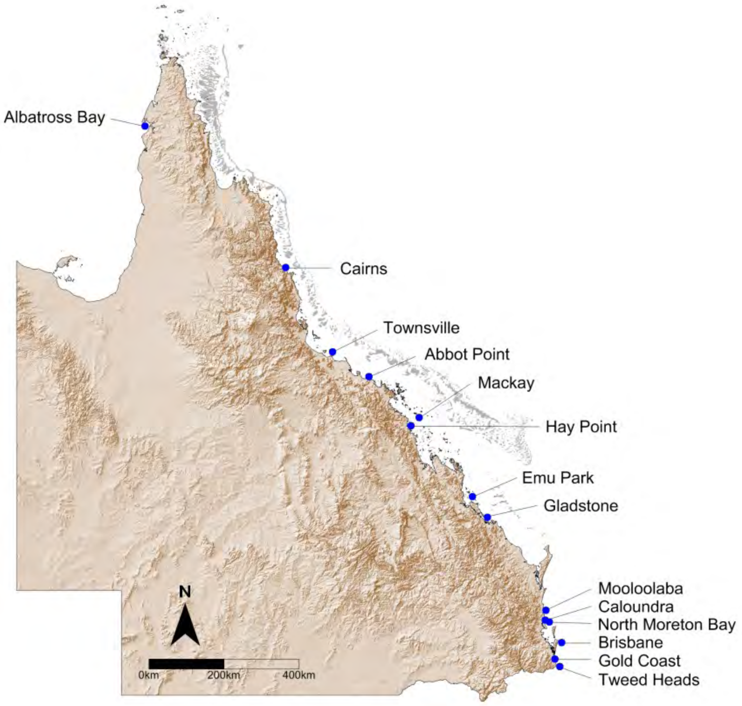
Department of Science, Information Technology and Innovation



Queensland Wave Climate

Wave Monitoring Program Annual Summary

November 2012 to October 2013

Coastal Impacts Unit, DSITI

Prepared by

Coastal Impacts Unit
Science Delivery Division
Department of Science, Information Technology and Innovation
PO Box 5078
Brisbane QLD 4001

Citation

The state of Queensland, Department of Science Information Technology and Innovation (2014).Queensland wave climate: wave monitoring program annual summary, Nov 2012 to Oct 2013.

Acknowledgements

This report has been prepared by the Department of Science, Information Technology, and Innovation. DSITI acknowledges the following team members who contributed their time and effort to the preparation of this report:

Daryl Metters, James Donald, Paul Boswood and John Ryan

May 2015

Executive Summary

The information presented here summarises the primary analyses of wave data recorded using Datawell Waverider buoys positioned off the Queensland coastline from 1 November 2012 to 31 October 2013.

The data covers all of the seasonal variations for one year, and includes the 2012–13 cyclone season, which extends from 1 November 2012 through to 30 April 2013. This period is also classed as ‘summer’ in both this annual report and the regional technical reports. The remainder of the year (1 May 2013 to 31 October 2013) is classed as ‘winter’ in these reports.

The wave monitoring program utilises the Waverider system, manufactured by Datawell of the Netherlands, to measure the sea surface fluctuations at each offshore location. Directional Waverider buoys are operated at all sites except Cairns where a non-directional Waverider buoy is deployed due to the sheltered nature of the site. The directional buoys also record temperature in the bottom of the hull; the temperature record is called Sea Surface Temperature (SST) here.

For all stations, the wave data has been statistically compared to the long-term average conditions at each site. Also provided are brief details of the recording equipment, the methods of handling raw data and the type of analyses employed.

There were four tropical cyclones that moved within Queensland waters in the reporting period. Tropical Cyclone (TC) Oswald posed the biggest threat to life and property despite being downgraded to an extreme low pressure system after being classified as a category 1 tropical cyclone briefly in the Gulf of Carpentaria. Ex-TC Oswald travelled southward and inland of the Queensland coast, bringing high rainfall, cyclonic winds, extreme sea levels and large waves to most of the coastline. Wave heights that resulted were within the top ten highest waves recorded for 13 out of the 14 wave monitoring sites.

Although TC Sandra was the most extreme cyclone during the season, developing into a category 4, it remained well off the east coast travelling close enough to generate a significant meteorological event at the North Moreton and Gold Coast buoys. TC Tim began on 23 March 2013 in the Northern Territory then crossed the top of the Gulf of Carpentaria and Cape York Peninsula before moving towards the Coral Sea. TC Tim then moved back toward the coast as a category 2 tropical cyclone; however, no significant meteorological event or top ten wave height records were reported. TC Zane formed on 26 April 2013, late in the season, east of Cape York Peninsula. TC Zane developed into a category 3 cyclone while travelling towards the coast. A significant meteorological event eventuated at Cairns on 1 May 2013 as TC Zane approached the coast as a category 1 cyclone.

Contents

List of tables

List of figures

1. Introduction

This summary of wave climate in Queensland is one of a series of technical wave reports prepared annually by the Coastal Impacts Unit of the Department of Science, Information Technology and Innovation (DSITI). Annual wave reports supplement the reporting capability of DSITI's Coastal Impacts Unit by providing information on wave climates in Queensland.

1.1 Wave monitoring stations

The Department of Science, Information Technology and Innovation (DSITI), as part of its long-term data collection program, has maintained a network of wave recording stations along the Queensland coast since 1968.

The network of wave recording stations has been grouped into two categories:

Long-term sites: These core sites provide valuable long-term wave climates along the Queensland coast for coastal and disaster management purposes. The stations are fully funded and operated by DSITI.

Partnership sites: The operation of these sites will vary in duration, and they are associated with specific projects, to assess wave conditions or to manage maritime activities. These stations are operated by DSITI in conjunction with (and jointly-funded by) other agencies.

Table 1.1: Wave recording stations November 2012–October 2013

Long-term	Joint project	Joint project partners
Brisbane	Tweed Heads	TRESBP *
Emu Park	Gold Coast	Gold Coast City Council
Mackay	Caloundra **	Port of Brisbane Corporation
Townsville	North Moreton	Port of Brisbane Corporation
Cairns	Mooloolaba	Department of Transport
	Gladstone	Gladstone Ports Corporation
	Hay Point	North Queensland Bulk Ports
	Abbot Point ***	North Queensland Bulk Ports
	Weipa	North Queensland Bulk Ports

* Tweed River Entrance Sand Bypassing Project is a joint project of Queensland and New South Wales Governments with support from the Gold Coast City Council

** Abbot Point has less than two years of service so some analysis is not included in this report

*** Caloundra is a new site, established when Central Moreton was discontinued.

For all stations, the wave data collected for the current year is statistically compared to the long-term average conditions at the site. Brief details of the recording equipment, the methods of handling raw data and the type of analyses employed are provided within this report.

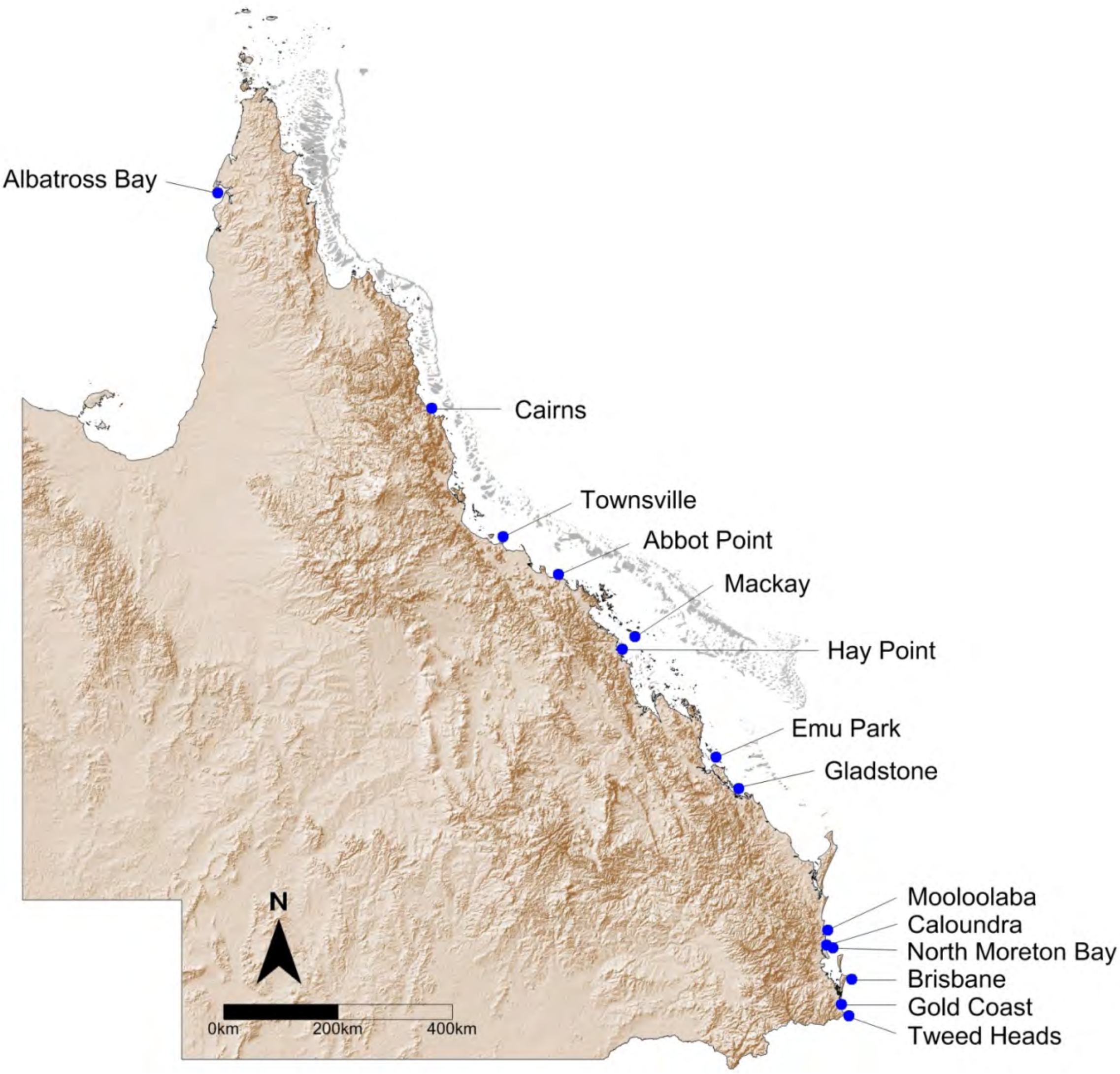


Figure 1.1: DSITI wave monitoring sites in Queensland

1.2 Recording

For the monitoring period documented in this summary report, DSITI's Coastal Impacts Unit wave monitoring program utilised the Waverider buoy system manufactured by Datawell of the Netherlands to measure the sea surface fluctuations at an offshore location. Directional Waverider buoys were in operation at all sites except Cairns during the period of this report. A non-directional Waverider buoy is deployed at Cairns due to the sheltered nature of the site limiting wave direction.

Table 1.2: Wave monitoring history

Site	Start date	End date	Restart	Directional start date	Total years	Directional years
Tweed Heads	13/01/1995	-	-	13/01/1995	17.8	17.8
Gold Coast	21/03/1987	-	-	17/07/2007	25.6	5.3
Brisbane	31/10/1976	-	-	20/01/1997	36.0	15.8
Central Moreton Bay	19/10/2000	-	-	19/10/2000	12.0	12.0
North Moreton Bay	22/09/2003	-	-	22/09/2003	9.1	9.1
Mooloolaba	20/04/2000	-	-	11/05/2005	12.5	7.5
Gladstone	23/09/2009	-	-	23/09/2009	3.1	3.1
Emu Park	24/07/1996		-	24/07/1996	16.3	16.3
Hay Point	24/04/1977	25/05/1987	3/04/1993	31/10/2009	29.7	3.0
Mackay	19/09/1975	-	-	13/03/2002	37.1	10.6
Abbot Point	17/01/2012	-	-	17/01/2012	0.75	0.75
Townsville	20/11/1975		-	29/10/2008	36.9	4.0
Cairns	04/05/1975	-	-	-	37.5	0.0
Albatross Bay (Weipa)	25/11/2008	-	-	25/11/2008	3.9	3.9

1.1.1 Accelerometer Buoys

The directional Waverider buoys at the Brisbane, Gold Coast, Gladstone, Mackay, and Townsville sites measure vertical accelerations by means of an accelerometer, placed on a gravity-stabilised platform. This platform is formed by a disk which is suspended in fluid within a plastic sphere placed at the bottom of the buoy. Two vertical coils are wound around the plastic sphere and one small horizontal coil is placed on the platform. The pitch and roll angles are defined by the amount of magnetic coupling between the fixed coils and the coil on the platform. Measuring this coupling gives the sine of the angles between the coils (x and y axes) and the horizontal plane (= platform plane). An additional accelerometer unit measures the forces on the buoy with respect to its x and y axes.

A fluxgate compass provides a global directional reference with which to orient the buoy. The acceleration values that are relative to the buoy are then transformed into values that are relative to the fixed compass. The measured acceleration values are filtered and double integrated with respect to time to establish displacement values for recording.

Only waves with frequencies within the range of 0.033–0.64 Hz can be captured by the buoy, due to physical limitations of the system. Wave motion with higher frequencies cannot be followed/ridden properly due to the dimensions of the buoy, while lower frequency waves apply very small acceleration forces that become undetectable (Datawell, 2010).

1.1.2 GPS Buoys

The directional Waverider buoys at the Tweed Heads, Central Moreton Bay, North Moreton Bay, Mooloolaba, Emu Park, Hay Point, and Albatross Bay (Weipa) sites use the GPS satellite system to calculate the velocity of the buoy as it moves with the passing waves. The GPS based Waverider calculates velocity from changes in the frequency of GPS signals according to the Doppler principle. For example, if the buoy is moving towards the satellite the frequency of the signal is increased, and vice-versa. The velocities are integrated through time to determine buoy displacement. The measurement principle is illustrated in Figure 1.2, which shows a satellite directly overhead and a satellite at the horizon. In practice the GPS system uses signals from multiple satellites to determine three-dimensional buoy motion.

At all wave sites, the vertical buoy displacement representing the instantaneous water level and calculated directional data are transmitted to a receiver station as a frequency modulated high-frequency radio signal. The directional Waverider receiver stations on shore are each comprised of a desktop computer system connected to a Datawell receiver/digitiser. The water level data at each site is digitised at 0·78 sec intervals (1·28 Hz) and stored in bursts of 2048 points (approximately 26 min) on the hard disk of the computer.

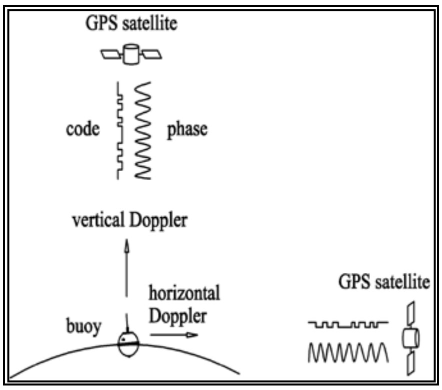


Figure 1.2: The GPS wave measurement principle (Datawell, 2010)

The proprietary software running on the computer 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 a Telstra NEXTG® link. Recorded data and analysis results are downloaded every hour to a central computer system in Brisbane for checking, further processing, and archiving. Data is also stored on the Waverider buoy and can be retrieved and included in the analysis at a later date.

Further information on the operation of the Waverider buoy and the recording systems can be obtained from the reference sources listed in section 0 of this report.

1.3 Laboratory calibration checks

Waverider buoys used by DSITI are calibrated before deployment and also after recovery. Normally, a buoy is calibrated once every 12 months. Calibration of accelerometer buoys is performed at DSITI's Deagon site using a buoy calibrator to simulate sinusoidal waves with vertical displacements of 2·7 metres. The calibrator is electrically controlled and the frequency may be adjusted from 0·016–0·25 hertz. It is usual to check three frequencies during a calibration. The following are also checked during the calibration procedure: compass, phase and amplitude response, accelerometer platform stability, platform tilt, battery capacity and power output.

Calibration of the GPS buoy involves placing it in a fixed location on land for a period of several days while it records data. This location should be such that there are no obstructions between the buoy and the orbiting GPS satellites. A GPS buoy in calibration should produce results showing no displacements between records – any differences can be attributed to errors in the transmission signal between the GPS buoy and the orbiting satellites or to faults in the buoy.

Monthly averages are calculated based on available data and no wave data records are rejected based on low capture rates. Research (Bacon & Carter, 1991 and Allan & Komar, 2001) has suggested rejecting entire records where less than a certain threshold has been recorded. All Queensland wave-recording sites generally have high-percentage capture rates for the seasonal year and thus minimal bias is introduced into calculations.

1.4 Wave recording and analysis procedures

The computer-based, wave-recording systems at all sites record data at half-hourly intervals. Raw data transmitted from the buoys is analysed in the time domain by the zero up-crossing method (see Appendix A) and in the frequency domain by spectral analysis using Fast Fourier Transform (FFT) techniques to give 128 spectral estimates in bands of 0·01 hertz. The directional information is obtained from initial processing on the buoy, where datasets are divided into data sub-sets and each sub-set is analysed using FFT techniques. The output from this processing is then transmitted to the shore station, along with the raw data, where it undergoes further analysis using FFT techniques to produce 128 spectral estimates in bands of 0·005 hertz.

The zero up-crossing analysis is equivalent in both the accelerometer and GPS systems. Wave parameters resulting from the time and frequency domain analysis included the following:

Table 1.3: Parameters involved in the analysis

Parameter	Description
S(f)	Energy density spectrum (frequency domain)
Hsig	Significant wave height (time domain), the average of the highest 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 third of waves in the record
Tz	The average period of all zero up-crossing 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)
Dir	The direction (frequency domain) from which the peak period waves (Tp) are coming (in º True)
SST	The sea surface temperature (in º Celsius) obtained by a sensor mounted in the bottom of the buoy.

These parameters form the basis for the summary plots and tables included in this report.

1.5 Data losses

Data losses can be divided into two categories: losses due to equipment failure and losses during data processing from 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 platform in the accelerometer-based Waverider buoy.

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.

1.6 Major Meteorological Events

Table 1.4: Tropical Cyclones in the Queensland region during the 2012 – 2013 season.

Name	Start Time (AEDT)	End Time (AEDT)	Category	Central Pressure (hPa)
Oswald	17/01/2013 12:00	28/01/2013 12:00	1	989
Tim	10/03/2013 06:00	20/03/2013 18:00	2	991
Zane	25/04/2013 12:00	1/05/2013 17:00	3	983
Sandra	7/03/2013 18:00	14/03/2013 18:00	4	930

Figure 1.3: Tropical cyclones affecting Queensland coastline 2012–13

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, the exact location of the buoy, and the water depth in which the buoy was moored, should be noted. This information is provided in subsequent sections for each monitoring site.

2. Tweed Heads

Data Overview

The Tweed Heads wave buoy has been operational for nearly 19 years with an overall data return of 98.46 per cent. The data record for the period November 2012 to October 2013 was exceptional, with total gaps of only 5.73 days, equivalent to 99.43% data return. The buoy was replaced during the reporting period on 08 February 2013 (Table 2.2).

A significant wave height (Hsig) recorded during the reporting period made it into the top ten ranks (see Table 2.2), one maximum wave height (Hmax) also made the top ten ranking. Notably, a Hsig of 6.7 m was reported during the passage of Ex- TC Oswald and ranked second, while a Hmax of 11.8 m was also reported 30 minutes later on the same day and also ranked second.

Ex-TC Oswald passed along the Queensland coast during January 2013 as a low-pressure system travelling from north to south. The system downgraded just to the north west of the buoy (inland). The atmospheric pressure fell to 996.1 hPa at Deagon, the nearest DSITI measurement point to the buoy (see the report on TC Oswald for more details, (DSITIA, 2013)). The wave climate during Ex-TC Oswald's passage, stayed high at over 2.0 m Hsig for two days from 28 January to 30 January. The wave period also rose to around 12 seconds from 30 January indicating the presence of swell incident on the coast. After the lowest central pressure of Ex-TC Oswald had passed, Hsig fell to just below 2.0 m; however, the wave period of the highest energy waves continued to increase from around 16 seconds as the swell developed in the wake of Ex-TC Oswald.

There are differences in the wave climate off Tweed Heads between summer and winter seasons. Over 14 % of the time Hsig exceeds 2.0 m during summer whereas during winter Hsig exceeds 2.0 m only 2.5% of the time (Table 2.3). The most common Tp is 10 seconds both in summer and winter however there is a small increase from in Tp during winter in the 12 second range (from 16% to 24% occurrence).

The wave climate during the reporting period was very similar to the wave climate of the whole record, evidenced in the percentage time exceedance (Table 2.3) and histograms of the occurrence of Hsig and Tp (Figure 2.3 and Figure 2.4). It is also worth noting that the ratios between different wave parameters such as Hmax/Hsig were consistent between this reporting period and all of the historic data, these are plotted in Figure 2.5. The monthly average Hsig generally fell within one standard deviation (sd) of the long-term mean with the exception of two months: February and August. In February the mean was higher than the mean +1 sd, possibly influenced by the passage of Ex-TC Oswald, see Figure 2.6.

The plot of wave direction over the 2012–13 season (Figure 2.8) showed a dominant easterly (slightly South of East) direction with an occasional swing to the north, mostly during summer. The dominance of incident wave direction is reflected in the directional wave rose plot (Figure 2.9) along with the most common wave height (Hsig) of 1.0 m to 1.5 metres.

The temperature (sea surface temperature, SST) measured in the buoy hull showed a seasonal high average around 27 °C with peaks of over 30 °C in summer (Figure 2.8). The SST from January and February was intermittently warm enough for tropical cyclone development, however the data from February 8 may be erroneous as calibration of the SST sensor post retrieval showed that the sensor was potentially measuring up to 7 °C too low.

Tweed Heads

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 359.25
Gaps in data used in analysis (days)	= 5.73
Number of records used in analysis	= 17244

All data since-1995

Maximum possible analysis years (last record - first record)	= 18.80
Total number of years used in analysis	= 18.51
Gaps in data used in analysis (years)	= 0.29
Number of records used in analysis	= 273827

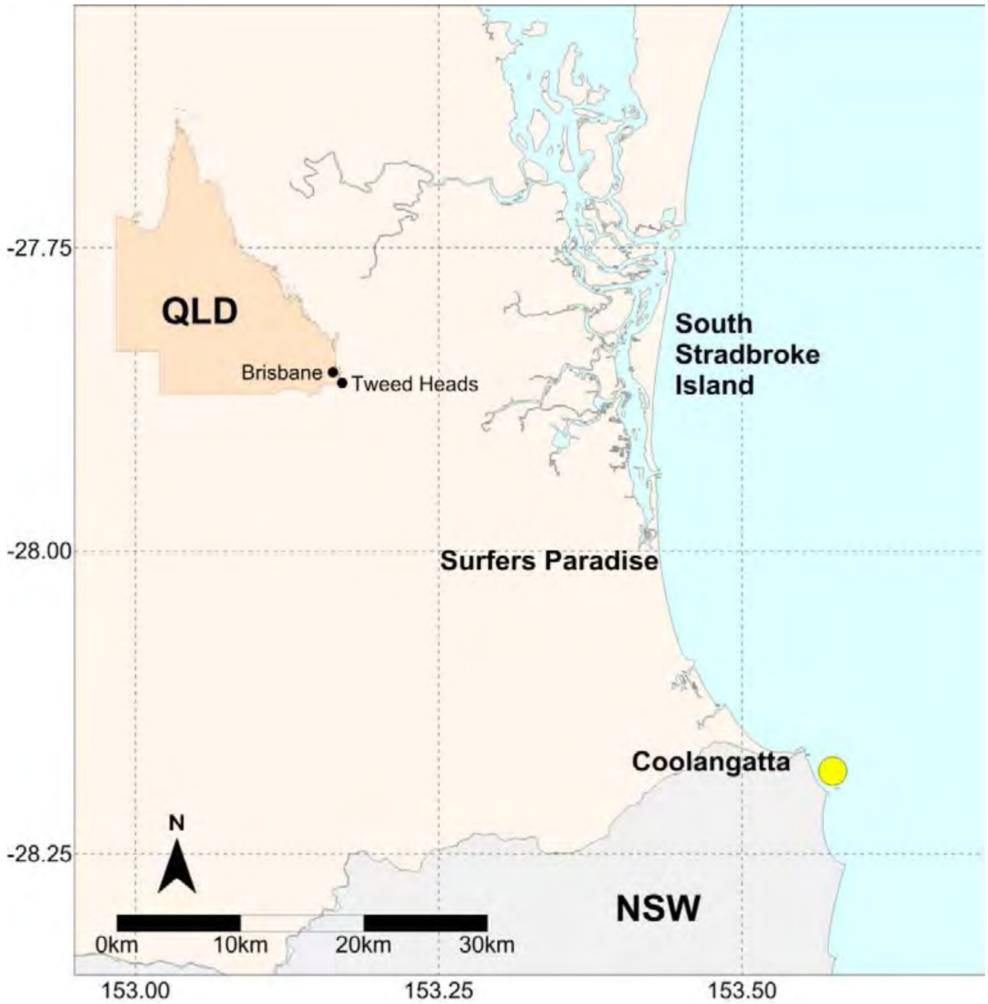


Figure 2.1: Tweed Heads - Locality plan

Table 2.1: Tweed Heads – Buoy deployments during the 2012-13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
28°10.890'S	153°34.48'E	23	23/01/2012	08/02/2013
28°10.890'S	153°34.607'E	22	08/02/2013	current

Table 2.2: Tweed Heads - Highest waves during the 2012-13 season

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	3/05/1996 01:00	7.5	2/05/1996 14:30	13.1
2	28/01/2013 08:30	6.7	28/01/2013 09:00	11.8
3	6/03/2004 01:00	6.1	5/03/2004 23:30	11.1
4	21/05/2009 19:30	5.6	30/06/2005 06:30	9.9
5	24/05/1999 05:00	5.2	22/05/2009 07:00	9.7
6	4/03/2006 20:30	5.2	4/03/2006 12:00	9.6
7	12/06/2012 10:00	5.2	25/03/1998 22:30	9.5
8	15/02/1995 11:30	5.2	15/02/1995 15:30	9.3
9	30/06/2005 09:00	4.9	12/06/2012 11:30	9.3
10	24/03/2004 06:00	4.8	2/02/2001 02:00	9.1

Table 2.3: Tweed Heads - Significant meteorological events with threshold Hsig of 2.5 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
28/01/2013 08:30	6.3 (6.7)	10.0 (11.8)	11.1	Ex TC Oswald passed from north to south as a low pressure system with a central pressure of 996.1 hPa at Deagon.
22/02/2013 04:00	3.8 (4.1)	6.1 (7.4)	11.9	A low pressure system 130 nm east of Coolangatta moving west southwest.
13/04/2013 10:30	2.9 (3.1)	4.5 (5.7)	9.8	A trough extending from a low [1005 hPa] off the northeast tropical coast to a second low [1005 hPa] over the central Coral Sea.
01/07/2013 16:30	3.3 (3.6)	5.3 (6.7)	9.9	An east coast low pressure system with a central pressure of 1005 hPa

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

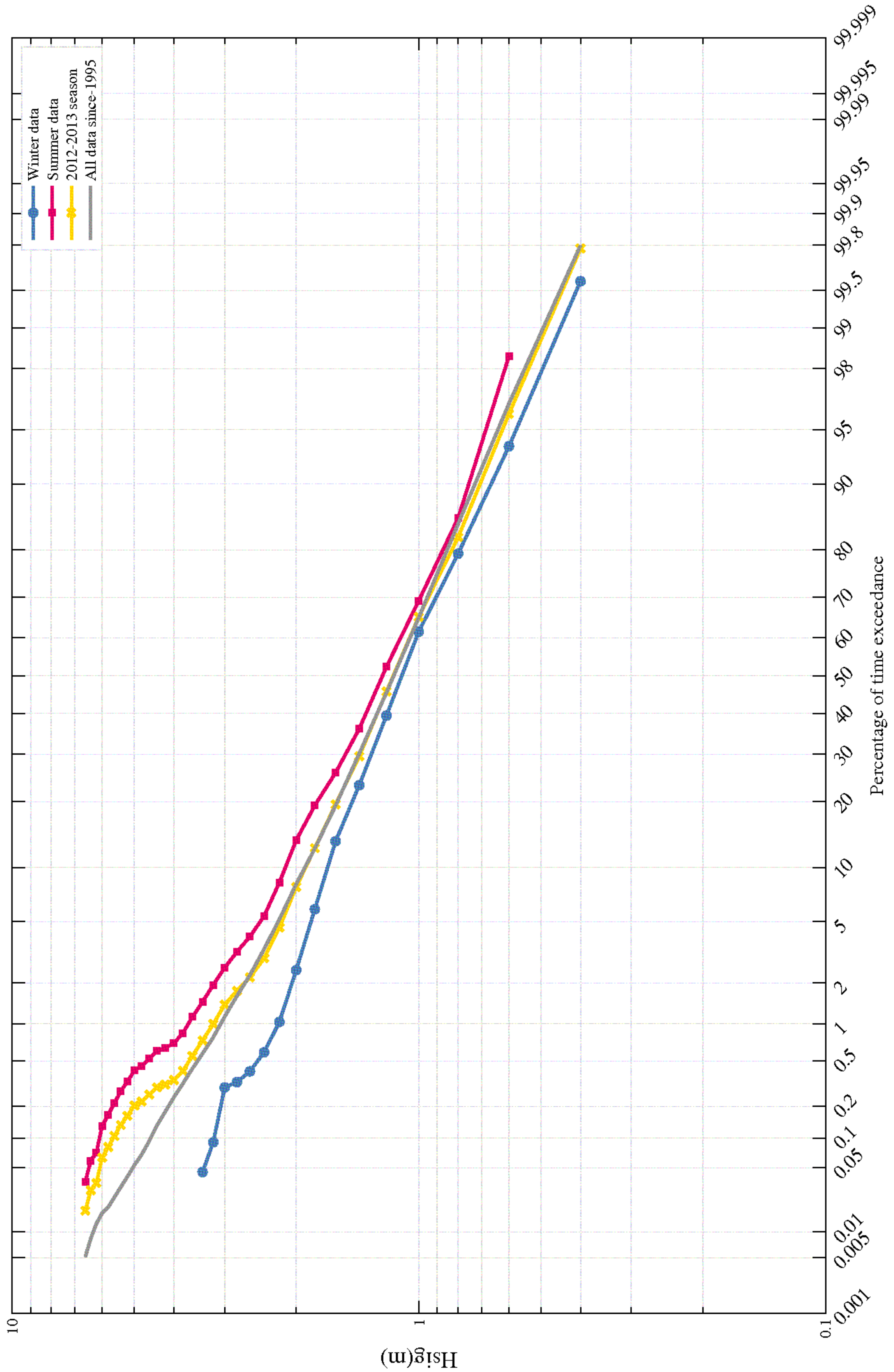


Figure 2.2: Tweed Heads - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

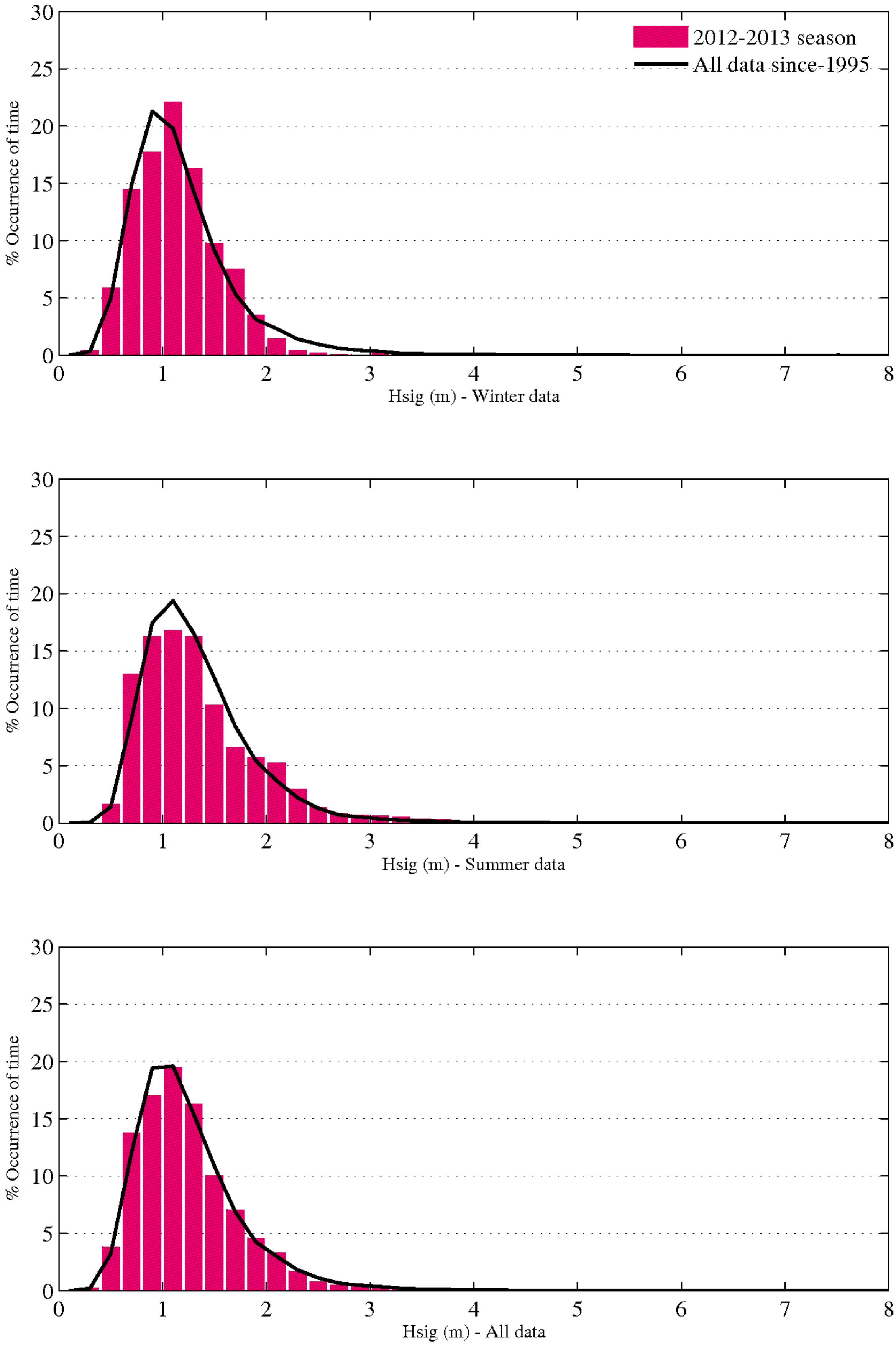


Figure 2.3: Tweed Heads - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

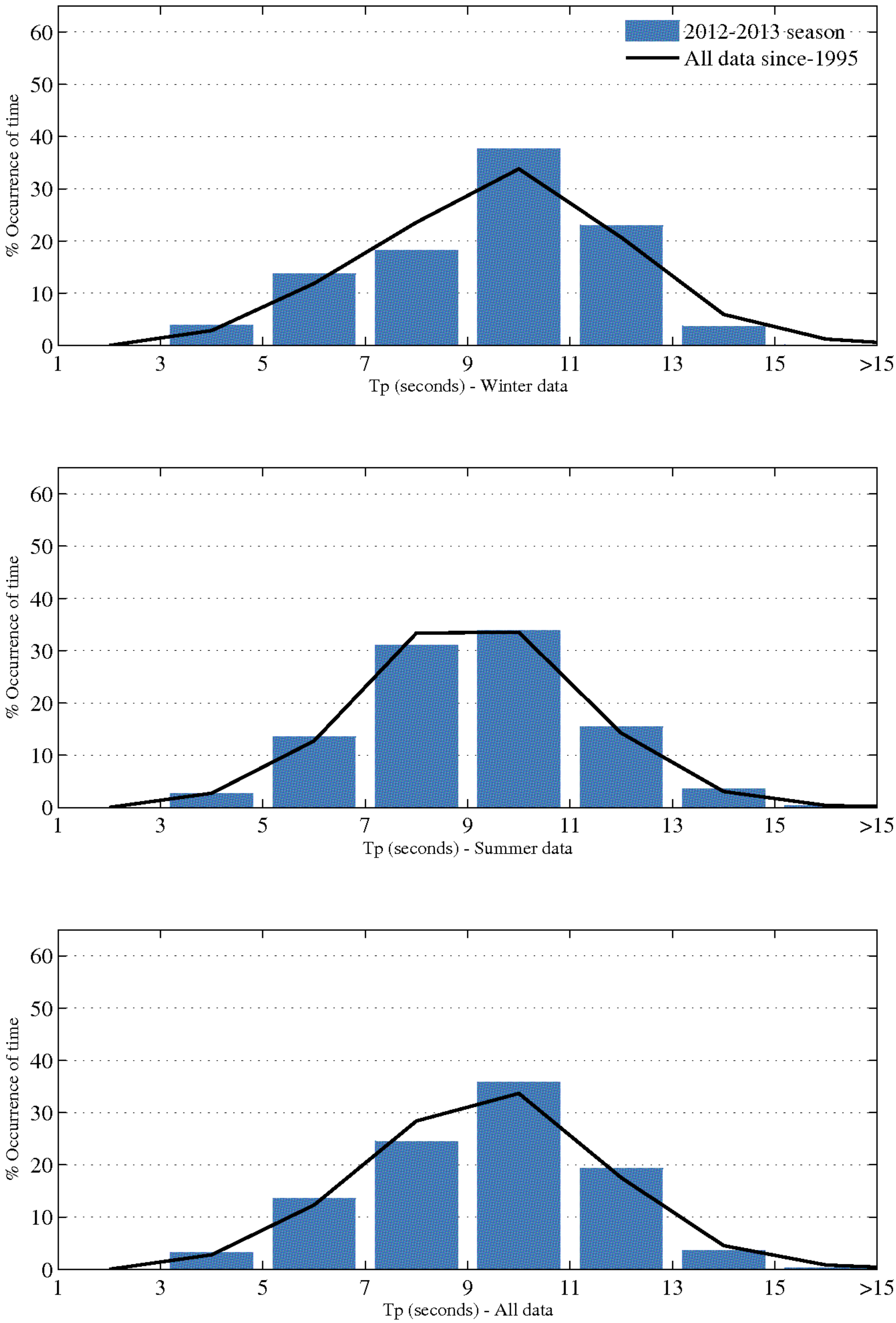


Figure 2.4: Tweed Heads - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

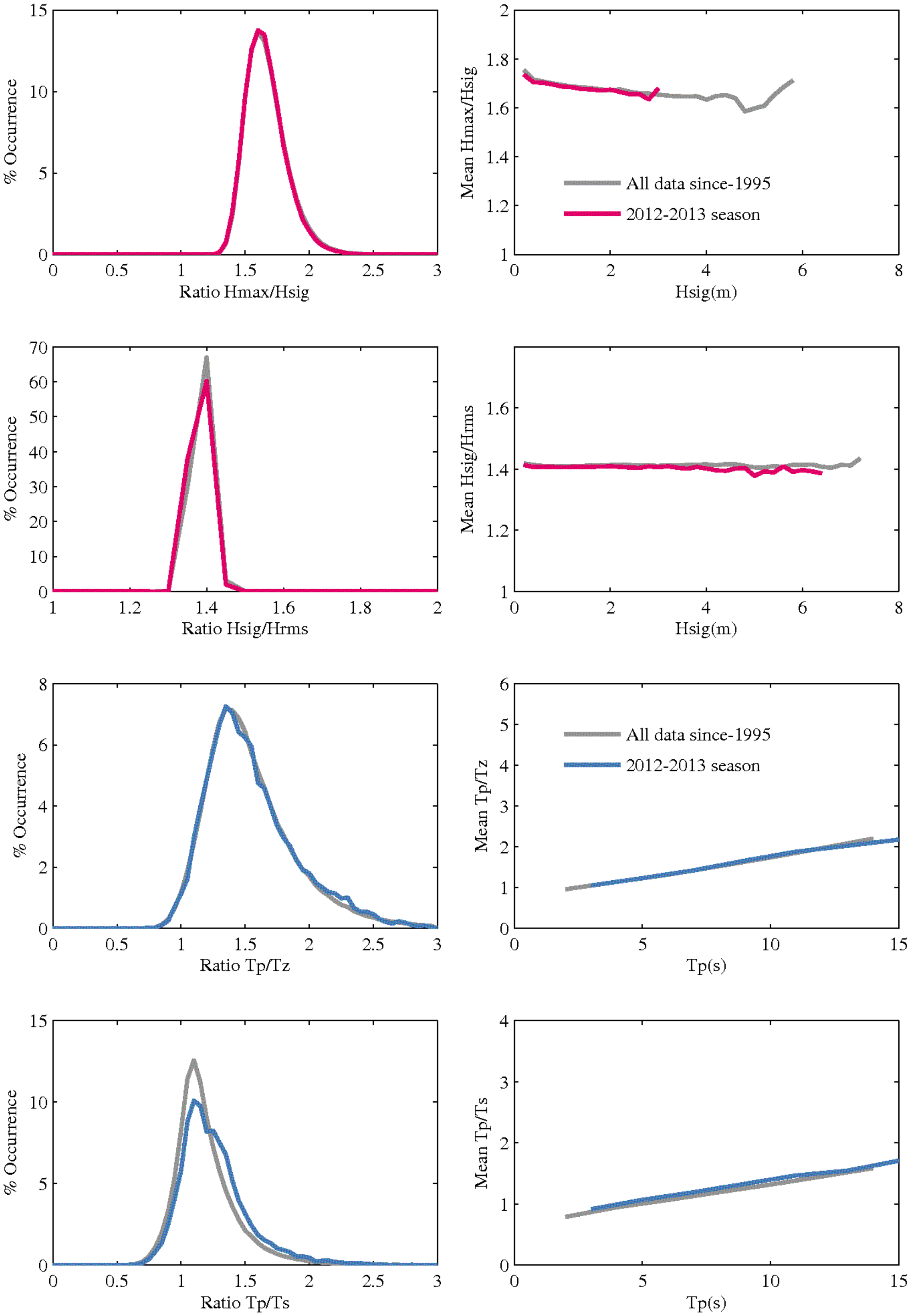


Figure 2.5: Tweed Heads - Wave parameter relationships

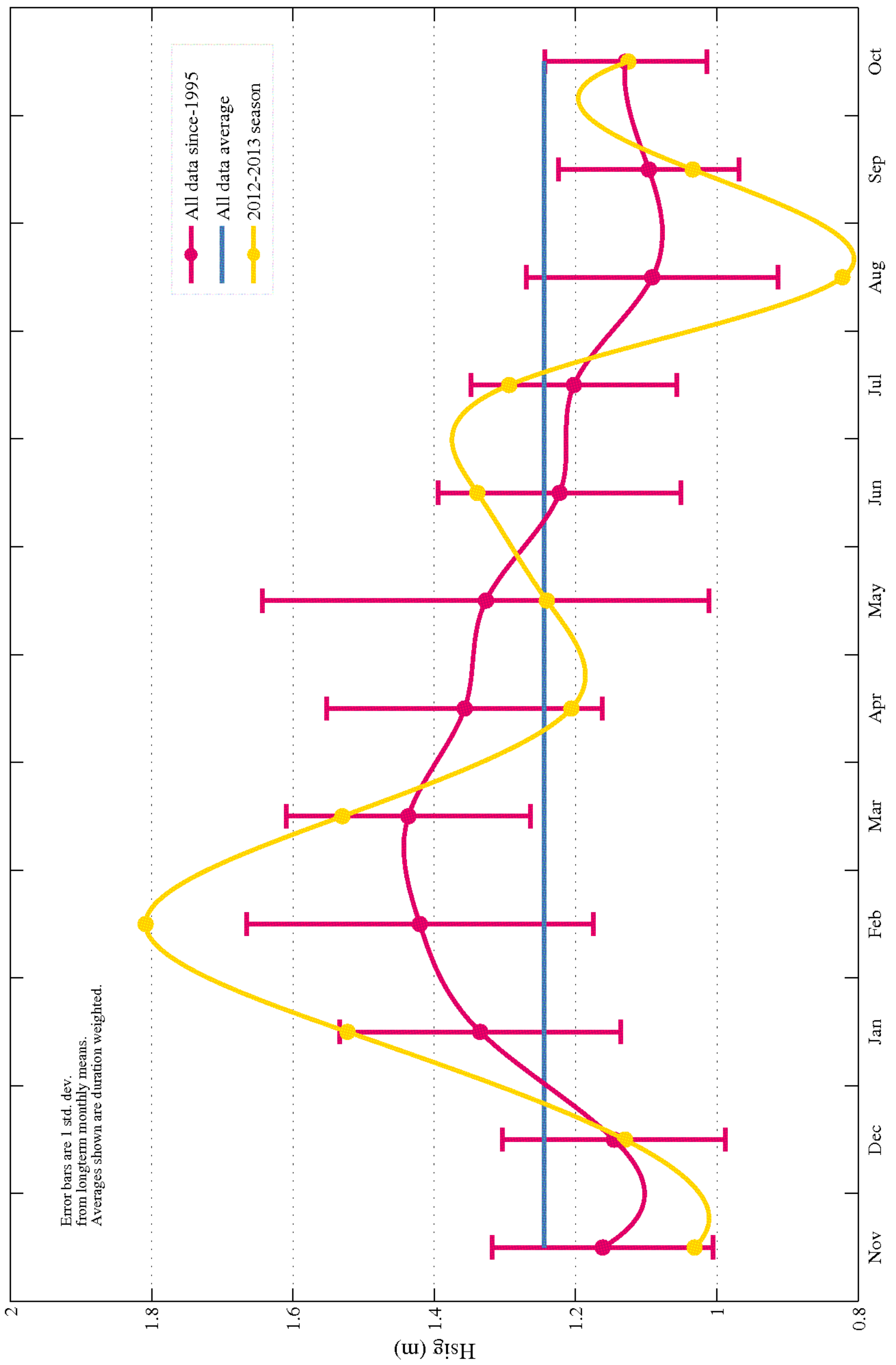


Figure 2.6: Tweed Heads – Monthly average wave height (Hsig) for seasonal year and for all data

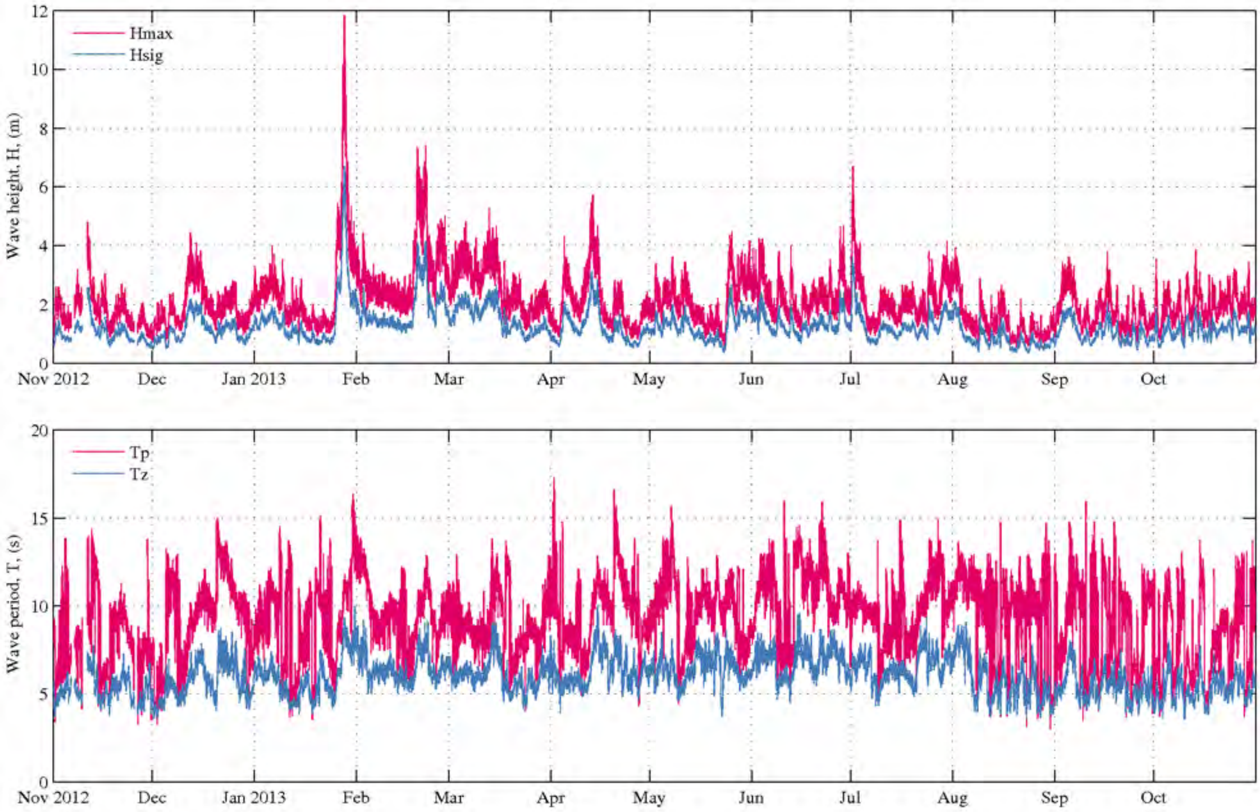
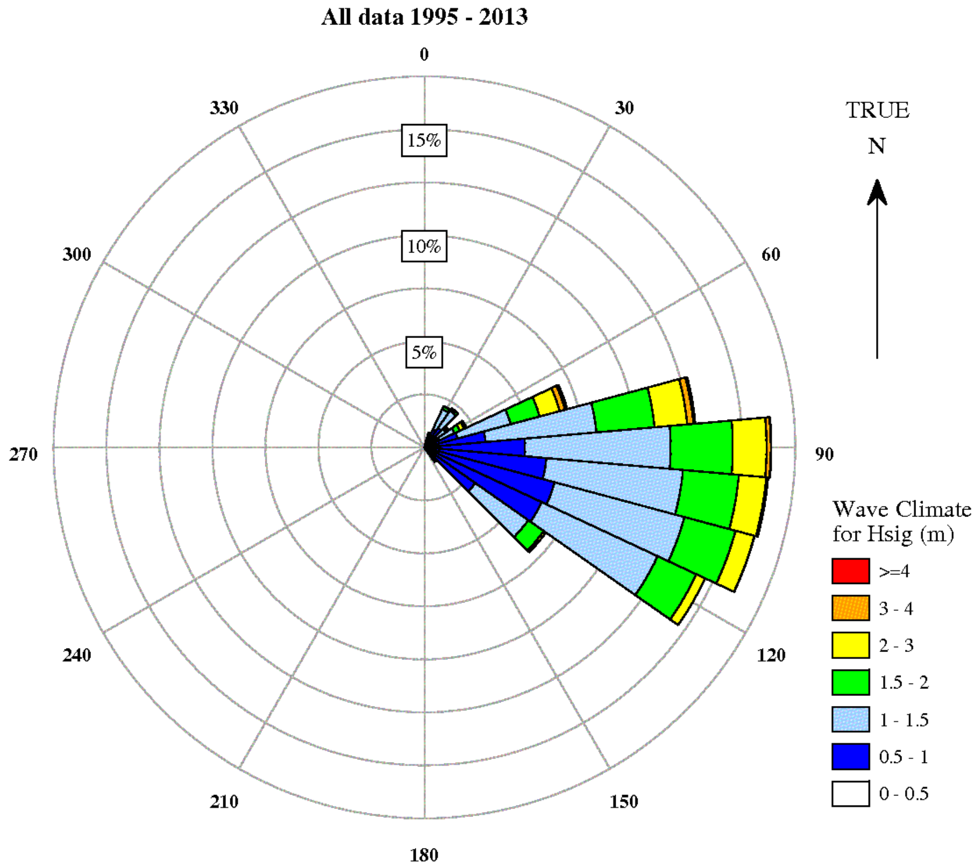


Figure 2.7: Tweed Heads - Daily wave recordings

Figure 2.8: Tweed Heads - Sea surface temperature and peak wave directions



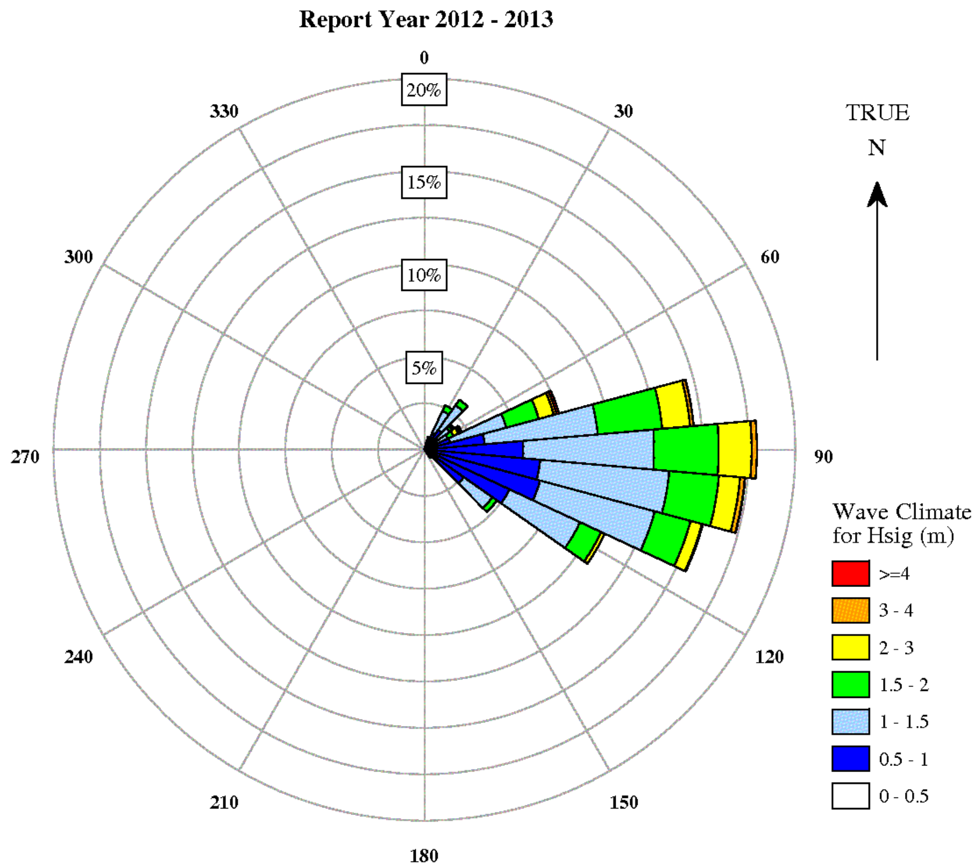


Figure 2.9: Tweed Heads - Directional wave rose

3. Gold Coast

Data Overview

The Gold Coast wave buoy has been operational for over 26 years with an overall data return of 87.4%. The data record for the period November 2012 to October 2013 was exceptional, with total gaps of only 5.65 days, equivalent to 98.5% data return. The buoy was replaced during the reporting period on 15 February 2013 (Table 3.2).

A significant wave height (Hsig) recorded during the reporting period made it into the top ten ranks (see Table 3.2) and one maximum wave height (Hmax) also made the top ten ranking. Notably, a Hsig of 6.3 m was reported during the passage of Ex-TC Oswald and ranked second, while a Hmax of 10.5 m was also reported an hour earlier on the same day and ranked seventh.

Ex-TC Oswald passed along the Queensland coast in January 2013 as a low pressure system travelling from north to south. The system downgraded just to the north west of the buoy (inland). The atmospheric pressure fell to 996.1 hPa at Deagon, the nearest DSITI measurement point to the buoy (see the report on TC Oswald for more details, (DSITIA, 2013)). The wave climate during Ex-TC Oswald's passage, stayed high at over 2.0 m Hsig for four days from 28 January to 01 February. The wave period also rose to around 11 seconds from 28 January indicating the presence of swell incident on the coast. After the lowest central pressure of Ex-TC Oswald had passed, Hsig fell to just below 2.0 m; however, the wave period of the highest energy waves continued to increase up to around 15 seconds as the swell developed in the wake of Ex-TC Oswald.

There are differences in the wave climate off the Gold Coast between summer and winter seasons. Over 14% of the time Hsig exceeds 2.0 m during summer whereas during winter Hsig exceeds 2.0 m only 2% of the time (Figure 3.2). The most common Tp is 10 seconds both in summer and winter however there is a small increase in Tp during winter in the 12 second range (from 13% to 23% occurrence).

The wave climate during the reporting period was very similar to the wave climate of the whole record, evidenced in the percentage time exceedance (Figure 3.2) and histograms of the occurrence of Hsig and Tp (Figure 3.3 and Figure 3.4). It is also worth noting that the ratios between different wave parameters such as Hmax/Hsig were consistent between this reporting period and all of the historic data, these are plotted in Figure 3.5. The monthly average Hsig generally fell within one standard deviation (sd) of the long-term mean with the exception of two months: February and August. In February the mean was higher than the mean +1 sd, possibly influenced by the passage of Ex-TC Oswald, see Figure 3.6.

The plot of wave direction over the 2012–13 season (Figure 3.8) showed a dominant easterly (slightly south of east) direction with an occasional swing to the north, mostly during summer. The dominance of incident wave direction is reflected in the directional wave rose plot (Figure 3.9) along with the most common wave height (Hsig) of 1.0 m to 1.5 metres.

The temperature (sea surface temperature, SST) measured in the buoy hull showed a seasonal high average around 25 °C with peaks approaching 27 °C in summer (Figure 3.8). The SST from January and February was intermittently warm enough for tropical cyclone development.

Gold Coast

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 359.33
Gaps in data used in analysis (days)	= 5.65
Number of records used in analysis	= 17248

All data since-1987

Maximum possible analysis years (last record - first record)	= 26.69
Total number of years used in analysis	= 23.31
Gaps in data used in analysis (years)	= 3.39
Number of records used in analysis	= 303163

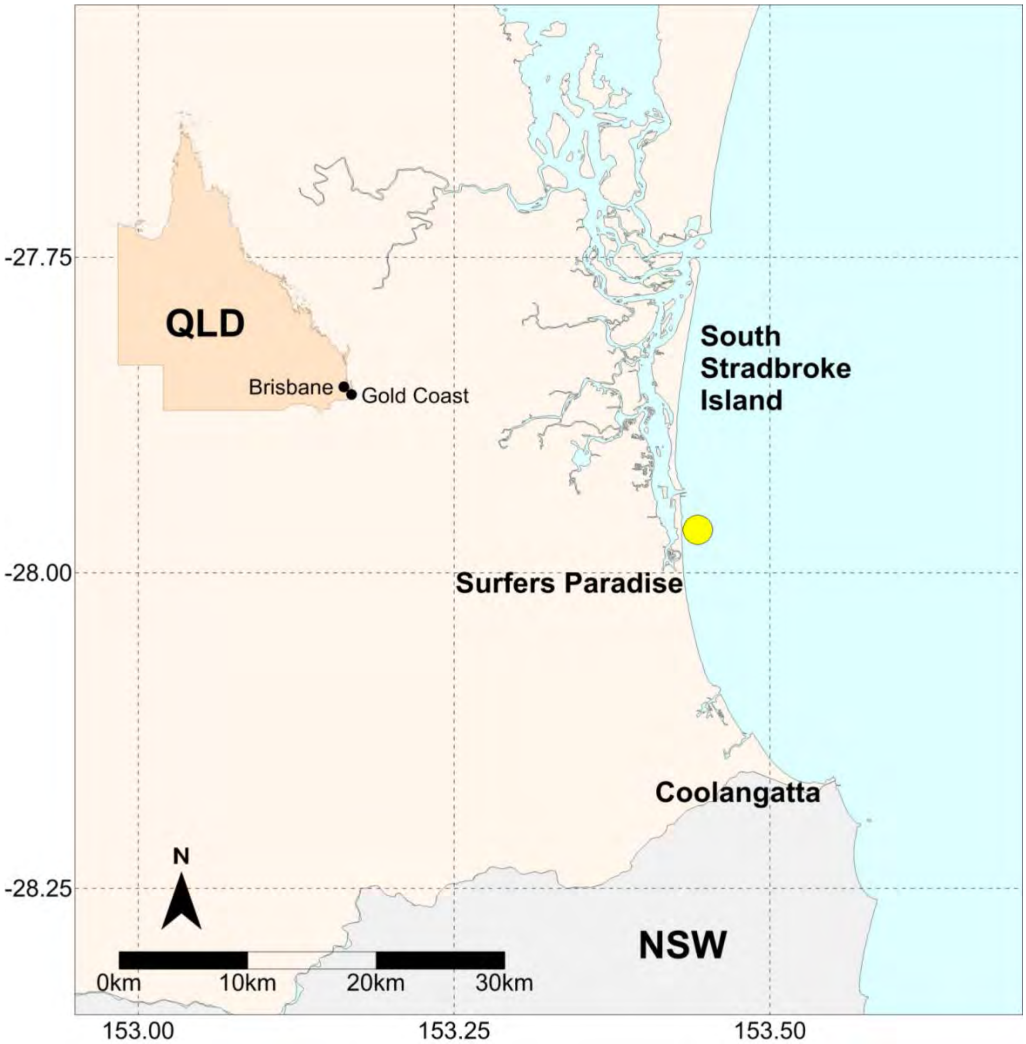


Figure 3.1: Gold Coast - Locality plan

Table 3.1: Gold Coast – Buoy deployments during the 2012-13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
27°57.966'S	153°33.574'E	18	15/05/2012	15/02/2013
27°57.914'S	153°26.555'E	17	15/02/2013	current

Table 3.2: Gold Coast - Highest waves

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	3/05/1996 06:30	7.1	3/05/1996 06:30	12.0
2	28/01/2013 10:30	6.3	17/03/1993 04:30	11.0
3	23/05/2009 03:30	6.1	5/03/2006 05:00	10.7
4	5/03/2004 23:00	5.9	22/05/2009 12:30	10.6
5	17/03/1993 12:30	5.7	5/03/2004 22:00	10.6
6	25/04/1989 21:00	5.6	12/06/2012 07:00	10.5
7	12/06/2012 07:00	5.5	28/01/2013 09:30	10.5
8	5/03/2006 08:00	5.3	25/04/1989 09:30	10.0
9	15/02/1995 07:00	5.0	15/02/1995 10:30	9.2
10	2/04/2009 05:30	4.9	2/04/2009 05:30	9.0

Table 3.3: Gold Coast - Significant meteorological events with threshold Hsig of 3 m.

