Potential effects of mussel farms on surf

Hindcast wave statistics at several surf breaks in the Firth of Thames

Report prepared for Ponui Aquaculture Ltd

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MetOcean SOLUTIONS

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1.Introduction

Ponui Aquaculture Ltd. has commissioned a desktop study of the possible effect of mussel farms on several surf breaks in the Firth of Thames (Hauraki Gulf, New Zealand) in terms of surfability assessment and potential wave attenuation/dissipation.

An overview of the wave conditions in the area is required to provide an initial characterisation of the potential effect of mussel farms. Nine (9) surf breaks on the western coast of the Firth of Thames that may be affected are considered in this study have been identified by Surfbreak Protection Society and eCoast (see Appendix), while there approximate locations are given in Table 1.1 and shown in Figure 1.1. These breaks are characterised as either gravel beach brakes or point brakes. Locations of consented and proposed farms within the wider Firth of Thames are provided in Figure 1.2.

Numerical hindcast data have been used to characterise the wave and wind climate at these nine surf spots, with data sources detailed in Section 2 of the report. Analytical methods to calculate the wave parameters are described in Section 3. Background information on the area of interest and potential effects of mussel farms on wave climate is provided in Section 4. Results for wind conditions representative of the area of interest are given in Section 5. The wave climate at each representative site is detailed in Section 6. Conclusions are provided in Section 7 and the references cited are listed in the final Section.

Note that the standard oceanographic directional conventions are applied in this report, with waves and winds reported in the ‘coming from’ directional reference.

Table 1.1 Coordinates of the surf breaks and corresponding offshore representative data reporting sites.

Surf breaks	World Geodetic System 1984 (WGS84)		Offshore representative site	World Geodetic System 1984 (WGS84)	
	Longitude (E)	Latitude (N)		Longitude (E)	Latitude (N)
Pokopoko	175.23001	-36.95040	P1	175.23664	-36.94335
Orere Point	175.24887	-36.95762	P2	175.25651	-36.95134
Tapapakanga	175.25776	-36.97464	P3	175.26534	-36.96803
Matingarahi	175.28527	-36.98824	P4	175.29409	-36.98390
IDKs	175.29222	-37.00904	P5	175.30289	-37.00681
Waihihi Bay	175.29230	-37.02712	P6	175.30399	-37.02490
Waihihi South	175.29404	-37.03294	P7	175.30493	-37.03072
Waharau	175.29787	-37.04033	P8	175.30916	-37.03710
Wharekawa	175.30159	-37.04926	P9	175.31379	-37.04719

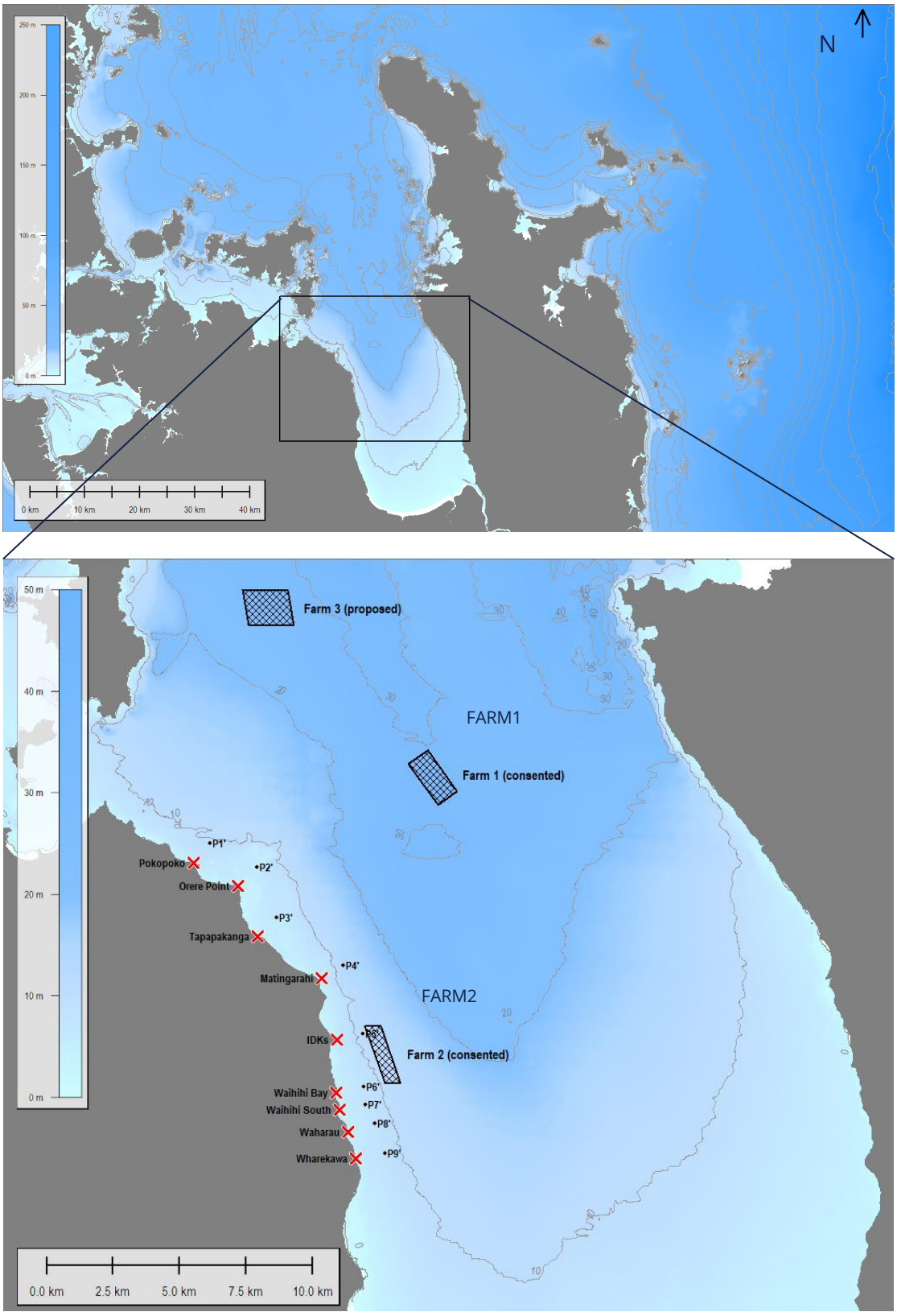

Figure 1.1 Bathymetry maps showing the proposed mussel farms (FARM1 and FARM2), surf breaks and offshore representative sites (P1-P9). The lower map is a zoom into the area of interest in the Firth of Thames.

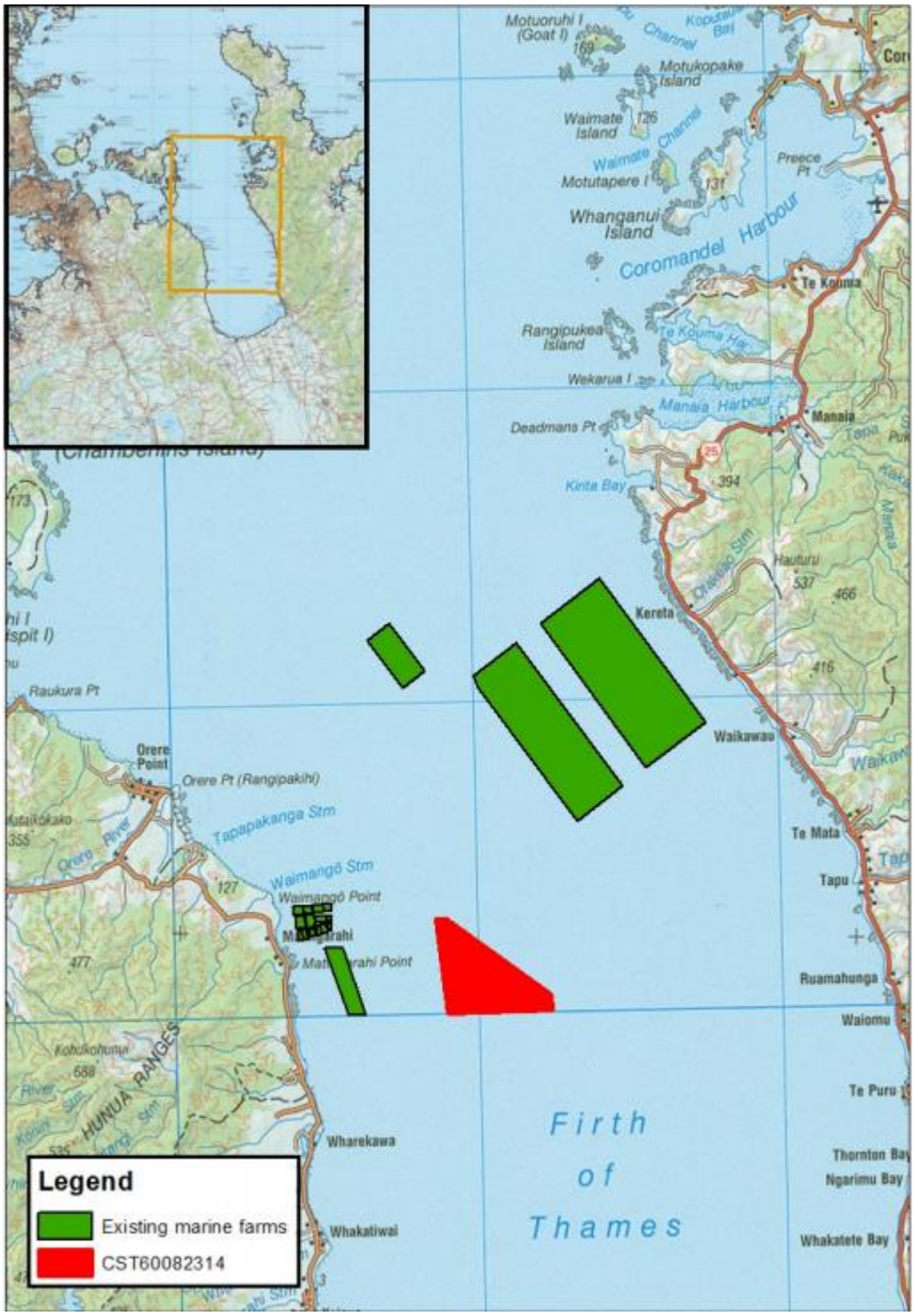

Figure 1.2 Topographical map illustrating existing marine farm consents (green) within the Firth of Thames, and as proposed (CST60082314)

2. Metocean data sources

2.1 Wind data

The near surface wind fields were prescribed by a 37-year regional atmospheric hindcast carried out by MetOcean Solutions (MOS). The WRF (Weather Research and Forecasting) model was established over all New Zealand at hourly intervals and 12 km resolution, with a nested 4 km resolution domain over the Hauraki Gulf. The hindcast was specifically tuned to provide highly accurate marine wind fields for metocean studies around New Zealand.

The WRF model boundaries were sourced from the CFSR (Climate Forecast System Reanalysis) dataset distributed by NOAA (Saha et al., 2010). These data span 37 years (1979-2015) at hourly intervals and 0.31° spatial resolution.

Validation of the WRF reanalysis has been undertaken at various locations around New Zealand.

