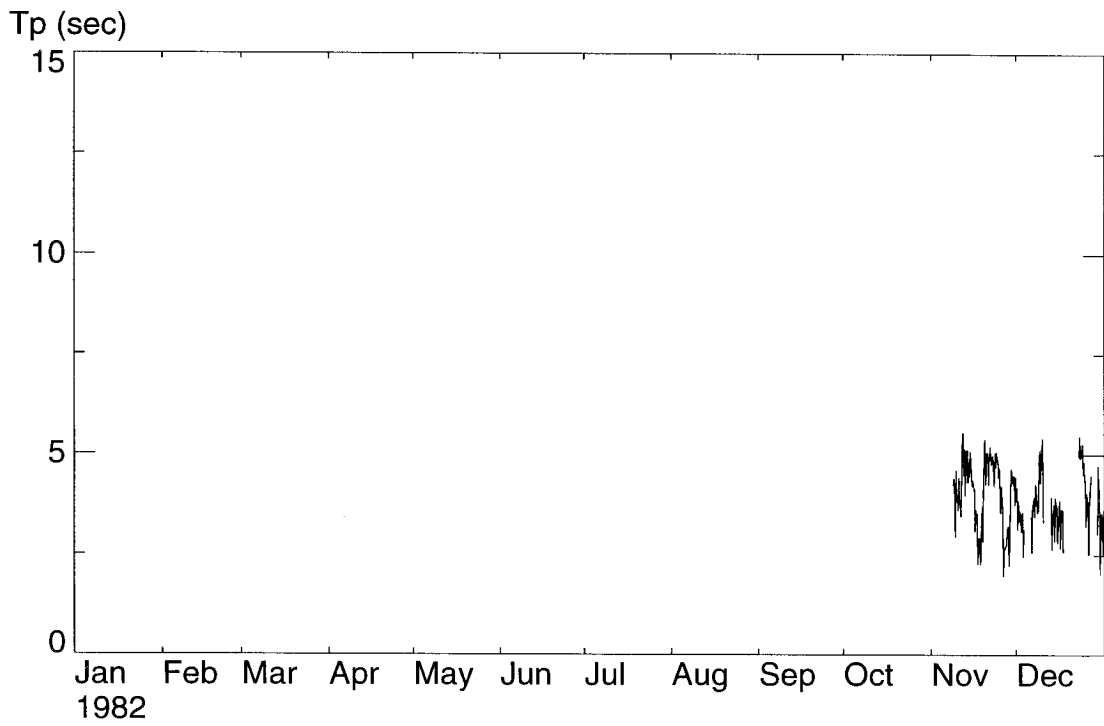
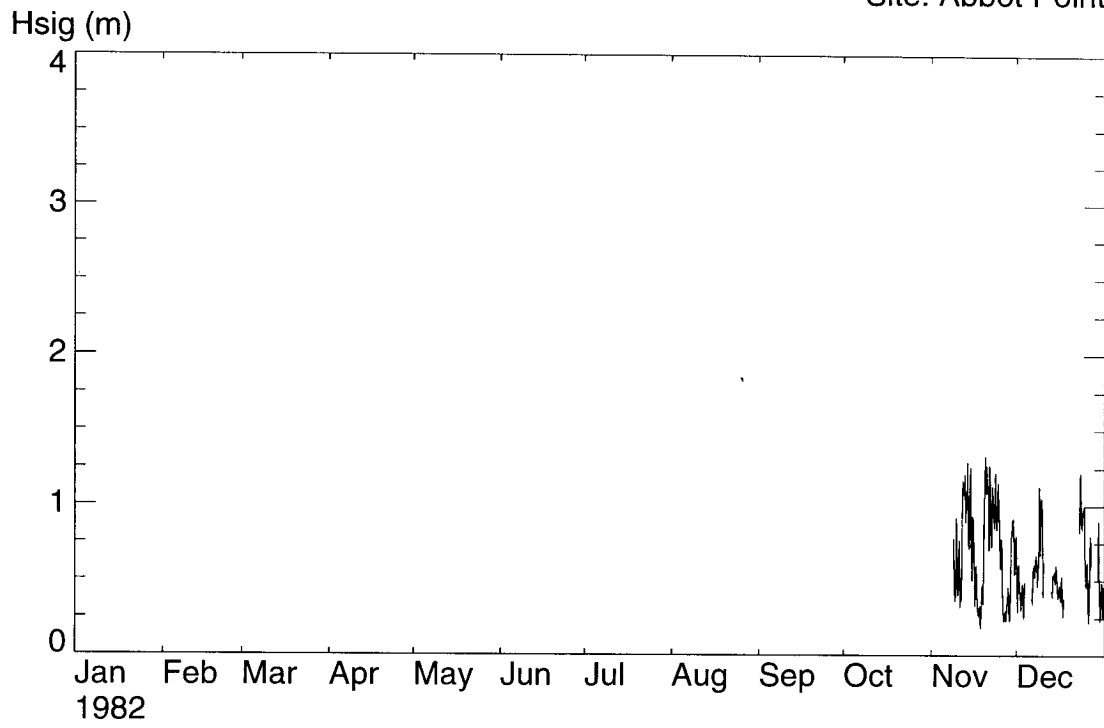


DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.03

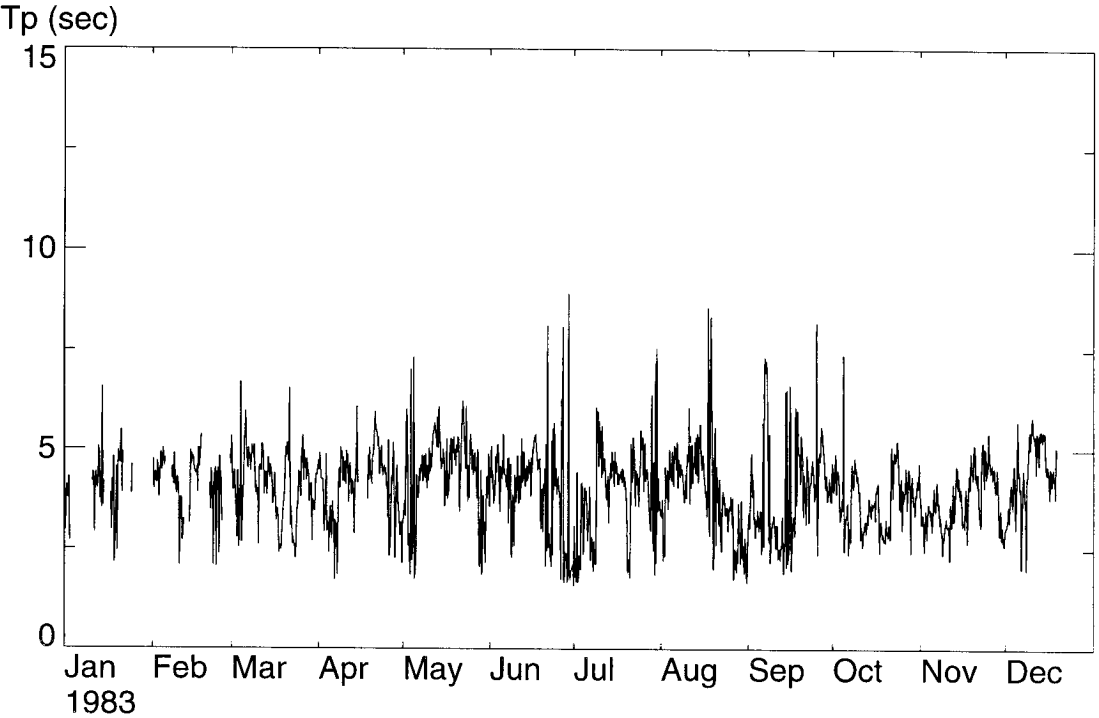
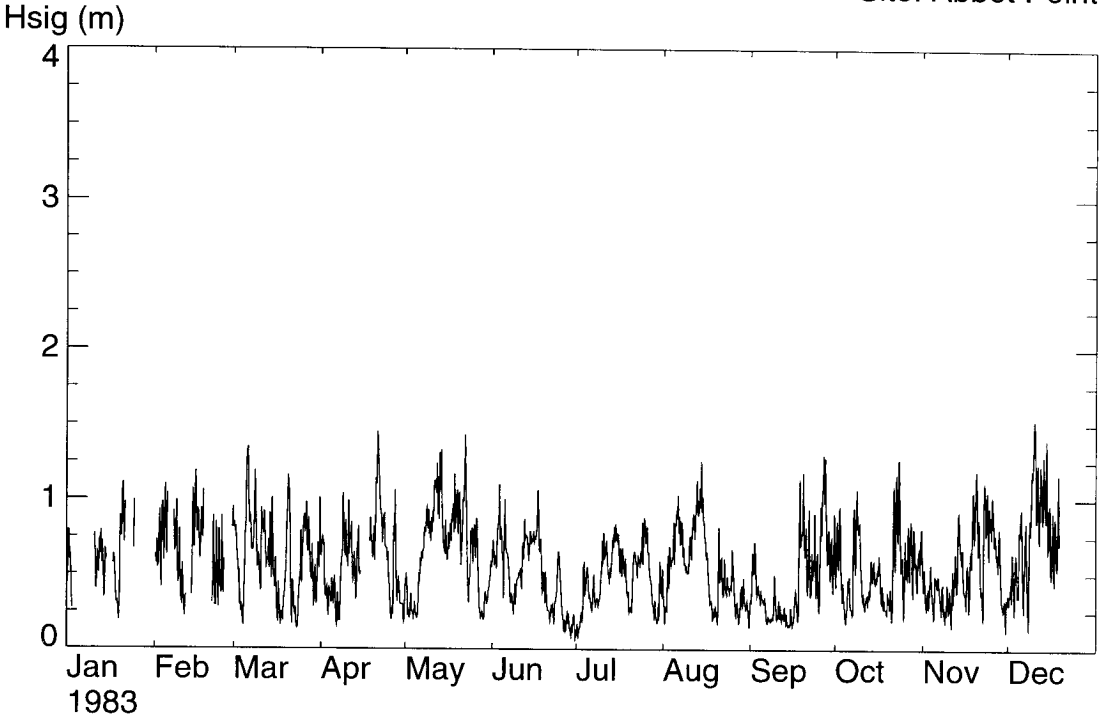
Site: Abbot Point



DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.04

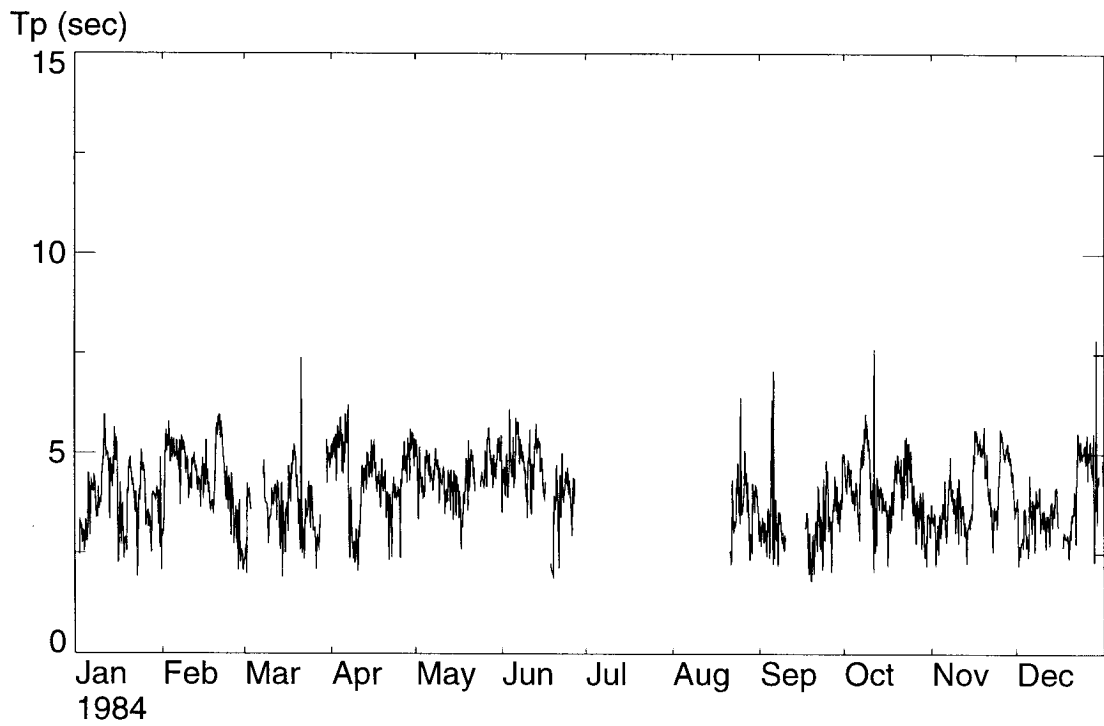
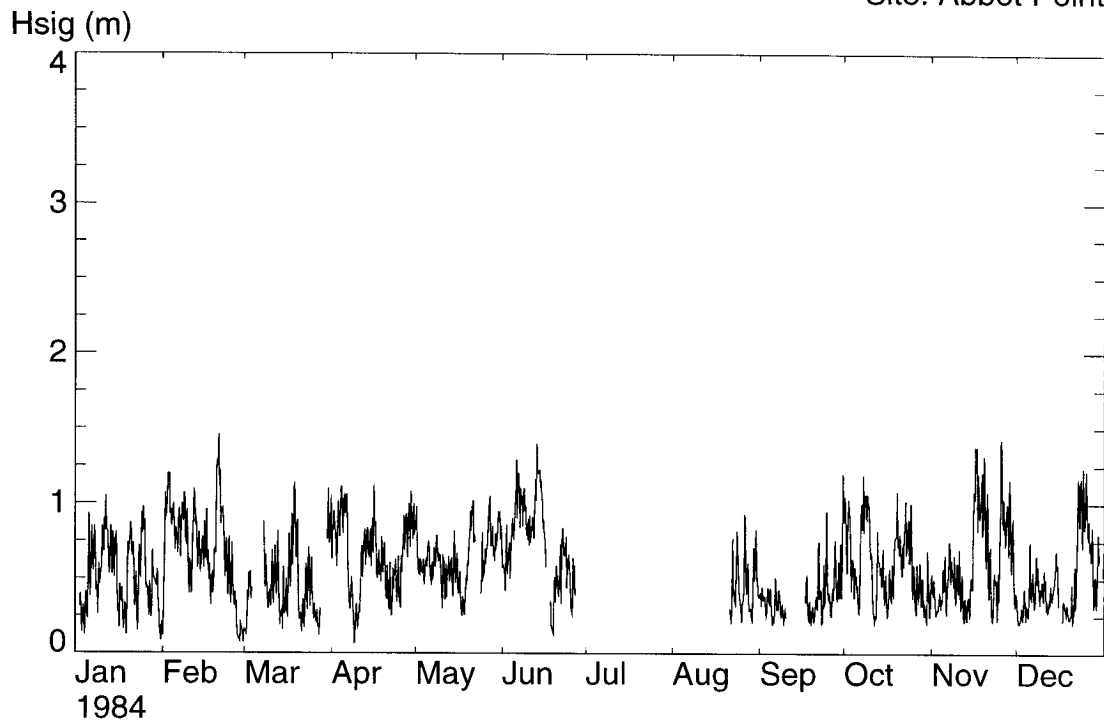


DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.05

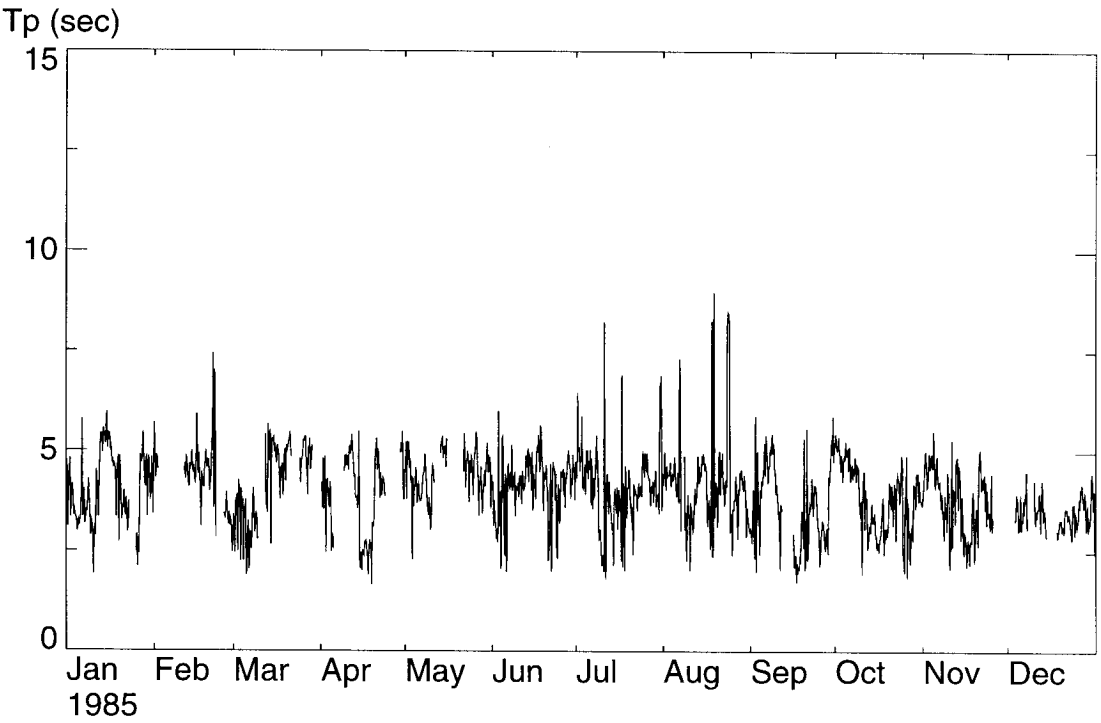
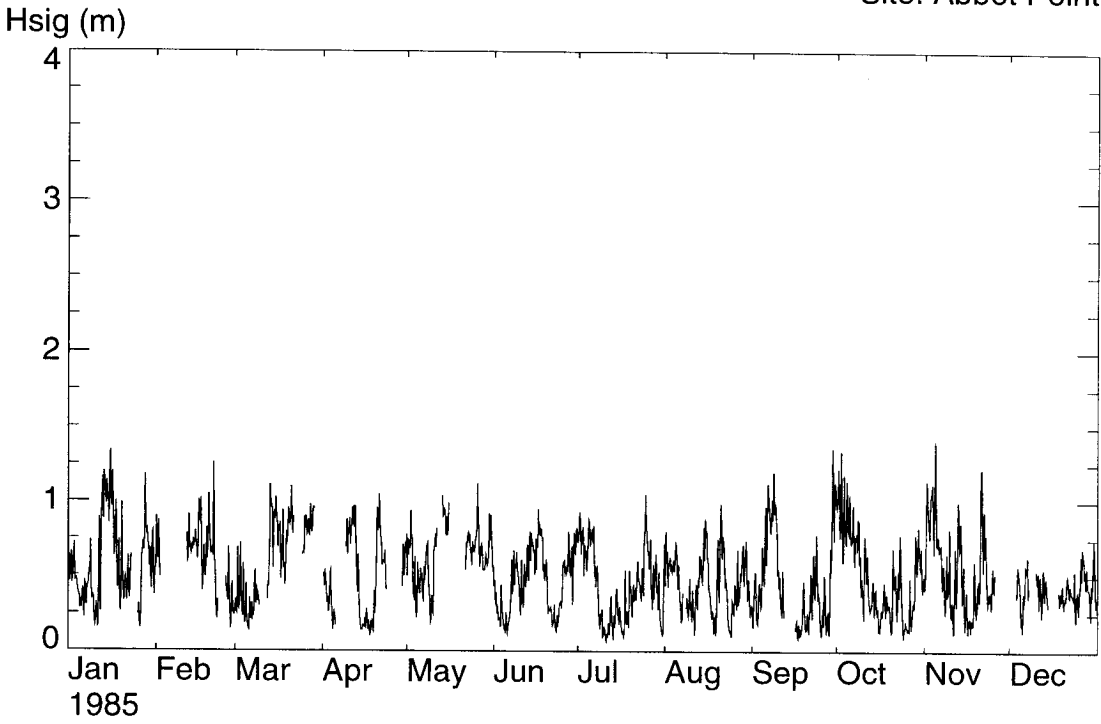
Site: Abbot Point



DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.06

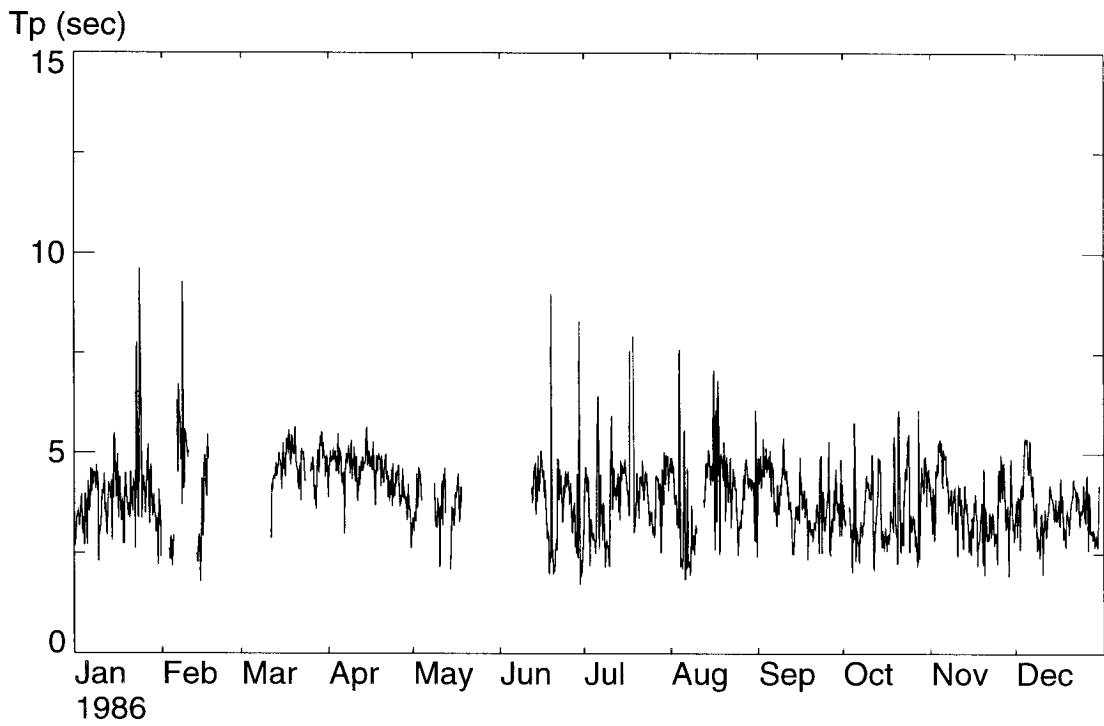
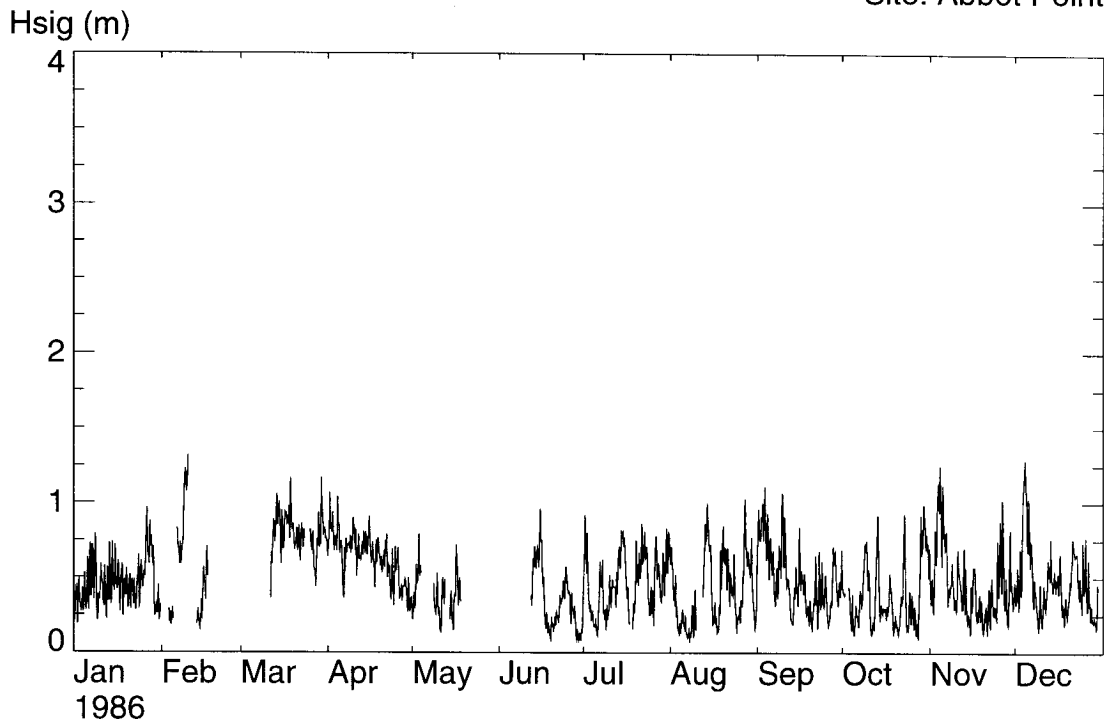


DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.07

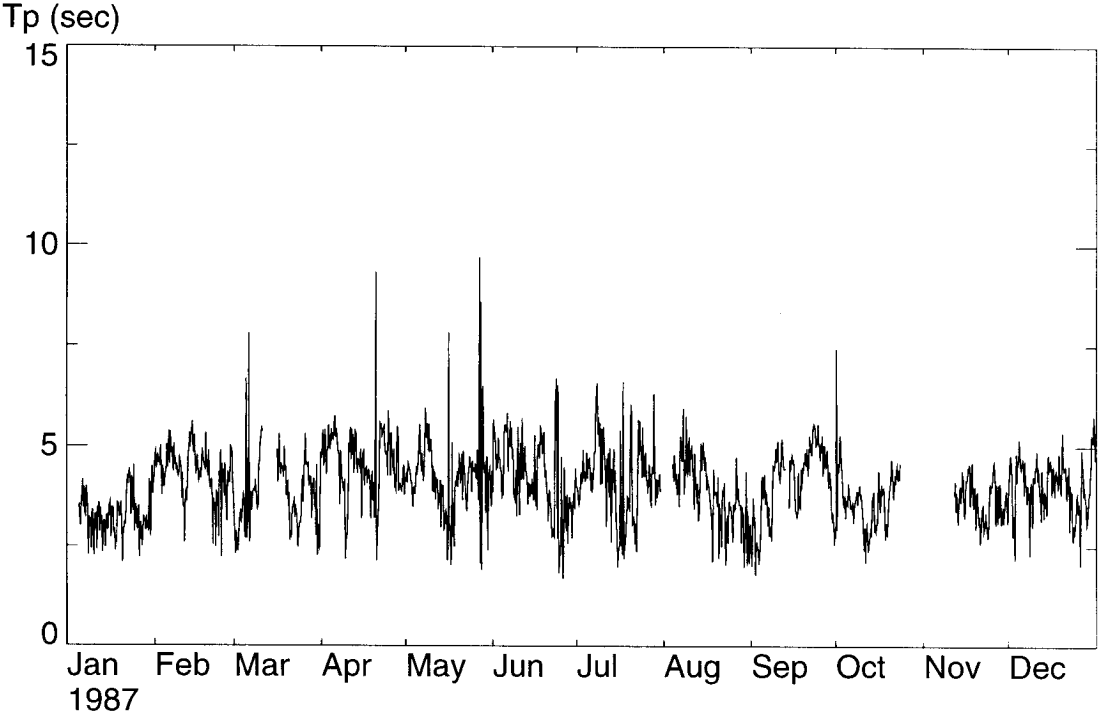
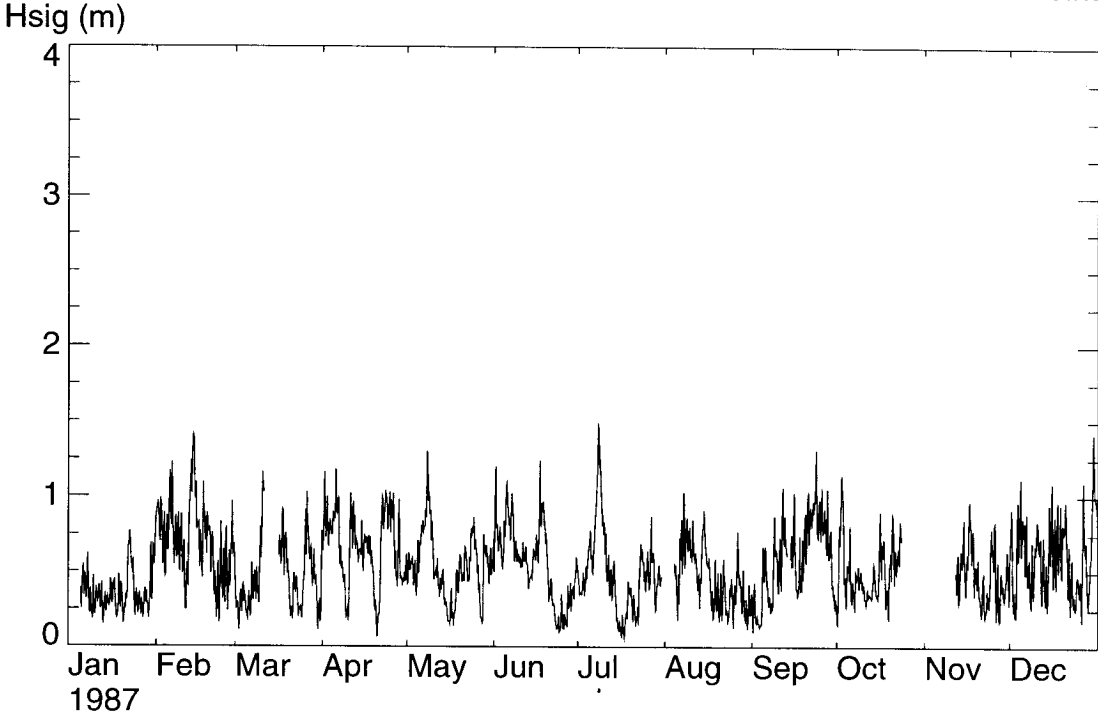
Site: Abbot Point



DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.08

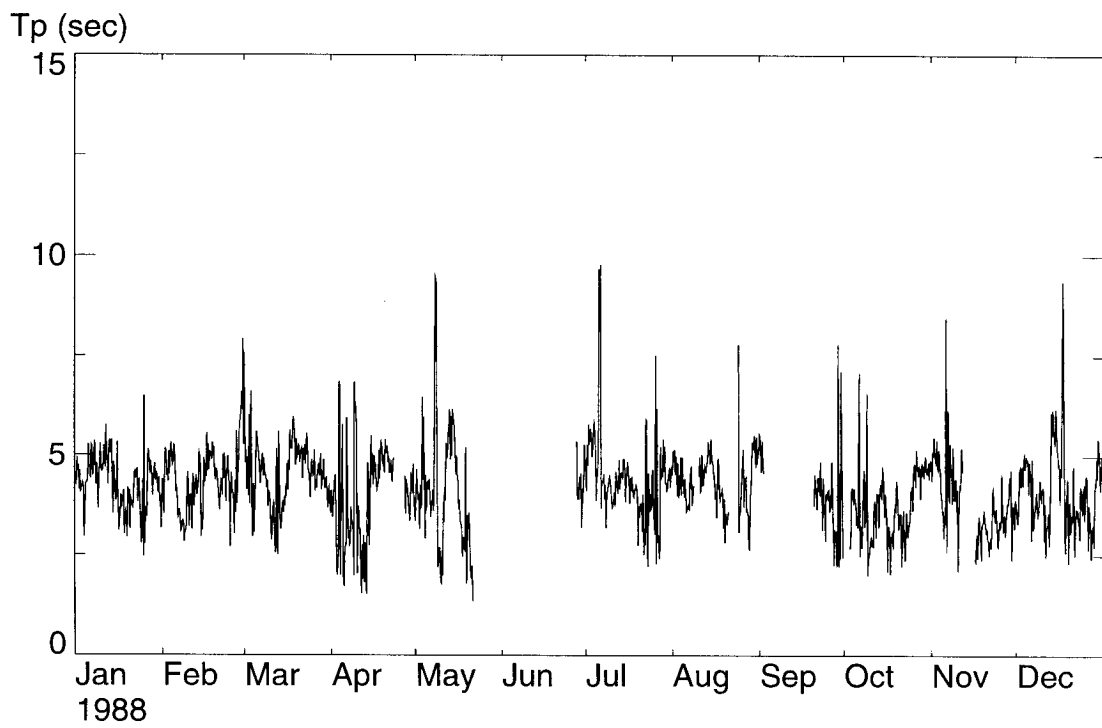
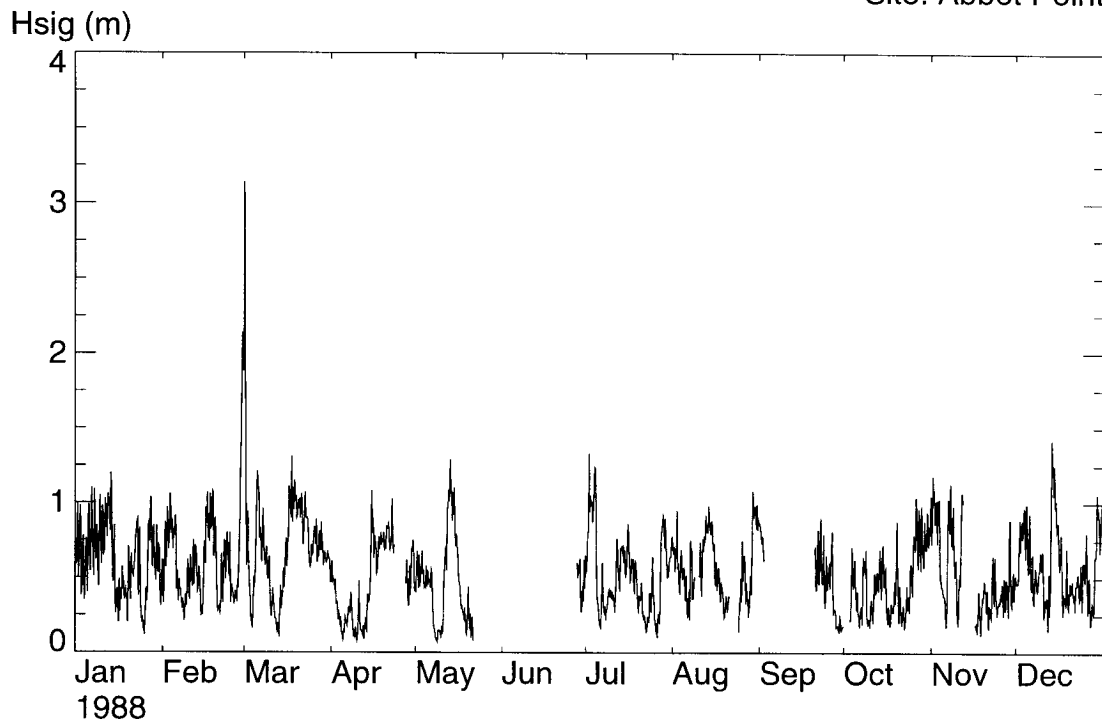


DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.09

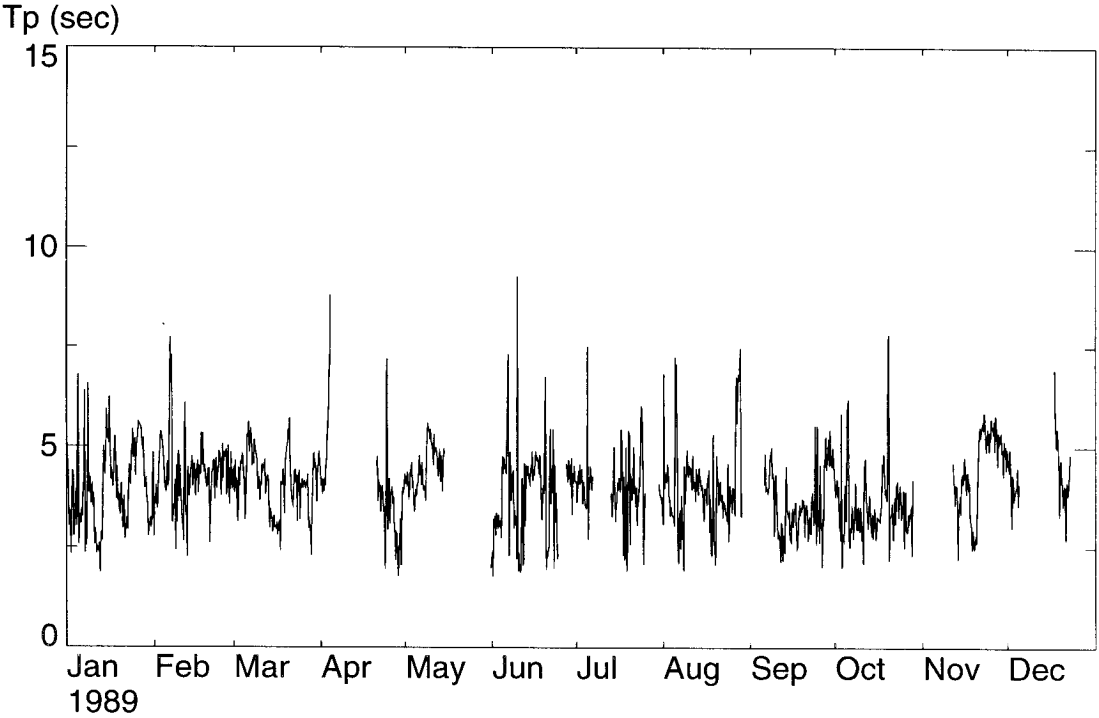
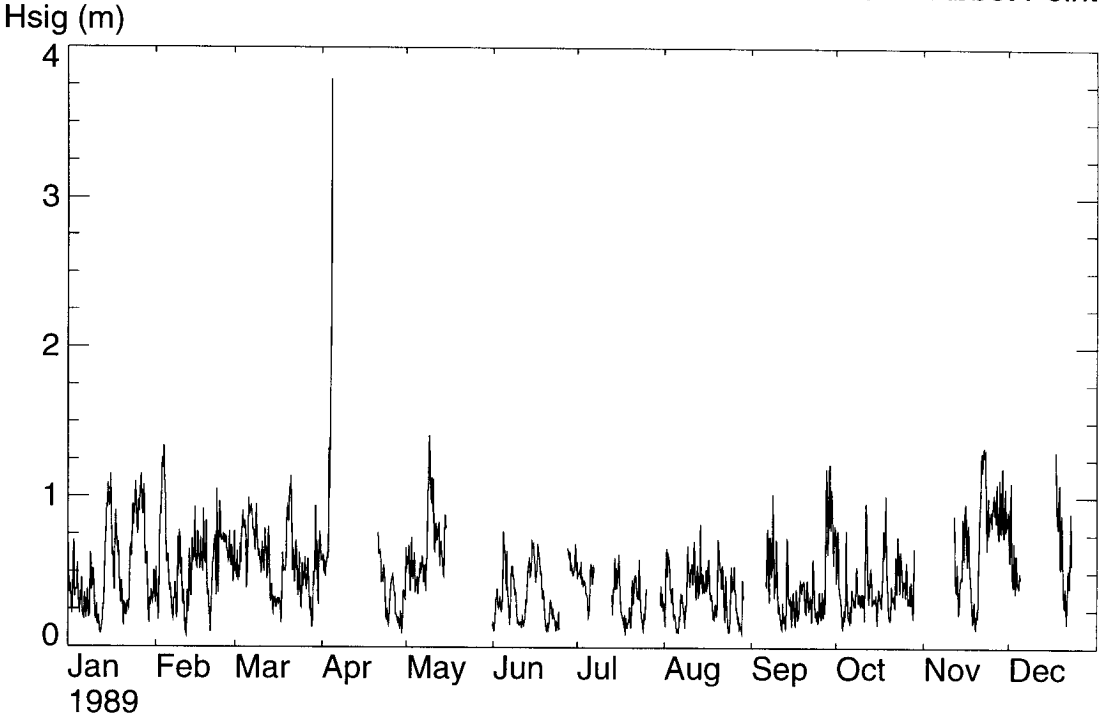
Site: Abbot Point



DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.10

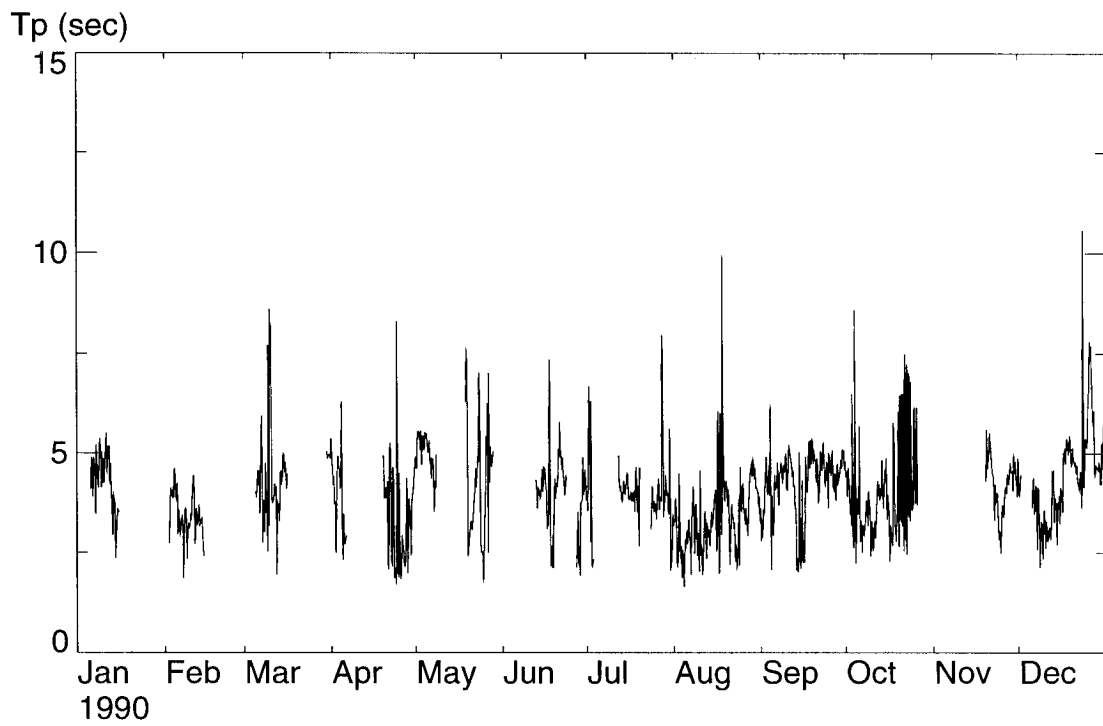
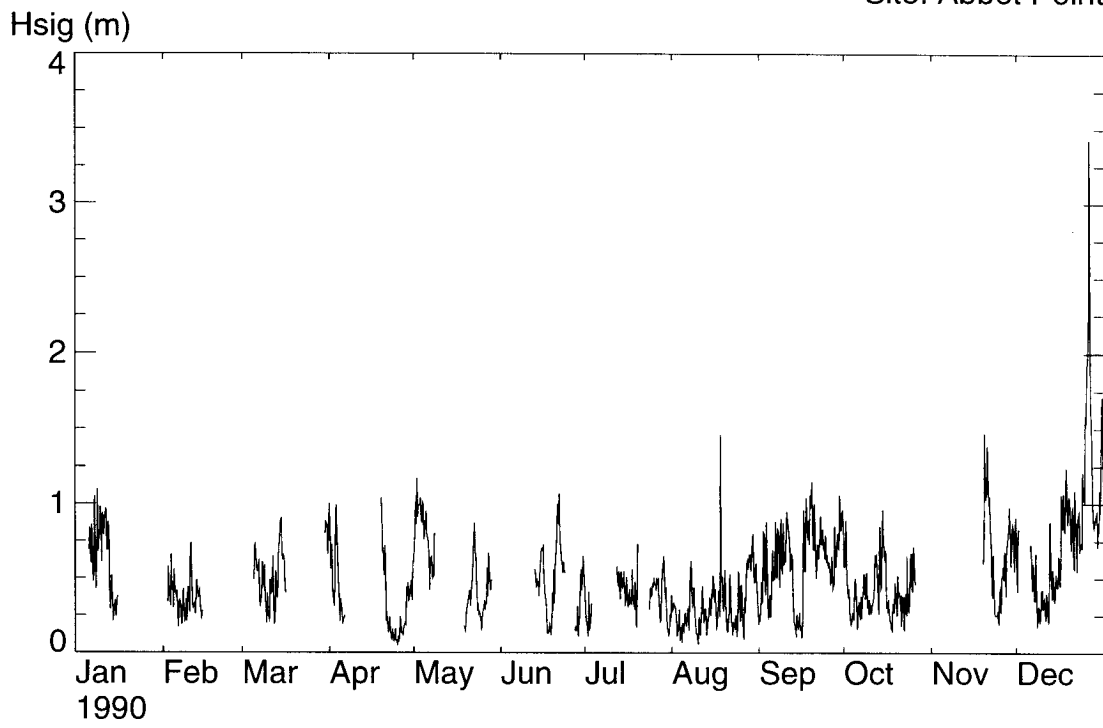


DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.11

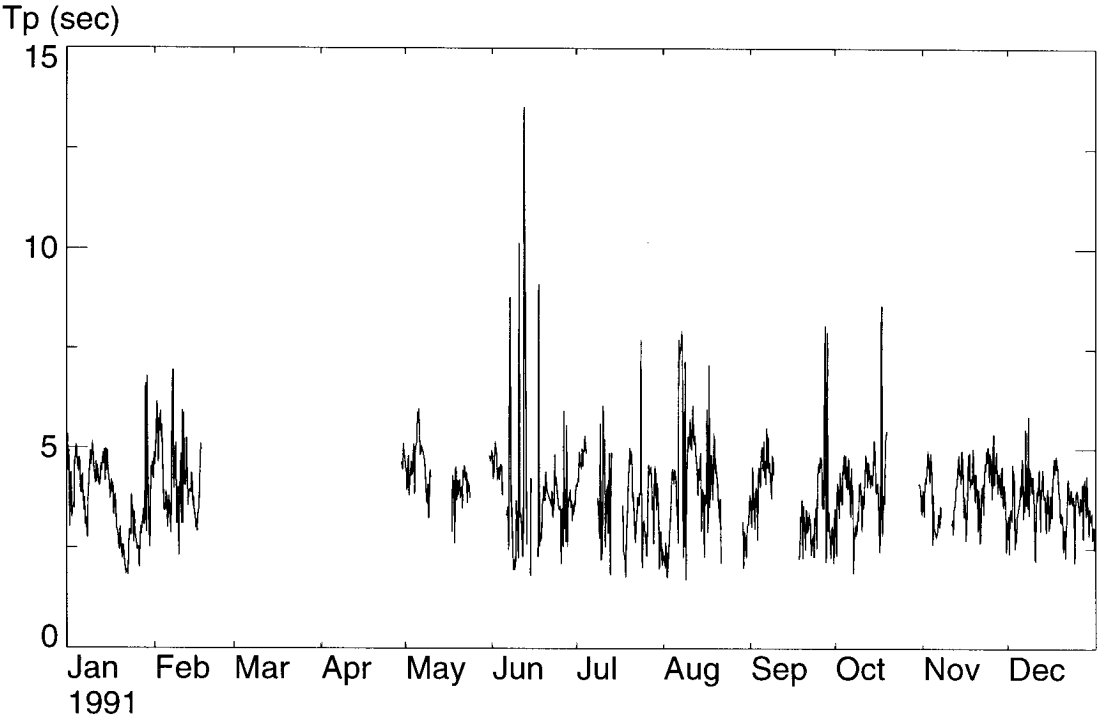
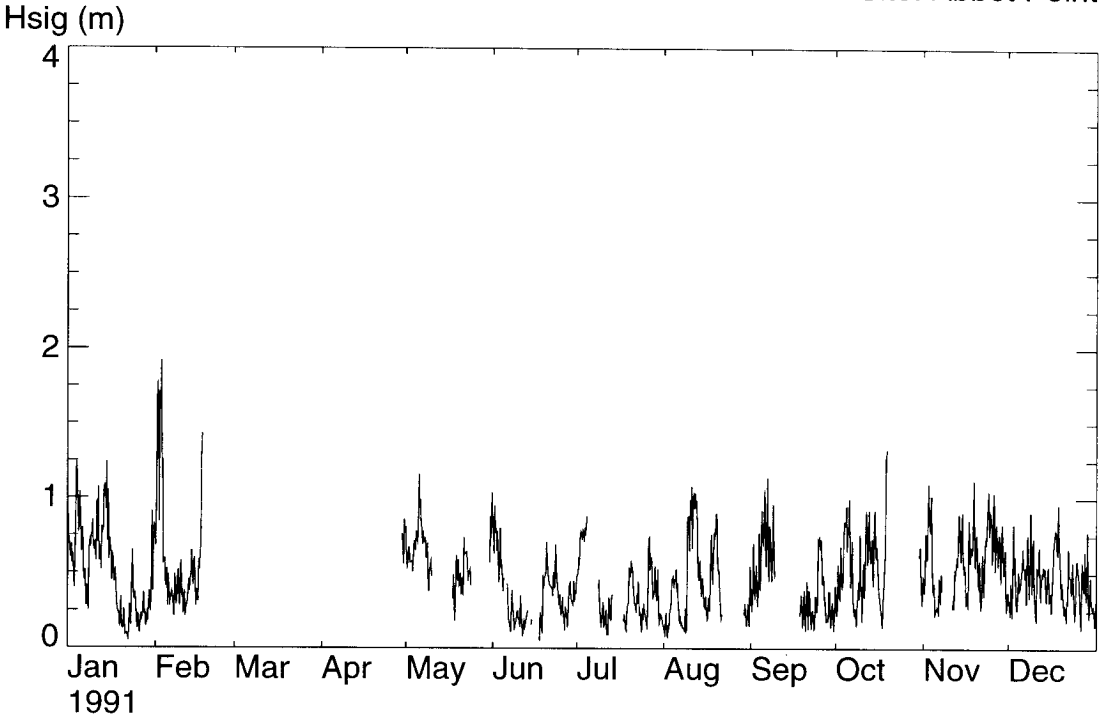
Site: Abbot Point



DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.12

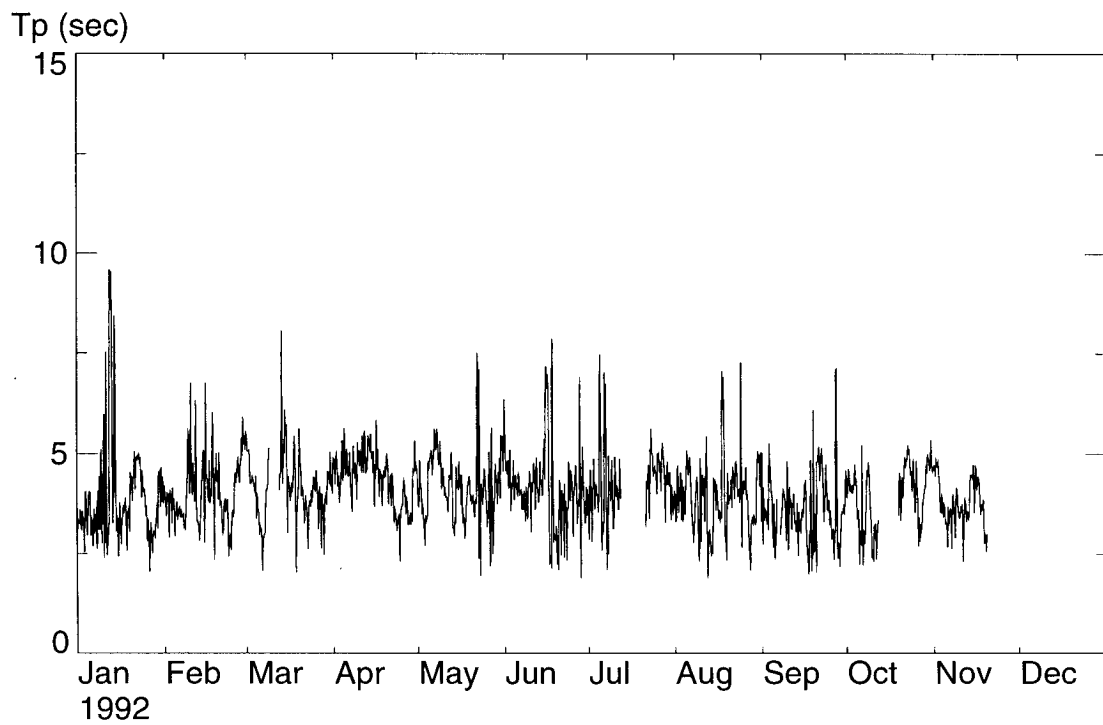
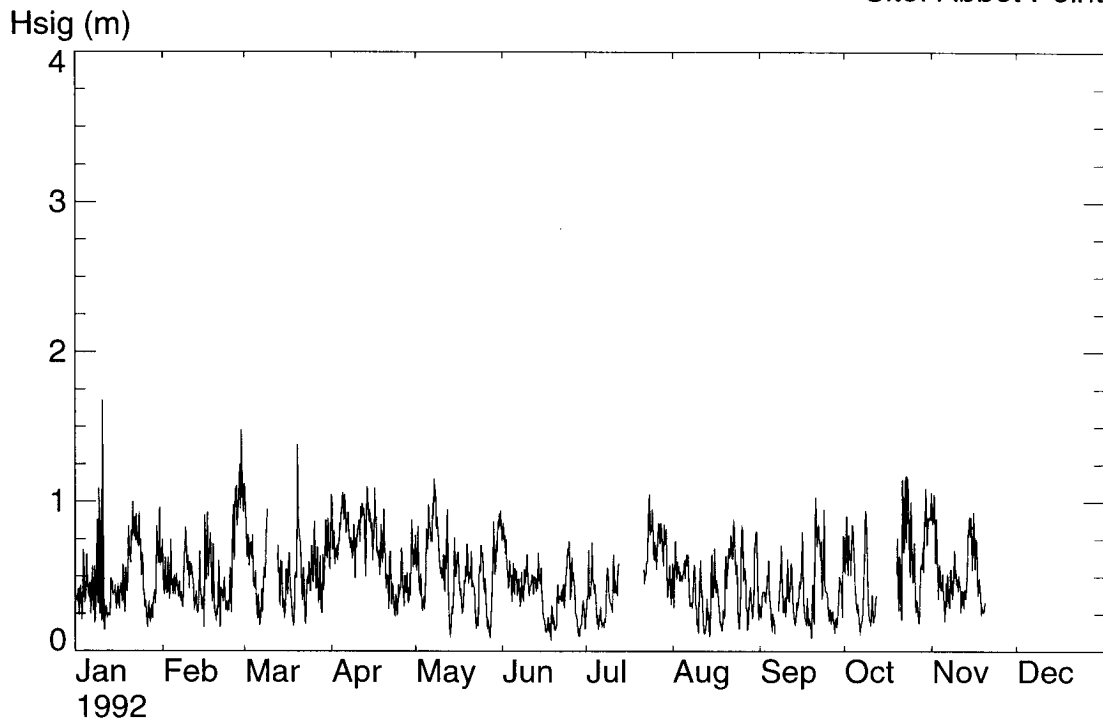


DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.13

Site: Abbot Point

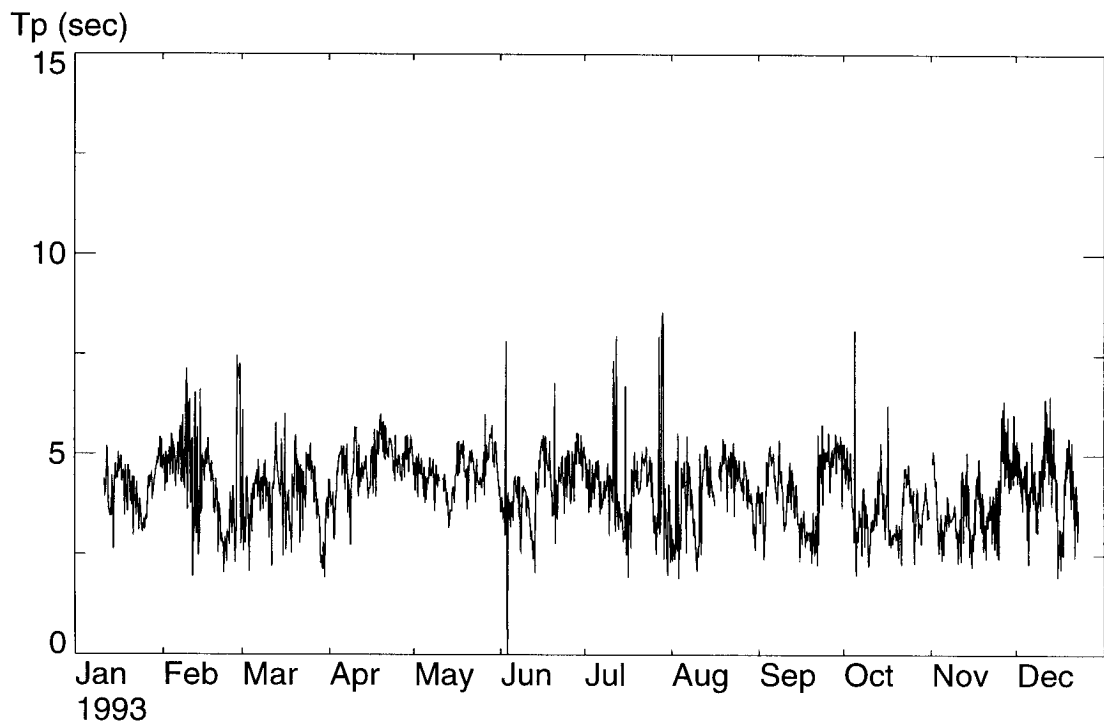
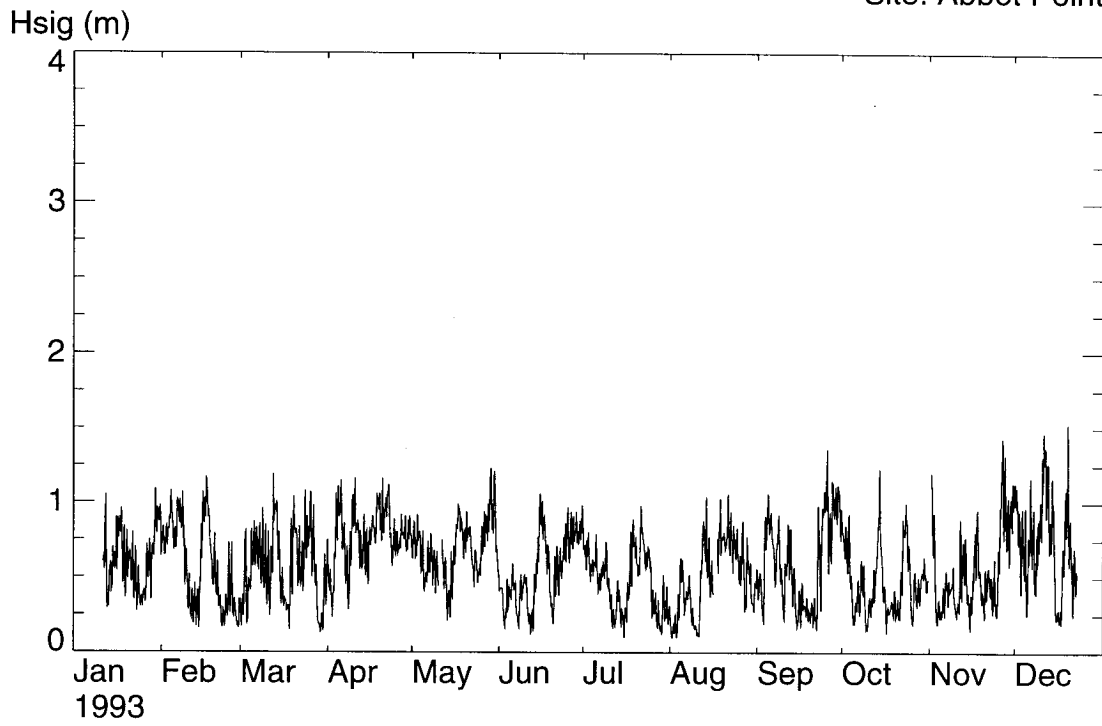


DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.14

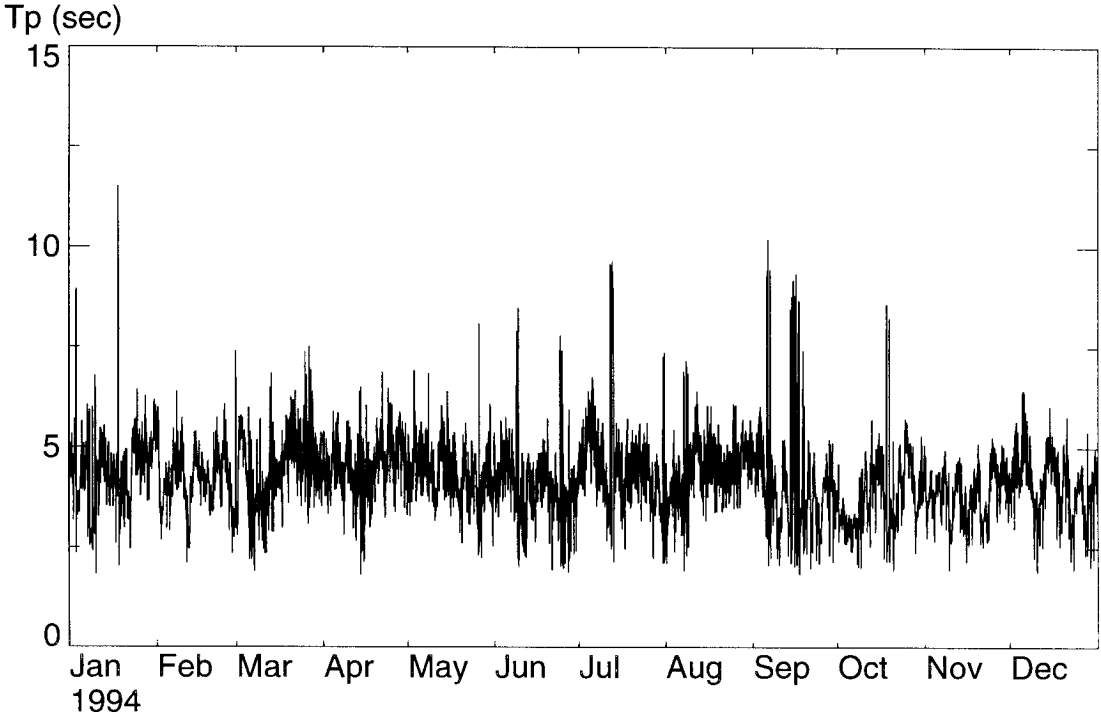
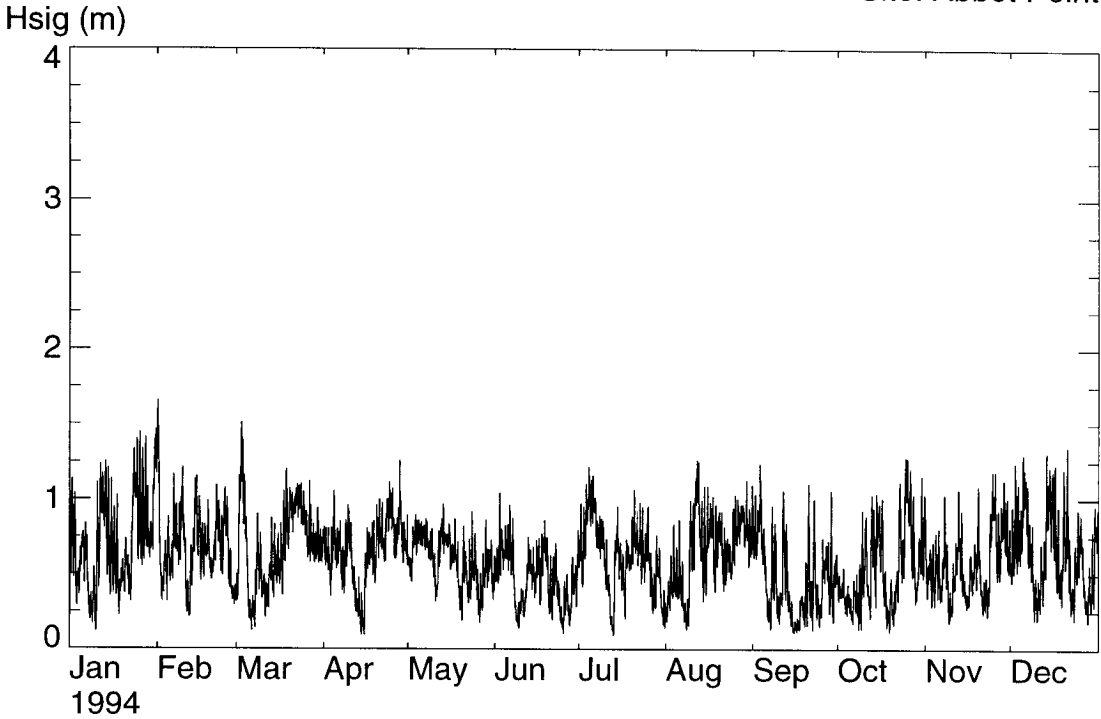
Site: Abbot Point



DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.15

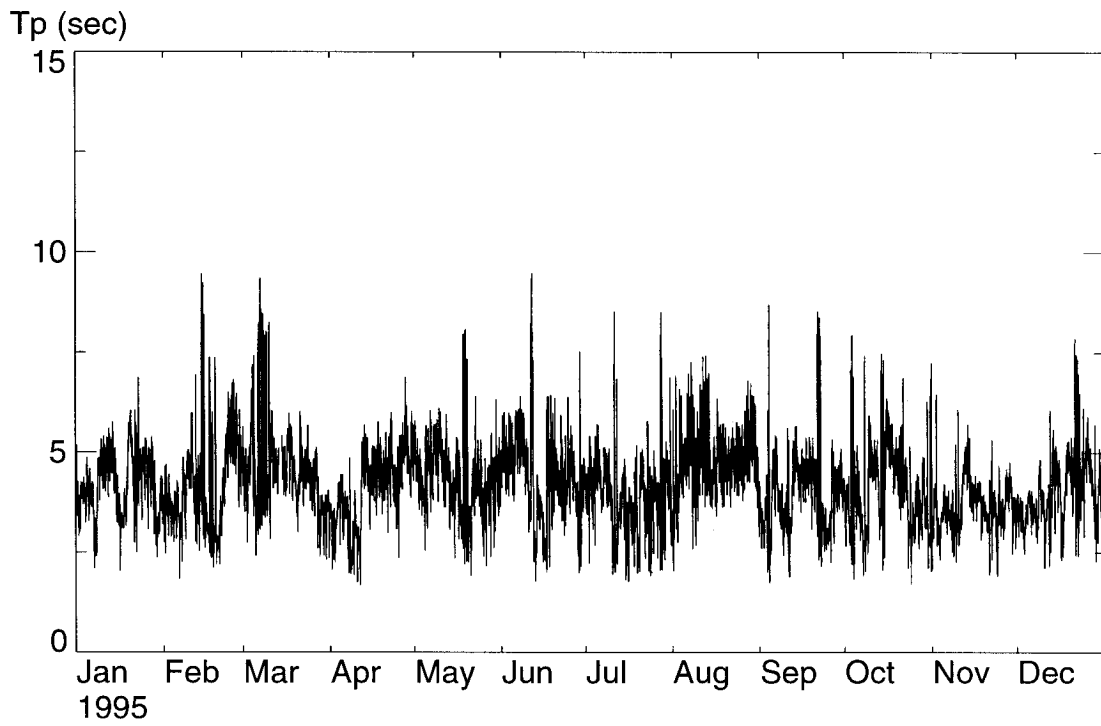
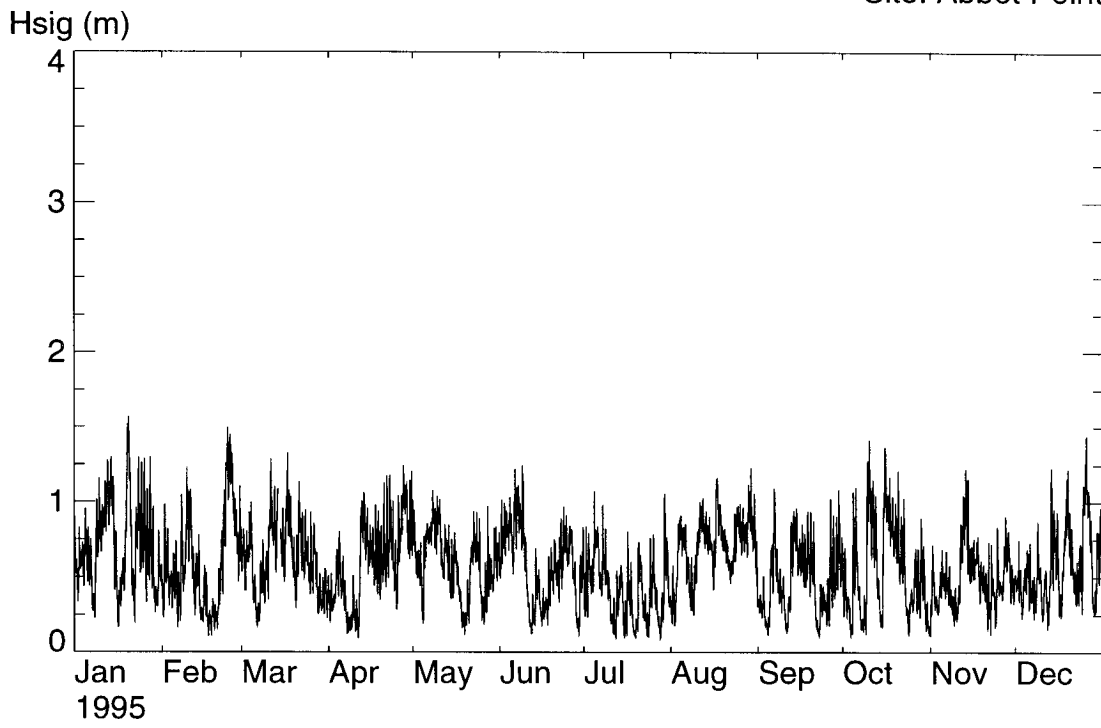


DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.16

Site: Abbot Point

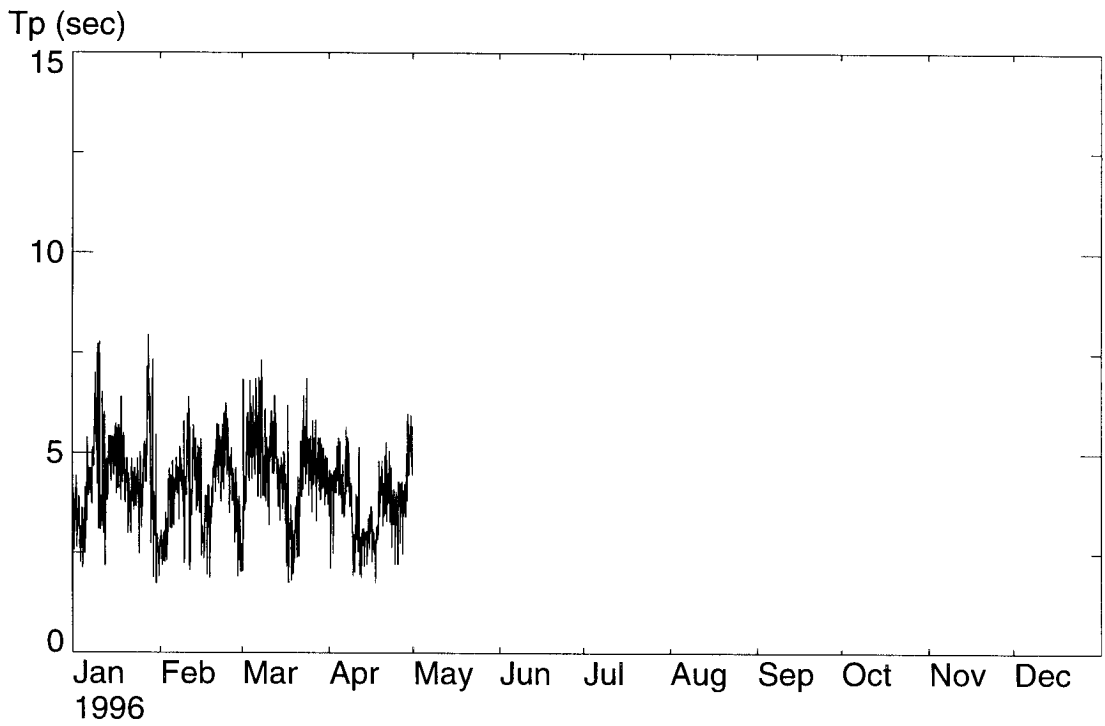
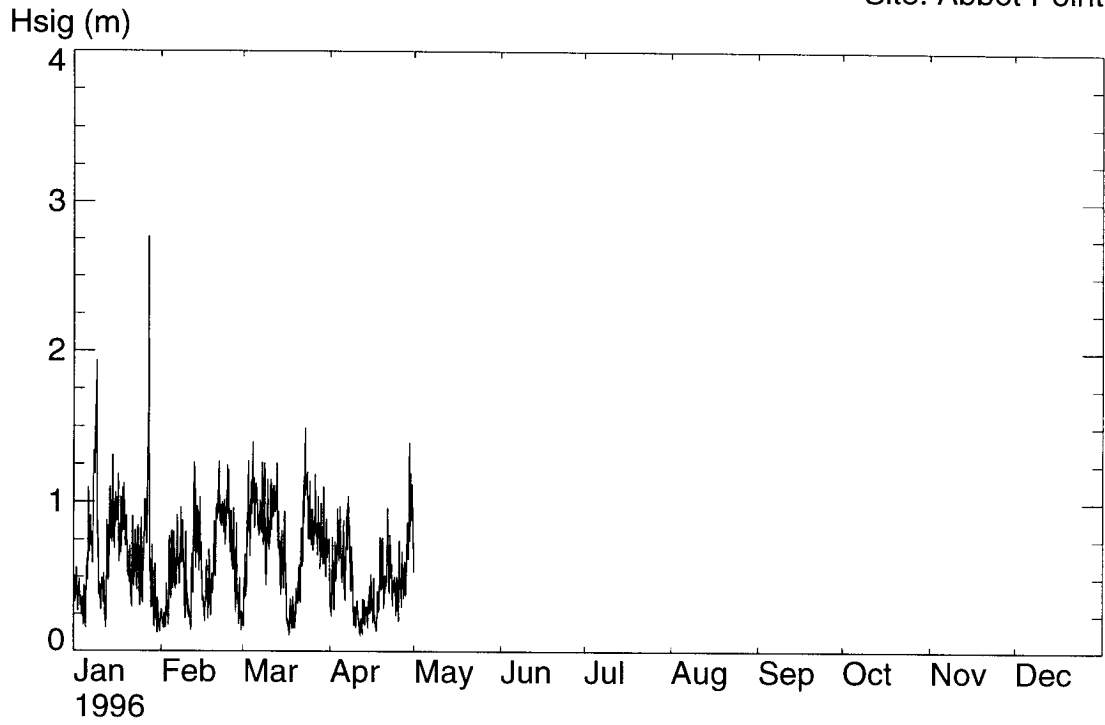


DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.17

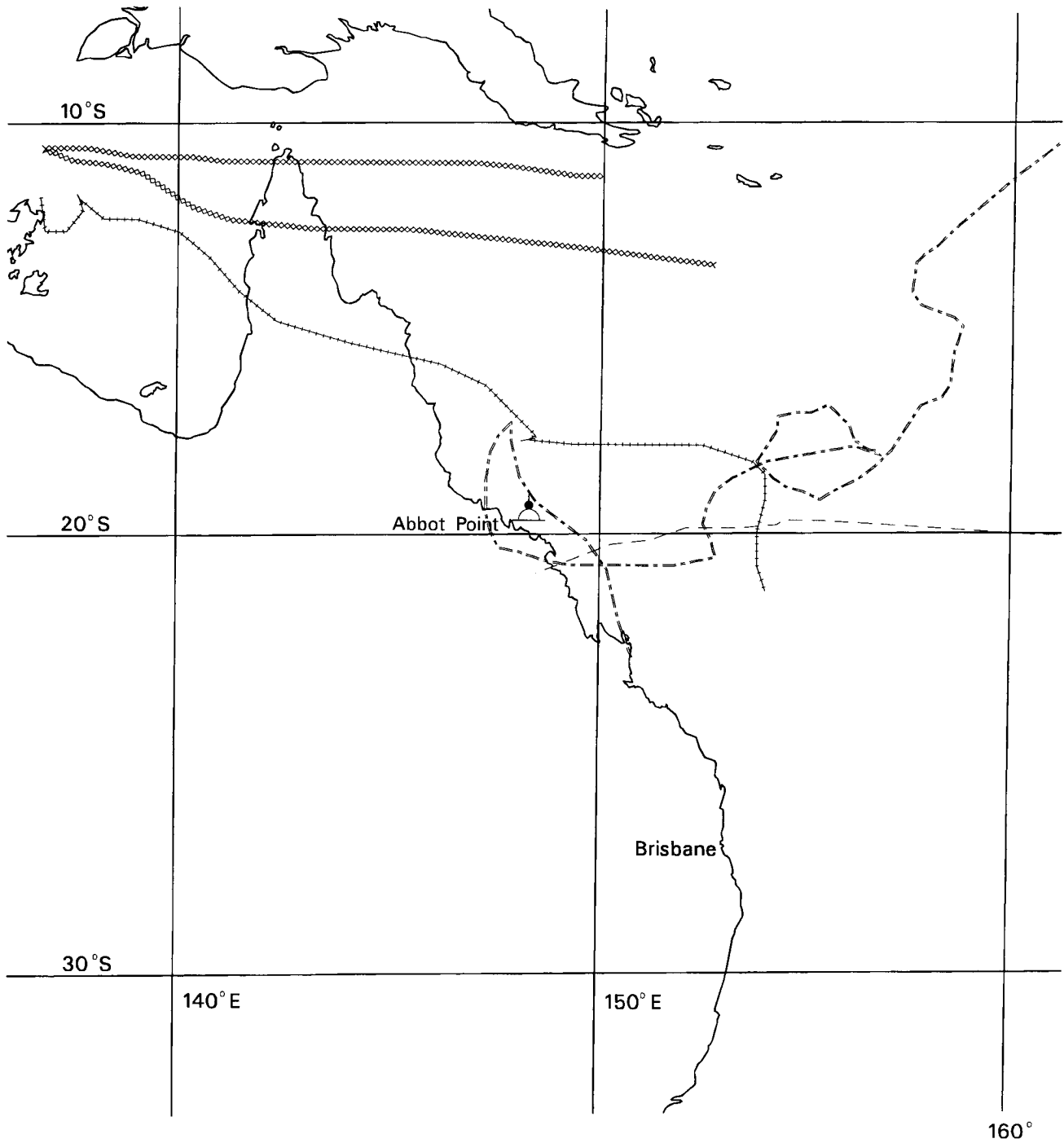
Site: Abbot Point



DAILY WAVE RECORDINGS
7 May 1977 to 30 April 1996

Wave Data Recording Program
ABBOT POINT REGION

Figure: 6.18



KEY TO CYCLONES

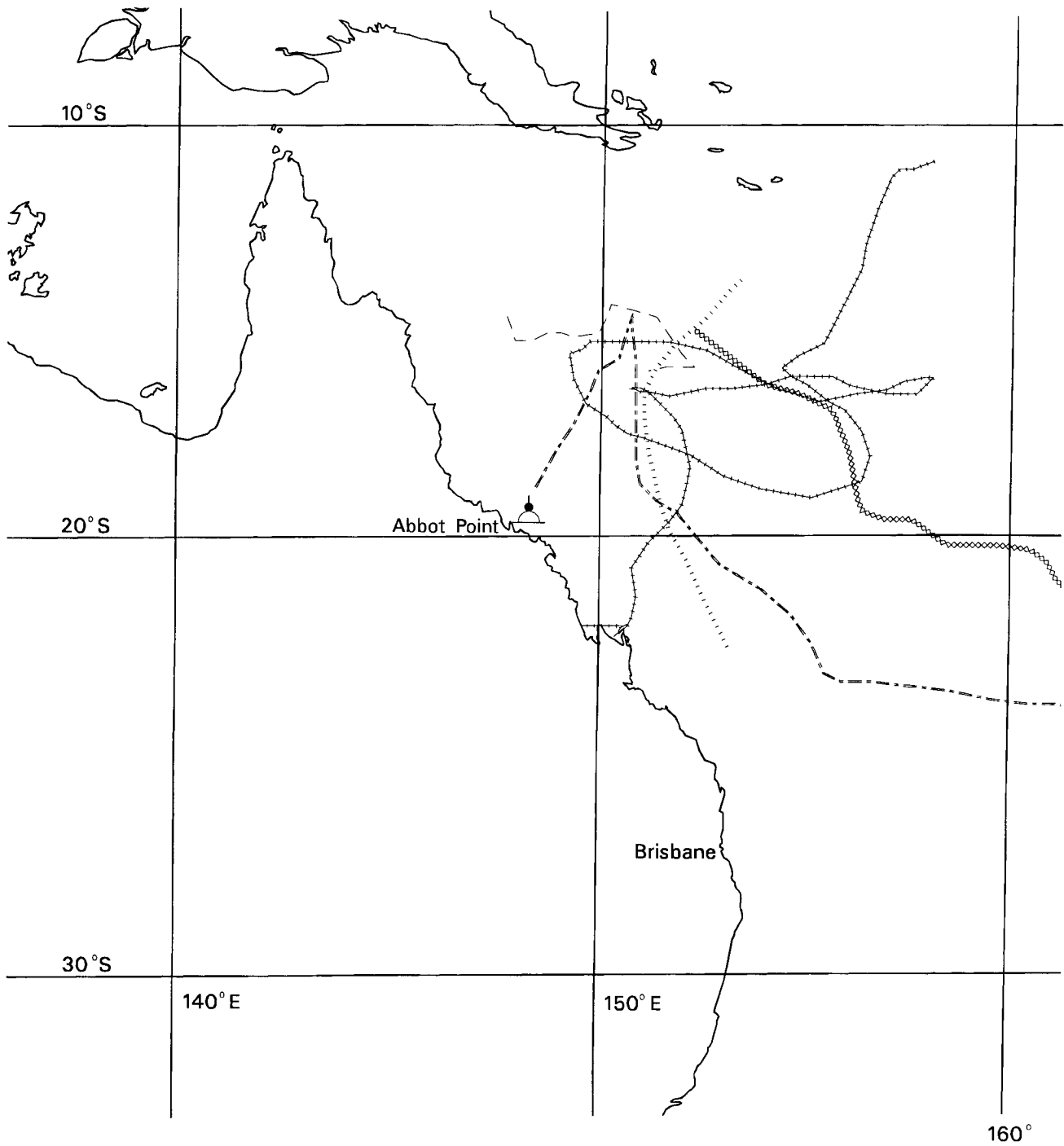
- | | | | |
|-------------|-------|---------|--------|
| | HAL | - - - | GORDON |
| - . - . - . | KERRY | xxxxxxx | STAN |



Cyclone Tracks

Wave Data Recording Program
 ABBOT POINT REGION

Figure: 7.1



KEY TO CYCLONES

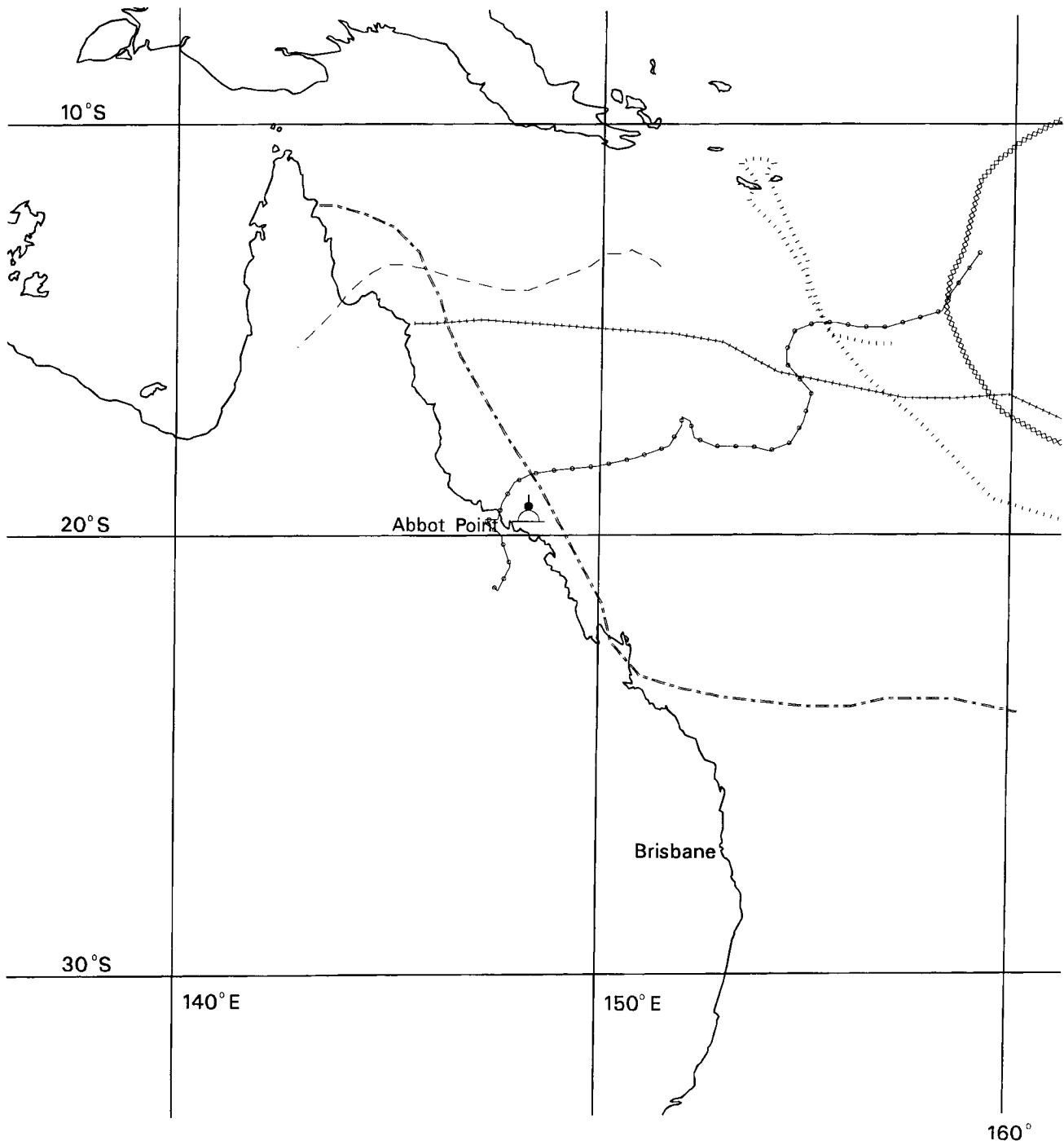
- | | | | |
|-------------|--------|-------------|--------|
| ----- | ELINOR | - - - - | FRITZ |
| - . - . - . | GRACE | o x o x o x | HARVEY |
| | LANCE | | |