Date	Hs (m)	Hmax (m)	Tp (s)	Event
28/01/2013 10:30	5.8 (6.3)	9.3 (10.5)	11.3	Ex Tropical Cyclone Oswald passed from north to south as a low pressure system with a central pressure of 996.1 hPa at Deagon.
22/02/2013 03:30	4.2 (4.7)	7.1 (8.7)	11.7	A low pressure system 130 nm east of Coolangatta moving west southwest.
15/03/2013 14:00	3.4 (3.6)	5.2 (5.8)	12.6	Ex-tropical cyclone Sandy came closest to the Queensland Coast on 14 March 2013, with a central pressure of 983 hPa
1/07/2013 17:00	3.0 (3.3)	5.0 (5.6)	9.7	An east coast low pressure system with central pressure of 1005 hPa

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa) The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

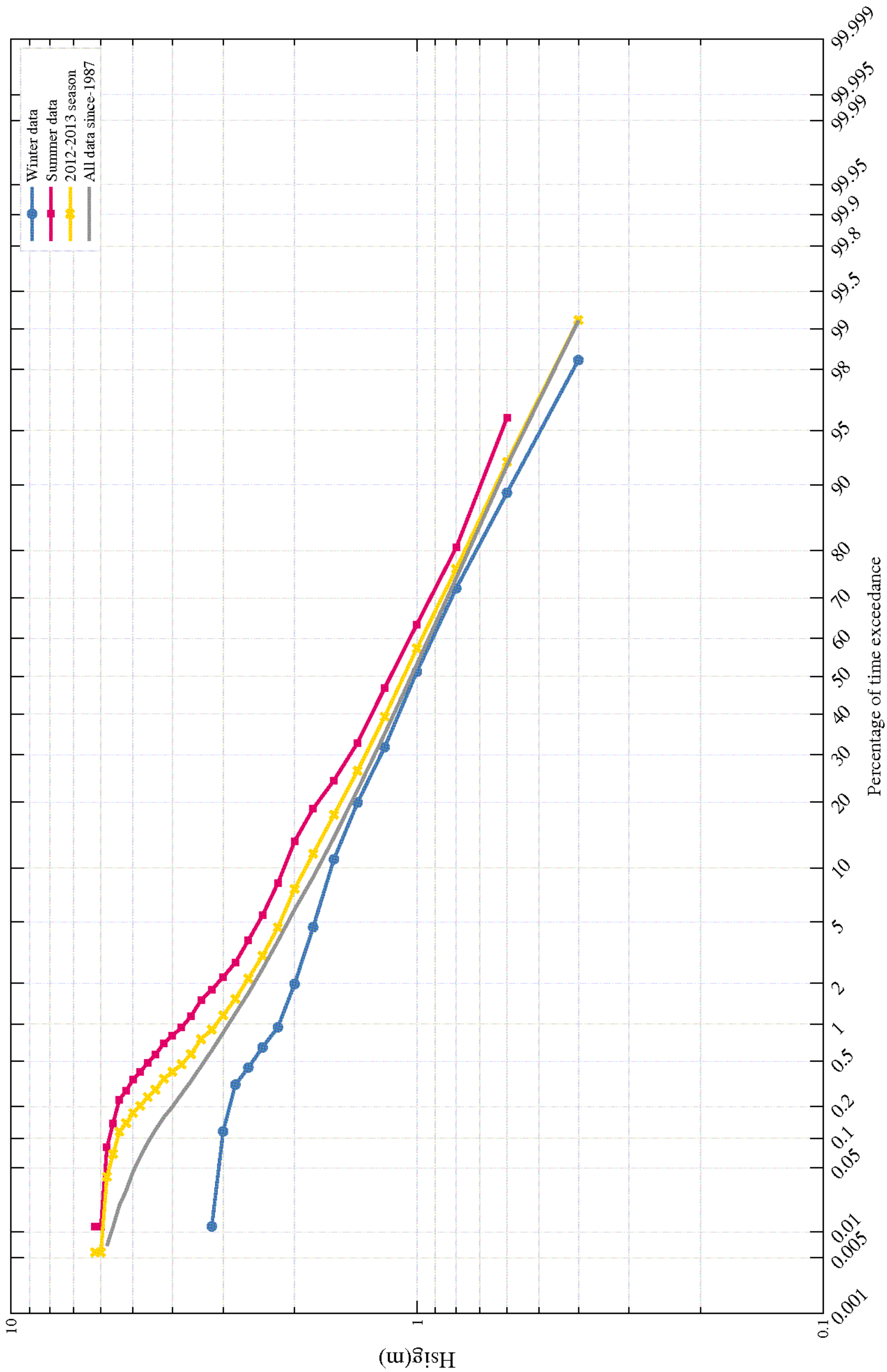


Figure 3.2: Gold Coast - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

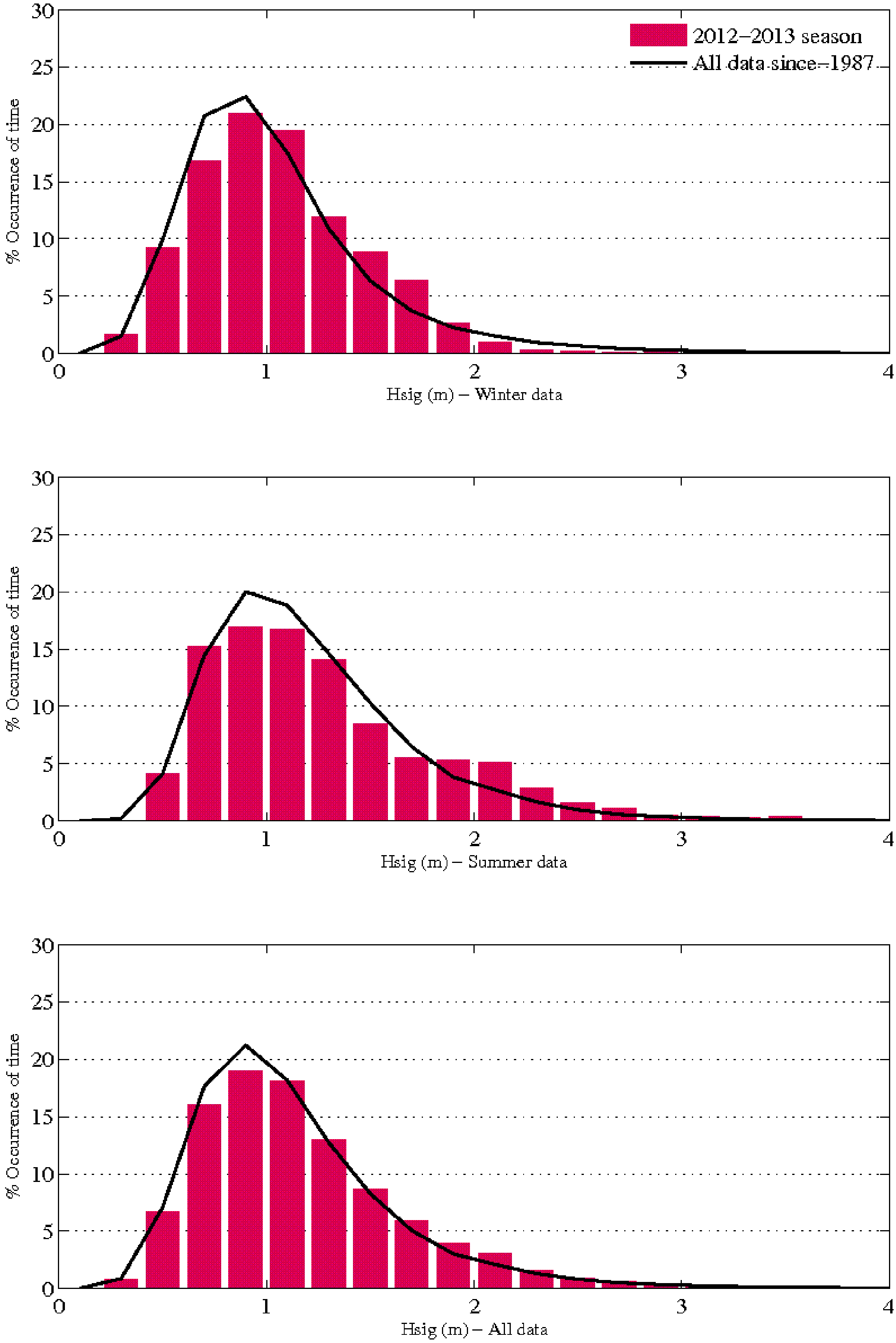


Figure 3.3: Gold Coast - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

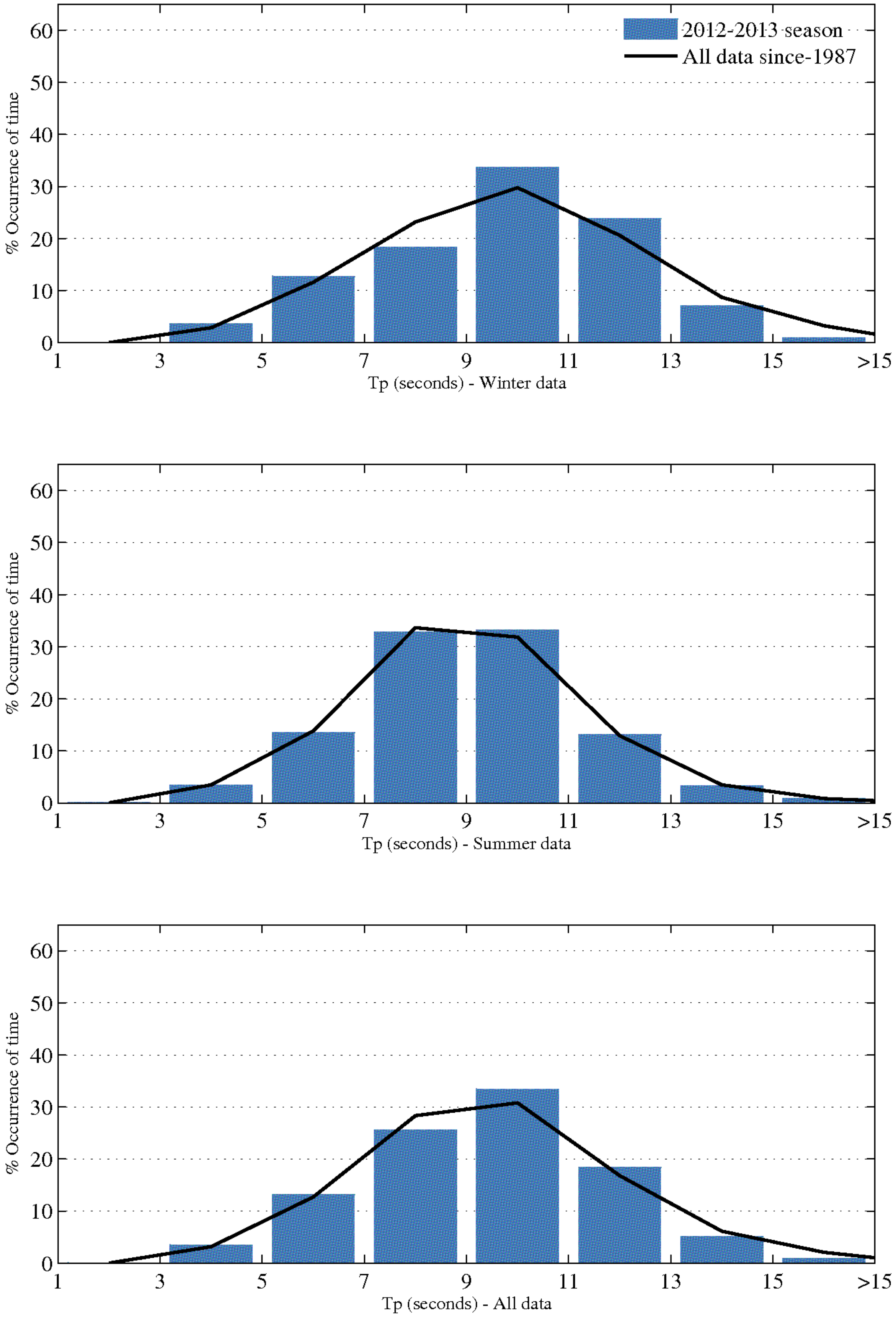


Figure 3.4: Gold Coast - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

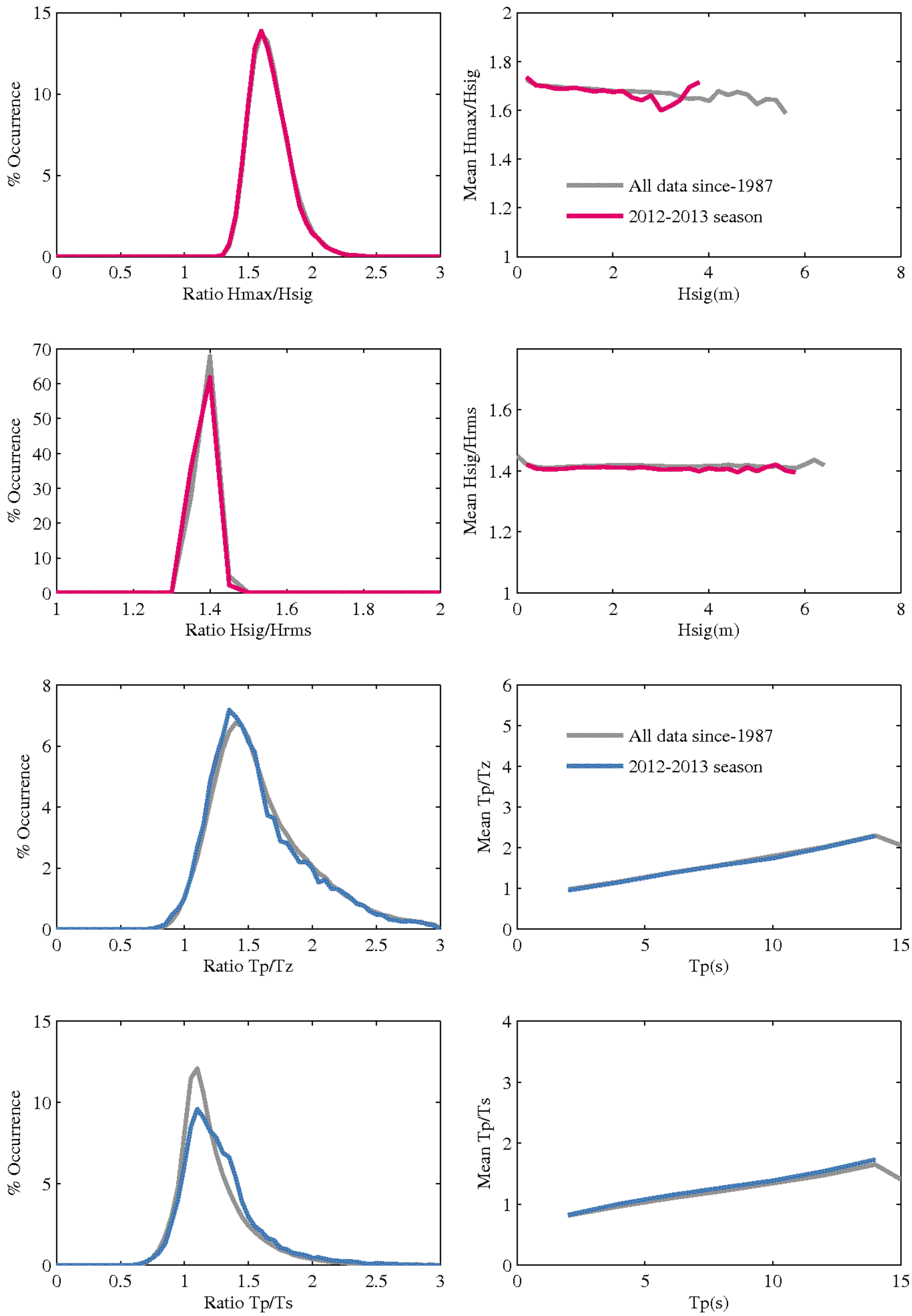


Figure 3.5: Gold Coast - Wave parameter relationships

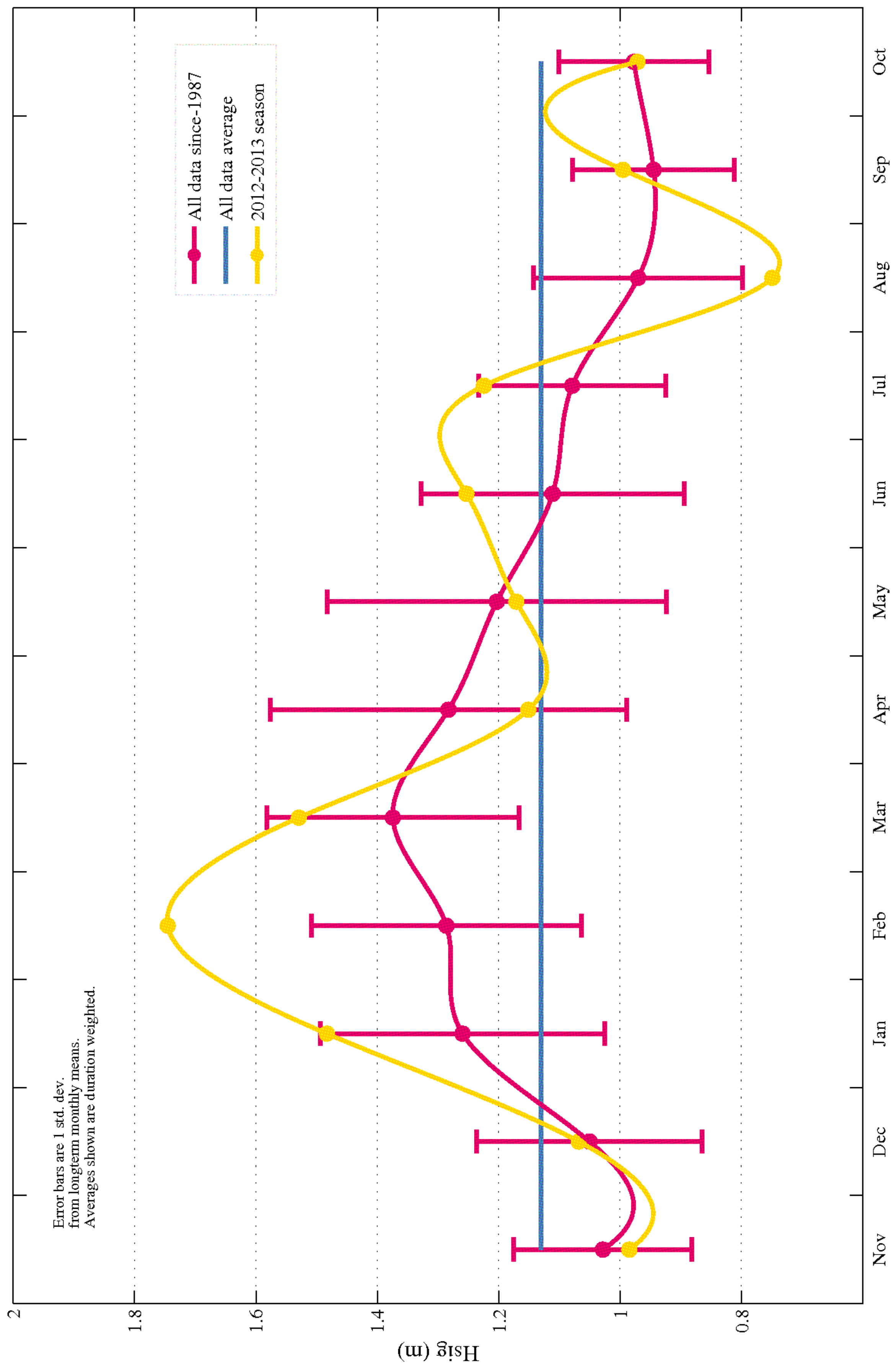


Figure 3.6: Gold Coast - Monthly average wave height (Hsig) for seasonal year and for all data

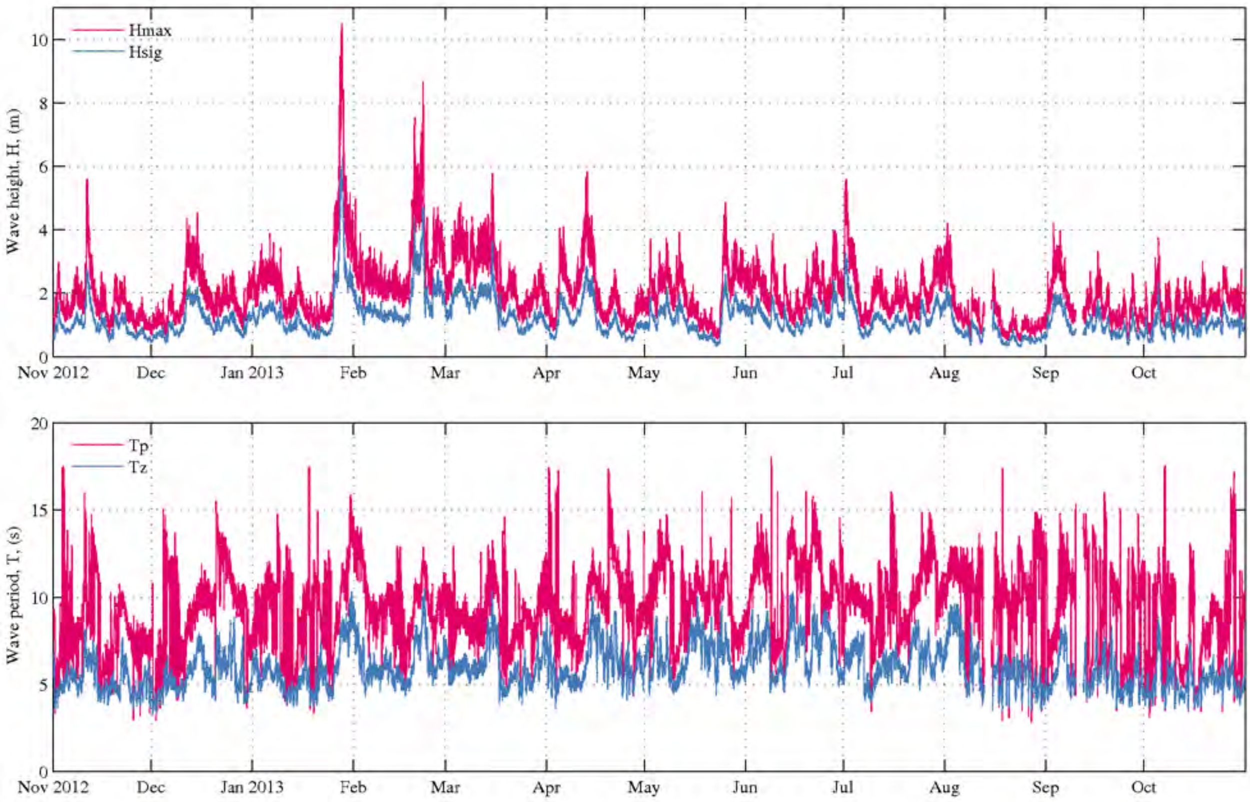


Figure 3.7: Gold Coast - Daily wave recordings

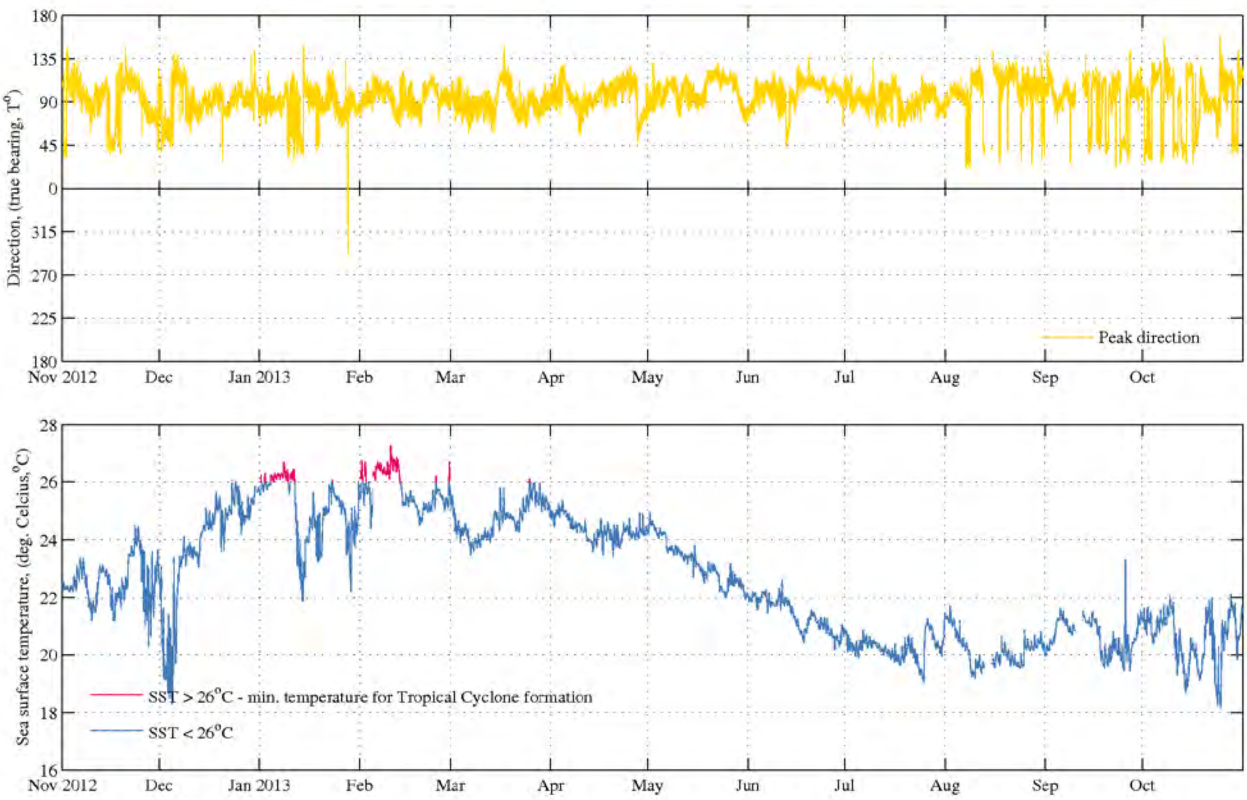
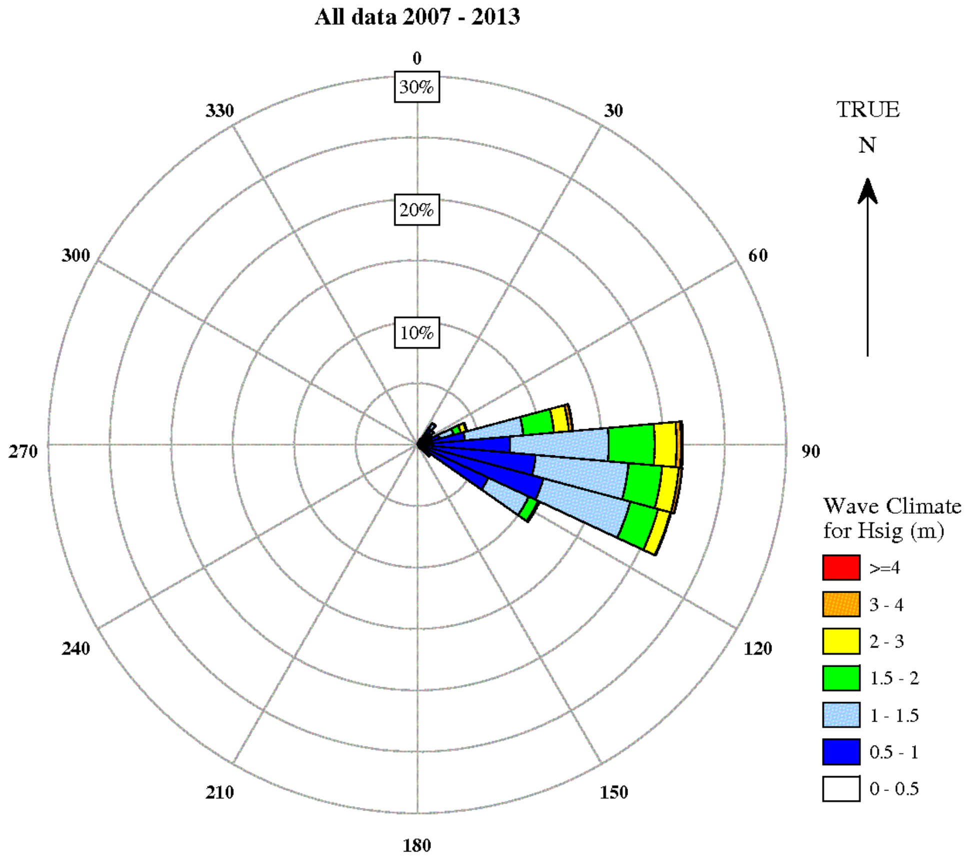


Figure 3.8: Gold Coast - Sea surface temperature and peak wave directions



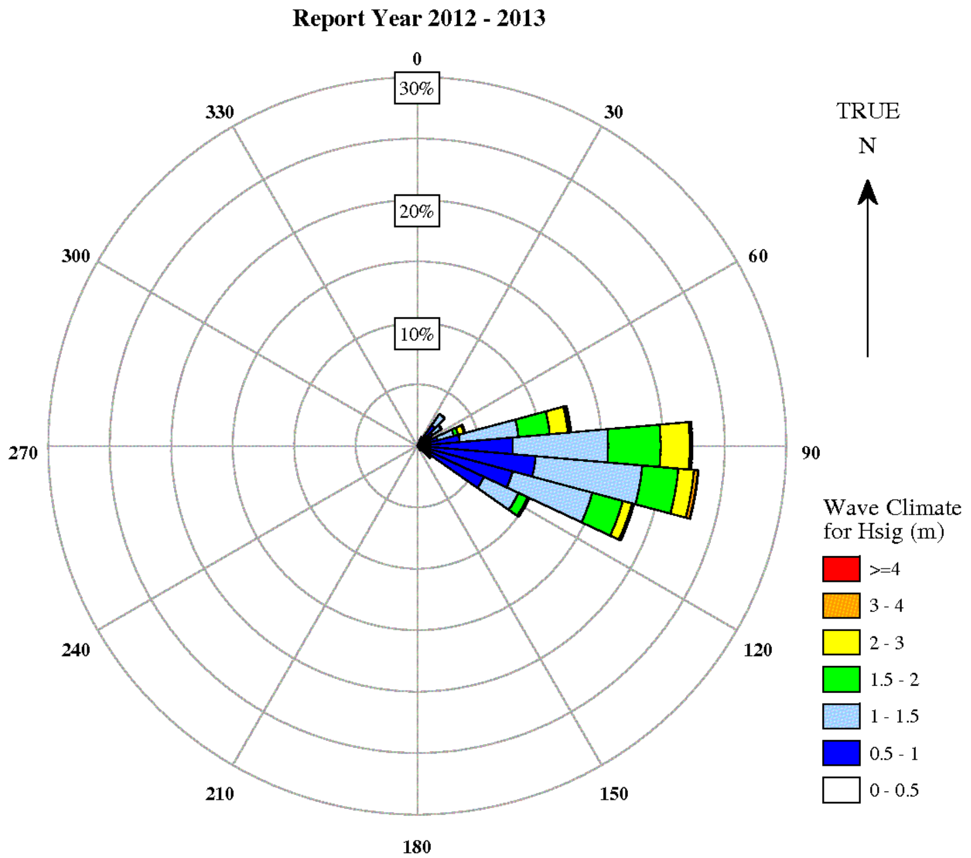


Figure 3.9: Gold Coast - Directional wave rose

4. Brisbane

Data Overview

The Brisbane wave buoy has been operational for over 37 years. The data record for the period November 2012 to October 2013 was exceptional, with total gaps of only three days, equivalent to a 99.1 per% data return. The buoy was replaced during the reporting period on 26 June 2013 (Table 4.1).

One significant wave height (Hsig) recorded during the reporting period made it into the top ten ranks and one maximum wave height (Hmax) also made the top ten ranking (see Table 4.2). Notably, a Hsig of 7.1 m was reported during the passage of Ex-Tropical Cyclone (TC) Oswald and ranked third, while a Hmax of 12.1 m was also reported at the same time and ranked sixth.

Ex-TC Oswald passed along the Queensland Coast during January 2013 as a low pressure system travelling from north to south. As the system passed to the west of Brisbane the atmospheric pressure fell to 996.1 hPa at Deagon, the nearest measurement point to the buoy (see the report on TC Oswald for more details, (DSITIA, 2013)). The measured Hmax of 12.1 m was the largest significant wave height observed by DSITI’s entire wave monitoring network during the passing of Ex TC Oswald.

Figure 4.3 and 4.4, show some small notable differences in the recorded wave parameters between the summer and winter seasons. Figure 4.3 shows a higher occurrence of waves between 1 m and 1.4 m Hsig during winter. Figure 4.4 illustrates that the most common Tp was between 7 and 9 seconds during summer, while during winter the most common Tp was between 9 and 11 seconds. This suggests the occurrence of more developed swell events occurring during the winter months.

The wave climate during the reporting period was very similar to the wave climate of the whole record. This is evident in the percentage time exceedance (Figure 4.2) and histograms of the occurrence of Hsig and Tp (Figure 4.3 and Figure 4.4). It is also worth noting that the ratios between different wave parameters such as Hmax/Hsig were consistent between this reporting period and all of the historic data (Figure 4.5). The monthly average Hsig generally fell close to within one standard deviation (sd) of the long-term mean with the exception of February. In February the mean was significantly higher than the mean +1 sd (Figure 4.6), which was possibly a result of the recent passage of Ex-TC Oswald earlier in the month and the presence of a deep low (997 hPa) off South East Queensland later in the month.

The plot of wave direction over the 2012-13 seasons (Figure 4.7) showed a dominant south easterly direction with an occasional swing to the north, mainly during summer. The dominance of incident wave direction in the south-easterly direction is reflected in the directional wave rose plot (Figure 4.9).

The temperature (sea surface temperature, SST) measured in the buoy hull showed a seasonal high average around 25 °C with peaks exceeding 27 °C in summer (Figure 4.8). The SST throughout January, February and March was intermittently warm enough for tropical cyclone development.

Brisbane

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 361.98
Gaps in data used in analysis (days)	= 3.00
Number of records used in analysis	= 17375

All data since-1976

Maximum possible analysis years (last record - first record)	= 37.00
Total number of years used in analysis	= 25.33
Gaps in data used in analysis (years)	= 11.67
Number of records used in analysis	= 303018

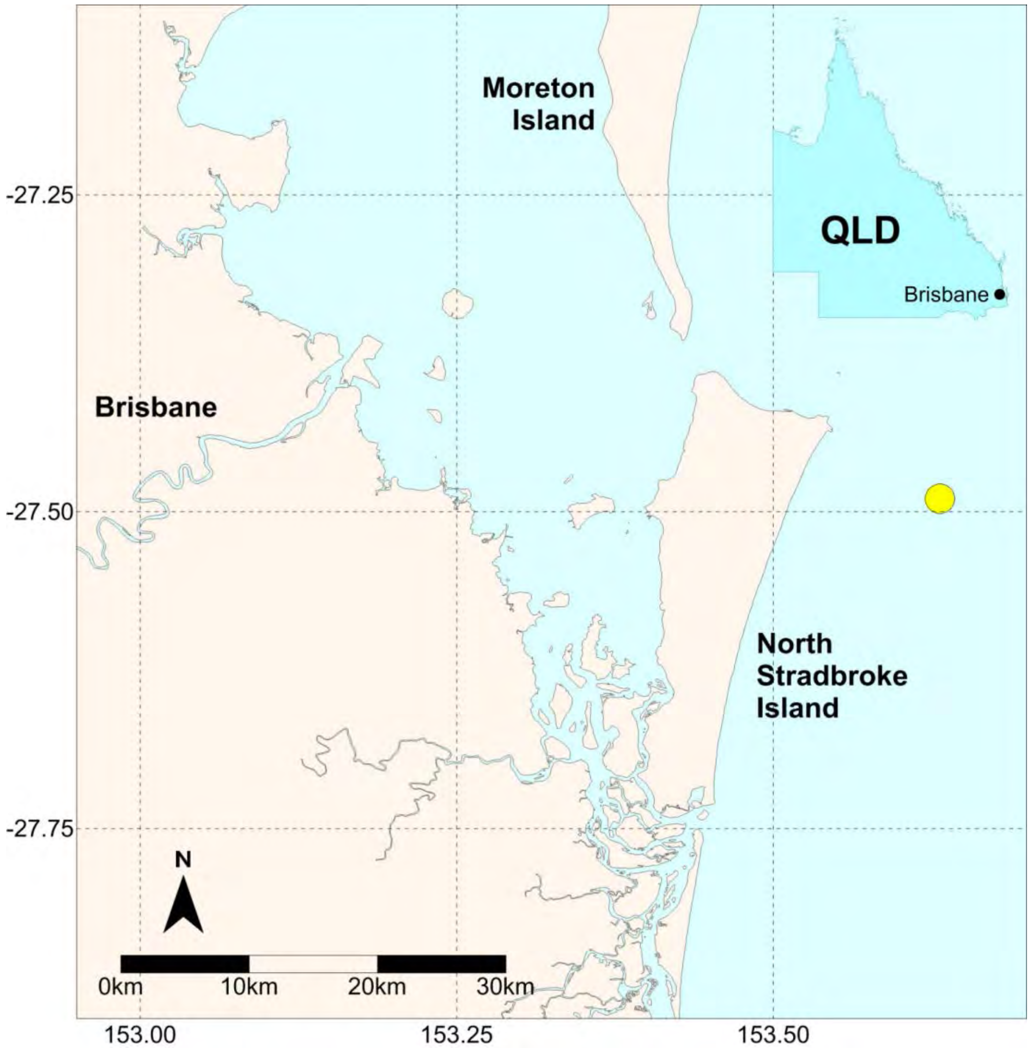


Figure 4.1: Brisbane - Locality plan

Table 4.1: Brisbane – Buoy deployments during the 2012-13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
27°29.376’S	153°37.897’E	70	03/04/2012	26/06/2013
27°29.450’S	153°37.990’E	70	26/06/2013	current

Table 4.2: Brisbane - Highest waves

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	17/03/1993 10:30	7.4	4/03/2006 21:00	16.8
2	4/03/2006 09:00	7.2	5/03/2004 17:30	14.3
3	28/01/2013 07:30	7.1	17/03/1993 03:30	13.1
4	5/03/2004 17:30	7.0	2/05/1996 14:00	12.8
5	2/05/1996 20:30	6.9	15/02/1995 06:30	12.2
6	15/02/1995 06:00	6.4	28/01/2013 07:30	12.1
7	23/08/2008 23:00	6.4	15/02/1996 19:00	12.1
8	12/06/2012 09:30	6.4	24/08/2008 02:00	11.5
9	6/06/2012 19:30	6.3	26/03/1998 07:00	11.5
10	31/12/2007 03:00	6.3	6/06/2012 19:30	11.1

Table 4.3: Brisbane - Significant meteorological events with threshold Hsig of 4.5 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
28/01/2013 07:30	6.5 (7.1)	10.7 (12.1)	9.8	Ex Tropical Cyclone Oswald passed from north to south as a low pressure system with a central pressure of 996.1 hPa at Deagon.
3/02/2013 05:00	4.5 (4.9)	7.4 (8.7)	11.7	Low [1000 hPa] situated off the Central NSW coast with a trough extending northward along the coast.
19/02/2013 11:00	4.7 (5.5)	8.6 (10.5)	10.0	A low pressure system 130 nm east of Coolangatta moving west southwest.
1/07/2013 17:00	4.5 (4.9)	7.7 (10.0)	9.7	An east coast low pressure system with central pressure of 1005 hPa.

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

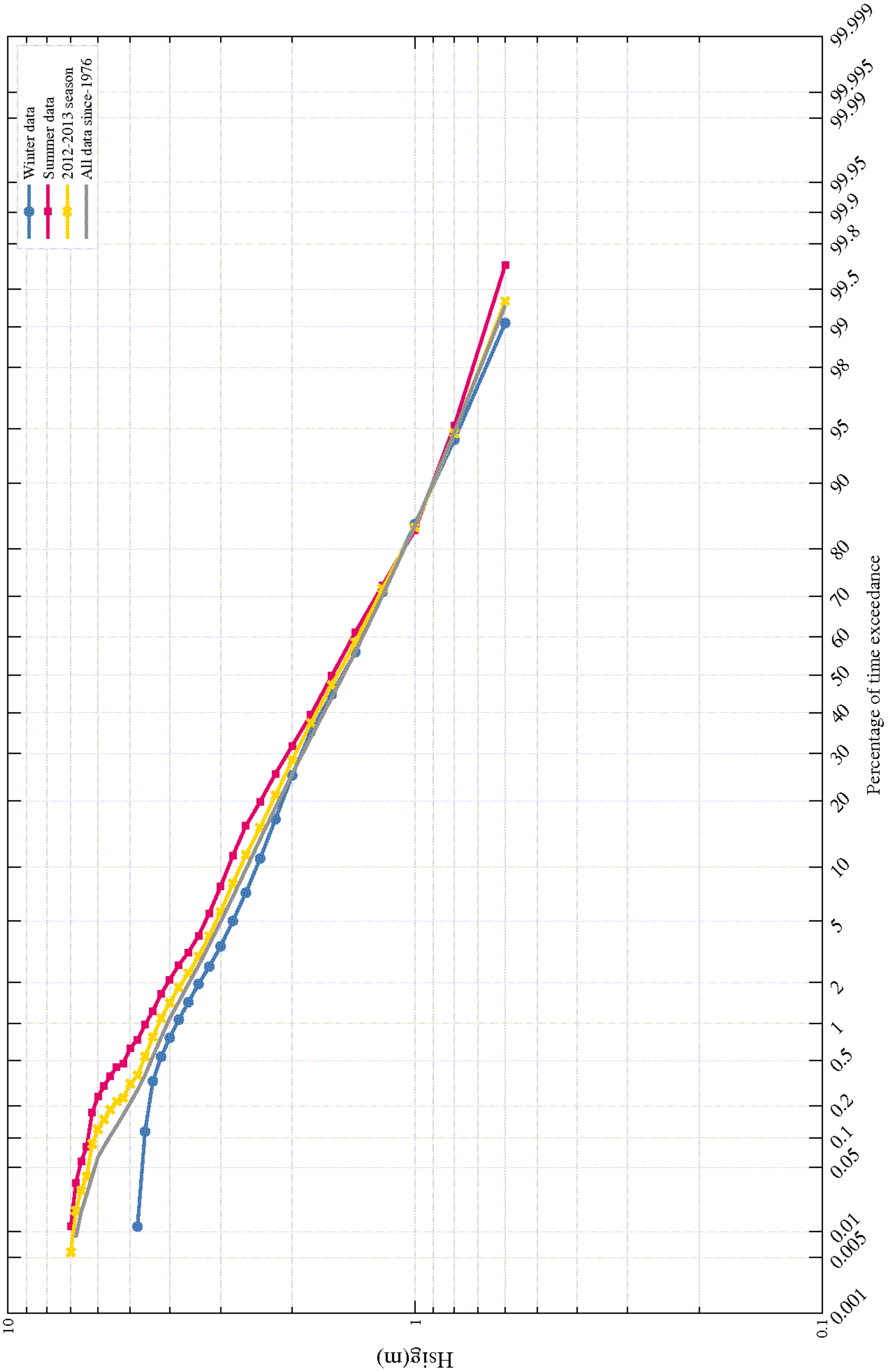


Figure 4.2: Brisbane - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

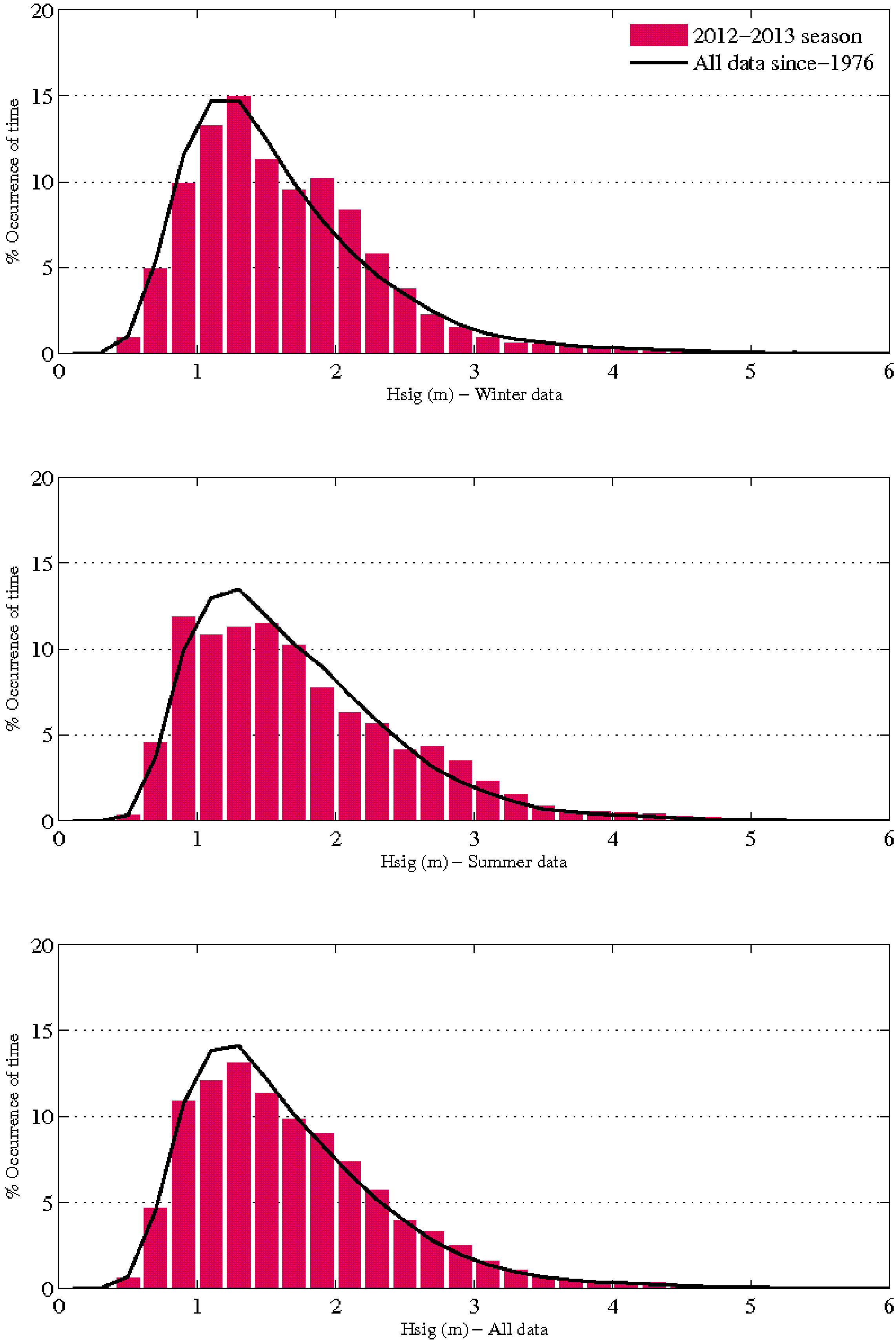


Figure 4.3: Brisbane - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

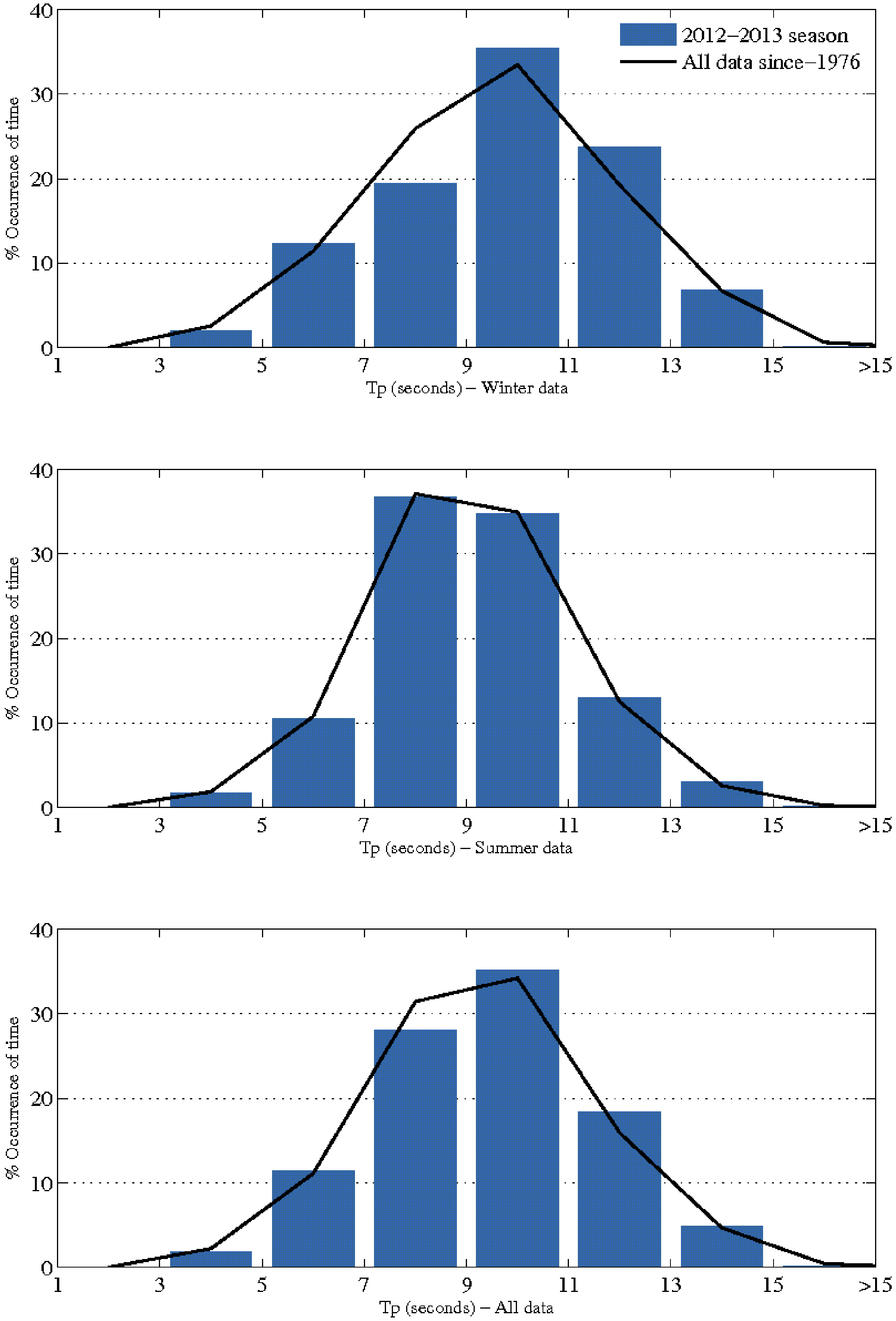


Figure 4.4: Brisbane - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

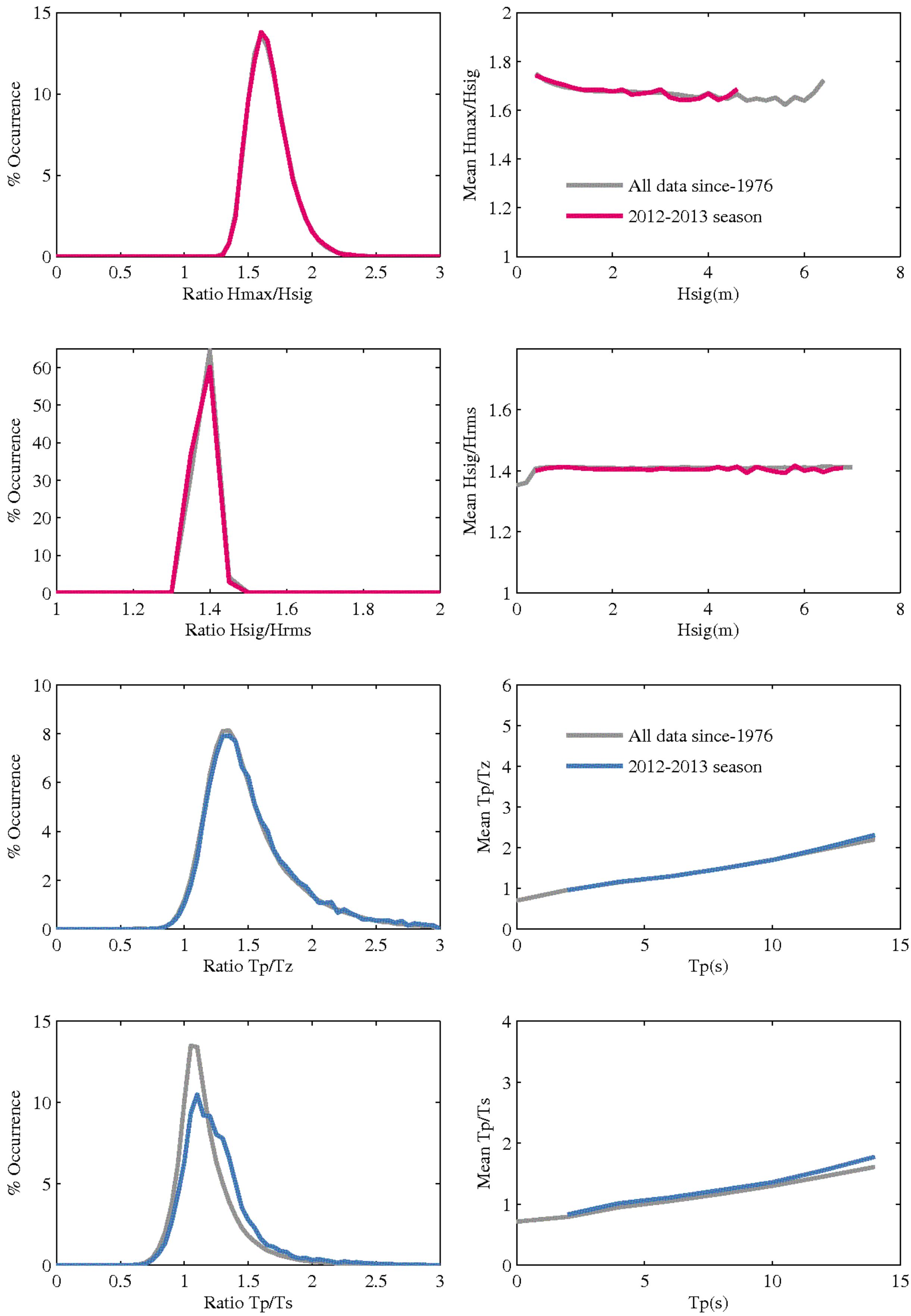


Figure 4.5: Brisbane - Wave parameter relationships

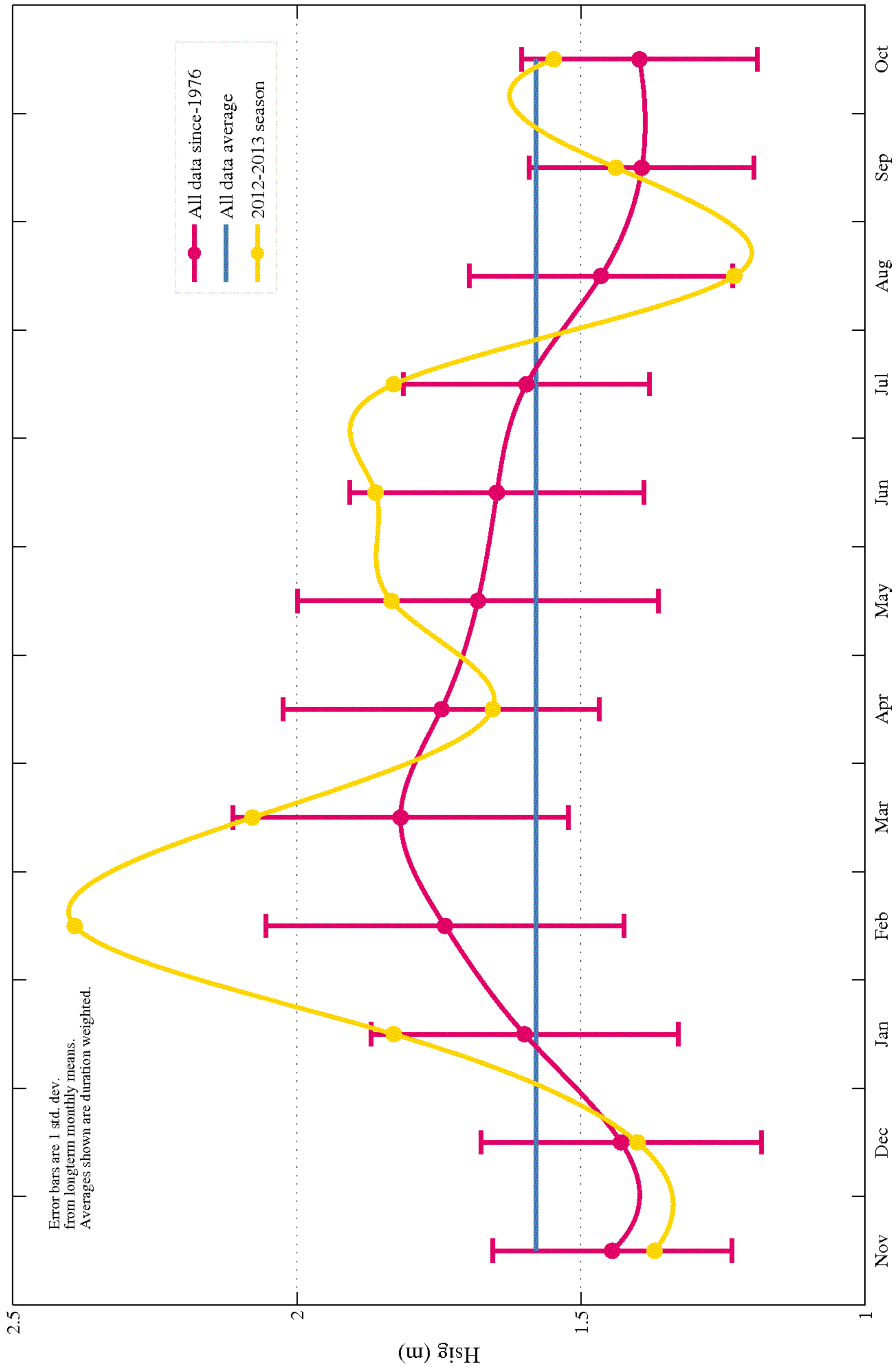


Figure 4.6: Brisbane - Monthly average wave height (Hsig) for seasonal year and for all data

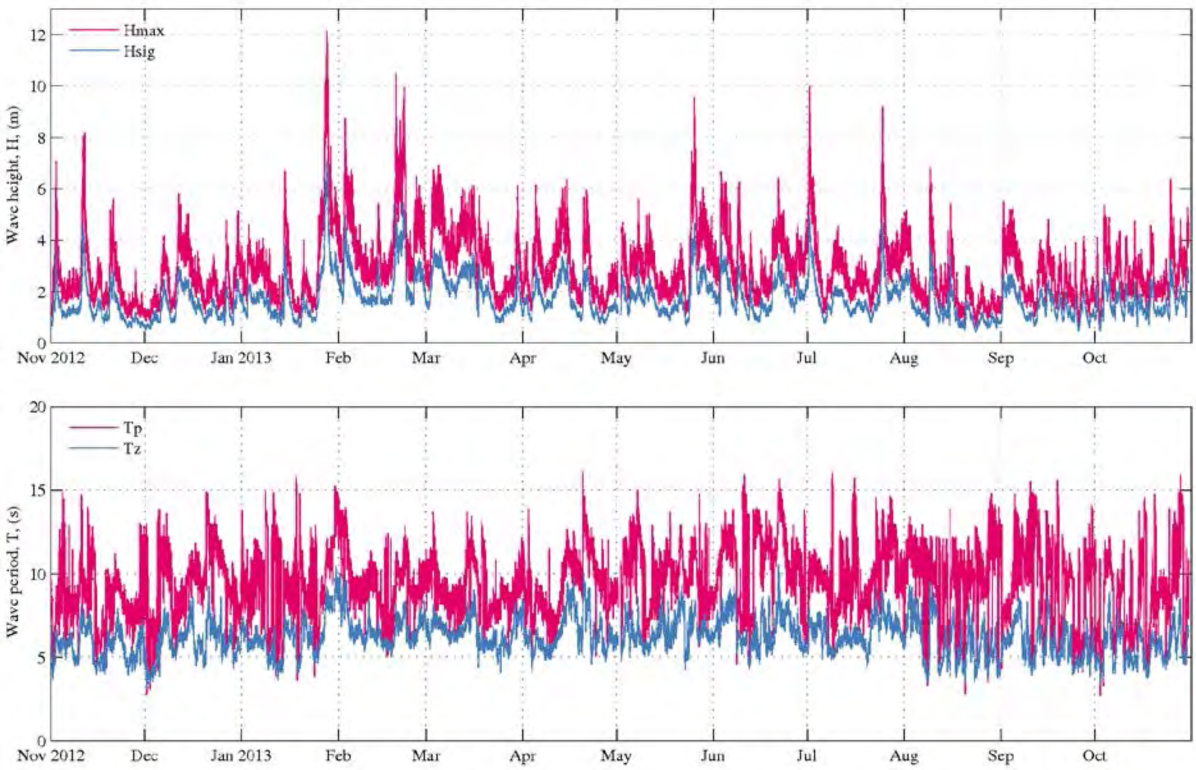


Figure 4.7: Brisbane - Daily wave recordings

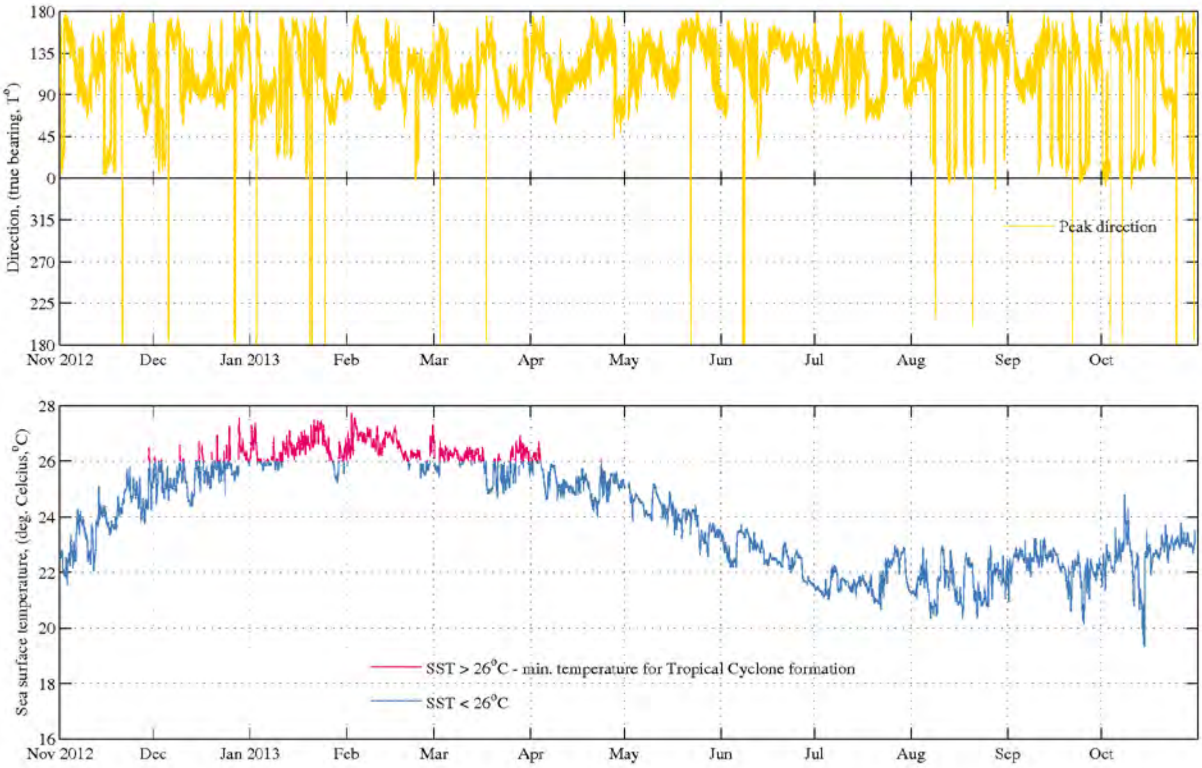
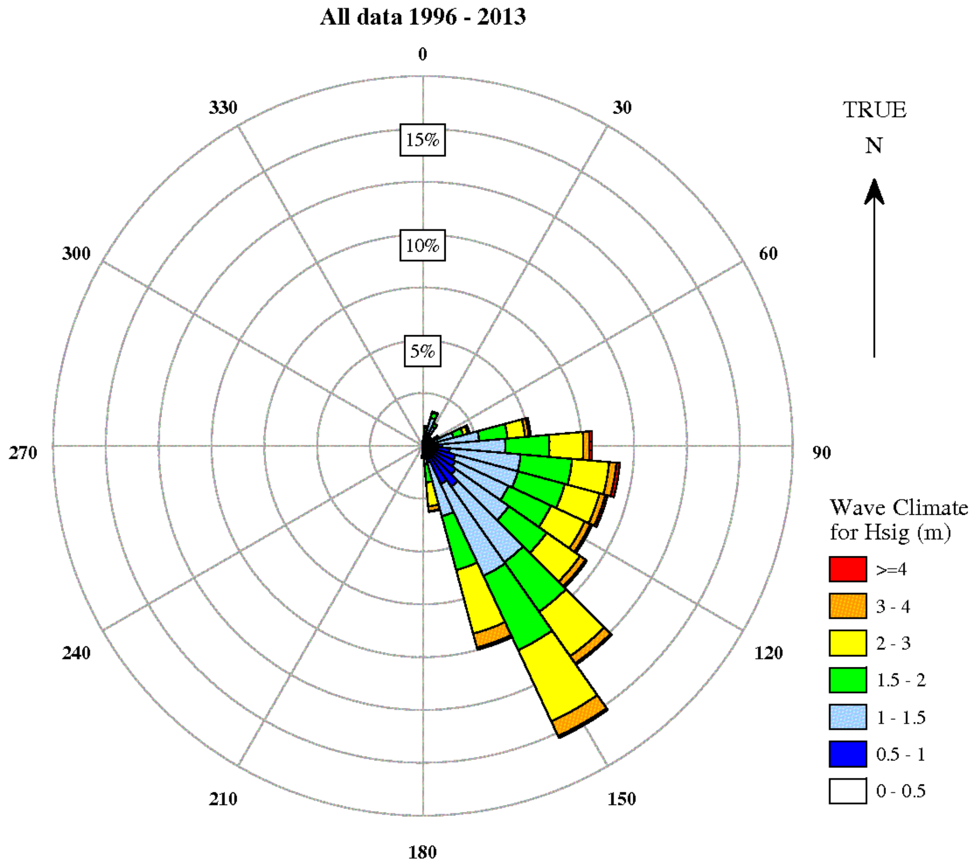


Figure 4.8: Brisbane - Sea surface temperature and peak wave directions



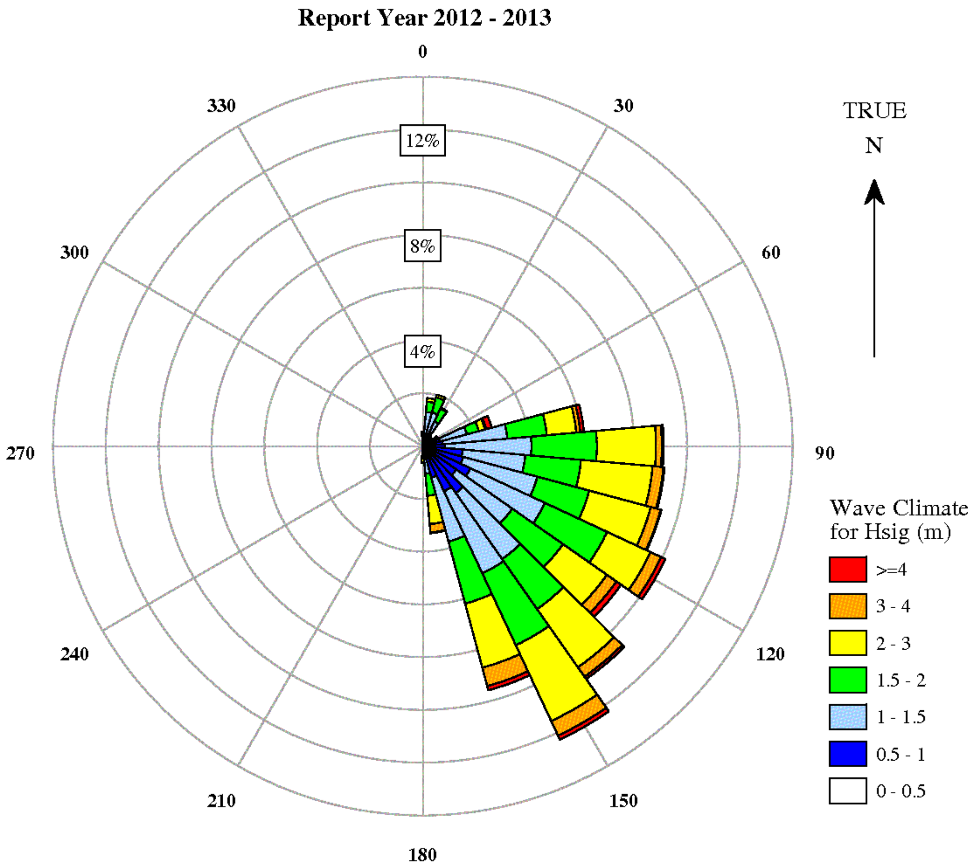


Figure 4.9: Brisbane - Directional wave rose

5. Central Moreton

Data Overview

The Central Moreton wave buoy was operational for just over 2.5 years with an overall data return of 77.5%. On 26 April 2013 wave monitoring at the Central Moreton site discontinued as the buoy was repositioned for Port of Brisbane operation purposes. For this reason the data presented in this report is only for the period November 2012 to April 2013. The buoy was replaced just prior to this reporting period on 02 June 2012 (Table 5.1).

There were two significant wave heights (Hsig) recorded during the reporting period that made it into the top five ranks and two maximum wave heights (Hmax) that also made the top five ranking (Table 5.2). Notably, a Hsig of 2.3 m was reported during the passage of Ex TC Oswald and was the largest Hsig ever recorded at this particular monitoring location, while a Hmax of 4.4 m was also reported later on the same day and also ranked as the highest on record. The relatively short historical wave record for the Central Moreton site means that the highest top five ranked waves should be exceeded with relative ease.

Since only six months of wave data has been recorded from the Central Moreton site for this reporting period no comment can be made on the differences between the summer and winter wave climates.

The wave climate during the reporting period was very similar to the wave climate for the whole record. This is evident in Figure 5.4, which shows the recorded monthly Hsig averages falling within one standard deviation (sd) of the long-term mean.

The plot of wave direction over the 2012–13 season (Figure 5.5) showed a dominant north easterly direction with an occasional swing to the south, possibly due to waves radiating out of Moreton bay. The dominance of the north easterly incident wave direction is reflected in the directional wave rose plot (Figure 5.7). It is important to note that due to the position of the buoy in Northern Moreton Bay it is sheltered from east to southern easterly swells by Moreton Island. Being in shallow water this site it is also influenced by refraction processes

The temperature (sea surface temperature, SST) measured in the buoy hull showed the recorded values ranging from 21 °C to 28 °C (Figure 5.6). The SST during January was warm enough for tropical cyclone development but fell below the 26 °C threshold temperature for the remaining months.