2.2 Wave data

Directional wave spectra within the Hauraki Gulf have been defined from a 37-year period (1979–2015) high-resolution SWAN (Simulating WAves Nearshore) wave hindcast. First, a global scale wave hindcast was produced by MetOcean Solutions Ltd using the WW3 (WAVEWATCH III) model with a resolution of 0.5° by 0.5° applying the source terms parameterisations of Ardhuin et al. (2010). The CFSR wind field was used for wind forcing and the Tolman and Chalikov (1996) physics options were applied in the model configuration. No wave height data assimilation was performed on this hindcast. These hindcast data were extracted at 3-hour intervals and were used to prescribe spectral boundaries for a regional New Zealand North Island SWAN wave model domain (at 0.04° by 0.04° resolution, i.e. approximately 4 km). Finally, a high-resolution nest of the Hauraki Gulf (at 0.008° by 0.008° resolution, i.e. approximately 800 m) has been implemented and run over 37-years. Both SWAN model domains are illustrated in Figure 2.1.

SWAN is a third generation ocean wave propagation model which solves the spectral action density balance equation (Booij et al., 1999). The model simulates the growth, refraction and decay of each frequency-direction component of the complete sea state, providing a realistic description of the wave field as it changes in time and space. Physical processes that are modelled include the generation of waves by surface wind, dissipation by white-capping, resonant nonlinear interaction between the wave components, bottom friction and depth limited

breaking dissipation. A detailed description of the model equations, parameterisations and numerical schemes can be found in Holthuijsen et al. (2007) and in the SWAN documentation[1]. SWAN was configured with 23 frequency bins and 36 directional bins.

SWAN was run with wind fields specified from the WRF model as described in Section 2.1. Model depths were constructed from a combination of several surveys which include multibeam, single beam, LiDAR, Electronic Nautical Charts (ENCs), obtained from different organisations (including councils, NIWA, LINZ and the Department of Conservation).

Extensive wave model validation has been performed at locations around New Zealand, including within the Hauraki Gulf. No measured wave data were made available at the sites of interest. However, a YouTube video of a surf session at the surf break Matingarahi (P4) on 29 January 2011 (Post Cyclone Wilma) is available online[2]. Visual estimations of wave heights from this video are consistent with the hindcast significant wave height of 0.9 m (i.e. maximum wave height of ~1.7 m) modelled that day at P4 (Figure 2.2).

[1] http://swanmodel.sourceforge.net/online_doc/online_doc.htm

[2] https://www.youtube.com/watch?v=_TKZnFx8qJs

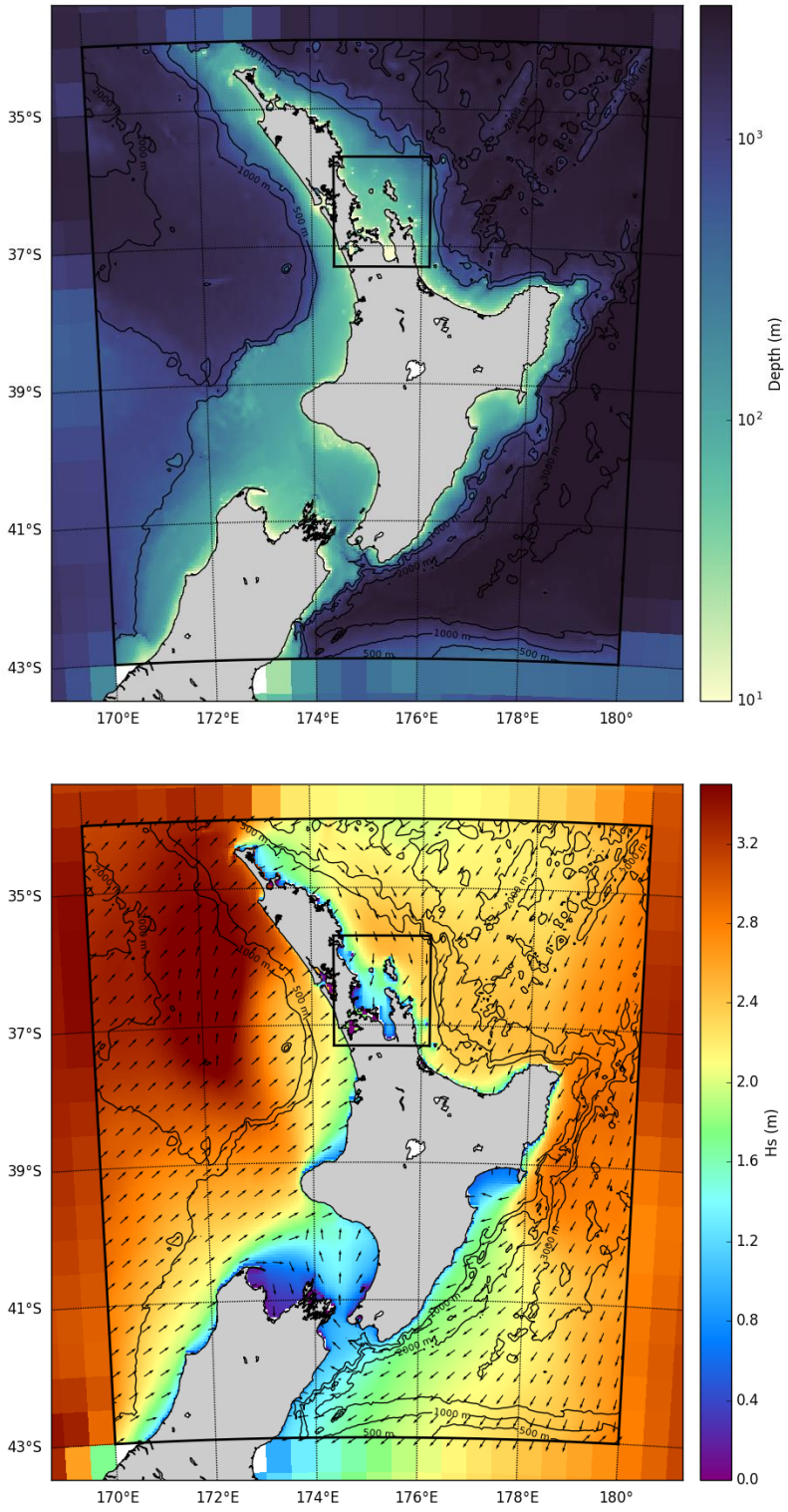

Figure 2.1. Snapshots of (top) model depths and (bottom) significant wave height from the regional NZ North Island 4-km SWAN domain on 01 January 2012, shown within the area delimited by the outer black rectangle. Model data from the 0.5° global wave model are shown outside of this area. Extension of high resolution Hauraki Gulf 800-m SWAN nest is shown by the inner black rectangle.

Figure 2.2. Snapshots of the two highest waves recorded in the YouTube video of 29 January 2011 at Matingarahi (https://www.youtube.com/watch?v=_ TKZnFx8qJs), consistent with the hindcast modelled significant wave height of 0.9 m (i.e. maximum wave height of 1.7 m) at P4.

3.Analytical methods

The hindcast 2D (frequency-direction) wave spectra $E_n(f,\theta)$ were converted into one-dimensional spectra as:

$$S_n(f) = \int_{-\pi}^{\pi} E_n(f,\theta) d\theta \tag{3.1}$$

and the peak frequency, f_p of the one-dimensional spectrum was identified. The significant wave height, H_s, mean direction at peak energy, θ_p and peak period, T_p are defined as:

$$H_s = 4\sqrt{\int_0^{\infty} S_n(f) df}$$

$$\theta_p = \arctan \frac{\int_{-\pi}^{\pi} E_n(f_p,\theta)\sin(\theta) d\theta}{\int_{-\pi}^{\pi} E_n(f_p,\theta)\cos(\theta) d\theta} \tag{3.2 a,b,c}$$

$$T_p = 1/f_p$$

4. Background

The locations of the nine surf breaks of interest and the orientation of the Hauraki Gulf / Firth of Thames result in a limited number of "surfable" days on an annual basis relative to other most exposed surf breaks in New Zealand. Most "surfable" days are characterised by N/NNE incident waves generated by ex-tropical storms/cyclones. Local northerly winds can increase the total sea states during such events, however decreasing the surf quality due to the limited fetch.

To our knowledge, there are no references to potential impacts of marine mussel farms on surf breaks in the Firth of Thames. Plew et al. (2005) examined the wave and current implications of a 650 m wide mussel farm offshore Collingwood, Golden Bay, New Zealand. They observed that wave energy attenuation was predominantly frequency dependent. Little or no dissipation was observed at frequencies less than 0.1 Hz (i.e. at wave periods above 10 s) but increases as frequency increases. Plew et al. (2005) observed that the dissipation was around 5% at 0.15 Hz (wave period ~7 s) and 10% at 0.2 Hz (5 seconds) and suggested that wave dissipation increases further at higher frequencies (however Plew et al. 2005 was unable to quantify this increase due to the type of instrumentation used and deployment method). Note that during the deployment period, the significant wave heights did not exceed 0.25 m and Plew et al. (2005) was unable to comment on the accuracy of the model for more exposed sites.

Wave attenuation is also expected to be dependent on the dropper density and size of the farm (Plew et al., 2005). Furthermore, Plew et al. (2005) pointed out there is a possibility for the mussel farm structure to resonate at particular frequencies, which will potentially increase the drag.

5. Wind statistics

Little variation in wind climate was noted between all reporting sites P1-P9 and the wind climate is not the main focused of this study, therefore the wind statistics are described for site P4 and taken to be representative of all sites (P1-P9).

A summary of the wind speed statistics for the 10-minute mean at 10 m elevation is provided in Table 5.1. The annual mean wind speed is 5.38 $m.s^{-1}$, while the windiest month is July (mean 5.89 $m.s^{-1}$) and the least windy month is February (mean 4.80 $m.s^{-1}$).

The monthly and annual wind speed exceedance probabilities are provided in Table 5.2, and indicate that wind speeds exceeding 16 $m.s^{-1}$ can occur throughout the year, with March, June and July having the highest occurrence of strong wind events.

Joint probability distributions of the wind speed and direction are presented in Table 5.3 for the annual conditions. The same data are presented in the wind rose plots in Figure 5.1, showing the annual predominance of winds coming from the SW quadrant, however with the strongest wind events typically occurring from the N and NE octants.

Note the wind directions are reported in the "*coming from*" convention (clockwise from True North).

Table 5.1 Annual and monthly wind speed statistics at P4.

