

Wave data recording program

Tweed Heads/Brisbane wave climate annual summary
May 2020–April 2021



Queensland
Government

Prepared by: Queensland Government Hydraulics Laboratory, Department of Environment and Science

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Introduction

This summary of wave climate from the Tweed Heads and Brisbane wave sites is one of a series of technical wave reports prepared annually by the Queensland Government Hydraulics Laboratory (QGHL) of the Department of Environment and Science (DES).

This report has been prepared for the Tweed River Entrance Sand Bypassing Project, in which the primary analyses of wave data recorded using Datawell directional Waverider buoys positioned off Tweed Heads and Brisbane for the period 01 May 2020 to 30 April 2021 is presented. The data recorded covers all the seasonal variations for one year and includes the 2020–21 cyclone season.

Data is presented in a variety of graphical and tabulated forms, exploring the relationship between the measured wave parameters that define the sea state.

The wave data collected for the analysis period is statistically compared to the long-term average conditions at the sites. Brief details of the recording equipment, the methods of handling raw data and the type of analyses employed are provided within this report.

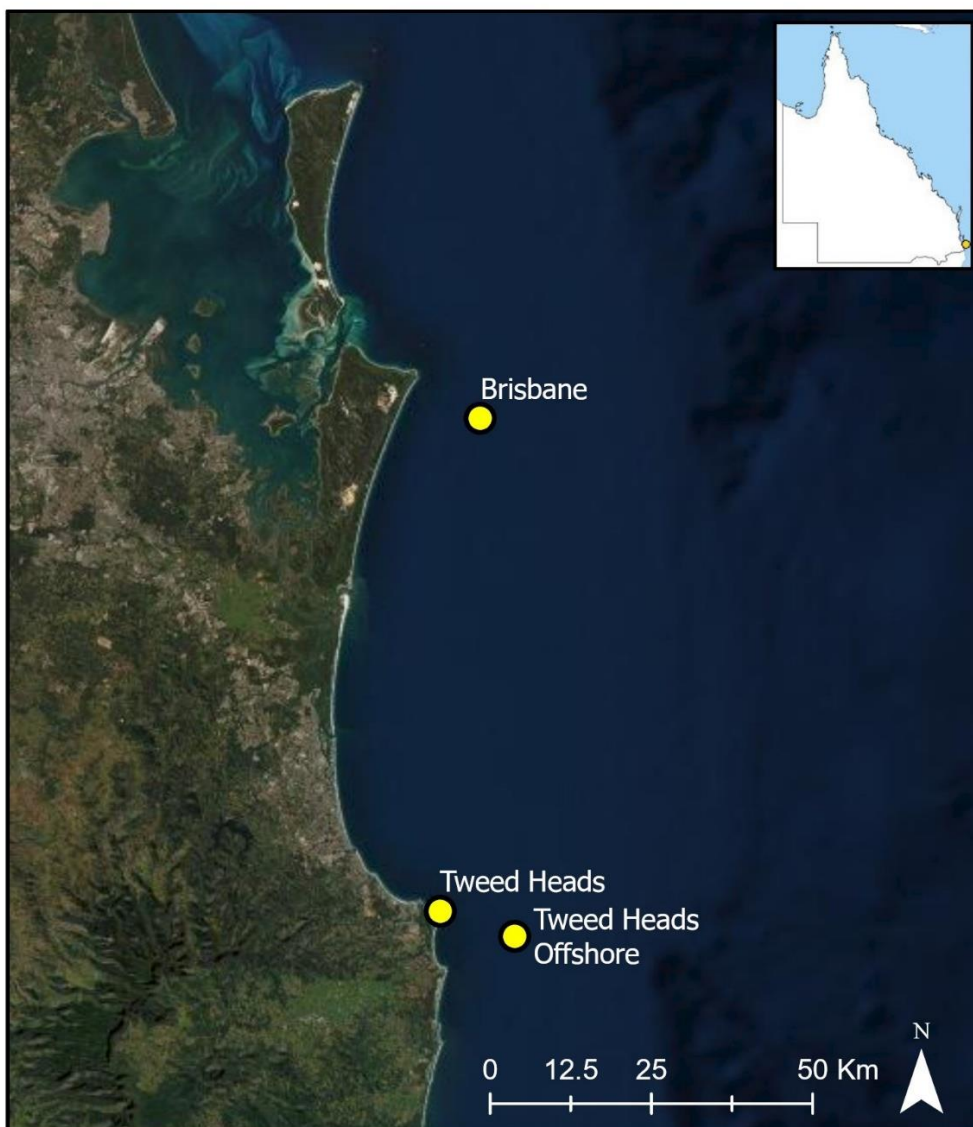


Figure 1.1 Tweed regional wave recording sites – locality plan

Recording

The QGHL wave recording program uses the Waverider system manufactured by Datawell of the Netherlands to measure sea surface fluctuations. Directional Waverider buoys were in operation at Tweed Heads and Brisbane during the period of this report.

Datawell DWR4 (MK4) waverider buoy

The Brisbane, Tweed Heads and the Tweed Heads offshore buoys are Waverider DWR4 (MK4) buoys. The DWR4 uses the same measuring sensor as the DWR-MkIII, which measures 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.

With the DWR-MkIII system, only waves with frequencies within the range of 0.033–0.64 Hz could be captured by the buoy, due to physical limitations of the system. However, the DWR4 can capture waves within the frequency range of 0.033–1 hertz. 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). For more information regarding the DWR4 see DES (2019). A report investigating the differences between the DWR-MkIII system and the DWR4 system has been undertaken by DES (DSITI, 2017).

Datawell DWRG (GPS) waverider buoy

The directional Waverider DWR-G buoy at the Tweed Heads (removed from service in July 2019) site used the GPS satellite system to calculate the velocity of the buoy (as it moves with the passing waves) from changes in the frequency of GPS signals according to the Doppler effect. 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.

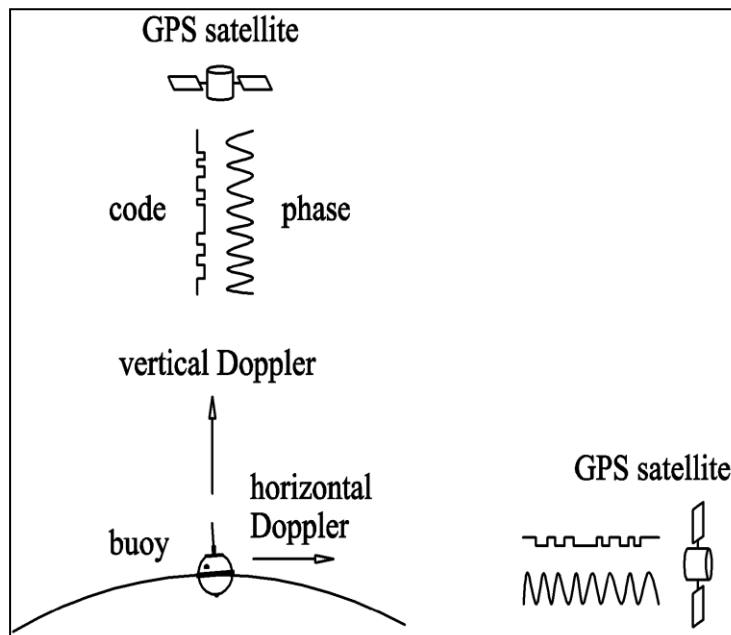


Figure 1.2 The GPS wave measurement principle (Source: Datawell, 2000)

At both Tweed Heads and Brisbane, the vertical buoy displacement representing the instantaneous water level and calculated directional data are transmitted to a receiver station as a modulated high-frequency radio signal. The DWR-MkIII and DWR-G 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 seconds intervals (1.28 Hz) and stored in bursts of 2,048 points (approximately 26 minutes) on the hard disk of the computer. The DWR4 has a few subtle differences regarding data transmission, namely due to a higher sample frequency. As such the water level data for the DWR4 are digitised at 0.39 second intervals (2.56 Hz) and stored in daily files rather than 26.6-minute bursts like the DWR-MkIII.

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 two hours to a central computer system in Brisbane for checking, further processing, and archiving.

Further information on the operation of the Waverider buoys and the recording systems can be obtained from the Datawell references listed in Chapter 6 of this report.

Laboratory calibration checks

Waverider buoys used by QGHL undergo equipment verification checks, before and after deployment, which is approximately every 12 months. Accelerometer buoys (including DWR4) are verified at the QGHL's Brisbane site using a sinusoidal wave simulator with vertical displacements of 2.7 metres. It is usual to check three frequencies between 0.005–0.64 Hz during a verification. Numerous mechanism responses of the buoy are also checked throughout the procedure, including: the compass; phase and amplitude response; accelerometer platform stability and tilt; battery capacity; and power output.

While Datawell (2017) states that calibration of a GPS buoy is not necessary, the QGHL runs a verification process to ensure the system is operating correctly. This process involves placing the buoy in a fixed, unobstructed location – to ensure satellite line of sight – on land for several days while it records data. If the resulting north, west and vertical displacements remain within a few centimetres then the GPS sensor is deemed functional and accurate. There are no adjustments to the recorded wave data, based on the laboratory calibration results; this process is simply to ensure that devices deployed are functioning correctly.

Wave recording and analysis procedures

The computer-based, wave-recording systems at Tweed Heads and Brisbane record data at half-hourly intervals received from the DWR-MkIII and DWR-G. Alternatively data received from the DWR4 is recorded in daily files.

Raw wave data transmitted from the DWR-MkIII and DWR-G 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 64 spectral estimates in bands of 0.01 hertz (0.1 to 0.58 Hz). 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 64 spectral estimates in bands of 0.025 to 0.1 hertz.

Whilst similar, there are several differences in how the DWR4 calculates wave records compared to the DWR-MkIII. Primarily the zero up-crossing analysis is processed on-board (as opposed to post processing) before being transmitted. Additionally, H_s on the DWR4 is calculated using $H_{rms}\sqrt{2}$ as an alternative for $H_{\frac{1}{3}}$.

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

Table 1: Wave parameters analysed

S(f)	energy density spectrum (frequency domain)
H_{sig} (or H_s)	Significant wave height (time domain), the average of the highest third of the waves in the record.
H_{max}	The highest individual wave in the record (time domain).
H_{rms}	The root mean square of the wave heights in the record (time domain).
T_{sig}	Significant wave period (time domain), the average period of the highest third of waves in the record.
T_z	The average period of all zero up-crossing waves in the record (time domain).
T_p	The wave period corresponding to the peak of the energy density spectrum (frequency domain).
T_c	The average period of all the waves in the record based on successive crests (time domain).
Direction (Dir; Dir_{Tp})	The direction that peak period (T_p) waves are coming (in ° True North). In other words, where the waves with the most wave energy in a wave record are coming from.
SST	The sea surface temperature (in ° 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.

Data losses

Data losses can be divided into two categories: losses due to equipment failure; and losses during data processing due to signal corruption. Common causes of data corruption include radio interference and a spurious, low-frequency component in the water-level signal caused by a tilting platform in the accelerometer-based Waverider buoy. Obstructions in the data path between the GPS buoy and the orbiting satellites can also cause data corruption and loss of signal.

Analysis of recorded data by the computer systems includes some data rejection checks which may result in a small number of spurious and rejected data points being replaced using an interpolation procedure. Otherwise, the entire series is rejected, as per research conducted by Bacon & Carter (1991) and Allan & Kormer (2001) who suggested rejecting entire records where less than a certain threshold has been recorded.

As discussed above, the various sources of data losses can cause occasional gaps in the data record. Gaps may be relatively short, caused by rejection of data records or much longer if caused by malfunction of the Waverider buoy or the recording equipment.

No significant gap (larger than two days) in the Tweed data record was found for the period from 01 May 2020 to 30 April 2021.

Overview

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; (refer to Table 2 and Table 3). Data percentage capture rates for each wave site over the reporting period are presented in Table 4.

Table 2: Deployment details for the Tweed Heads buoy

Buoy	Latitude	Longitude	Estimated depth (m)	Calibration date	Deployed date	Removal date
DWR-G	28° 10.715' S	153° 34.635' E	25	19/06/2018	29/06/2018	15/06/2019
DWR4	28° 10.689' S	153° 34.527' E	25	01/11/2020	03/11/2020	current
DWR4	28° 10.665' S	153° 34.594' E	25	10/09/2019	14/09/2019	03/11/2020
DWR4 Offshore	28° 12.822' S	153° 40.871' E	60	17/03/2021	19/03/2021	current
DWR4 Offshore	28° 12.749' S	153° 40.831' E	60	15/01/2020	17/01/2020	19/03/2021

Table 3: Deployment details for the Brisbane buoy

Buoy	Latitude	Longitude	Estimated depth (m)	Calibration date	Deployed date	Removal date
DWR4	27° 29.405' S	153° 38.025' E	80	01/11/2020	04/11/2020	current
DWR4	27° 29.451' S	153° 37.980' E	80	10/07/2019	15/07/2019	04/11/2020

Table 4: Wave recording program percentage data capture May 2020–April 2021

Station	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Avg.
Tweed Heads	97.92	97.71	97.78	94.15	97.78	97.71	97.71	97.65	97.78	96.98	98.18	97.70	97.42
Tweed Offshore	97.92	97.85	97.78	93.81	97.5	97.78	97.64	94.62	93.48	98.71	97.71	97.84	96.89
Brisbane	97.85	97.92	97.92	96.77	97.92	67.52	89.58	40.08	83.86	99.64	97.85	97.84	88.73

A summary of major meteorological events, where the recorded H_s value reached the 3-hour storm threshold wave height of two metres for Tweed Heads and four metres for Brisbane, for the period from 01 May 2020 to 30 April 2021 is shown in Table 5 and Table 6. Weather systems that contributed to the H_s reaching the storm threshold value are listed and may be direct reproductions of synoptic descriptions provided by the Australian Bureau of Meteorology (BoM, 2020).