Central Moreton

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 155.60
Gaps in data used in analysis (days)	= 209.37
Number of records used in analysis	= 7469

All data since-2011

Maximum possible analysis years (last record - first record)	= 2.58
Total number of years used in analysis	= 2.00
Gaps in data used in analysis (years)	= 0.58
Number of records used in analysis	= 35100

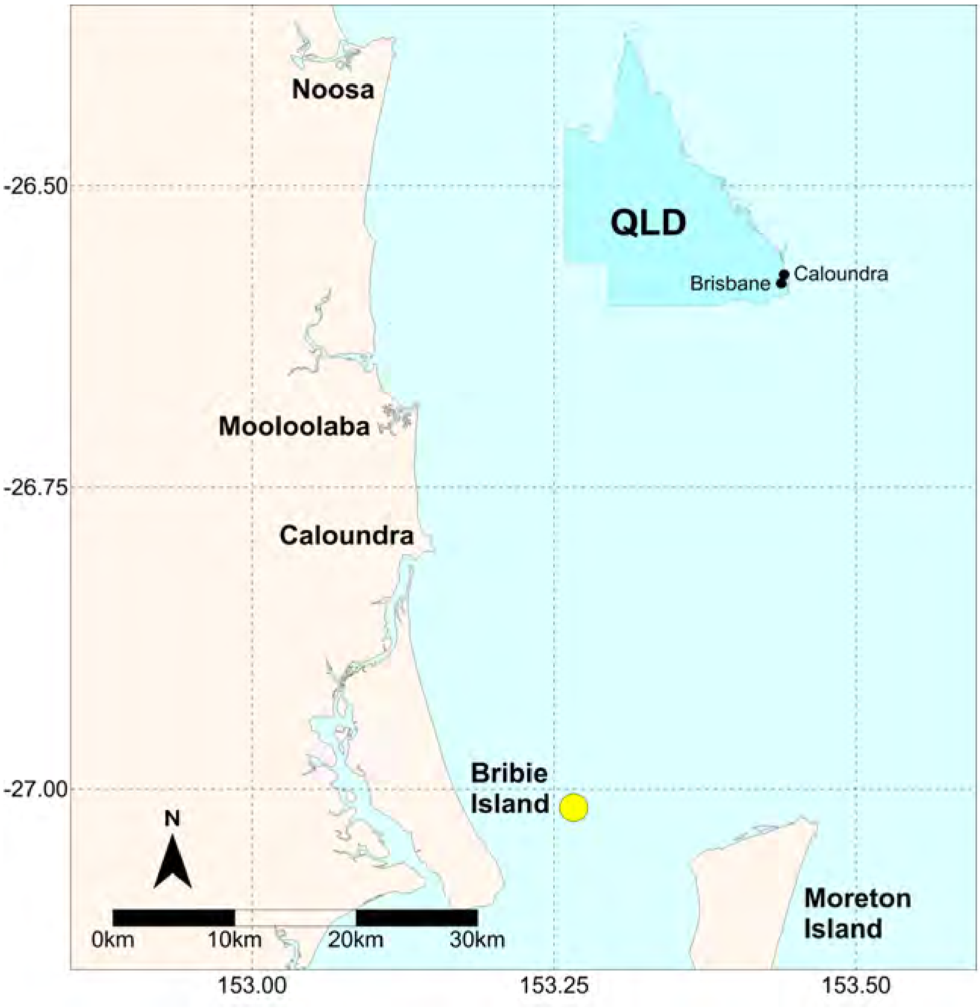


Figure 5.1: Central Moreton - Locality plan

Table 5.1: Central Moreton – Buoy deployments during the 2012-13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
27°0.933'S	153°15.380'E	16	02/06/2012	26/04/2013

Table 5.2: Central Moreton - Highest waves

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	28/01/2013 07:30	2.3	27/01/2013 09:00	4.4
2	25/12/2011 08:00	1.9	19/02/2013 12:30	4.0
3	28/06/2012 16:00	1.8	22/08/2011 13:30	3.6
4	19/02/2013 14:00	1.8	28/06/2012 15:30	3.4
5	22/08/2011 15:00	1.8	25/12/2011 19:00	3.4

Table 5.3: Central Moreton - Significant meteorological events with threshold Hsig of 1.5 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
28/01/2013 7:30	2.1 (2.3)	3.7 (4.4)	8.5	Ex TC Oswald passed from north to south as a low pressure system with a central pressure of 996.1 hPa at Deagon.
19/02/2013 14:00	1.7 (1.8)	3.1 (4.0)	6.4	Low pressure system off the far Southern Capricornia Coast causing fresh to strong south easterly winds along the Southern Queensland Coast.

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996). 2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

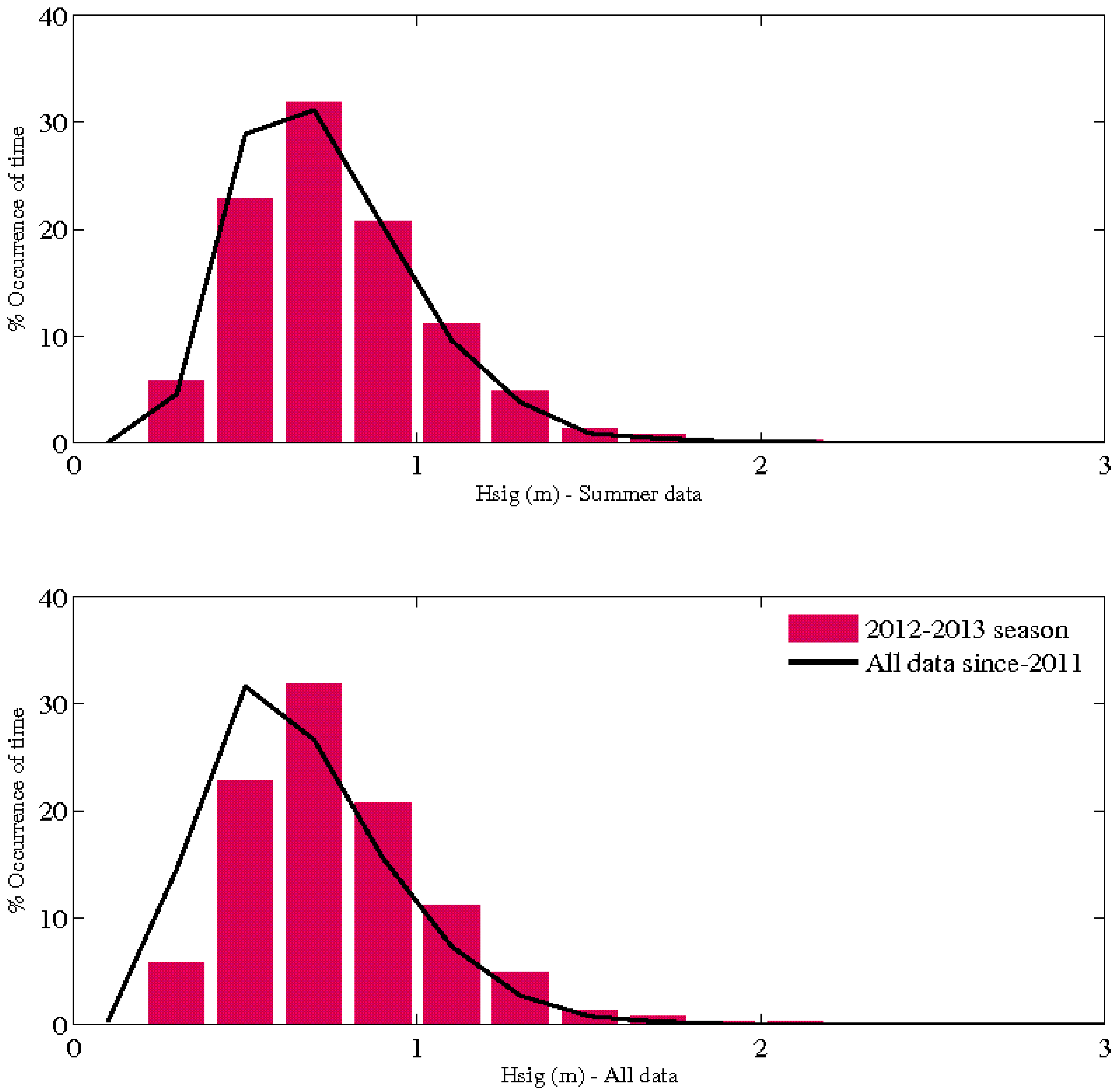


Figure 5.2: Central Moreton - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

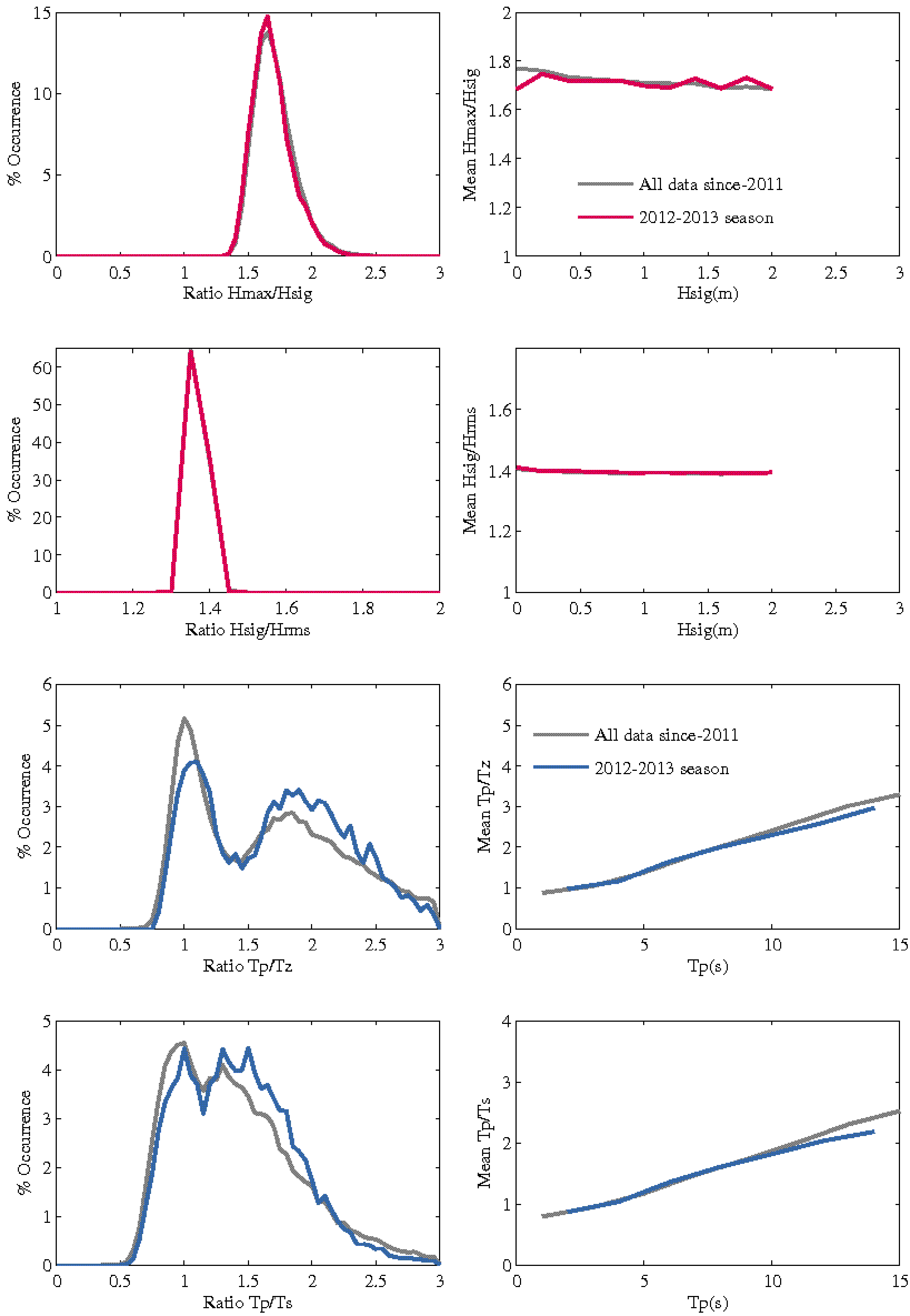


Figure 5.3: Central Moreton - Wave parameter relationships

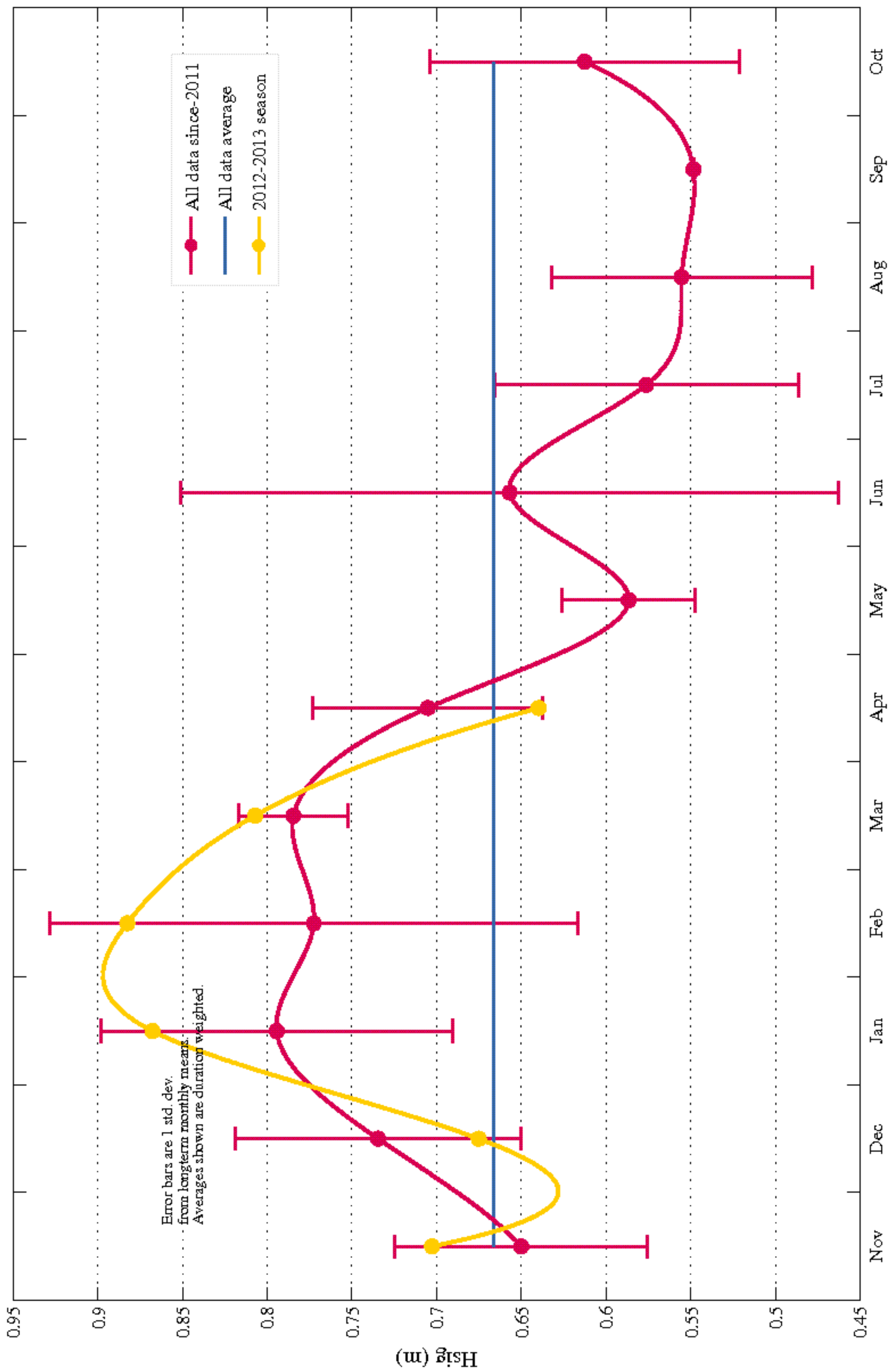


Figure 5.4: Central Moreton - Monthly average wave height (Hsig) for seasonal year and for all data

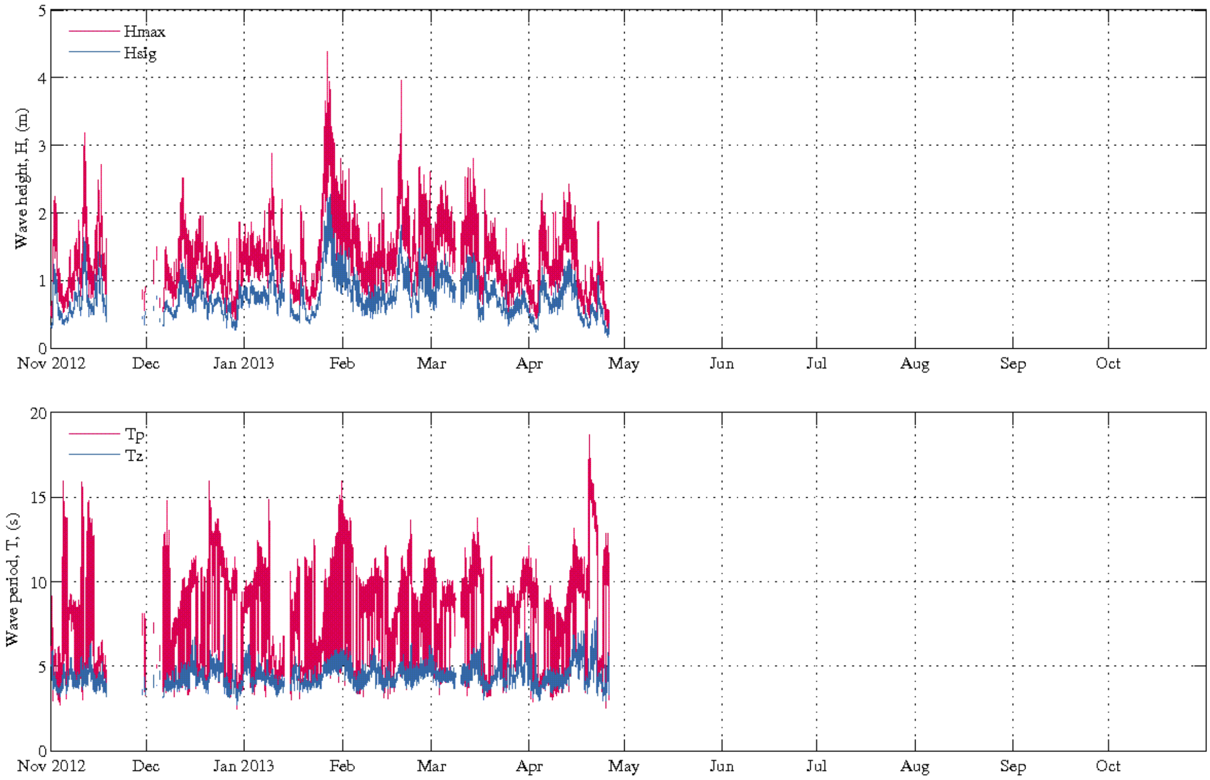
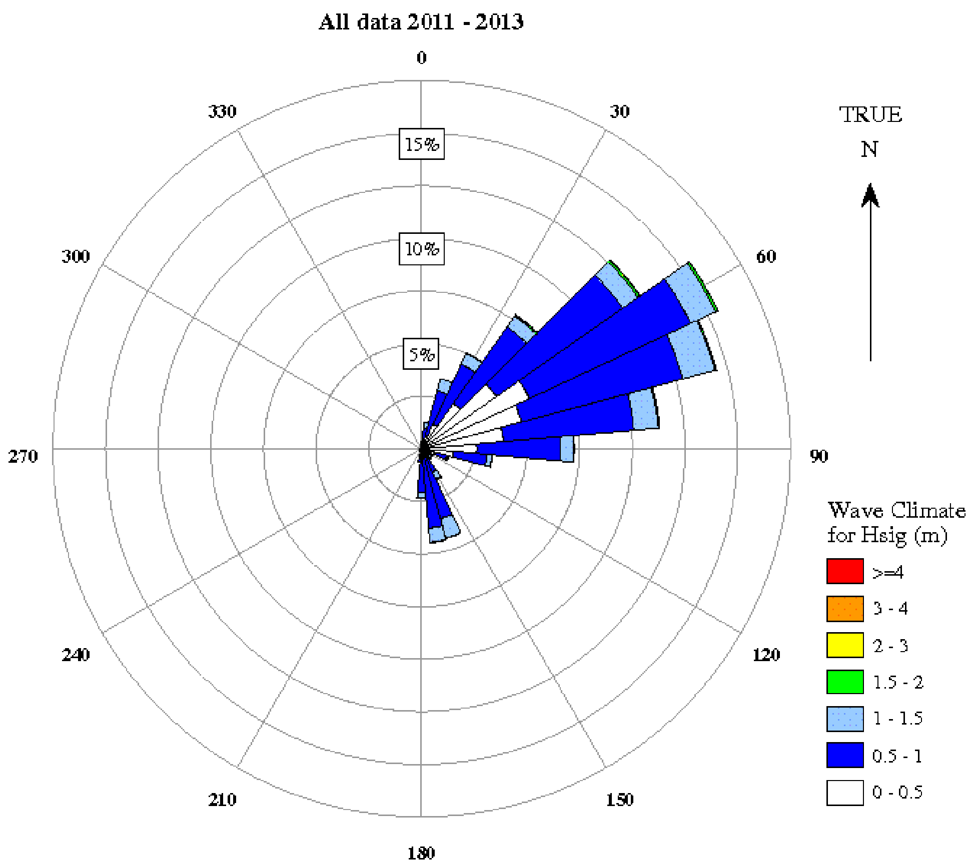


Figure 5.5: Central Moreton - Daily wave recordings

Figure 5.6: Central Moreton - Sea surface temperature and peak wave directions



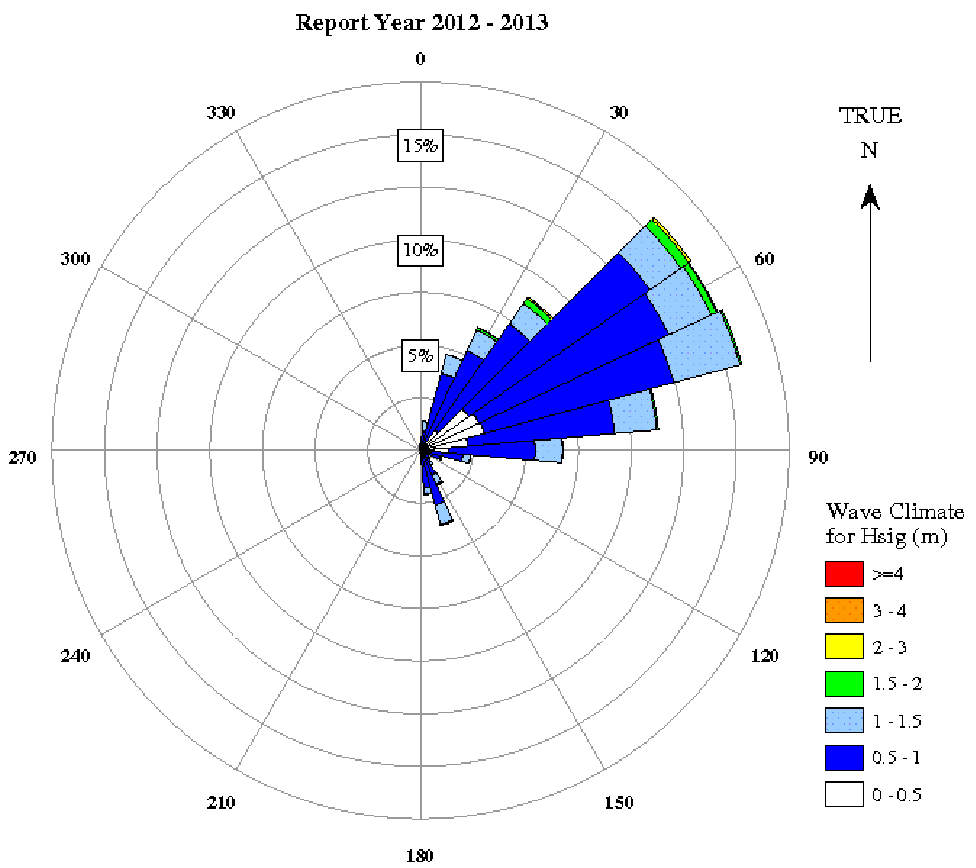


Figure 5.7: Central Moreton - Directional wave rose

6. North Moreton

Data Overview

The North Moreton wave buoy has been operational for just over three years with an overall data return of 96.4%. The data record for the period November 2012 to October 2013 was reasonable, with total gaps of only 17.1 days. The primary reason for the majority of the data loss is a result of the buoy being unserviceable for 12 days in November. The buoy was replaced prior to this reporting period on 08 April 2012 and again on 26 April 2013 (Table 6.1).

There were two significant wave heights (Hsig) recorded during the reporting period that made it into the top ten ranks and two maximum wave heights (Hmax) that also made the top ten ranking (Table 6.2). Notably, a Hsig of 5.9 m was reported during the passage of Ex- TC Oswald and was the largest Hsig ever recorded since monitoring began at that particular location. While a Hmax of 10.3 m was also reported later on the same day and was also the largest Hmax ever recorded. The relatively short record (three years) means that the highest top ten ranked waves should be exceeded relatively frequently.

Ex-TC Oswald passed along the Queensland Coast in January 2013 as a low pressure system travelling from north to south. As the system passed to the west of Brisbane the atmospheric pressure fell to 996.1 hPa at Deagon, the nearest DSITI measurement point to the buoy (see the report on TC Oswald for more details, (DSITIA, 2013)). As a result of Ex-TC Oswald's influence the wave climate at the monitoring location rose to over 2.0 m Hsig for four days from 25 January to 29 January.

There are some notable differences in the wave climate at the North Moreton monitoring location between the summer and winter seasons. It is evident from Figure 6.2 and Figure 6.3 that during winter no waves were recorded that exceeded 2 m Hsig. There were also some notable differences in the seasonal recording of Tp. Figure 6.4 illustrates a higher occurrence of Tp recordings greater than 11 seconds during winter than compared to summer. This suggests the occurrence of more developed swell events taking place during winter months.

The wave climate during the reporting period was similar to the wave climate of the whole record, albeit a short record, as evident from the percentage time exceedance figure (Figure 6.2) and the histograms of the occurrence of Hsig and Tp (Figure 6.3 and Figure 6.4). The monthly average Hsig generally fell within one standard deviation (sd) of the long-term mean with the exception of January and September. During these months the mean was higher than the mean +1 sd. During February, the recent passage of Ex-TC Oswald earlier in the month and the presence of a deep low (997 hPa) off South East Queensland later in the month most likely contributed to the recorded above average wave height. While during September the occurrence of a number of east coast lows would have likely contributed to the above average wave heights recorded for the month.

The plot of wave direction over the 2012–13 season (Figure 6.7) showed a dominant easterly (slightly north of east) direction with an occasional swing to the north, mostly during winter. It is important to note that waves generated from the south east are restricted in the recordings due to the location of the wave buoy in relation to Moreton Island.

The temperature (sea surface temperature, SST) measured in the buoy hull showed the recorded values ranging from 19 °C to 29 °C during the year (Figure 6.8).

North Moreton

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 347.87
Gaps in data used in analysis (days)	= 17.10
Number of records used in analysis	= 16698

All data since-2010

Maximum possible analysis years (last record - first record)	= 3.24
Total number of years used in analysis	= 3.19
Gaps in data used in analysis (years)	= 0.05
Number of records used in analysis	= 55789

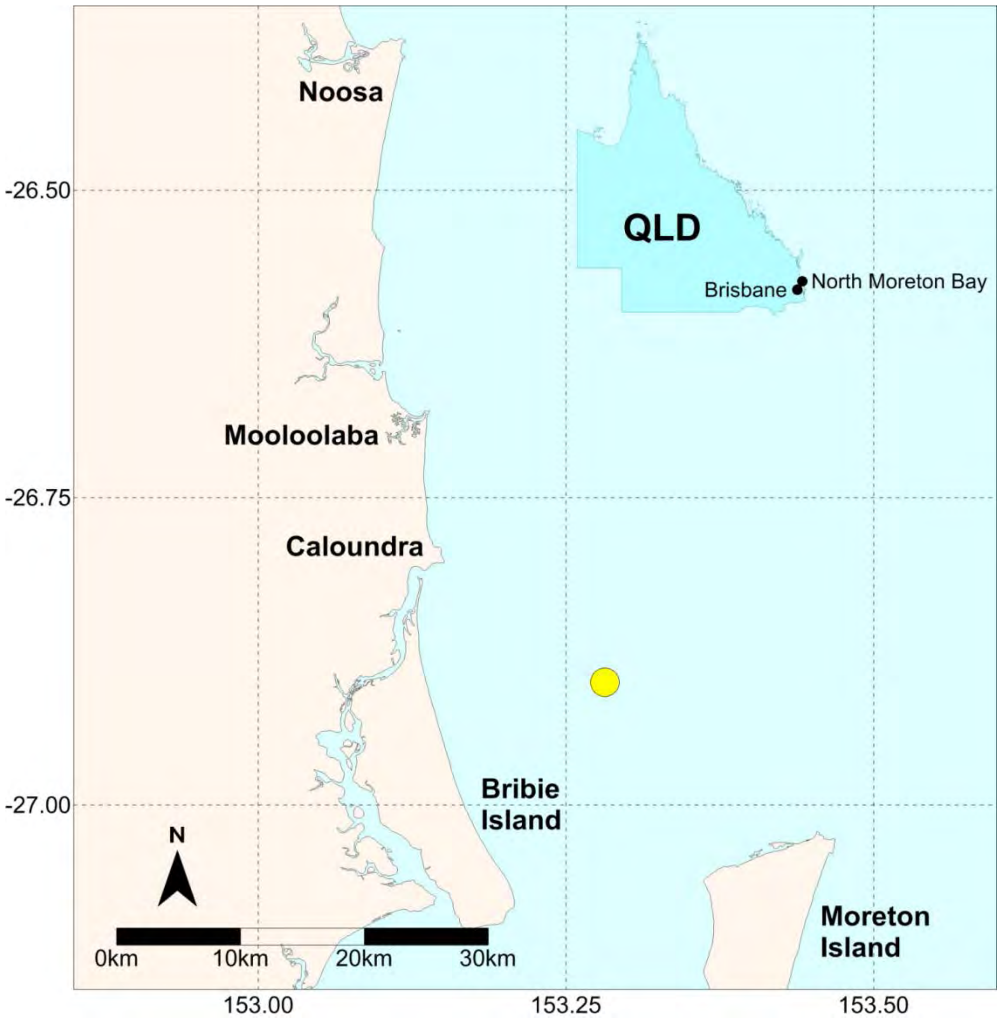


Figure 6.1: North Moreton - Locality plan

Table 6.1: North Moreton - Buoy deployments during the 2012–13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
26°54.006'S	153°16.908'E	35	08/04/2012	26/04/2013
26°54.930'S	153°16.842'E	35	26/04/2013	current

Table 6.2: North Moreton - Highest waves

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	27/01/2013 22:00	5.9	27/01/2013 23:30	10.3
2	25/12/2011 07:00	3.9	25/12/2011 07:00	7.3
3	19/02/2013 11:30	3.5	19/02/2013 15:30	6.3
4	28/06/2012 02:30	3.2	28/06/2012 05:30	5.7
5	17/01/2012 06:30	3.0	22/08/2011 08:30	5.7
6	12/10/2010 13:30	3.0	16/01/2011 22:00	5.7
7	12/06/2012 15:30	2.9	17/01/2012 06:30	5.6
8	11/08/2010 02:00	2.9	12/06/2012 13:00	5.5
9	08/12/2011 13:30	2.8	11/10/2010 14:00	5.4
10	05/03/2012 10:00	2.7	11/08/2010 06:00	5.2

Table 6.3: North Moreton - Significant meteorological events with threshold Hsig of 2.0 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
27/01/2013 22:00	5.5 (5.9)	9.0 (10.3)	10.5	Ex- Tropical Cyclone Oswald passed from north to south as a low pressure system with a central pressure of 996.1 hPa at Deagon.
19/02/2013 11:30	3.3 (3.5)	5.3 (6.3)	10.1	Low pressure system off the far Southern Capricornia Coast causing fresh to strong south easterly winds along the southern Queensland Coast.
25/02/2013 12:00	2.4 (2.5)	4.0 (4.9)	8.1	Low [1009 hPa] situated over NSW along with an inland trough extending through QLD.
14/03/2013 11:00	2.3 (2.6)	3.8 (4.9)	12.3	Tropical Cyclone Sandy came closest to the Queensland Coast on March 14–15 2013, with a central pressure of 983 hPa.

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

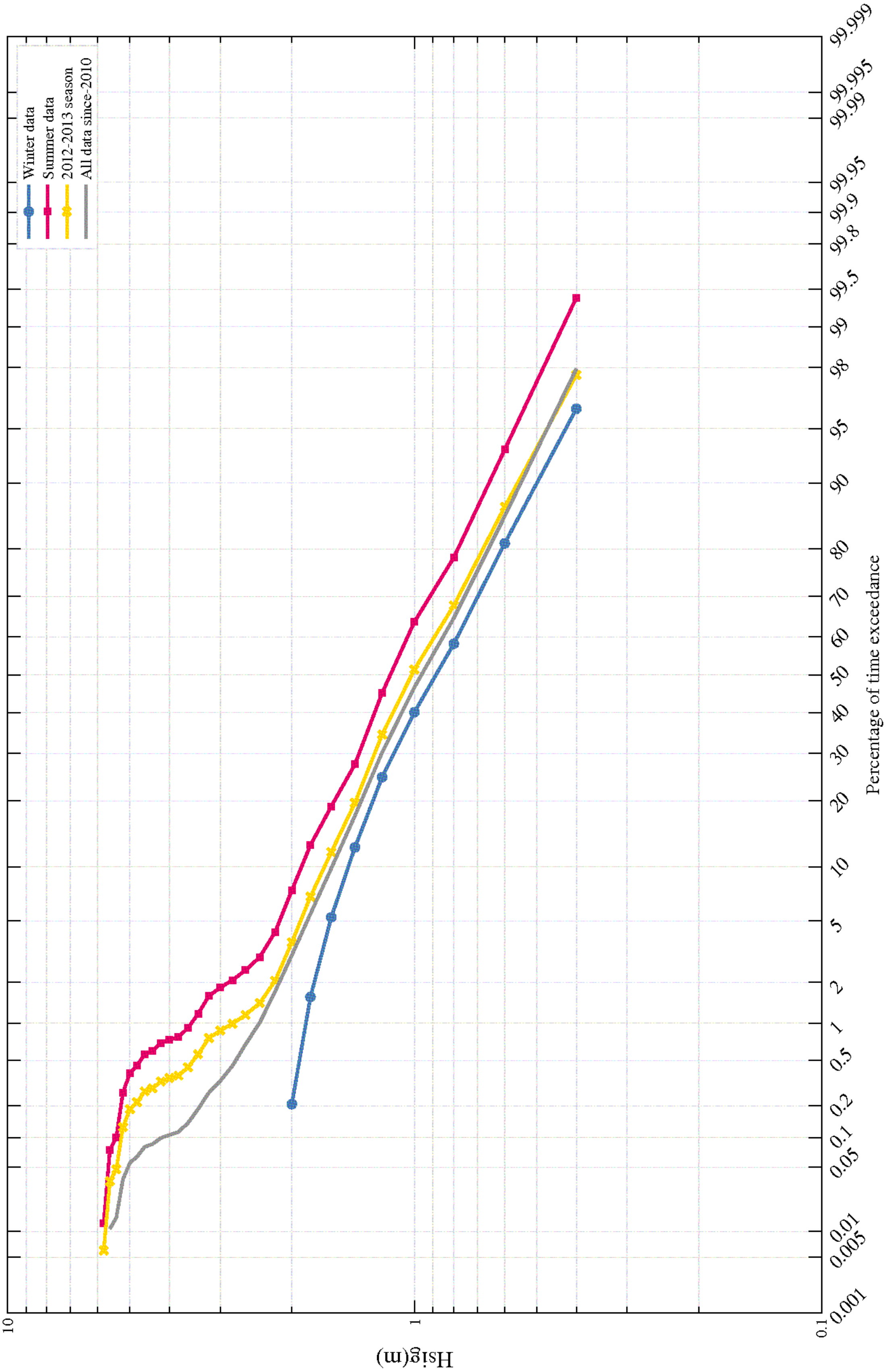


Figure 6.2: North Moreton Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

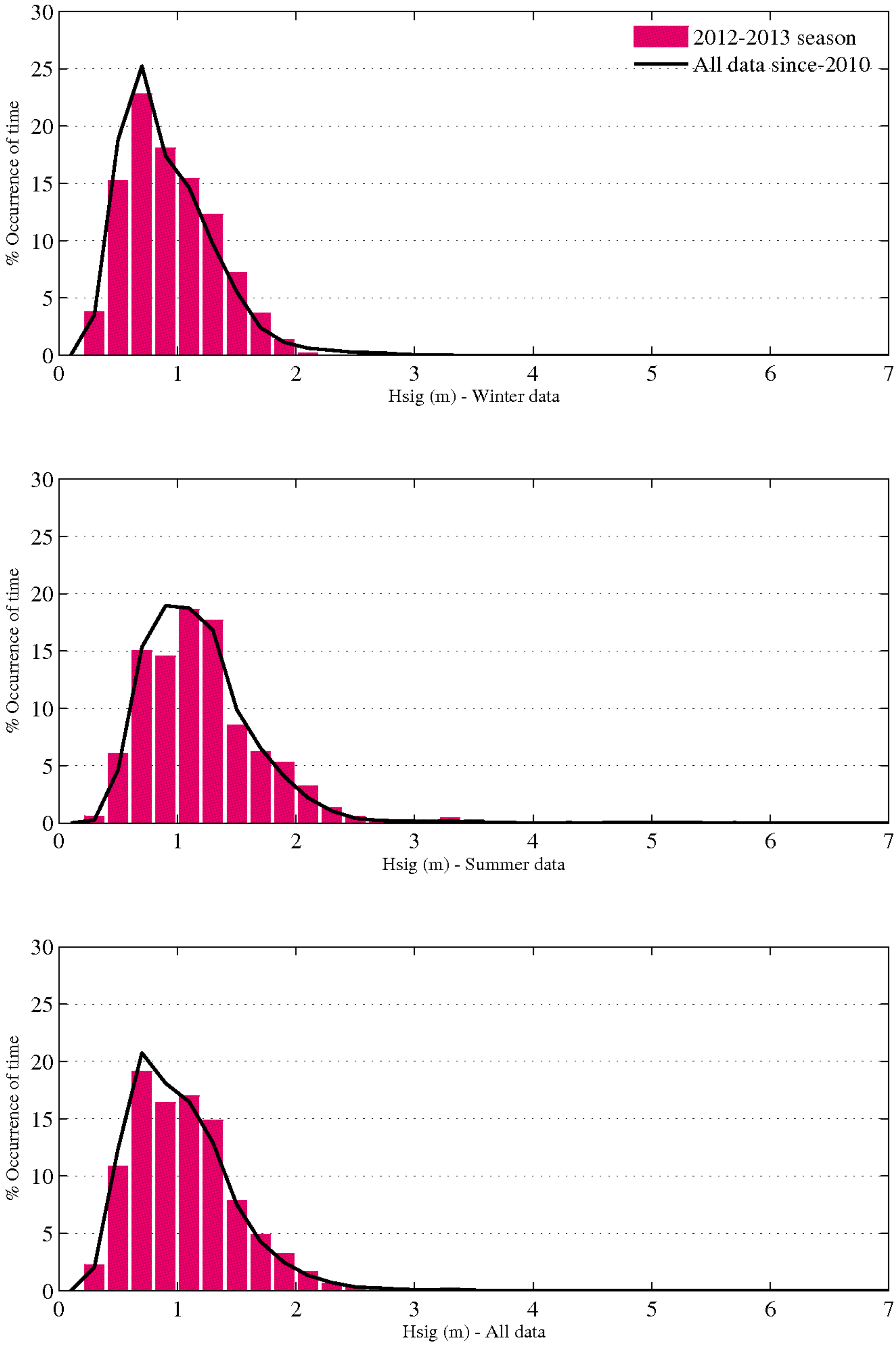


Figure 6.3: North Moreton - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

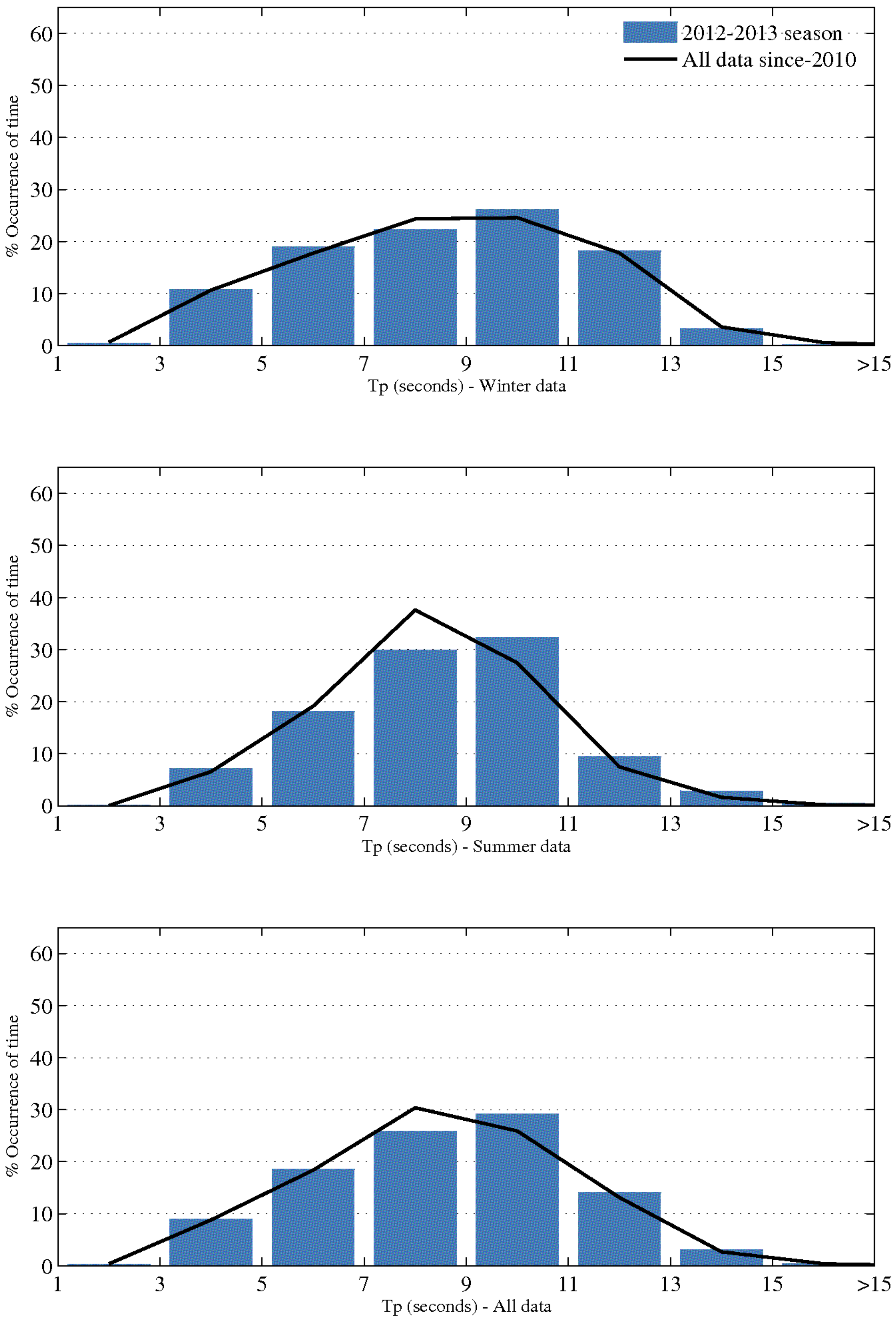


Figure 6.4: North Moreton - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

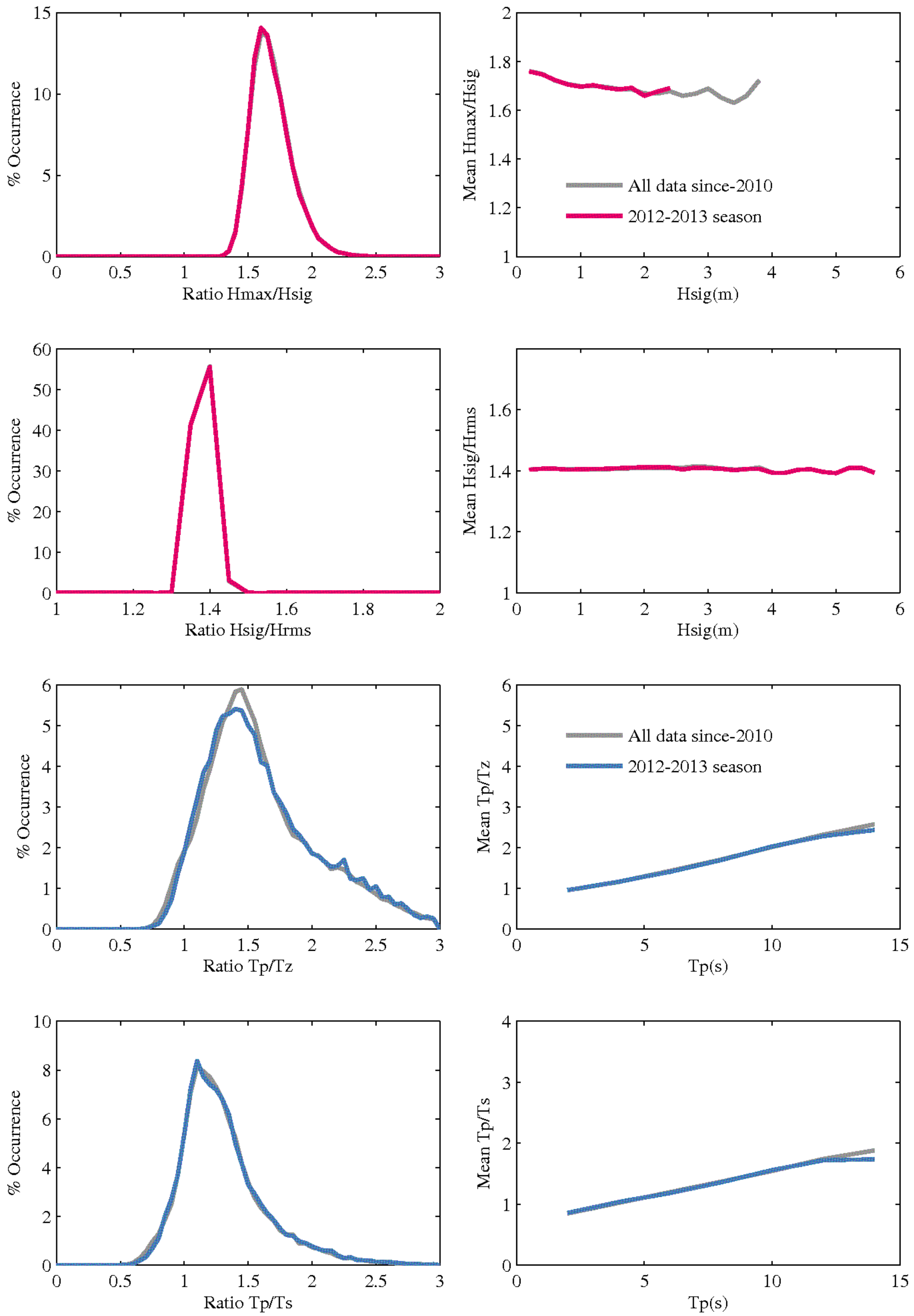


Figure 6.5: North Moreton - Wave parameter relationships

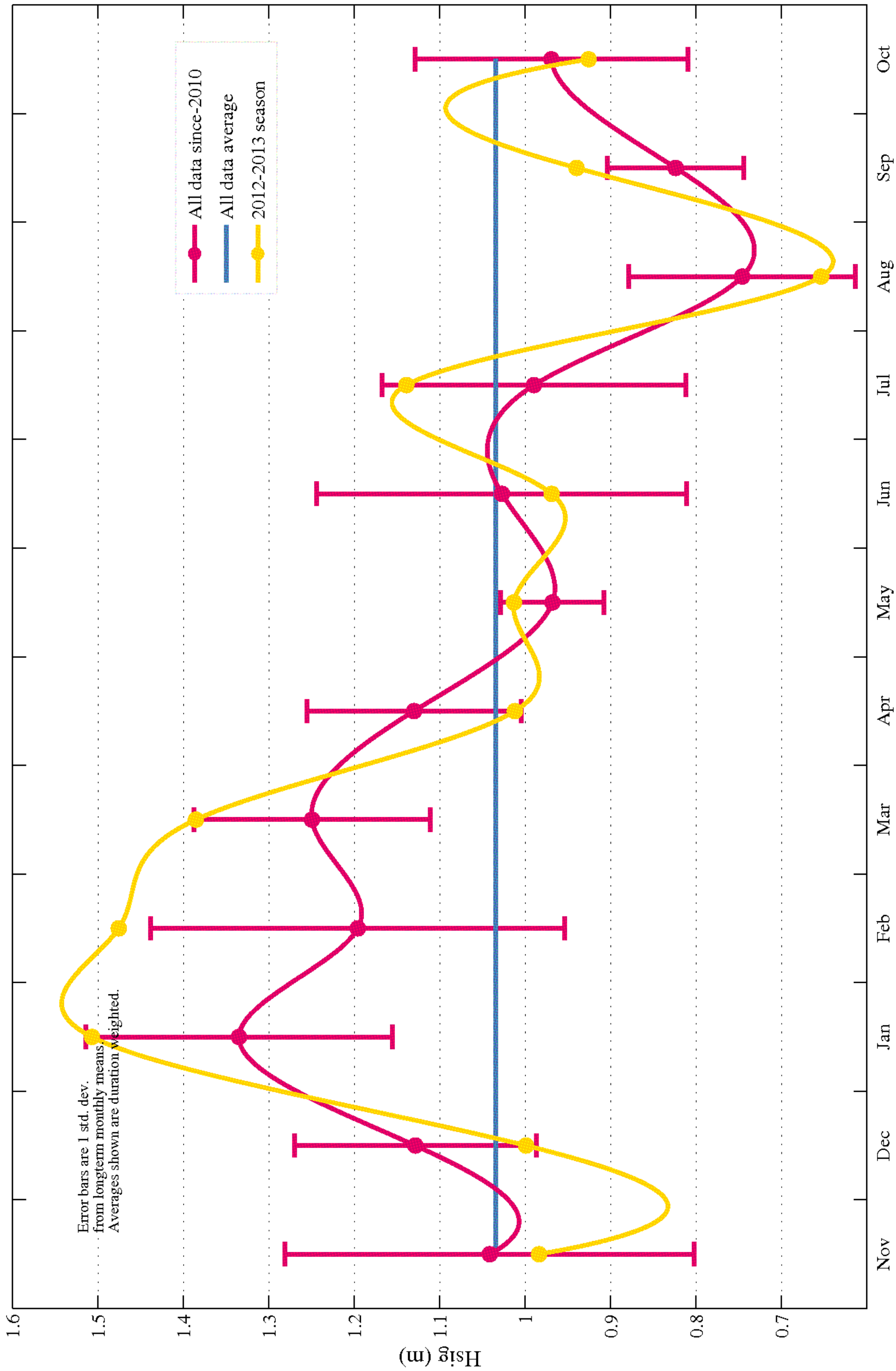


Figure 6.6: North Moreton - Monthly average wave height (Hsig) for seasonal year and for all data

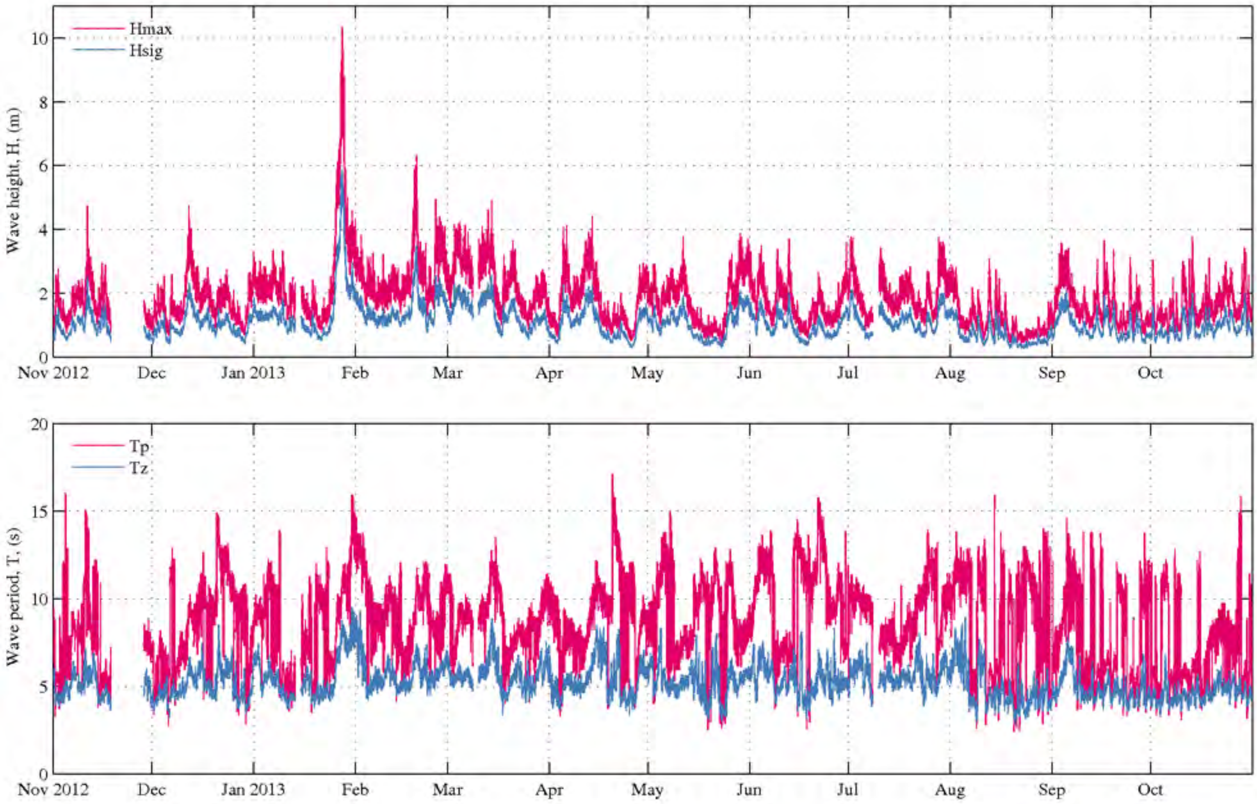
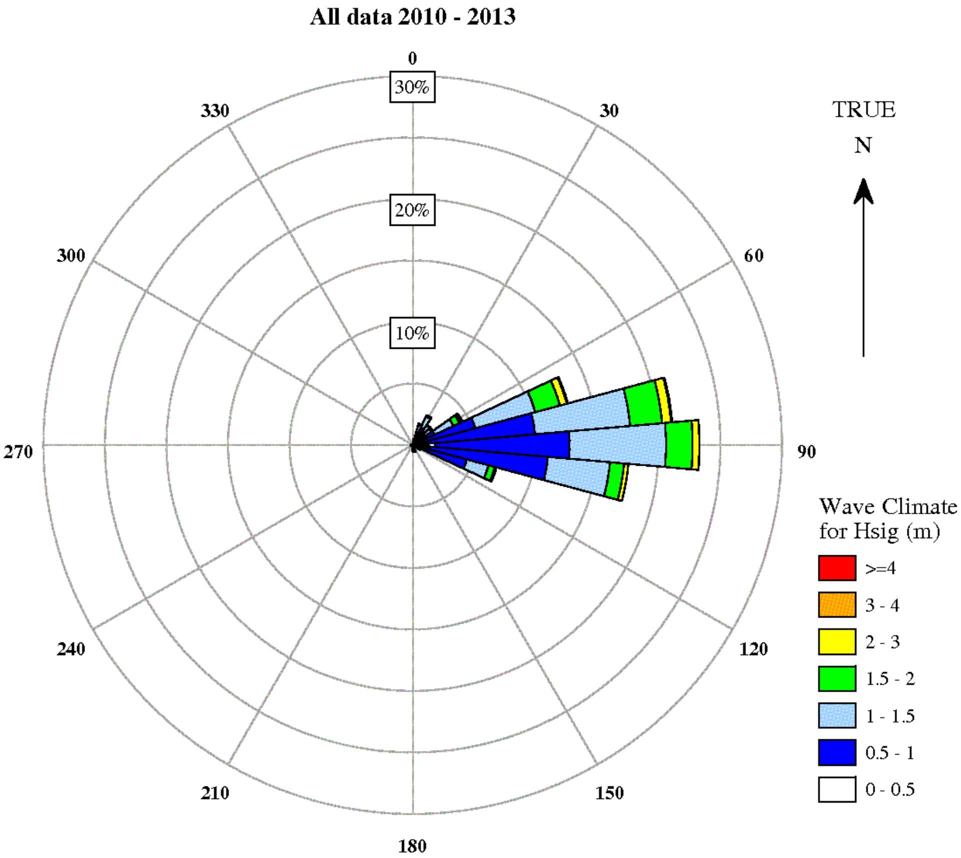


Figure 6.7: North Moreton - Daily wave recordings

Figure 6.8: North Moreton - Sea surface temperature and peak wave directions



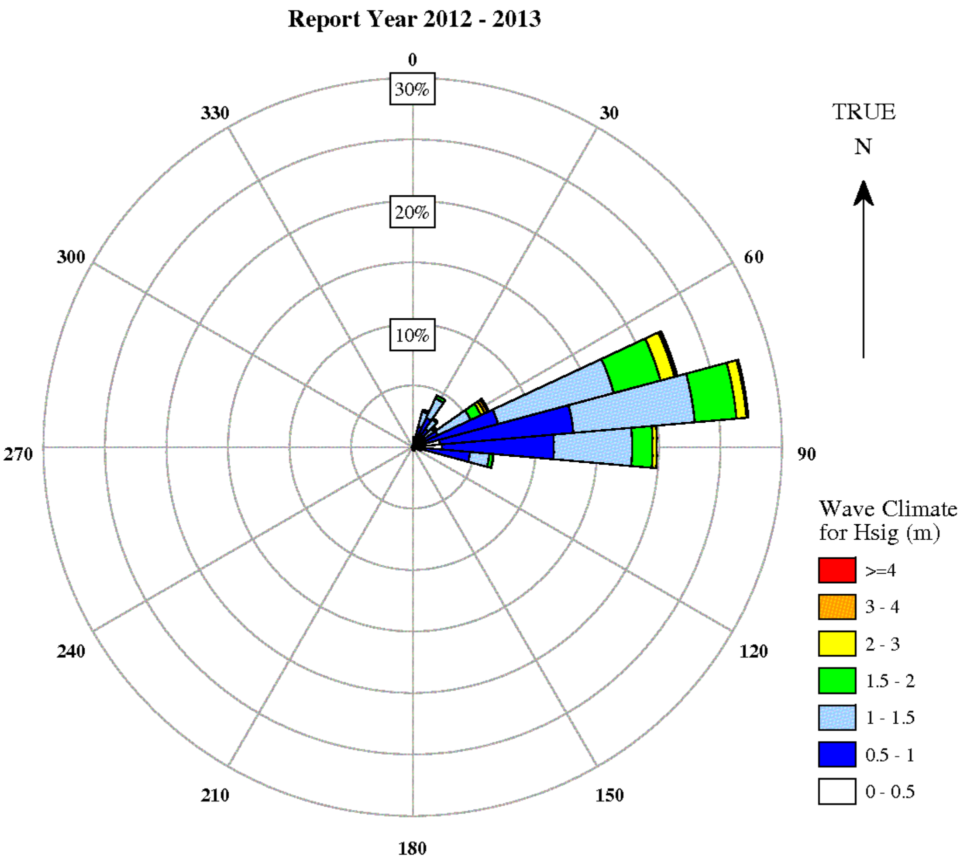


Figure 6.9: North Moreton - Directional wave rose

7. Caloundra

Data Overview

The Caloundra wave buoy has only recently become operational. It was deployed on 26 April 2013 and has continued to record wave data since. There is a break in the recorded wave data beginning on 26 October 2013 as a result of a power issue on board the buoy. Due to the relatively short data set available, this report has made no comments or comparisons against any historical data. Additionally, since only six months of wave data has been recorded from the Caloundra site no comment or comparison can be made on the differences between the summer and winter wave climates.

Figure 7.3 shows the highest occurring significant wave (Hsig) being 0.6–0.8 m and the highest occurring peak period (Tp) being 9–11 seconds for the data recorded during this reporting period. The plot of wave direction (Figure 7.6) showed a dominant easterly direction with an occasional swing to the north east during August, September and October. The temperature (sea surface temperature, SST) measured in the buoy hull showed the recorded values ranging from 18 °C to 24 °C between April and October 2013 (Figure 7.7).

Caloundra

Wave recording station

Details of data collected

2012–2013 season

Maximum possible analysis days (last record – first record)	= 364.98
Total number of days used in analysis	= 172.77
Gaps in data used in analysis (days)	= 192.21
Number of records used in analysis	= 8293

Less than 2 years of data recorded, historical trends are not shown for this site.