U_{10min} ($m.s^{-1}$)	Parameter						
	Mean ($m.s^{-1}$)	Std. dev. ($m.s^{-1}$)	Median ($m.s^{-1}$)	P90 ($m.s^{-1}$)	P95 ($m.s^{-1}$)	P99 ($m.s^{-1}$)	Max ($m.s^{-1}$)
Jan	5.03	2.61	4.79	8.36	9.82	12.55	19.73
Feb	4.80	2.51	4.56	8.05	9.35	12.43	17.42
Mar	4.99	2.69	4.71	8.50	9.79	12.76	22.45
Apr	4.96	2.74	4.65	8.60	9.90	12.89	18.49
May	5.42	2.88	5.13	9.25	10.73	13.44	17.54
Jun	5.82	3.16	5.46	10.06	11.64	14.85	22.08
Jul	5.89	3.19	5.44	10.14	11.68	15.27	22.60
Aug	5.60	3.10	5.20	9.84	11.32	14.41	19.55
Sep	5.66	3.06	5.31	9.85	11.34	14.21	20.14
Oct	5.71	2.95	5.38	9.66	11.09	14.20	19.78
Nov	5.47	2.78	5.16	9.10	10.42	13.50	18.36
Dec	5.21	2.63	4.98	8.54	10.02	12.74	20.27
1979	5.11	2.80	4.78	8.77	10.36	13.67	17.33
1980	5.47	2.97	5.21	9.39	10.95	13.75	19.36
1981	5.33	2.93	4.99	9.12	10.65	14.72	18.49
1982	5.22	2.76	4.99	8.84	10.21	12.99	17.44
1983	5.37	2.87	5.04	9.13	10.71	13.69	19.61
1984	5.16	2.92	4.79	8.99	10.68	14.00	19.42
1985	5.43	2.96	5.10	9.35	10.81	14.07	19.55
1986	5.02	2.88	4.66	8.84	10.19	13.92	19.48
1987	5.17	2.93	4.80	9.13	10.71	13.86	19.73
1988	5.50	3.09	5.02	9.78	11.37	14.59	22.45
1989	5.60	3.03	5.27	9.76	11.29	13.91	18.36
1990	5.08	2.74	4.86	8.57	9.90	13.31	19.42
1991	5.29	2.69	5.07	8.82	9.92	12.59	18.92
1992	5.47	2.86	5.23	9.27	10.60	13.33	19.08
1993	5.19	2.82	4.88	8.89	10.45	13.23	19.83
1994	5.59	2.93	5.32	9.35	10.98	14.69	18.37
1995	5.32	2.88	5.00	9.21	10.75	13.16	20.14
1996	5.60	2.89	5.31	9.38	10.98	13.95	18.69
1997	5.25	2.84	4.86	9.09	10.70	13.98	18.60
1998	5.62	3.17	5.17	9.78	11.62	15.40	20.40
1999	5.18	2.81	4.83	8.88	10.25	12.90	20.27
2000	5.22	2.98	4.76	9.33	10.63	13.35	19.43
2001	5.33	2.86	5.07	9.09	10.44	13.45	17.98
2002	5.67	2.88	5.41	9.45	10.94	13.74	20.97
2003	5.56	2.92	5.21	9.47	10.94	14.14	17.89
2004	5.41	2.96	5.12	9.48	10.91	13.98	17.34
2005	4.97	2.78	4.61	8.71	10.00	13.26	18.72
2006	5.34	2.86	4.97	9.02	10.46	14.29	22.08
2007	5.31	2.92	4.91	9.22	10.78	13.86	18.12
2008	5.69	2.97	5.31	9.59	11.20	14.09	22.60
2009	5.48	2.86	5.15	9.30	10.74	14.21	20.46
2010	5.37	2.96	4.93	9.40	11.09	13.91	17.86
2011	5.55	2.89	5.18	9.53	11.03	13.68	15.53
2012	5.84	2.82	5.57	9.49	10.82	14.01	19.78
2013	5.42	2.77	5.05	9.28	10.67	13.34	18.15
2014	5.67	2.80	5.42	9.32	10.67	13.48	17.32
2015	5.37	2.59	5.17	8.66	10.10	12.93	18.24
Annual	5.38	2.89	5.05	9.21	10.71	13.80	22.60

Table 5.2 Monthly and annual wind speed exceedance probabilities at P4.

U_{10min} ($m.s^{-1}$)	Exceedance (%)												
	January	February	March	April	May	June	July	August	September	October	November	December	Year
>2	88.40	87.78	87.66	86.28	89.09	90.17	90.55	88.59	89.08	90.79	90.67	89.92	89.09
>4	63.36	58.90	61.16	60.25	65.79	68.67	69.68	66.82	68.50	70.73	68.30	65.96	65.72
>6	31.00	27.33	31.00	31.55	38.02	43.32	43.36	39.65	39.98	41.63	38.79	34.09	36.69
>8	12.07	10.29	13.06	13.39	18.00	22.24	23.47	20.26	20.66	19.74	17.10	13.34	17.00
>10	4.51	3.54	4.50	4.74	6.94	10.30	10.66	9.35	9.44	8.77	6.14	5.04	7.01
>12	1.47	1.34	1.44	1.50	2.59	4.17	4.40	3.49	3.60	3.16	2.17	1.69	2.59
>14	0.46	0.37	0.52	0.60	0.63	1.51	1.81	1.20	1.15	1.10	0.77	0.50	0.89
>16	0.15	0.05	0.13	0.16	0.11	0.41	0.56	0.34	0.26	0.26	0.27	0.13	0.24
>18	0.05	0.00	0.08	0.02	0.00	0.14	0.17	0.12	0.06	0.07	0.02	0.05	0.07
>20	0.00	0.00	0.07	0.00	0.00	0.02	0.03	0.00	0.01	0.00	0.00	0.01	0.01
>22	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.3 Annual joint probability distribution (parts per thousand) of the wind speed and wind direction at P4.

U_{10min} (m.s^{-1})	Wind direction (degT)								
	337.5 -22.5	22.5 -67.5	67.5 -112.5	112.5 -157.5	157.5 -202.5	202.5 -247.5	247.5 -292.5	292.5 -337.5	Total
0 - 2	16.3	10.2	10.3	20.2	17.5	8.9	10.7	14.9	109.0
2 - 4	27.0	15.9	12.1	26.1	50.1	32.6	38.9	30.8	233.5
4 - 6	30.0	23.1	15.4	15.8	52.0	49.7	67.1	37.1	290.2
6 - 8	25.6	18.0	11.5	9.9	34.7	27.6	40.8	28.8	196.9
8 - 10	18.8	10.8	6.5	7.7	15.7	7.9	13.6	18.8	99.8
10 - 12	11.0	6.3	2.6	4.1	4.2	2.0	4.6	9.4	44.2
12 - 14	5.9	2.8	1.2	1.3	1.4	0.4	1.1	2.9	17.0
14 - 16	2.5	1.4	0.6	0.5	0.5	0.1	0.1	0.8	6.5
16 - 18	0.7	0.4	0.2	0.1	0.1	0.0	0.0	0.1	1.6
18 - 20	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.4
20 - 22	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Total	138.0	89.0	60.5	85.8	176.2	129.2	176.9	143.6	1000.0

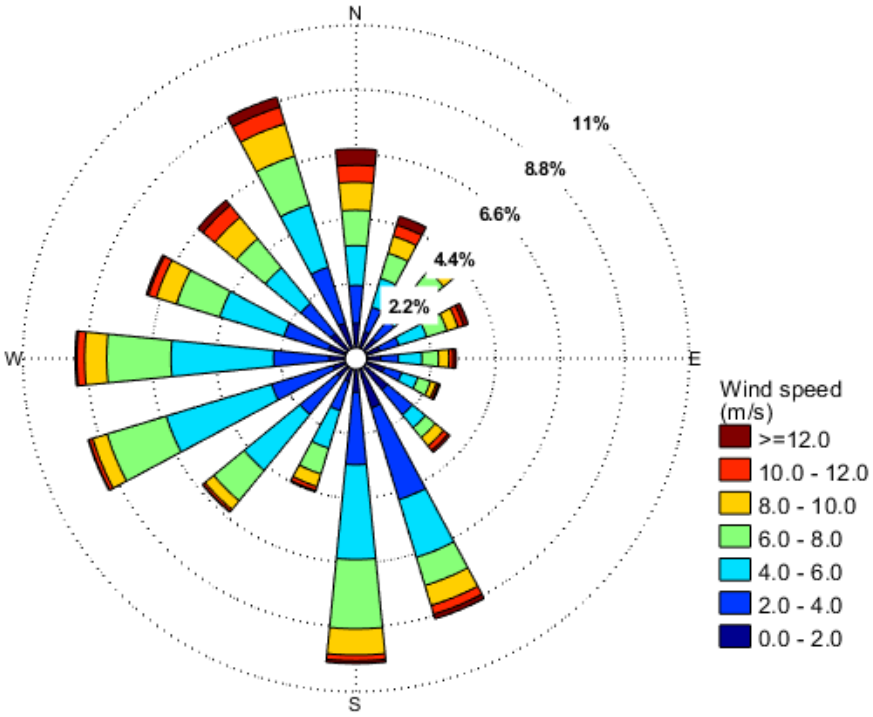

Figure 5.1. Annual wind rose plot at P4. Sectors indicate the direction from which wind is coming.

6. Wave statistics

The wave climate is described for the nine representative locations in Section 6.1. The wave fields of five typical surfing events are presented in Section 6.2. Note the wave directions are reported in the "*coming from*" convention (clockwise from True North).

6.1 Site statistics

The wave climate within the Firth of Thames is relatively benign and dominated by locally derived seas characterised by short periods and comparatively low wave heights.

The wave climate is described for the nine representative locations (P1-P9). The following statistics are provided:

- Annual and monthly significant wave height statistics (Mean; standard deviation; median; 90th, 95th and 99th percentile exceedance levels; and maximum) for significant wave height, H_s (Table 6.1- Table 6.9).
- Table of the annual and monthly H_s exceedance (Table 6.10- Table 6.18).
- Annual joint probability distributions of H_s and peak wave period, T_p (Table 6.19-Table 6.27).
- Annual joint probability distributions of H_s and mean wave direction at peak energy, θ_p (Table 6.28- Table 6.36).
- Annual wave roses (Figure 5.1- Figure 6.9).
- Annual wave roses for "surfable" events, inclusive of poor surfing conditions (i.e. H_s > 0.5 m and T_p > 6 s) (Figure 6.10- Figure 6.18).

Assuming that "surfable" conditions are met when $H_s \geq 0.5$ m and $T_p \geq 6$ s, the statistics indicate that these conditions occur on average 11.5% of the time at site P2 and only 3.8% of the time at site P9 (Table 6.37) (gradually decreasing from P2 to P9 and from P2 to P1). These values are considered conservative, as in reality wave periods of T_p < 8 s or H_s < 0.75 m are considered poor to average surfing conditions[3]. As such, Mead et al., (2004) used a threshold of H_s > 0.75, and T_p > 6 s, and Black et al. (2004) used similar wave height and period limitations while

[3] https://www.surfertoday.com/surfing/9116-the-importance-of-swell-period-in-surfing

restricting the directional spreading to less than 40, which effectively increased the period (T_p) threshold.

Considering a $H_s \geq 0.75$ m and $T_p > 6$ s results in surfable conditions (inclusive of poor conditions) of 5.8% of the time at site P2 and only 1.8% of the time at site P9 (Table 6.37).

Average to good surfable conditions (i.e. $H_s \geq 0.75$ m and $T_p \geq 8$ s) are expected to occur ~2.6% of the time at site P2 and ~0.02% of the time at P6-P9, corresponding to 9-10 days per year at P2 and ~ 1 day every 2-3 years at sites P6-P9 (Table 6.37).

To our knowledge, Plew et al. (2005) is the most relevant study to assess the potential impact on offshore mussel farms on wave climate. However, the main limitation of Plew et al. (2005)'s experiment is that only wave heights up to 0.25 m were measured during the deployment period. It was also recognised that the effect of the mussel farms is dependent on the density of the droppers and the dimensions of the farm. Irrespective of this, Plew et al. (2005) found that the wave dissipation due to mussel farms is frequency dependent, from which a conservative interpretation of the results was applied here: 10% decrease in wave amplitudes for incident wave conditions with peak periods of 7 seconds or less and a 5% decrease in wave amplitudes for incident waves with peak periods of 7-10 s. Incident waves with longer periods were not significantly affected by the presence of the mussel farms.

Importantly, it is noted that these frequencies are representative of the component of the complete sea state that is locally wind generated. Given that the proposed farm is approximately 10 km from the nearest surf site (P1), removal of these frequencies completely from the analysis is considered highly conservative as in reality these frequency components will be generated/added to between the farm location and the surf breaks, particularly for events with onshore directed winds.