Table 5: Significant meteorological events May 2020–April 2021, Tweed Heads buoy

Tweed Heads Storm threshold value: 2.0 metres (H_s)				
Date	H_s (m)	H_{max} (m)	T_p (s)	Event
15/05/2020 17:00	2.3	4.4	11.2	A complex frontal system moved across southeastern Australia and developed into a complex low off the central and southern New South Wales coast.
25/05/2020 11:00	2.2	3.9	14	A deep low pressure system was in the Tasman Sea off the Illawarra and Sydney coasts between 24 and 26 May. This brought damaging surf conditions to parts of the Sydney and South Coast regions.
10/06/2020 14:00	2.6	4.9	8.6	A trough developed off New South Wales coast, extended north through inland Queensland.
18/06/2020 15:30	2.2	3.9	7.8	A broad area of low pressure developed and moved across southeastern South Australia into Victoria, New South Wales and Tasmania.
18/07/2020 00:30	2.4	4.5	12.4	From 14 July, a trough created a powerful sea swell, with wave heights of 5 to 6 metres, leading to significant coastal erosion and hazardous beach conditions, notably at Wamberal where residents were evacuated due to significant erosion.
25/07/2020 23:30	2.8	5.4	9.2	A low formed off the Queensland coast in late July, before the deepening low moving south along the New South Wales coast from 26 to 28 July.
31/07/2020 13:30	2.2	4.8	10.9	As a result of the two lows, flash flooding was reported in several areas,
11/09/2020 11:00	2.3	4.3	9	Showers and storms produced moderate falls over south-east inland parts on 11 September
25/09/2020 22:00	2.2	3.9	6.8	On 24 and 25 September a vigorous cold front followed by a cold southerly flow crossed the southeast Australia.
06/10/2020 22:00	2.4	4.3	11.8	On 6 October, broad troughs extended across most of Australia and brought tropical moisture to central and eastern Australia.
14/10/2020 19:30	2.1	4	9.2	A high-pressure ridge extended along eastern Queensland.
14/12/2020 8:30	6.4	11.8	11.7	Periods of very heavy rainfall associated with a surface- and upper-level trough affected south-east Queensland and north-eastern New South Wales from 12 to 18 December. A storm surge of up to 50 centimetres coincided with high tides to produce coastal flooding in low-lying areas south of Fraser Island.
09/01/2021 06:00	2.2	4.8	8.5	A coastal trough, combined with an upper-level disturbance, and produced widespread moderate falls across most of eastern Queensland.
06/02/2021 21:00	2.7	5.1	10.9	Tropical cyclone Lucas formed in the Coral Sea on 01 February. The system moved east-south-east and made landfall in New Caledonia on 02 February. The system remained far enough offshore to have minimal impact on the Queensland coast besides generating some moderate easterly swell and dangerous surf conditions.
20/02/2021 13:30	2.6	4.8	10.8	A Tasman low pressure system formed off the north coast of New South Wales on 20 February.

Tweed Heads				
Storm threshold value: 2.0 metres (H_s)				
Date	H_s (m)	H_{max} (m)	T_p (s)	Event
20/03/2021 16:00	3.3	6	10.5	A trough developed near the north coast of New South Wales and produced moderate rainfall along the state's coast. The coastal trough in New South Wales deepened and expanded north along the south-east Queensland coast and down to the south coast of New South Wales.
06/04/2021 04:30	3	5.7	8.6	A coastal trough developed off the Queensland coast from 04 April, with a low-pressure system deepening off the Capricornia coast. The system brought heavy falls to south-eastern Queensland and minor flooding to the Stanley River.

Denotes peak H_{sig} event**Table 6: Significant meteorological events May 2020–April 2021, Brisbane buoy**

Brisbane				
Storm threshold value: 4.0 metres (H_{sig})				
Date	H_s (m)	H_{max} (m)	T_p (s)	Event
04/05/2020 14:00	4.7	8.4	12.1	At the beginning of the month, low pressure systems and cold fronts tracked across the southeast.
15/05/2020 22:00	4.6	7.8	10.2	A high-pressure system in the Tasman Sea extended a ridge along Queensland's east coast, providing moist onshore flow onto the north tropical Queensland coast.
15/07/2020 10:00	4.6	8.4	14.1	A complex low-pressure system deepened off the coast of New South Wales from 13 July, then lingered for a couple of days before moving slowly eastwards to the central Tasman Sea by 16 July.
12/12/2020 21:30	4.7	7.9	11.1	Periods of very heavy rainfall associated with a surface- and upper-level trough affected south-east Queensland and north-eastern New South Wales from 12 to 18 December.
08/01/2021 00:00	4.6	9.2	9.3	Tropical cyclone Imogen formed in the south-east Gulf of Carpentaria on 03 January, making it the first tropical cyclone of the 2020–21 season in the Australian Region. The system moved over the north tropical coast by 05 January and became embedded in a coastal trough off the north tropical coast.
16/03/2021 02:00	4.9	9.7	10.7	The surface trough in central and south-east Australia deepened and moved slowly east and north through inland Queensland and New South Wales.

Denotes peak H_{sig} event

Note: Barometric pressure measured in hectopascals (hPa). The H_s and H_{max} values are the maximums recorded for each event and are not necessarily coincident in time. The T_p and H_s 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 H_s and H_{max} 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).

Details of the wave recorder installations for the Tweed Heads and Brisbane sites are shown on the first page of each site section, including information on buoy location, recording station location, recording intervals and data collection.

The wave climate data presented in this report are based on statistical analyses of the parameters obtained from the recorded wave data. Software programs developed by DES provide statistical information on percentage of time occurrence and exceedance for wave heights and periods. The results of these analyses are presented in Figure 2.2 to Figure 2.4, Figure 3.3 to Figure 3.5 and Figure 4.2 to Figure 4.4. In each of these figures for each site, the term 'All data' refers to the combined number of years of operation for each site. In addition, similar statistical analysis provides monthly averages of wave heights for the seasonal year and all data. At the request of the TRESBP, morphological energy weighted average H_s are also provided for the Tweed buoy, being a proxy for

sediment transport capacity (WBM, 1997).

Daily wave recordings, average water temperature and peak direction (Dir_{Tp}) recordings are shown for the period from 01 May 2020 to 30 April 2021. Directional wave roses for the same period are also presented. These wave roses summarise wave occurrence at Tweed Heads and Brisbane by indicating their height, direction and frequency. Each branch of a wave rose represents waves coming from that direction with branches divided into H_{sig} segments of varying range. The length of each branch represents the total percentage of waves from that direction with the length of each segment within a branch representing the percentage of waves, in that size range, arriving from that direction for all wave periods. Note that the wave rose is only intended as a visual guide to the wave climate at the site.

This report covers the period from 01 May 2020 to 30 April 2021 to align with TRESBP environmental monitoring periods. For the purposes of analysis, summer has been taken as the period from 01 November to 30 April of the following year and winter covers the period 01 May to 31 October in any one year.

Tweed Heads

Near real time data feed: [Tweed Heads wave monitoring page](#)

Details of data collection	
2020 – 2021 season	
Maximum possible analysis days (last record - first record)	365
Total number of days used in analysis	355.58
Gaps in data used in analysis(days)	9.42
Number of records used in analysis	17,068
All data since 1995 – 2021	
Maximum possible analysis years (last record – first record)	26.3
Total number of years used in analysis	25.93
Gaps in data used in analysis (years)	0.36
Number of records used in analysis	402.9

Table 7: Table of highest ranked un-smoothed waves at Tweed Heads

Rank	Date (H_s)	H_s (m)	Date (H_{max})	H_{max} (m)
1	03/05/1996 01:00	7.5	02/05/1996 14:30	13.1
2	28/01/2013 08:30	6.7	28/01/2013 09:00	11.8
3	14/12/2020 08:30	6.4	14/12/2020 04:00	11.8
4	06/03/2004 01:00	6.1	05/03/2004 23:30	11.1
5	21/05/2009 19:30	5.6	30/06/2005 06:30	9.9
6	04/06/2016 19:30	5.6	05/06/2016 00:30	9.8
7	01/05/2015 22:30	5.5	22/05/2009 07:00	9.7
8	24/05/1999 05:00	5.2	04/03/2006 12:00	9.6
9	04/03/2006 20:30	5.2	25/03/1998 22:30	9.5
10	12/06/2012 10:00	5.2	15/02/1995 15:30	9.3

Table 8: Wave conditions 2020-21, Tweed Heads Waverider buoy

	Average H_s (m)	Min H_s (m)	Max H_s (m)	Average Direction for Peak Period Dir_{Tp} (° True North)	90% of waves within the range of (m)	No. of Days when $H_s \geq 2$ m	No. of Days when $H_s \leq 0.75$ m	Date of events where $H_s > 3$ m
May-20	1.37	0.54	2.32	100	0.9 – 1.9	6	2	
Jun-20	1.18	0.37	2.61	106	0.6 – 1.9	5	8	
Jul-20	1.27	0.37	2.81	105	0.6 – 2.2	7	7	
Aug-20	1.03	0.4	2.09	107	0.5 – 1.6	1	15	
Sep-20	1.22	0.45	2.3	88	0.6 – 1.9	5	5	
Oct-20	1.17	0.66	2.38	92	0.7 – 1.8	3	7	
Nov-20	1.13	0.64	1.99	97	0.8 – 1.6	0	7	
Dec-20	1.52	0.58	6.41	93	0.8 – 3.9	6	3	12 13 14 15
Jan-21	1.36	0.75	2.22	81	0.9 – 1.9	4	1	
Feb-21	1.52	0.76	2.75	87	0.9 – 2.3	11	0	
Mar-21	1.27	0.56	3.29	91	0.7 – 2.4	6	7	20
Apr-21	1.21	0.48	3.04	93	0.6 – 2.4	5	13	6
May to Apr	1.27	0.37	6.41	95	0.7 – 2.1	59	75	6

Table 9: Mean Values, Tweed Heads buoy

Month	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May–Apr
Mean H_s (m) 2020–21	1.37	1.18	1.27	1.03	1.22	1.17	1.13	1.52	1.36	1.52	1.27	1.21	1.27
Mean H_s (m) Average from 1995–2021	1.29	1.23	1.15	1.07	1.09	1.13	1.14	1.17	1.29	1.48	1.43	1.34	1.23
Average direction for peak period Dir_{Tp} (° True North) 2020–21	100	105	104	106	87	90	96	92	81	86	91	93	94
Average direction for peak period Dir_{Tp} (° True North) 1995–2021	99	101	102	101	93	92	92	91	90	94	93	97	95

$$Mean H_s = \sum H_s / N$$

$$Average\ of\ Peak\ Period\ Direction: Dir_{Tp} = \sum D / N$$

Where:

H_s = Significant wave height

D = Direction at Peak Period (Dir_{Tp})

N = number of records

Table 10: Weighted Mean Values, Tweed Heads buoy

Month	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May–Apr
Weighted Mean H_s (m) 2020–21	1.43	1.27	1.38	1.11	1.3	1.24	1.18	1.9	1.41	1.61	1.41	1.38	1.38
Weighted Mean H_s (m) 1995–2021	1.54	1.41	1.29	1.22	1.18	1.25	1.22	1.3	1.43	1.64	1.59	1.47	1.38
Weighted direction for peak period Dir_{Tp} (° True North) 2020–21	101	101	99	104	85	87	99	91	78	84	91	77	91
Weighted direction for peak period Dir_{Tp} (° True North) 1995–2021	89	96	99	96	92	90	94	89	88	92	88	94	92

$$Weighted\ Mean\ H_{sig} = \left(\sum (H_s^{2.5}) / N \right)^{0.4}$$

$$Weighted\ Mean\ Direction = \sum (H_s^{2.5} * D) / \sum H_s^{2.5}$$

Where:

H_s = Significant wave height

D = Direction at Peak Period (Dir_{Tp})

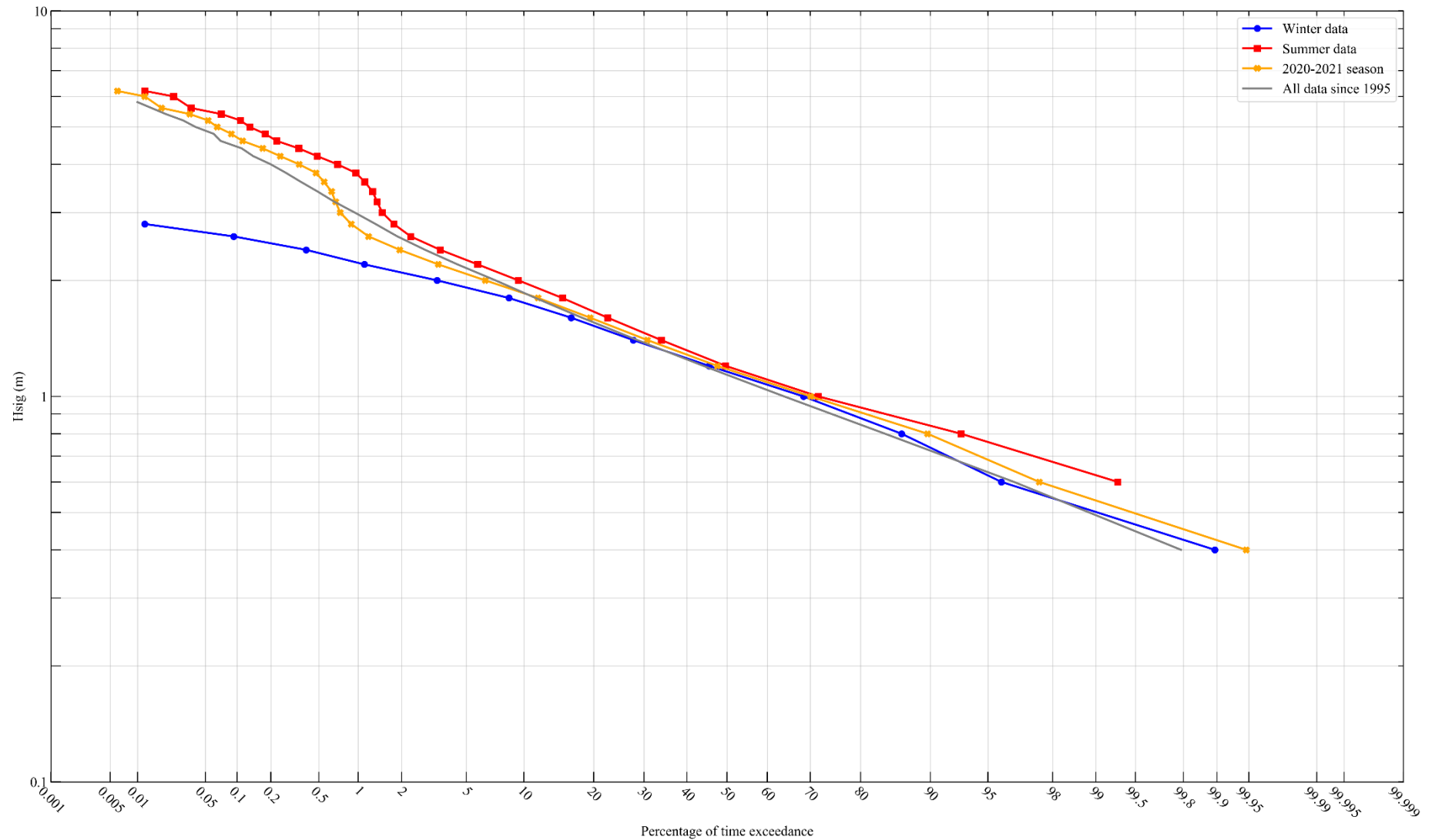


Figure 2.1 Tweed Heads buoy – percentage (of time) exceedance of wave heights (H_s) for all wave periods (T_p)