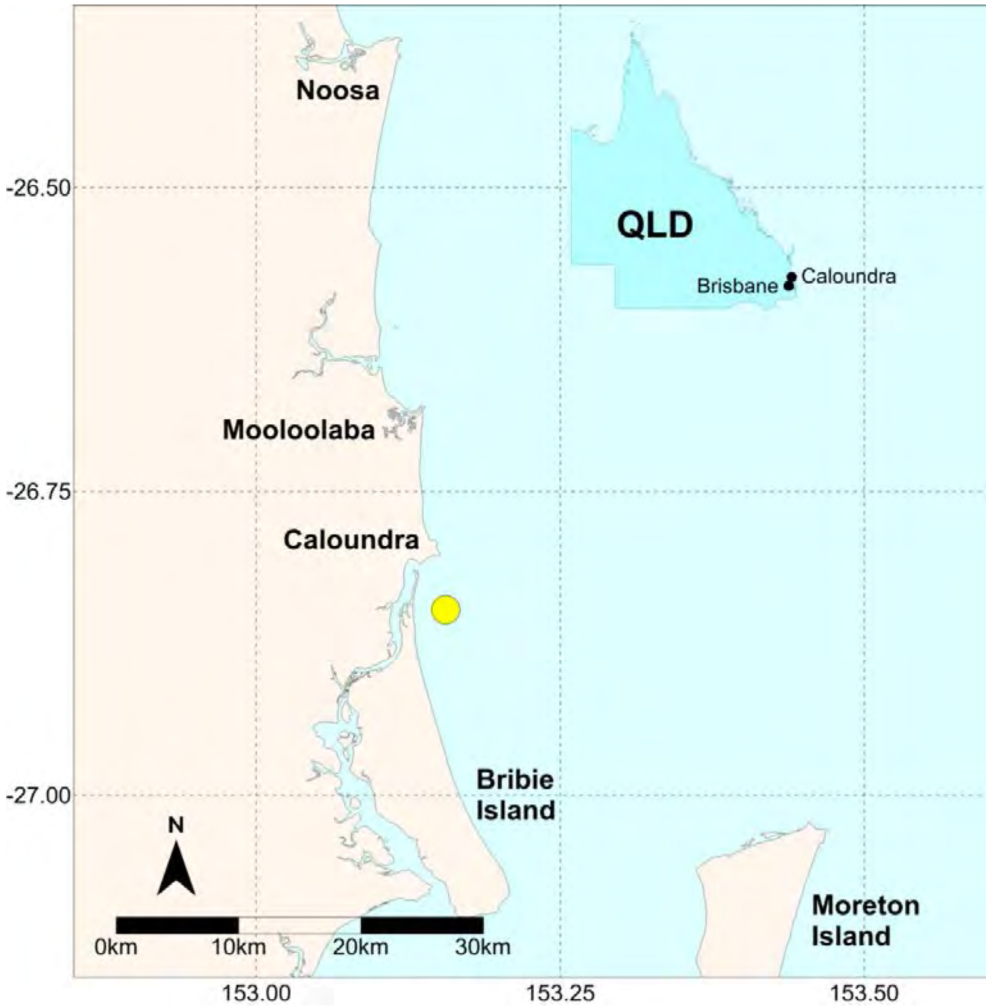


Figure 7.1: Caloundra - Locality plan

Table 7.1: Caloundra - Buoy deployments for 2012-13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
27°50.868'S	153°10.962'E	15	26/04/2013	26/06/2013
26°50.850'S	153°09.350'E	15	26/06/2013	26/10/2013
26°50.855'S	153°09.340'E	12	26/10/2013	current

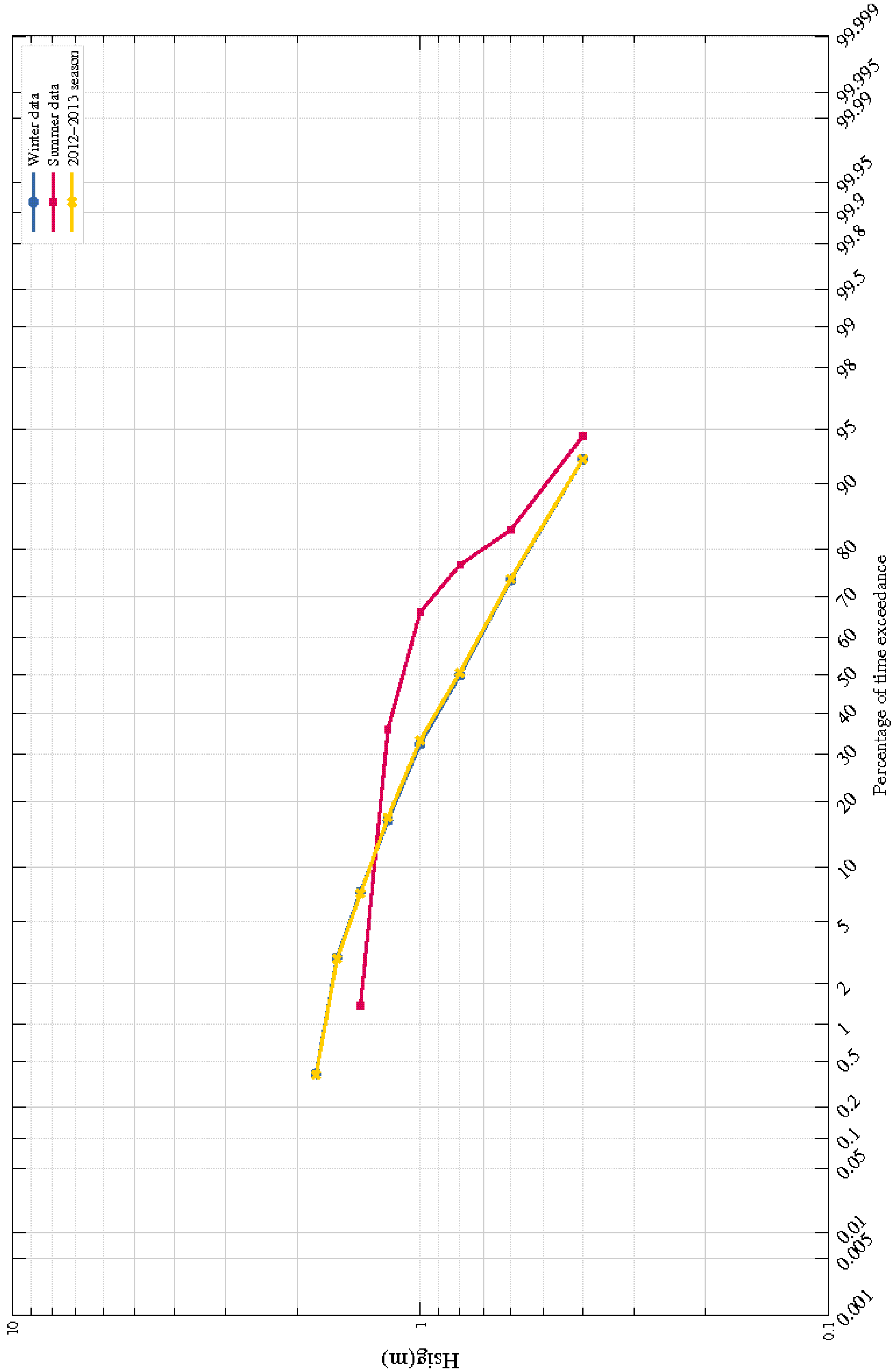


Figure 7.2: Caloundra - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

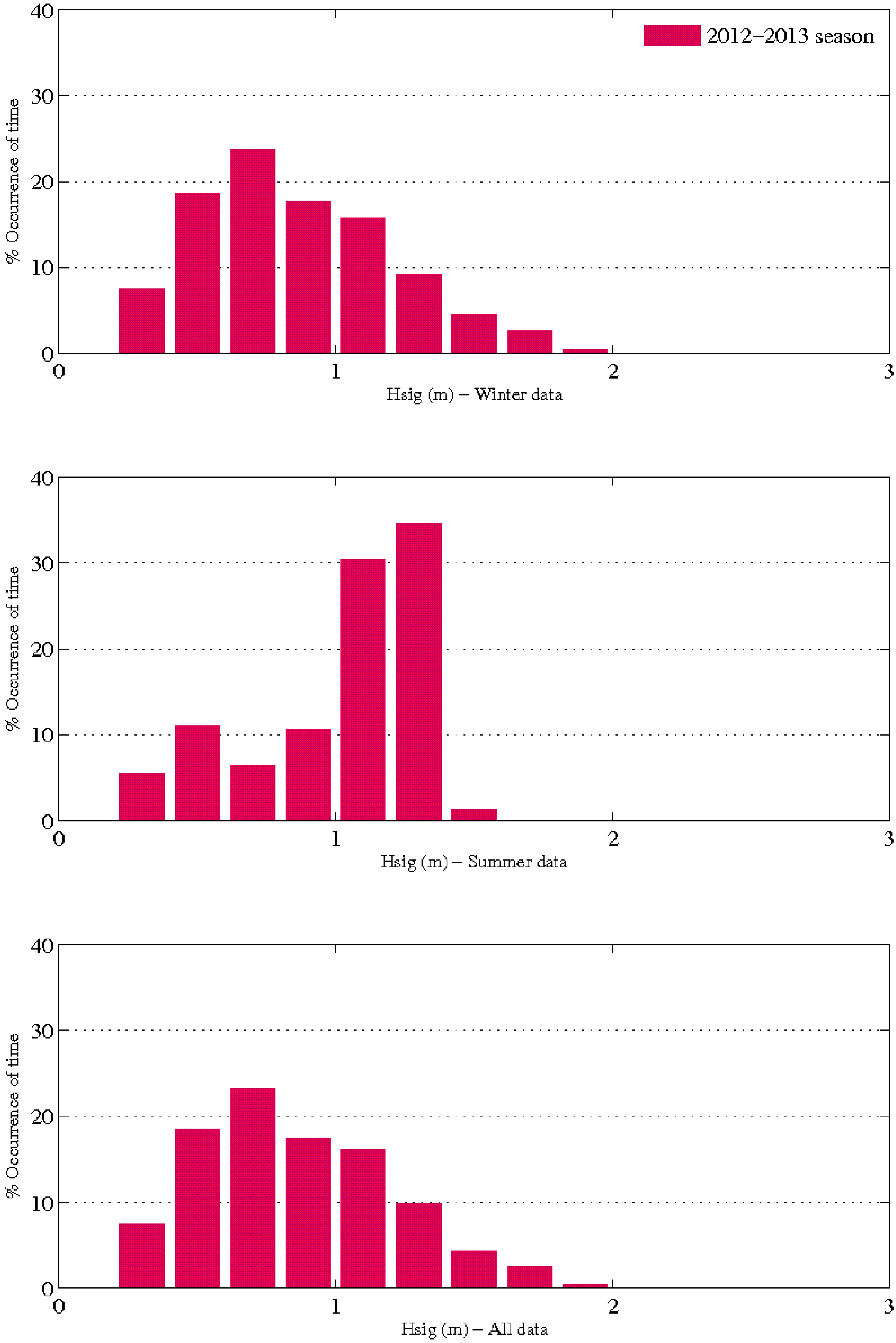


Figure 7.3: Caloundra - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

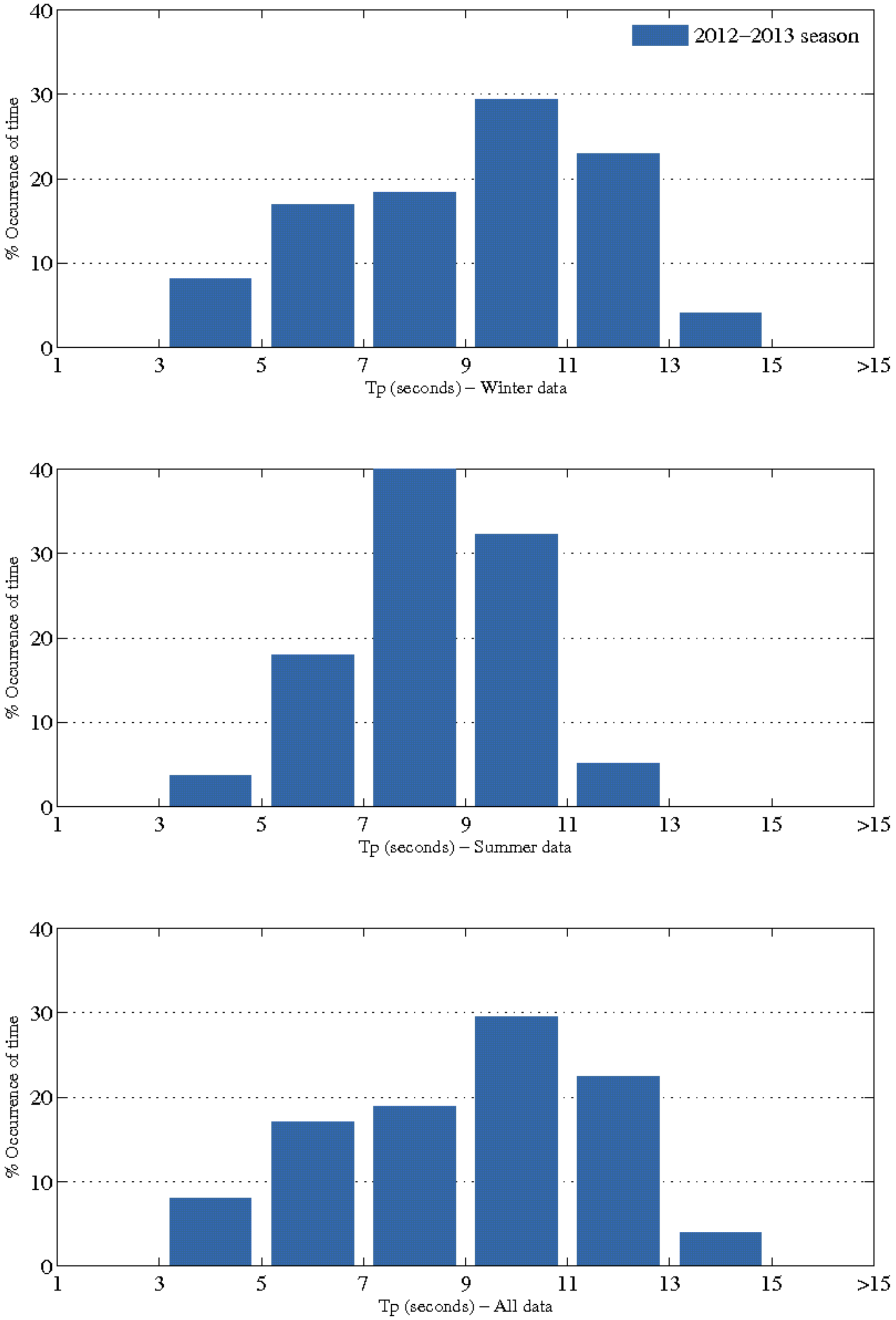


Figure 7.4: Caloundra - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

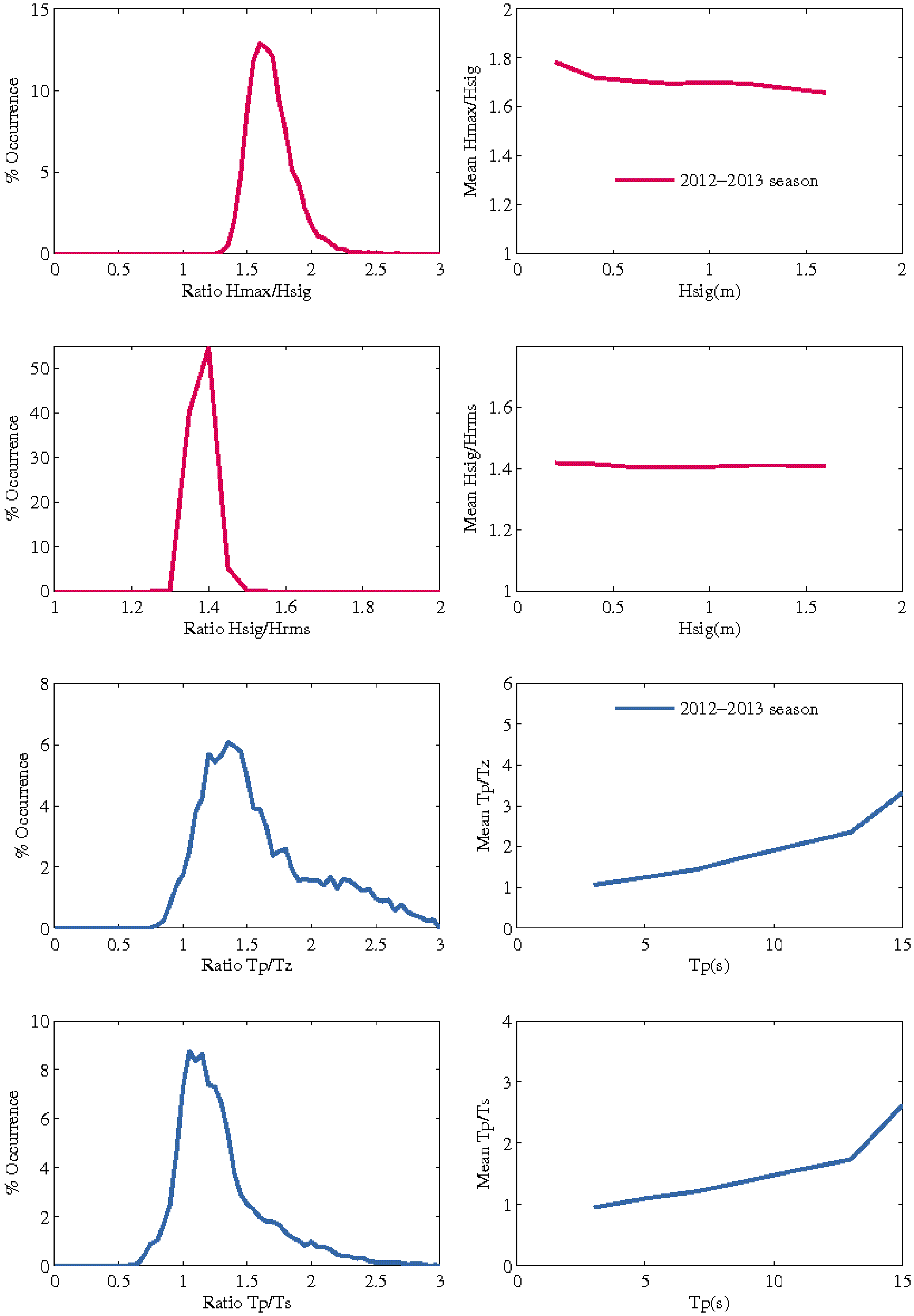


Figure 7.5: Caloundra - Wave parameter relationships

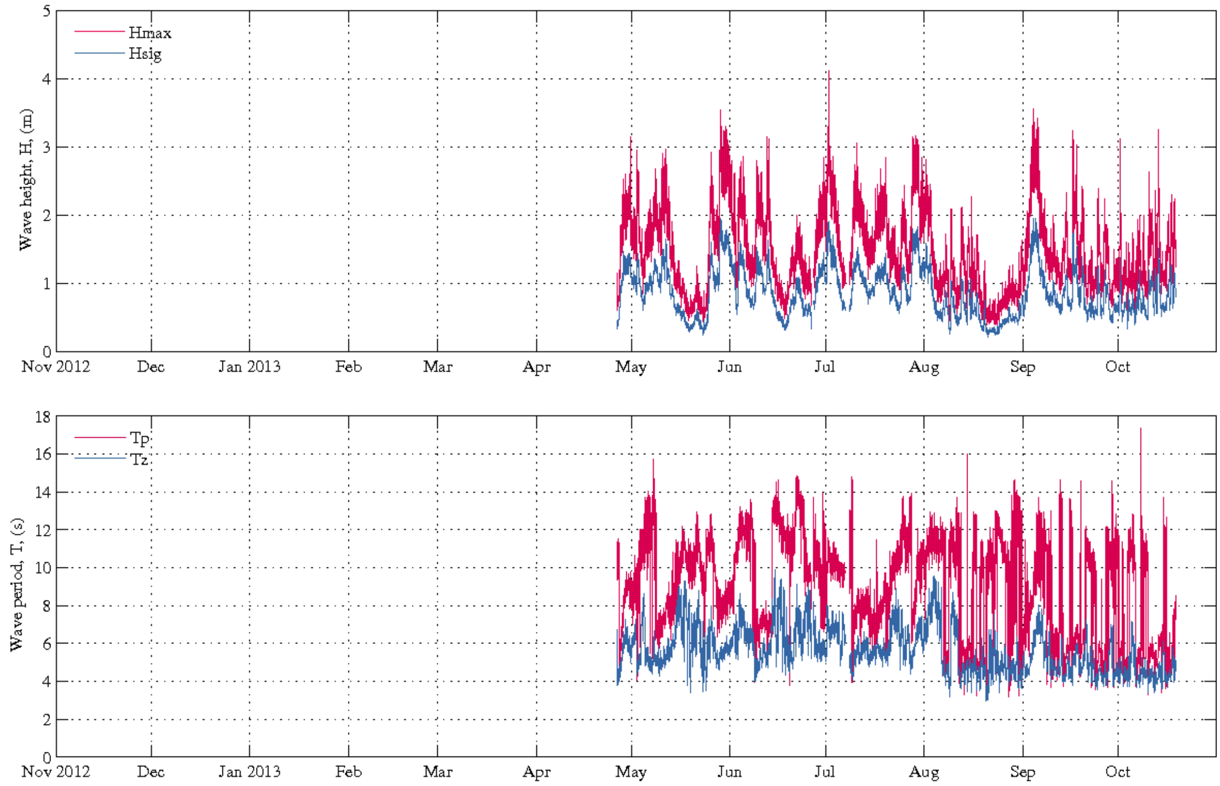


Figure 7.6: Caloundra - Daily wave recordings

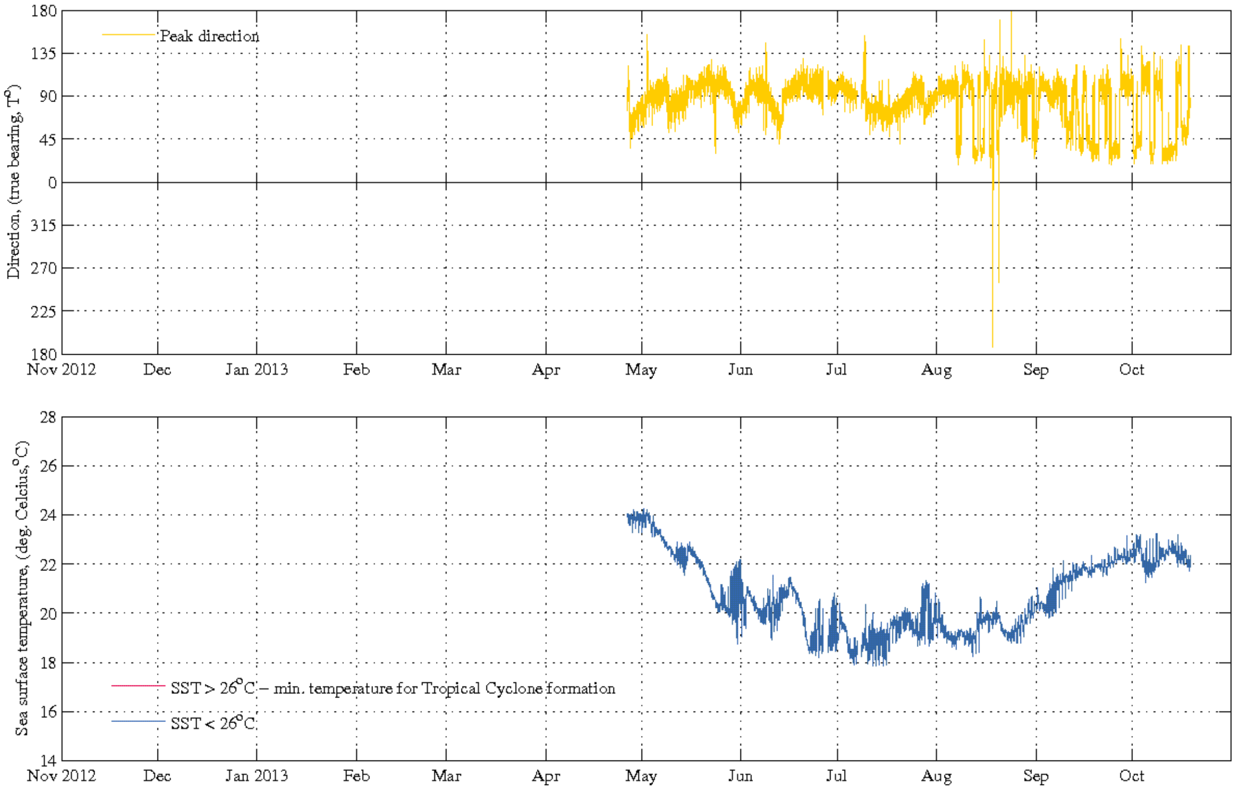


Figure 7.7: Caloundra - Sea surface temperature and peak wave directions

8. Mooloolaba

Data Overview

The Mooloolaba wave buoy has been operational for just over 13.5 years with an overall data return of 94.4%. The data record for the period November 2012 to October 2013 was good, with total gaps of only 12.19 days, equivalent to 96.6% data return. The buoy was replaced once during the reporting period on 16 December 2012 (Table 8.1).

On the 28 January 2013, Ex- TC Oswald passed through the Mooloolaba region as a low pressure system travelling in a southerly direction just to the west of the buoy (inland). As a result of Ex-TC Oswald's passing there was one significant wave height (Hsig) recorded that made it into the top ten ranks and one maximum wave height (Hmax) that also made the top ten ranking (Table 8.2). This being a Hsig of 5.6 m recorded, ranking second in respect to the highest significant waves recorded at the site, while a Hmax of 10.5 m was also recorded earlier on the same day and also ranked second.

There are some notable differences in the wave climate at Mooloolaba in respect to the summer and winter seasons. Over 20%of the time Hsig exceeds 2.0 m during summer whereas during winter Hsig exceeds 2.0 m only 5% of the time (Figure 8.2). There is also a higher occurrence in recorded peak periods over 11 seconds during winter than compared to summer. This suggests the occurrence of more developed swell events occurring during the winter months.

The wave climate during the reporting period was similar to the wave climate of the whole record, as evident in the percentage time exceedance figure (Figure 8.2) and histograms of the occurrence of Hsig and Tp (Figure 8.3 and Figure 8.4). The monthly average Hsig generally fell within one standard deviation (sd) of the long-term mean with the exception of three months: January, February and July. During these months the mean was +1 sd higher than the historical monthly average. During January, the passage of Ex-TC Oswald likely contributed to the recorded above average wave height. While during July and September the occurrence of a number of east coast lows would have likely contributed to the above average wave heights recorded for those months.

The plot of wave direction over the 2012–13 season (Figure 8.8) showed a dominant east south easterly direction with an occasional swing to the north, mostly during summer. This dominant east south easterly incident wave direction is reflected in the directional wave rose plot (Figure 8.9). Figure 8.9 also highlights the similarities in the wave direction recorded during this reporting period when compared to all directional data recorded since 2005.

The temperature (sea surface temperature, SST) measured in the buoy hull showed the recorded values ranging from 19 °C to 29 °C during the year. January was the only time the SST was warm enough for tropical cyclone development. The lowest SST occurred at the end of June when it fell to 19 ° celsius.

Mooloolaba

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 352.79
Gaps in data used in analysis (days)	= 12.19
Number of records used in analysis	= 16934

All data since-2000

Maximum possible analysis years (last record - first record)	= 13.53
Total number of years used in analysis	= 12.78
Gaps in data used in analysis (years)	= 0.75
Number of records used in analysis	= 218283

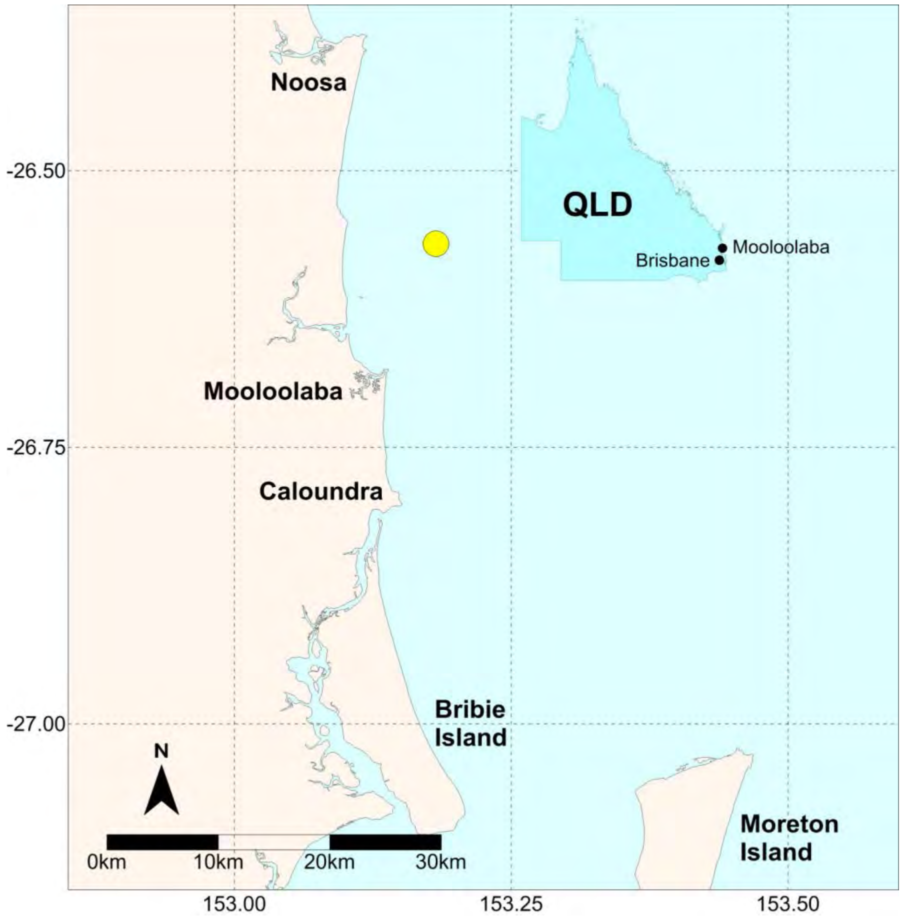


Figure 8.1: Mooloolaba - Locality plan

Table 8.1: Mooloolaba - Buoy deployments for 2012–13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
26°33.816'S	153°10.962'E	32	13/02/2012	16/12/2012
26°33.960'S	153°10.920'E	32	16/12/2012	current

Table 8.2: Mooloolaba - Highest waves

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	5/03/2004 16:00	5.9	5/03/2004 15:30	12.1
2	28/01/2013 05:30	5.6	28/01/2013 05:00	10.5
3	3/03/2006 06:30	5.3	1/05/2000 18:30	10.0
4	1/05/2000 19:30	5.1	3/03/2006 06:30	9.2
5	24/08/2007 01:00	5.1	31/12/2007 08:00	8.9
6	30/05/2008 20:30	4.5	24/08/2007 01:30	8.5
7	30/12/2007 22:00	4.4	25/12/2011 07:30	8.4
8	25/12/2011 08:30	4.3	28/06/2012 04:30	7.9
9	28/06/2012 07:00	4.3	2/02/2001 06:00	7.6
10	24/03/2004 05:30	4.1	22/08/2011 13:00	7.6

Table 8.3: Mooloolaba - Significant meteorological events with threshold Hsig of 2.5 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
11/11/2012 9:30	3.1 (3.4)	4.9 (6.1)	9.3	Low [1014 hPa] located in the Coral Sea along with a trough extending along the Queensland Coast.
28/01/2013 5:30	5.3 (5.6)	8.9 (10.5)	11.2	Ex-TC Oswald passed from north to south as a low pressure system with a central pressure of 994 hPa at Mooloolaba.
19/02/2013 13:00	3.8 (4.0)	6.0 (7.4)	10.9	Low pressure system off the far Southern Capricornia Coast causing fresh to strong south easterly winds along the Southern Queensland Coast.
1/07/2013 22:30	2.9 (3.0)	4.5 (5.4)	11.5	Low [1006 hPA] positioned off the Southern Queensland Coast.

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

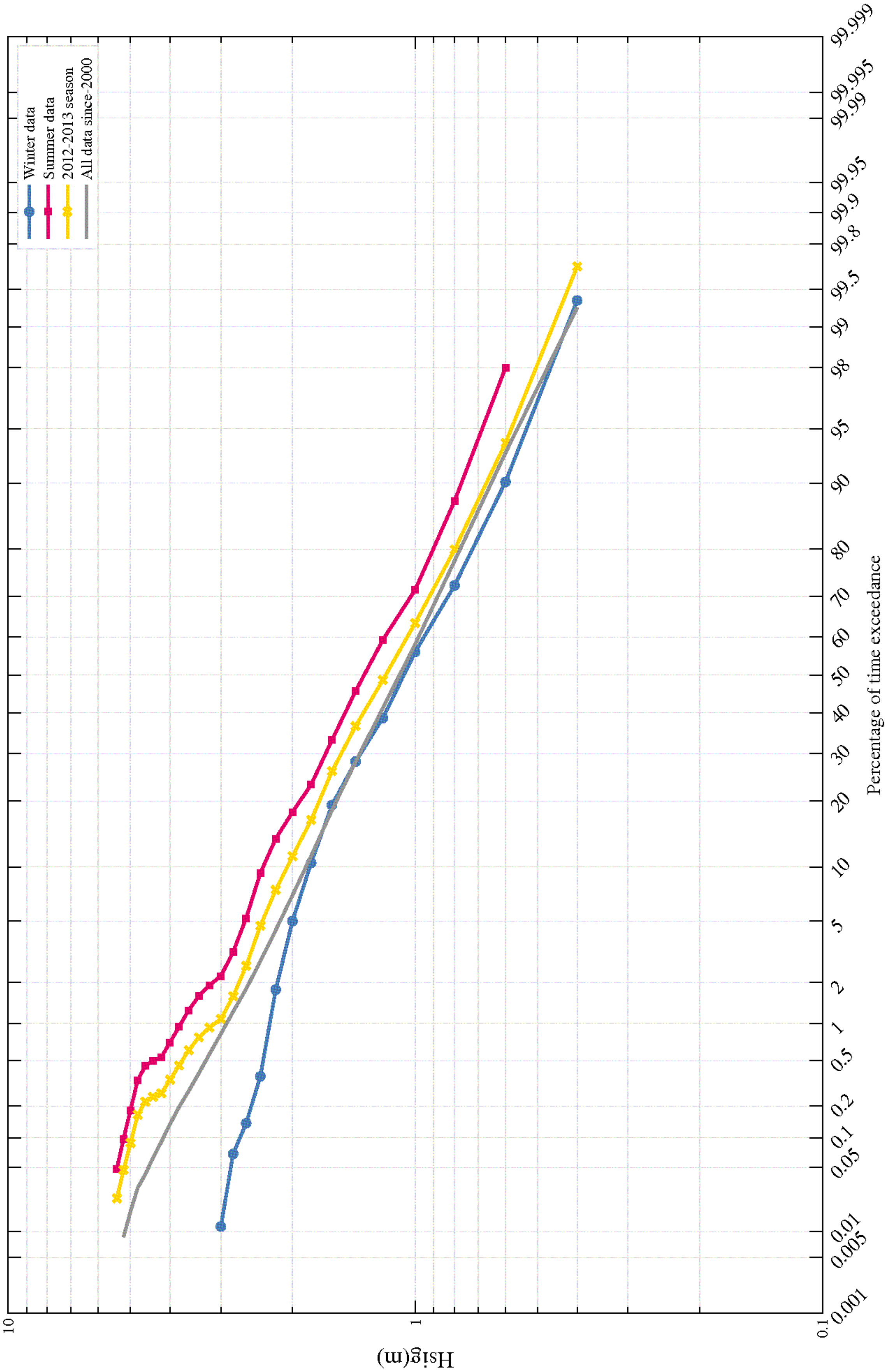


Figure 8.2: Mooloolaba - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

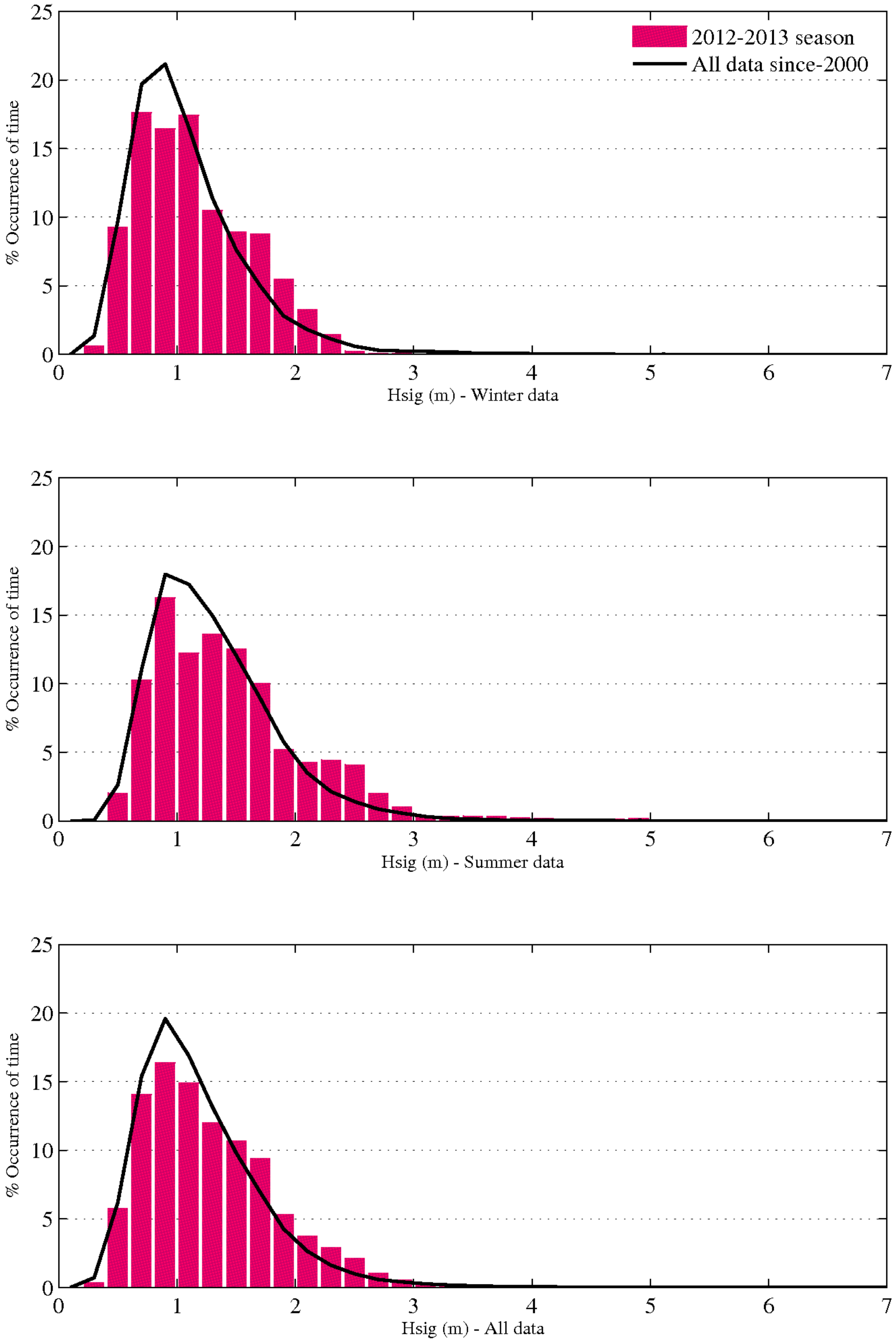


Figure 8.3: Mooloolaba - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

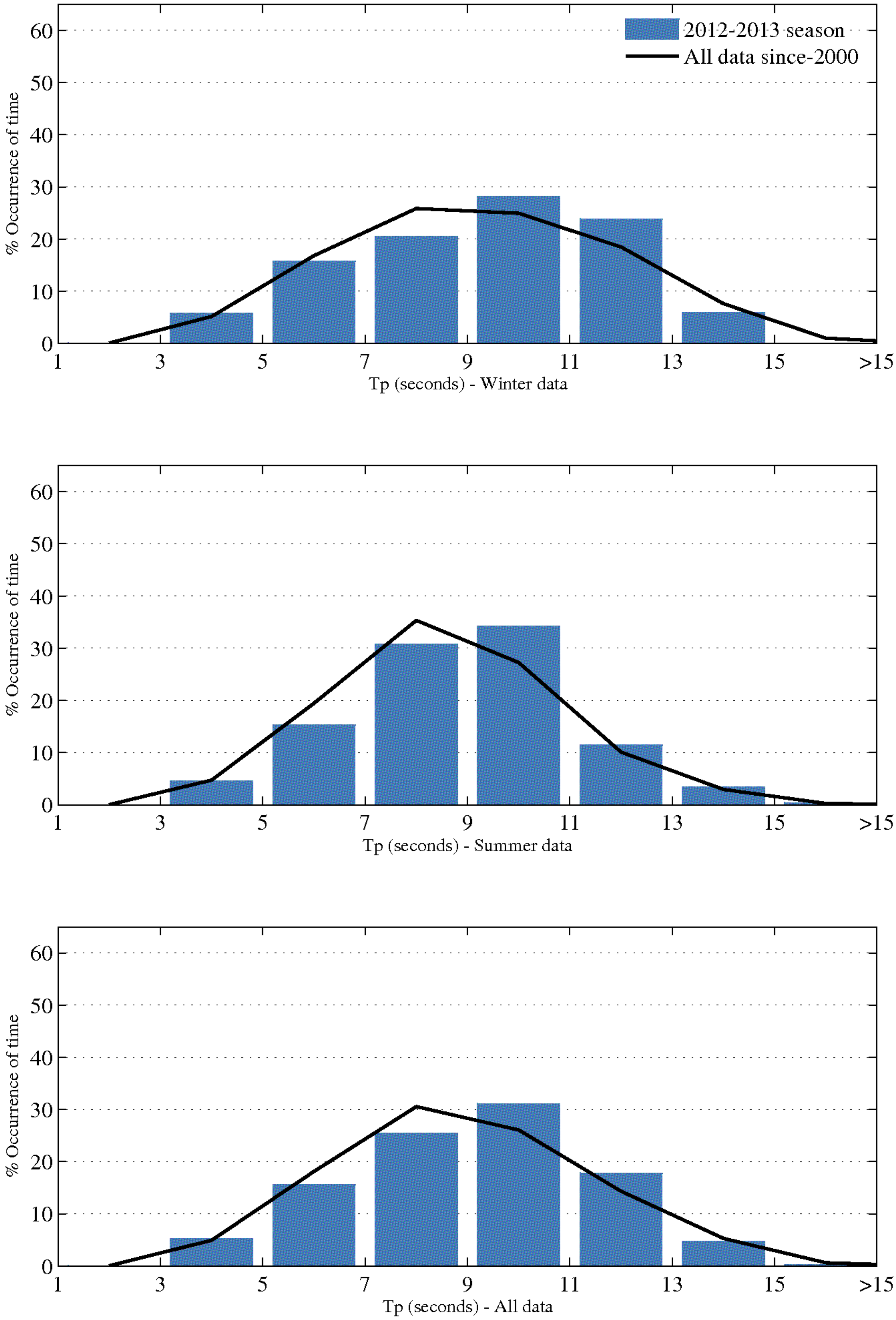


Figure 8.4: Mooloolaba - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

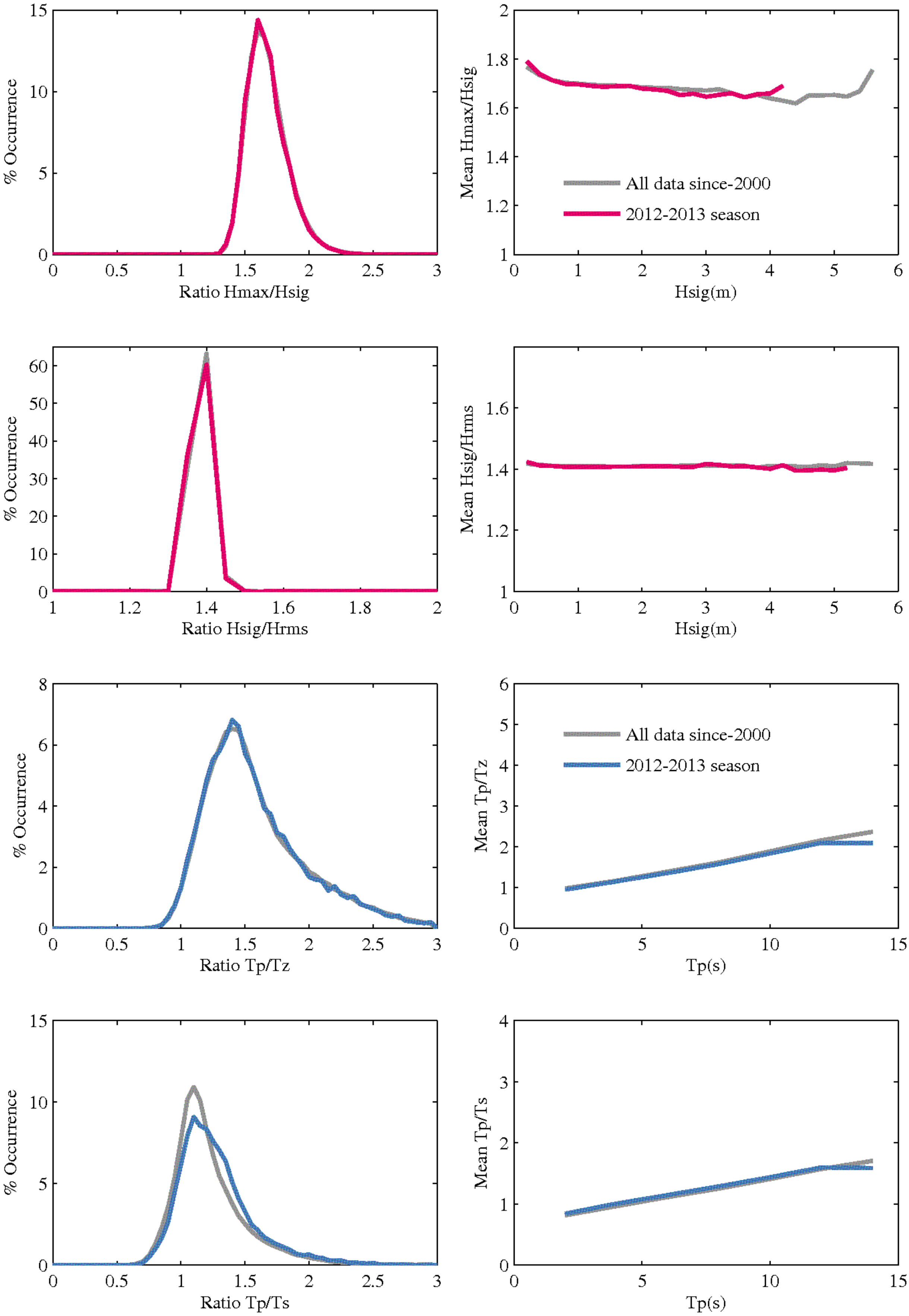


Figure 8.5: Mooloolaba - Wave parameter relationships

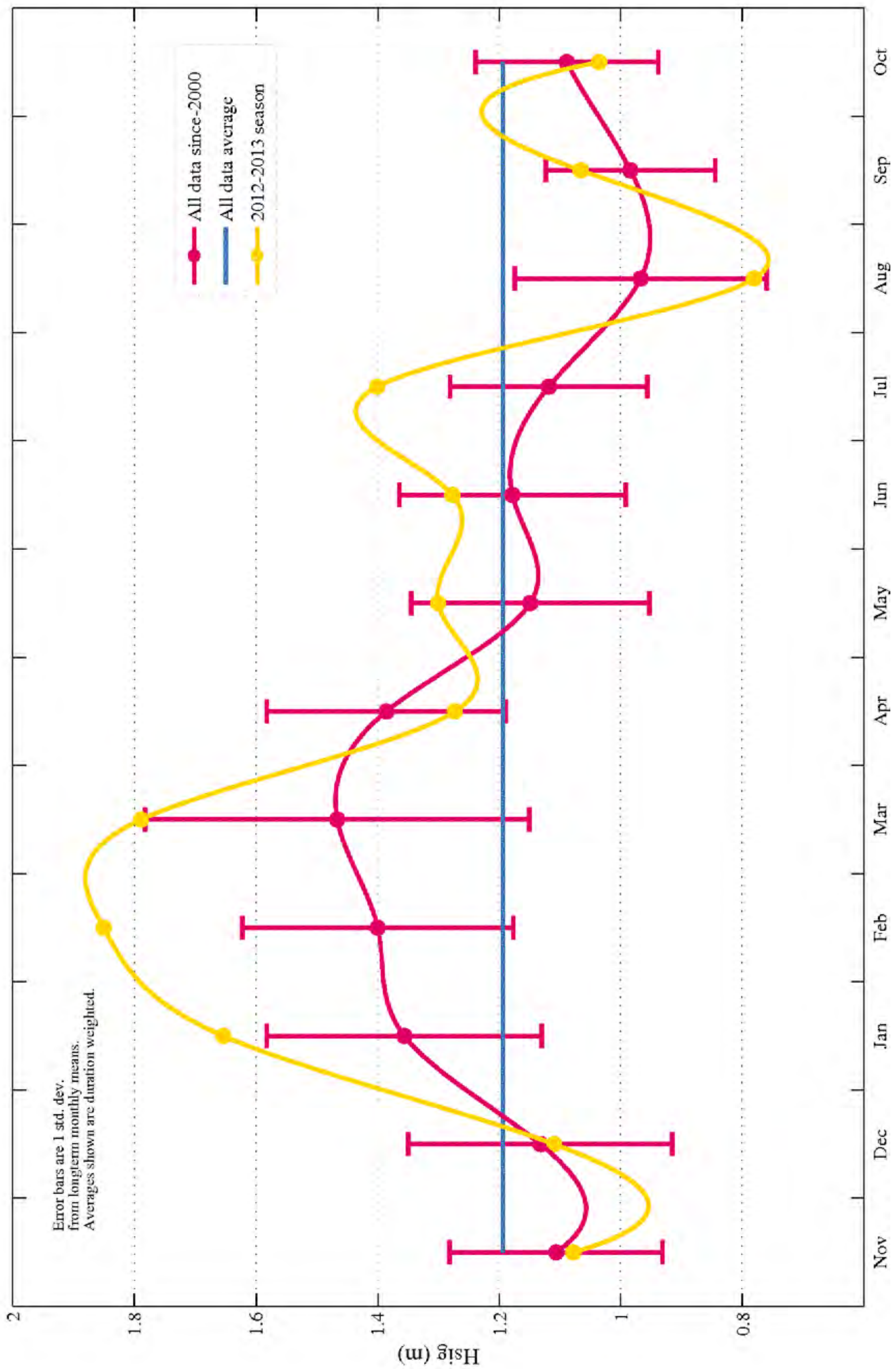


Figure 8.6: Mooloolaba Monthly average wave height (Hsig) for seasonal year and for all data

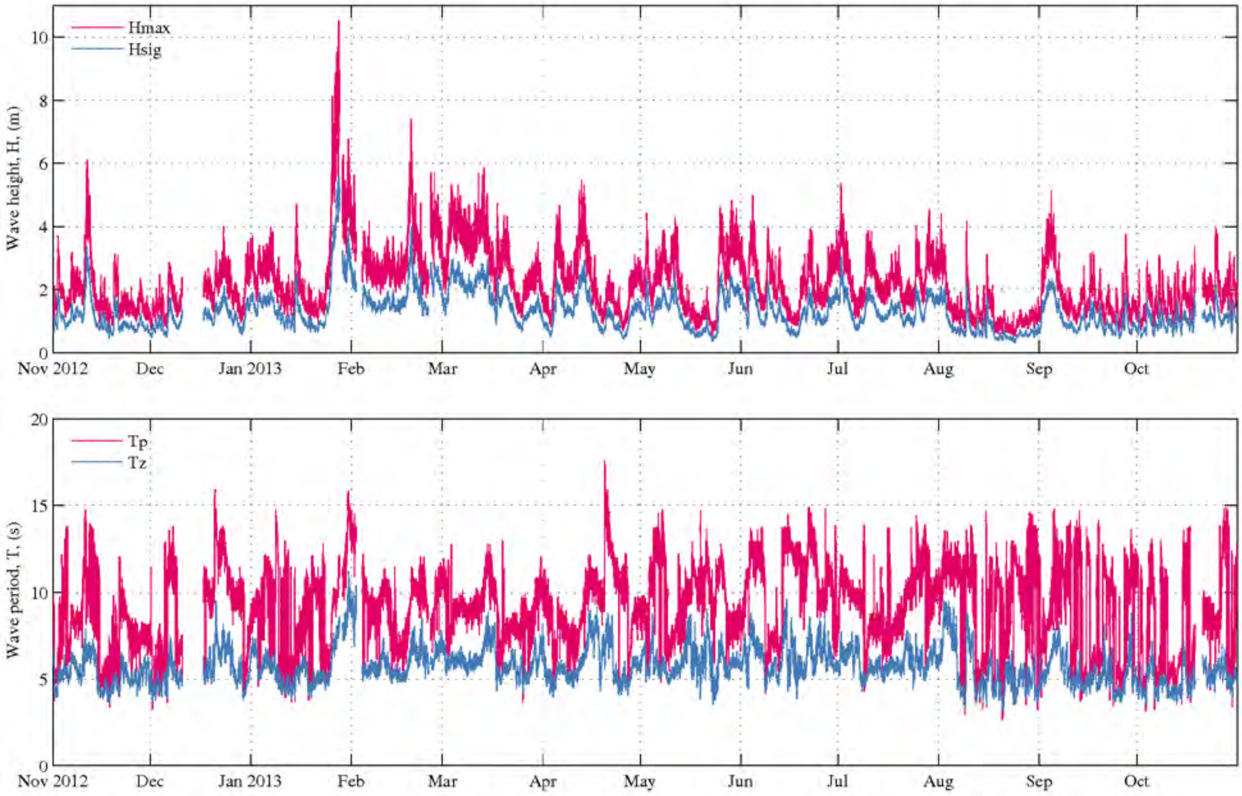


Figure 8.7: Mooloolaba - Daily wave recordings

Figure 8.8: Mooloolaba - Sea surface temperature and peak wave directions

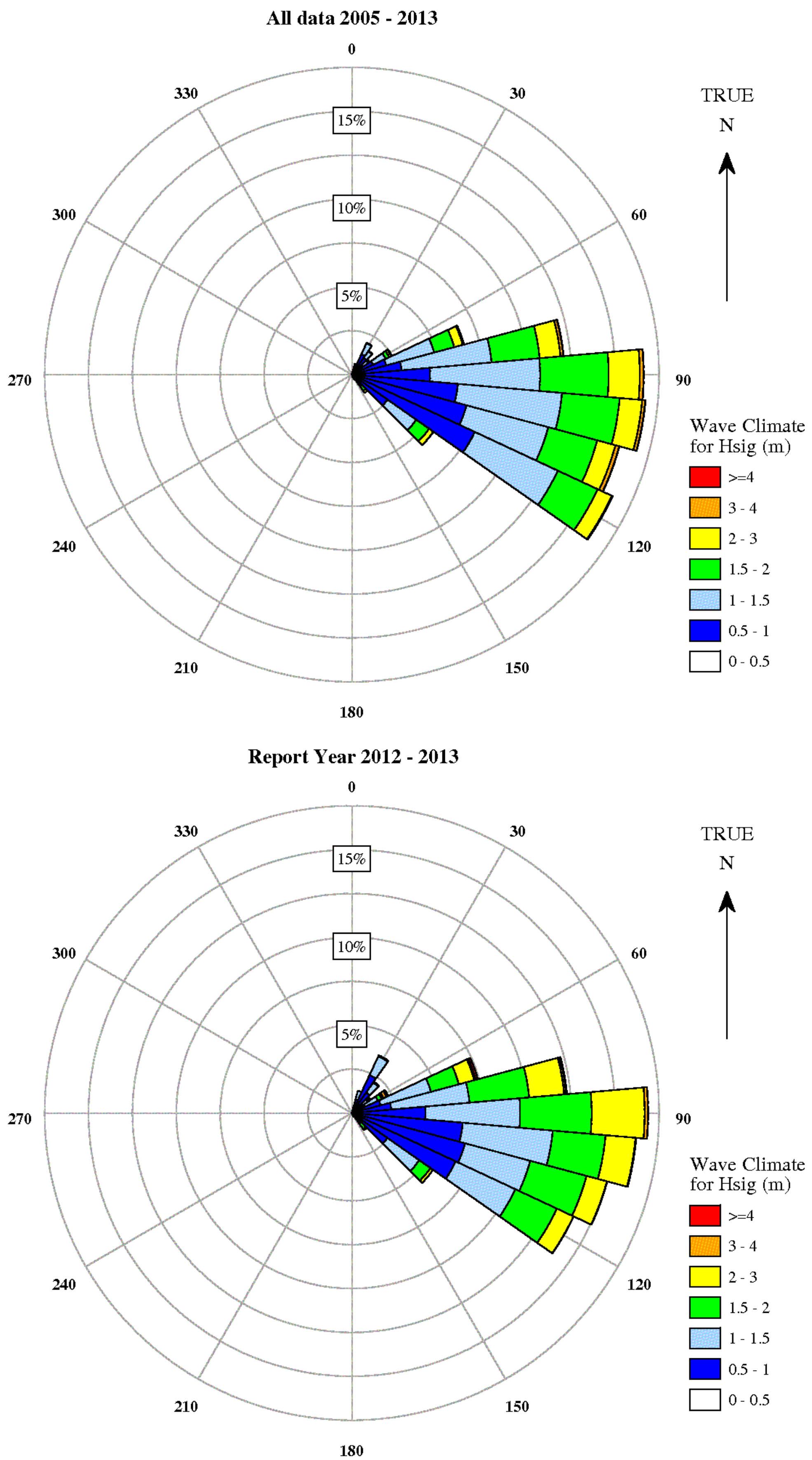


Figure 8.9: Mooloolaba - Directional wave rose

9. Gladstone

Data Overview

The Gladstone wave buoy has been operational for just over four years with an overall data return of 96.6%. The data record for the period November 2012 to October 2013 was exceptional, with total gaps of only 1.2 days, equivalent to 99.7% data return. The buoy was replaced just prior to this reporting period on 26 October 2012 and again on 2 October 2013 (Table 9.1).

There were three significant wave heights (Hsig) recorded during the reporting period that made it into the top ten ranks and three maximum wave heights (Hmax) that also made the top ten ranking (Table 9.2). Notably, a Hsig of 3.2 m was reported during the passage of Ex-TC Oswald and ranked second, while a Hmax of 5.8 m was also reported later on the same day and also ranked second. The relatively short record means that there is a high probability that the highest top ten ranked waves can be exceeded.

Ex-TC Oswald passed through the Gladstone region as a low pressure system travelling from north to south just to the West of the buoy (inland). The atmospheric pressure fell to 992.9 hPa at Southtrees Island, the nearest measurement point to the buoy (see the report on TC Oswald for more details, (DSITIA, 2013)). The wave climate during Ex-TC Oswald's passage rose to over 2.0 m Hsig for three consecutive days from 24 January to 27 January. The wave period also rose to around 7.5 seconds indicating the presence of swell incident on the coast. After the lowest central pressure of Ex-TC Oswald had passed, Hsig fell to below 1.0 m; however, the wave period of the highest energy waves continued to increase up to around 15 seconds as the swell developed in the wake of Ex-TC Oswald.

There are differences in the wave climate off Gladstone between summer and winter seasons. Over 30% of the time Hsig exceeds 1.0 m during summer whereas during winter Hsig exceeds 1.0 m only 17% of the time (Figure 9.2). The most common Tp is six seconds both in summer and winter however there is a slight increase in Tp during winter in the 10 to 12 second range.

The wave climate during the reporting period was very similar to the wave climate of the whole record, evidenced in the percentage time exceedance (Figure 9.2) and histograms of the occurrence of Hsig and Tp (Figure 9.3 and Figure 9.4). It is also worth noting that the ratios between different wave parameters such as Hmax/Hsig were consistent between this reporting period and all of the historic data, these are plotted in Figure 9.5. The monthly average Hsig generally fell within one standard deviation (sd) of the long-term mean with the exception of three months: January, July and September. During these months the mean was higher than the mean +1 sd. The passage of Ex-TC Oswald increased mean Hsig in January, see Figure 9.6.

The plot of wave direction over the 2012–13 season (Figure 9.8) showed a dominant easterly (slightly north of east) direction with an occasional swing to the north, mostly during winter. The dominance of incident wave direction is reflected in the directional wave rose plot (Figure 9.9) along with the most common wave height (Hsig) of 0.5 m to 1.0 metre.

The temperature (sea surface temperature, SST) measured in the buoy hull showed a seasonal high average around 27 °C with peaks of over 30 °C in summer. The SST from December to the beginning of March was warm enough for tropical cyclone development but fell below the 26 °C threshold temperature for the remaining nine months. The lowest SST occurred at the end of June where it fell to 19 °C.

Gladstone

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 363.79
Gaps in data used in analysis (days)	= 1.19
Number of records used in analysis	= 17462

All data since-2009

Maximum possible analysis years (last record - first record)	= 4.11
Total number of years used in analysis	= 3.97
Gaps in data used in analysis (years)	= 0.14
Number of records used in analysis	= 69338

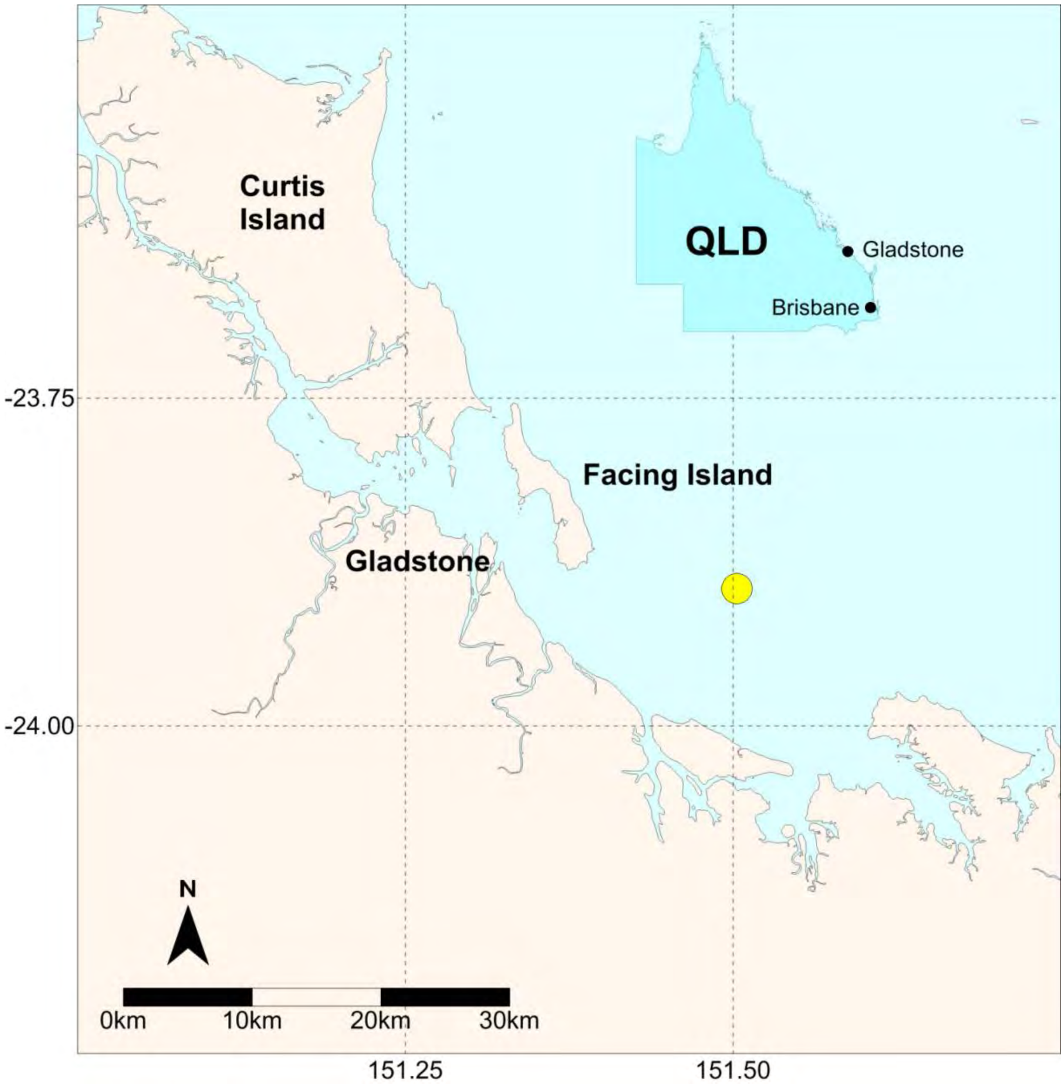


Figure 9.1: Gladstone - Locality plan

Table 9.1: Gladstone - Buoy deployments during the 2012–13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
23°53.640'S	151°30.243'E	16	26/10/2012	2/10/2013
23°53.750'S	151°30.122'E	13	2/10/2013	current

Table 9.2: Gladstone - Highest waves

Rank	Date	Hs (m)	Date	Hmax (m)
1	1/02/2010 20:00	3.2	1/02/2010 20:00	6.1
2	25/01/2013 02:00	3.2	25/01/2013 14:00	5.8
3	20/03/2010 10:30	2.3	20/03/2010 21:30	4.7
4	16/01/2012 22:00	2.3	12/04/2013 03:00	4.5
5	12/04/2013 04:00	2.3	16/01/2012 22:30	4.5
6	18/04/2011 14:30	2.2	4/12/2010 01:30	4.1
7	12/10/2010 12:00	2.2	20/03/2013 01:30	4.1
8	29/05/2013 08:30	2.1	12/10/2010 08:30	4.0
9	4/12/2010 01:30	2.1	30/01/2011 09:30	3.9
10	30/12/2012 18:00	2.0	28/10/2009 02:00	3.8

Table 9.3: Gladstone - Significant meteorological events with threshold Hsig of 2.0 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
25/01/2013 2:00	2.0 (3.2)	4.9 (5.8)	7.5	Ex-TC Oswald passed from north to south as a low pressure system with a central pressure of 992.9 hPa nearest to the wave buoy.
12/04/2013 4:00	2.1 (2.3)	3.5 (3.9)	7.6	Deepening surface trough over the Western Coral Sea [1004 hPa]

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

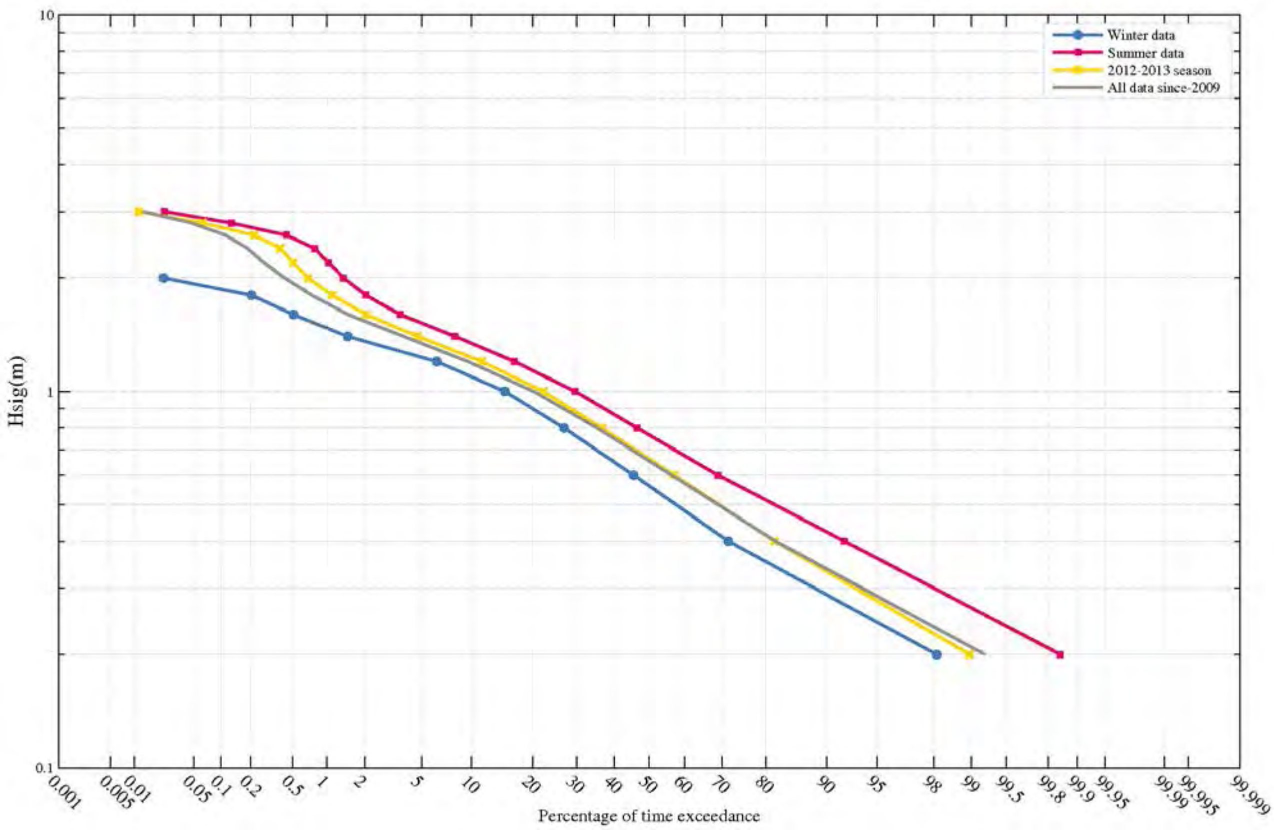


Figure 9.2: Gladstone - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

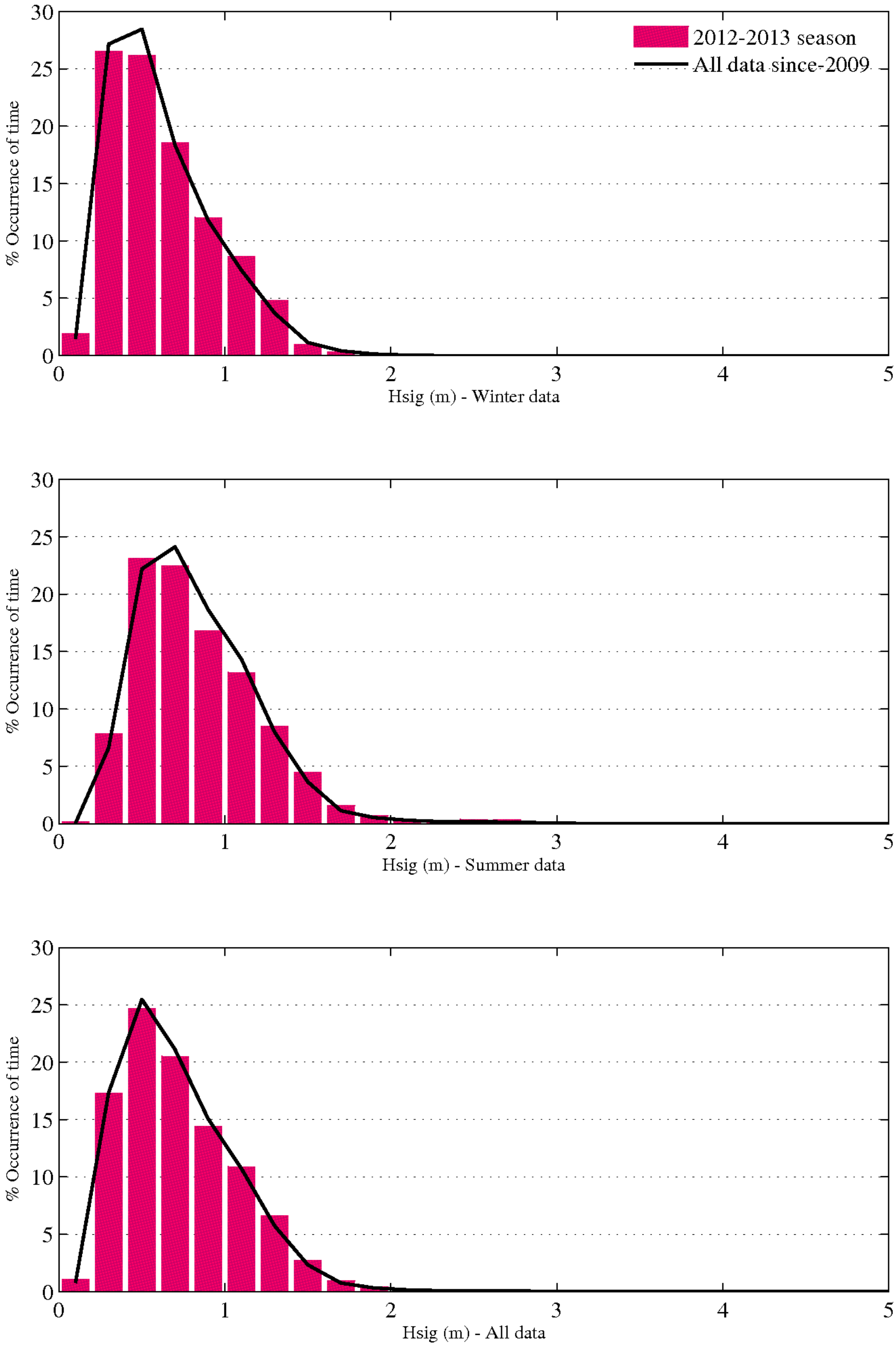


Figure 9.3: Gladstone - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

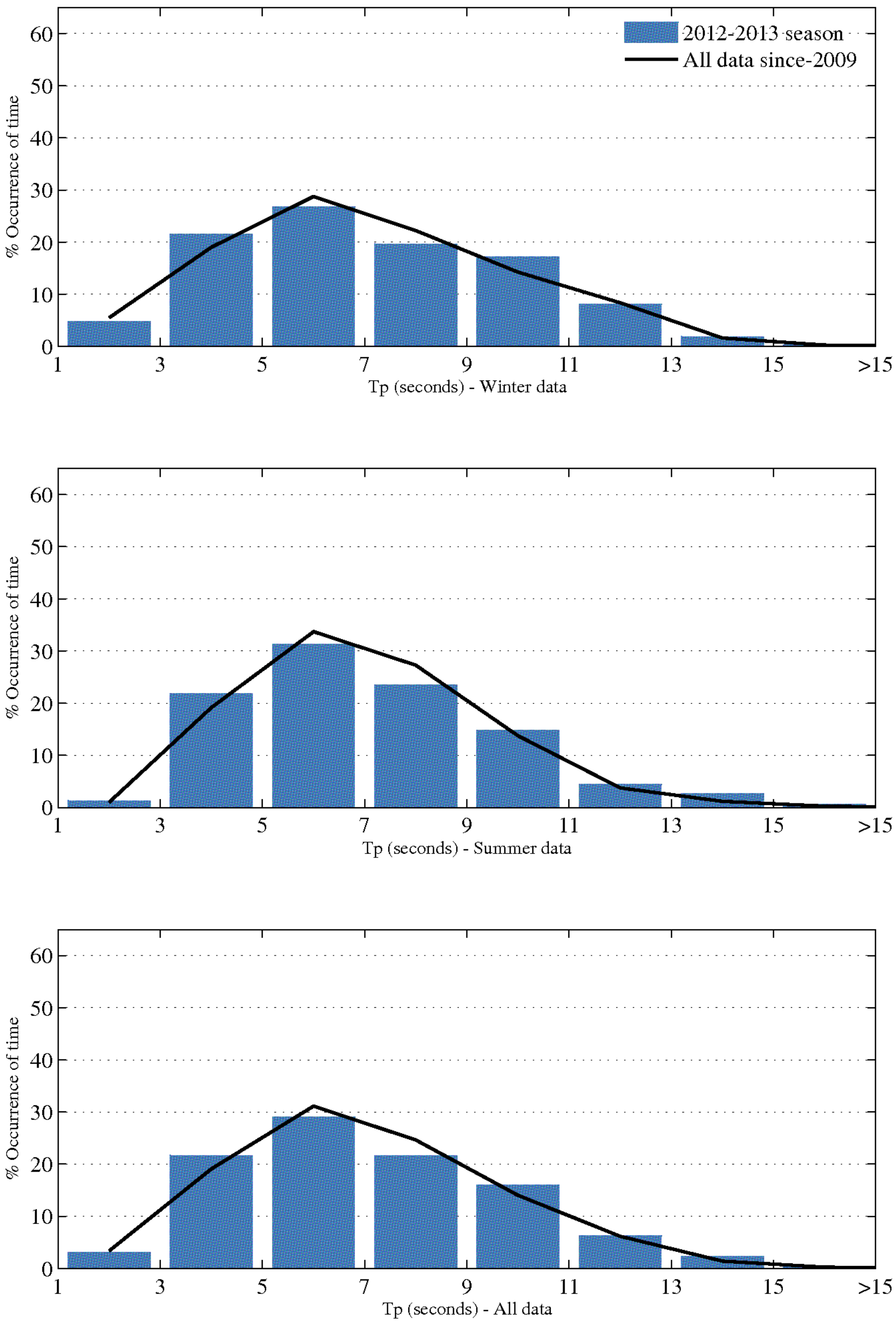


Figure 9.4: Gladstone - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

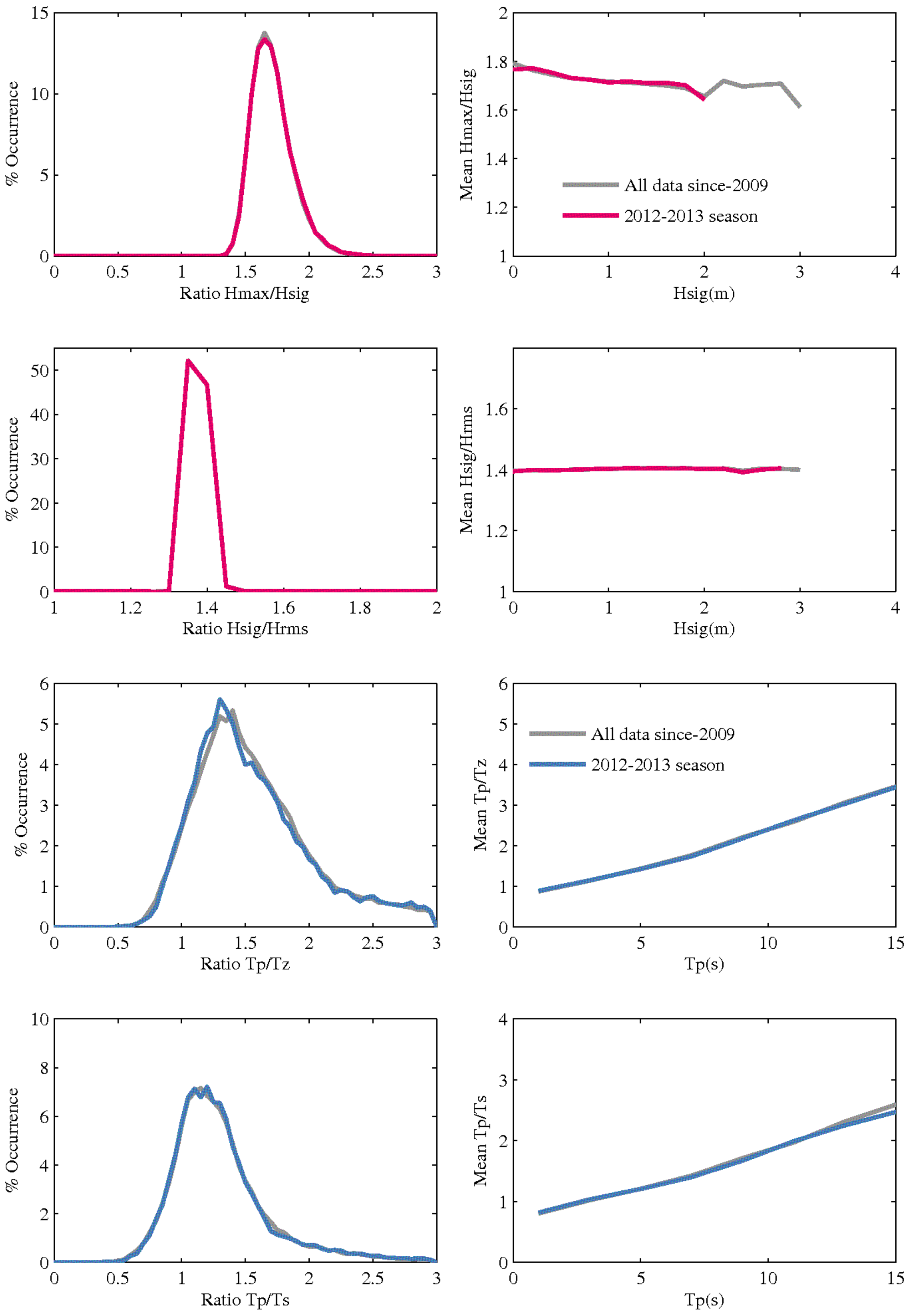


Figure 9.5: Gladstone - Wave parameter relationships

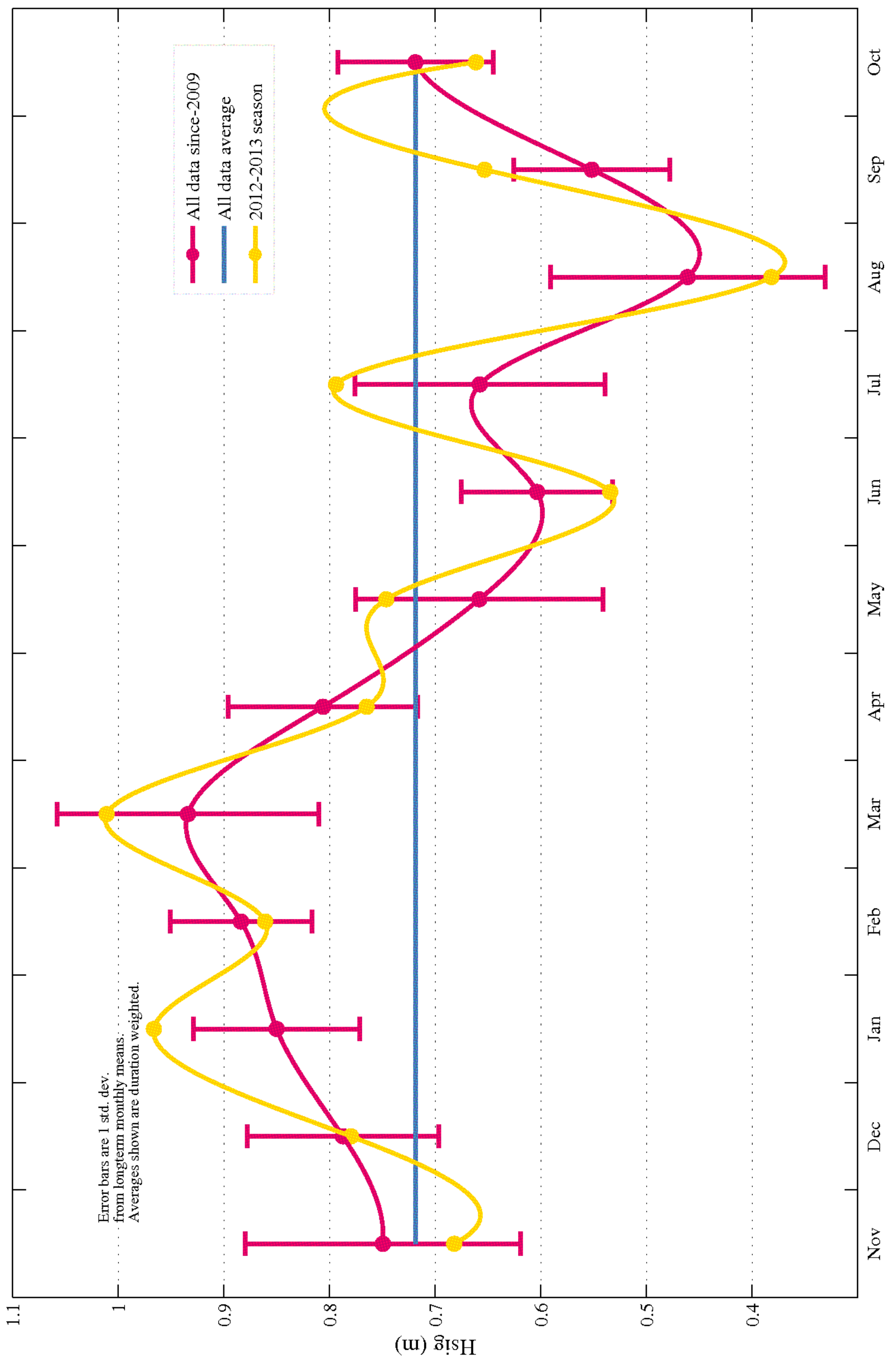


Figure 9.6: Gladstone - Monthly average wave height (Hsig) for seasonal year and for all data