While it is recognised that there is uncertainty as to the applicability of the findings of Plew et al. (2005) to wave conditions outside those measured in his assessment; applying the frequency dependency to the hindcast and assessing the effect on surfability does provide some context as to the potential of the marine farm to effect the inshore surfability. Annual joint probability distributions of H_s and peak wave period, T_p assuming the frequency dependencies derived by Plew et al. (2005) are given in Table 6.38-Table 6.46 for Sites P1 to P9, while the percentage of time each of the surf breaks would be surfable are provided in Table 6.47 for the different thresholds considered. The effect of the frequency dependent wave

height attenuation is to reduce the number of surfable days by between 0.7% to 0.0% (depending on the surfability threshold considered).

Incoming wave directions during “surfable” conditions are strongly dominated by the N and NNE sectors at Sites P1, P2, P4 and P5 (Figure 6.10, Figure 6.11, Figure 6.13 and Figure 6.14, respectively), while it narrows to the NNE sector at sites P3 and P6-P9 (Figure 6.12 and Figure 6.15-Figure 6.18).

Table 6.1 Annual and monthly significant wave height statistics at P1.

H_s(m)	Parameter						
	Mean (m)	Std. dev. (m)	Median (m)	P90 (m)	P95 (m)	P99 (m)	Max (m)
Jan	0.39	0.26	0.31	0.69	0.90	1.38	2.70
Feb	0.37	0.25	0.28	0.65	0.85	1.42	2.40
Mar	0.37	0.27	0.29	0.71	0.91	1.41	2.06
Apr	0.34	0.29	0.24	0.74	0.95	1.39	2.48
May	0.37	0.33	0.26	0.80	1.05	1.58	2.62
Jun	0.42	0.38	0.29	0.94	1.23	1.75	2.81
Jul	0.43	0.38	0.29	0.95	1.21	1.77	3.13
Aug	0.41	0.37	0.28	0.93	1.22	1.76	2.80
Sep	0.42	0.36	0.29	0.89	1.16	1.71	2.96
Oct	0.41	0.34	0.29	0.85	1.15	1.69	2.62
Nov	0.39	0.31	0.28	0.77	1.02	1.57	2.64
Dec	0.41	0.29	0.31	0.77	1.00	1.43	2.80
1979	0.39	0.32	0.29	0.78	1.04	1.62	2.42
1980	0.40	0.34	0.29	0.85	1.11	1.66	2.32
1981	0.41	0.33	0.30	0.85	1.13	1.60	2.38
1982	0.36	0.27	0.28	0.70	0.89	1.46	2.15
1983	0.39	0.34	0.28	0.80	1.09	1.76	3.03
1984	0.39	0.33	0.28	0.86	1.09	1.56	2.46
1985	0.43	0.34	0.33	0.88	1.14	1.64	2.80
1986	0.38	0.34	0.26	0.78	1.11	1.71	2.80
1987	0.38	0.33	0.27	0.78	1.11	1.63	2.63
1988	0.43	0.35	0.31	0.90	1.14	1.77	2.20
1989	0.44	0.36	0.31	0.99	1.27	1.62	2.07
1990	0.38	0.31	0.28	0.76	1.03	1.62	2.40
1991	0.37	0.29	0.28	0.72	0.95	1.51	2.44
1992	0.39	0.30	0.29	0.79	1.02	1.51	2.15
1993	0.36	0.31	0.26	0.73	0.97	1.52	2.81
1994	0.40	0.34	0.30	0.77	1.07	1.84	2.64
1995	0.42	0.32	0.31	0.83	1.10	1.55	2.96
1996	0.42	0.32	0.33	0.82	1.09	1.63	2.46
1997	0.37	0.30	0.27	0.76	0.99	1.48	2.54
1998	0.46	0.41	0.32	0.99	1.31	2.01	3.13
1999	0.39	0.31	0.28	0.79	1.00	1.51	2.44
2000	0.39	0.31	0.27	0.84	1.05	1.42	1.99
2001	0.39	0.31	0.30	0.79	0.98	1.55	2.48
2002	0.40	0.31	0.29	0.83	1.05	1.50	2.31
2003	0.40	0.33	0.30	0.82	1.12	1.71	2.62
2004	0.39	0.32	0.29	0.79	1.06	1.69	2.12
2005	0.35	0.27	0.26	0.67	0.86	1.37	2.76
2006	0.36	0.31	0.26	0.77	0.98	1.57	2.76
2007	0.38	0.30	0.29	0.79	0.98	1.50	2.21
2008	0.43	0.36	0.32	0.90	1.19	1.80	2.63
2009	0.39	0.31	0.28	0.80	1.03	1.51	2.44
2010	0.39	0.31	0.28	0.82	1.04	1.55	2.31
2011	0.41	0.33	0.30	0.86	1.11	1.57	2.21
2012	0.43	0.32	0.32	0.86	1.11	1.58	2.53
2013	0.37	0.30	0.27	0.75	1.01	1.54	2.37
2014	0.39	0.31	0.28	0.77	1.03	1.51	2.13
2015	0.37	0.29	0.28	0.72	0.96	1.53	2.49
Annual	0.39	0.32	0.29	0.81	1.06	1.60	3.13

Table 6.2 Annual and monthly significant wave height statistics at P2.

H_s(m)	Parameter						
	Mean (m)	Std. dev. (m)	Median (m)	P90 (m)	P95 (m)	P99 (m)	Max (m)
Jan	0.42	0.26	0.34	0.73	0.95	1.44	2.35
Feb	0.39	0.26	0.32	0.68	0.90	1.45	2.23
Mar	0.40	0.27	0.32	0.75	0.96	1.46	2.03
Apr	0.37	0.29	0.27	0.77	0.99	1.43	2.26
May	0.41	0.34	0.30	0.87	1.12	1.62	2.30
Jun	0.47	0.39	0.34	1.01	1.28	1.77	2.37
Jul	0.47	0.38	0.35	1.01	1.26	1.80	2.52
Aug	0.46	0.38	0.33	0.98	1.28	1.79	2.37
Sep	0.46	0.37	0.34	0.96	1.22	1.76	2.44
Oct	0.45	0.35	0.34	0.92	1.22	1.73	2.31
Nov	0.43	0.32	0.32	0.83	1.09	1.59	2.32
Dec	0.44	0.29	0.34	0.82	1.04	1.48	2.39
1979	0.43	0.32	0.33	0.83	1.09	1.67	2.22
1980	0.44	0.35	0.33	0.90	1.17	1.71	2.15
1981	0.45	0.34	0.34	0.91	1.18	1.67	2.19
1982	0.40	0.29	0.31	0.75	0.96	1.51	2.00
1983	0.42	0.34	0.32	0.87	1.14	1.76	2.48
1984	0.42	0.33	0.32	0.89	1.14	1.60	2.23
1985	0.46	0.34	0.36	0.92	1.16	1.67	2.37
1986	0.41	0.34	0.30	0.84	1.20	1.75	2.39
1987	0.41	0.34	0.30	0.85	1.16	1.70	2.29
1988	0.46	0.36	0.35	0.96	1.22	1.78	2.09
1989	0.48	0.37	0.35	1.03	1.30	1.68	2.02
1990	0.41	0.32	0.31	0.83	1.11	1.65	2.22
1991	0.41	0.30	0.32	0.80	1.02	1.60	2.22
1992	0.44	0.31	0.34	0.85	1.08	1.58	2.06
1993	0.39	0.31	0.29	0.78	1.02	1.57	2.37
1994	0.44	0.34	0.34	0.85	1.16	1.88	2.32
1995	0.46	0.33	0.36	0.90	1.16	1.60	2.44
1996	0.47	0.33	0.37	0.90	1.18	1.67	2.24
1997	0.40	0.31	0.30	0.82	1.03	1.56	2.29
1998	0.50	0.40	0.36	1.05	1.39	2.01	2.52
1999	0.42	0.32	0.32	0.84	1.07	1.57	2.21
2000	0.42	0.32	0.31	0.90	1.11	1.48	1.96
2001	0.43	0.31	0.33	0.83	1.03	1.59	2.26
2002	0.44	0.33	0.33	0.90	1.14	1.59	2.14
2003	0.44	0.34	0.34	0.87	1.18	1.75	2.31
2004	0.43	0.33	0.33	0.88	1.15	1.71	2.06
2005	0.38	0.28	0.30	0.73	0.94	1.44	2.39
2006	0.40	0.32	0.29	0.83	1.05	1.62	2.36
2007	0.42	0.31	0.32	0.85	1.04	1.51	2.11
2008	0.47	0.36	0.36	0.97	1.24	1.84	2.35
2009	0.42	0.31	0.32	0.86	1.08	1.55	2.23
2010	0.43	0.32	0.32	0.90	1.10	1.62	2.18
2011	0.45	0.34	0.34	0.91	1.16	1.58	2.12
2012	0.46	0.33	0.36	0.92	1.17	1.65	2.26
2013	0.41	0.32	0.30	0.82	1.07	1.60	2.21
2014	0.42	0.31	0.32	0.83	1.07	1.54	2.00
2015	0.41	0.30	0.31	0.80	1.03	1.61	2.25
Annual	0.43	0.33	0.33	0.87	1.13	1.65	2.52

Table 6.3 Annual and monthly significant wave height statistics at P3.

H_s(m)	Parameter						
	Mean (m)	Std. dev. (m)	Median (m)	P90 (m)	P95 (m)	P99 (m)	Max (m)
Jan	0.36	0.25	0.28	0.65	0.85	1.34	2.41
Feb	0.34	0.24	0.26	0.60	0.81	1.34	2.23
Mar	0.35	0.26	0.26	0.66	0.87	1.34	1.98
Apr	0.32	0.28	0.22	0.70	0.90	1.34	2.26
May	0.35	0.32	0.24	0.79	1.02	1.52	2.35
Jun	0.40	0.37	0.27	0.91	1.17	1.67	2.42
Jul	0.41	0.36	0.28	0.91	1.14	1.66	2.57
Aug	0.40	0.36	0.27	0.89	1.18	1.69	2.44
Sep	0.40	0.35	0.28	0.87	1.13	1.64	2.52
Oct	0.40	0.34	0.28	0.84	1.13	1.62	2.35
Nov	0.37	0.30	0.26	0.76	1.00	1.50	2.36
Dec	0.38	0.28	0.29	0.74	0.96	1.38	2.42
1979	0.37	0.31	0.28	0.74	1.01	1.55	2.25
1980	0.38	0.33	0.27	0.81	1.06	1.61	2.15
1981	0.39	0.32	0.29	0.82	1.10	1.55	2.18
1982	0.34	0.27	0.25	0.67	0.88	1.40	1.93
1983	0.36	0.33	0.25	0.79	1.06	1.64	2.54
1984	0.37	0.31	0.26	0.82	1.04	1.50	2.25
1985	0.40	0.32	0.30	0.84	1.07	1.56	2.44
1986	0.36	0.33	0.25	0.76	1.09	1.64	2.42
1987	0.36	0.33	0.25	0.78	1.07	1.58	2.33
1988	0.40	0.33	0.29	0.85	1.11	1.65	2.07
1989	0.42	0.35	0.29	0.94	1.20	1.56	1.97
1990	0.36	0.31	0.26	0.76	1.01	1.56	2.23
1991	0.35	0.29	0.26	0.72	0.95	1.48	2.24
1992	0.38	0.30	0.28	0.77	1.00	1.47	2.03
1993	0.33	0.29	0.23	0.69	0.93	1.44	2.42
1994	0.38	0.33	0.28	0.77	1.05	1.78	2.36
1995	0.41	0.32	0.30	0.82	1.07	1.48	2.52
1996	0.40	0.32	0.31	0.81	1.08	1.55	2.25
1997	0.34	0.29	0.25	0.72	0.95	1.43	2.31
1998	0.44	0.39	0.30	0.95	1.28	1.92	2.57
1999	0.37	0.30	0.26	0.77	0.99	1.46	2.23
2000	0.36	0.30	0.26	0.81	1.02	1.38	1.89
2001	0.37	0.30	0.27	0.75	0.95	1.49	2.26
2002	0.38	0.31	0.27	0.80	1.03	1.46	2.14
2003	0.38	0.32	0.28	0.79	1.06	1.63	2.35
2004	0.37	0.32	0.26	0.79	1.05	1.62	2.03
2005	0.33	0.27	0.25	0.65	0.85	1.33	2.41
2006	0.34	0.30	0.23	0.75	0.95	1.49	2.42
2007	0.36	0.29	0.27	0.76	0.94	1.39	2.09
2008	0.41	0.35	0.30	0.88	1.13	1.72	2.35
2009	0.36	0.30	0.26	0.77	0.99	1.45	2.23
2010	0.37	0.30	0.26	0.80	1.00	1.51	2.16
2011	0.39	0.32	0.28	0.82	1.06	1.48	2.09
2012	0.40	0.31	0.29	0.82	1.07	1.52	2.30
2013	0.35	0.30	0.25	0.74	0.97	1.49	2.20
2014	0.36	0.29	0.26	0.75	0.97	1.44	1.96
2015	0.35	0.29	0.25	0.71	0.94	1.47	2.27
Annual	0.37	0.31	0.27	0.79	1.03	1.54	2.57

Table 6.4 Annual and monthly significant wave height statistics at P4.