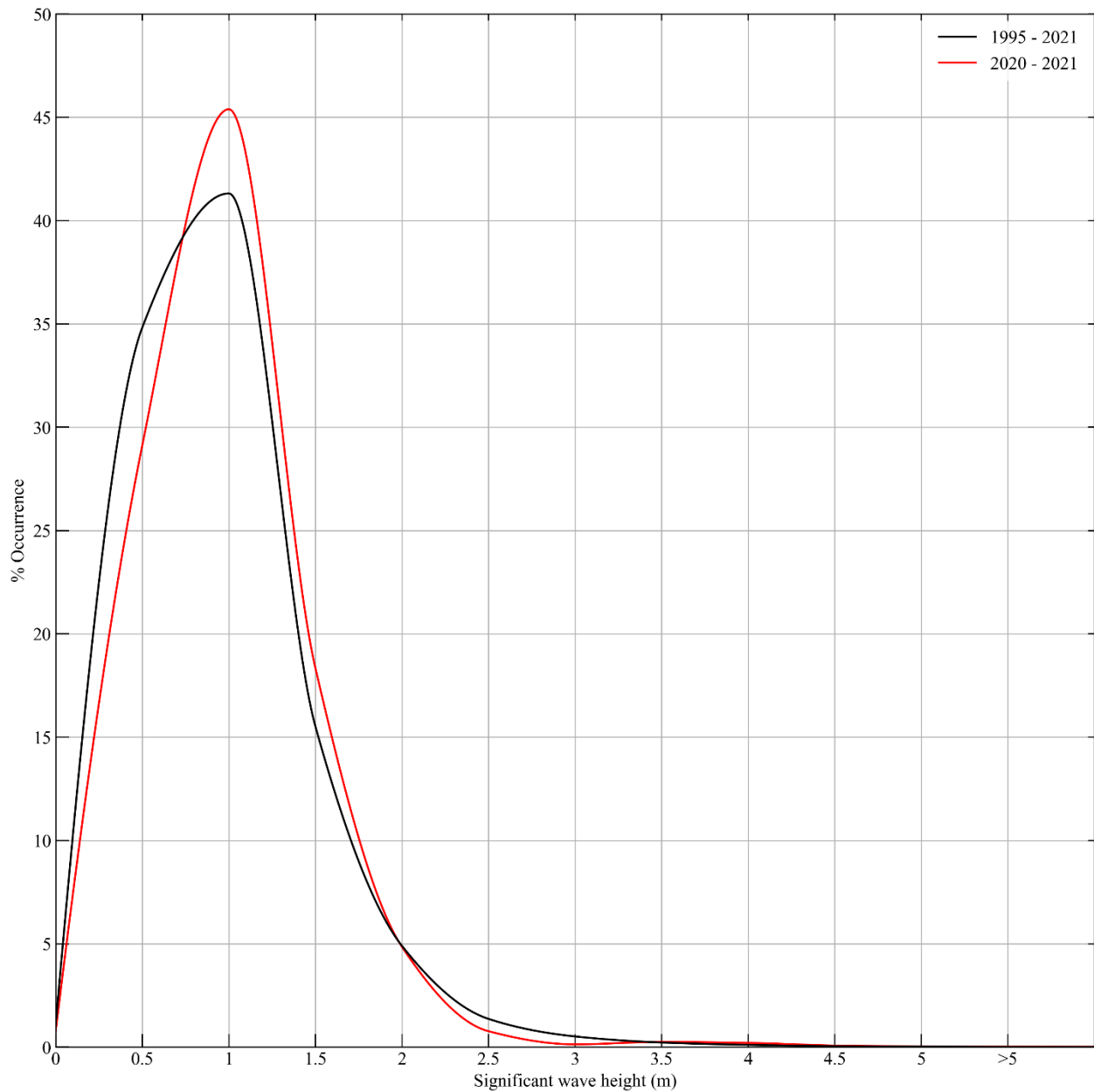


Figure 2.2 Tweed Heads buoy – H_s percentage (%) occurrence

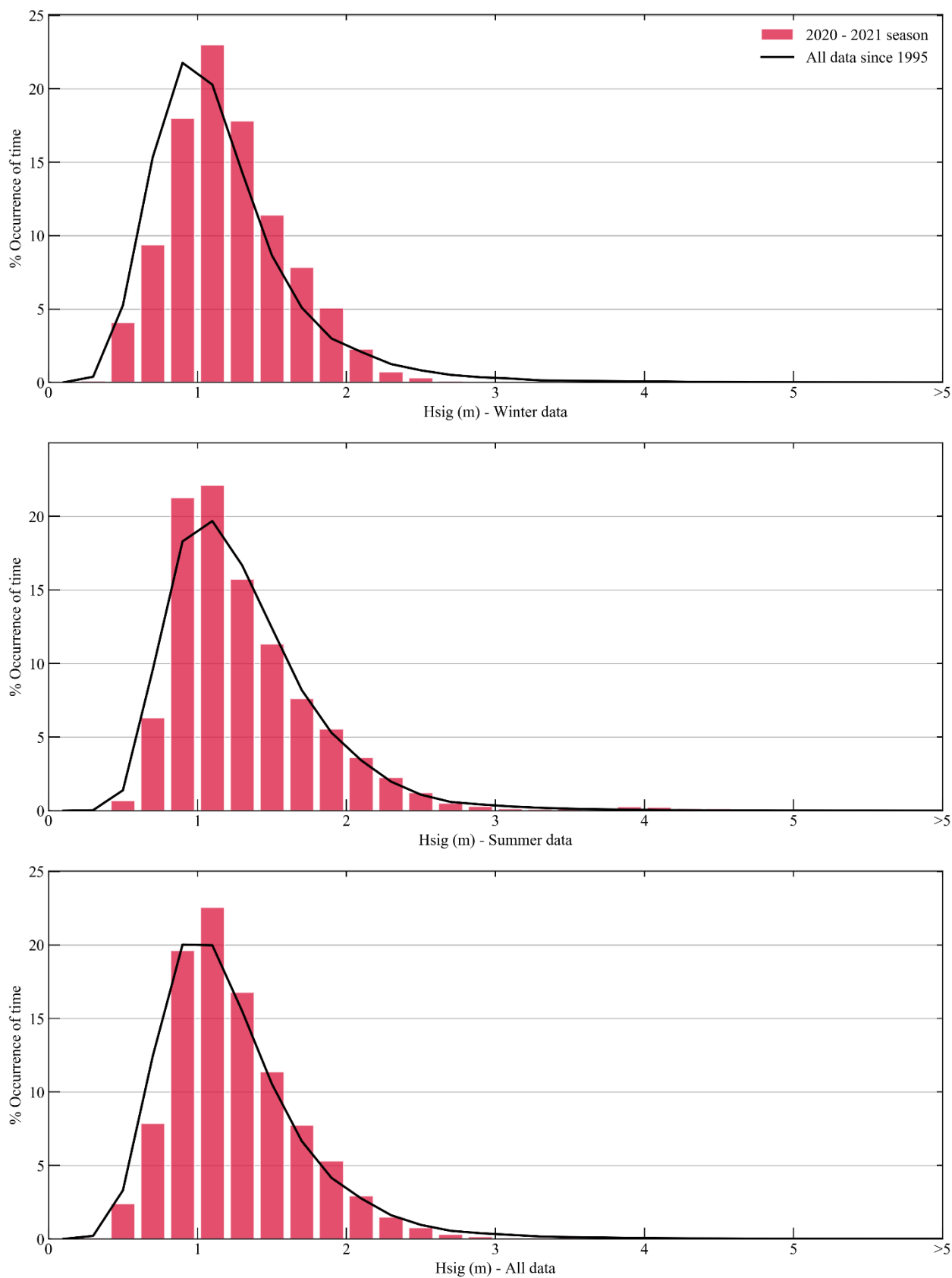


Figure 2.3 Tweed Heads buoy – histogram percentage (of time) occurrence of wave heights (H_s) for all wave periods (T_p)

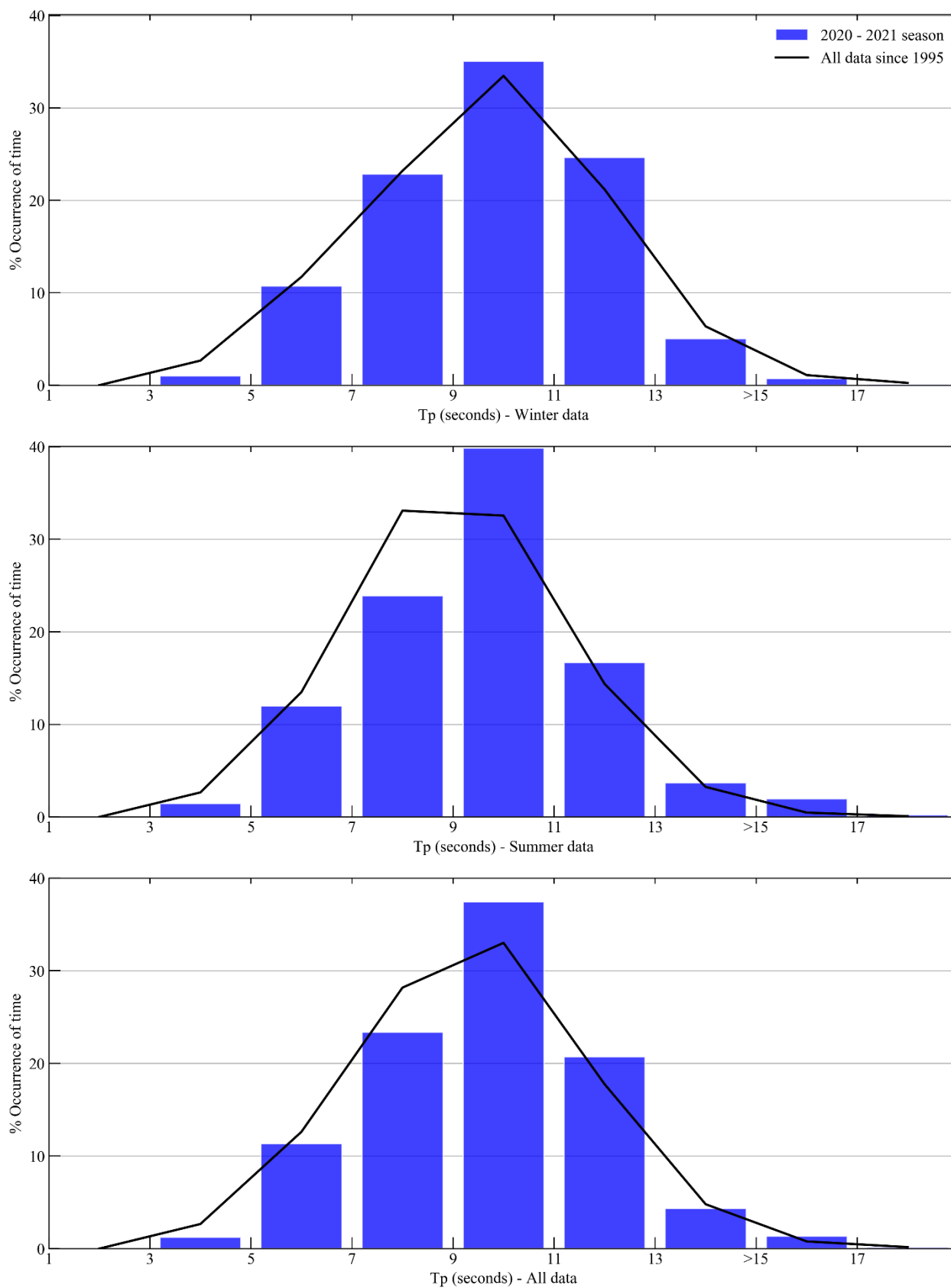


Figure 2.4 Tweed Heads buoy – histogram percentage (of time) occurrence of wave periods (T_p) for all wave heights (H_s)

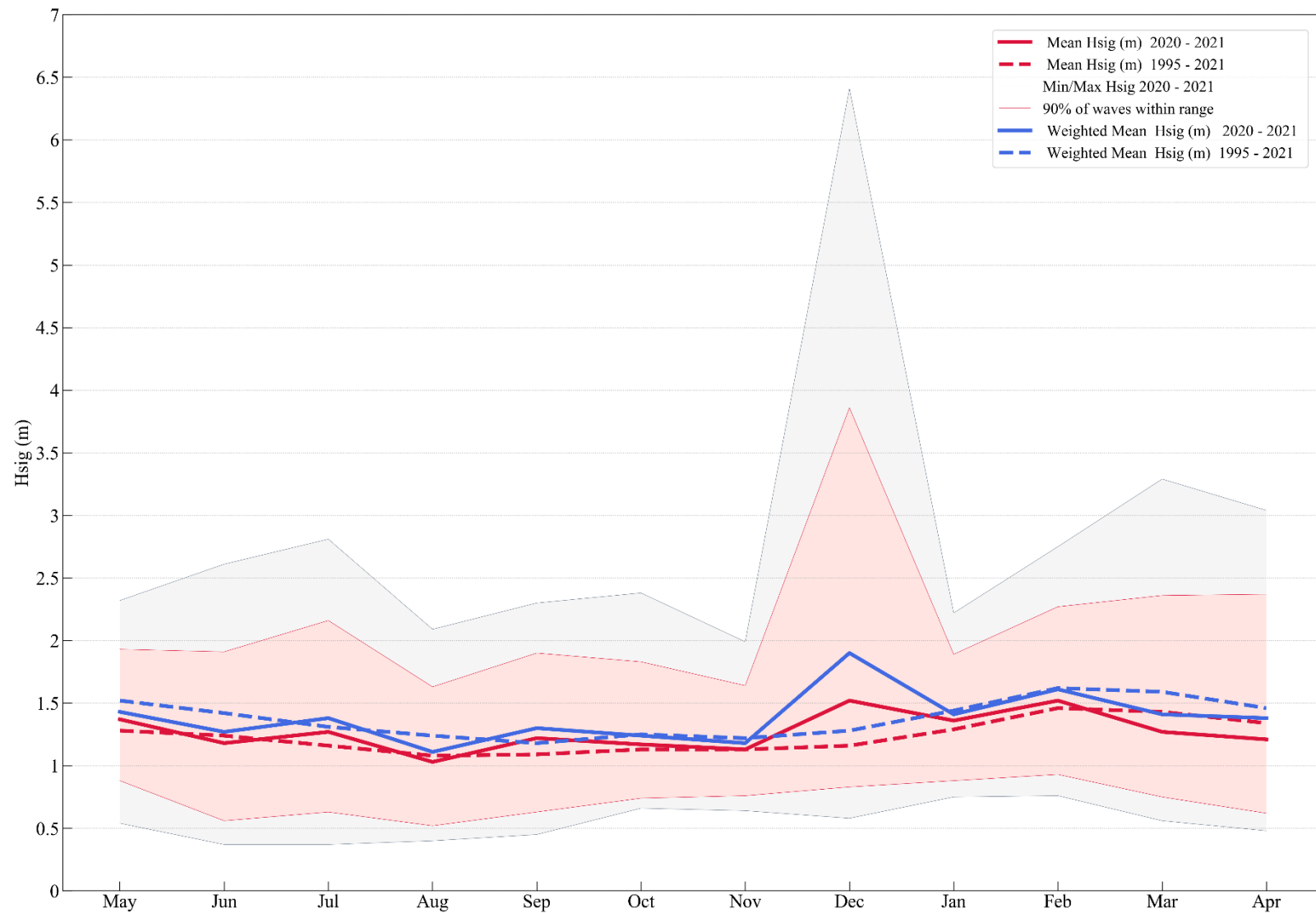


Figure 2.5 Tweed Heads buoy – monthly average H_s for seasonal year and for all data. The weighted mean H_s provides an indicative potential for sediment transport.