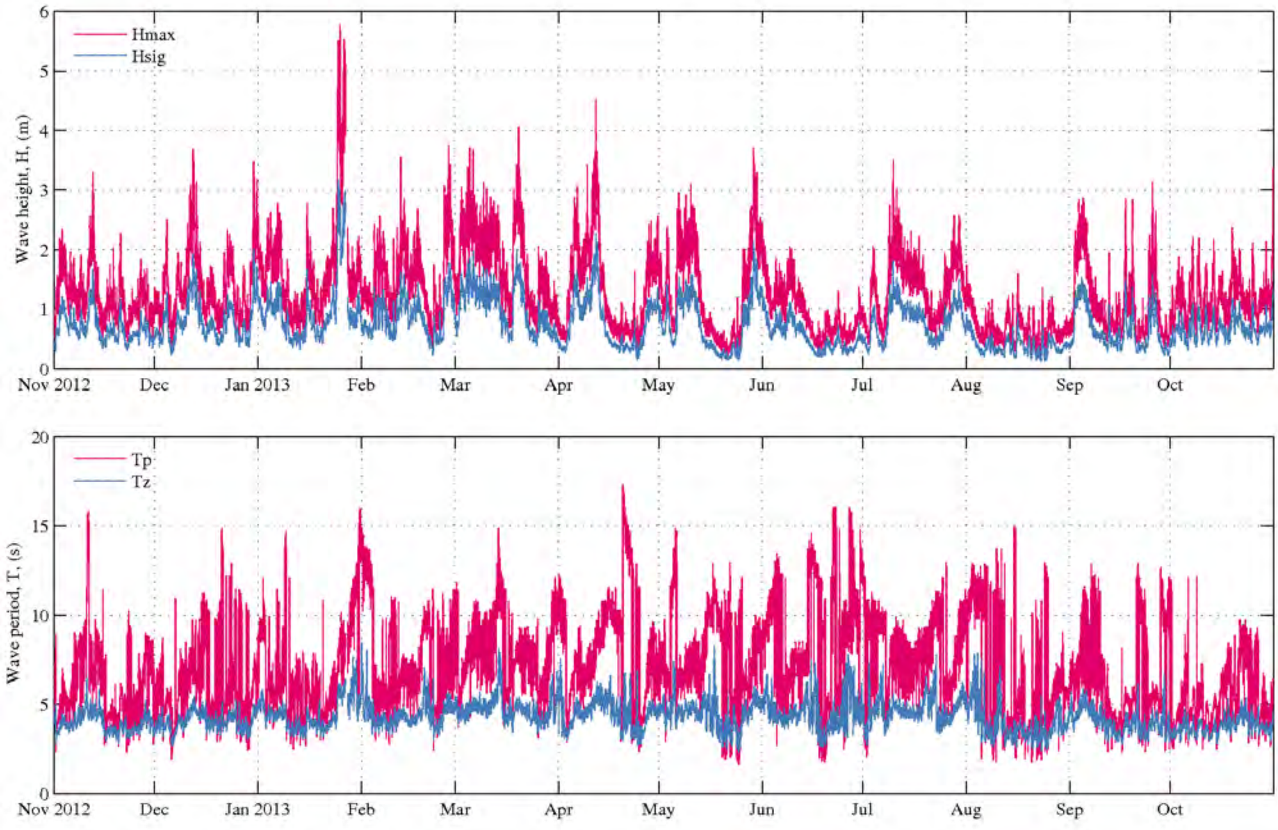


Figure 9.7: Gladstone - Daily wave recordings

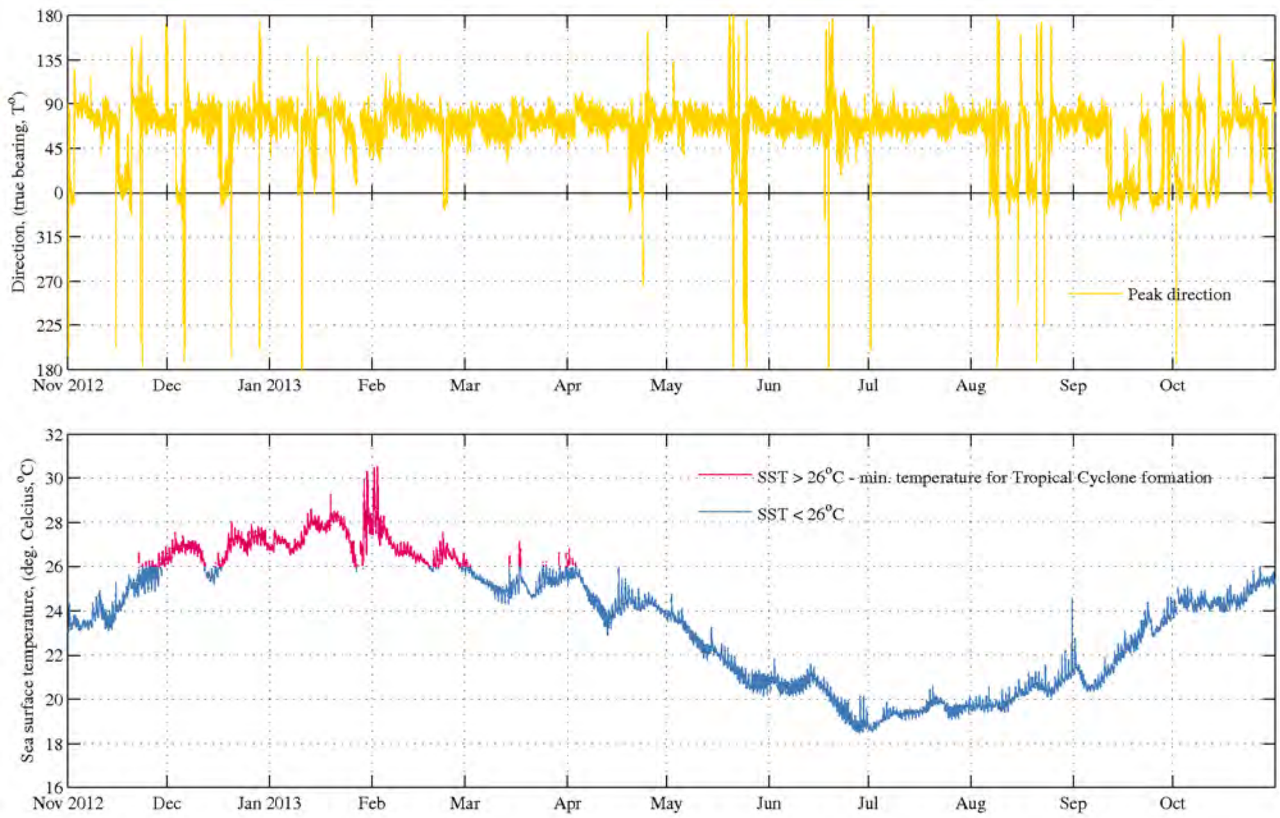
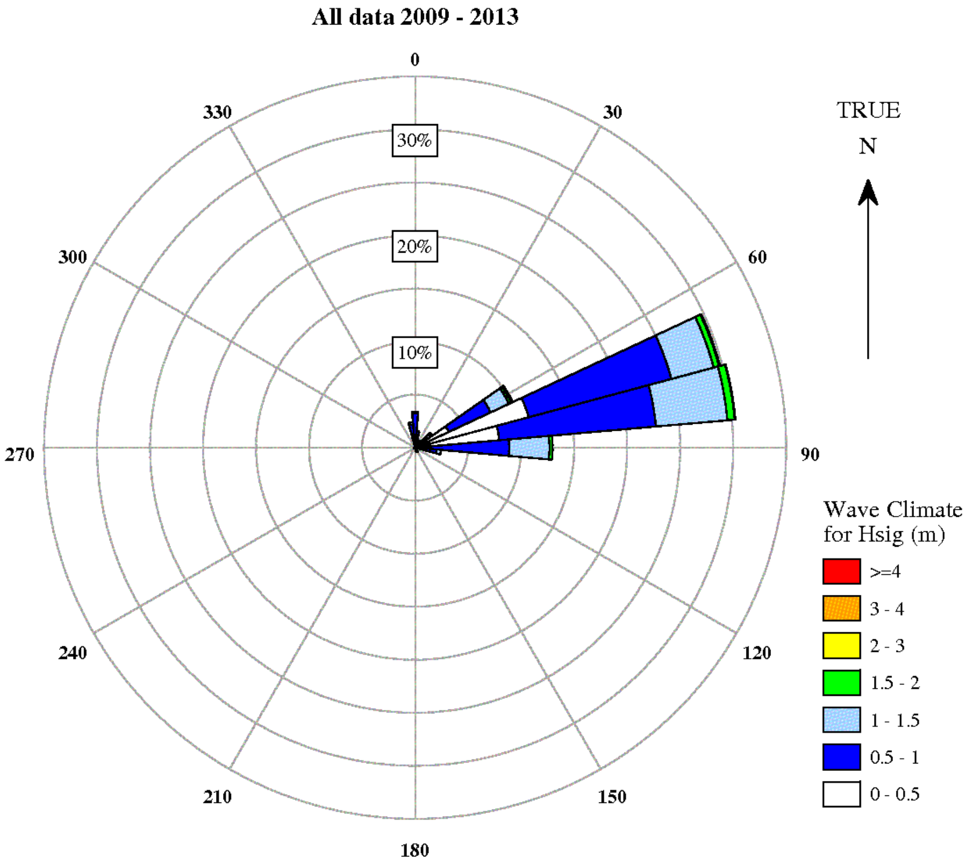


Figure 9.8: Gladstone - Sea surface temperature and peak wave directions



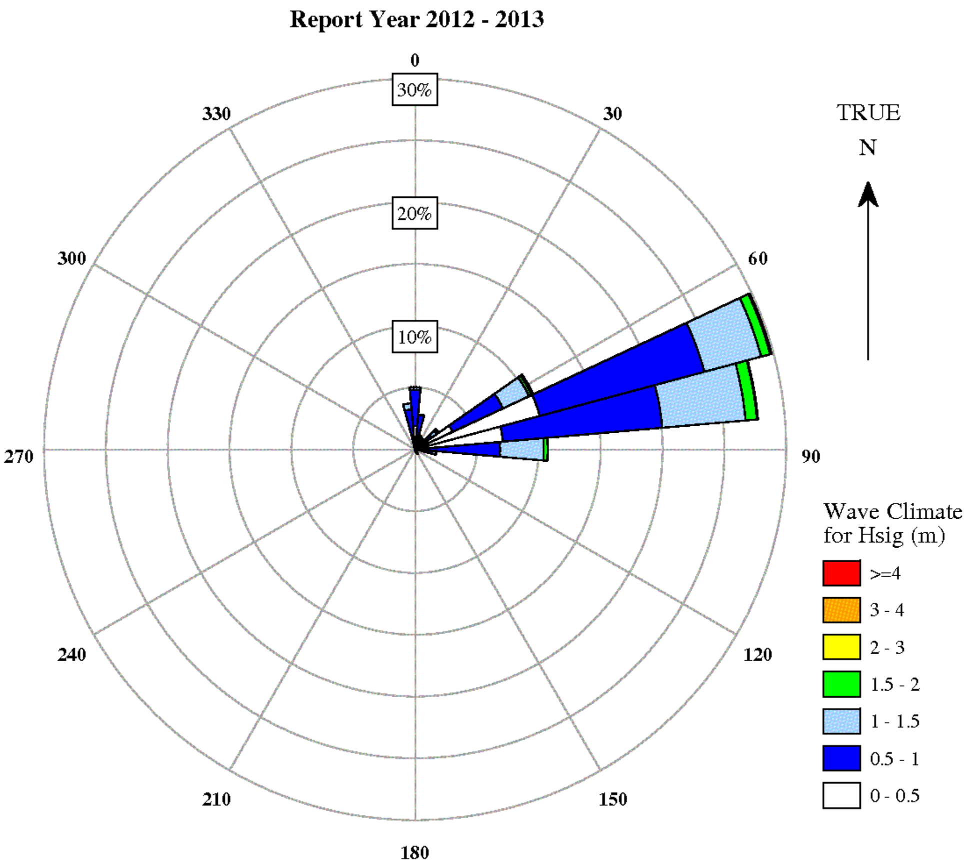


Figure 9.9: Gladstone - Directional wave rose

10. Emu Park

Data Overview

The Emu Park wave buoy has been operational for just over 17 years with an overall data return of 94.9%. The data record for the period November 2012 to October 2013 was exceptional, with total gaps of only 1.2 days, equivalent to 98.9% data return. The buoy was replaced just prior to this reporting period on the 26 October 2012 and was not replaced during the reporting period (Table 10.1).

There was one significant wave height (Hsig) recorded during the reporting period that made it into the top ten ranks and also one maximum wave height (Hmax) that made the top ten ranking (Table 10.2). Both of these recorded events occurred as a result of Ex-TC Oswald passing through the region as a low pressure system. As the system passed the atmospheric pressure fell to 992 hPa at Rosslyn Bay, the nearest DSITI measurement point to the buoy (see the report on TC Oswald for more details, (DSITIA, 2013)). As a result of the passing system a Hsig of 3.9 m was recorded and ranked first, while a Hmax of 7.4 m was also reported later on the same day and ranked second in relation to the largest wave events recorded at the monitoring location.

There is a notable difference in the height of waves recorded at Emu Park between the summer and winter seasons. Over 75% of the time Hsig exceeds 0.6 m during summer whereas during winter Hsig exceeds 0.6 m only 50% percent of the time (Figure 10.2). Figure 10.3 also highlights the higher occurrence of waves under 0.6 m Hsig during winter.

The wave climate during the reporting period was similar to the wave climate of the whole record, as evident in the percentage time exceedance figure (Figure 10.2) and histograms of the occurrence of Hsig and Tp (Figure 10.3 and Figure 10.4). The monthly average Hsig generally fell within one standard deviation (sd) of the long-term mean with the exception of July and August. A series of passing cold fronts affected the Queensland Coast during the month of July which likely contributed to the above average recorded wave heights for the month. August did not see a maximum wave height over 2 m recorded for the entire month, which resulted in the mean Hsig being more than −1 sd below the long term monthly average (Figure 10.6).

The plot of wave direction over the 2012–13 season (Figure 10.8) showed a dominant easterly (slightly north of east) direction with an occasional swing to the north, mostly during summer. Figure 10.9 shows that the majority waves recorded over 2 m Hsig come from an east south easterly direction.

The temperature (sea surface temperature, SST) measured in the buoy hull showed the recorded values ranging from 19 °C to 30 °C over the year. The SST from December to the beginning of March was warm enough for tropical cyclone development but fell below the 26 °C threshold for the remaining nine months. The sporadic temperatures recorded by the buoy towards the end of January maybe erroneous as the actual SST at the monitoring location unlikely fluctuated to that degree.

Emu Park

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 361.29
Gaps in data used in analysis (days)	= 3.69
Number of records used in analysis	= 17342

All data since-1996

Maximum possible analysis years (last record - first record)	= 17.27
Total number of years used in analysis	= 16.40
Gaps in data used in analysis (years)	= 0.87
Number of records used in analysis	= 236609

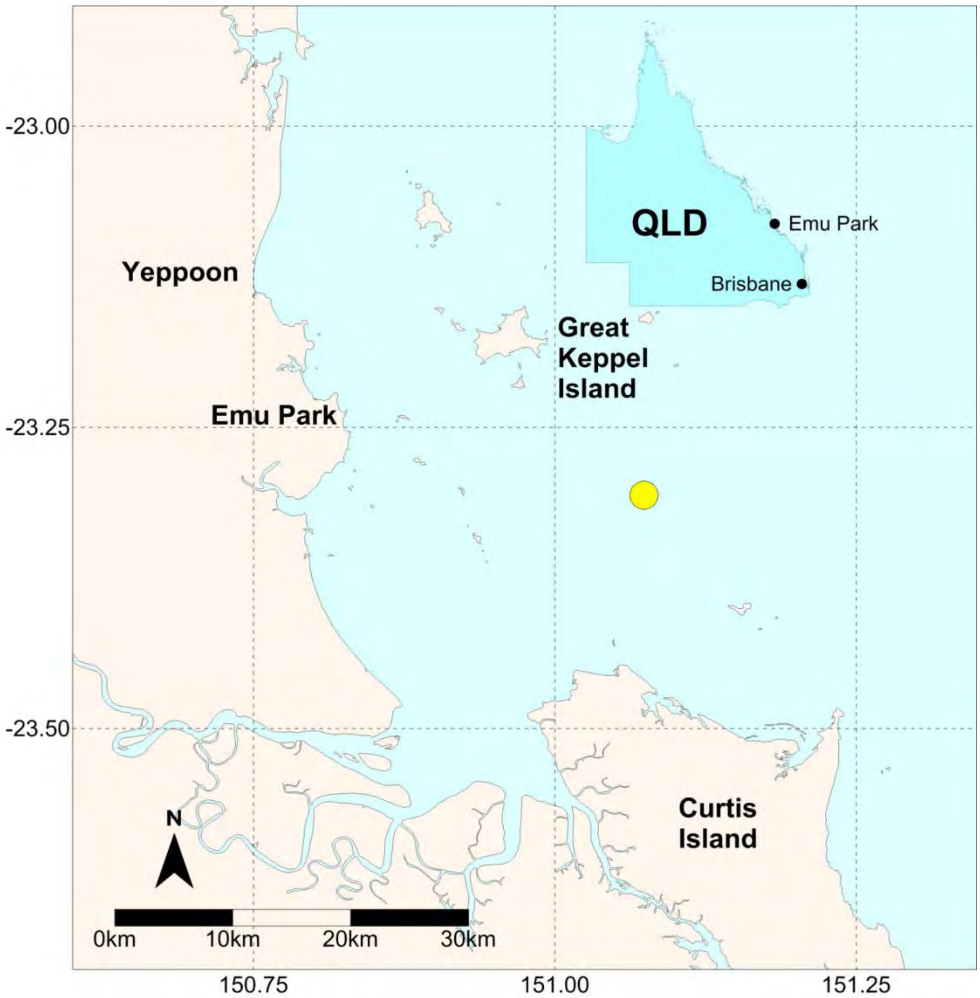


Figure 10.1: Emu Park - Locality plan

Table 10.1: Emu Park - Buoy deployments during the 2012–13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
21°18.385’S	151°04.388’E	10	26/10/2012	current

Table 10.2: Emu Park - Highest waves

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	25/01/2013 11:00	3.9	1/02/2010 03:30	8.2
2	1/02/2010 02:00	3.7	25/01/2013 11:30	7.4
3	28/08/1998 06:30	3.2	9/03/1997 11:30	6.9
4	4/06/2002 13:00	3.2	28/08/1998 08:00	6.4
5	9/03/1997 19:30	3.1	4/06/2002 17:30	6.4
6	20/03/2010 16:00	3.0	20/03/2010 12:30	5.9
7	9/03/2009 01:30	3.0	4/03/2003 11:30	5.9
8	23/04/2000 20:30	3.0	26/02/2010 01:00	5.9
9	31/05/2008 06:00	2.9	18/02/2008 14:30	5.8
10	2/03/2004 16:00	2.9	31/05/2008 06:00	5.5

Table 10.3: Emu Park - Significant meteorological events with threshold Hsig of 2.5 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
30/12/2012 22:00	2.5 (2.8)	4.5 (5.2)	7.2	High over the Great Australian Bight pushed a fresh southerly change up the Queensland Coast.
25/01/2013 11:00	3.7 (3.9)	6.0 (7.4)	8.6	Ex-TC Oswald passed from north to south as a low pressure system with a central pressure of 992 hPa at Rosslyn Bay.
19/03/2013 14:30	2.6 (2.7)	4.3 (5.3)	7.1	Ex- tropical cyclone Tim [1004 hPa] located approximately 210 km north of Mackay.
12/04/2013 08:00	2.5 (2.7)	4.5 (5.0)	7.5	Deepening surface trough in the Western Coral Sea [1004 hPa]

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

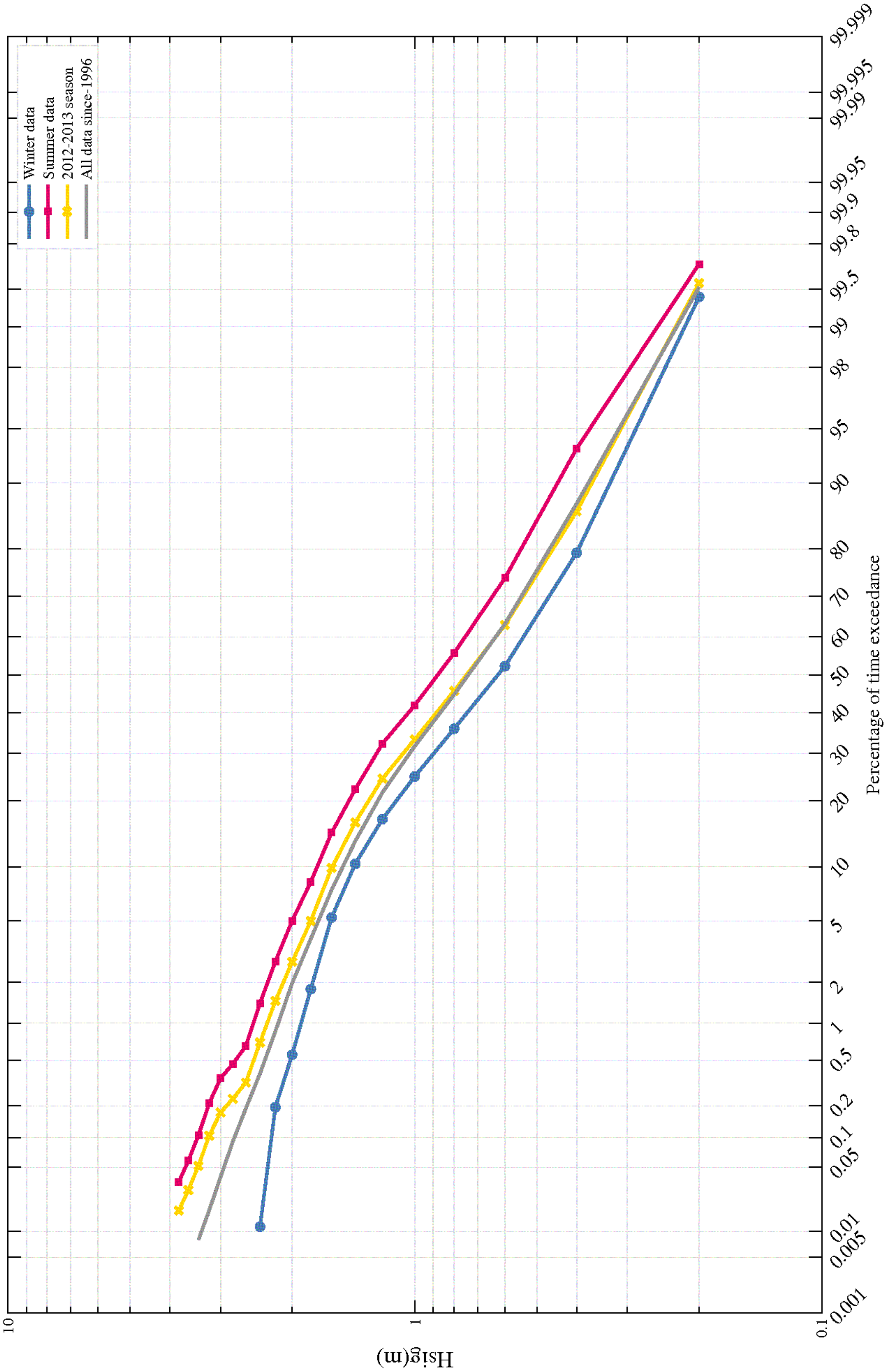


Figure 10.2: Emu Park - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

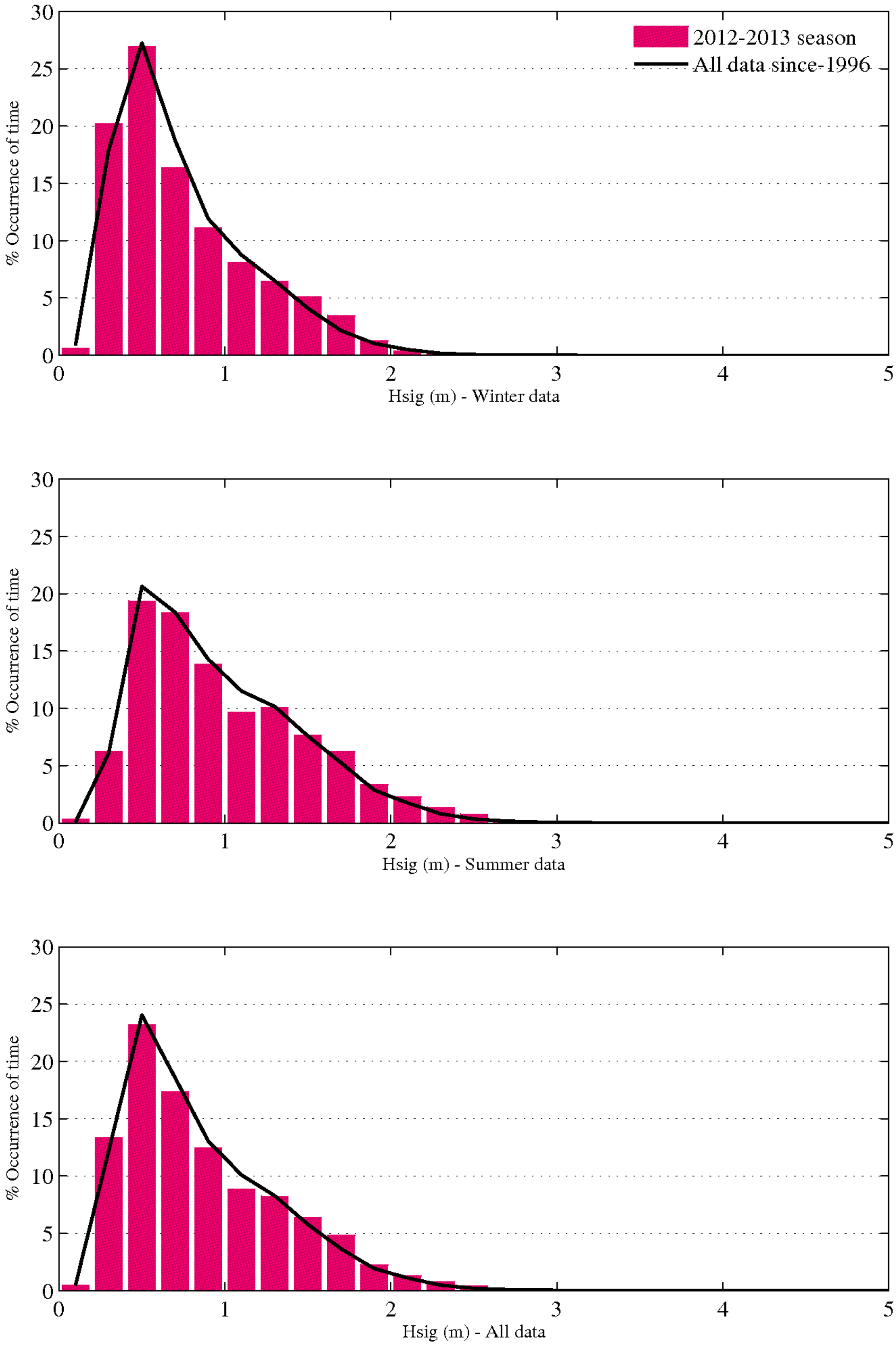


Figure 10.3: Emu Park - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

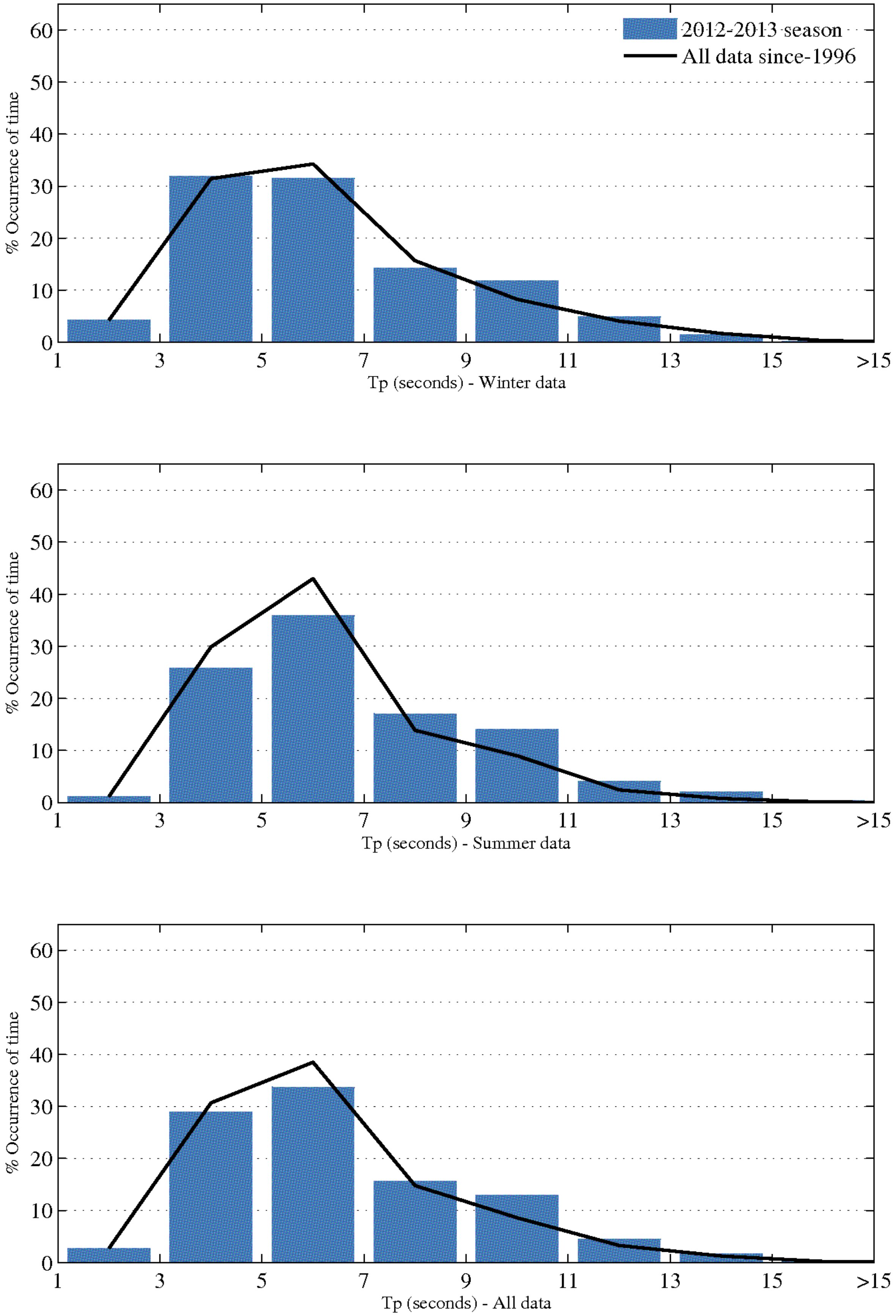


Figure 10.4: Emu Park - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

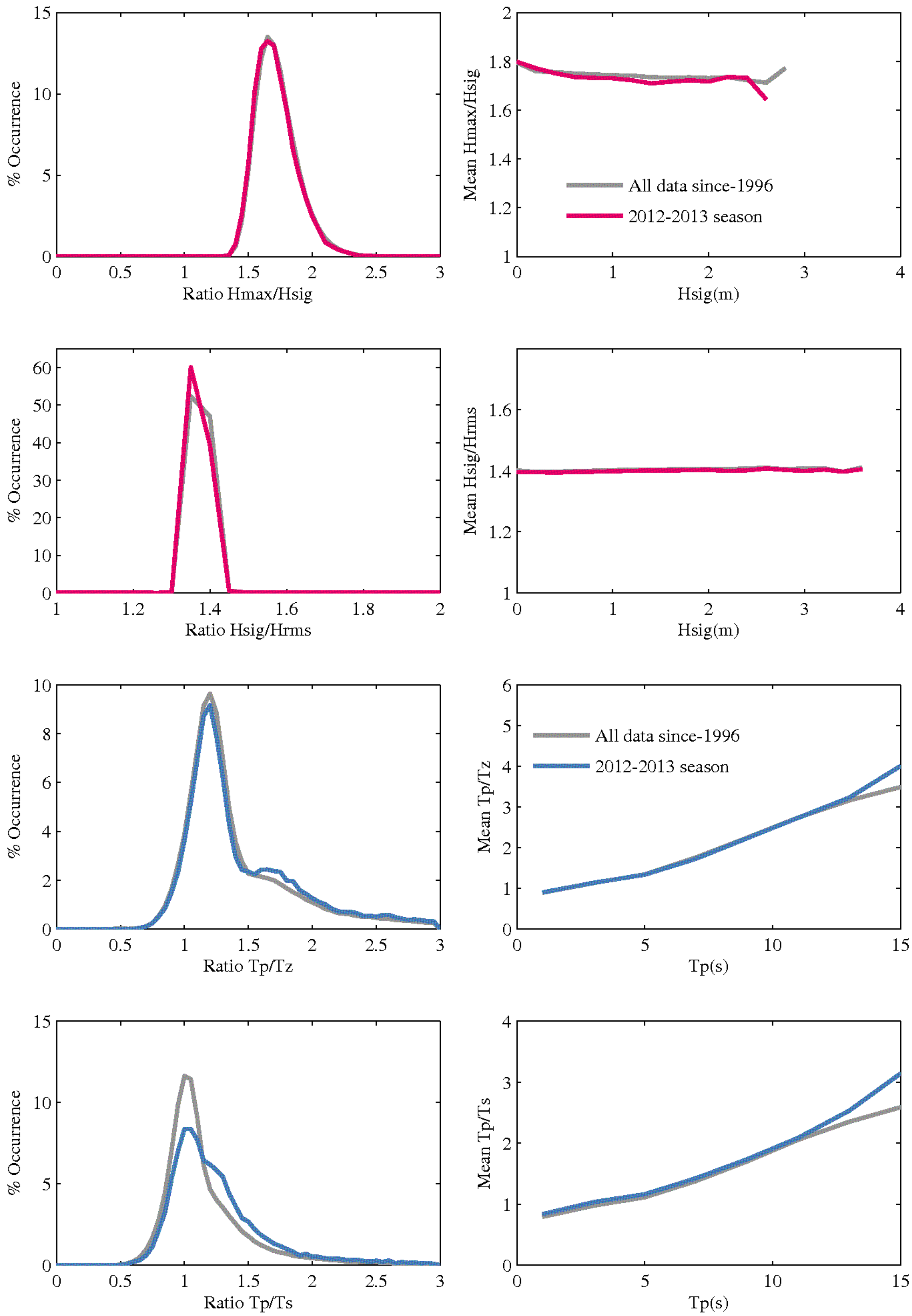


Figure 10.5: Emu Park - Wave parameter relationships

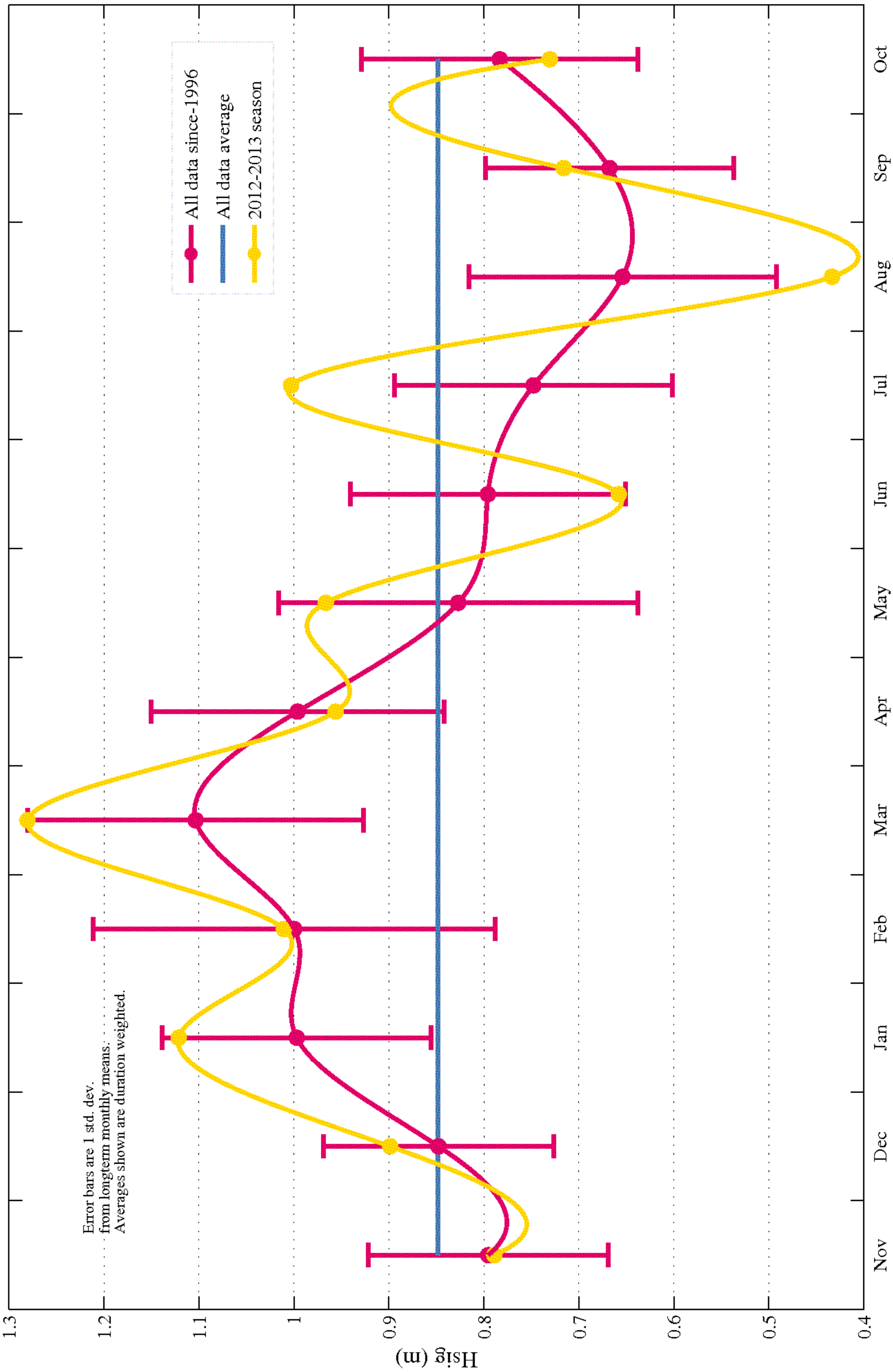


Figure 10.6: Emu Park - Monthly average wave height (Hsig) for seasonal year and for all data

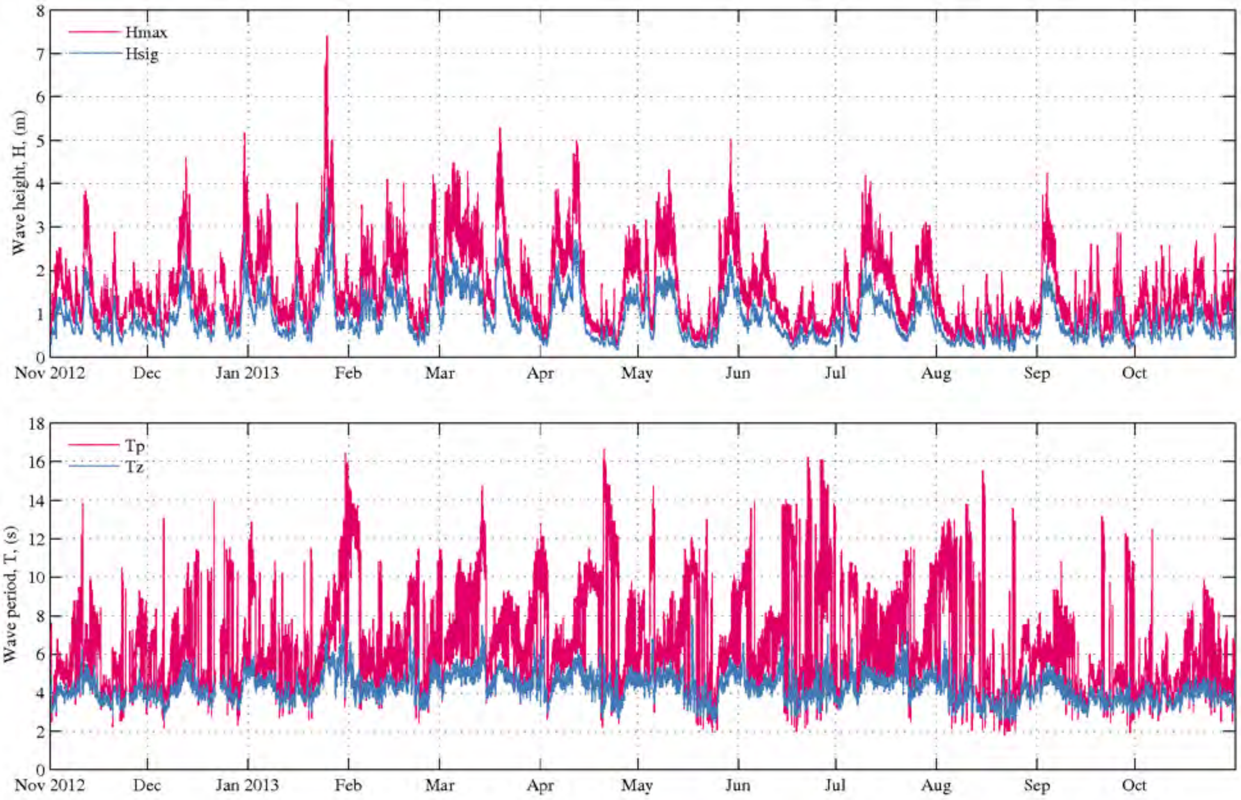


Figure 10.7: Emu Park - Daily wave recordings

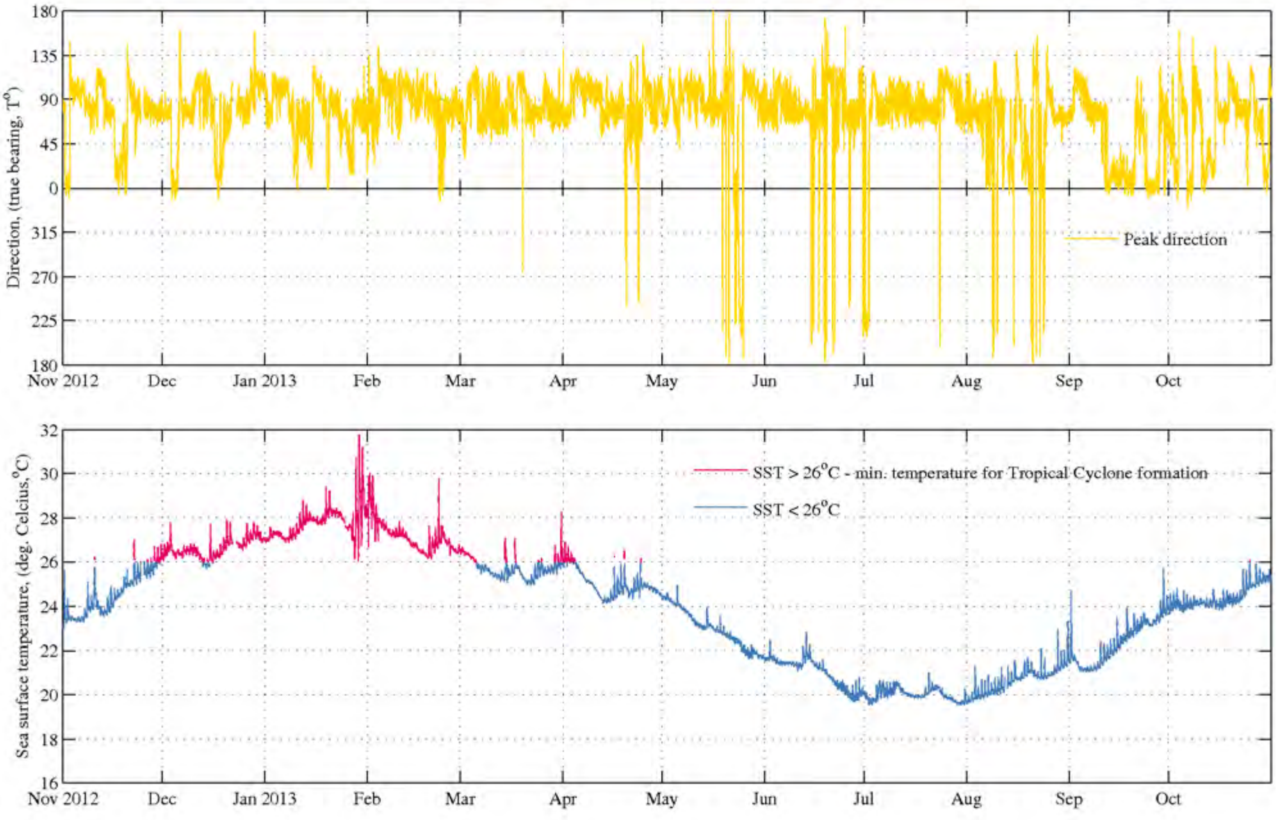
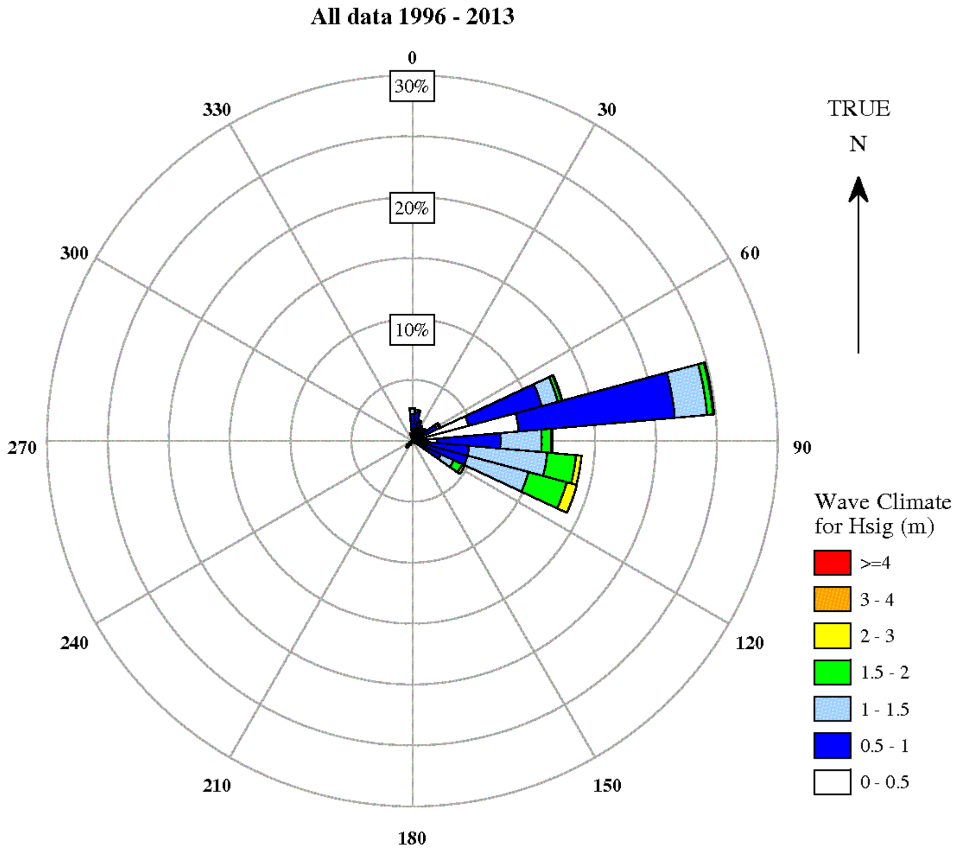


Figure 10.8: Emu Park - Sea surface temperature and peak wave directions



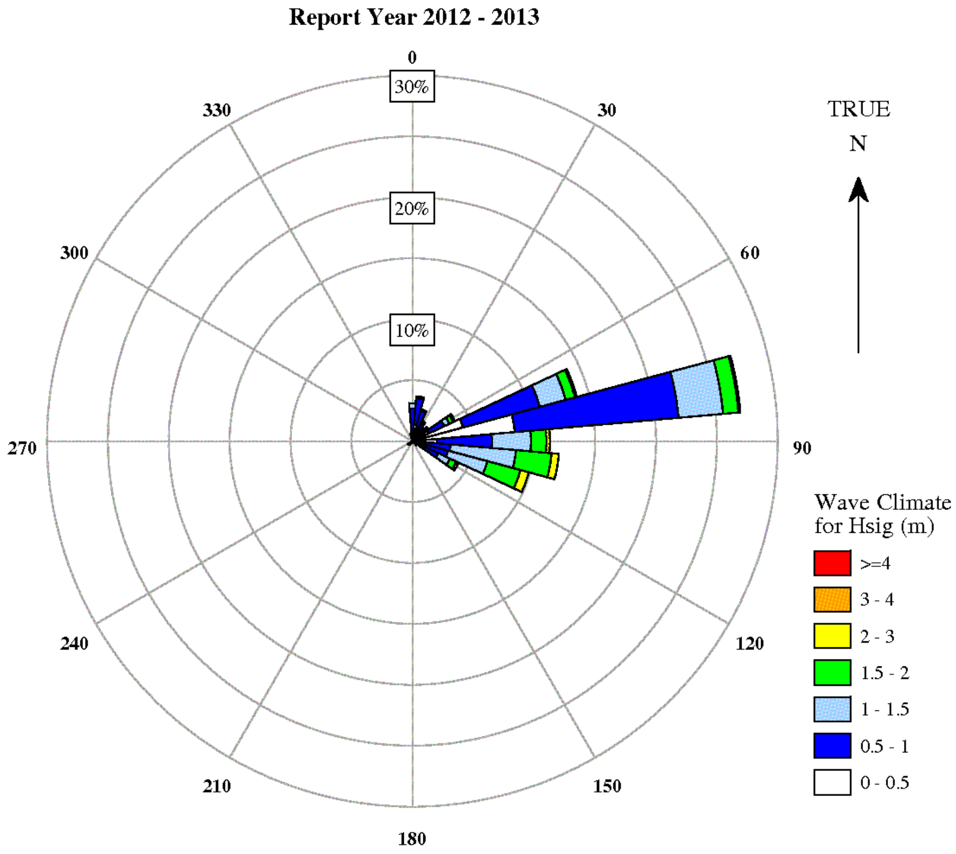


Figure 10.9: Emu Park - Directional wave rose

11. Hay Point

Data Overview

The Hay Point wave buoy has been operational for just over 36.5 years. The data record for the period November 2012 to October 2013 was exceptional, with total gaps of only 2.48 days, equivalent to 99.3% data return. The buoy was replaced once during this reporting period on 21 November 2012 (Table 11.1).

There were no significant (Hsig) or maximum (Hmax) wave heights recorded during the reporting period that made it into the top ten ranks (see Table 11.2). The largest wave event recorded during this reporting period occurred on 24 January 2014 and coincided with the passing of Ex-TC Oswald. Ex-TC Oswald passed through the Mackay region as a low pressure system travelling from north to south just to the west of the buoy (inland). As a result of the passing system a Hsig of 2.4 m along with a Hmax of 4.3 m was recorded by the buoy.

It is evident from Figure 11.2 and Figure 11.3 that the average wave height in summer was greater than that of winter. Figure 11.3 shows that there was a much higher occurrence of waves under 0.4 m during the winter months. The most common Tp is 3–5 seconds both in summer and winter however there was a slight increase in recorded Tp over nine seconds during winter.

The wave climate during the reporting period was very similar to the wave climate of the whole record, as evident in the percentage time exceedance figure (Figure 11.2) and histograms of the occurrence of Hsig and Tp (Figure 11.3 and Figure 11.4). The monthly average Hsig generally fell within one standard deviation (sd) of the long term mean with the exception of July and August. A series of passing cold fronts effected the Queensland coast during the month of July which likely contributed to the above average recorded wave height for the month. While August did not see a maximum wave height over 2 m recorded for the entire month, which resulted in the mean Hsig being more than −1 sd below the long term monthly average (Figure 11.6).

The plot of wave direction over the 2012–13 season (Figure 11.8) showed a dominant east south easterly direction. The dominance of the incident wave direction is reflected in the directional wave rose plot (Figure 11.9). Figure 11.9 also shows that waves less than 0.5 m are more likely to come from an east north easterly direction while waves greater than 0.5 m are more likely to come from an east south easterly direction.

The temperature (sea surface temperature, SST) measured in the buoy hull showed the recorded values ranging from 19 °C to 31 °C during the reporting year. It is evident from Figure 11.8 that there is an obvious jump in the recorded temperature on 21 November 2012 when the buoy was replaced. This suggests that there was a possible issue with either the initial or replacements buoys temperature sensor and therefore care must be taken when interpreting the recorded temperature data.