H_s(m)	Parameter						
	Mean (m)	Std. dev. (m)	Median (m)	P90 (m)	P95 (m)	P99 (m)	Max (m)
Jan	0.38	0.28	0.29	0.72	0.95	1.45	2.90
Feb	0.35	0.27	0.26	0.66	0.87	1.43	2.48
Mar	0.36	0.29	0.27	0.72	0.96	1.44	2.24
Apr	0.35	0.31	0.24	0.76	0.98	1.45	2.51
May	0.40	0.35	0.29	0.86	1.12	1.65	2.80
Jun	0.45	0.40	0.33	1.00	1.27	1.80	3.05
Jul	0.46	0.39	0.34	1.00	1.25	1.81	3.33
Aug	0.45	0.39	0.32	0.97	1.27	1.83	3.04
Sep	0.45	0.38	0.33	0.97	1.23	1.80	3.24
Oct	0.45	0.37	0.32	0.94	1.24	1.79	2.82
Nov	0.41	0.34	0.30	0.84	1.10	1.63	2.78
Dec	0.41	0.31	0.30	0.81	1.06	1.51	2.78
1979	0.40	0.33	0.30	0.81	1.07	1.66	2.50
1980	0.42	0.37	0.30	0.90	1.17	1.78	2.53
1981	0.42	0.36	0.31	0.90	1.17	1.73	2.34
1982	0.37	0.30	0.27	0.75	0.96	1.54	2.10
1983	0.40	0.36	0.28	0.87	1.16	1.77	3.19
1984	0.40	0.35	0.28	0.88	1.13	1.65	2.58
1985	0.44	0.35	0.33	0.88	1.13	1.69	3.04
1986	0.39	0.36	0.27	0.83	1.16	1.74	2.88
1987	0.40	0.36	0.27	0.87	1.18	1.73	2.90
1988	0.44	0.37	0.31	0.95	1.22	1.83	2.36
1989	0.45	0.37	0.33	1.00	1.26	1.69	2.23
1990	0.39	0.33	0.28	0.82	1.09	1.64	2.60
1991	0.39	0.32	0.29	0.79	1.04	1.59	2.64
1992	0.42	0.33	0.31	0.85	1.08	1.61	2.27
1993	0.37	0.33	0.27	0.79	1.02	1.61	3.05
1994	0.42	0.37	0.32	0.85	1.15	1.96	2.78
1995	0.44	0.35	0.34	0.90	1.16	1.60	3.24
1996	0.44	0.35	0.34	0.89	1.16	1.70	2.63
1997	0.37	0.32	0.27	0.80	1.01	1.52	2.65
1998	0.48	0.43	0.33	1.06	1.38	2.10	3.33
1999	0.40	0.33	0.30	0.84	1.06	1.55	2.46
2000	0.40	0.34	0.28	0.90	1.13	1.52	2.15
2001	0.41	0.33	0.30	0.82	1.04	1.60	2.52
2002	0.42	0.35	0.31	0.90	1.16	1.65	2.42
2003	0.43	0.36	0.31	0.88	1.18	1.76	2.82
2004	0.41	0.35	0.29	0.86	1.14	1.73	2.32
2005	0.36	0.30	0.27	0.74	0.96	1.44	2.92
2006	0.39	0.34	0.28	0.83	1.08	1.61	3.00
2007	0.40	0.32	0.30	0.84	1.06	1.54	2.27
2008	0.45	0.38	0.32	0.96	1.22	1.86	2.71
2009	0.40	0.33	0.30	0.85	1.07	1.60	2.61
2010	0.41	0.34	0.29	0.89	1.13	1.64	2.50
2011	0.42	0.34	0.30	0.88	1.13	1.61	2.32
2012	0.44	0.35	0.33	0.92	1.17	1.67	2.79
2013	0.39	0.33	0.27	0.82	1.06	1.64	2.57
2014	0.40	0.32	0.29	0.83	1.07	1.53	2.17
2015	0.38	0.31	0.28	0.77	1.02	1.61	2.65
Annual	0.41	0.35	0.30	0.86	1.12	1.67	3.33

Table 6.5 Annual and monthly significant wave height statistics at P5.

H_s(m)	Parameter						
	Mean (m)	Std. dev. (m)	Median (m)	P90 (m)	P95 (m)	P99 (m)	Max (m)
Jan	0.35	0.26	0.27	0.66	0.88	1.36	2.69
Feb	0.32	0.25	0.24	0.61	0.82	1.34	2.31
Mar	0.34	0.27	0.25	0.68	0.89	1.36	2.11
Apr	0.32	0.29	0.22	0.71	0.92	1.38	2.33
May	0.36	0.33	0.27	0.80	1.04	1.55	2.60
Jun	0.42	0.37	0.30	0.93	1.20	1.70	2.82
Jul	0.43	0.37	0.31	0.93	1.17	1.71	3.07
Aug	0.41	0.36	0.29	0.90	1.18	1.72	2.85
Sep	0.41	0.36	0.30	0.90	1.15	1.69	3.02
Oct	0.41	0.35	0.30	0.87	1.15	1.67	2.64
Nov	0.37	0.32	0.27	0.78	1.02	1.54	2.57
Dec	0.37	0.29	0.28	0.75	0.98	1.42	2.59
1979	0.37	0.31	0.28	0.75	1.00	1.54	2.32
1980	0.38	0.34	0.28	0.82	1.08	1.68	2.38
1981	0.39	0.33	0.28	0.84	1.10	1.62	2.18
1982	0.33	0.28	0.24	0.69	0.89	1.46	1.95
1983	0.37	0.34	0.26	0.81	1.09	1.65	2.99
1984	0.36	0.33	0.26	0.82	1.06	1.56	2.42
1985	0.41	0.33	0.30	0.82	1.06	1.59	2.85
1986	0.36	0.33	0.25	0.76	1.09	1.64	2.66
1987	0.36	0.34	0.25	0.80	1.11	1.63	2.69
1988	0.41	0.35	0.29	0.88	1.14	1.74	2.24
1989	0.42	0.35	0.30	0.94	1.20	1.58	2.15
1990	0.36	0.31	0.26	0.75	1.02	1.55	2.41
1991	0.35	0.30	0.27	0.74	0.96	1.50	2.46
1992	0.38	0.31	0.29	0.78	1.00	1.52	2.12
1993	0.34	0.31	0.24	0.73	0.94	1.51	2.82
1994	0.39	0.35	0.29	0.78	1.06	1.83	2.57
1995	0.40	0.33	0.31	0.83	1.09	1.51	3.02
1996	0.41	0.33	0.31	0.81	1.09	1.60	2.46
1997	0.34	0.30	0.25	0.74	0.95	1.43	2.46
1998	0.44	0.41	0.30	0.99	1.29	1.99	3.07
1999	0.37	0.31	0.28	0.79	0.99	1.45	2.32
2000	0.37	0.32	0.26	0.85	1.06	1.42	2.02
2001	0.37	0.31	0.27	0.76	0.97	1.52	2.36
2002	0.38	0.32	0.29	0.83	1.07	1.49	2.27
2003	0.39	0.34	0.29	0.82	1.10	1.64	2.64
2004	0.37	0.32	0.26	0.78	1.05	1.64	2.19
2005	0.33	0.28	0.24	0.69	0.89	1.35	2.69
2006	0.36	0.32	0.26	0.77	1.01	1.51	2.79
2007	0.37	0.30	0.27	0.77	0.98	1.46	2.13
2008	0.41	0.35	0.29	0.89	1.14	1.74	2.50
2009	0.37	0.31	0.28	0.79	1.01	1.52	2.44
2010	0.38	0.32	0.27	0.83	1.05	1.55	2.34
2011	0.39	0.32	0.28	0.82	1.04	1.52	2.17
2012	0.41	0.33	0.30	0.85	1.09	1.56	2.60
2013	0.35	0.31	0.25	0.75	0.97	1.52	2.40
2014	0.37	0.30	0.27	0.76	0.99	1.45	2.06
2015	0.35	0.29	0.26	0.71	0.94	1.53	2.46
Annual	0.38	0.32	0.27	0.80	1.05	1.57	3.07

Table 6.6 Annual and monthly significant wave height statistics at P6.