Figure 2.6 Tweed Heads buoy – daily wave recordings

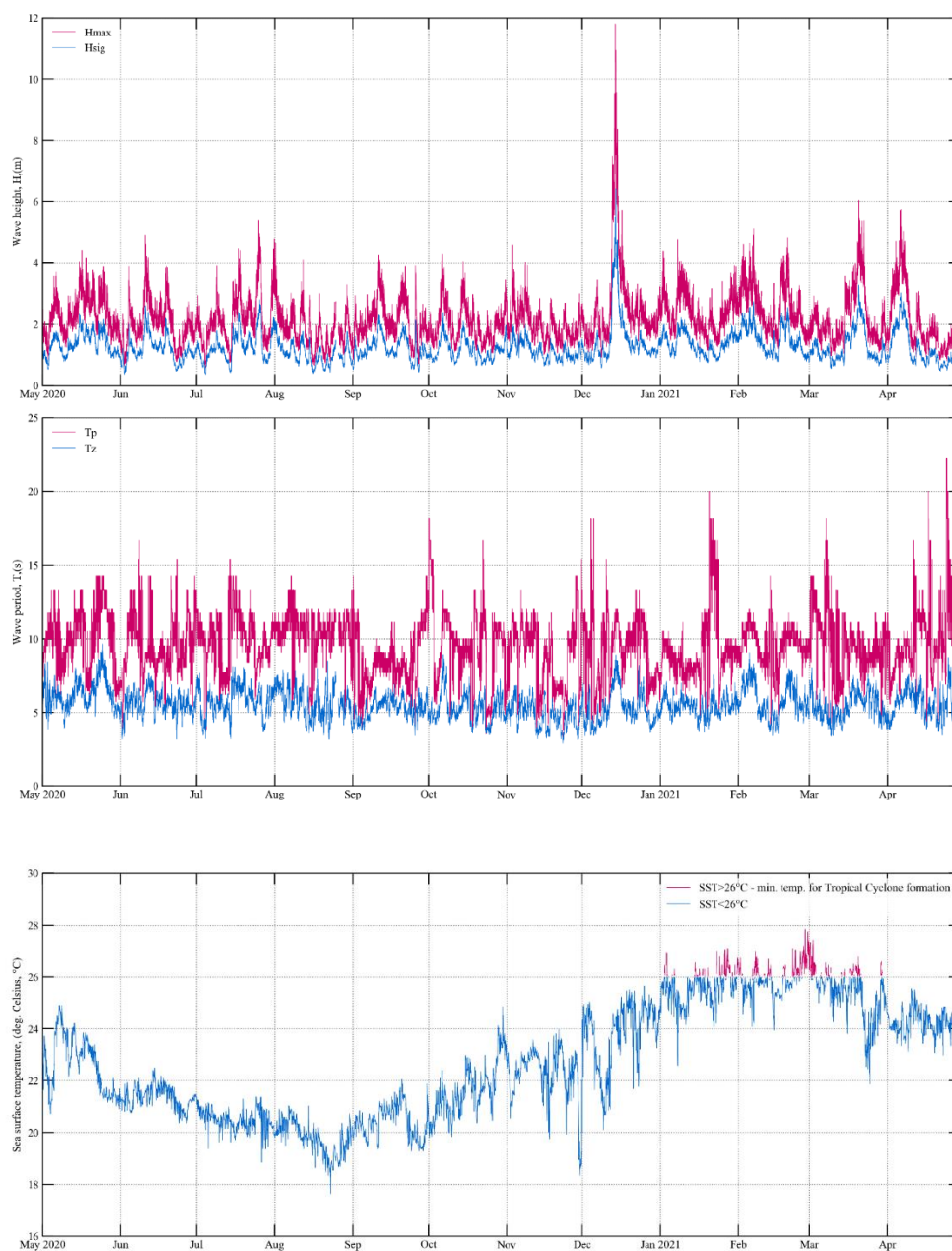
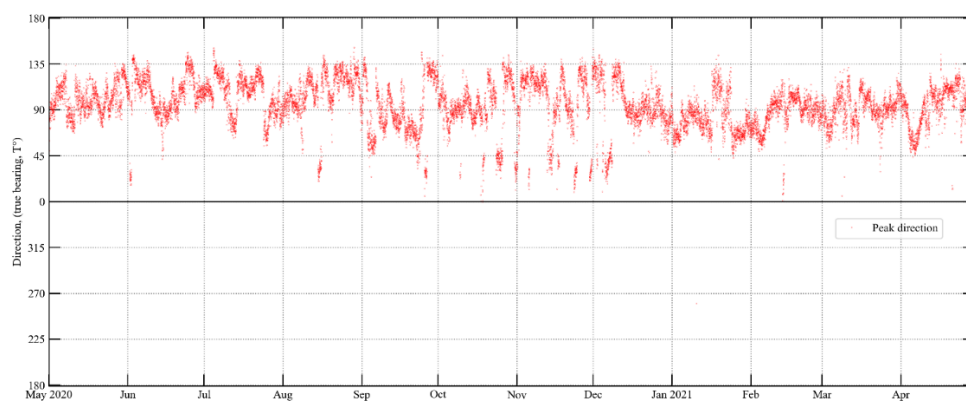


Figure 2.7 Tweed Heads buoy – sea surface temperature and peak wave directions



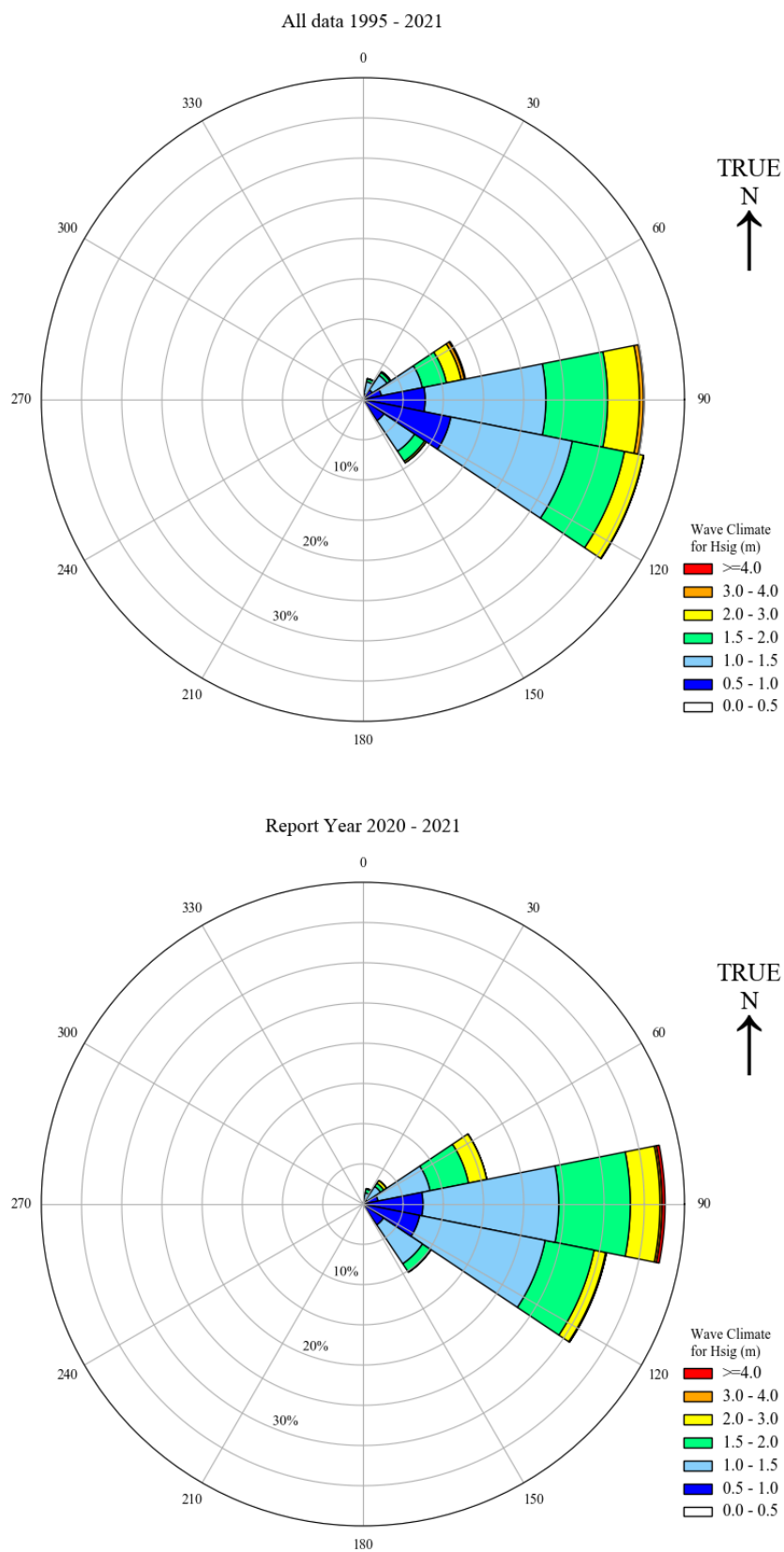


Figure 2.8 Tweed Heads buoy – directional wave rose

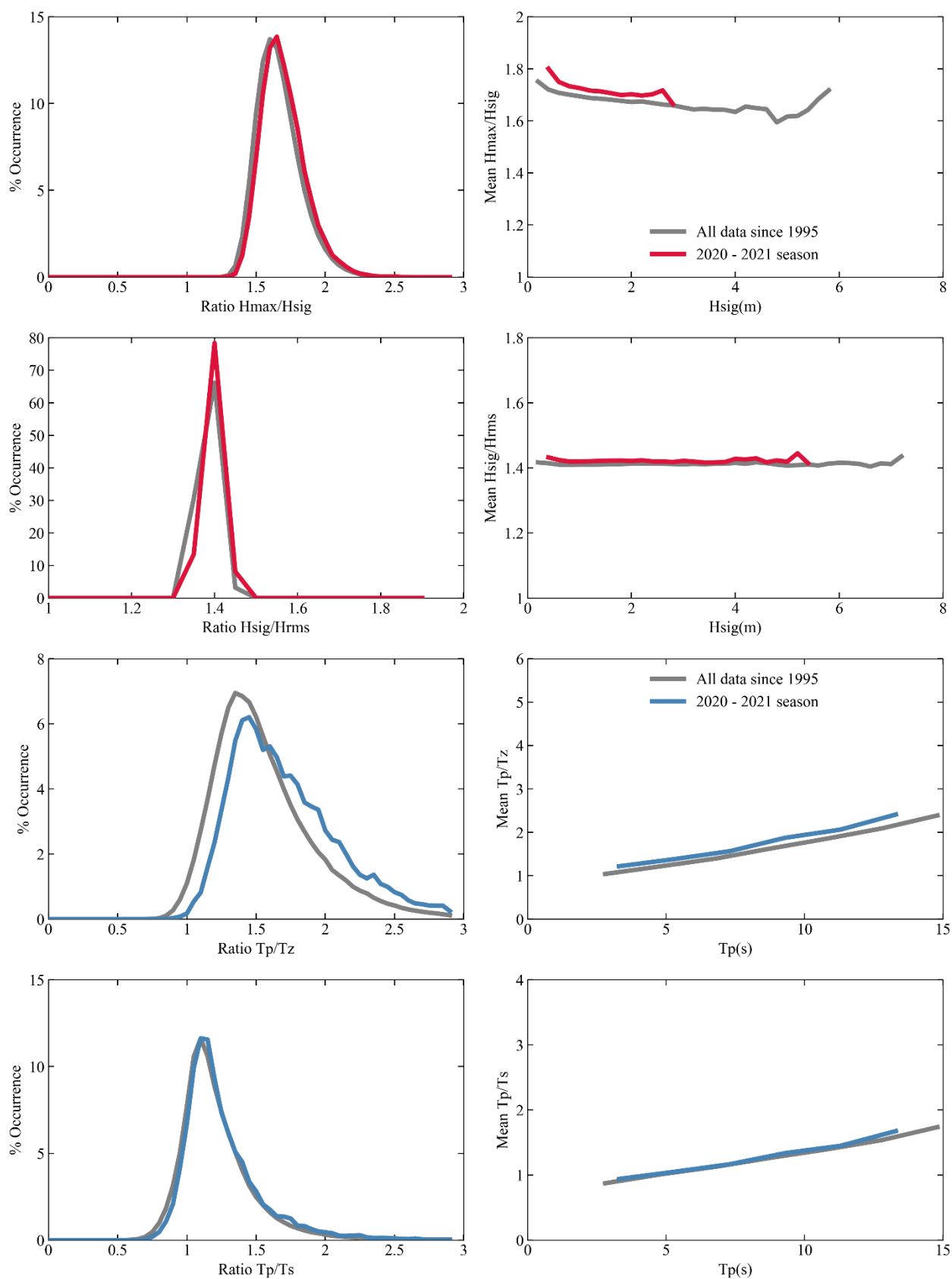


Figure 2.9 Tweed Heads buoy – wave parameter relationships

Tweed Heads – Offshore

Near real time data feed: [Tweed Offshore wave monitoring page](#)

Details of data collection	
2020 – 2021 season	
Maximum possible analysis days (last record - first record)	365
Total number of days used in analysis	353.36
Gaps in data used in analysis(days)	11.4
Number of records used in analysis	16,925
All data since 1995 – 2021	
Maximum possible analysis years (last record – first record)	1.49
Total number of years used in analysis	1.49
Gaps in data used in analysis (years)	0.36
Number of records used in analysis	25,409