Hay Point

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 362.50
Gaps in data used in analysis (days)	= 2.48
Number of records used in analysis	= 17400

All data since-1977

Maximum possible analysis years (last record - first record)	= 36.61
Total number of years used in analysis	= 24.96
Gaps in data used in analysis (years)	= 11.65
Number of records used in analysis	= 307010

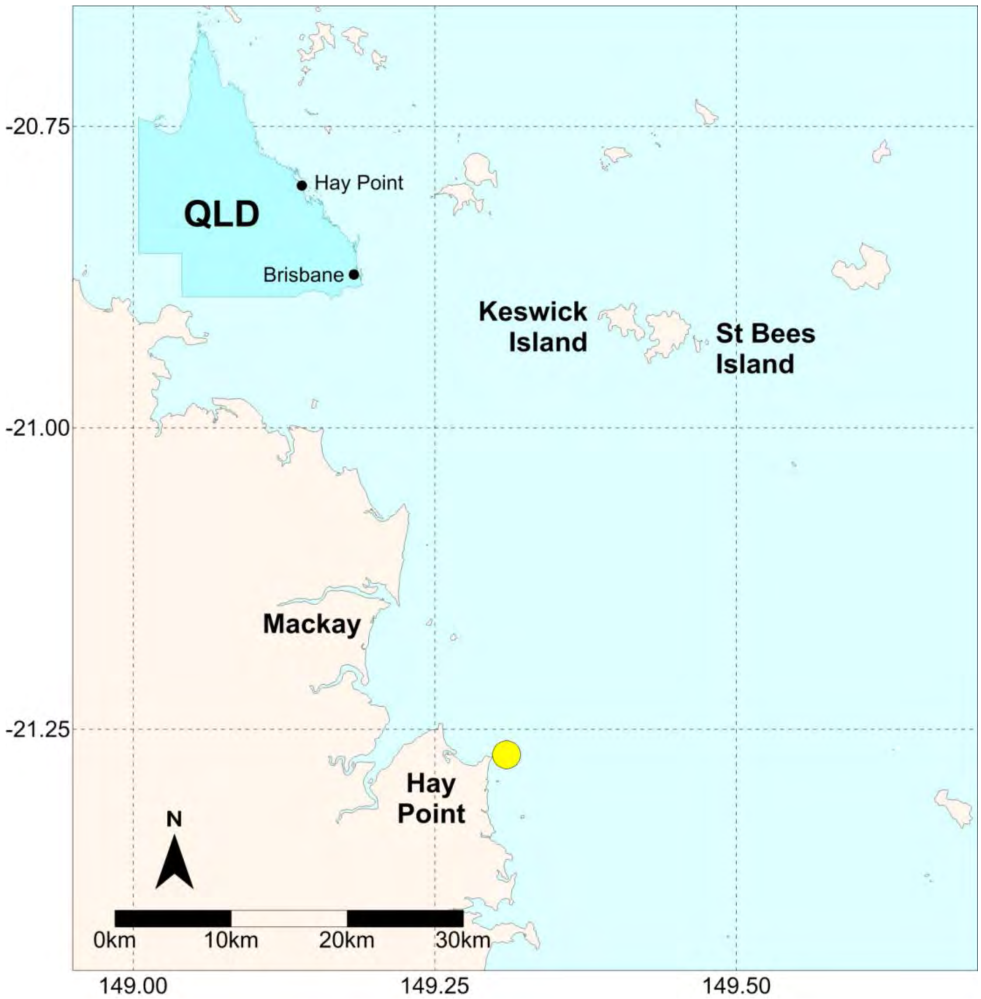


Figure 11.1: Hay Point - Locality plan

Table 11.1: Hay Point - Buoy deployments for the 2012–13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
21°16.254'S	149°18.558'E	10	27/11/2011	21/11/2012
21°16.266'S	149°18.586'E	10	21/11/2012	current

Table 11.2: Hay Point - Highest waves

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	21/03/2010 01:30	4.0	10/03/1997 10:00	6.8
2	9/03/1997 20:00	3.1	21/03/2010 04:30	6.3
3	31/01/2010 07:30	2.8	24/02/1996 02:00	5.6
4	16/02/2008 17:30	2.8	17/02/2008 21:00	5.4
5	1/02/1978 03:00	2.6	10/02/1999 18:00	5.3
6	29/08/1998 18:00	2.5	19/01/2004 18:00	5.0
7	24/01/2005 23:30	2.5	26/12/2007 0:30	5.0
8	1/02/2007 22:30	2.4	22/03/1994 19:00	4.8
9	3/05/2000 05:30	2.4	3/03/2004 21:00	4.7
10	19/01/2004 19:30	2.4	31/01/2010 06:30	4.7

Table 11.3: Hay Point - Significant meteorological events with threshold Hsig of 2.0 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
24/01/2013 23:00	2.1 (2.4)	3.6 (4.3)	7.3	Ex- tropical cyclone Oswald passed from north to south as a low pressure system with a central pressure of 989 hPa at Dalrymple Bay.
5/03/2013 0:30	2.0 (2.2)	3.4 (4.0)	6.6	Low [1000 hPa] located off the central Queensland Coast along with a monsoon trough situated across northern Queensland and the Coral Sea.
11/04/2013 23:30	2.0 (2.1)	3.5 (4.0)	6.3	Deepening surface trough in the western Coral Sea [1004 hPa]

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

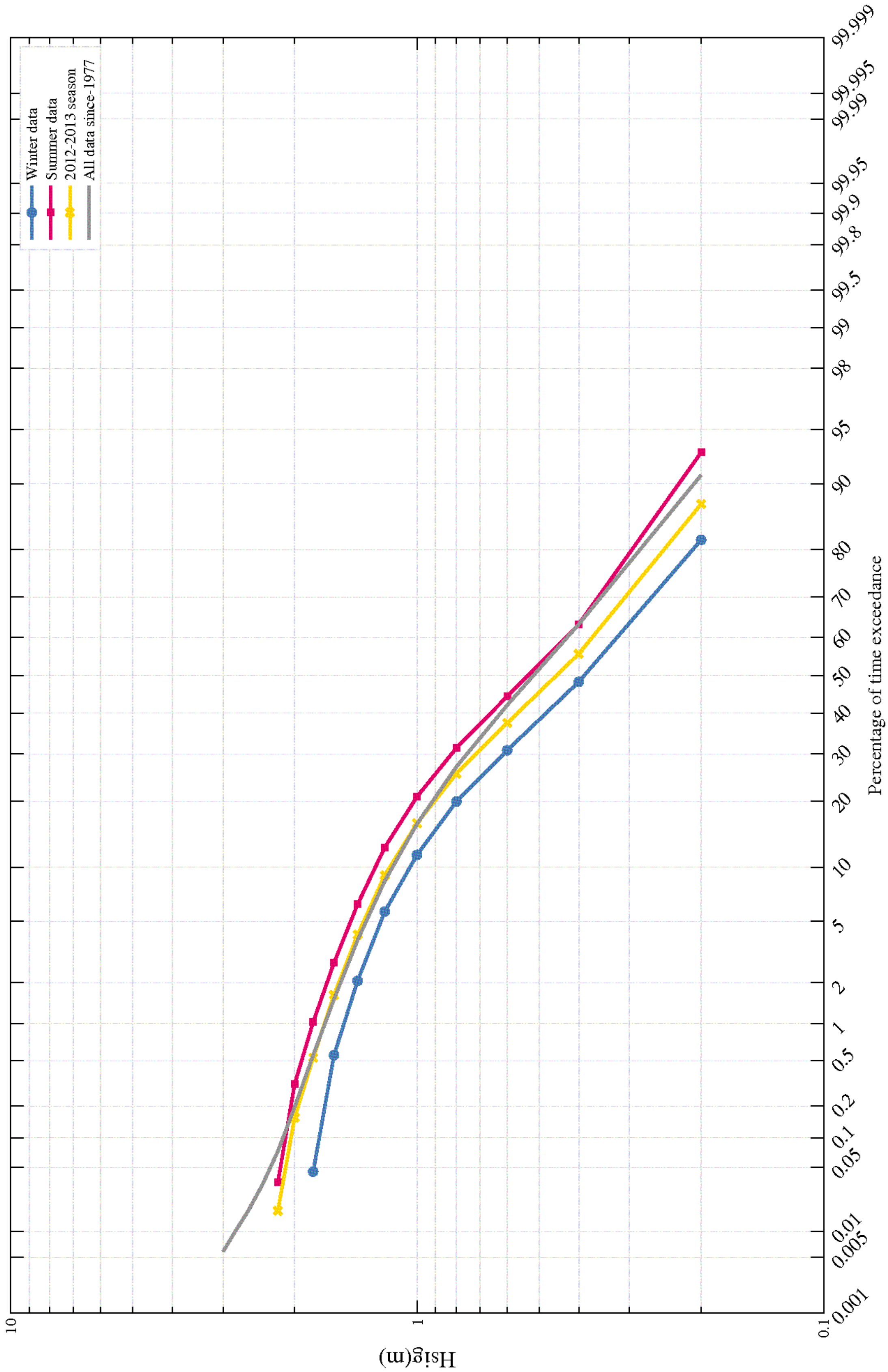


Figure 11.2: Hay Point - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

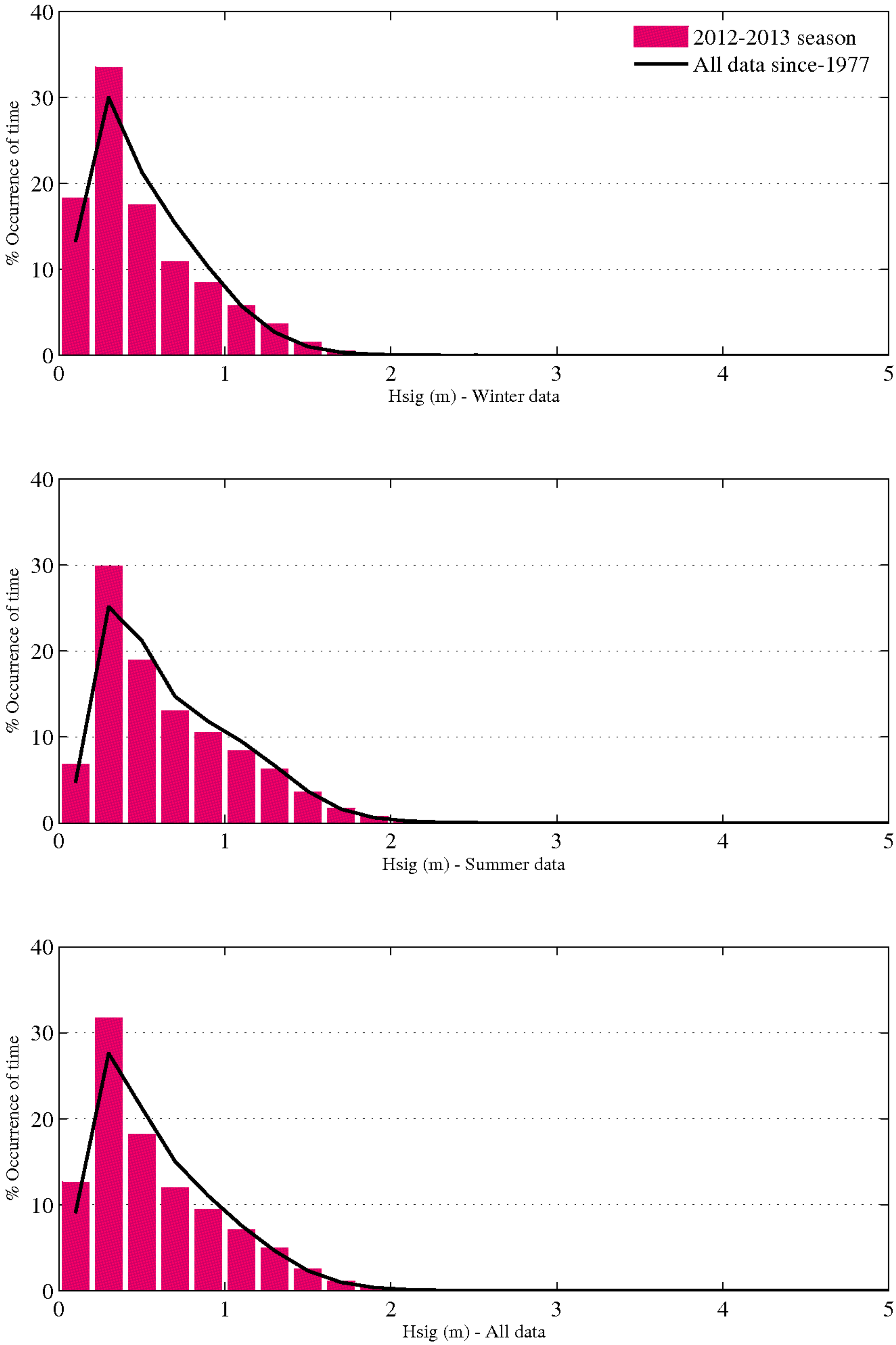


Figure 11.3: Hay Point - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

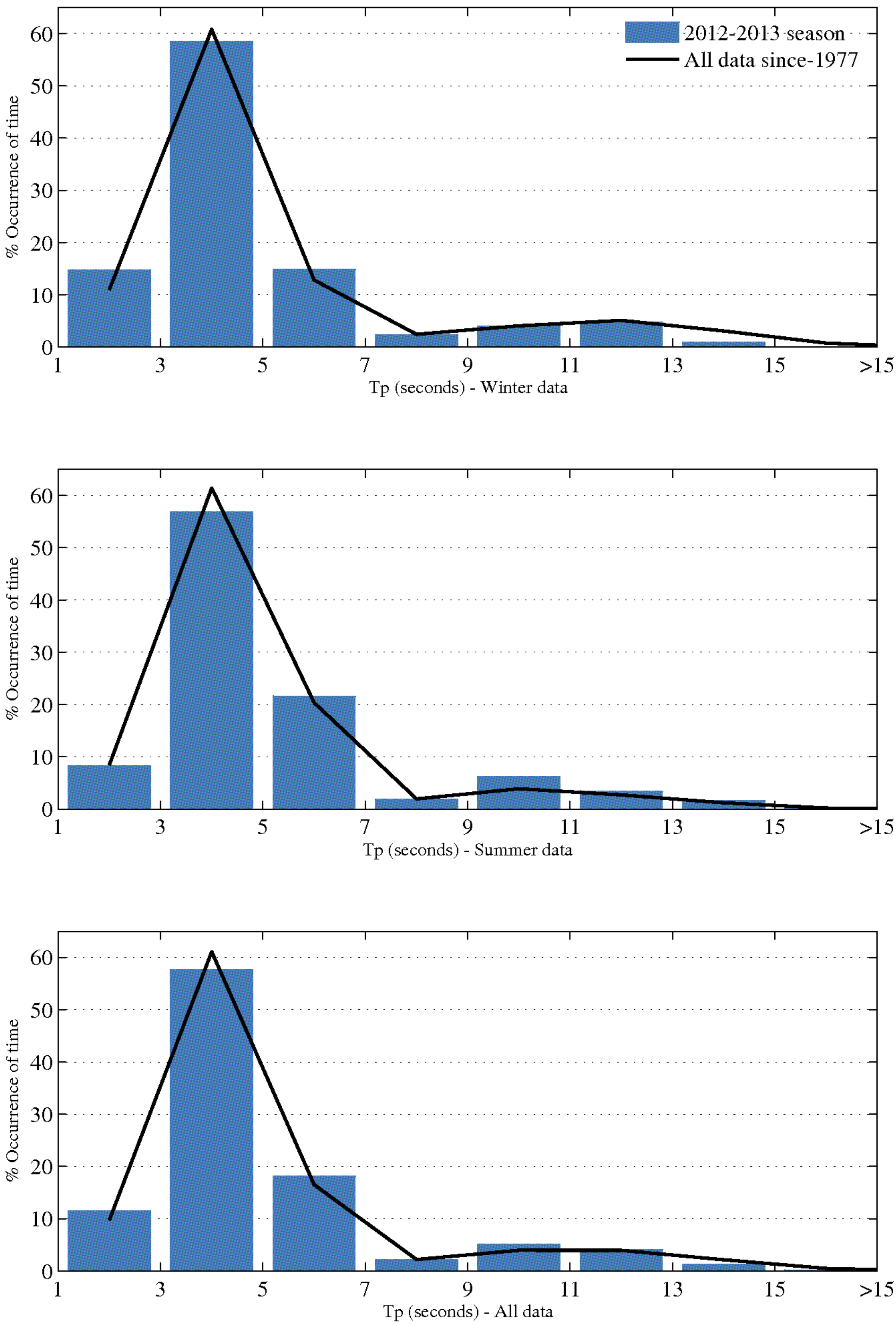


Figure 11.4: Hay Point - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

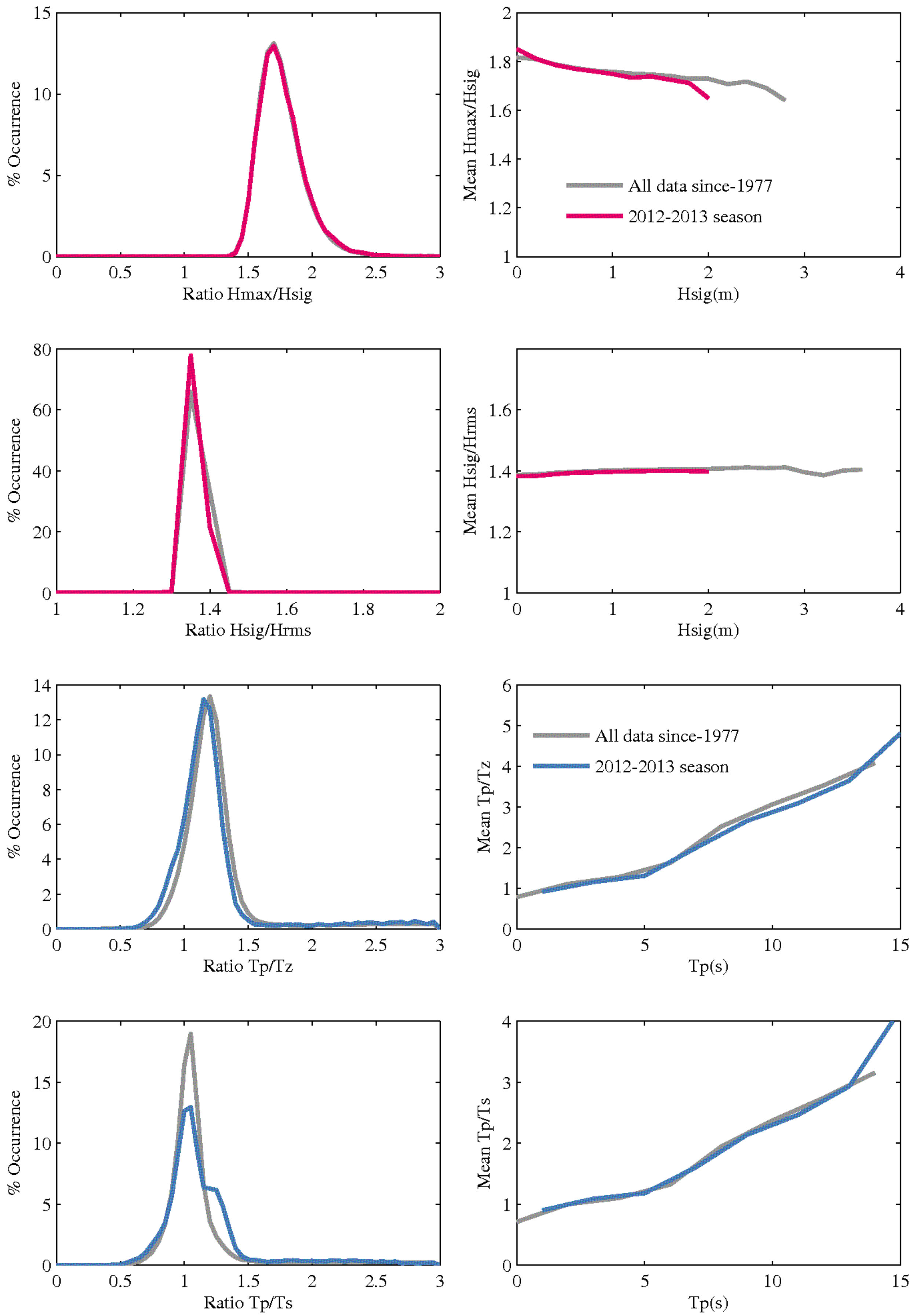


Figure 11.5: Hay Point - Wave parameter relationships

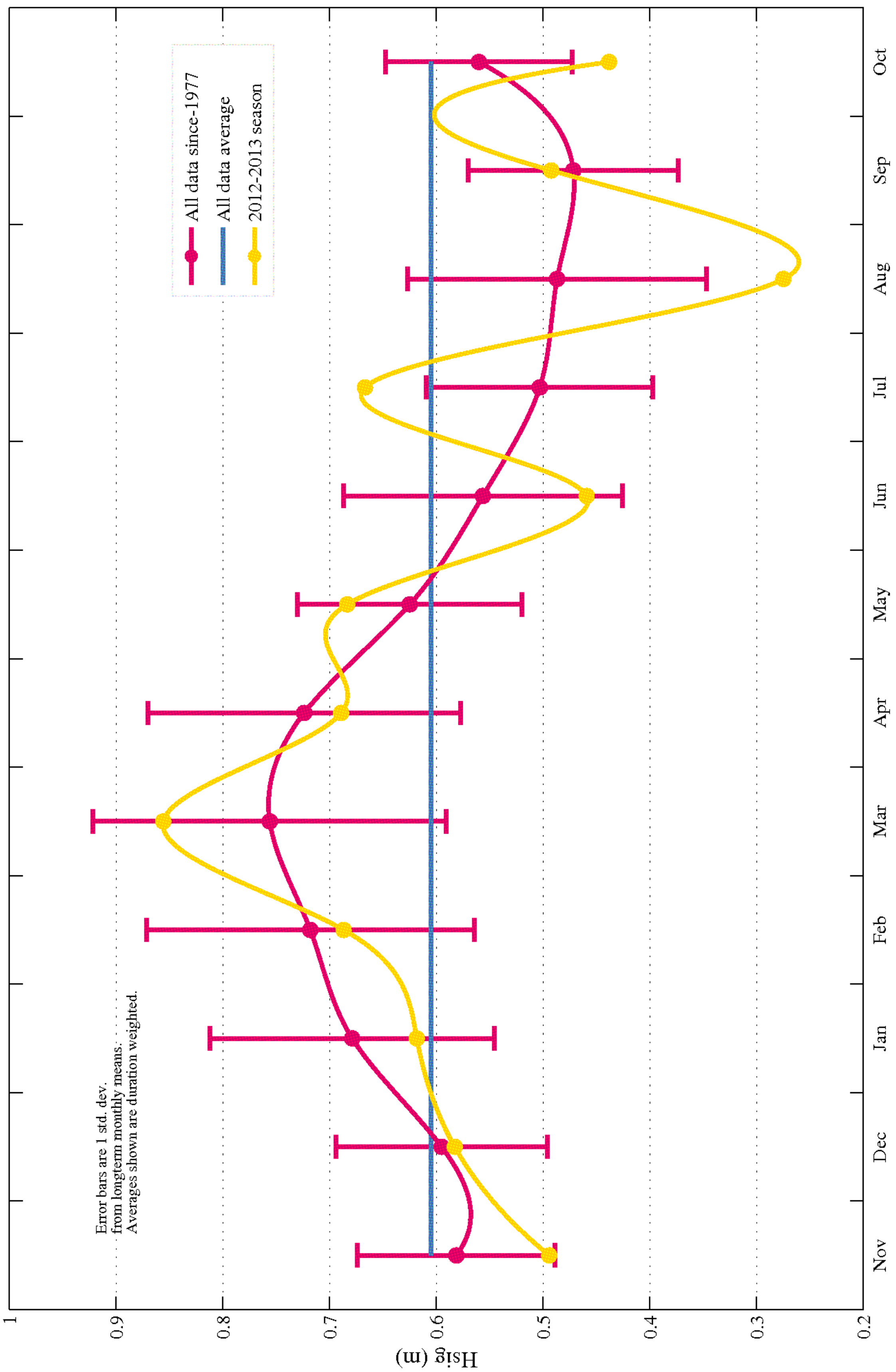


Figure 11.6: Hay Point - Monthly average wave height (Hsig) for seasonal year and for all data

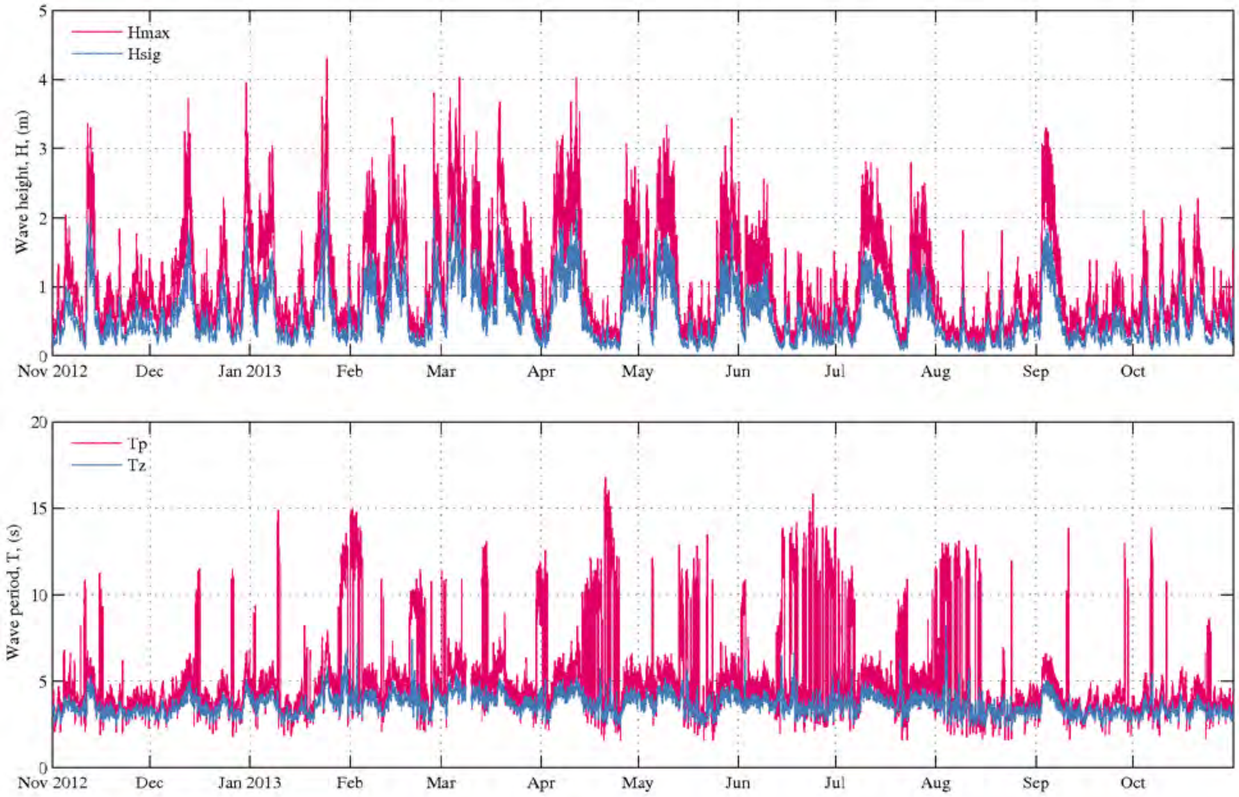


Figure 11.7: Hay Point - Daily wave recordings

Figure 11.8: Hay Point - Sea surface temperature and peak wave directions

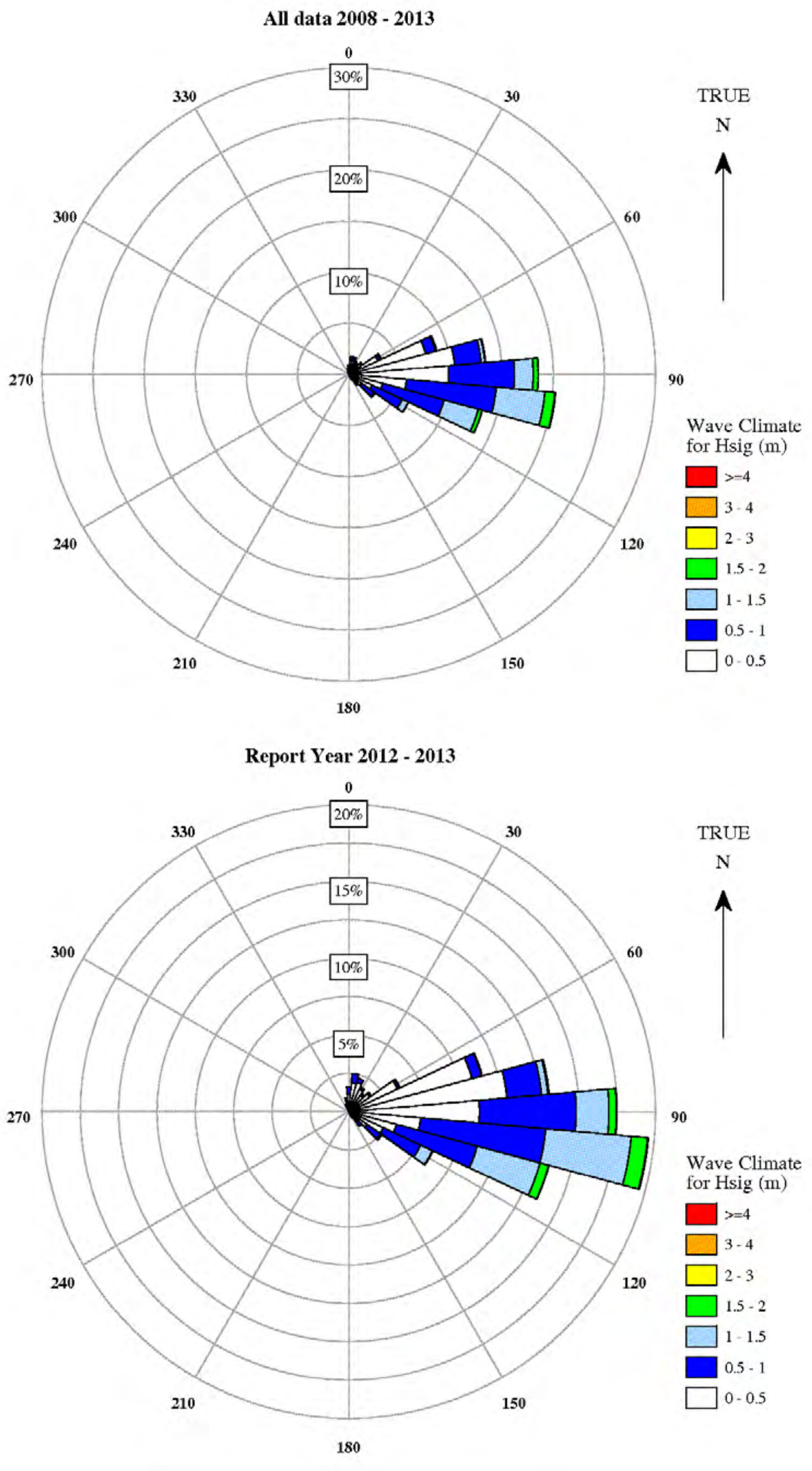


Figure 11.9: Hay Point - Directional wave rose

12. Mackay

Data Overview

The Mackay wave buoy has been operational for just over 38 years. The data recorded for the period from November 2012 to October 2013 was good, with total gaps of only 10.98 days, equivalent to 96.9% data return. The buoy was replaced just prior to this reporting period on 18 September 2012 and again on 23 October 2013 (Table 12.1).

There were no significant (Hsig) or maximum (Hmax) wave heights recorded during the reporting period that made it into the top ten ranks. The largest wave event recorded during this reporting period occurred on 24 January 2014 and coincided with the passing of Ex-TC Oswald. Ex-TC Oswald passed through the Mackay region as a low pressure system travelling from north to south just to the west of the buoy (inland). The atmospheric pressure fell to 989 hPa at Mackay as the system passed (see the report on TC Oswald for more details, (DSITIA, 2013)). As a result of the passing system a Hsig of 3.3 m along with a Hmax of 5.5 m was recorded by the buoy.

It is evident from Figure 12.2 and Figure 12.3 that the average wave height in summer was greater than that of winter. Figure 12.3 shows that there was a higher occurrence of waves under 0.6 m during the winter months. There was also a higher occurrence of recorded peak period (Tp) values less than 5 seconds during the winter months.

The wave climate during the reporting period was very similar to the wave climate of the whole record, as evident in the percentage time exceedance figure (Figure 12.2) and histograms of the occurrence of Hsig and Tp (Figure 12.3 and Figure 12.4). The monthly average Hsig generally fell within one standard deviation (sd) of the long term mean with the exception of July and August. A series of passing cold fronts effected the Queensland Coast during the month of July which likely contributed to the above average recorded wave height for the month. August saw a relatively subdued wave climate, which resulted in the mean Hsig being less than −1 sd below the historical monthly average (Figure 12.6).

The plot of wave direction over the 2012–13 season (Figure 12.8) showed a dominant east south easterly direction, being the direction of unobstructed or longer fetch. The dominance of this incident wave direction is reflected in the directional wave rose plot (Figure 12.9).

The temperature (sea surface temperature, SST) measured in the buoy hull showed the recorded values ranging from 21 °C to 31 C during the reporting year. It is evident from Figure 12.8 that there is an obvious drop in the recorded temperature on the 23 October 2012 when the buoy was replaced. This suggests that there may be an issue with either the initial or replacements buoys temperature sensor and therefore care must be taken when interpreting the recorded temperature data.

Mackay

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	=	364.98
Total number of days used in analysis	=	354.00
Gaps in data used in analysis (days)	=	10.98
Number of records used in analysis	=	16992

All data since-1975

Maximum possible analysis years (last record - first record)	=	38.12
Total number of years used in analysis	=	24.86
Gaps in data used in analysis (years)	=	13.26
Number of records used in analysis	=	266379

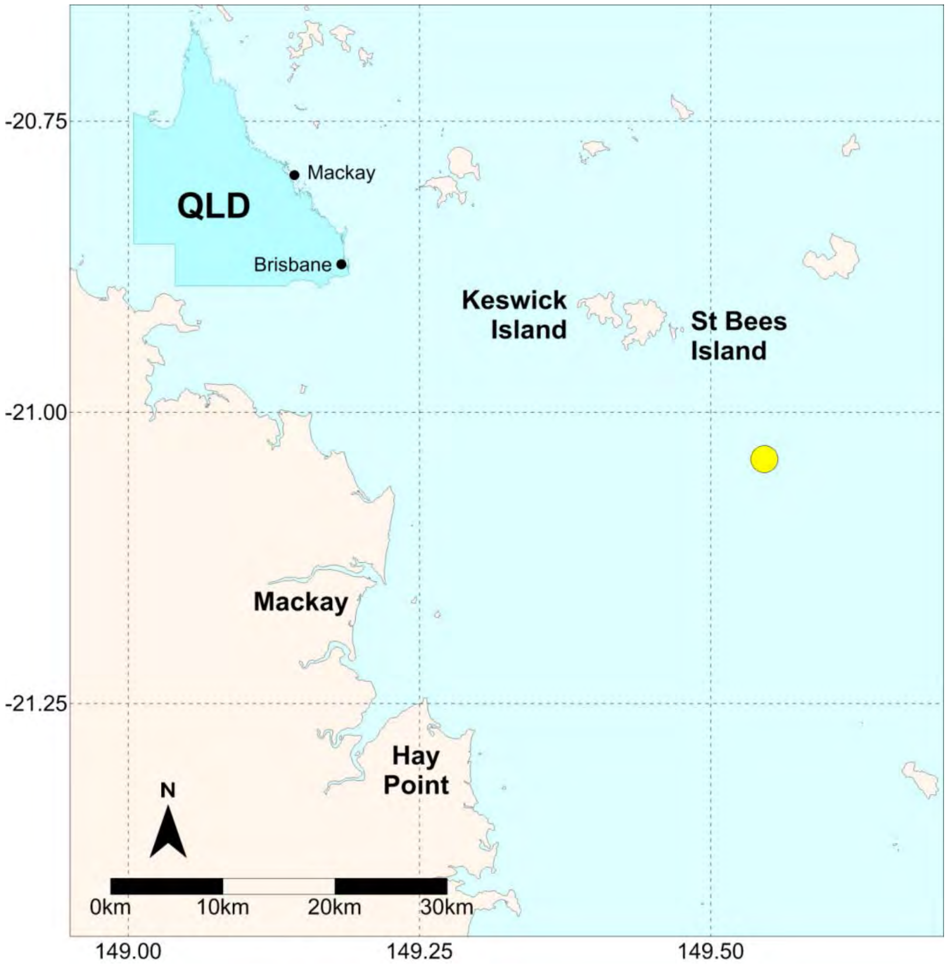


Figure 12.1: Mackay - Locality plan

Table 12.1: Mackay - Buoy deployments during the 2012–13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
21°02.350'S	149°32.700'E	33	18/09/2012	23/10/2013
21°02.395'S	149°32.759'E	25	23/10/2013	current

Table 12.2: Mackay - Highest waves

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	20/03/2010 22:30	5.7	21/03/2010 00:00	9.4
2	10/03/1997 00:00	4.8	9/03/1997 11:00	8.5
3	1/03/1979 03:00	4.0	8/03/2009 17:00	7.7
4	27/12/1990 03:41	3.9	19/01/2004 19:30	7.5
5	5/06/2002 00:00	3.8	4/03/2002 15:00	7.3
6	19/01/2004 19:30	3.6	17/02/2008 19:30	7.1
7	17/02/2008 19:30	3.6	5/06/2002 01:00	6.9
8	12/01/1979 03:00	3.6	26/12/2007 01:30	6.9
9	18/03/2012 23:30	3.5	9/05/1996 19:30	6.8
10	4/04/1989 17:54	3.5	19/03/2006 19:00	6.8

Table 12.3: Mackay - Significant meteorological events with threshold Hsig of 2.5 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
30/12/2012 23:00	2.7 (2.8)	4.5 (5.4)	7.9	High over the Great Australian Bight pushed a fresh southerly change up the Queensland Coast.
23/01/2013 9:30	2.8 (3.1)	5.0 (5.6)	7.8	Ex-TC Oswald passed from north to south as a low pressure system with a central pressure of 989 hPa at Mackay.
5/03/2013 21:00	2.5 (2.7)	4.1 (4.9)	6.4	Low [1000 hPa] located off the Central Queensland Coast along with a monsoon trough situated across Northern Queensland and the Coral Sea.
19/03/2013 03:30	3.0 (3.3)	5.0 (5.5)	8.0	Ex- Tropical Cyclone Tim [1004 hPa] located approximately 210 km north of Mackay.
11/04/2013 21:00	2.6 (3.1)	4.9 (5.8)	7.9	Deepening surface trough in the Western Coral Sea [1004 hPa]

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

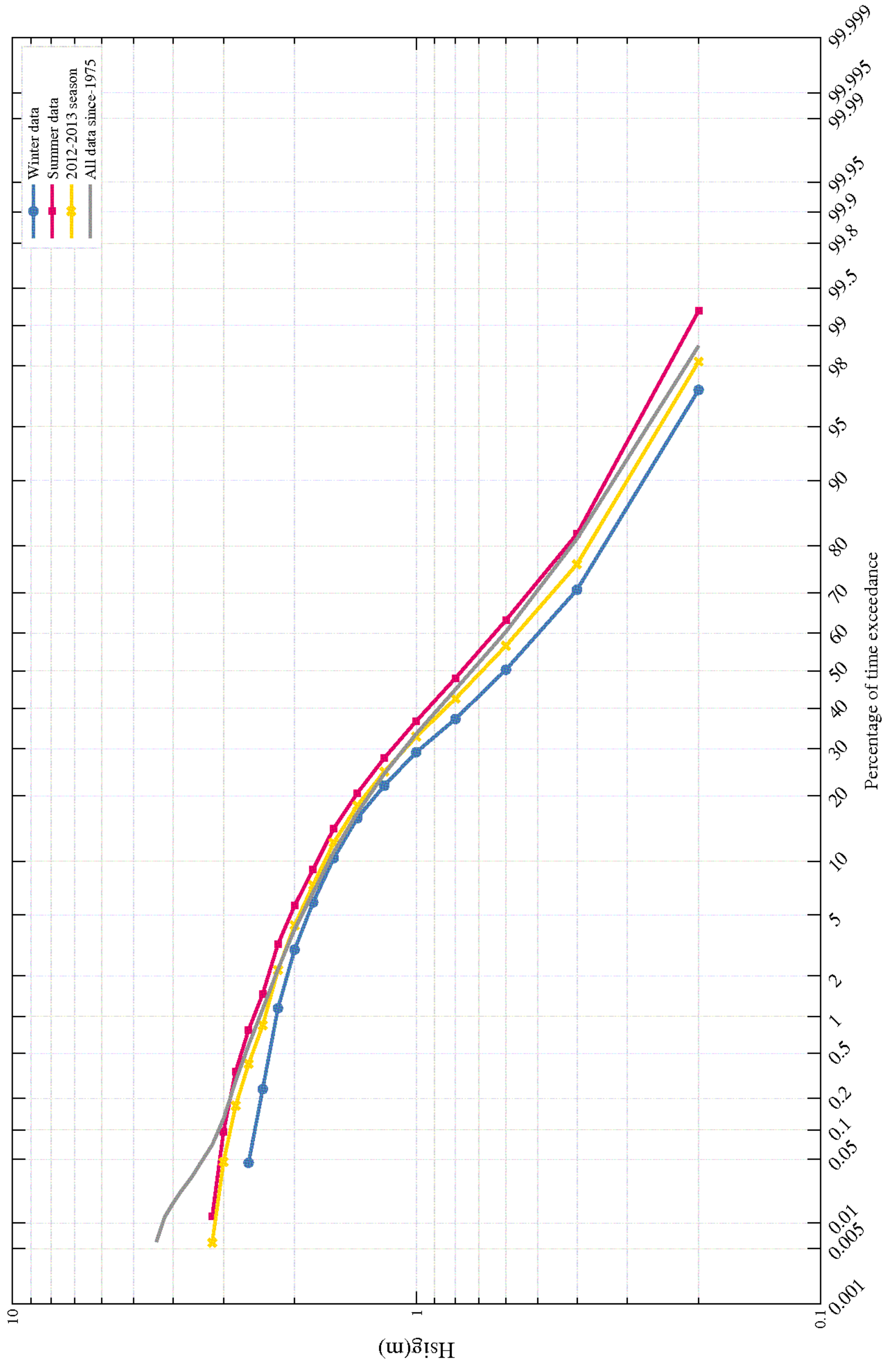


Figure 12.2: Mackay - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

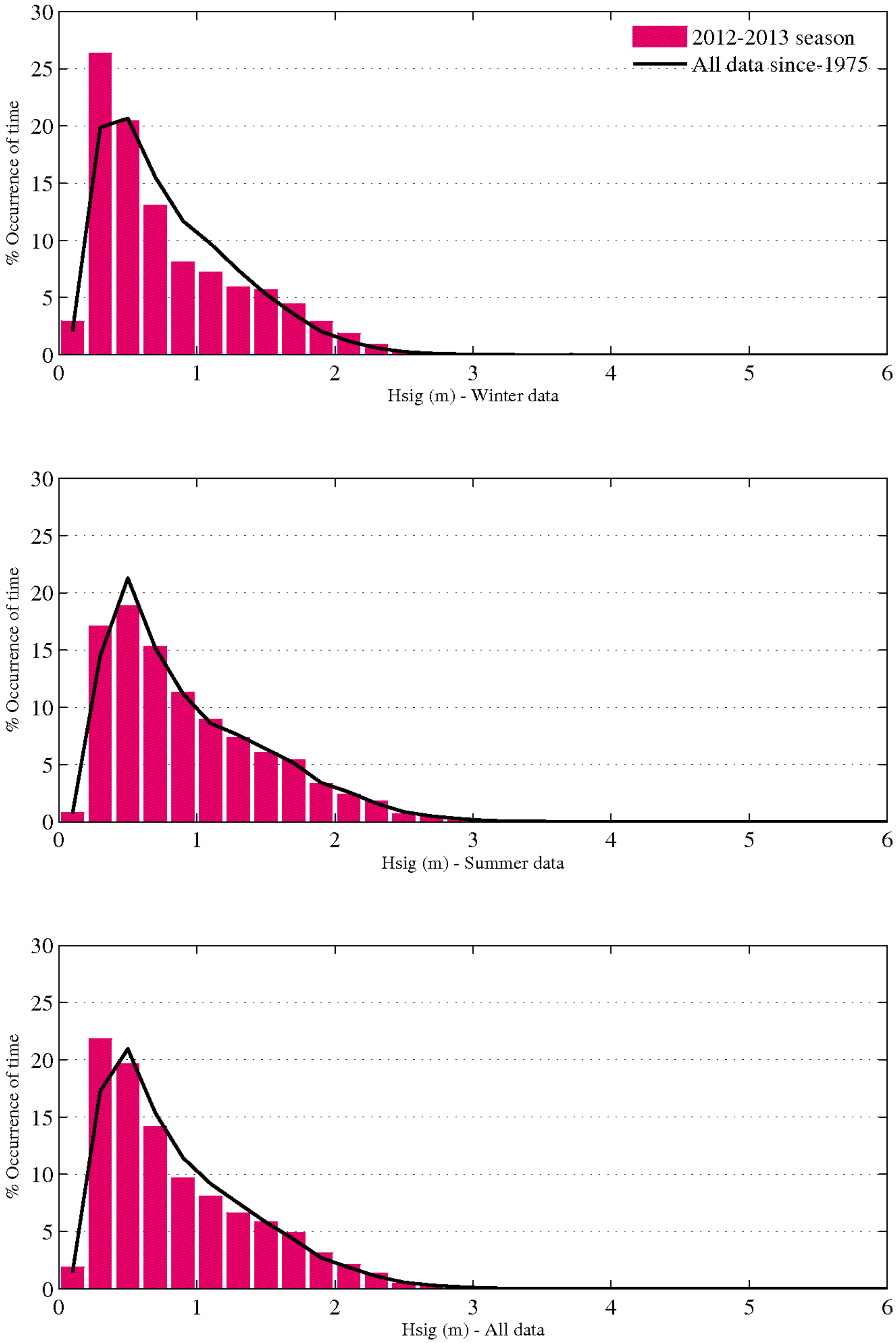


Figure 12.3: Mackay - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

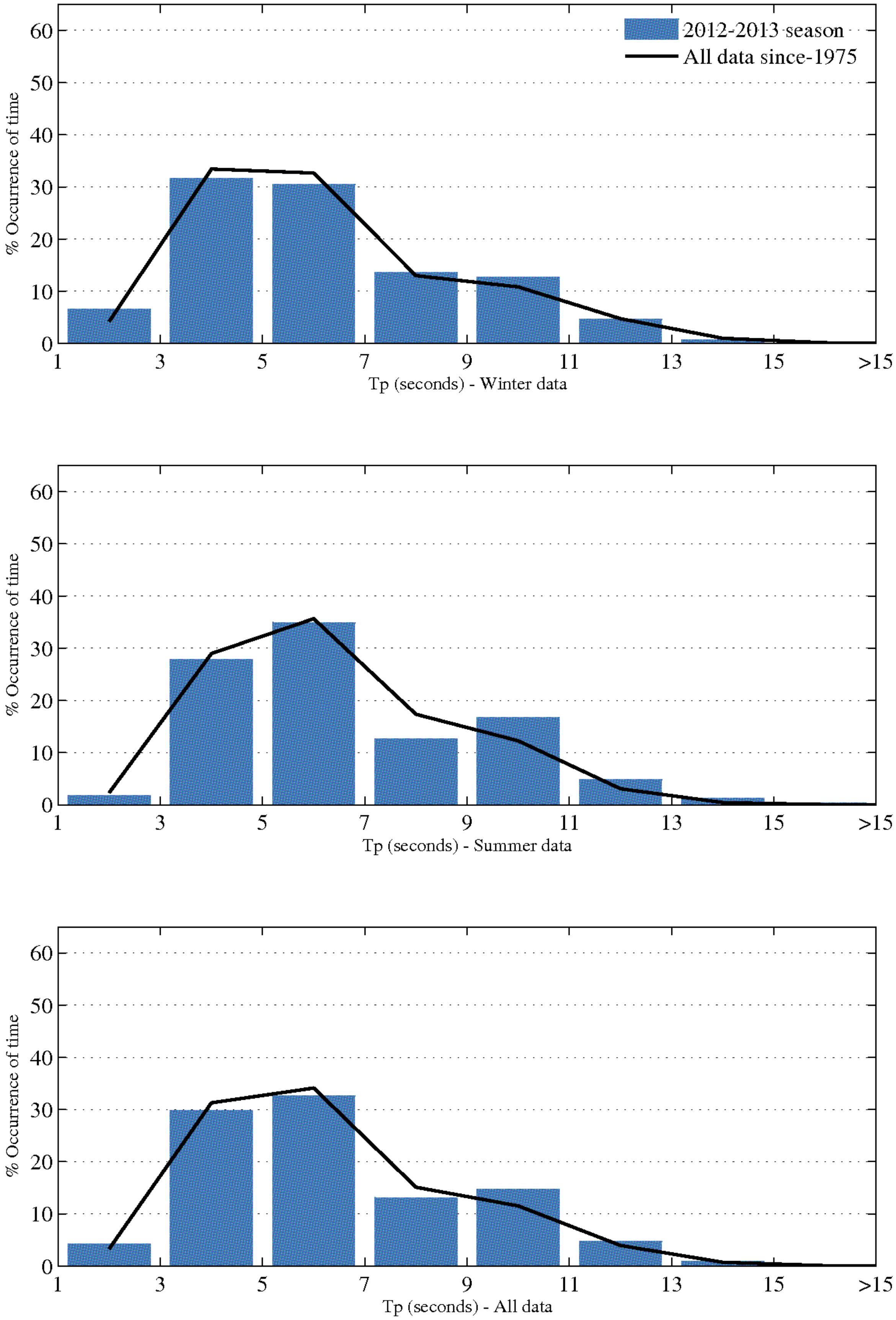


Figure 12.4: Mackay - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

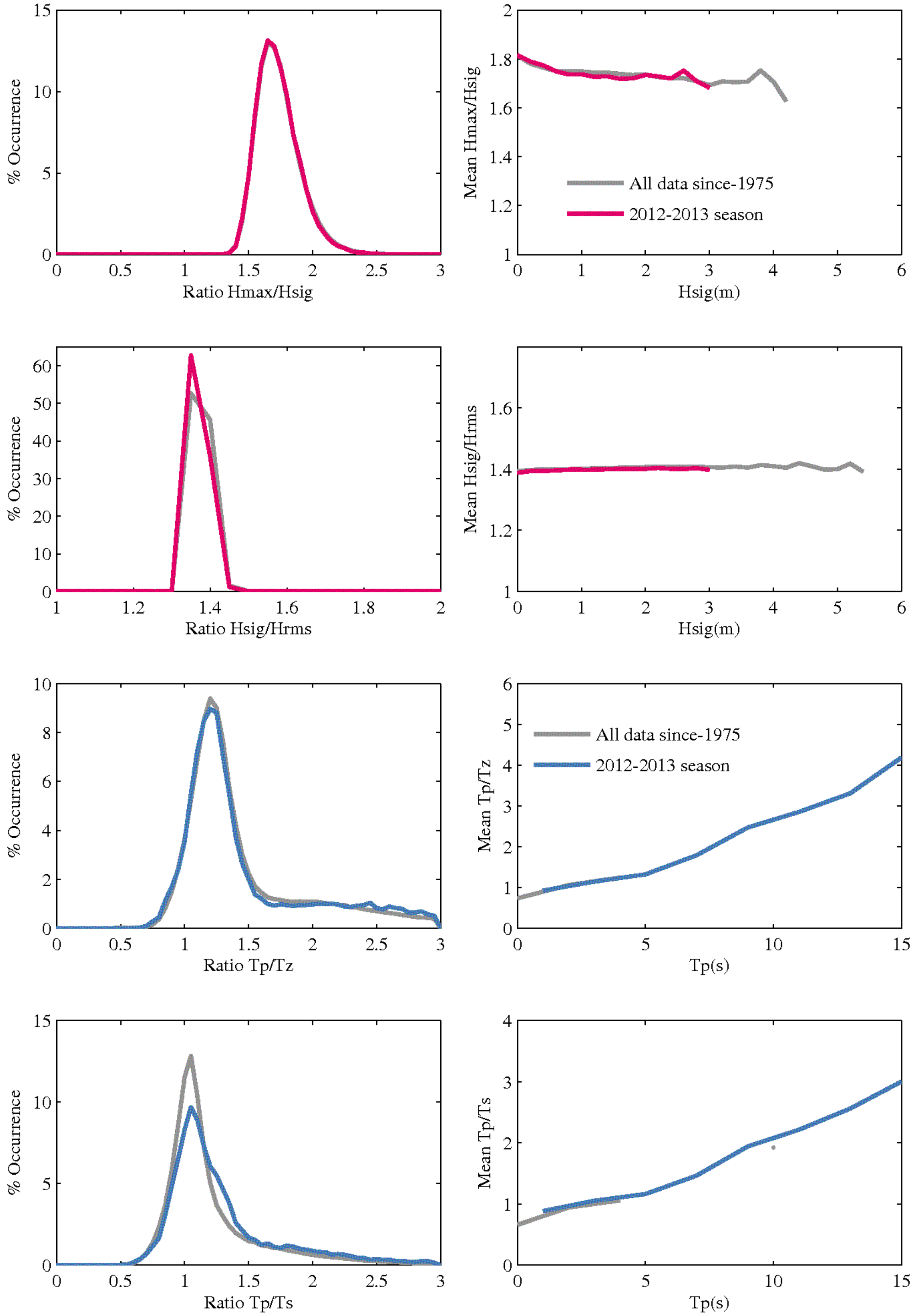


Figure 12.5: Mackay - Wave parameter relationships

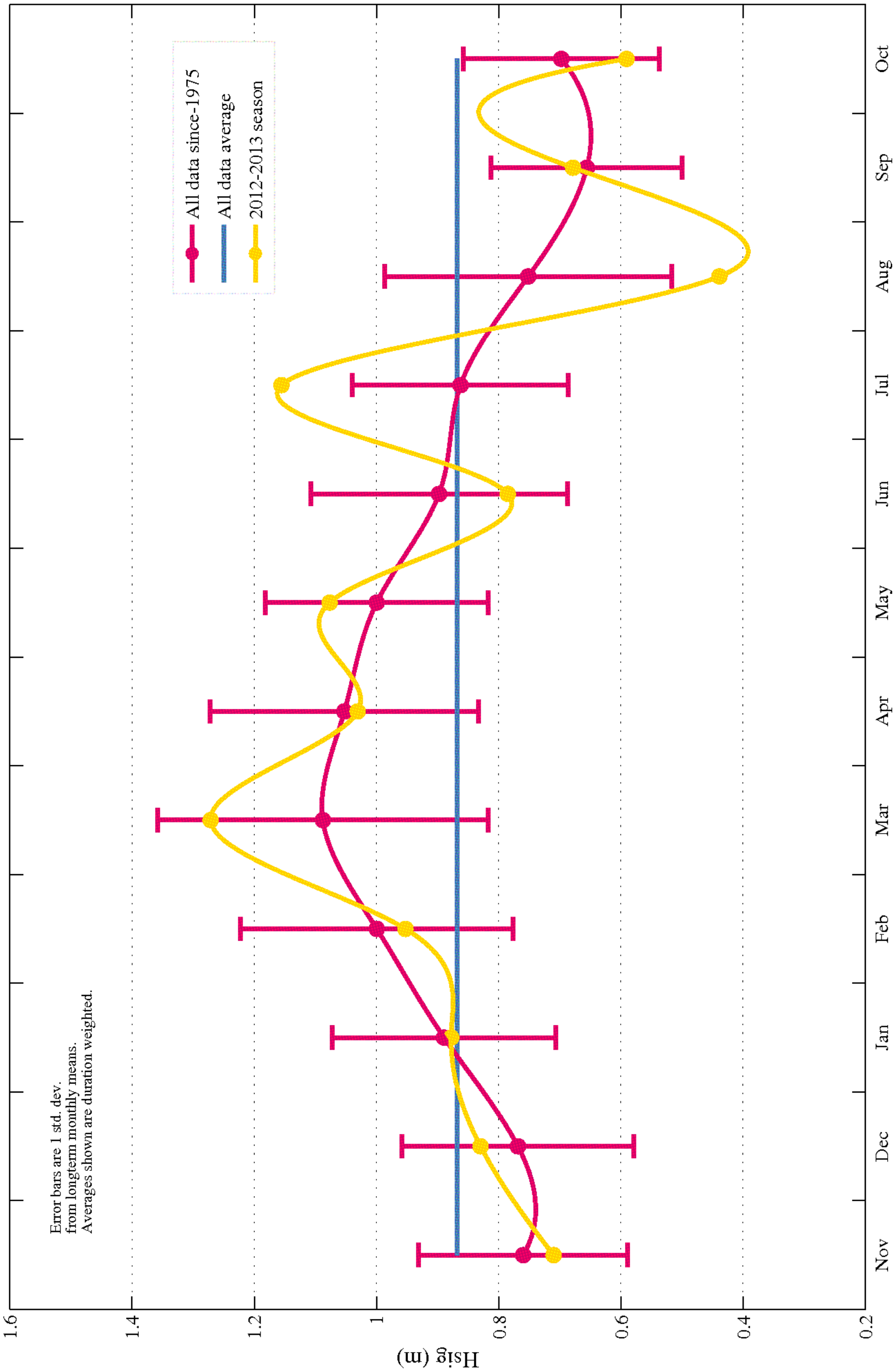


Figure 12.6: Mackay - Monthly average wave height (Hsig) for seasonal year and for all data

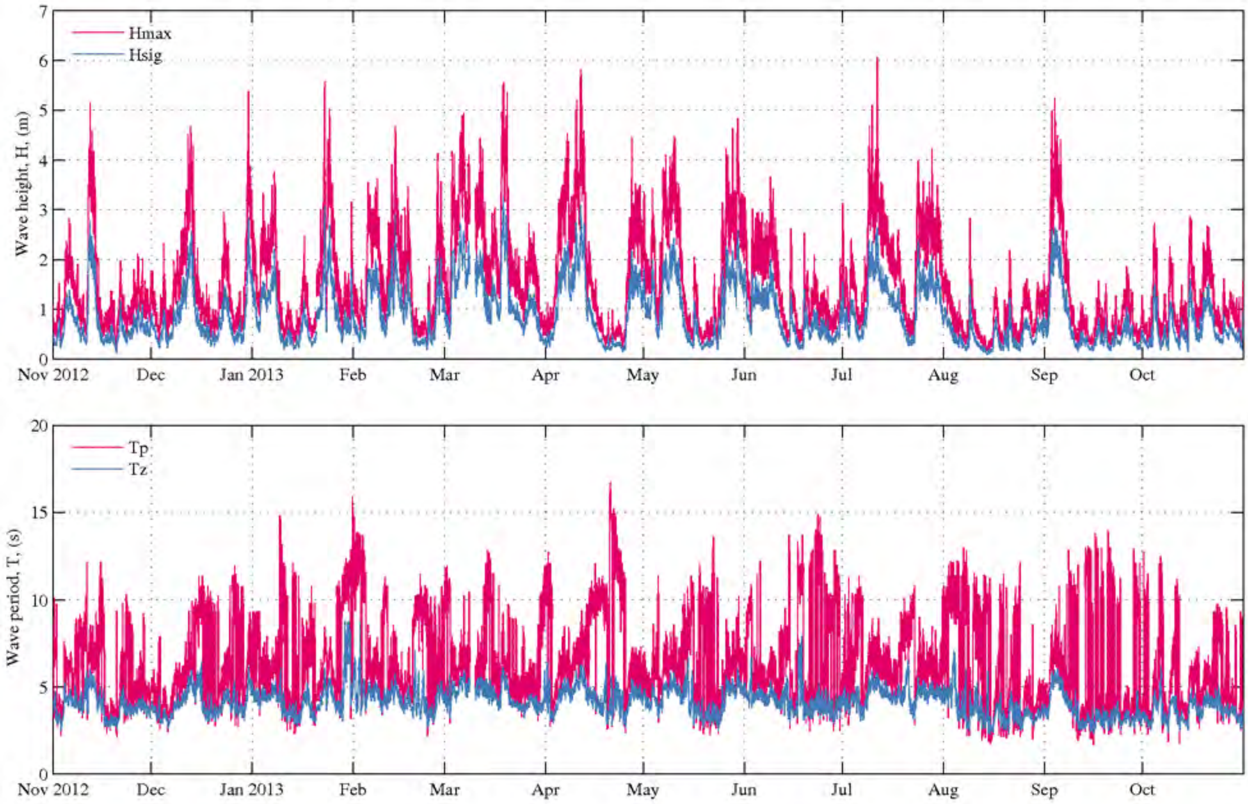


Figure 12.7: Mackay - Daily wave recordings

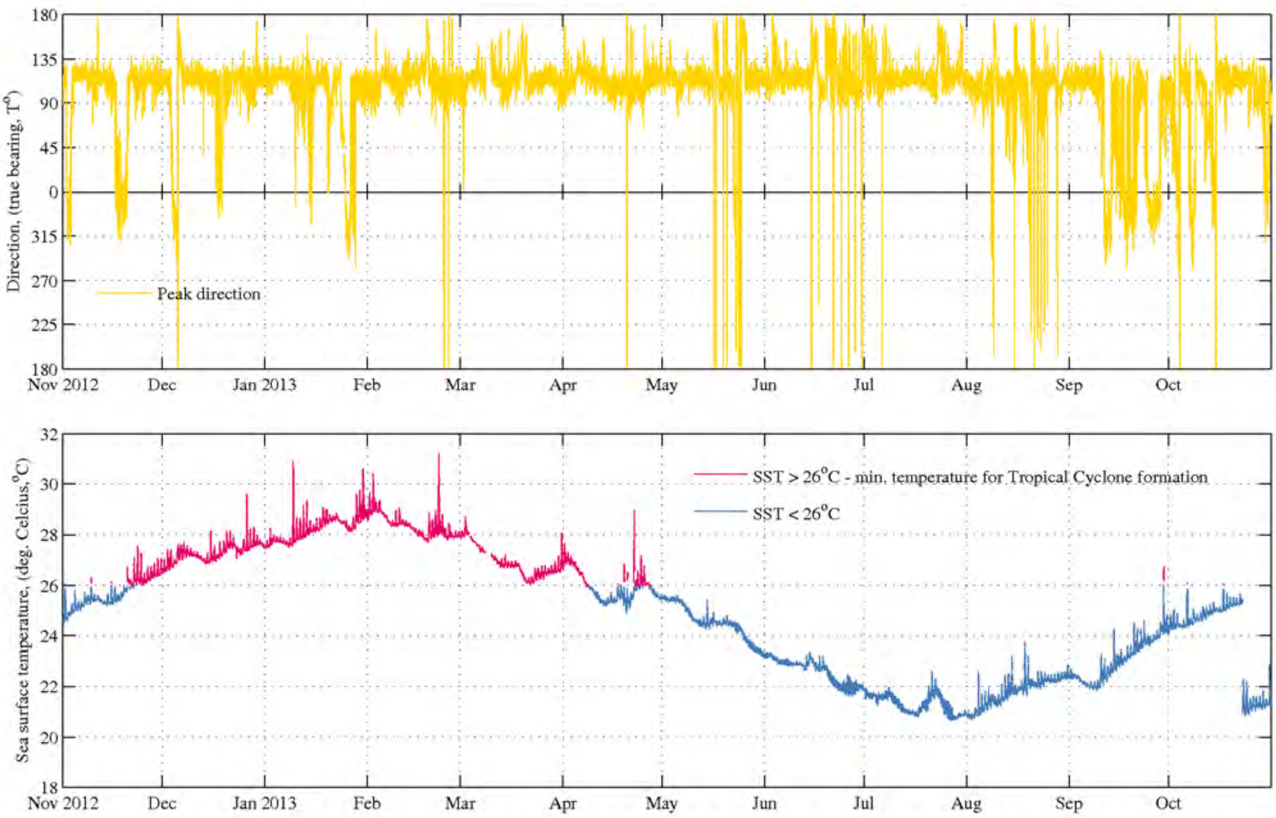


Figure 12.8: Mackay - Sea surface temperature and peak wave directions

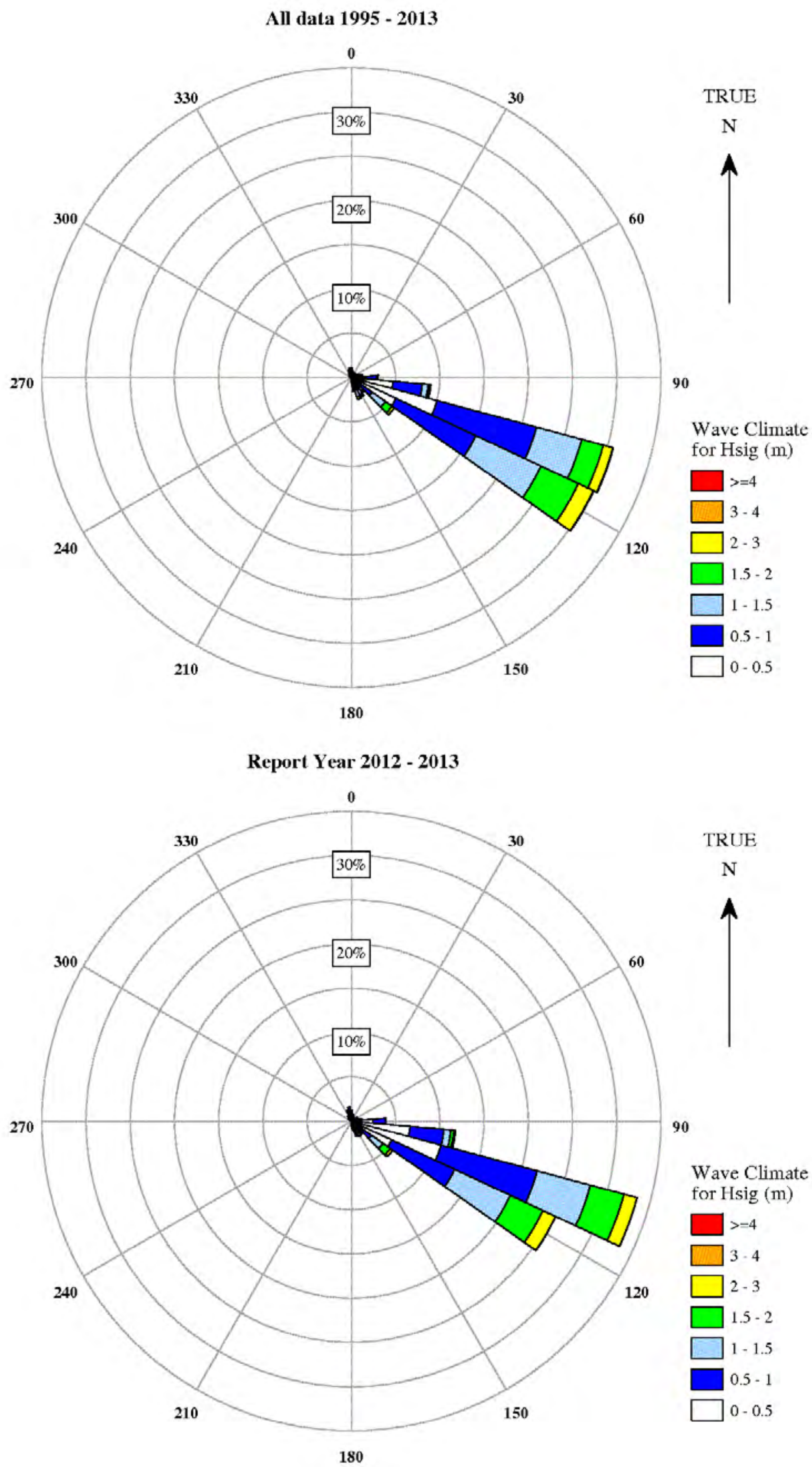


Figure 12.9: Mackay - Directional wave rose

13. Abbot Point

Data Overview

The Abbot Point wave buoy has only been operational for just under two years. Since the Abbot Point buoy has only been operational for a short period of time no comparisons have been made in this report between previous recordings and recordings made in this reporting period. The buoy was replaced just prior to this reporting period on 31 October 2012 and again on 31 October 2013 (Table 13.1).

The largest waves recorded by the Abbot Point wave rider buoy during the reporting period occurred during the passage of Ex-TC Oswald. Ex-TC Oswald passed just to the west of Bowen as a low pressure system travelling from north to south resulting in the atmospheric pressure falling to 990 hPa at Bowen (see the report on TC Oswald for more details, (DSITIA, 2013)). As result of the passing system a Hsig of 3.0 m and Hmax of 5.5 m was recorded by the buoy.

Figure 13.3 and Figure 13.4 suggested that wave heights are on average greater during summer then compared to winter. This is expected as cyclones which occur during the summer months contribute to the majority of significant wave events recorded at Abbot Point. Figure 13.4 illustrates that the most common peak period (Tp) recorded at Abbot Point was between three and five seconds in both summer and winter.

The plot of wave direction over the 2012–13 season (Figure 13.7) showed a dominant east north easterly direction with an occasional swing to the north west north. This dominate incident wave direction is also reflected in the directional wave rose plot (Figure 13.8).

The temperature (sea surface temperature, SST) measured in the buoy hull showed the recorded values ranging from 21 °C to 31 °C during the reporting year. The SST was warm enough for tropical cyclone development most of the year, except for May through to October when the SST fell below the 26 °C threshold.

Abbot Point

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 363.06
Gaps in data used in analysis (days)	= 1.92
Number of records used in analysis	= 17427

Less than 2 years of data recorded, historical trends are not shown for this site.

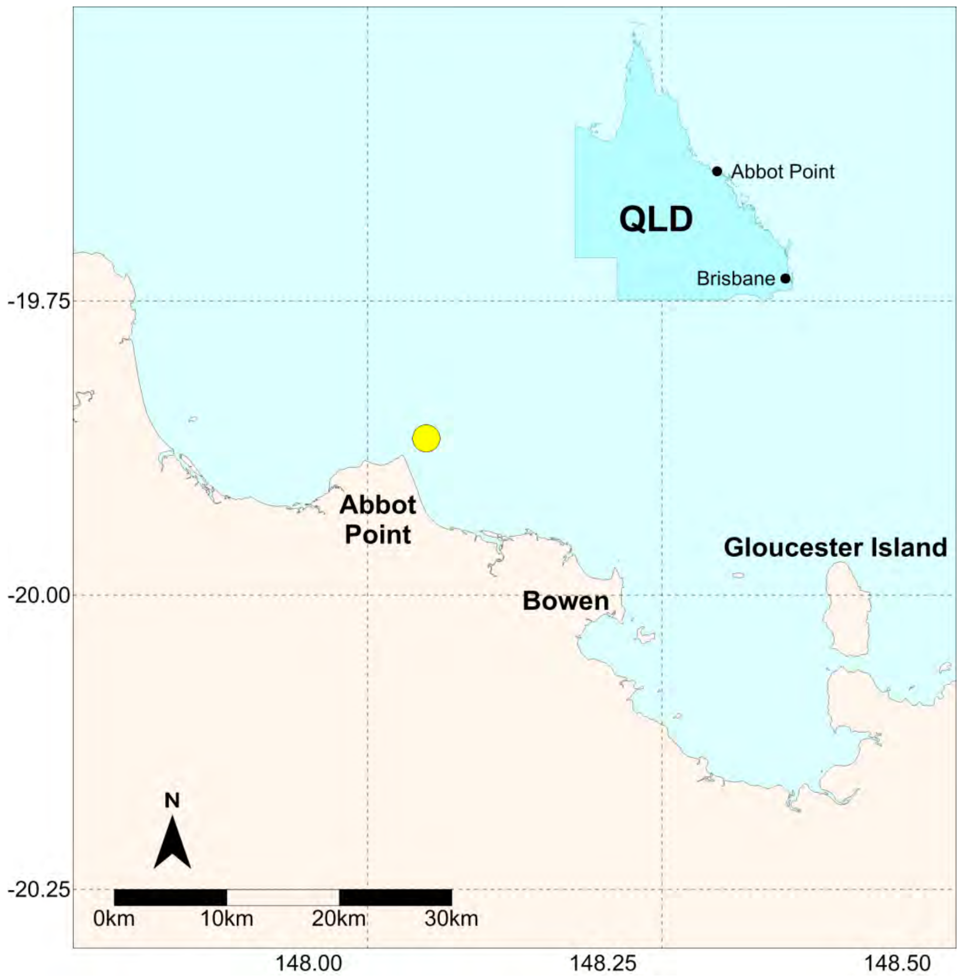


Figure 13.1 Abbot Point - Locality plan

Table 13.1: Abbot Point - Buoy deployment for the 2012–13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
19°51.994'S	148°05.974'E	16	17/01/2012	31/10/2012
19°52.085'S	148°05.968'E	16	31/10/2012	current

Table 13.2: Abbot Point - Significant meteorological events with threshold Hsig of 2.5 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
24/01/2013 16:00	2.8 (3.0)	4.6 (5.5)	6.9	Ex-TC Oswald passed from north to south as a low pressure system with a central pressure of 990 hPa at Bowen.