H_s(m)	Parameter						
	Mean (m)	Std. dev. (m)	Median (m)	P90 (m)	P95 (m)	P99 (m)	Max (m)
Jan	0.33	0.25	0.25	0.63	0.82	1.28	2.47
Feb	0.30	0.24	0.23	0.58	0.77	1.26	2.15
Mar	0.31	0.26	0.23	0.64	0.84	1.29	1.98
Apr	0.30	0.28	0.20	0.67	0.87	1.29	2.17
May	0.34	0.31	0.24	0.75	0.98	1.47	2.40
Jun	0.39	0.35	0.28	0.87	1.13	1.61	2.57
Jul	0.39	0.35	0.28	0.87	1.10	1.60	2.77
Aug	0.38	0.35	0.27	0.84	1.11	1.62	2.63
Sep	0.39	0.34	0.28	0.85	1.08	1.60	2.74
Oct	0.38	0.33	0.28	0.81	1.09	1.58	2.42
Nov	0.35	0.30	0.25	0.73	0.96	1.47	2.37
Dec	0.35	0.28	0.26	0.71	0.93	1.34	2.40
1979	0.34	0.30	0.26	0.71	0.95	1.48	2.17
1980	0.36	0.32	0.26	0.78	1.02	1.59	2.22
1981	0.36	0.32	0.26	0.78	1.05	1.52	2.04
1982	0.31	0.27	0.23	0.65	0.83	1.37	1.88
1983	0.34	0.32	0.24	0.76	1.02	1.57	2.75
1984	0.34	0.31	0.24	0.78	1.00	1.48	2.28
1985	0.38	0.31	0.28	0.79	1.01	1.51	2.63
1986	0.34	0.31	0.23	0.71	1.02	1.55	2.45
1987	0.34	0.32	0.23	0.75	1.04	1.54	2.47
1988	0.38	0.33	0.27	0.82	1.08	1.64	2.11
1989	0.39	0.34	0.27	0.89	1.14	1.48	2.04
1990	0.33	0.30	0.24	0.71	0.96	1.49	2.22
1991	0.33	0.28	0.25	0.69	0.90	1.40	2.27
1992	0.35	0.29	0.27	0.73	0.94	1.42	1.99
1993	0.32	0.29	0.23	0.69	0.89	1.41	2.55
1994	0.36	0.33	0.28	0.73	0.99	1.71	2.37
1995	0.38	0.31	0.28	0.77	1.02	1.44	2.74
1996	0.38	0.31	0.29	0.76	1.01	1.51	2.28
1997	0.32	0.28	0.22	0.70	0.90	1.33	2.26
1998	0.41	0.38	0.28	0.93	1.22	1.87	2.77
1999	0.35	0.29	0.25	0.75	0.94	1.38	2.19
2000	0.34	0.31	0.24	0.80	0.99	1.35	1.89
2001	0.34	0.30	0.25	0.71	0.92	1.44	2.19
2002	0.36	0.30	0.27	0.78	0.99	1.43	2.12
2003	0.36	0.32	0.27	0.77	1.04	1.54	2.42
2004	0.34	0.31	0.24	0.73	1.00	1.55	2.06
2005	0.30	0.26	0.23	0.64	0.83	1.26	2.44
2006	0.33	0.30	0.23	0.71	0.93	1.42	2.57
2007	0.34	0.28	0.26	0.73	0.92	1.37	2.01
2008	0.38	0.33	0.27	0.83	1.06	1.65	2.29
2009	0.34	0.29	0.26	0.74	0.95	1.43	2.24
2010	0.35	0.30	0.25	0.77	0.98	1.47	2.16
2011	0.36	0.30	0.26	0.78	0.97	1.44	2.02
2012	0.38	0.31	0.28	0.80	1.04	1.48	2.39
2013	0.33	0.29	0.23	0.71	0.91	1.44	2.23
2014	0.34	0.29	0.25	0.71	0.94	1.37	1.94
2015	0.32	0.28	0.24	0.66	0.89	1.45	2.29
Annual	0.35	0.31	0.25	0.75	0.99	1.49	2.77

Table 6.7 Annual and monthly significant wave height statistics at P7.

H_s(m)	Parameter						
	Mean (m)	Std. dev. (m)	Median (m)	P90 (m)	P95 (m)	P99 (m)	Max (m)
Jan	0.32	0.24	0.24	0.61	0.80	1.26	2.40
Feb	0.29	0.23	0.22	0.57	0.76	1.23	2.10
Mar	0.30	0.25	0.22	0.62	0.82	1.27	1.94
Apr	0.29	0.27	0.19	0.66	0.86	1.27	2.12
May	0.33	0.30	0.23	0.73	0.95	1.44	2.34
Jun	0.37	0.35	0.26	0.85	1.11	1.58	2.50
Jul	0.38	0.34	0.27	0.85	1.08	1.57	2.68
Aug	0.37	0.34	0.26	0.83	1.09	1.59	2.56
Sep	0.37	0.33	0.26	0.83	1.06	1.57	2.67
Oct	0.37	0.32	0.26	0.80	1.07	1.55	2.35
Nov	0.34	0.29	0.24	0.71	0.95	1.44	2.31
Dec	0.34	0.27	0.25	0.70	0.91	1.32	2.34
1979	0.33	0.29	0.25	0.70	0.93	1.45	2.12
1980	0.35	0.32	0.24	0.76	1.00	1.56	2.17
1981	0.35	0.31	0.25	0.77	1.03	1.49	2.01
1982	0.30	0.26	0.22	0.63	0.82	1.34	1.85
1983	0.33	0.31	0.23	0.75	1.00	1.54	2.67
1984	0.33	0.31	0.23	0.76	0.98	1.45	2.23
1985	0.37	0.31	0.27	0.78	0.99	1.48	2.56
1986	0.33	0.31	0.22	0.70	1.01	1.52	2.38
1987	0.33	0.32	0.22	0.73	1.02	1.52	2.40
1988	0.37	0.33	0.26	0.80	1.06	1.62	2.06
1989	0.38	0.33	0.26	0.87	1.12	1.46	2.00
1990	0.32	0.29	0.23	0.69	0.94	1.46	2.16
1991	0.32	0.27	0.24	0.67	0.88	1.37	2.21
1992	0.34	0.28	0.26	0.71	0.91	1.39	1.95
1993	0.31	0.29	0.22	0.66	0.87	1.38	2.48
1994	0.35	0.32	0.26	0.71	0.97	1.67	2.31
1995	0.37	0.31	0.28	0.75	1.00	1.42	2.67
1996	0.36	0.30	0.27	0.74	0.99	1.47	2.21
1997	0.31	0.28	0.22	0.68	0.88	1.29	2.20
1998	0.40	0.38	0.27	0.91	1.20	1.82	2.68
1999	0.34	0.29	0.25	0.73	0.92	1.35	2.15
2000	0.33	0.30	0.23	0.79	0.97	1.32	1.85
2001	0.33	0.29	0.24	0.70	0.90	1.42	2.13
2002	0.35	0.30	0.25	0.76	0.97	1.39	2.08
2003	0.35	0.31	0.25	0.75	1.02	1.51	2.35
2004	0.33	0.30	0.23	0.71	0.97	1.53	2.01
2005	0.29	0.26	0.22	0.62	0.81	1.23	2.36
2006	0.32	0.29	0.22	0.70	0.91	1.39	2.50
2007	0.33	0.28	0.24	0.71	0.89	1.33	1.98
2008	0.37	0.33	0.26	0.81	1.04	1.62	2.23
2009	0.33	0.28	0.24	0.72	0.93	1.40	2.17
2010	0.34	0.29	0.24	0.75	0.96	1.44	2.11
2011	0.35	0.30	0.25	0.76	0.95	1.42	1.98
2012	0.37	0.31	0.27	0.78	1.01	1.45	2.32
2013	0.32	0.28	0.23	0.69	0.89	1.42	2.18
2014	0.33	0.28	0.23	0.70	0.92	1.34	1.89
2015	0.31	0.27	0.23	0.64	0.87	1.43	2.24
Annual	0.34	0.30	0.24	0.73	0.97	1.46	2.68

Table 6.8 Annual and monthly significant wave height statistics at P8.

H_s(m)	Parameter						
	Mean (m)	Std. dev. (m)	Median (m)	P90 (m)	P95 (m)	P99 (m)	Max (m)
Jan	0.33	0.25	0.25	0.62	0.82	1.28	2.42
Feb	0.30	0.24	0.23	0.57	0.77	1.25	2.11
Mar	0.31	0.25	0.23	0.64	0.83	1.28	1.96
Apr	0.29	0.28	0.20	0.67	0.87	1.29	2.13
May	0.34	0.31	0.24	0.74	0.97	1.46	2.35
Jun	0.38	0.35	0.28	0.87	1.13	1.60	2.53
Jul	0.39	0.35	0.28	0.87	1.09	1.59	2.70
Aug	0.38	0.34	0.27	0.84	1.11	1.61	2.58
Sep	0.38	0.33	0.28	0.84	1.08	1.59	2.70
Oct	0.38	0.33	0.28	0.82	1.09	1.57	2.37
Nov	0.35	0.30	0.25	0.73	0.96	1.46	2.35
Dec	0.35	0.28	0.26	0.71	0.93	1.33	2.36
1979	0.34	0.29	0.26	0.71	0.94	1.46	2.12
1980	0.36	0.32	0.26	0.78	1.01	1.58	2.20
1981	0.36	0.32	0.26	0.78	1.05	1.50	2.01
1982	0.31	0.27	0.23	0.64	0.83	1.35	1.85
1983	0.34	0.32	0.24	0.76	1.02	1.56	2.70
1984	0.34	0.31	0.24	0.77	1.00	1.47	2.24
1985	0.38	0.31	0.28	0.78	1.01	1.50	2.58
1986	0.34	0.31	0.23	0.71	1.02	1.54	2.40
1987	0.34	0.32	0.23	0.75	1.04	1.54	2.42
1988	0.38	0.33	0.27	0.82	1.08	1.63	2.09
1989	0.39	0.33	0.27	0.89	1.12	1.48	2.03
1990	0.33	0.30	0.24	0.71	0.96	1.48	2.18
1991	0.33	0.28	0.25	0.69	0.90	1.39	2.24
1992	0.35	0.29	0.27	0.73	0.92	1.40	1.97
1993	0.32	0.29	0.23	0.68	0.89	1.40	2.50
1994	0.36	0.32	0.28	0.73	0.99	1.70	2.35
1995	0.38	0.31	0.28	0.77	1.02	1.43	2.70
1996	0.37	0.31	0.29	0.76	1.01	1.49	2.23
1997	0.32	0.28	0.23	0.69	0.89	1.32	2.22
1998	0.41	0.38	0.28	0.93	1.22	1.84	2.70
1999	0.35	0.29	0.26	0.75	0.94	1.37	2.17
2000	0.34	0.30	0.23	0.80	0.99	1.33	1.88
2001	0.34	0.29	0.25	0.71	0.91	1.44	2.16
2002	0.36	0.30	0.26	0.78	0.99	1.41	2.09
2003	0.36	0.31	0.27	0.77	1.04	1.53	2.37
2004	0.34	0.30	0.24	0.73	1.00	1.55	2.04
2005	0.30	0.26	0.22	0.64	0.82	1.26	2.39
2006	0.33	0.30	0.24	0.71	0.93	1.41	2.53
2007	0.34	0.28	0.26	0.72	0.91	1.36	1.99
2008	0.38	0.33	0.28	0.83	1.05	1.63	2.25
2009	0.34	0.29	0.26	0.74	0.94	1.42	2.19
2010	0.35	0.30	0.25	0.77	0.98	1.47	2.13
2011	0.36	0.30	0.26	0.77	0.97	1.43	2.00
2012	0.38	0.31	0.28	0.80	1.04	1.47	2.34
2013	0.33	0.29	0.23	0.70	0.91	1.43	2.21
2014	0.34	0.29	0.24	0.71	0.93	1.35	1.92
2015	0.32	0.28	0.24	0.66	0.89	1.45	2.25
Annual	0.35	0.30	0.25	0.75	0.98	1.48	2.70

Table 6.9 Annual and monthly significant wave height statistics at P9.