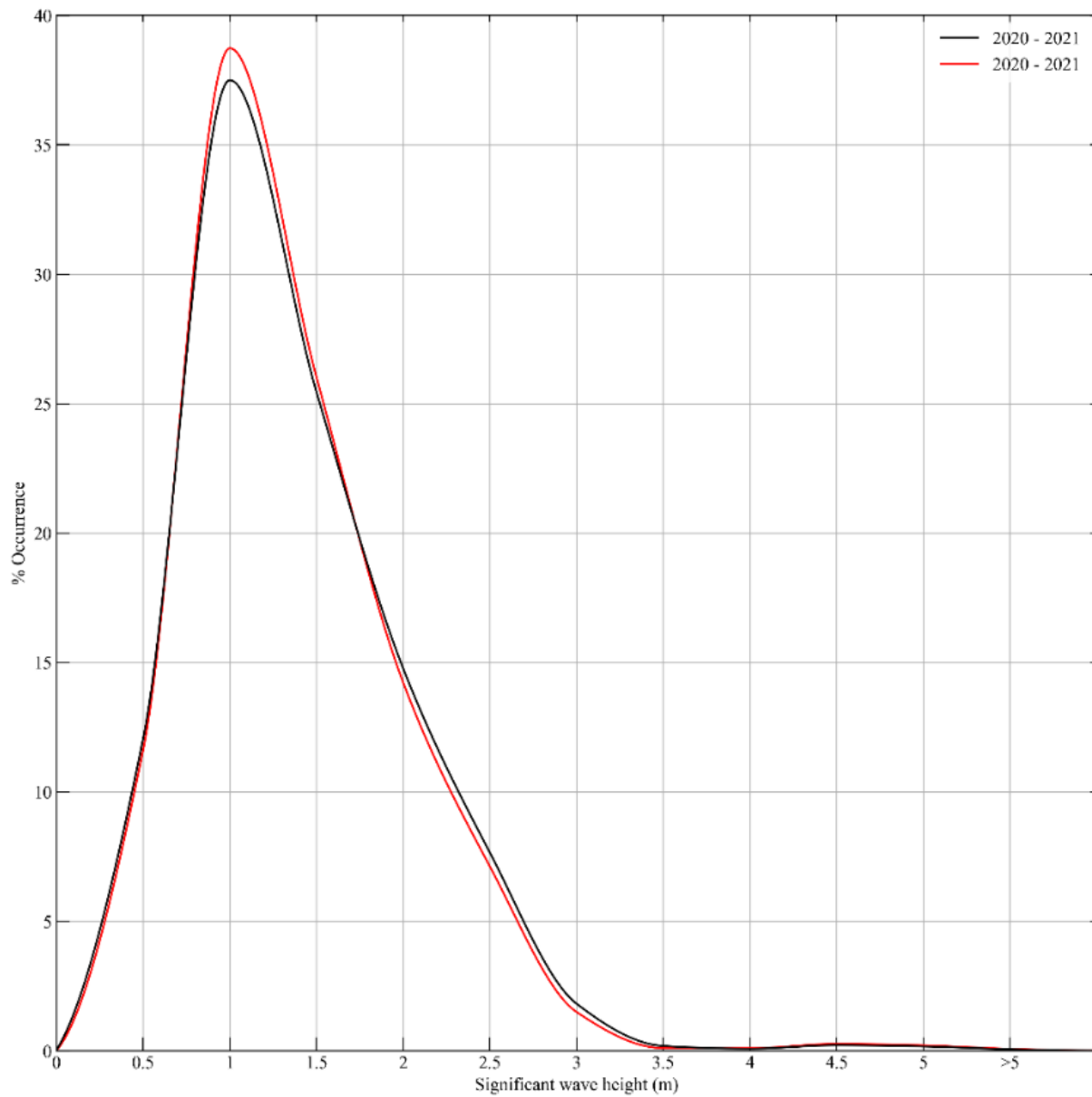


Figure 3.1 Tweed Heads offshore buoy – H_s percentage (%) occurrence

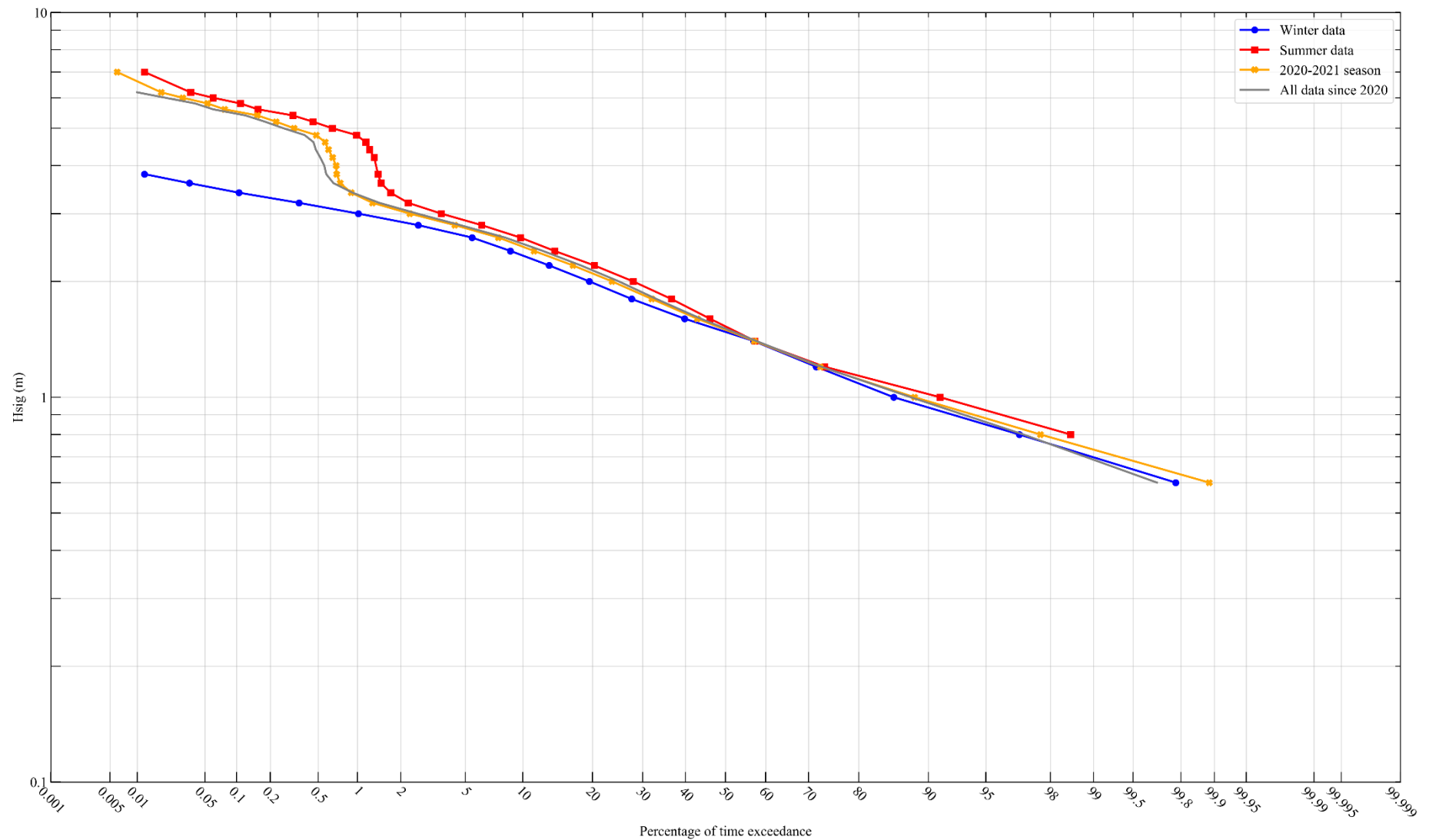


Figure 3.2 Tweed Heads offshore buoy – percentage (of time) exceedance of wave heights (H_s) for all wave periods (T_p)

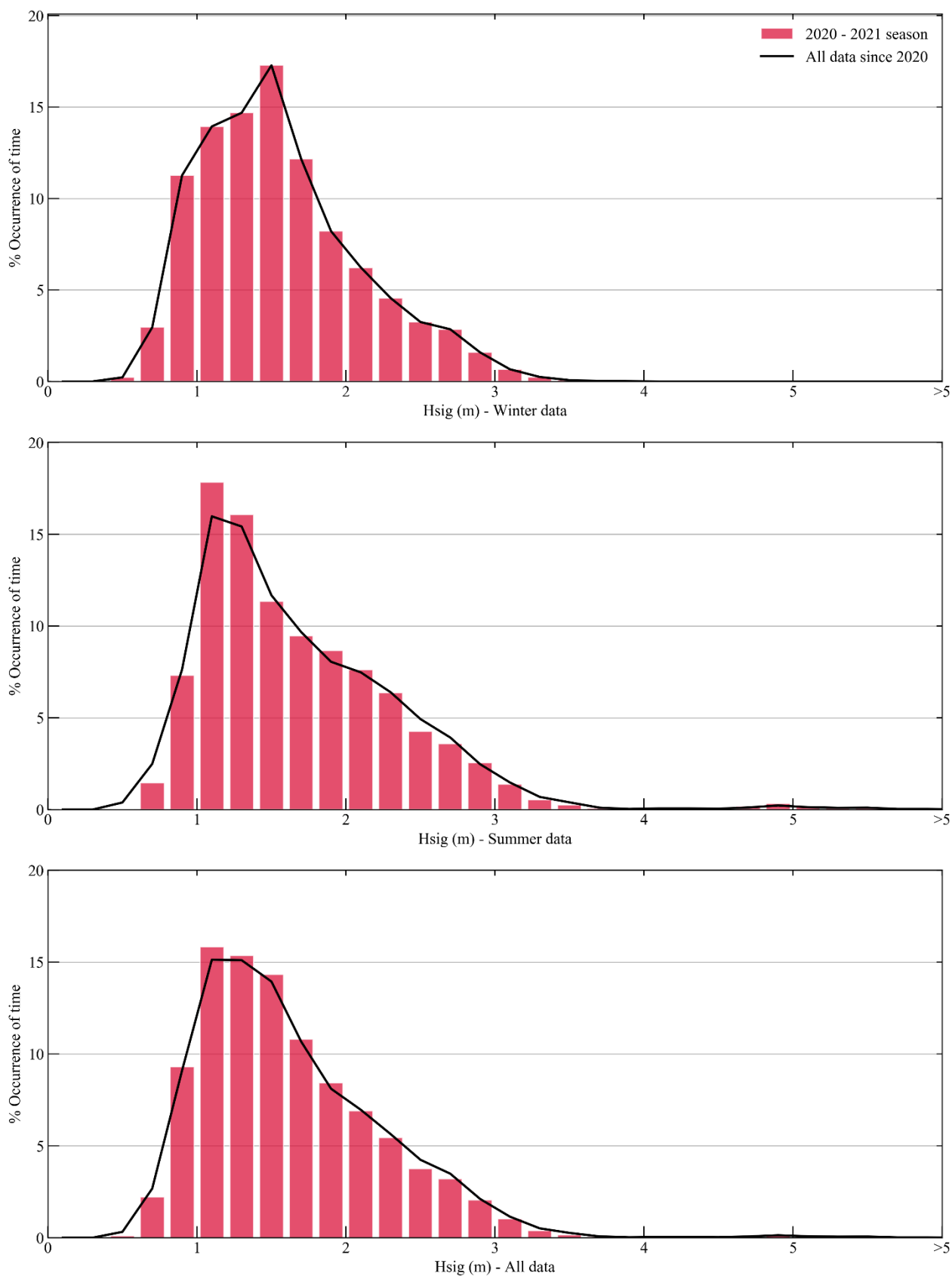


Figure 3.3 Tweed Heads offshore buoy – histogram percentage (of time) occurrence of wave heights (H_s) for all wave periods (T_p)

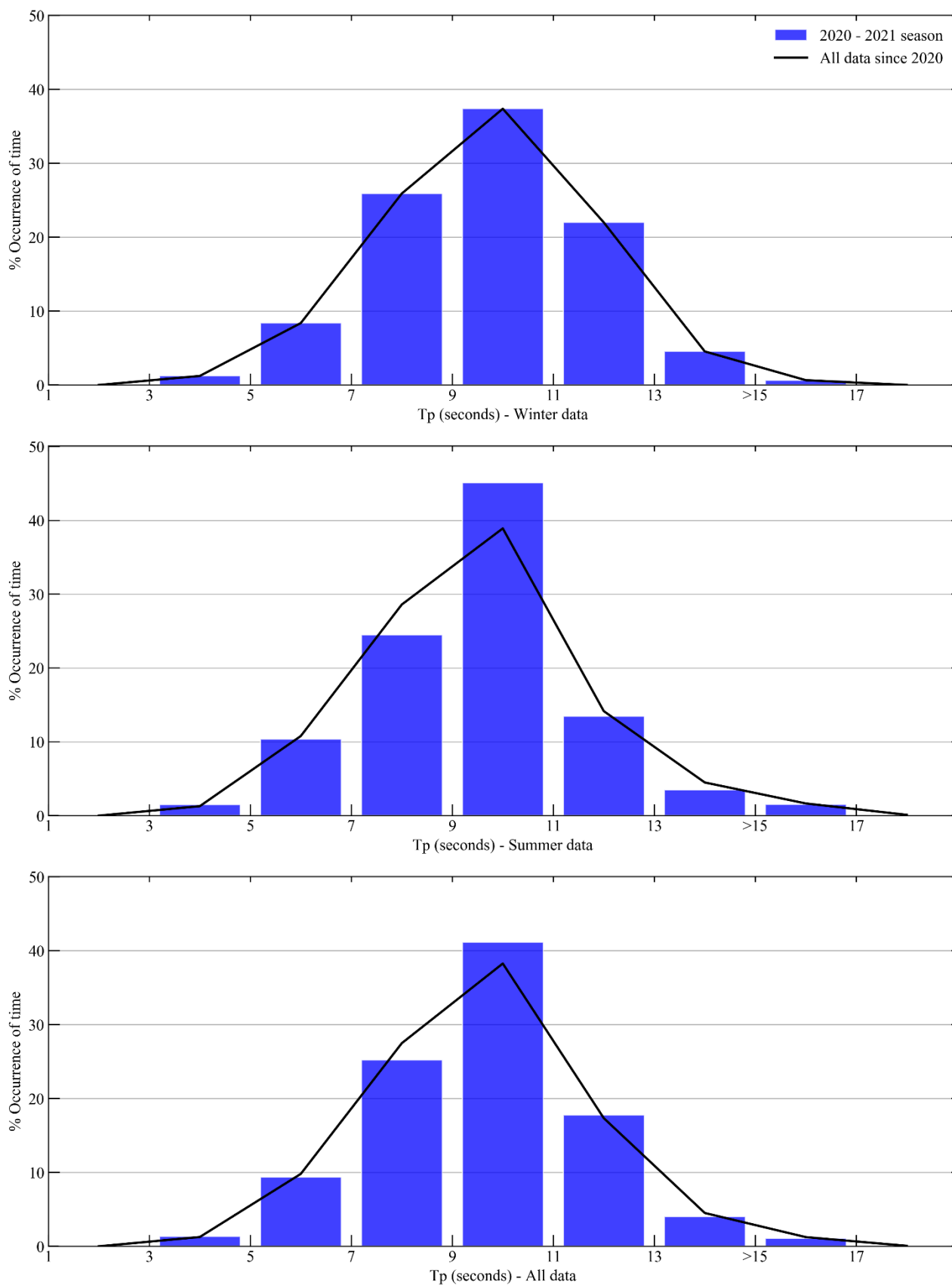


Figure 3.4 Tweed Heads offshore buoy – histogram percentage (of time) occurrence of wave periods (T_p) for all wave heights (H_s)