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

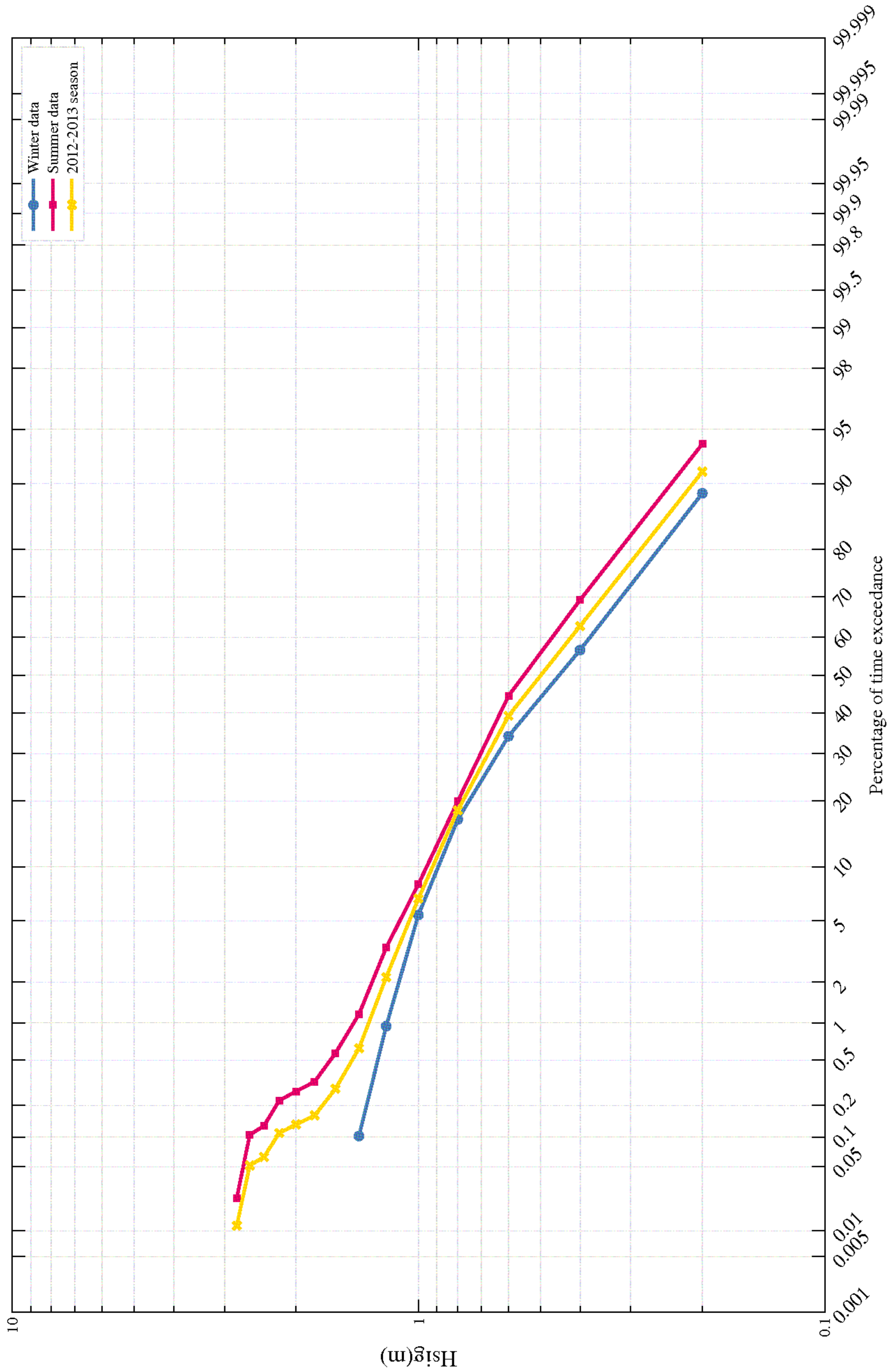


Figure 13.2: Abbot Point - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

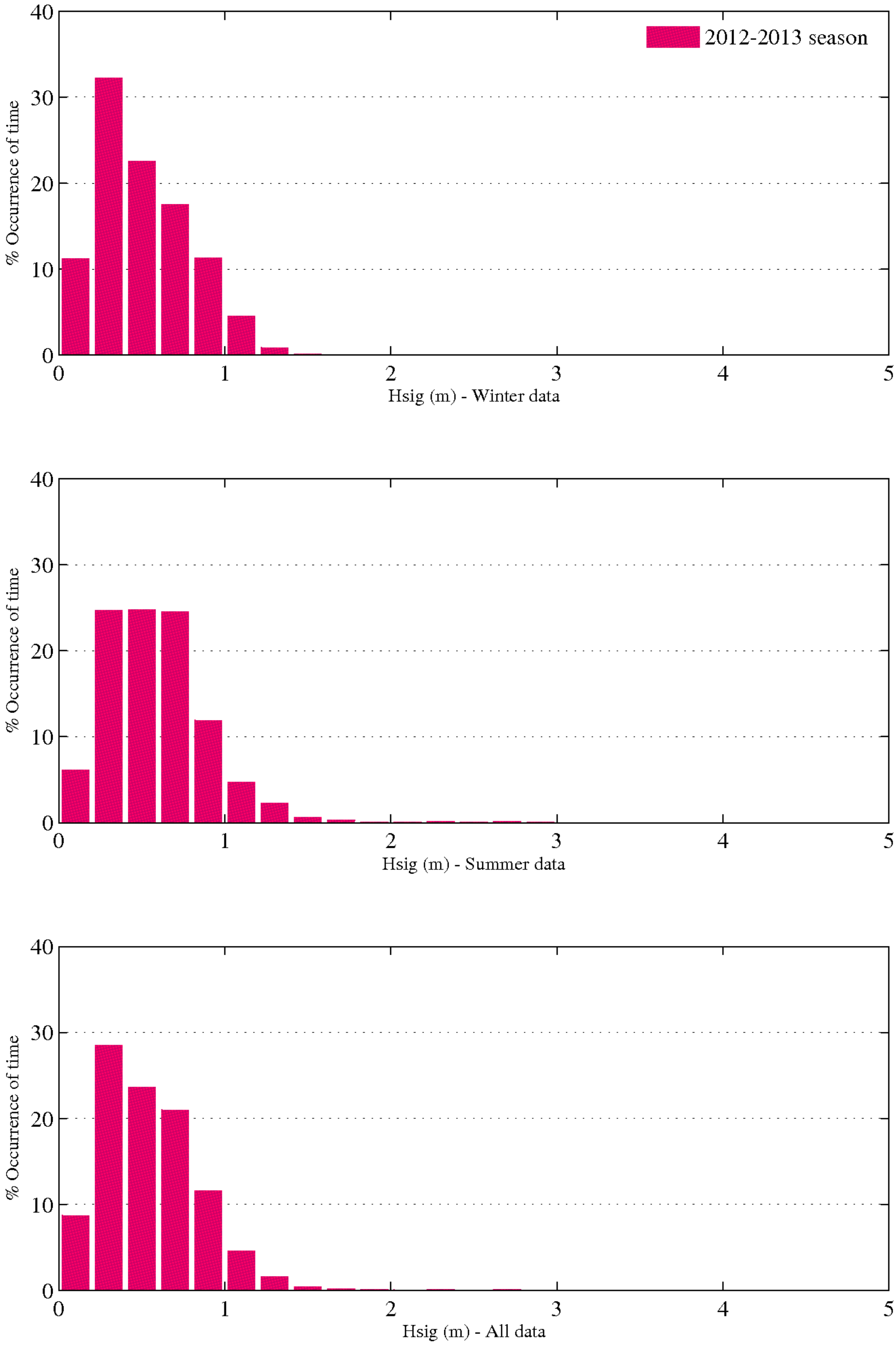


Figure 13.3: Abbot Point - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

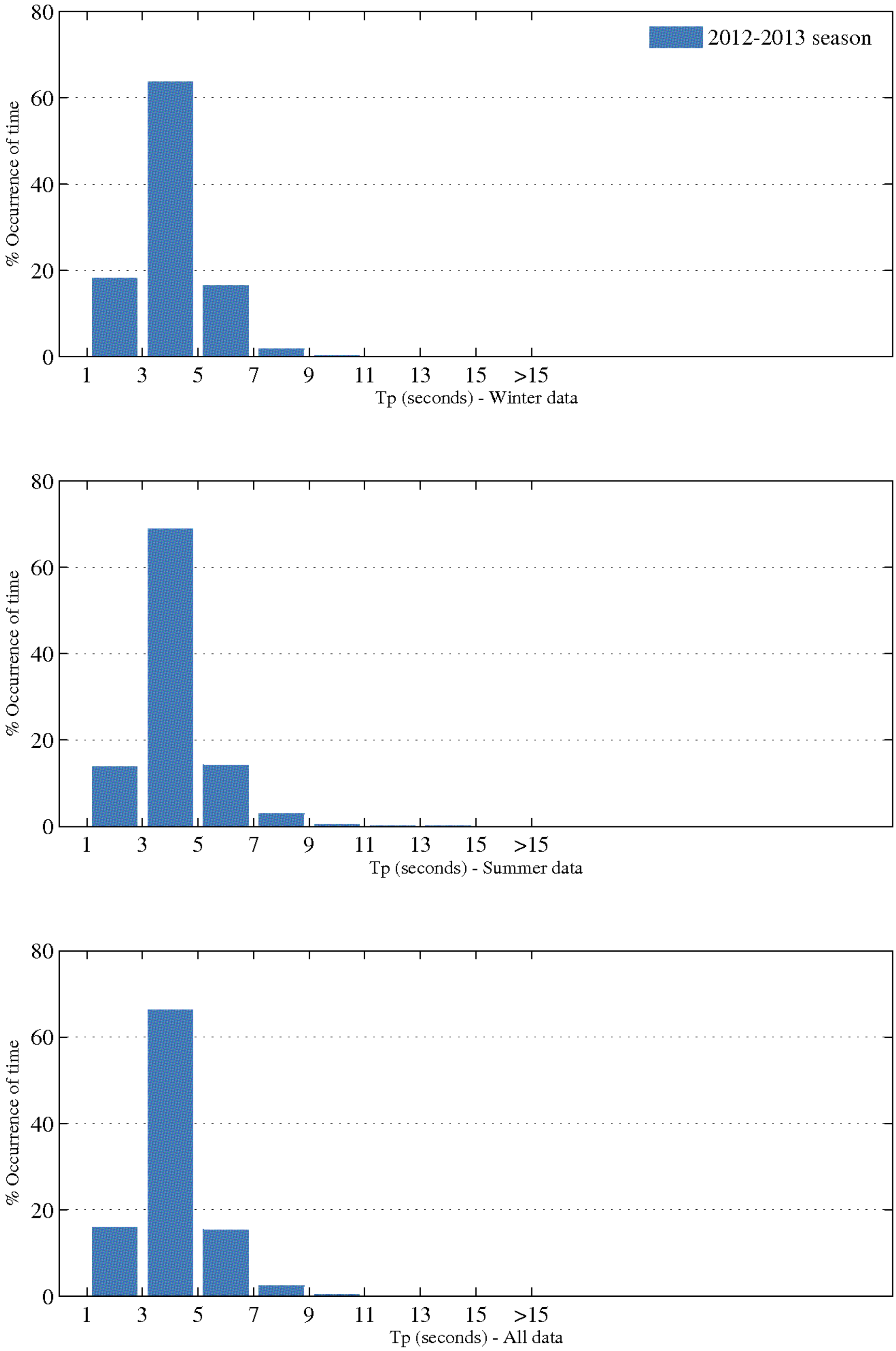


Figure 13.4: Abbot Point - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

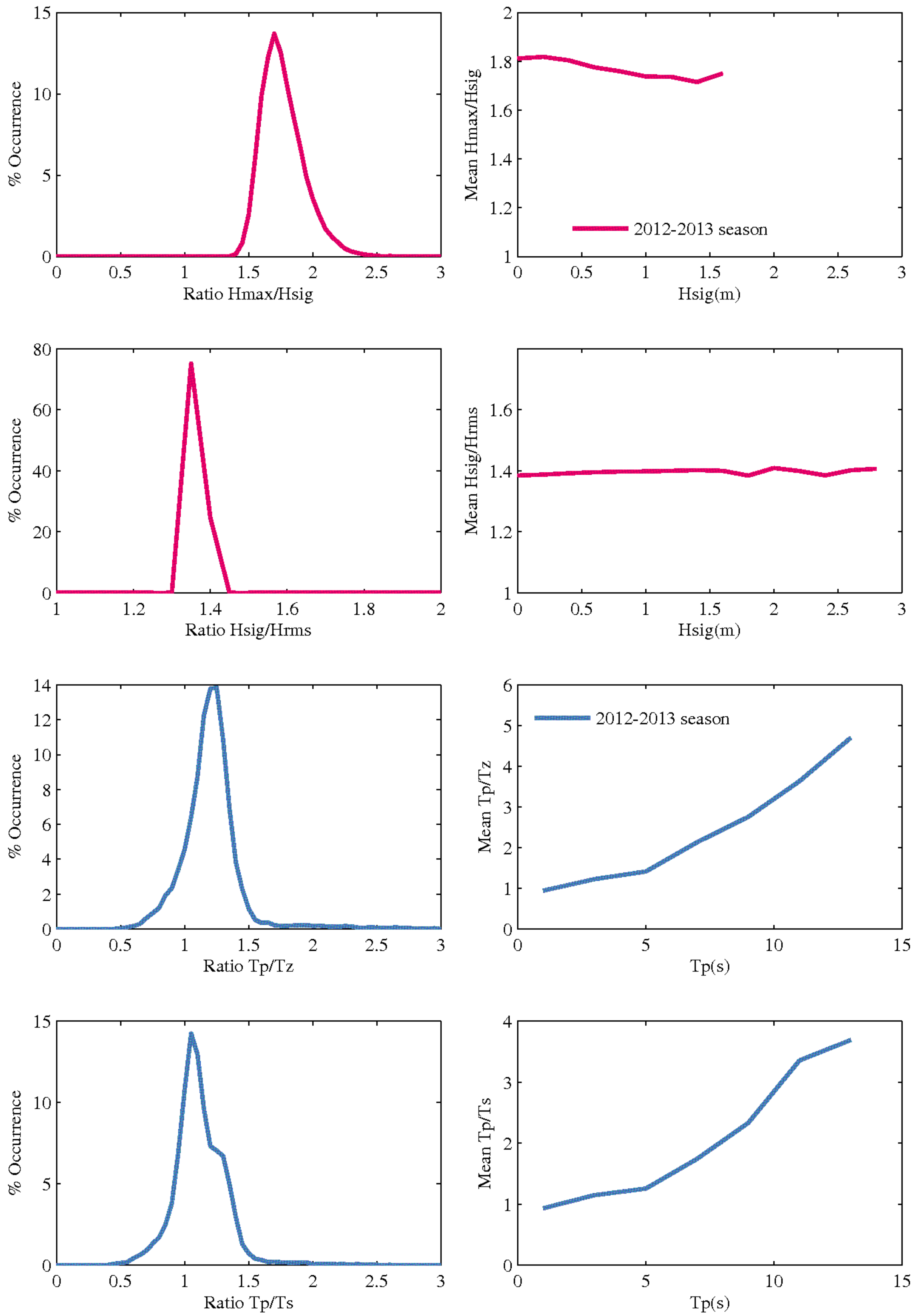


Figure 13.5: Abbot Point - Wave parameter relationships

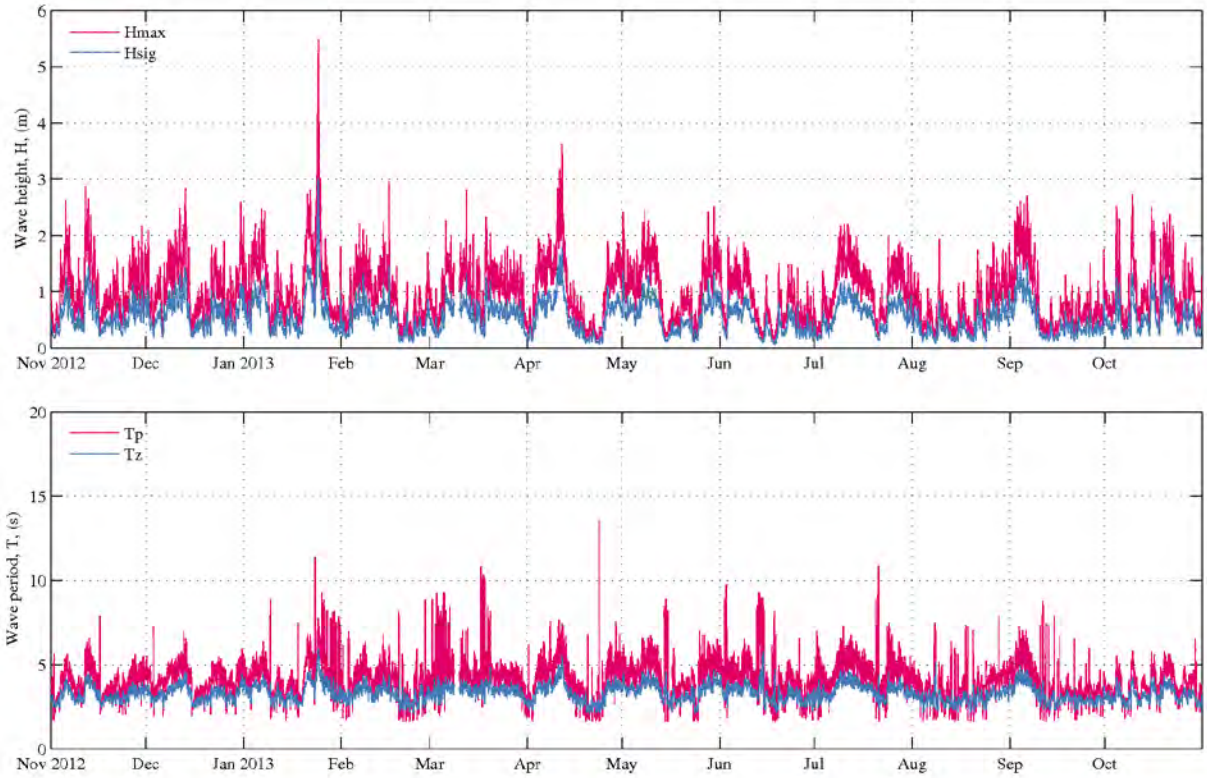


Figure 13.6: Abbot Point - Daily wave recordings

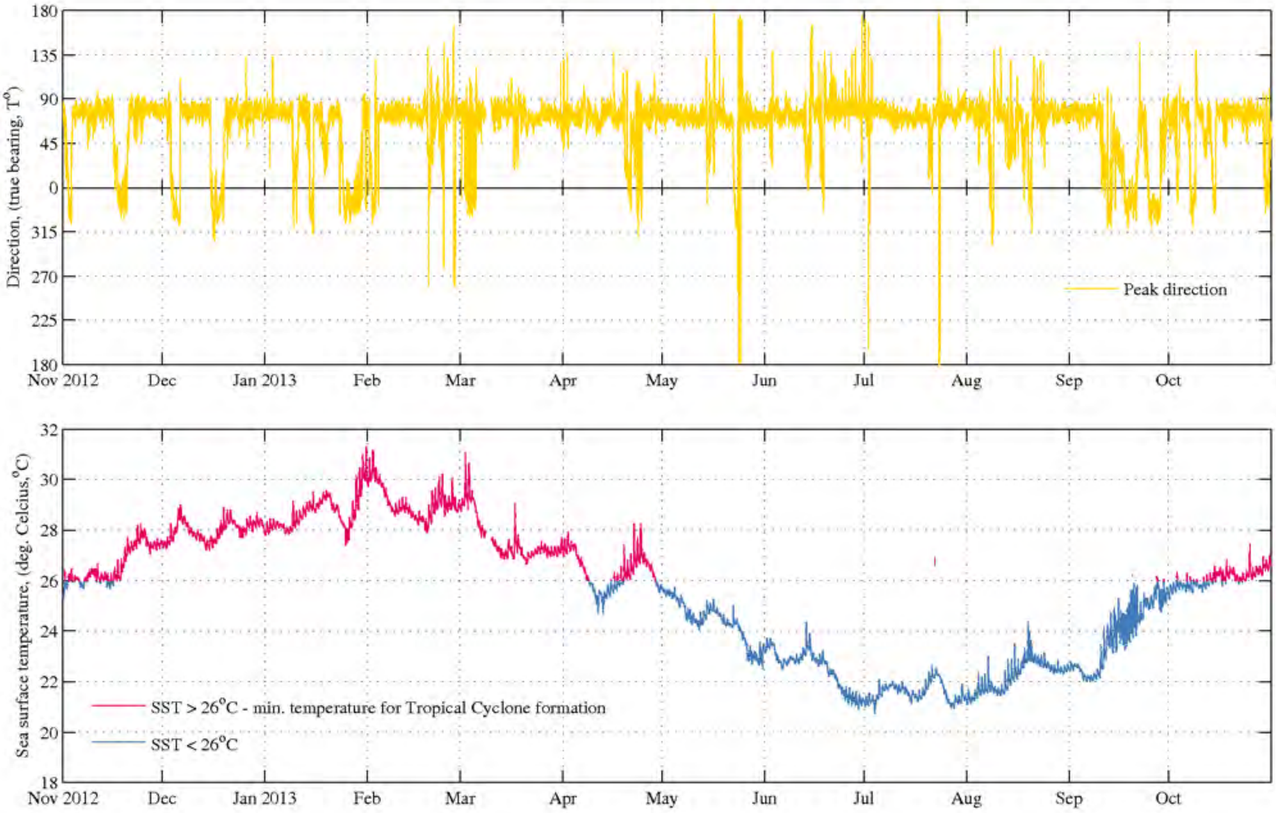


Figure 13.7: Abbot Point - Sea surface temperature and peak wave directions

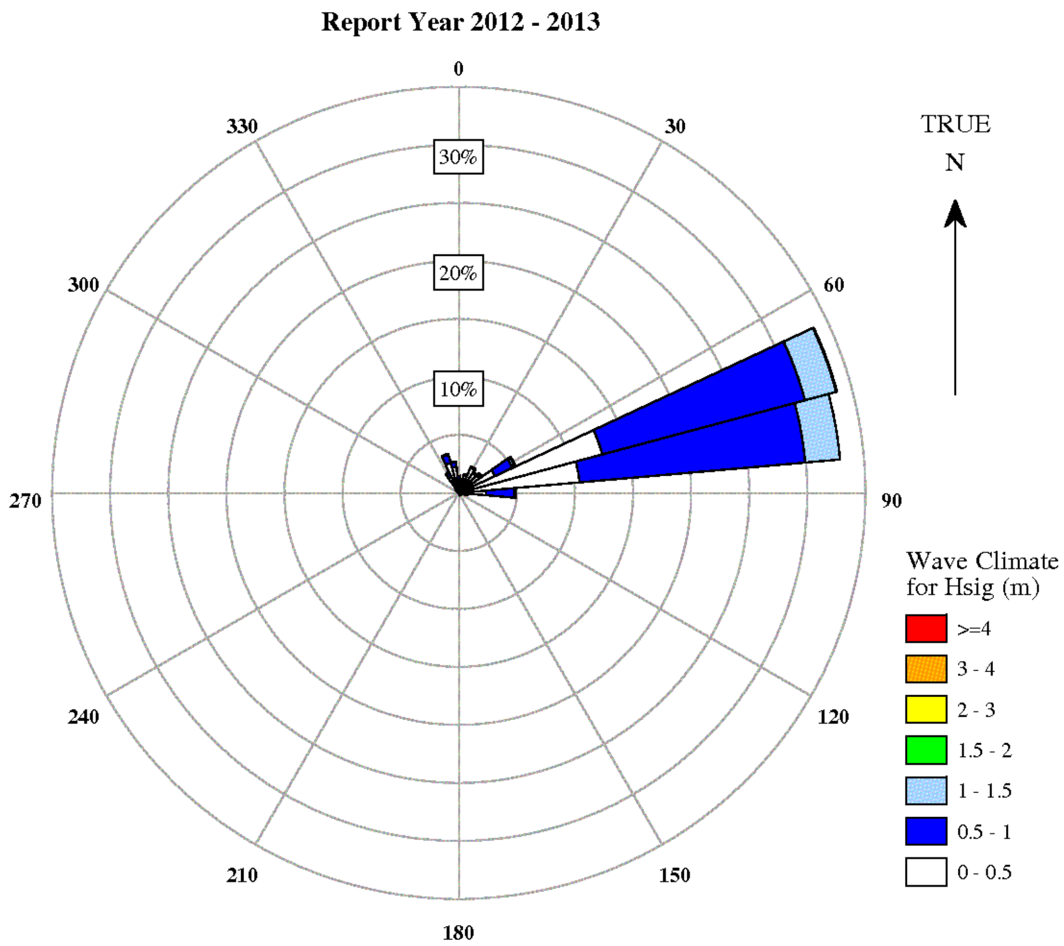


Figure 13.8: Abbot Point - Directional wave rose

14. Townsville

Data Overview

The Townsville wave buoy has been operational for nearly 38 years. The data record for the period November 2012 to October 2013 was exceptional, with total gaps of only 3.98 days, equivalent to 98.9% data return. The buoy was replaced once during this reporting period on 29 January 2013 (Table 14.1).

On 28 January 2013, Ex-TC Oswald passed through the Townsville region as a low pressure system travelling from north to south just to the west of the buoy (inland). As a result of Ex-TC Oswald's passing there was one significant wave height (Hsig) recorded that made it into the top ten ranks and one maximum wave height (Hmax) that also made the top ten ranking (Table 14.2). This being a Hsig of 2.7 m, ranking ninth in respected to the highest waves recoded at the site, while a Hmax of 5.4 m was also reported later on the same day and ranked fourth.

The recorded wave heights over the reporting period are relatively similar for both the summer and winter seasons. There was however some differences in the recorded peak period (Tp) values. Figure 14.4 illustrates that there was a higher occurrence of recorded Tp values over five seconds during the winter months.

The wave climate during the reporting period was very similar to the wave climate of the whole record, as evident in the percentage time exceedance figure (Figure 14.2) and histograms of the occurrence of Hsig and Tp (Figure 14.3 and Figure 14.4). The monthly average Hsig generally fell within one standard deviation (sd) of the long-term mean with the exception of three months: February, July and August. During July the mean was higher than the mean +1 sd while during February and August the mean was −1 sd below the historical monthly mean.

The plot of wave direction over the 2012-13 season (Figure 14.8) showed a dominant easterly direction with an occasional swing to the north east, mostly during summer. The dominance of this incident wave direction is reflected in the directional wave rose plot (Figure 14.9).

The temperature (sea surface temperature, SST) measured in the buoy hull showed the recorded values ranging from 21 °C to 33 °C during the reporting year. The SST from October to the beginning of May was generally warm enough for tropical cyclone development but fell below the 26 °C threshold temperature for the remaining months.

Townsville

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 361.00
Gaps in data used in analysis (days)	= 3.98
Number of records used in analysis	= 17328

All data since-1975

Maximum possible analysis years (last record - first record)	= 37.95
Total number of years used in analysis	= 26.08
Gaps in data used in analysis (years)	= 11.86
Number of records used in analysis	= 282907

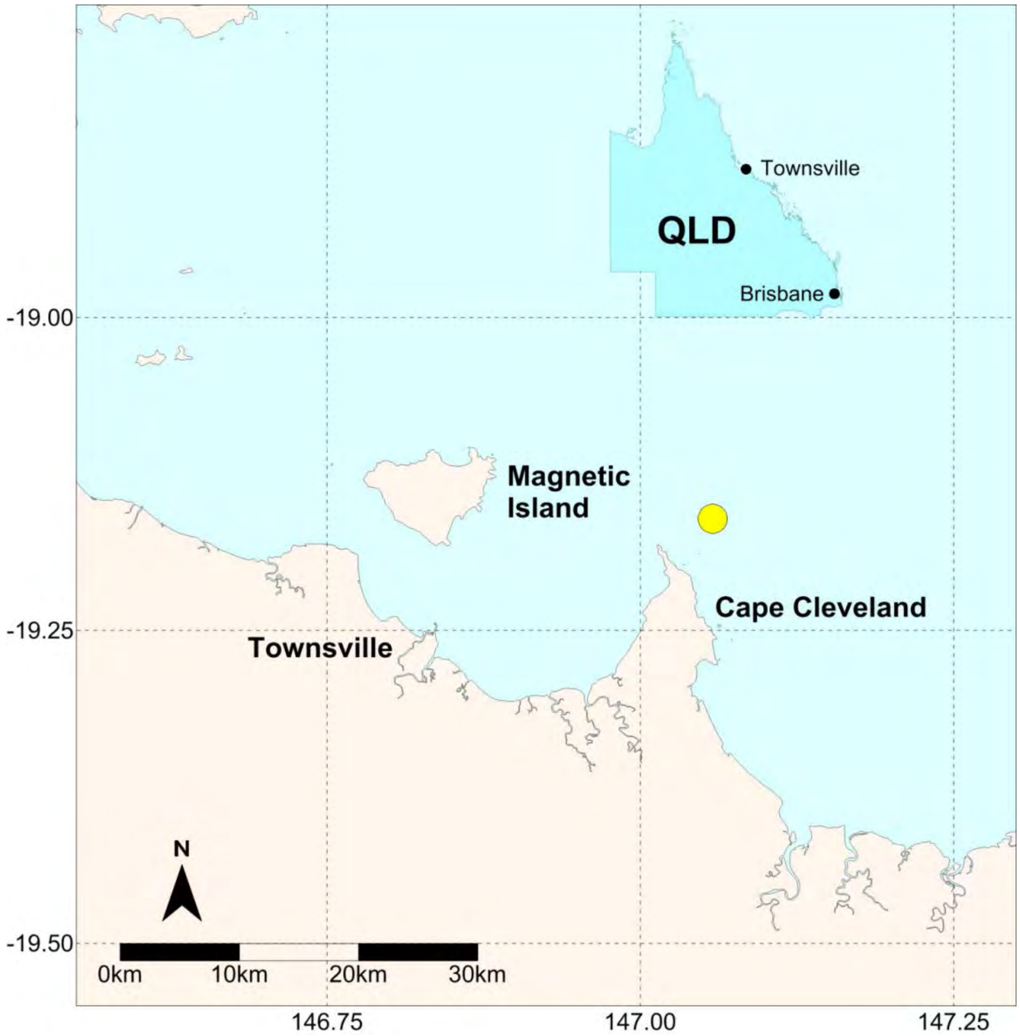


Figure 14.1: Townsville - Locality plan

Table 14.1: Townsville - Buoy deployments during the 2012–13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
19°09.624'S	147°03.504'E	16	5/06/2012	29/01/2013
19°09.648'S	147°03.521'E	16	29/01/2013	current

Table 14.2: Townsville - Highest waves

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	3/02/2011 01:30	5.5	3/02/2011 01:00	10.1
2	13/01/2009 08:00	3.7	13/01/2009 07:30	6.6
3	24/03/1997 02:00	3.6	24/03/1997 03:00	6.0
4	30/01/2010 22:30	3.0	24/01/2013 07:30	5.4
5	23/12/1990 09:27	3.0	10/01/1998 15:00	5.4
6	10/01/1998 15:00	2.9	20/03/2006 08:00	5.3
7	20/03/2006 08:00	2.9	30/01/2010 20:30	5.2
8	3/03/1979 03:00	2.8	11/02/1999 18:30	5.1
9	24/01/2013 06:00	2.7	1/02/1986 20:49	4.9
10	11/02/2008 19:00	2.7	22/10/1996 21:30	4.9

Table 14.3: Townsville - Significant meteorological events with threshold Hsig of 1.5 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
12/11/2012 23:00	1.8 (1.9)	3.2 (3.9)	7.2	Low [1014 hPa] situated in the Coral Sea.
24/01/2013 6:30	2.5 (2.7)	4.3 (5.4)	6.4	Ex TC Oswald passed from north to south as a low pressure system with a central pressure of 990 hPa at Townsville.
11/04/2013 8:30	2.0 (2.1)	3.6 (4.5)	7.7	Deepening surface trough in the Western Coral Sea [1004 hPa]

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

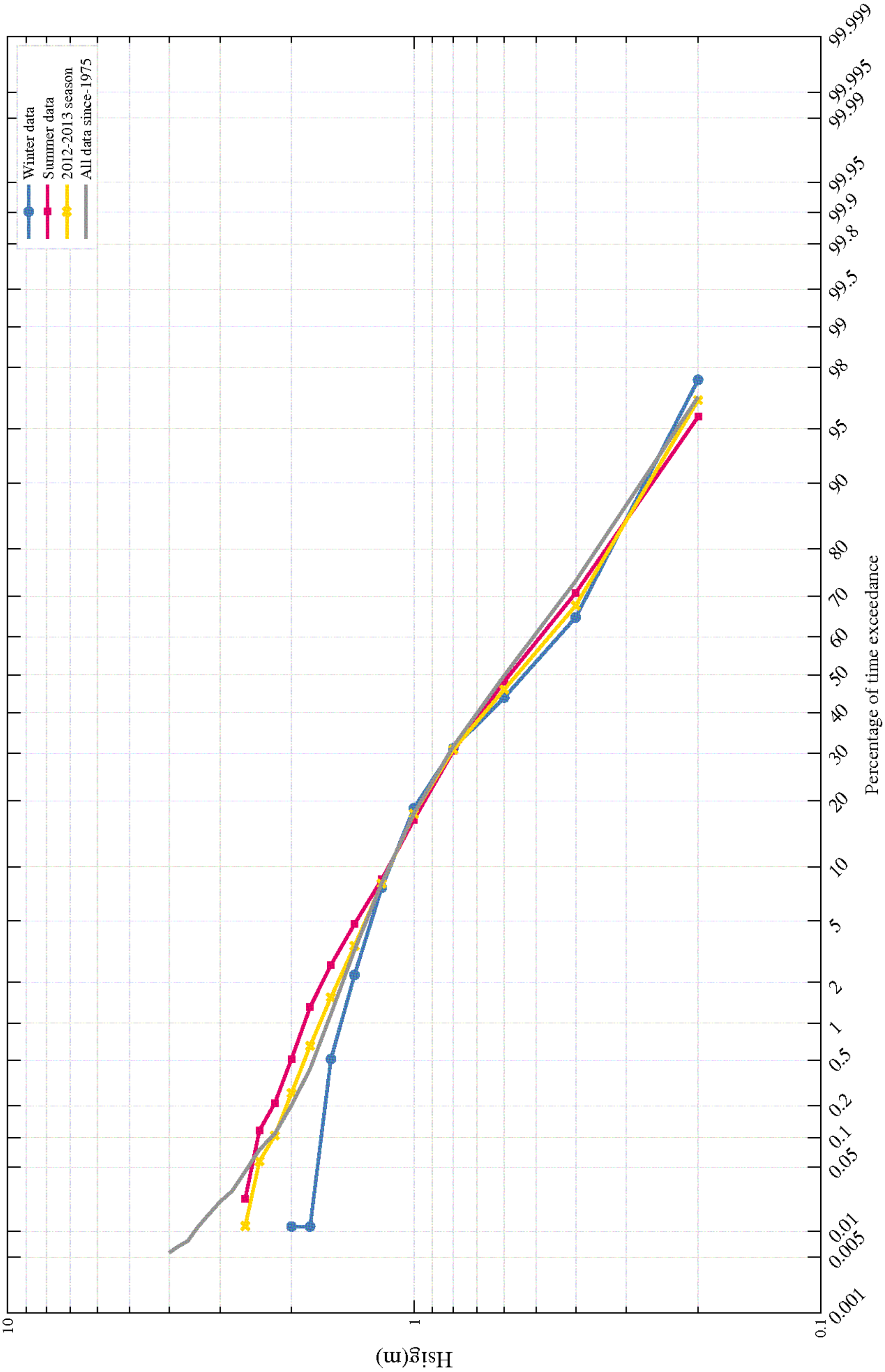


Figure 14.2: Townsville - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

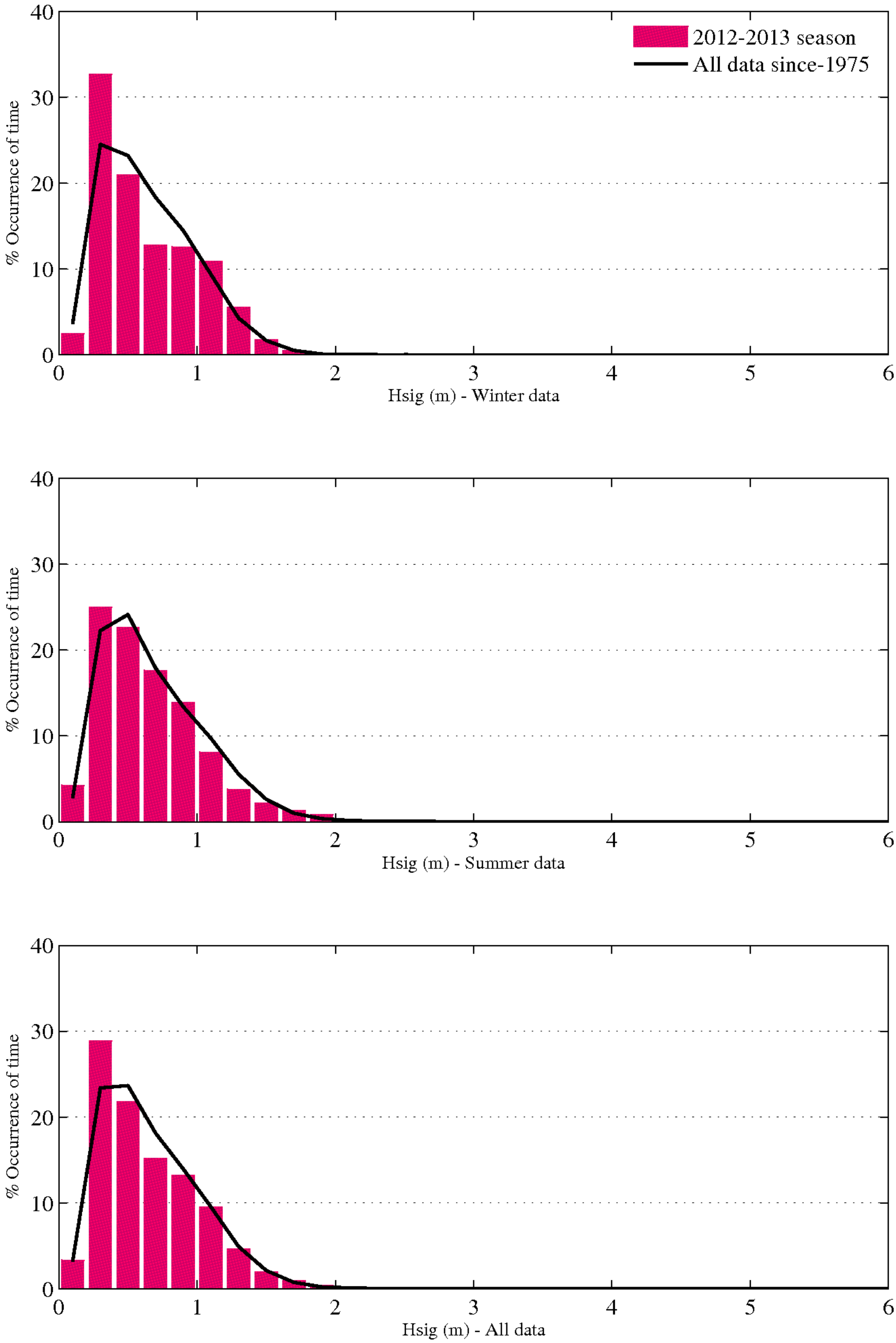


Figure 14.3: Townsville - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

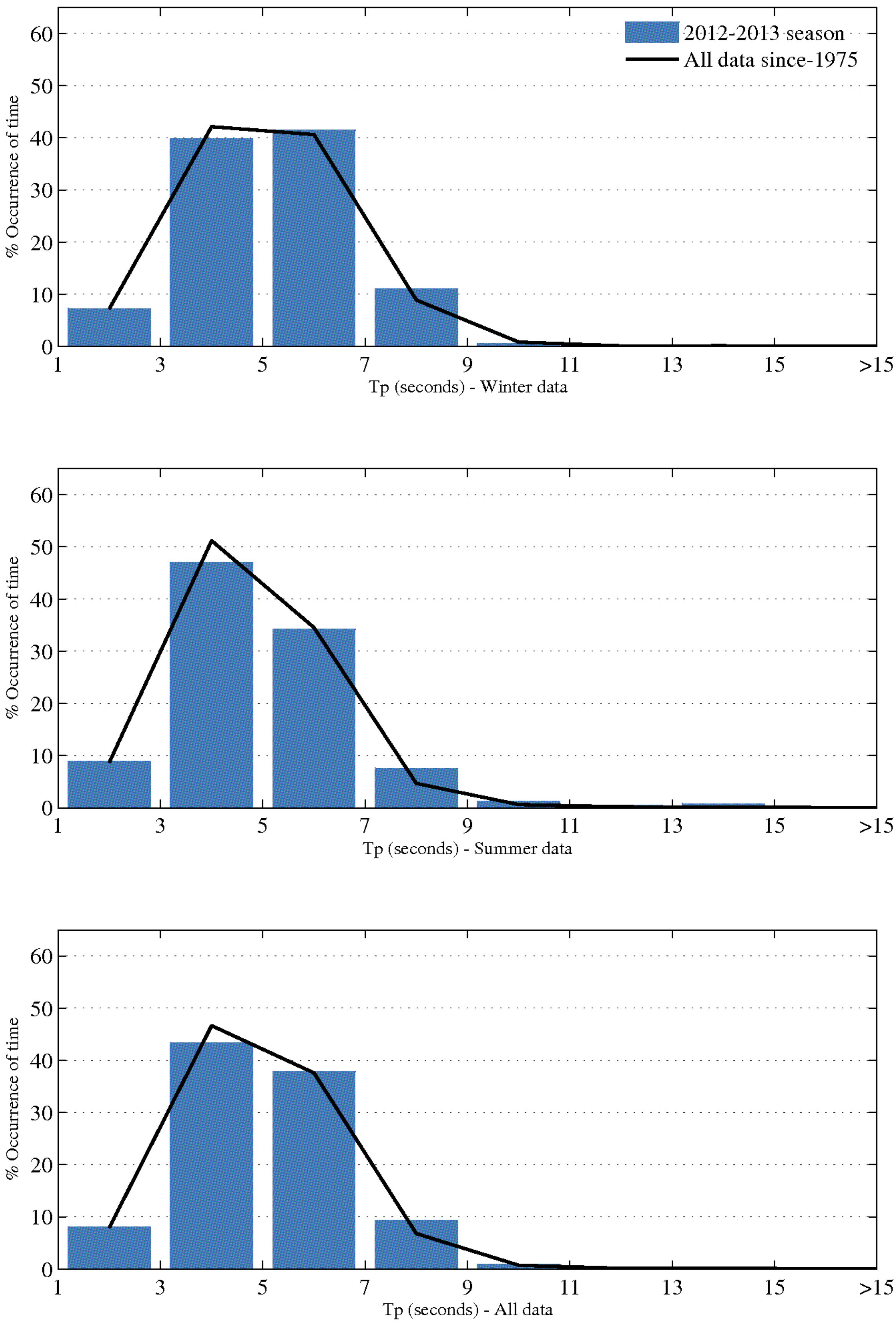


Figure 14.4: Townsville - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

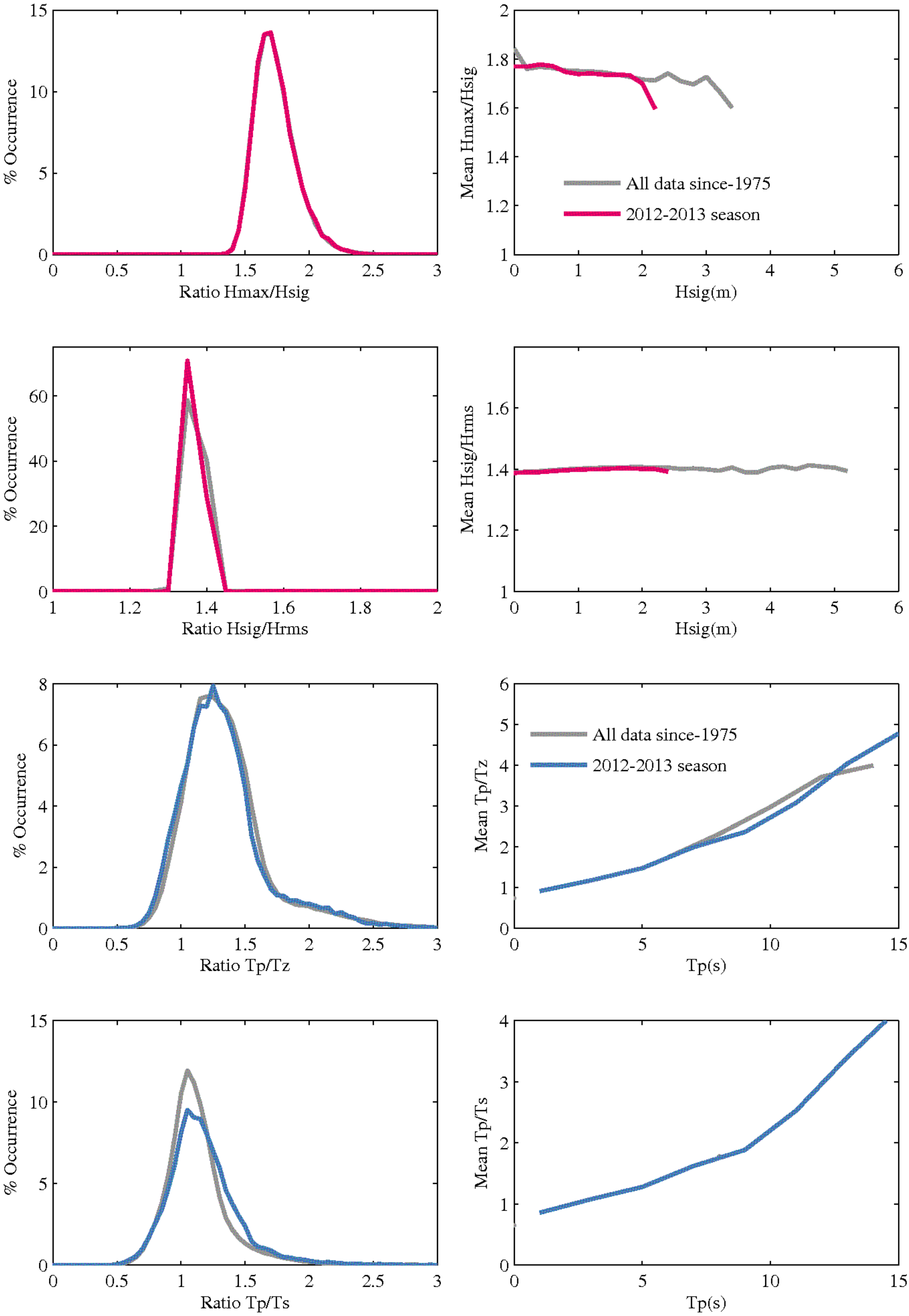


Figure 14.5: Townsville - Wave parameter relationships

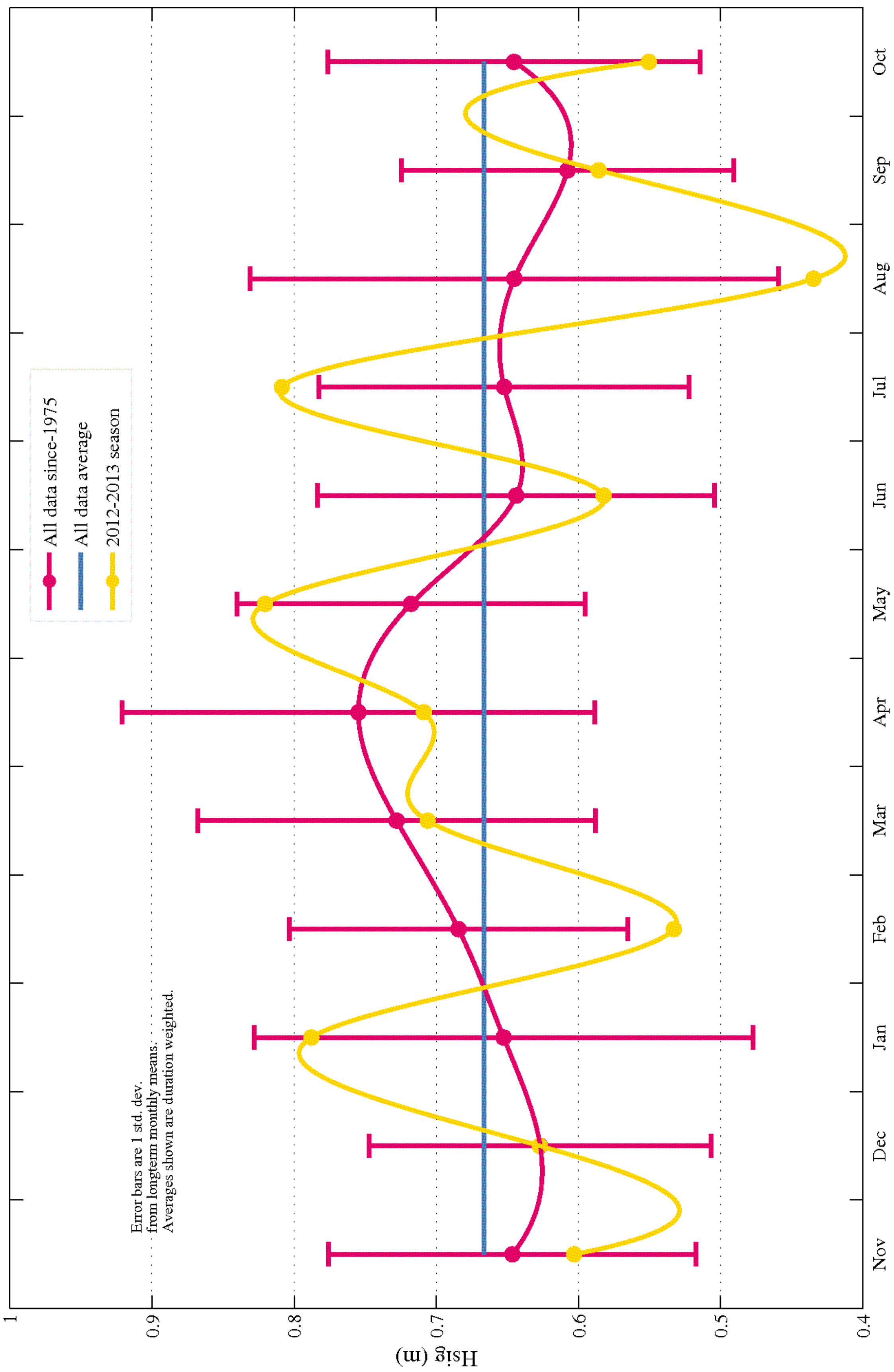


Figure 14.6: Townsville - Monthly average wave height (Hsig) for seasonal year and for all data

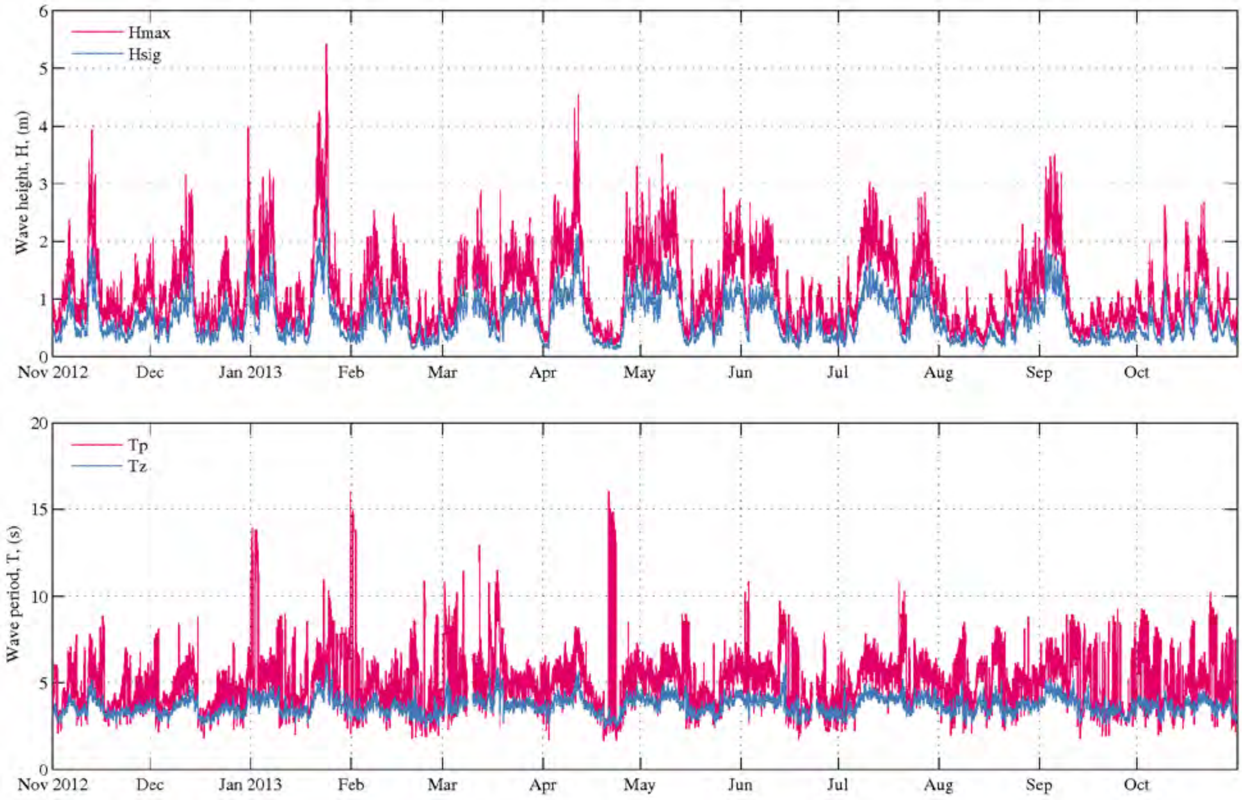


Figure 14.7: Townsville - Daily wave recordings

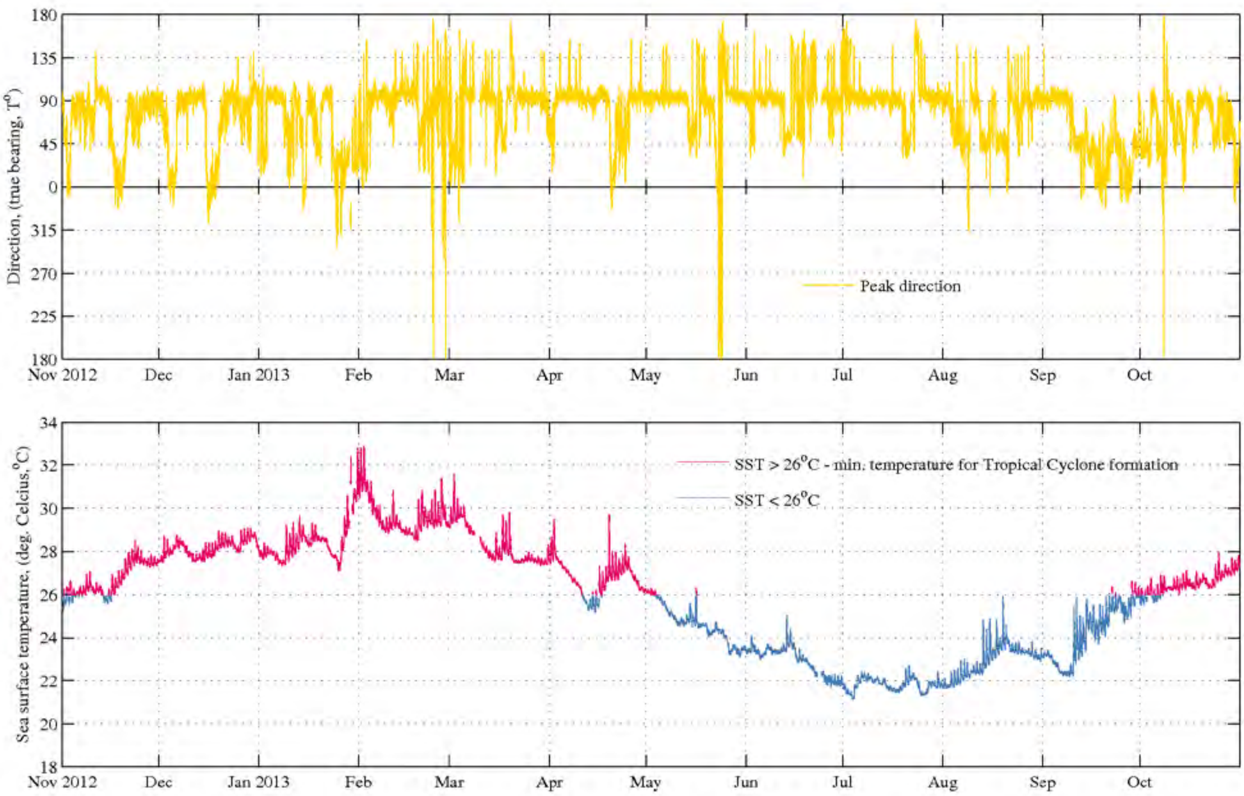
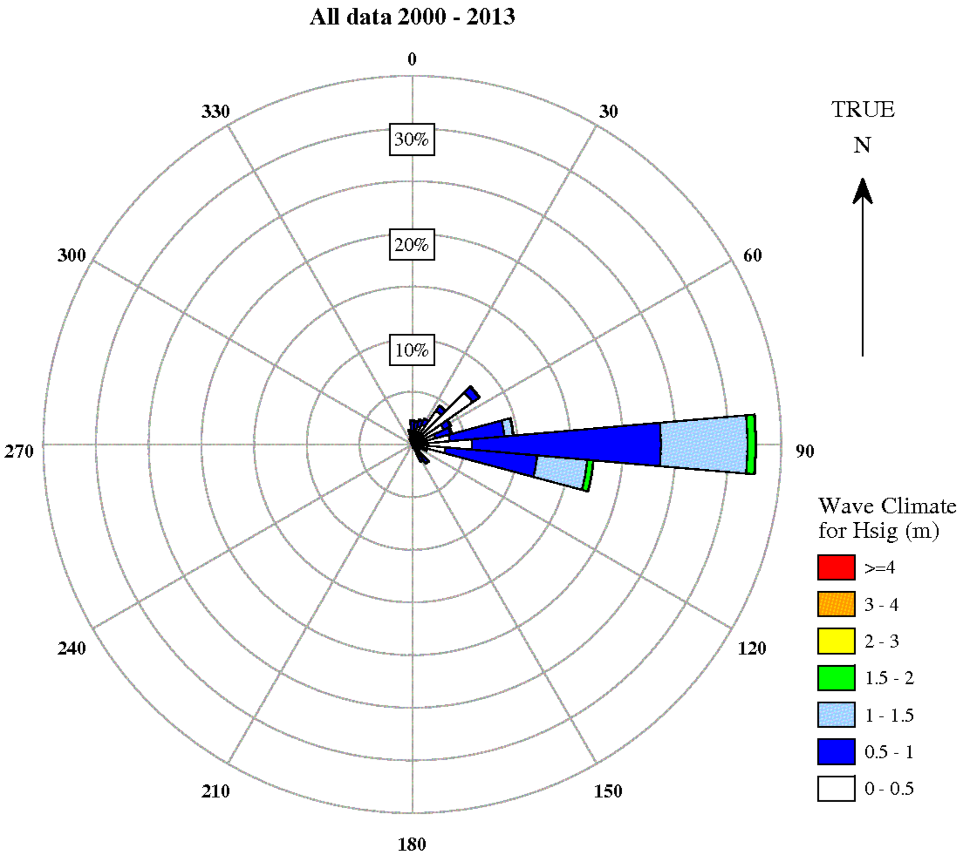


Figure 14.8: Townsville - Sea surface temperature and peak wave directions



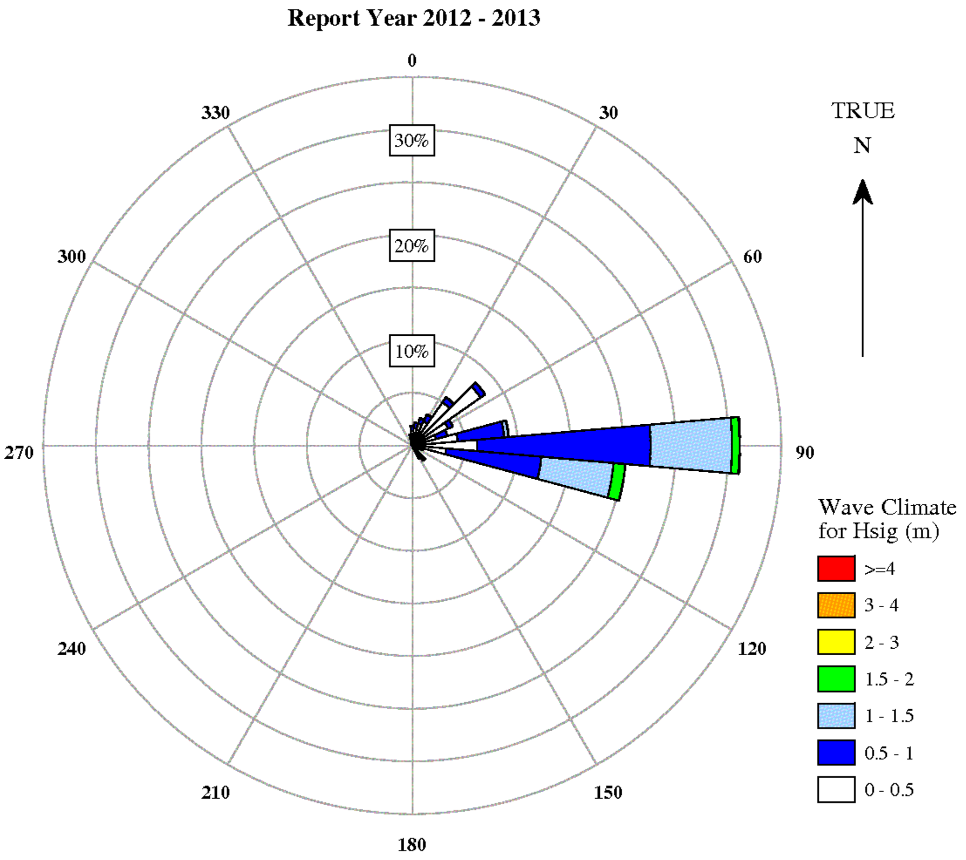


Figure 14.9: Townsville - Directional wave rose

15. Cairns

Data Overview

The Cairns wave buoy has been operational for 38.5 years. The data record for the period November 2012 to October 2013 was exceptional, with total gaps of only 2.54 days, equivalent to 99.3% data return. The buoy was replaced once during the reporting period on 17 May October 2012 (Table 15.1).

There was one significant wave height (Hsig) recorded during the reporting period that made it into the top ten ranks and also one maximum wave height (Hmax) that made the top ten ranking (Table 15.1). Both of these recorded events occurred as a result of Ex-TC Oswald passing through the region as a low pressure system. As a result of the passing system a Hsig of 2.3 m was recorded and ranked fourth, while a Hmax of 4.7 m was reported half an hour earlier on the same day and ranked second in relation to the largest wave events ever recorded at the monitoring location.

The recorded wave heights over the reporting period are relatively similar for both the summer and winter seasons (Figure 15.2 and Figure 15.3). There was however some differences in the recorded peak period (Tp) values. Figure 15.4 illustrates that there was a much higher occurrence of Tp measurements over five seconds during the winter months.

The wave climate during the reporting period was very similar to the wave climate of the whole record, as evident in the percentage time exceedance figure (Figure 15.2) and histograms of the occurrence of Hsig and Tp (Figure 15.3 and Figure 15.4). The monthly average Hsig generally fell within one standard deviation (sd) of the long-term mean with the exception of July. A series of passing cold fronts affected the Queensland Coast during the month of July, which likely contributed to the mean wave height being greater than +1sd above the historical monthly mean (Figure 15.6).

The current buoy deployed at Cairns is a non-directional buoy and therefore does not measure wave direction. Therefore no directional wave data for Cairns has been presented or commented on in this report.

Cairns

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 362.44
Gaps in data used in analysis (days)	= 2.54
Number of records used in analysis	= 17397

All data since-1975

Maximum possible analysis years (last record - first record)	= 38.50
Total number of years used in analysis	= 26.46
Gaps in data used in analysis (years)	= 12.04
Number of records used in analysis	= 291984

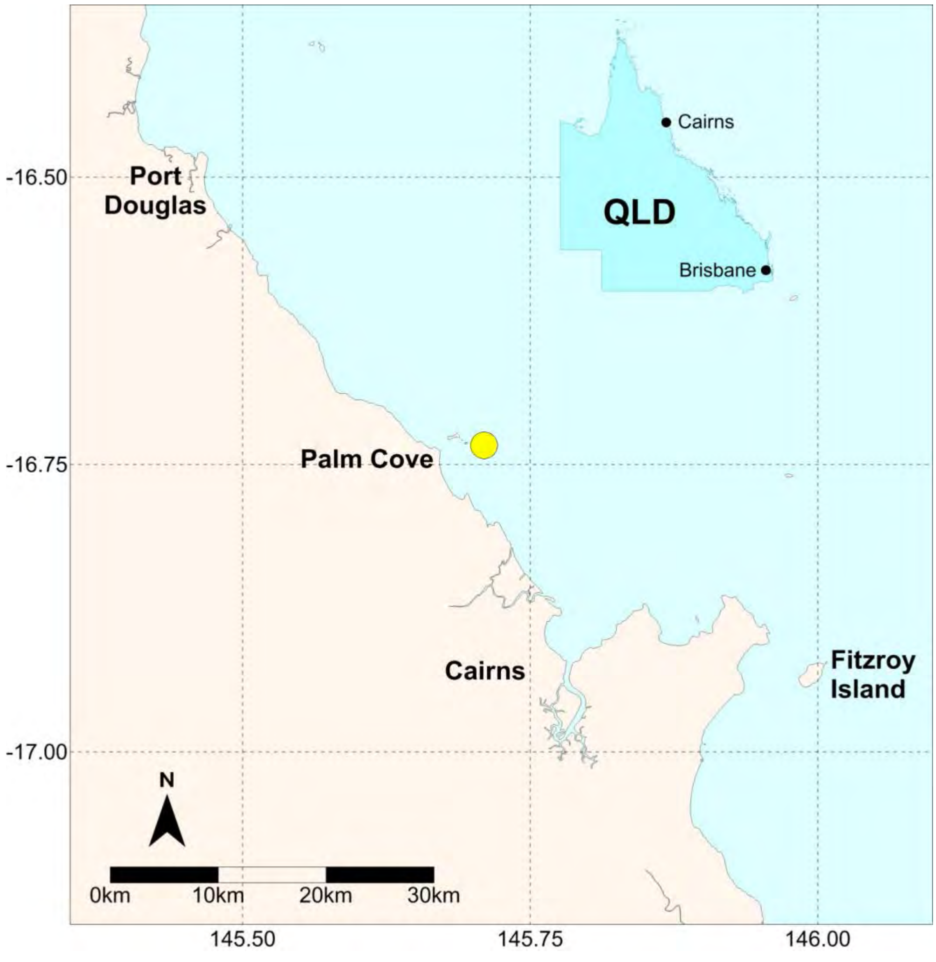


Figure 15.1: Cairns - Locality plan

Table 15.1: Cairns - Buoy deployments for the 2012–13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
16°44.010'S	145°42.594'E	12.5	20/04/2012	17/05/2013
16°43.950'S	145°42.620'E	12	17/05/2013	current

Table 15.2: Cairns - Highest waves

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	27/02/2000 21:30	2.8	28/02/2000 01:00	5.0
2	11/02/1999 21:00	2.5	23/01/2013 23:00	4.7
3	3/02/2011 04:30	2.4	11/02/1999 22:00	4.6
4	23/01/2013 23:30	2.3	23/12/1990 20:54	4.5
5	23/12/1990 20:54	2.2	3/02/2011 04:00	4.1
6	19/03/1990 08:42	1.9	12/01/2009 07:00	3.4
7	31/01/1977 09:00	1.9	3/01/1979 03:00	3.3
8	12/01/2009 07:00	1.9	4/03/2008 23:30	3.3
9	3/01/1979 03:00	1.8	31/01/1977 09:00	3.2
10	11/02/2004 06:00	1.6	26/04/2000 01:00	3.2

Table 15.3: Cairns - Significant meteorological events with threshold Hsig of 1.0 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
23/01/2013 23:30	2.2 (2.3)	3.8 (4.7)	6.1	Ex-TC Oswald passed from north to south as a low pressure system with a central pressure of 989 hPa at Cairns.
01/05/2013 13:00	1.2 (1.3)	1.9 (2.4)	5.3	Tropical Cyclone Zane [992 hPa] moving in a westerly direction, north of Cairns.
11/07/2013 21:30	1.3 (1.4)	2.2 (2.7)	4.5	A high [1039 hPa] over the Tasman Sea extending a firm ridge up the East Coast of Queensland.
04/09/2013 08:00	1.4 (1.5)	2.3 (3.0)	4.9	High [1034 hPa] in the Tasman Sea extending a firm ridge along the Queensland Coast.