Cyclone Tracks

Wave Data Recording Program
 ABBOT POINT REGION

Figure: 7.2



KEY TO CYCLONES

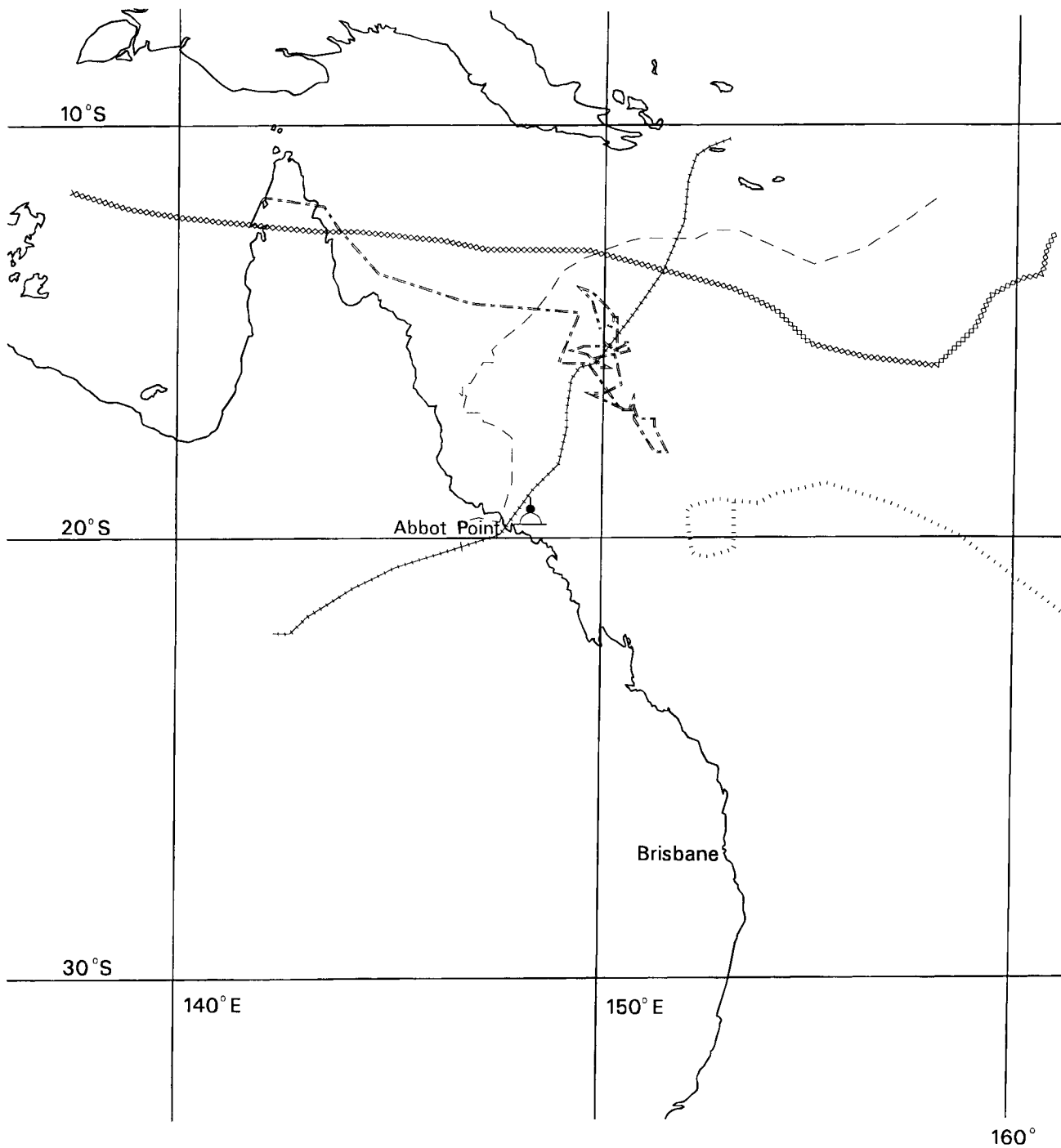
- | | | | |
|---------|--------|--------|---------|
| | ODETTE | - - - | TANYA |
| - . - . | PIERRE | xxxxxx | NAMU |
| | AGI | o-o-o | CHARLIE |



Cyclone Tracks

Wave Data Recording Program
 ABBOT POINT REGION

Figure: 7.3



KEY TO CYCLONES

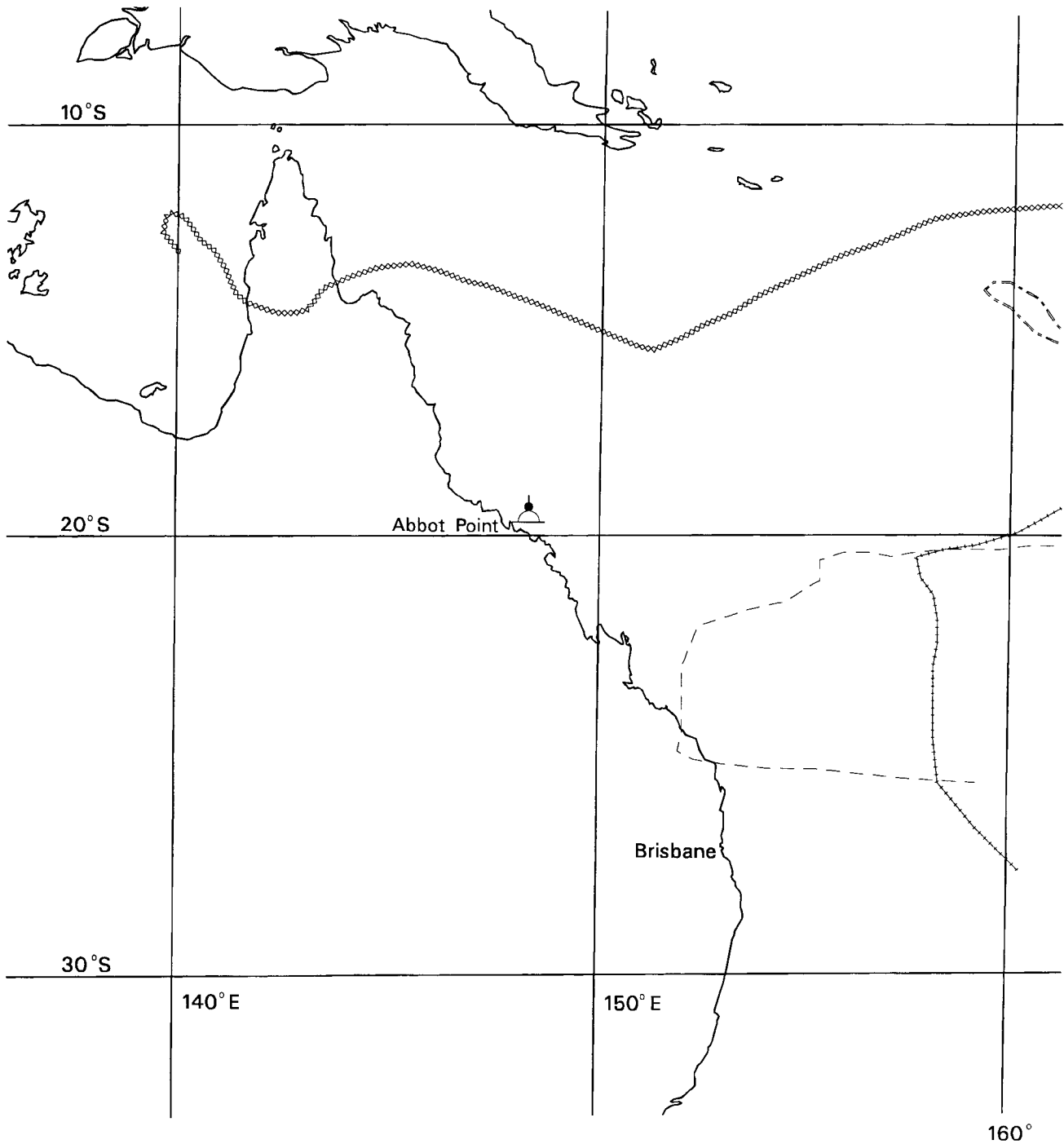
- | | | | |
|-----------|--------|---------|-------|
| ----- | AIVU | - - - - | JOY |
| - . - . - | KELVIN | | MEENA |
| | HILDA | | |



Cyclone Tracks

Wave Data Recording Program
 ABBOT POINT REGION

Figure: 7.4



KEY TO CYCLONES

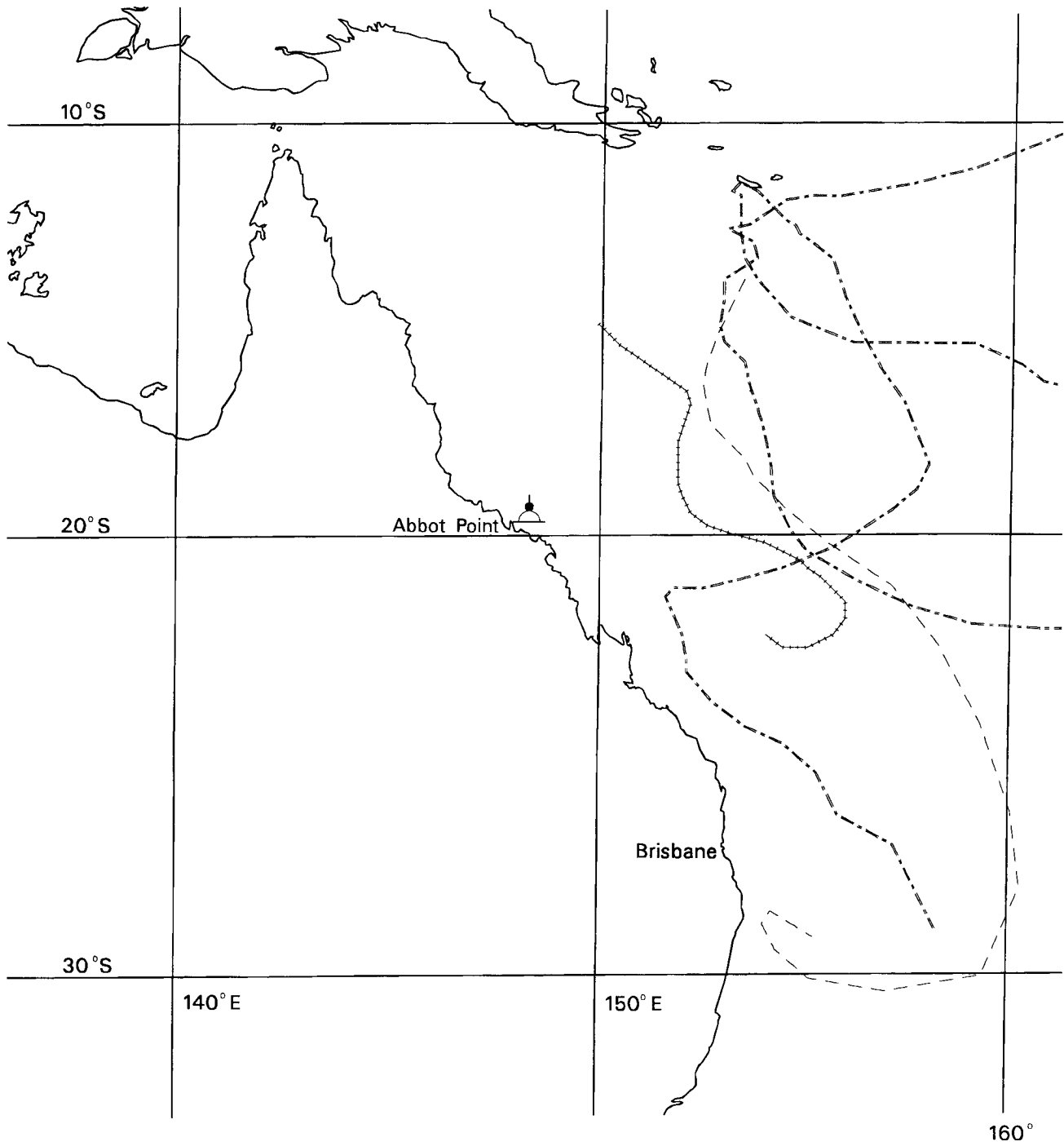
- | | | | |
|-----------|-------|--------|------|
| | BETSY | - - - | FRAN |
| - . - . - | ESAU | xxxxxx | NINA |



Cyclone Tracks

Wave Data Recording Program
 ABBOT POINT REGION

Figure: 7.5



KEY TO CYCLONES

- OLIVER
- . - . REWA
- - - VIOLET



Cyclone Tracks

Wave Data Recording Program
 ABBOT POINT REGION

Figure: 7.6