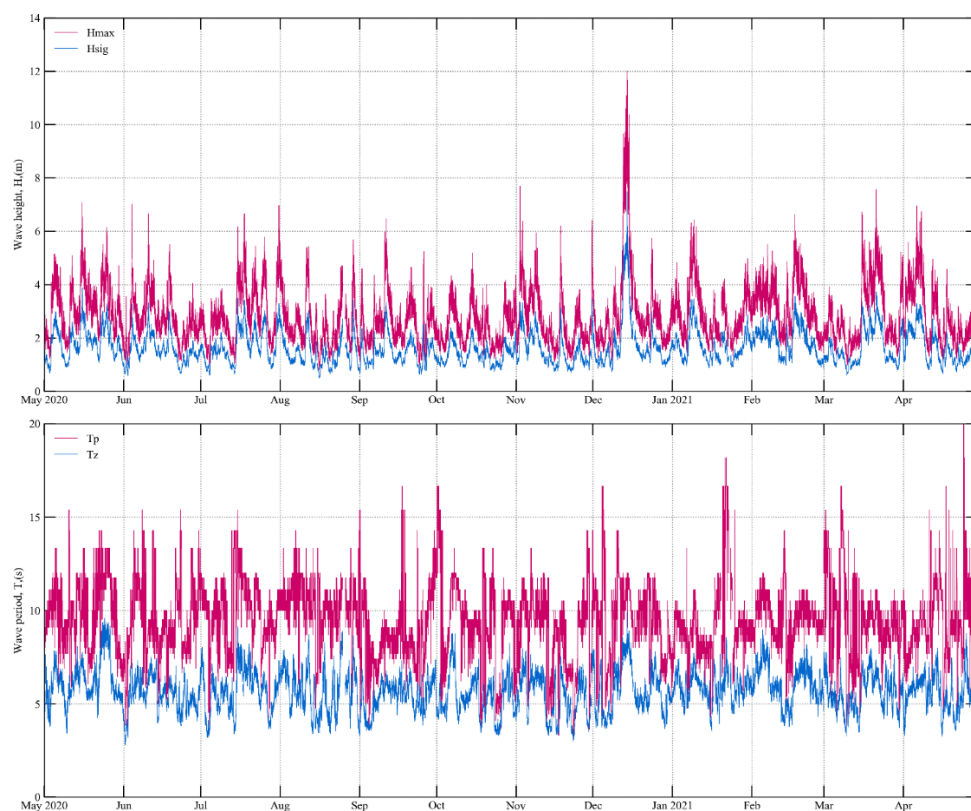


Figure 3.5 Tweed Heads offshore buoy – daily wave recordings

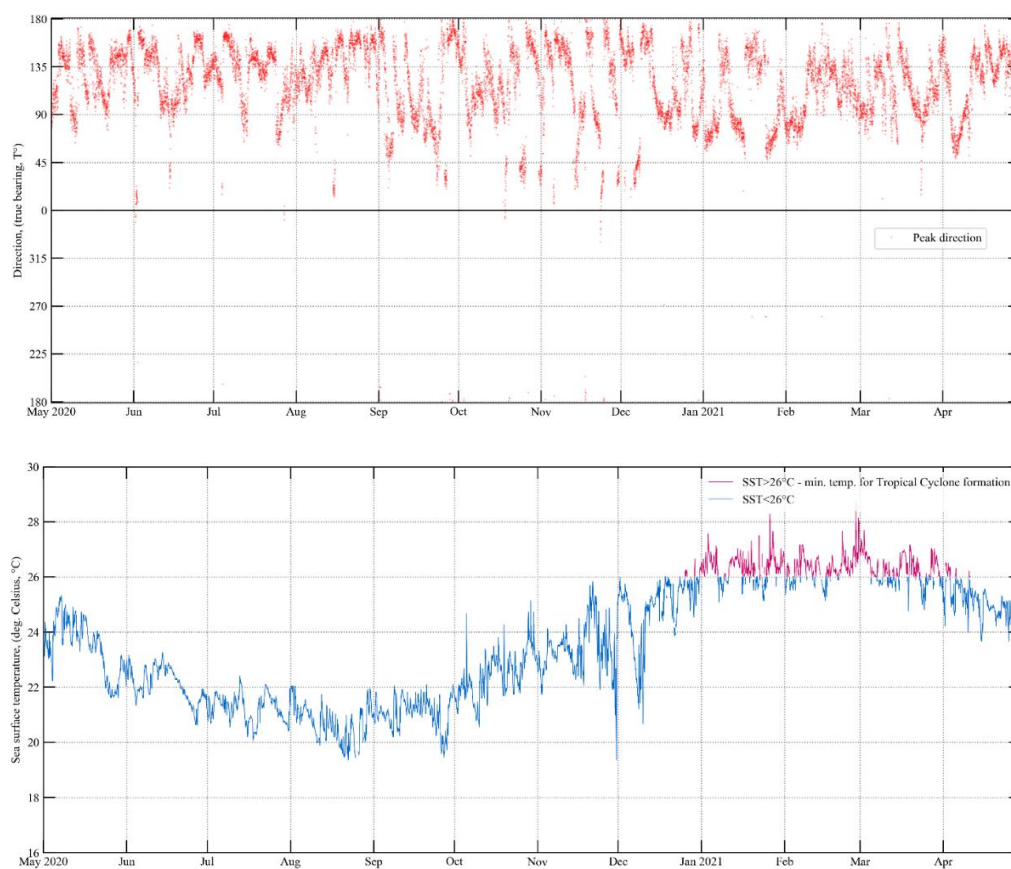


Figure 3.6 Tweed Heads offshore buoy – sea surface temperature and peak wave directions

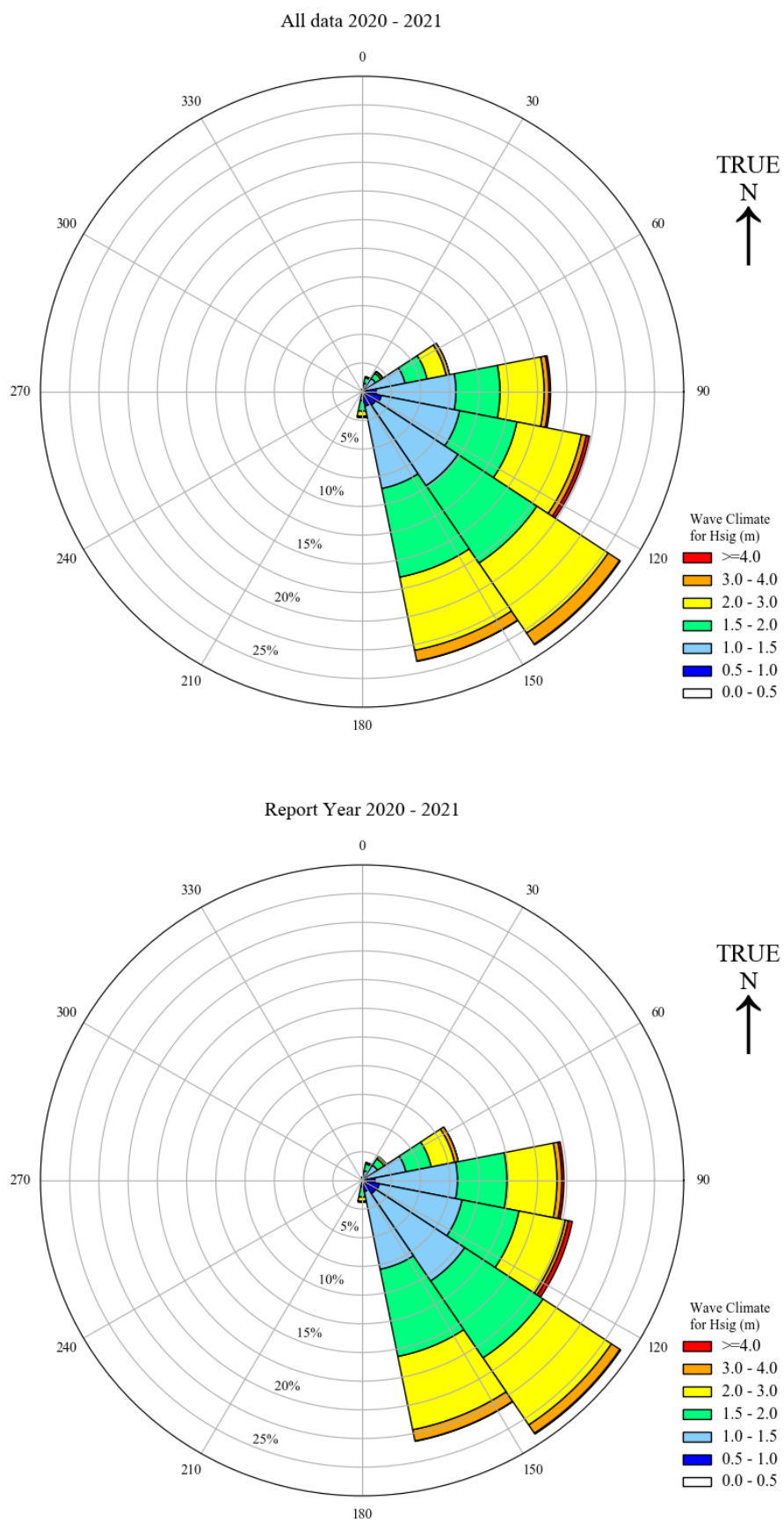


Figure 3.7 Tweed Heads offshore buoy – directional wave rose

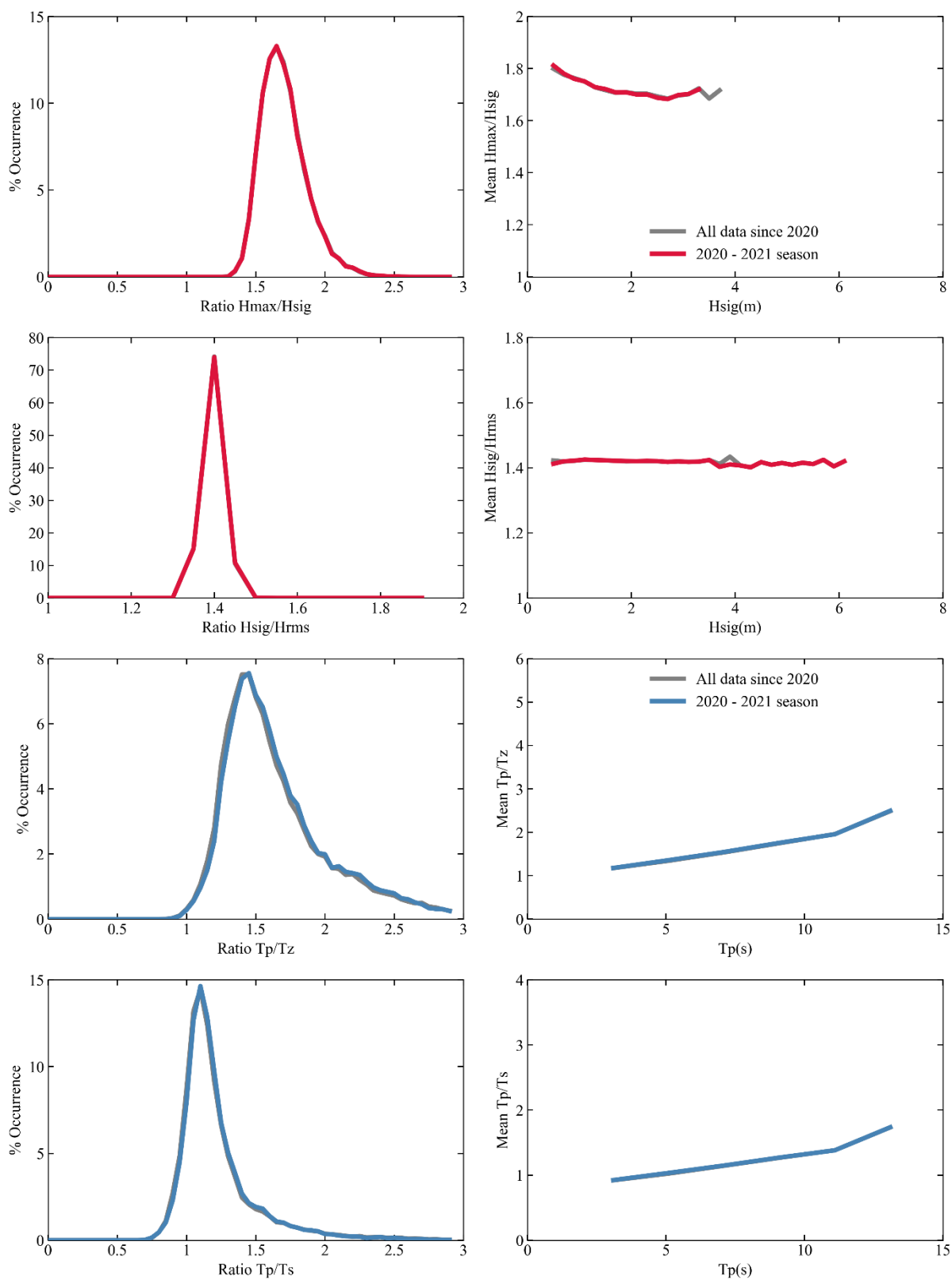


Figure 3.8 Tweed Heads offshore buoy – wave parameter relationships

Brisbane

Near real time data feed: [Brisbane wave monitoring page](#)