H_s(m)	Parameter						
	Mean (m)	Std. dev. (m)	Median (m)	P90 (m)	P95 (m)	P99 (m)	Max (m)
Jan	0.33	0.24	0.25	0.62	0.82	1.27	2.38
Feb	0.30	0.24	0.22	0.57	0.76	1.24	2.08
Mar	0.31	0.25	0.23	0.64	0.83	1.27	1.95
Apr	0.29	0.27	0.20	0.66	0.87	1.28	2.10
May	0.33	0.30	0.24	0.74	0.96	1.45	2.31
Jun	0.38	0.35	0.27	0.86	1.12	1.58	2.50
Jul	0.39	0.35	0.28	0.86	1.08	1.58	2.66
Aug	0.38	0.34	0.27	0.83	1.10	1.59	2.55
Sep	0.38	0.33	0.27	0.84	1.07	1.57	2.67
Oct	0.38	0.32	0.28	0.81	1.08	1.55	2.33
Nov	0.35	0.29	0.26	0.73	0.96	1.45	2.33
Dec	0.35	0.27	0.26	0.71	0.92	1.33	2.32
1979	0.34	0.29	0.26	0.70	0.94	1.45	2.09
1980	0.36	0.32	0.26	0.77	1.01	1.57	2.19
1981	0.36	0.31	0.26	0.77	1.04	1.49	1.99
1982	0.31	0.26	0.23	0.64	0.83	1.35	1.84
1983	0.34	0.32	0.24	0.76	1.02	1.55	2.66
1984	0.34	0.31	0.24	0.76	0.99	1.46	2.22
1985	0.38	0.31	0.28	0.77	1.01	1.49	2.55
1986	0.34	0.31	0.23	0.70	1.02	1.52	2.36
1987	0.34	0.32	0.24	0.74	1.03	1.53	2.38
1988	0.38	0.33	0.27	0.81	1.07	1.62	2.07
1989	0.38	0.33	0.27	0.88	1.11	1.48	2.03
1990	0.33	0.29	0.24	0.70	0.95	1.47	2.15
1991	0.33	0.27	0.25	0.68	0.90	1.38	2.22
1992	0.35	0.28	0.27	0.73	0.92	1.40	1.95
1993	0.32	0.29	0.23	0.68	0.88	1.40	2.48
1994	0.36	0.32	0.27	0.72	0.99	1.68	2.33
1995	0.37	0.31	0.28	0.76	1.02	1.41	2.67
1996	0.37	0.30	0.28	0.75	1.00	1.49	2.20
1997	0.32	0.28	0.23	0.68	0.89	1.31	2.18
1998	0.41	0.38	0.28	0.92	1.21	1.82	2.66
1999	0.35	0.29	0.26	0.74	0.94	1.37	2.15
2000	0.34	0.30	0.23	0.80	0.98	1.33	1.87
2001	0.34	0.29	0.25	0.71	0.91	1.44	2.13
2002	0.36	0.30	0.26	0.77	0.98	1.40	2.08
2003	0.36	0.31	0.27	0.76	1.03	1.52	2.33
2004	0.34	0.30	0.24	0.73	0.99	1.54	2.02
2005	0.30	0.26	0.23	0.63	0.82	1.25	2.35
2006	0.33	0.29	0.24	0.71	0.93	1.40	2.50
2007	0.34	0.28	0.26	0.71	0.90	1.35	1.97
2008	0.38	0.33	0.27	0.83	1.05	1.62	2.21
2009	0.34	0.28	0.25	0.73	0.94	1.40	2.15
2010	0.35	0.29	0.25	0.76	0.97	1.46	2.11
2011	0.36	0.30	0.26	0.77	0.97	1.43	1.97
2012	0.37	0.31	0.28	0.79	1.03	1.45	2.30
2013	0.32	0.28	0.23	0.69	0.90	1.42	2.18
2014	0.34	0.28	0.25	0.71	0.92	1.35	1.91
2015	0.32	0.27	0.24	0.66	0.88	1.44	2.21
Annual	0.35	0.30	0.25	0.74	0.98	1.47	2.67

Table 6.10 Monthly and annual significant wave height exceedance probabilities at P1.

H_s (m)	Exceedance (%)												
	January	February	March	April	May	June	July	August	September	October	November	December	Year
>0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
>0.25	68.16	61.06	60.00	48.87	52.53	57.55	57.86	55.81	57.92	59.80	59.02	66.06	58.73
>0.5	21.14	19.17	21.46	20.03	23.64	29.65	29.87	27.74	28.24	26.25	23.55	24.20	24.61
>0.75	7.93	6.93	8.77	9.64	11.63	16.01	16.30	15.28	14.58	12.83	10.46	10.55	11.77
>1	3.49	3.24	3.80	4.26	5.63	8.59	8.73	8.35	7.50	7.24	5.30	4.94	5.94
>1.25	1.61	1.75	1.87	1.86	2.87	4.73	4.50	4.65	3.93	3.80	2.62	2.14	3.03
>1.5	0.74	0.68	0.68	0.68	1.33	2.31	2.07	2.20	1.80	2.01	1.25	0.85	1.39
>1.75	0.32	0.33	0.26	0.24	0.48	1.00	1.07	1.07	0.90	0.82	0.57	0.44	0.63
>2	0.20	0.05	0.03	0.06	0.14	0.32	0.54	0.40	0.39	0.33	0.33	0.16	0.25
>2.25	0.09	0.01	0.00	0.02	0.04	0.08	0.26	0.15	0.19	0.15	0.17	0.04	0.10
>2.5	0.04	0.00	0.00	0.00	0.01	0.05	0.17	0.02	0.08	0.03	0.03	0.02	0.04
>2.75	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.01	0.03	0.00	0.00	0.01	0.01
>3	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00

Table 6.11 Monthly and annual significant wave height exceedance probabilities at P2.

H_s (m)	Exceedance (%)												
	January	February	March	April	May	June	July	August	September	October	November	December	Year
>0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
>0.25	75.92	69.08	67.57	55.62	59.06	63.65	65.33	62.98	64.80	67.38	67.69	73.98	66.10
>0.5	24.81	21.83	24.31	22.76	27.83	34.38	34.71	32.87	33.00	31.03	27.43	28.25	28.64
>0.75	9.52	7.87	10.06	10.80	13.91	19.21	19.13	17.86	17.39	15.39	12.50	12.40	13.87
>1	4.03	3.67	4.38	4.85	6.92	10.34	10.27	9.73	9.17	8.33	6.41	5.72	7.00
>1.25	1.81	1.90	2.05	2.22	3.49	5.46	5.21	5.46	4.63	4.65	3.19	2.50	3.56
>1.5	0.82	0.84	0.83	0.79	1.60	2.62	2.43	2.67	2.25	2.52	1.45	0.95	1.65
>1.75	0.39	0.38	0.26	0.27	0.58	1.08	1.12	1.17	1.02	0.92	0.63	0.46	0.69
>2	0.15	0.02	0.02	0.03	0.12	0.32	0.50	0.34	0.37	0.29	0.29	0.13	0.22
>2.25	0.05	0.00	0.00	0.01	0.01	0.05	0.16	0.02	0.08	0.03	0.03	0.02	0.04
>2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Table 6.12 Monthly and annual significant wave height exceedance probabilities at P3.

H_s (m)	Exceedance (%)												
	January	February	March	April	May	June	July	August	September	October	November	December	Year
>0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
>0.25	59.93	53.34	53.07	44.35	48.35	53.91	55.17	53.52	55.15	54.75	53.05	58.84	53.64
>0.5	18.66	16.12	18.82	18.68	22.55	29.07	29.32	27.56	27.86	25.77	22.44	23.35	23.39
>0.75	7.01	5.97	7.52	8.72	11.19	15.37	15.21	14.56	14.05	12.53	10.14	9.81	11.03
>1	2.89	2.80	3.24	3.61	5.38	7.94	7.80	7.75	7.08	6.87	4.94	4.47	5.41
>1.25	1.32	1.38	1.37	1.52	2.57	4.03	3.65	4.06	3.34	3.55	2.34	1.75	2.58
>1.5	0.63	0.56	0.51	0.51	1.09	1.86	1.67	1.83	1.53	1.68	0.99	0.74	1.14
>1.75	0.26	0.20	0.12	0.16	0.32	0.73	0.82	0.76	0.72	0.65	0.51	0.27	0.46
>2	0.13	0.01	0.00	0.03	0.07	0.24	0.38	0.27	0.29	0.23	0.25	0.08	0.17
>2.25	0.05	0.00	0.00	0.01	0.01	0.06	0.19	0.03	0.10	0.04	0.07	0.02	0.05
>2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	0.00	0.00	0.00	0.00

Table 6.13 Monthly and annual significant wave height exceedance probabilities at P4.

H_s (m)	Exceedance (%)												
	January	February	March	April	May	June	July	August	September	October	November	December	Year
>0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
>0.25	59.36	52.99	54.58	48.16	55.86	61.26	63.71	61.34	61.61	62.66	59.40	61.00	58.55
>0.5	21.87	18.40	21.81	22.32	27.52	33.22	33.65	31.88	33.04	30.84	26.69	26.97	27.40
>0.75	9.03	7.32	9.30	10.43	13.94	18.22	18.72	17.18	17.27	15.80	12.95	12.04	13.55
>1	3.97	3.52	4.18	4.74	6.79	10.12	9.98	9.40	9.37	8.61	6.57	5.83	6.94
>1.25	1.71	1.76	1.89	2.09	3.53	5.43	5.02	5.21	4.67	4.87	3.34	2.65	3.52
>1.5	0.87	0.80	0.82	0.82	1.72	2.68	2.41	2.65	2.27	2.66	1.63	1.01	1.70
>1.75	0.41	0.41	0.35	0.36	0.69	1.19	1.23	1.28	1.16	1.12	0.70	0.52	0.79
>2	0.20	0.14	0.09	0.08	0.19	0.47	0.65	0.57	0.59	0.47	0.36	0.24	0.34
>2.25	0.12	0.01	0.00	0.02	0.08	0.16	0.37	0.23	0.26	0.21	0.25	0.10	0.15
>2.5	0.05	0.00	0.00	0.01	0.02	0.07	0.19	0.12	0.11	0.07	0.12	0.03	0.07
>2.75	0.02	0.00	0.00	0.00	0.01	0.05	0.10	0.01	0.05	0.02	0.01	0.01	0.02
>3	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.01	0.02	0.00	0.00	0.00	0.01
>3.25	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Table 6.14 Monthly and annual significant wave height exceedance probabilities at P5.

H_s (m)	Exceedance (%)												
	January	February	March	April	May	June	July	August	September	October	November	December	Year
>0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
>0.25	54.26	48.49	50.32	45.16	52.90	58.33	59.72	57.51	58.14	58.71	54.56	55.81	54.54
>0.5	18.92	15.69	19.22	19.54	24.22	29.84	30.35	28.23	28.98	26.92	23.54	23.06	24.09
>0.75	7.57	6.03	7.99	8.98	11.64	15.64	15.90	14.71	14.81	13.34	10.80	10.06	11.48
>1	3.07	2.92	3.30	3.81	5.65	8.41	8.35	8.01	7.50	7.28	5.38	4.80	5.72
>1.25	1.39	1.34	1.48	1.63	2.71	4.35	3.91	4.08	3.60	3.90	2.55	1.87	2.74
>1.5	0.66	0.57	0.59	0.59	1.25	2.08	1.89	1.99	1.71	2.01	1.16	0.82	1.28
>1.75	0.28	0.25	0.23	0.24	0.44	0.82	0.89	0.90	0.87	0.83	0.55	0.36	0.56
>2	0.14	0.02	0.02	0.07	0.10	0.30	0.45	0.39	0.38	0.34	0.29	0.14	0.22
>2.25	0.07	0.01	0.00	0.01	0.04	0.10	0.23	0.15	0.15	0.12	0.16	0.04	0.09
>2.5	0.02	0.00	0.00	0.00	0.01	0.05	0.14	0.01	0.06	0.02	0.03	0.02	0.03
>2.75	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0.01	0.02	0.00	0.00	0.00	0.01
>3	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00

Table 6.15 Monthly and annual significant wave height exceedance probabilities at P6.