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

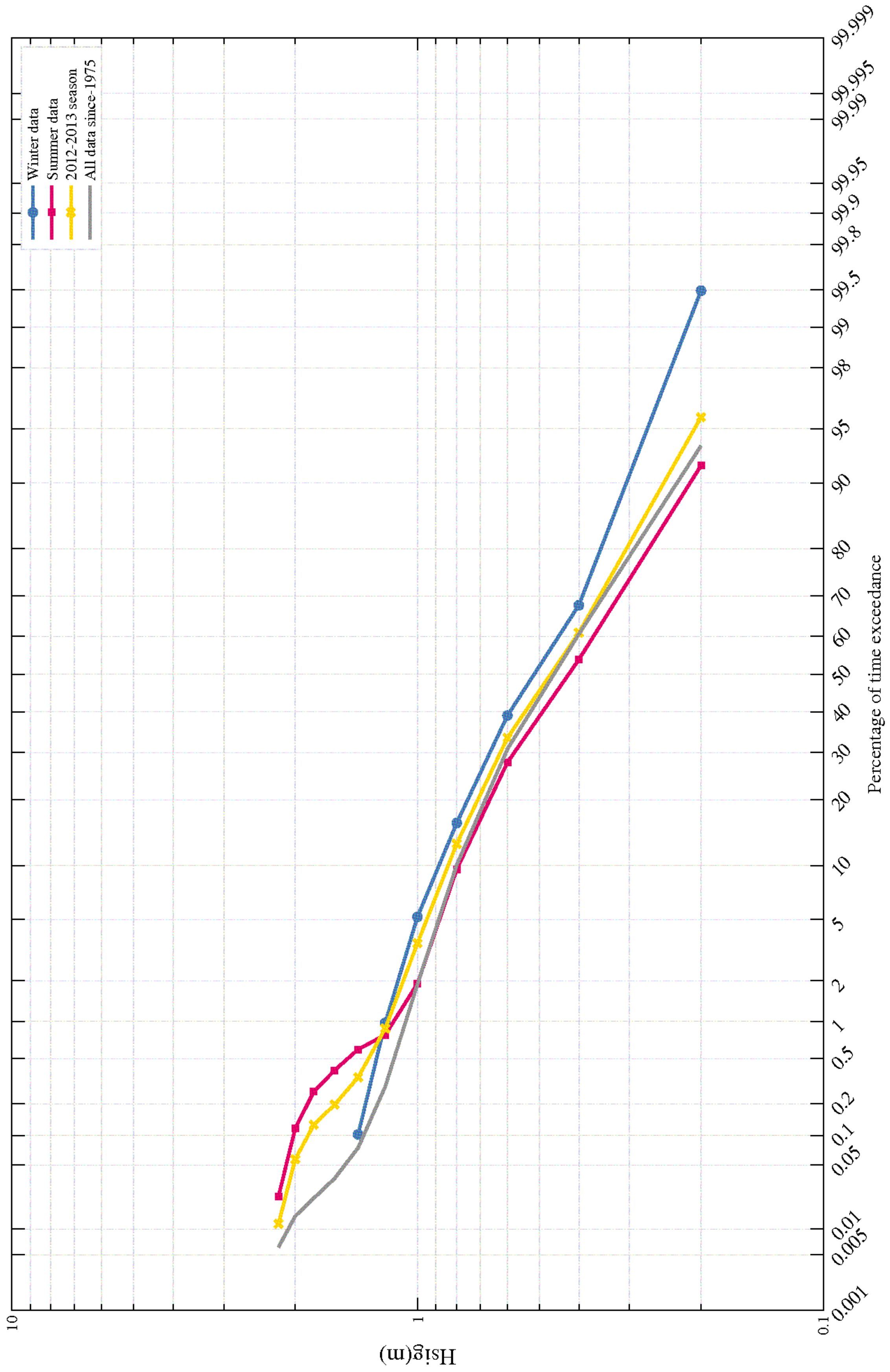


Figure 15.2: Cairns - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

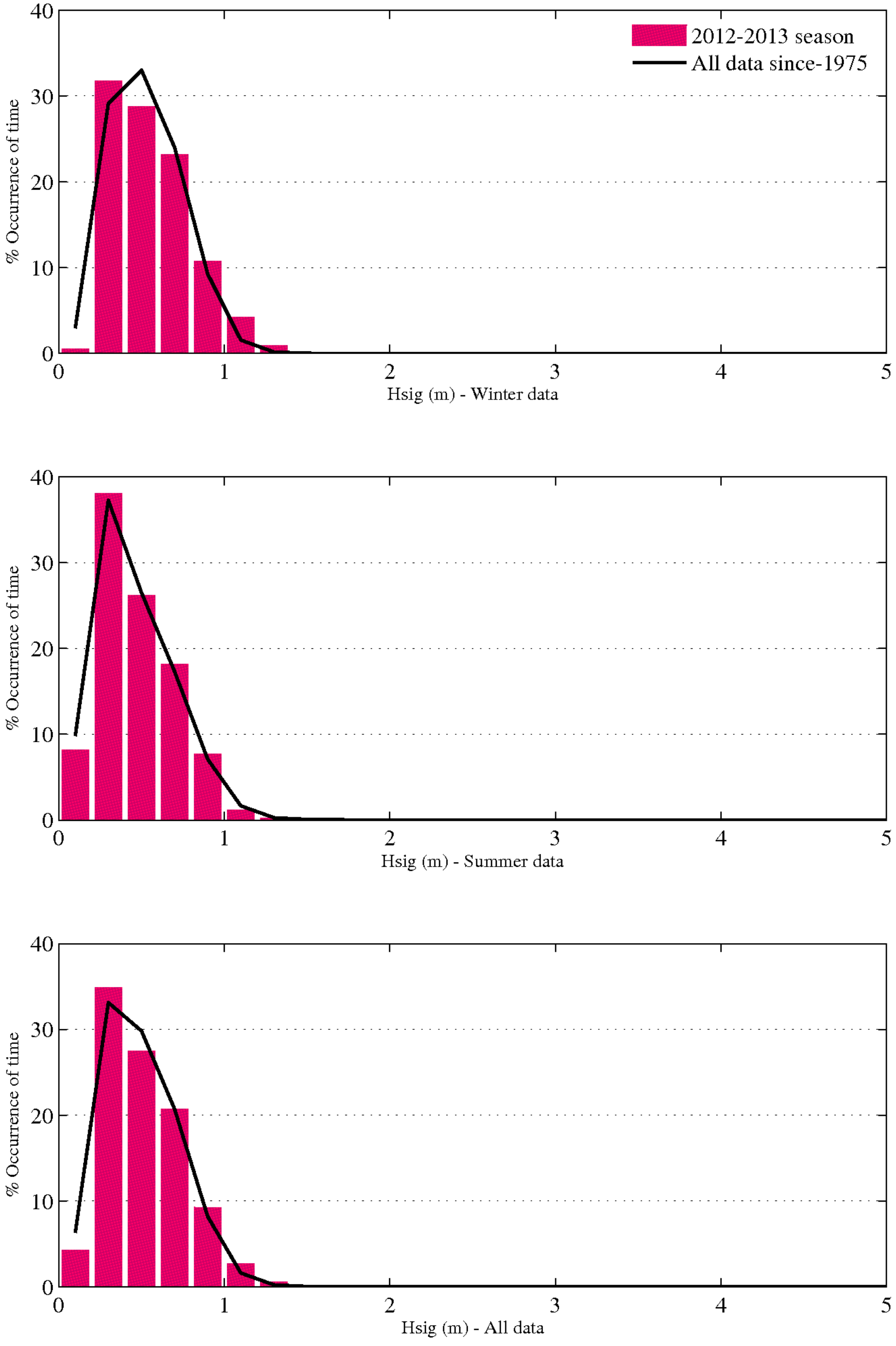


Figure 15.3: Cairns - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

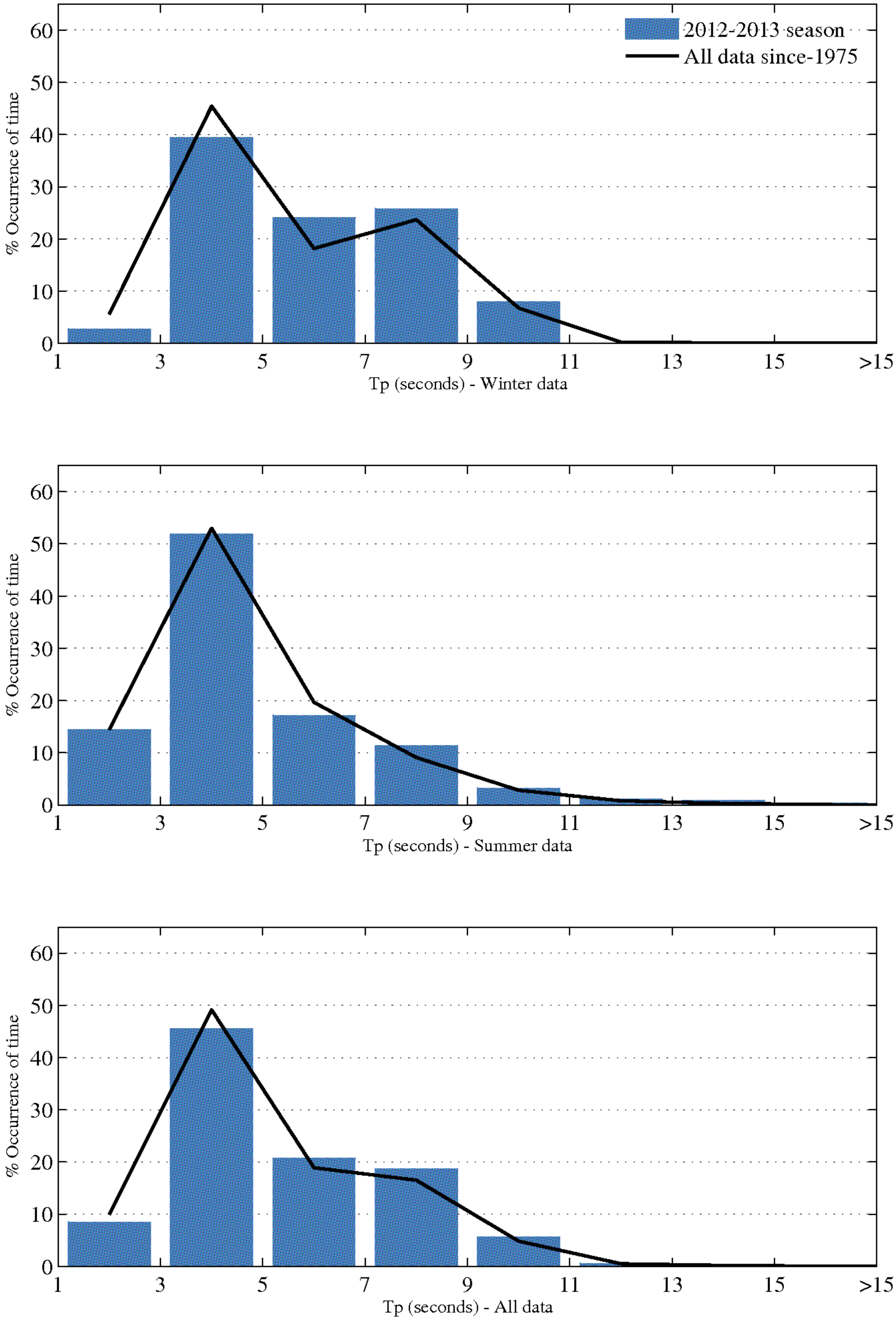


Figure 15.4: Cairns - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

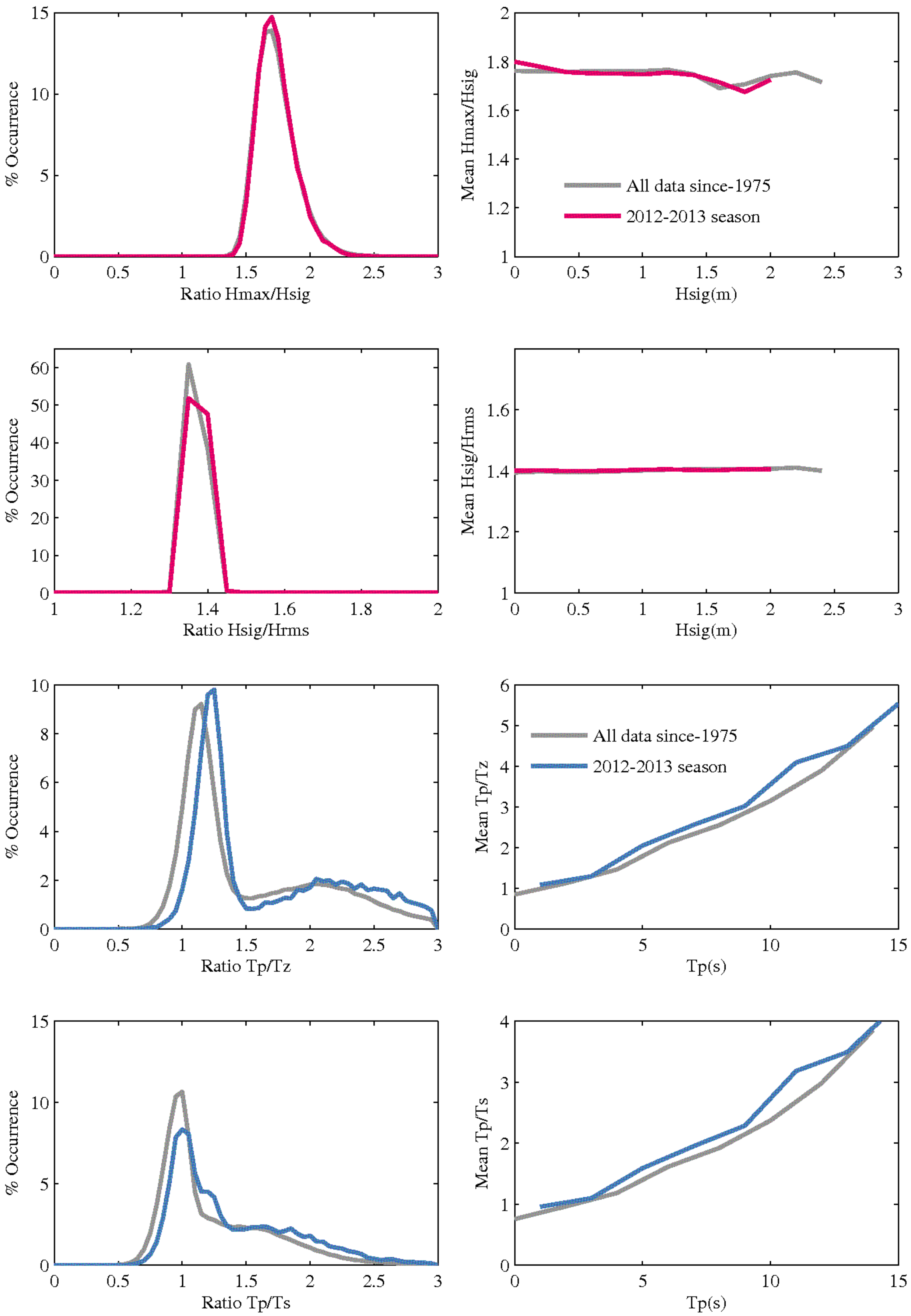


Figure 15.5: Cairns - Wave parameter relationships

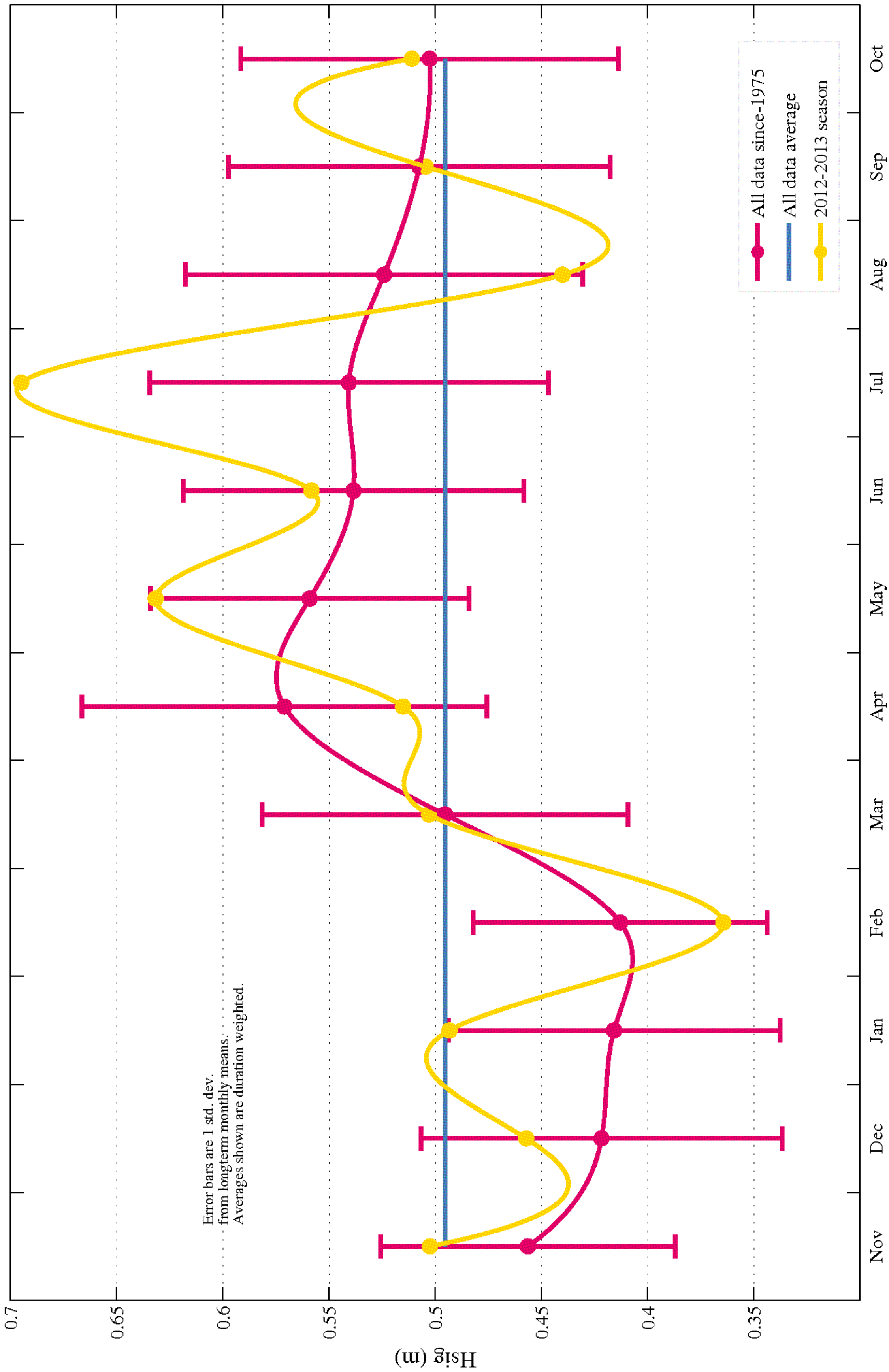


Figure 15.6: Cairns - Monthly average wave height (Hsig) for seasonal year and for all data

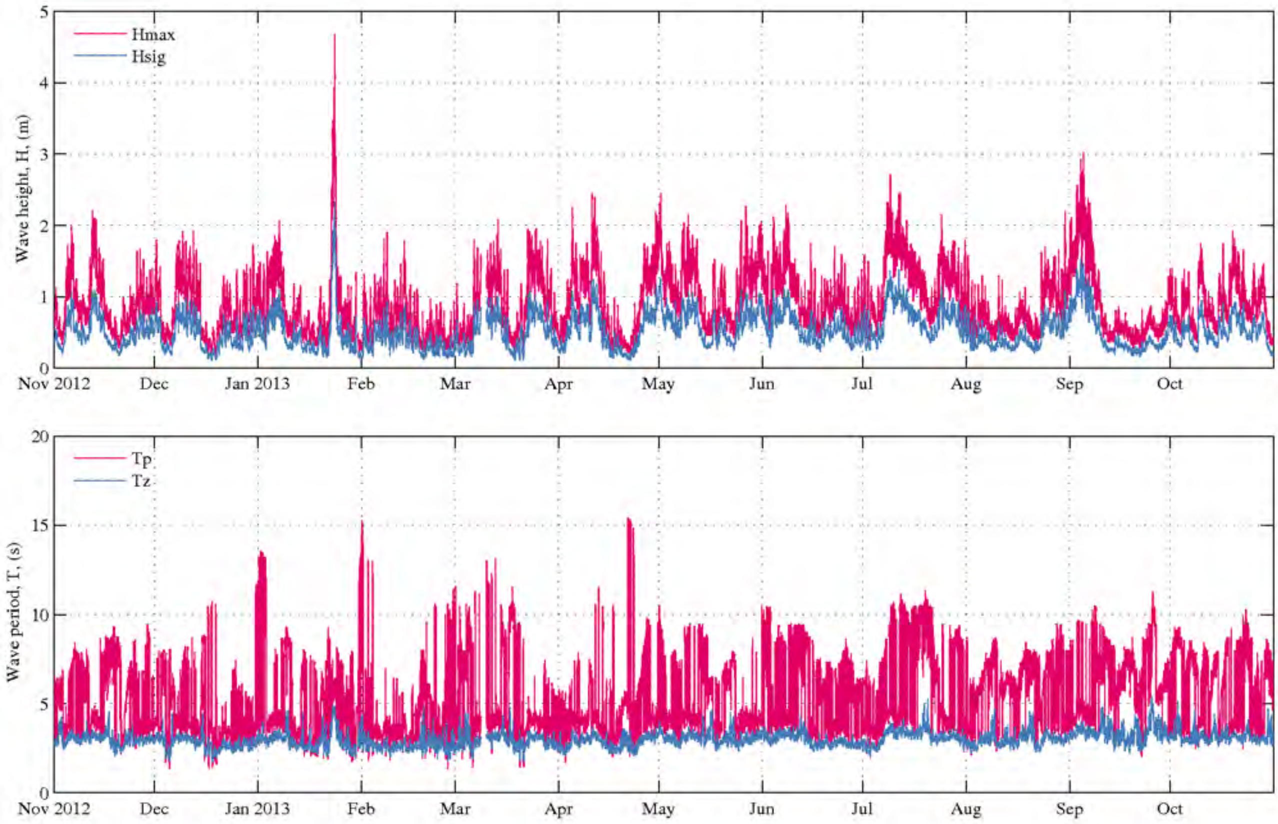


Figure 15.7: Cairns - Daily wave recordings

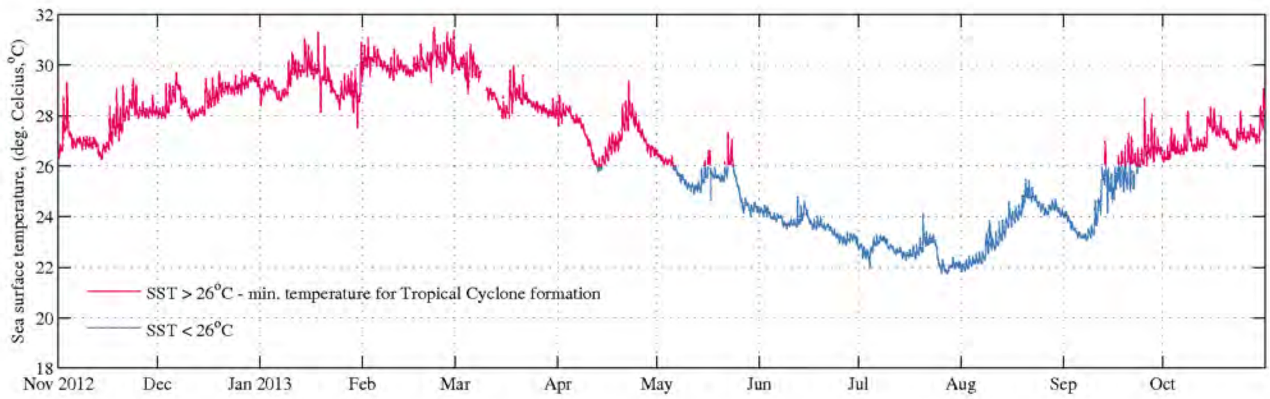


Figure 15.8: Cairns - Daily Sea surface temperature

16. Albatross Bay

Data Overview

The Albatross Bay wave buoy has been operational for just under five years with an overall data return of 94.7 per cent. The data record for the period November 2012 to October 2013 was good, with total gaps of only eight days, equivalent to 97.7 per cent data return. The buoy was replaced just prior to this reporting period on 26 June 2012 (Table 16.1).

The highest significant (Hsig) and maximum (Hmax) wave heights ever recorded at Albatross Bay were measured during this reporting period. These being a Hsig of 4.1 m and Hmax of 6.7 m recorded on 22 January 2013 at 13:00 (Table 16.2). Both of these wave events occurred as a result of the presence TC Oswald in the Gulf of Carpentaria.

Figure 16.2 and Figure 16.3 illustrate a notable difference in recorded wave heights between the winter and summer season. Figure 16.3 shows that no waves over 1 m Hsig were recorded during winter while during summer waves over 1 m occurred 7.5% of the time.

The wave climate during the reporting period was very similar to the wave climate of the whole record, as evident in the percentage time exceedance figure (Figure 16.2) and histograms of the occurrence of Hsig and Tp (Figure 16.3 and Figure 16.4). The monthly average Hsig generally fell within one standard deviation (sd) of the long-term mean with the exception of February. During February the mean was less than −1 sd below the historic monthly mean (Figure 16.6).

The plot of wave direction over the 2012-13 season (Figure 16.8) showed a dominant south westerly direction with an occasional swing to either the west or east. The dominance of the incident wave direction is reflected in the directional wave rose plot (Figure 16.9) along with the most common wave height (Hsig) of less than 0.5 metres.

The temperature (sea surface temperature, SST) measured in the buoy hull showed the recorded values ranging from 25 °C to 33 °C during the reported year. The SST was warm enough for tropical cyclone development most of the year, except for July, August and the beginning of September when the SST fell below the 26 °C threshold (Figure 16.8).

Albatross Bay

Wave recording station

Details of data collected

2012-2013 season

Maximum possible analysis days (last record - first record)	= 364.98
Total number of days used in analysis	= 356.92
Gaps in data used in analysis (days)	= 8.06
Number of records used in analysis	= 17132

All data since-2008

Maximum possible analysis years (last record - first record)	= 4.93
Total number of years used in analysis	= 4.67
Gaps in data used in analysis (years)	= 0.26
Number of records used in analysis	= 80568

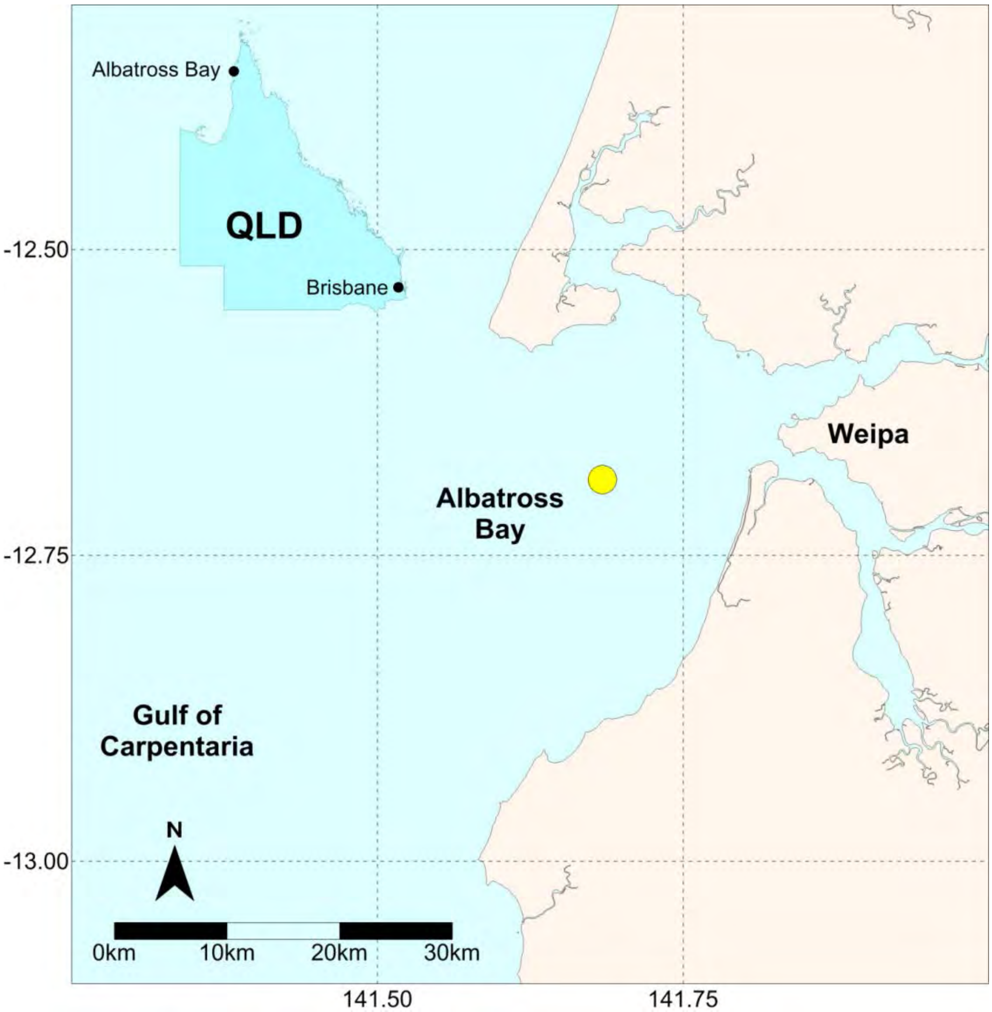


Figure 16.1: Albatross Bay - Locality plan

Table 16.1: Albatross Bay - Buoy deployments for the 2012–13 season

Latitude	Longitude	Depth (m)	Deployed date	Removal date
12°41.295'S	141°41.041'E	10	27/06/2012	current

Table 16.2: Albatross Bay - Highest waves

Rank	Date (Hs)	Hs (m)	Date (Hmax)	Hmax (m)
1	22/01/2013 13:00	4.1	22/01/2013 13:00	6.7
2	12/01/2009 00:00	3.5	11/01/2009 23:30	5.7
3	30/01/2010 03:00	3.3	30/01/2010 05:30	5.5
4	2/02/2012 08:30	2.7	3/02/2012 09:00	5.1
5	19/03/2012 02:30	2.6	18/03/2012 19:30	4.3
6	29/12/2011 17:30	2.4	22/01/2011 06:00	4.2
7	22/01/2011 01:00	2.3	2/02/2009 09:30	4.0
8	2/02/2009 11:00	2.0	29/12/2011 18:00	3.8
9	11/01/2011 04:00	2.0	27/12/2010 19:00	3.6
10	27/12/2010 22:00	1.8	11/01/2011 04:00	3.6

Table 16.3: Albatross Bay - Significant meteorological events with threshold Hsig of 1.0 m

Date	Hs (m)	Hmax (m)	Tp (s)	Event
22/01/2013 13:00	3.7 (4.1)	5.8 (6.7)	10.2	TC Oswald located over the Eastern Gulf of Carpentaria.
5/03/2013 4:00	1.3 (1.4)	2.3 (2.7)	8.8	Low pressure system situated over the Southern Gulf of Carpentaria.
24/05/2013 9:30	1.0 (1.1)	1.7 (2.0)	6.8	A large high [1032 hPa] moving into the Great Australian Bight, maintaining a firm ridge into Western Queensland and Gulf of Carpentaria waters.
01/07/2013 10:30	1.0 (1.1)	1.7 (1.8)	8.3	A large high [1033 hPa] over South Australia extending a firm ridge into the Northern Territory and Gulf of Carpentaria waters.

Denotes peak Hsig event

Notes: 1. Barometric pressure measured in hectopascals (hPa). The Hsig and Hmax values are the maximums recorded for each event and are not necessarily coincident in time. The Tp and Hsig values are coincident as a single event on the date shown. Due to possible statistical errors arising from finite length records used in calculating wave climate, the above storm peak Hsig and Hmax values are derived from the time series smoothed by a simple three hourly moving average following the recommendation of the literature (Forristall, Heideman, Leggett, Roskam, & Vanderschuren, 1996).

2. Hsig and Hmax values shown in brackets are unsmoothed values as recorded at the site.

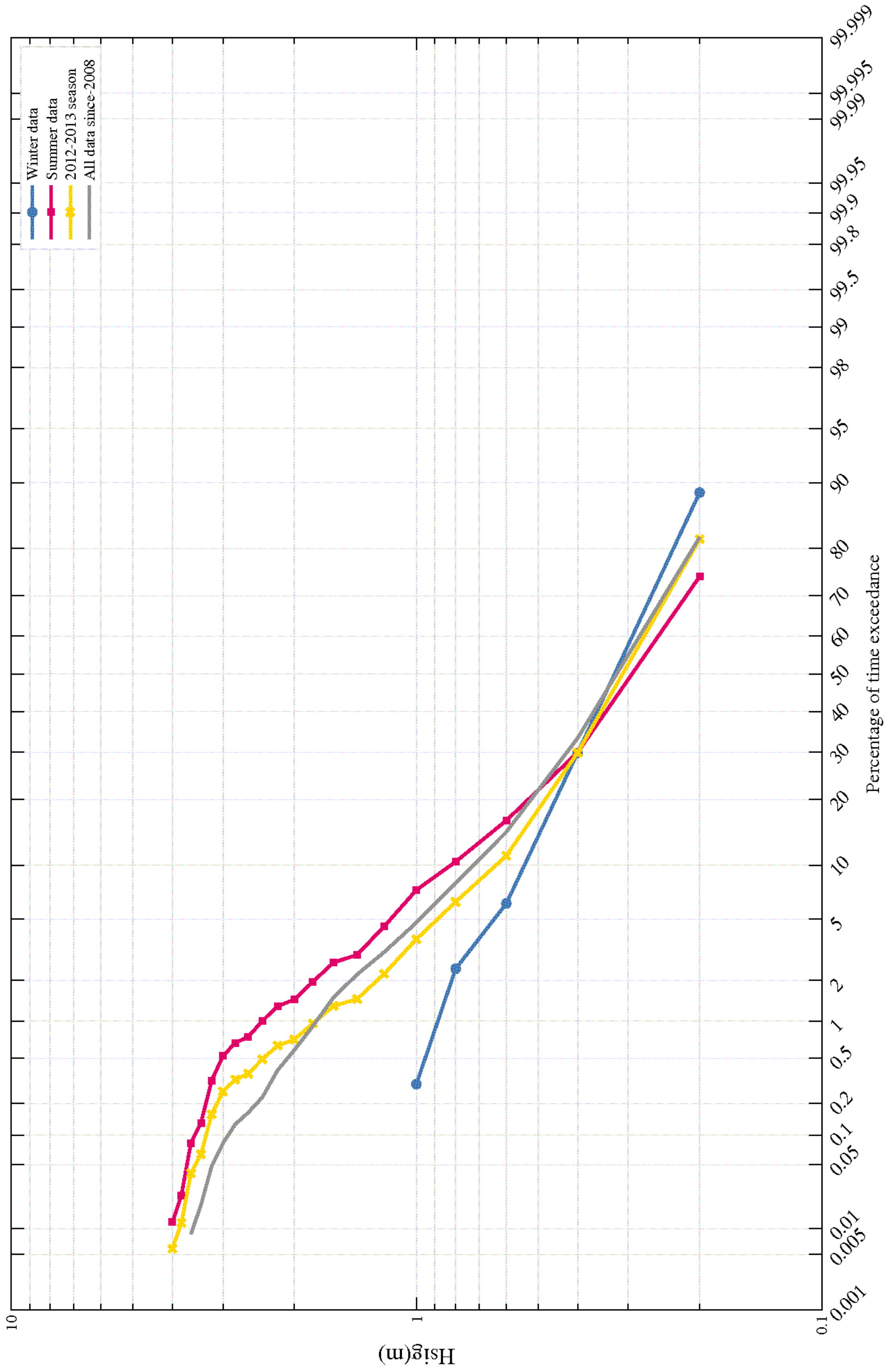


Figure 16.2: Albatross Bay - Percentage exceedance of wave height (Hsig) for all wave periods (Tp)

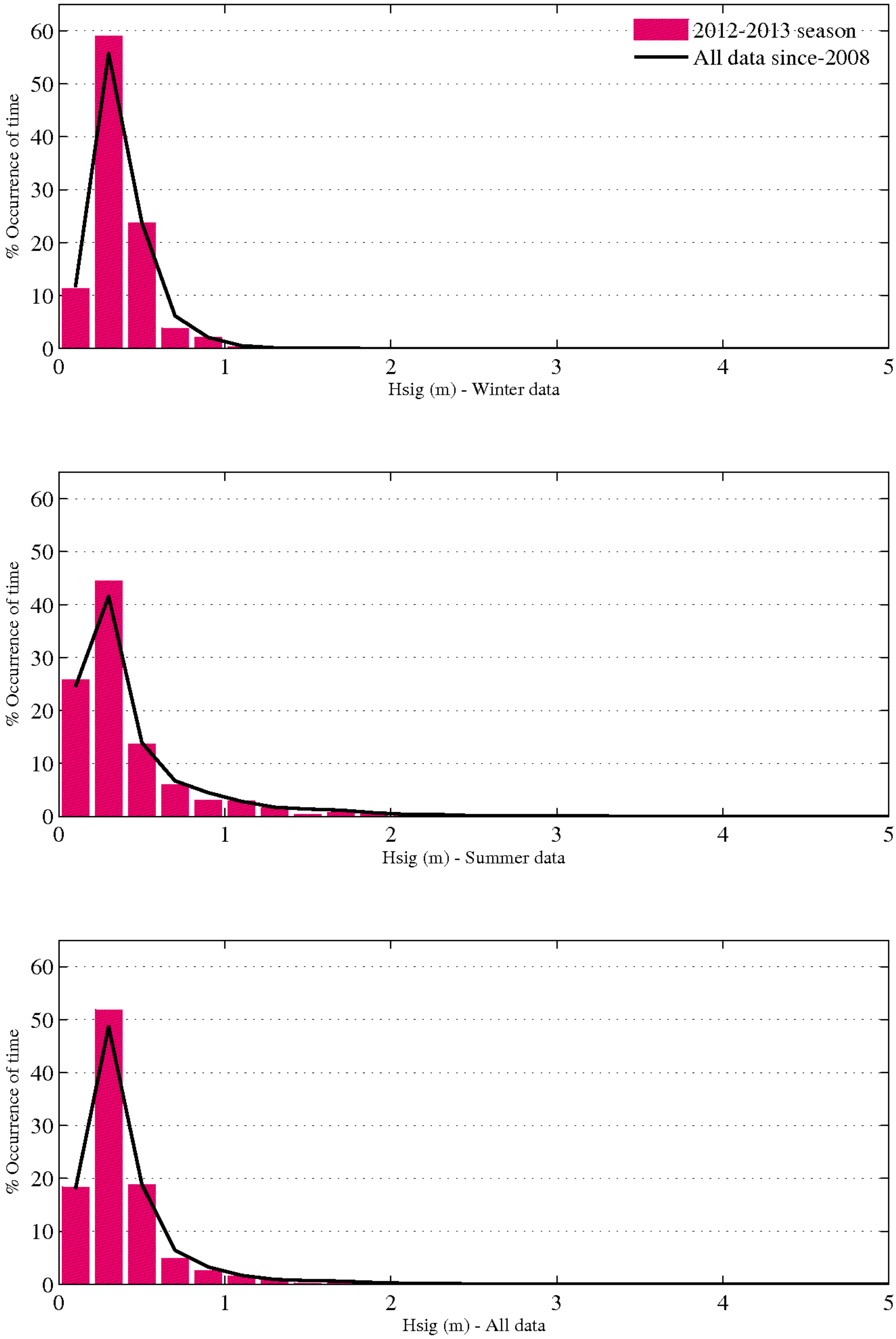


Figure 16.3: Albatross Bay - Histogram percentage (of time) occurrence of wave heights (Hsig) for all wave periods (Tp)

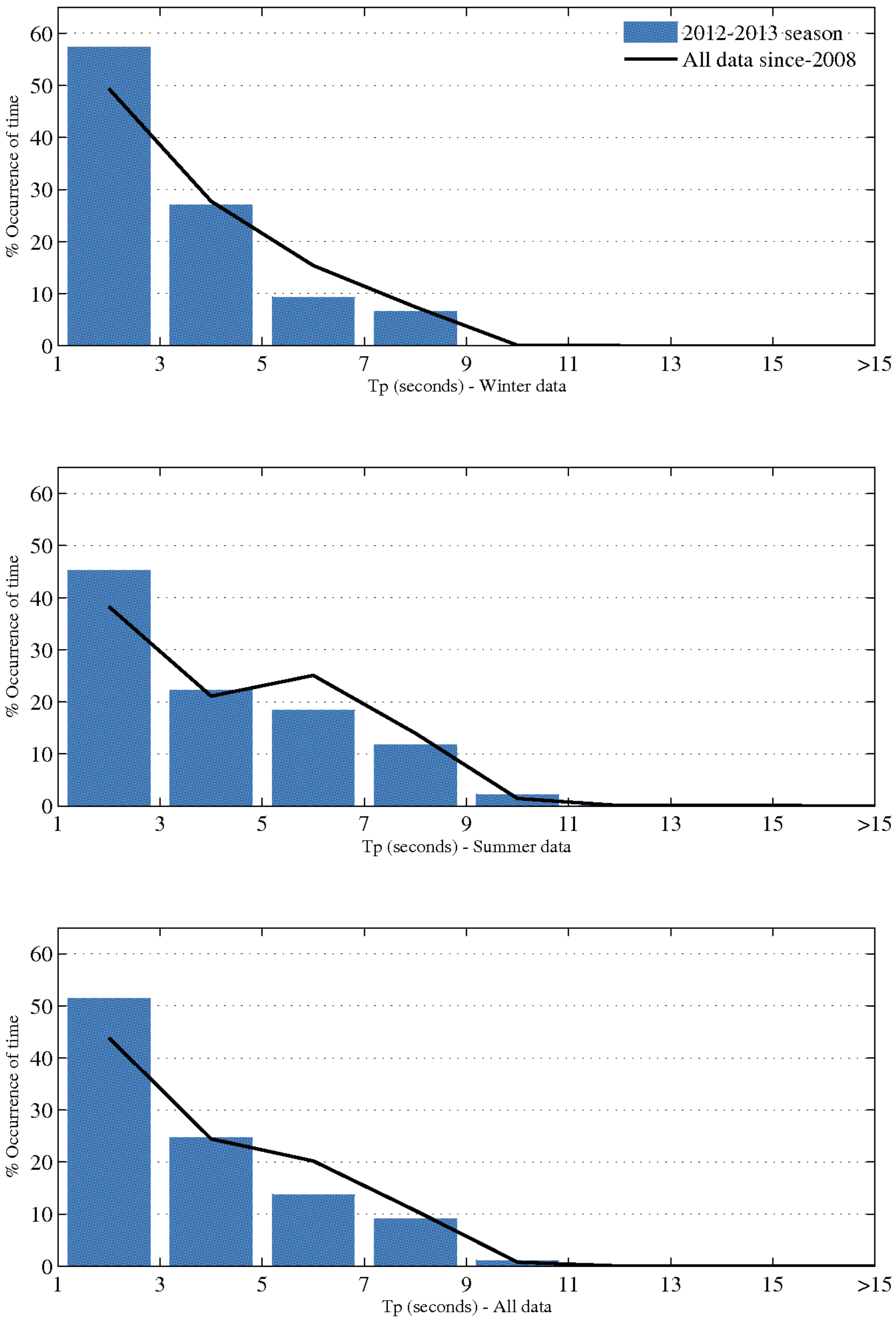


Figure 16.4: Albatross Bay - Histogram percentage (of time) occurrence of wave periods (Tp) for all wave heights (Hsig)

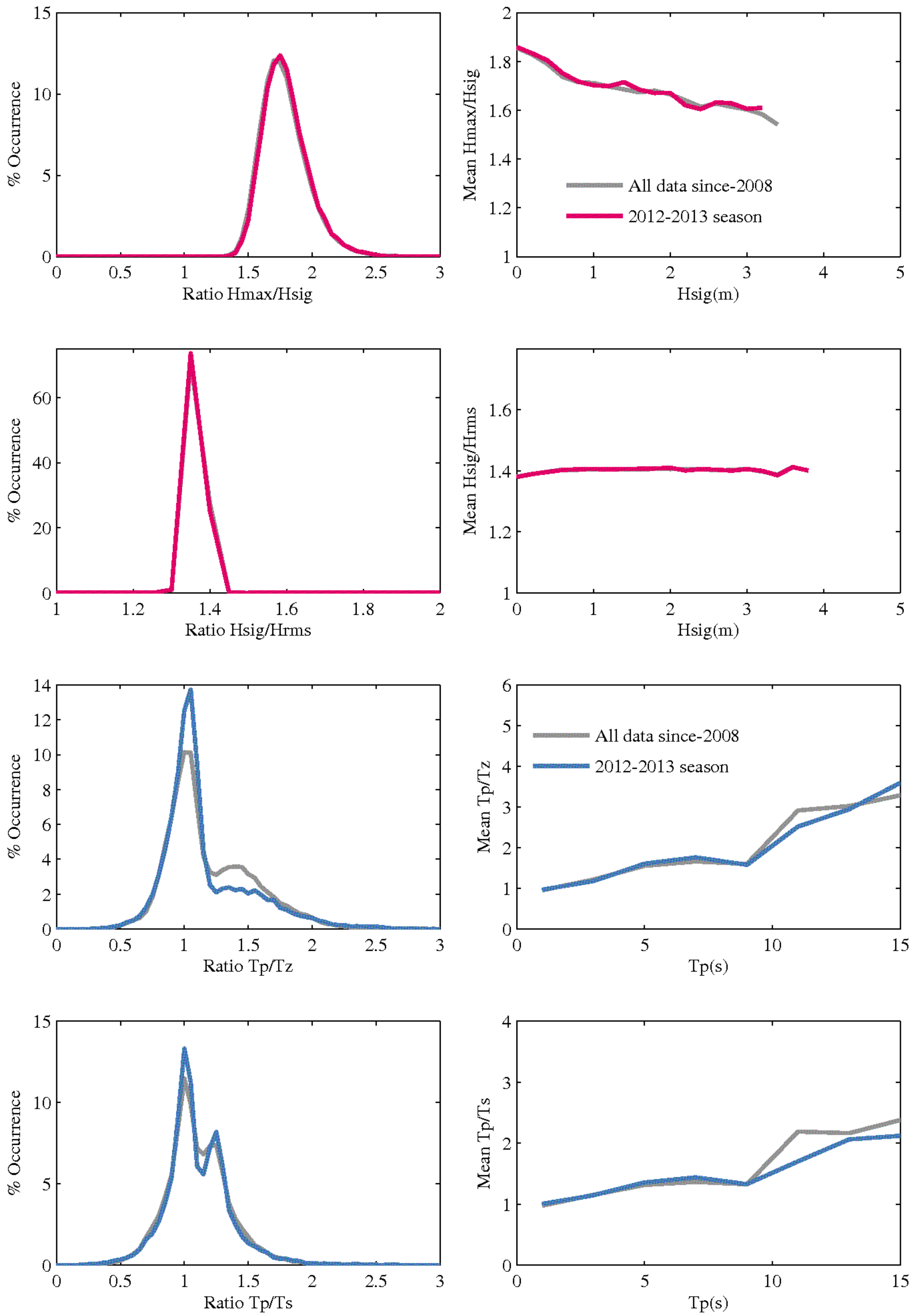


Figure 16.5: Albatross Bay - Wave parameter relationships

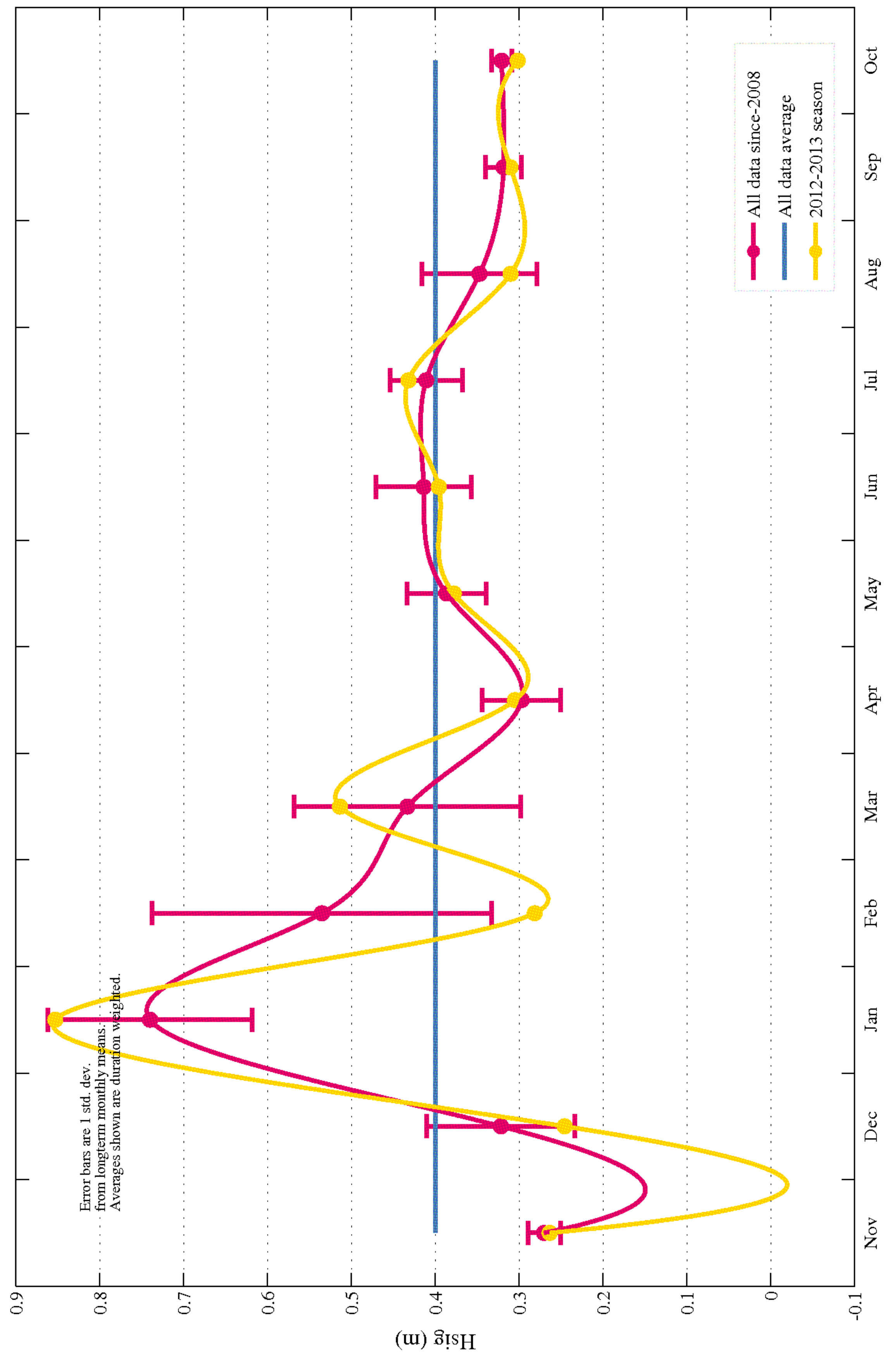


Figure 16.6: Albatross Bay Monthly average wave height (Hsig) for seasonal year and for all data

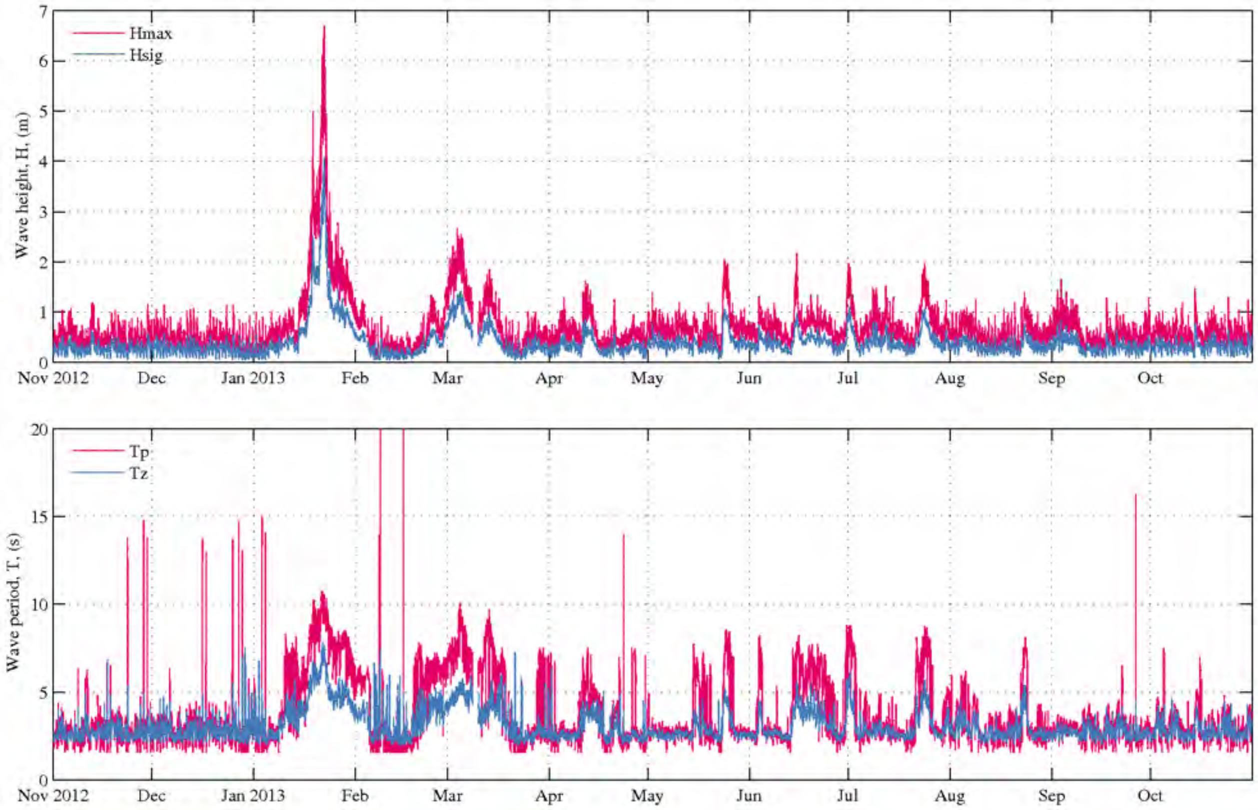


Figure 16.7: Albatross Bay - Daily wave recordings

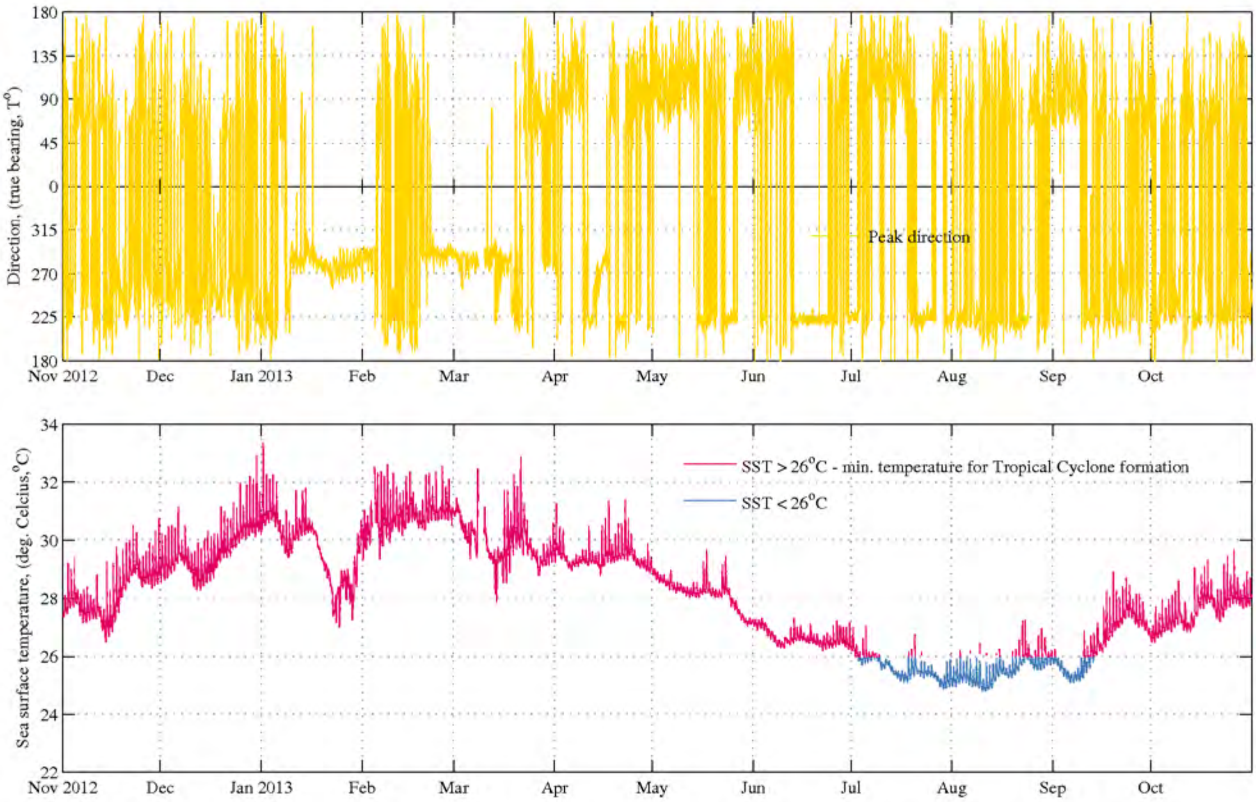


Figure 16.8: Albatross Bay - Sea surface temperature and peak wave directions

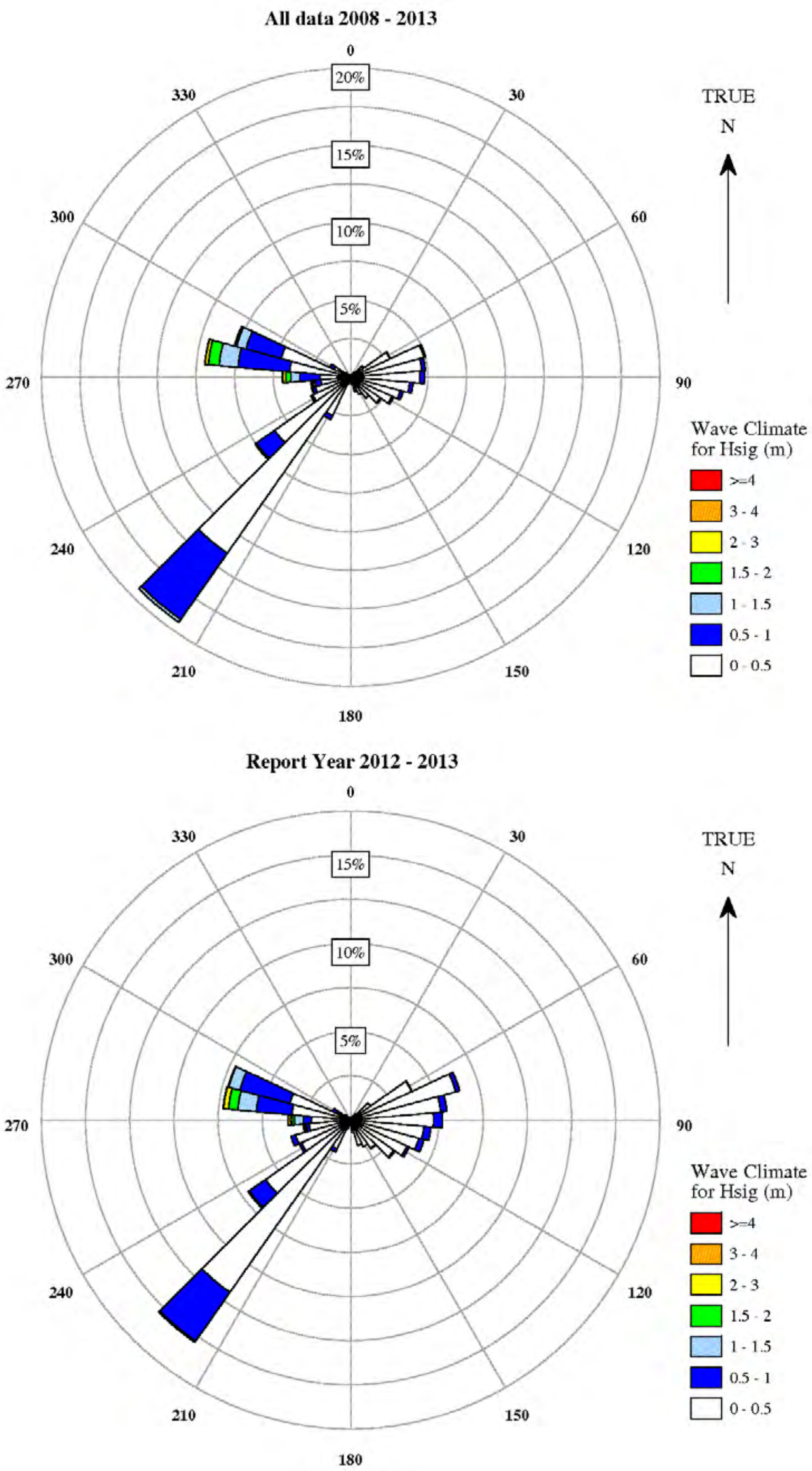


Figure 16.9: Albatross Bay - Directional wave rose

17. References

Allan, J., & Komar, P. (2001). Wave climate change and coastal erosion in the US Pacific Northwest. *Proceedings of the 4th Conference on Ocean Wave Measurement and Analysis* (pp. 680-690). San Francisco: ASCE.

Australian Hydrographic Service. (2011). *Australian National Tide Tables.*

Bacon, S., & Carter, D. (1991). Wave climate changes in the North Atlantic. *Int. J. Climatol*, 545-558.

Datawell. (2000). *Operations and Service Manual for Directional Waverider.* Haarlem, Netherlands.

Datawell. (2010). *Datawell Waverider Reference Manual WR-SG; DWR-MkIII, DWR-G.* Haarlem, Netherlands.

DSITIA. (2013) Tropical Cyclone Oswald, coastal monitoring report. Available online in the Queensland Government library, search for the article at: http://www.qld.gov.au/environment/library/.

Forristall, G., Heideman, J., Leggett, I., Roskam, B., & Vanderschuren, L. (1996). Effect of Sampling Variability on Hindcast and Measured Wave Heights. *Journal of Waterway, Port, Costal and Ocean Engineering, Vol 122, No. 5*, 216-225.

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

Queensland Transport. (2011). *The Official Tide Tables & Boating Safety Guide .*

Appendix A Zero up-crossing analysis

Zero up-crossing analysis is a direct, repeatable and widely accepted method to extract representative statistics from wave traces recorded by a wave measuring buoy. A wave is defined as the portion of the record between two successive zero up-crossings of the mean water line. Waves are ranked, with their corresponding periods, and statistical wave parameters are computed in the time domain.

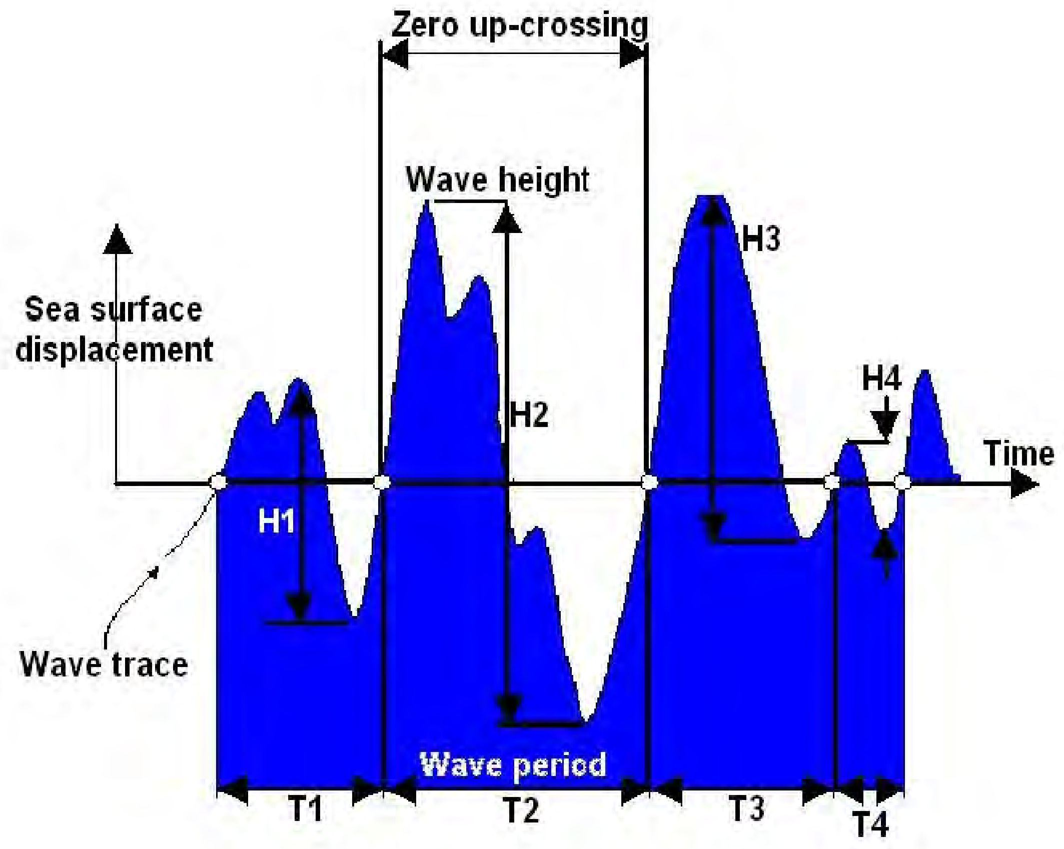


Figure 17 10 Diagram of Zero up-crossing analysis parameters.

Appendix B Glossary

Parameter	Description
Hs	The significant wave height (in metres), defined as the average of the highest one-third of the zero up-crossing wave heights in a 26.6-minute wave record. This wave height closely approximates the value a person would observe by eye. Significant wave heights are the values reported by the Bureau of Meteorology in their forecasts.
THsig	The average period of the highest one-third of zero up-crossing wave heights
Hrms	Root mean square wave height from the time domain
Hmax	The maximum zero up-crossing wave height (in metres) in a 26.6-minute record.
Tc	The average crest period (in seconds) in a 26.6-minute record.
Tz	The average of the zero up-crossing wave periods (in seconds) in a 26.6-minute record.
H10	Average of the highest 10 percent of all waves in a record
TH10	The period of the H10 waves
THmax	Period of maximum height, zero up-crossing
Tzmax	The maximum zero crossing in a record
Hm0	Estimate of the significant wave height from frequency domain $4\sqrt{m_0}$
T02	Average period from spectral moments zero and two, defined by $\sqrt{m_0/m_2}$
Tp	Wave period at the peak spectral energy (in seconds). This is an indication of the wave period of those waves that are producing the most energy in a wave record. Depending on the value of Tp, waves could either be caused by local wind fields (sea) or have come from distant storms and have moved away from their source of generation (swell).

Dir_p	Direction the Peak Period waves are coming from (in ° TRUE)
HAT	Highest Astronomical Tide is the highest water level which can be predicted to occur at a particular site under average weather conditions. This level may not be reached every year.
AHD	Australian Height Datum is the reference level used by the Bureau of Meteorology in Storm Tide Warnings. AHD is very close to the average level of the sea over a long period (preferably 18.6 years), or the level of the sea in the absence of tides.
Wave setup	The increase in mean water level above the SWL towards the shoreline caused by wave action in the surf zone. The amount of rise of the mean water level depends on wave height and beach slope such that setup increases with increasing wave height and increasing beach steepness. It can be very important during storm events as it results in a further increase in water level above the tide and surge levels.
Astronomical tide	Or more simply, the tide, is the periodic rise and fall of water along the coast because of gravitational attraction on the water by the moon and sun. When the moon, sun and earth are in line their combined attraction is strongest and the tide range is greater (spring tides). When the moon and sun are at right angles to each other (in relation to the earth) the effect of the attraction is somewhat reduced and the tide range is smaller (neap tides).
Predicted tide	The tide expected to occur under average meteorological conditions. Tide predictions are typically based on previous actual tide readings gathered over a long period (usually one year or more). The sun, moon and earth are not in the same relative position from year to year. Accordingly, the gravitational forces that generate the tides, and the tides themselves, are not the same each year.