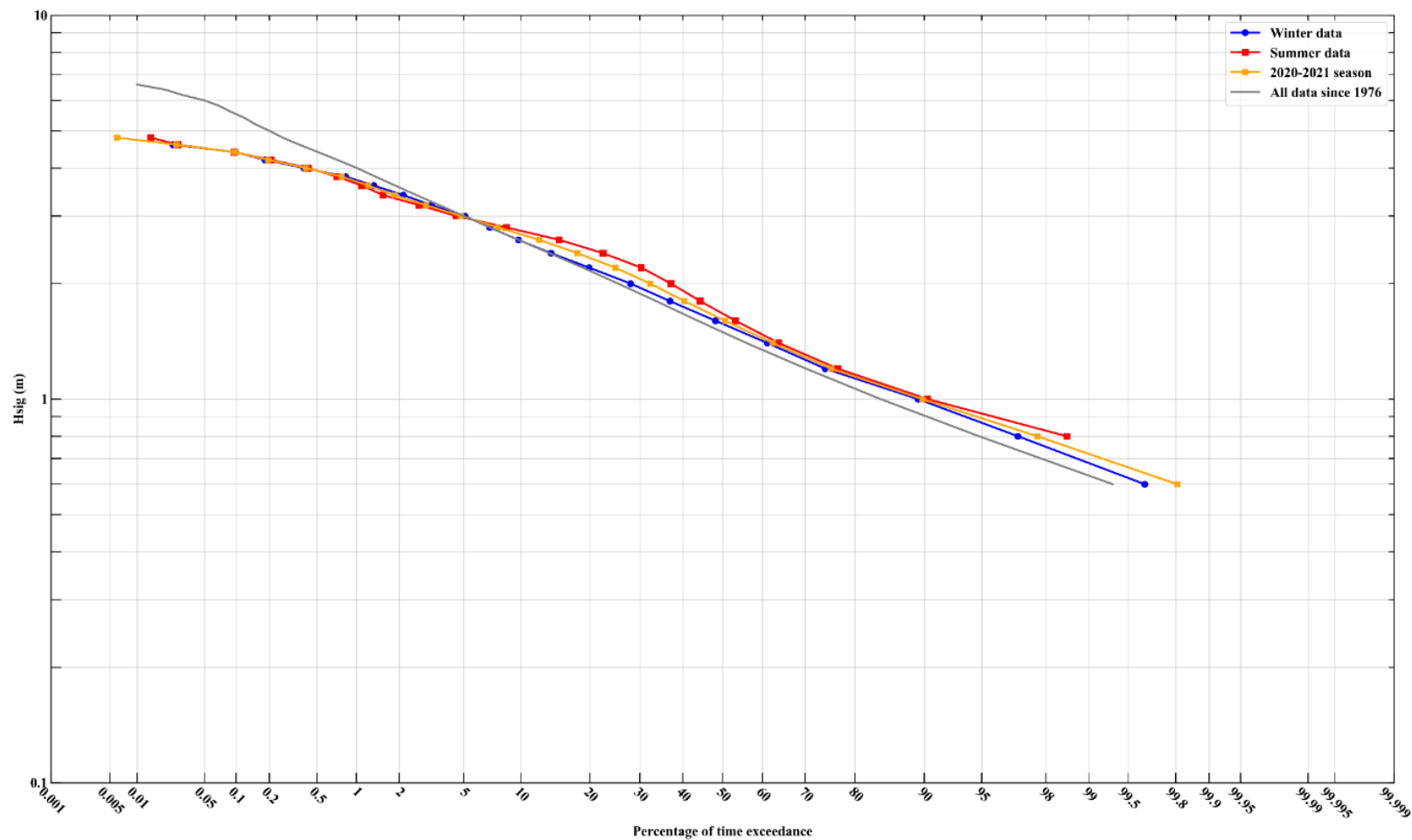


Figure 4.1 Brisbane buoy – percentage (of time) exceedance of wave heights (H_s) for all wave periods (T_p)

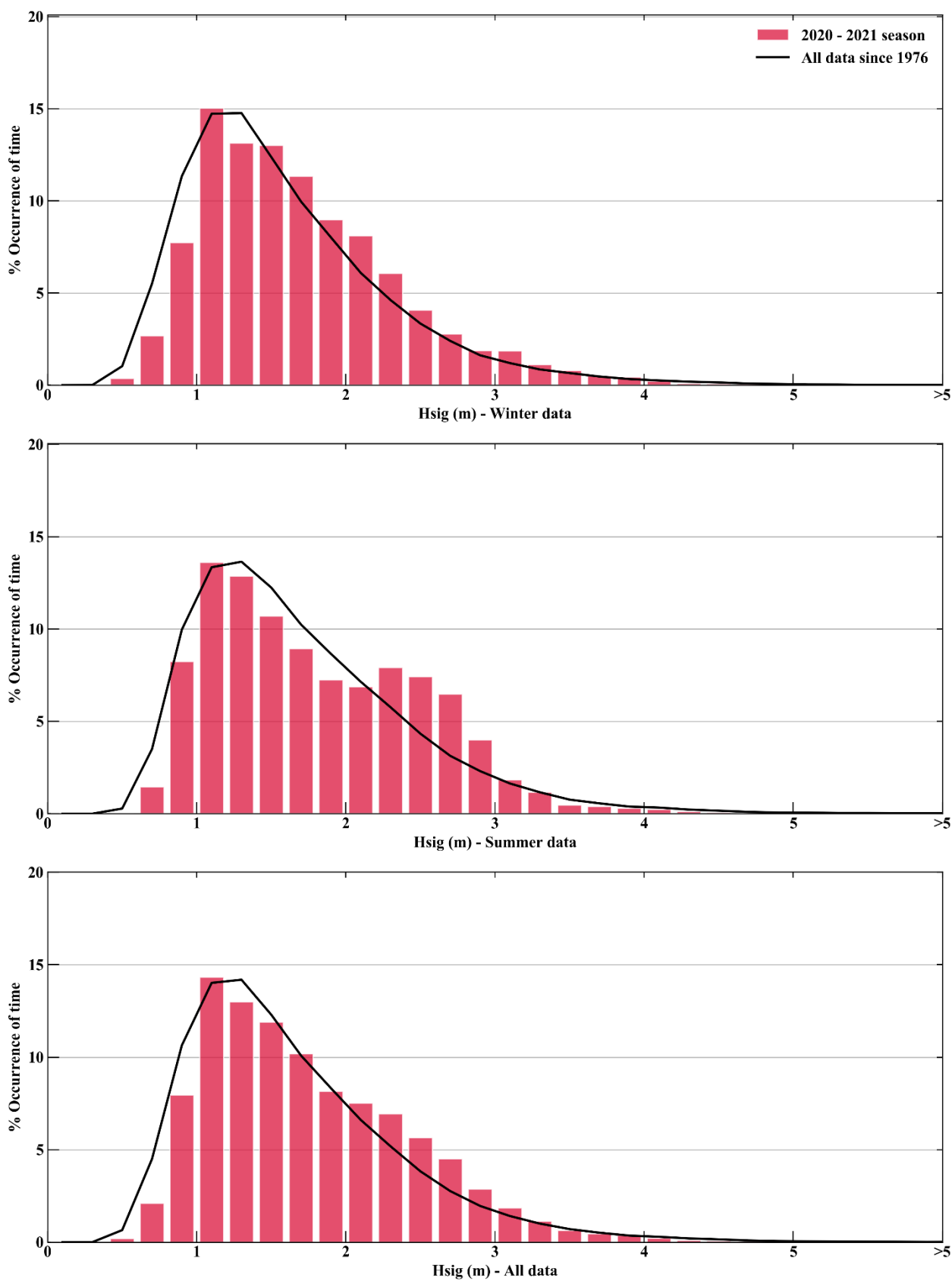


Figure 4.2 Brisbane buoy – histogram percentage (of time) occurrence of wave heights (H_s) for all wave periods (T_p)

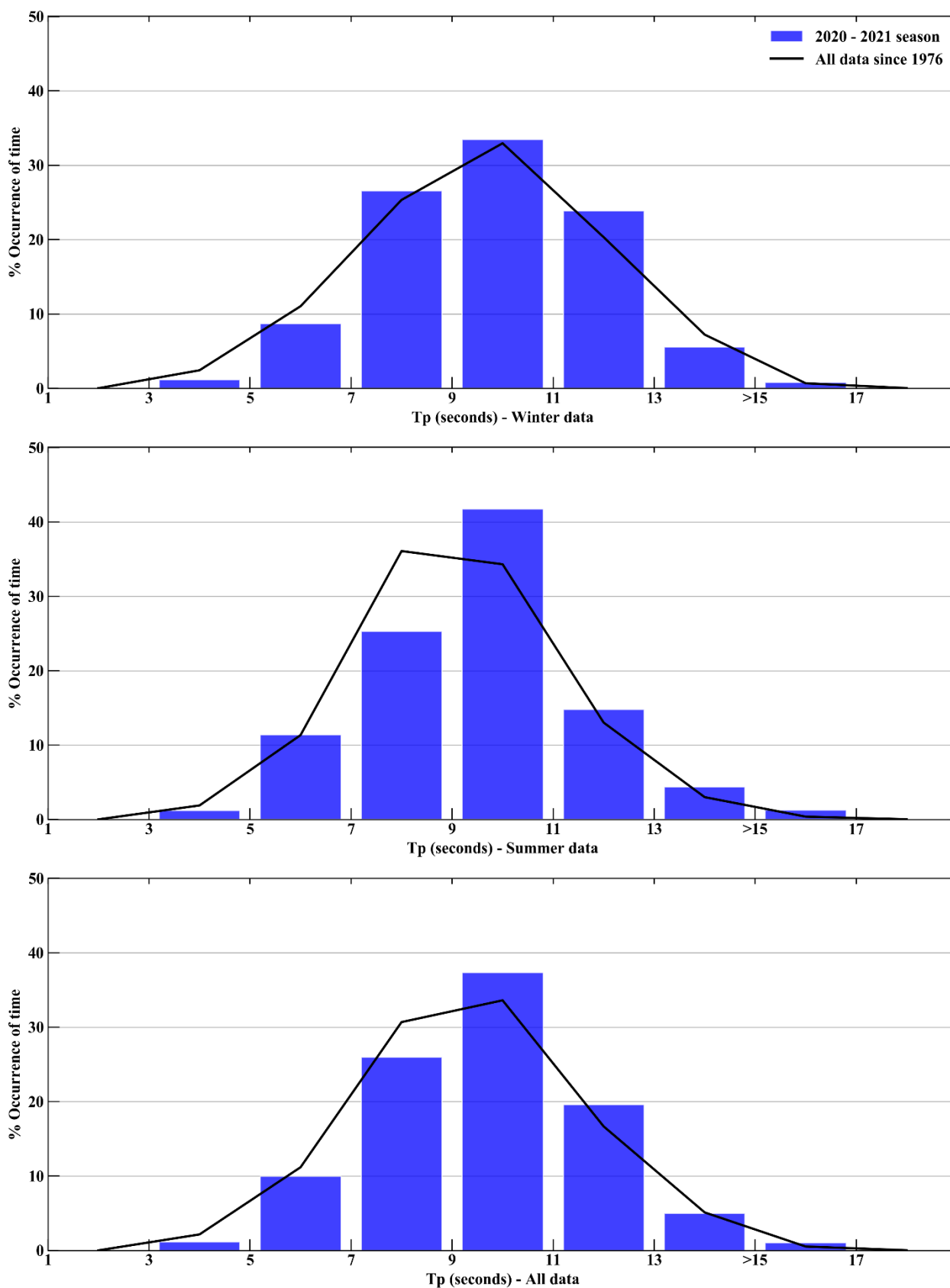


Figure 4.3 Brisbane buoy – histogram percentage (of time) occurrence of wave periods (T_p) for all wave heights (H_s)

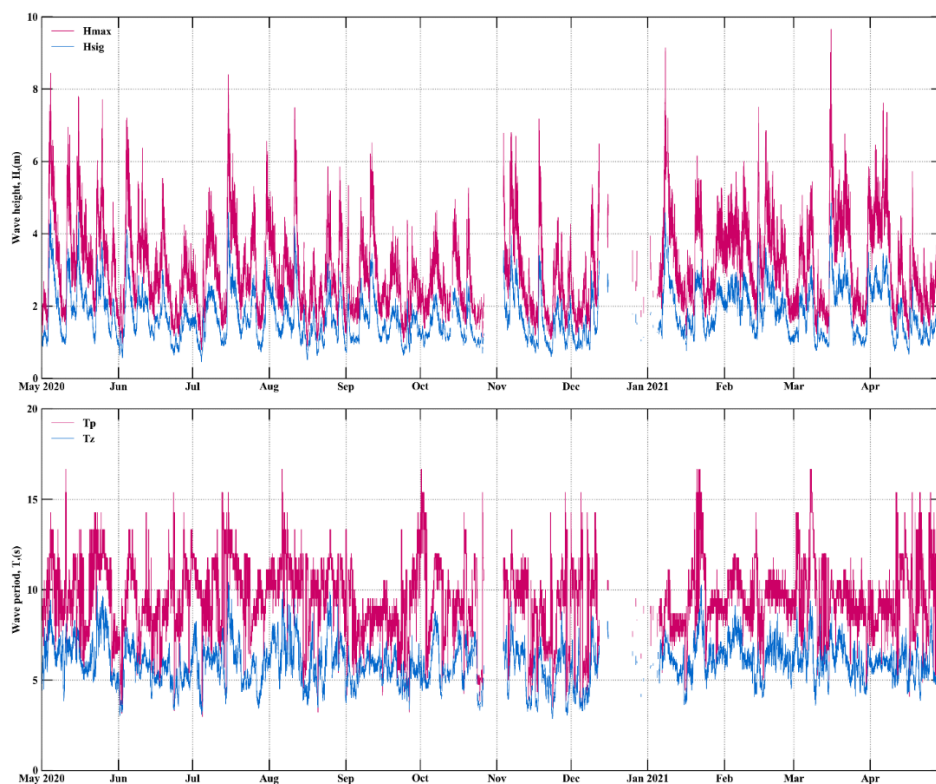


Figure 4.4 Brisbane buoy – daily wave recordings

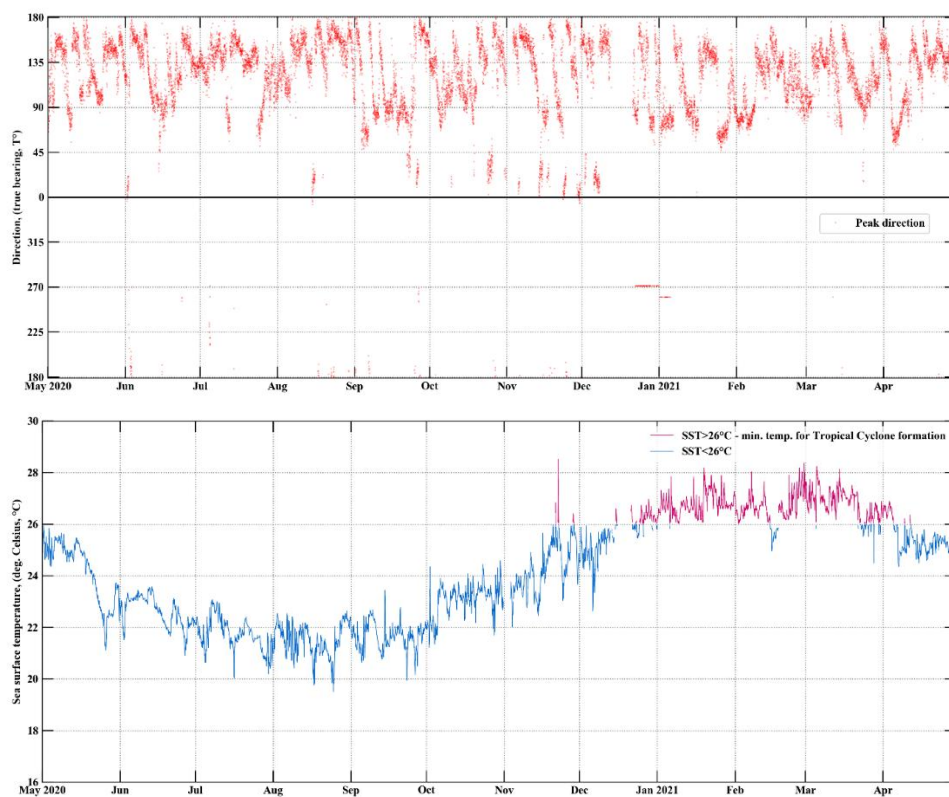


Figure 4.5 Brisbane buoy – sea surface temperature and peak wave directions

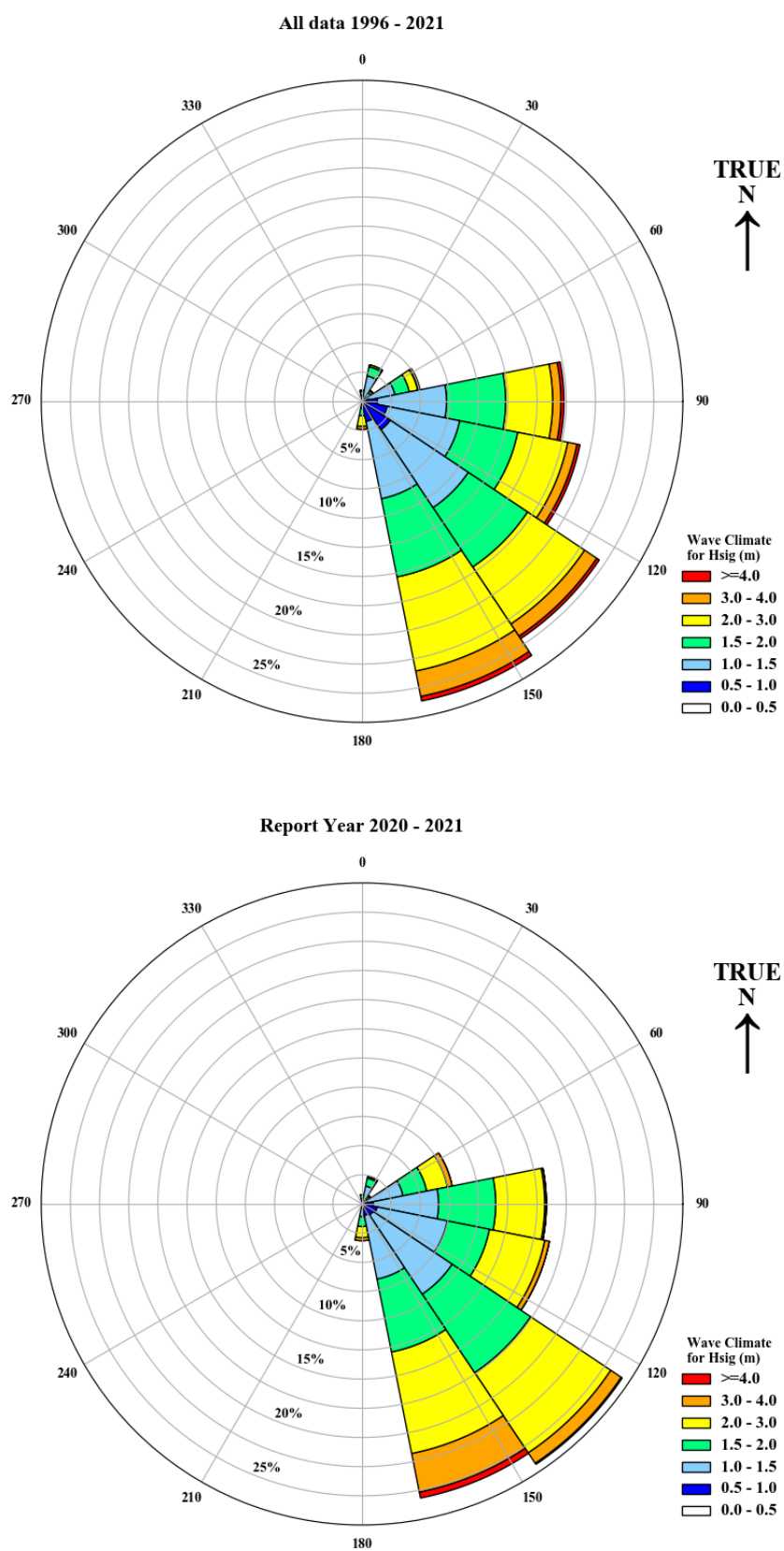


Figure 4.6 Brisbane buoy – directional wave rose

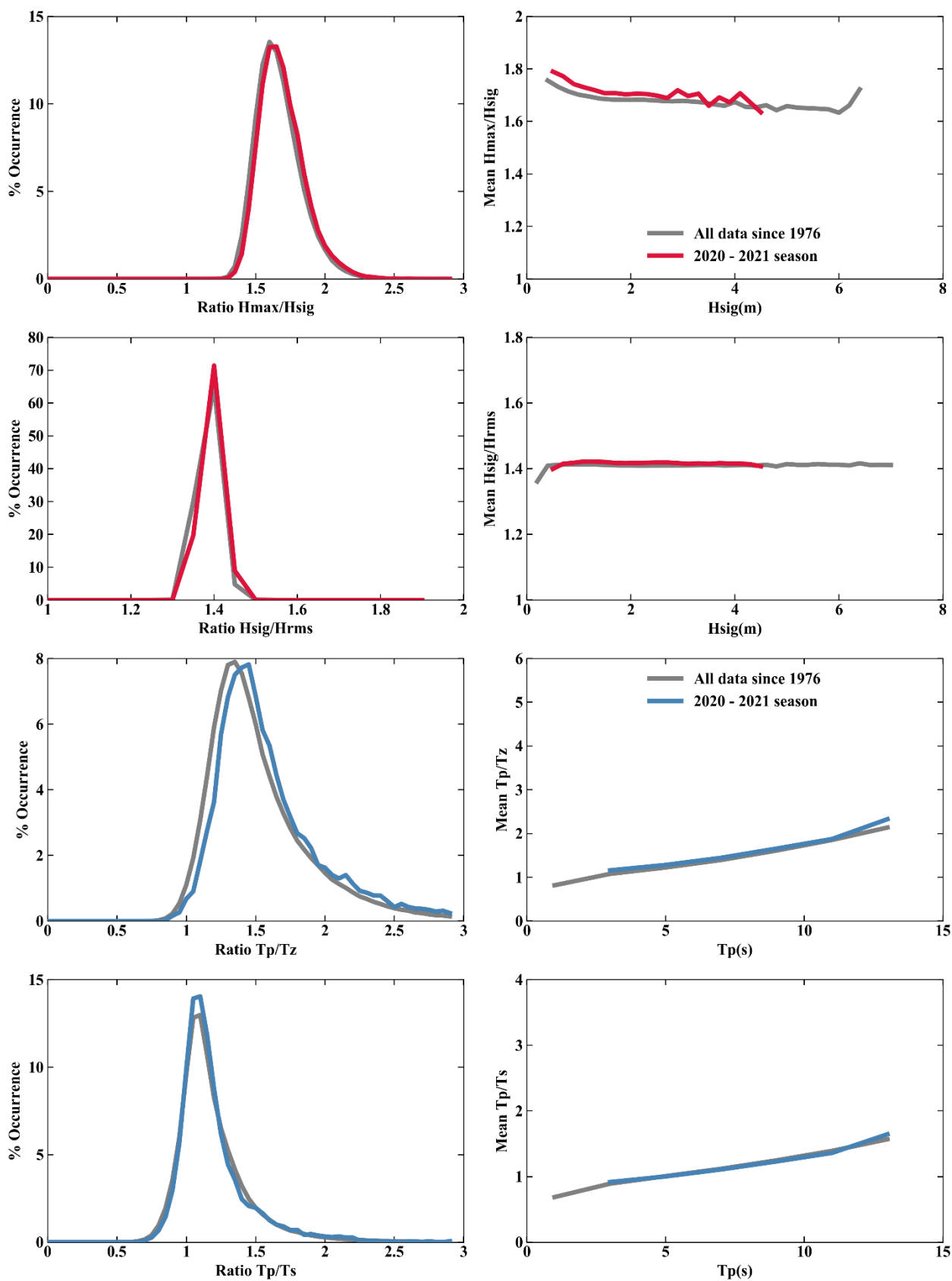


Figure 4.7 Brisbane buoy – wave parameter relationships

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Appendix A – Zero up-crossing analysis

Zero crossing analysis

A direct, repeatable, and widely accepted method to extract representative statistics from wave data recorded by a wave measuring buoy. For zero up-crossing (used by DES), a wave is defined as the portion of the record between two successive zero up-crossings of the mean water line.

Waves are ranked (within their corresponding periods), and statistical wave parameters are computed in the time domain.

An explanation of wave parameters is presented in the Glossary.

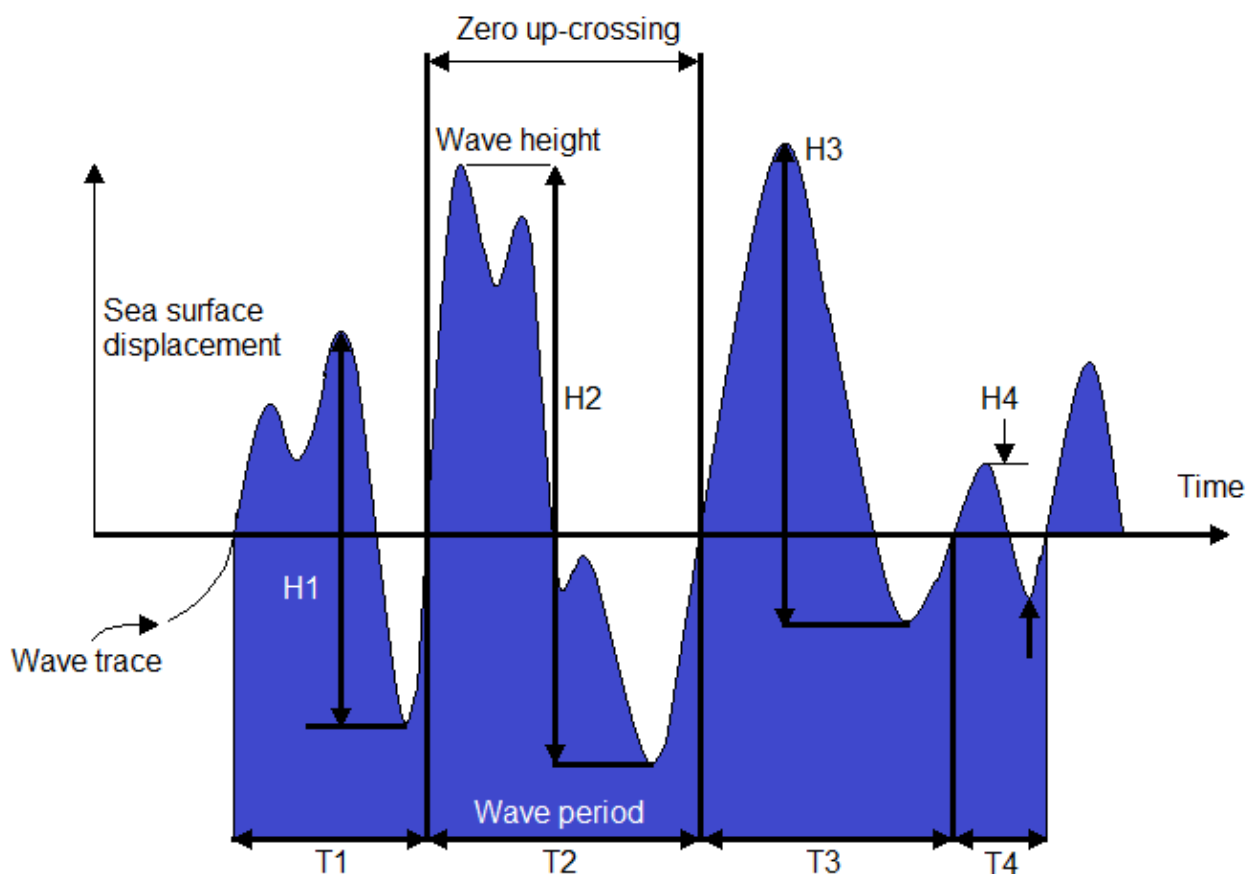


Figure A-1: An example of zero up-crossing method.

Appendix B – Glossary of Terms

Parameter	Description
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.
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).
Direction (Dir; Dir _p)	The direction that peak period (T _p) waves are coming (in ° True North). In other words, where the waves with the most wave energy in a wave record are coming from.
H ₁₀	Average of the highest 10% of all waves in a record.
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.
H _{m0}	Estimate of the significant wave height from frequency domain $4\sqrt{m_0}$.
H _{max}	The maximum zero up-crossing wave height (in metres) in a 26.6-minute record.
H _{rms}	Root mean square wave height from the time domain.
H _s (H _{sig} , significant wave height)	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.
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.
T ₀₂	Average period from spectral moments zero and two, defined by $\sqrt{m_0/m_2}$.
T _c	The average crest period (in seconds) in a 26.6-minute record.
T _{H10}	The period of the H10 waves.
T _{Hmax}	Period of maximum height, zero up-crossing.
T _{Hsig}	The average period of the highest one-third of zero up-crossing wave heights.
T _p	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 T _p , 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).
T _z	The average of the zero up-crossing wave periods (in seconds) in a 26.6-minute record.
T _{zmax}	The maximum zero crossing in a record.
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.

Appendix C – Other published wave data reports in this series

Tweed Heads Wave Climate Summary 2006–2007	Report No. 2007.1	01 May 2006–30 April 2007
Tweed Heads Wave Climate Summary 2007–2008	Report No. 2008.1	01 May 2007–30 April 2008
Tweed Heads Wave Climate Summary 2008–2009	Report No. 2009.1	01 May 2008–30 April 2009
Tweed Heads Wave Climate Summary 2009–2010	Report No. 2010.1	01 May 2009–30 April 2010
Tweed Heads Wave Climate Summary 2010–2011	Report No. 2011.1	01 May 2010–30 April 2011
Tweed Heads Wave Climate Summary 2011–2012	Report No. 2012.1	01 May 2011–30 April 2012
Tweed Heads Wave Climate Summary 2012–2013	Report No. 2013.1	01 May 2012–30 April 2013
Tweed Heads Wave Climate Summary 2013–2014	Report No. 2014.1	01 May 2013–30 April 2014
Tweed Heads Wave Climate Summary 2014–2015	Report No. 2015.1	01 May 2014–30 April 2015
Tweed Heads Wave Climate Summary 2015–2016	Report No. 2016.1	01 May 2015–30 April 2016
Tweed Heads Wave Climate Summary 2016–2017	Report No. 2017.1	01 May 2016–30 April 2017
Tweed Heads Wave Climate Summary 2017–2018	Report No. 2018.1	01 May 2017–30 April 2018
Tweed Heads Wave Climate Summary 2018–2019	Report No. 2019.1	01 May 2018–30 April 2019
Tweed Heads Wave Climate Summary 2019–2020	Report No. 2020.1	01 May 2019–30 April 2020