H_s (m)	Exceedance (%)												
	January	February	March	April	May	June	July	August	September	October	November	December	Year
>0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
>0.25	50.46	44.57	45.77	41.84	49.06	54.92	55.22	53.66	54.89	55.20	50.63	52.11	50.74
>0.5	16.75	13.77	16.90	17.51	21.21	26.60	27.47	25.23	26.01	24.31	20.98	21.01	21.52
>0.75	6.45	5.23	6.85	7.73	9.93	13.52	13.74	12.88	13.10	11.72	9.46	8.83	9.98
>1	2.43	2.43	2.78	3.05	4.70	7.11	6.85	6.87	6.35	6.26	4.57	4.03	4.80
>1.25	1.11	1.04	1.20	1.27	2.22	3.51	3.01	3.42	2.91	3.21	2.08	1.58	2.22
>1.5	0.50	0.45	0.46	0.42	0.83	1.55	1.46	1.54	1.31	1.42	0.86	0.68	0.96
>1.75	0.20	0.12	0.11	0.11	0.22	0.53	0.70	0.60	0.54	0.50	0.41	0.28	0.36
>2	0.11	0.01	0.00	0.02	0.05	0.14	0.34	0.25	0.20	0.17	0.24	0.07	0.13
>2.25	0.03	0.00	0.00	0.00	0.01	0.06	0.15	0.08	0.08	0.03	0.09	0.02	0.05
>2.5	0.00	0.00	0.00	0.00	0.00	0.05	0.04	0.01	0.02	0.00	0.00	0.00	0.01
>2.75	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00

Table 6.16 Monthly and annual significant wave height exceedance probabilities at P7.

H_s (m)	Exceedance (%)												
	January	February	March	April	May	June	July	August	September	October	November	December	Year
>0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
>0.25	48.51	42.60	44.18	40.00	46.85	52.52	53.44	51.71	52.66	52.55	48.18	50.04	48.65
>0.5	15.95	13.11	16.24	16.80	20.01	25.65	26.10	24.27	24.98	23.27	20.05	20.31	20.60
>0.75	6.08	5.06	6.51	7.33	9.22	12.95	13.03	12.18	12.30	11.26	8.87	8.34	9.45
>1	2.20	2.27	2.63	2.92	4.49	6.69	6.39	6.54	5.98	5.92	4.35	3.72	4.52
>1.25	1.04	0.94	1.06	1.14	2.09	3.36	2.81	3.16	2.70	2.96	1.93	1.36	2.05
>1.5	0.46	0.45	0.39	0.41	0.71	1.37	1.33	1.34	1.15	1.29	0.77	0.58	0.86
>1.75	0.20	0.11	0.07	0.08	0.16	0.41	0.62	0.56	0.48	0.40	0.36	0.23	0.31
>2	0.07	0.01	0.00	0.02	0.04	0.12	0.28	0.16	0.18	0.14	0.20	0.07	0.11
>2.25	0.02	0.00	0.00	0.00	0.01	0.05	0.13	0.02	0.07	0.03	0.05	0.02	0.03
>2.5	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.01	0.02	0.00	0.00	0.00	0.01

Table 6.17 Monthly and annual significant wave height exceedance probabilities at P8.

H_s (m)	Exceedance (%)												
	January	February	March	April	May	June	July	August	September	October	November	December	Year
>0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
>0.25	51.14	44.09	45.86	41.36	48.78	54.49	54.87	53.65	54.81	55.53	51.02	52.15	50.70
>0.5	16.75	13.68	16.90	17.56	20.96	26.61	27.23	25.11	25.81	24.20	20.95	21.11	21.45
>0.75	6.43	5.23	6.87	7.66	9.80	13.43	13.54	12.77	12.93	11.70	9.46	8.82	9.91
>1	2.41	2.40	2.77	3.03	4.62	7.00	6.63	6.77	6.31	6.27	4.56	3.97	4.74
>1.25	1.09	0.99	1.12	1.22	2.20	3.47	2.91	3.33	2.84	3.15	2.06	1.49	2.16
>1.5	0.46	0.45	0.44	0.41	0.80	1.52	1.41	1.48	1.22	1.35	0.81	0.61	0.91
>1.75	0.20	0.13	0.08	0.09	0.21	0.46	0.68	0.58	0.53	0.46	0.37	0.27	0.34
>2	0.07	0.01	0.00	0.02	0.04	0.12	0.33	0.21	0.18	0.16	0.23	0.07	0.12
>2.25	0.02	0.00	0.00	0.00	0.01	0.05	0.13	0.02	0.07	0.03	0.08	0.02	0.04
>2.5	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.01	0.02	0.00	0.00	0.00	0.01

Table 6.18 Monthly and annual significant wave height exceedance probabilities at P9.

H_s (m)	Exceedance (%)												
	January	February	March	April	May	June	July	August	September	October	November	December	Year
>0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
>0.25	51.14	43.68	45.59	41.00	48.35	53.96	54.46	53.05	54.44	55.59	51.43	52.52	50.49
>0.5	16.59	13.43	16.55	17.44	20.76	26.33	27.05	25.01	25.69	24.19	20.83	20.99	21.28
>0.75	6.33	5.23	6.69	7.56	9.60	13.29	13.30	12.55	12.75	11.61	9.34	8.71	9.77
>1	2.34	2.33	2.72	2.92	4.58	6.88	6.47	6.70	6.16	6.16	4.45	3.86	4.64
>1.25	1.08	0.97	1.09	1.22	2.17	3.43	2.89	3.21	2.78	3.07	2.02	1.43	2.12
>1.5	0.45	0.45	0.41	0.41	0.77	1.45	1.32	1.42	1.19	1.33	0.79	0.59	0.88
>1.75	0.20	0.11	0.07	0.09	0.17	0.44	0.63	0.56	0.50	0.44	0.35	0.25	0.32
>2	0.07	0.01	0.00	0.02	0.04	0.12	0.27	0.19	0.18	0.15	0.19	0.07	0.11
>2.25	0.02	0.00	0.00	0.00	0.01	0.05	0.13	0.02	0.07	0.03	0.06	0.02	0.03
>2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.02	0.00	0.00	0.00	0.01

Table 6.19 Annual joint probability distribution (parts per thousand) of the significant wave height and mean wave direction at peak energy at P1.

H_s (m)	Mean wave direction at peak energy, θ_p (from, degT)								
	337.5 -22.5	22.5 -67.5	67.5 -112.5	112.5 -157.5	157.5 -202.5	202.5 -247.5	247.5 -292.5	292.5 -337.5	Total
0 - 0.25	306.5	13.7	17.5	19.6	23.5	13.4	9.9	11.0	415.1
0.25 - 0.5	226.2	22.9	20.4	23.8	20.0	4.9	5.8	15.5	339.5
0.5 - 0.75	89.1	12.2	12.5	7.5	3.7	0.4	0.1	2.6	128.1
0.75 - 1	44.5	5.6	5.8	1.5	0.4	0.2	0.0	0.1	58.1
1 - 1.25	23.4	3.1	2.3	0.1	0.0	0.0	0.0	0.0	28.9
1.25 - 1.5	13.4	2.3	0.8	0.0	0.0	0.0	0.0	0.0	16.5
1.5 - 1.75	6.8	0.6	0.2	0.0	0.0	0.0	0.0	0.0	7.6
1.75 - 2	3.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0	3.8
2 - 2.25	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
2.25 - 2.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
2.5 - 2.75	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
2.75 - 3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	715.8	60.6	59.6	52.5	47.6	18.9	15.8	29.2	1000.0

Table 6.20 Annual joint probability distribution (parts per thousand) of the significant wave height and mean wave direction at peak energy at P2.

H_s (m)	Mean wave direction at peak energy, θ_p (from, degT)								
	337.5 -22.5	22.5 -67.5	67.5 -112.5	112.5 -157.5	157.5 -202.5	202.5 -247.5	247.5 -292.5	292.5 -337.5	Total
0 - 0.25	42.6	215.6	17.8	24.0	7.4	12.0	12.0	9.8	341.2
0.25 - 0.5	93.7	160.6	33.4	33.2	10.5	10.8	15.0	15.8	373.0
0.5 - 0.75	73.6	33.8	20.1	10.8	1.6	0.6	3.1	3.7	147.3
0.75 - 1	44.5	13.3	6.3	3.5	0.2	0.1	0.5	0.1	68.5
1 - 1.25	24.9	6.5	2.0	0.8	0.0	0.0	0.0	0.0	34.2
1.25 - 1.5	14.5	3.5	0.8	0.1	0.0	0.0	0.0	0.0	18.9
1.5 - 1.75	8.0	1.3	0.2	0.0	0.0	0.0	0.0	0.0	9.5
1.75 - 2	4.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	4.6
2 - 2.25	1.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.8
2.25 - 2.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Total	308.0	435.2	80.6	72.4	19.7	23.5	30.6	29.4	1000.0

Table 6.21 Annual joint probability distribution (parts per thousand) of the significant wave height and mean wave direction at peak energy at P3.

H_s (m)	Mean wave direction at peak energy, θ_p (from, degT)								
	337.5 -22.5	22.5 -67.5	67.5 -112.5	112.5 -157.5	157.5 -202.5	202.5 -247.5	247.5 -292.5	292.5 -337.5	Total
0 - 0.25	44.6	300.9	27.2	45.1	7.5	18.3	15.5	6.7	465.8
0.25 - 0.5	87.0	139.8	26.3	30.3	1.5	4.0	9.9	2.1	300.9
0.5 - 0.75	62.5	40.3	14.1	4.1	0.3	0.3	0.9	0.6	123.1
0.75 - 1	33.7	17.0	4.8	0.5	0.0	0.0	0.0	0.0	56.0
1 - 1.25	17.5	9.1	1.7	0.0	0.0	0.0	0.0	0.0	28.3
1.25 - 1.5	9.2	4.8	0.4	0.0	0.0	0.0	0.0	0.0	14.4
1.5 - 1.75	3.5	3.1	0.1	0.0	0.0	0.0	0.0	0.0	6.7
1.75 - 2	0.7	2.3	0.0	0.0	0.0	0.0	0.0	0.0	3.0
2 - 2.25	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1
2.25 - 2.5	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Total	258.7	518.8	74.6	80.0	9.3	22.6	26.3	9.4	1000.0

Table 6.22 Annual joint probability distribution (parts per thousand) of the significant wave height and mean wave direction at peak energy at P4.

H_s (m)	Mean wave direction at peak energy, θ_p (from, degT)								
	337.5 -22.5	22.5 -67.5	67.5 -112.5	112.5 -157.5	157.5 -202.5	202.5 -247.5	247.5 -292.5	292.5 -337.5	Total
0 - 0.25	108.0	169.6	23.3	56.2	18.2	22.1	3.6	15.3	416.3
0.25 - 0.5	129.2	45.3	28.1	56.4	7.1	27.7	2.5	14.2	310.5
0.5 - 0.75	51.5	15.4	21.2	19.5	0.6	27.8	0.0	2.1	138.1
0.75 - 1	18.1	12.3	13.4	6.2	0.1	15.5	0.0	0.2	65.8
1 - 1.25	10.7	9.7	8.8	1.8	0.0	3.1	0.0	0.0	34.1
1.25 - 1.5	8.8	6.8	2.1	0.5	0.0	0.1	0.0	0.0	18.3
1.5 - 1.75	7.4	1.3	0.3	0.1	0.0	0.0	0.0	0.0	9.1
1.75 - 2	4.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	4.4
2 - 2.25	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8
2.25 - 2.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
2.5 - 2.75	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
2.75 - 3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
3 - 3.25	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	341.2	260.5	97.3	140.7	26.0	96.3	6.1	31.8	1000.0

Table 6.23 Annual joint probability distribution (parts per thousand) of the significant wave height and mean wave direction at peak energy at P5.

H_s (m)	Mean wave direction at peak energy, θ_p (from, degT)								
	337.5 -22.5	22.5 -67.5	67.5 -112.5	112.5 -157.5	157.5 -202.5	202.5 -247.5	247.5 -292.5	292.5 -337.5	Total
0 - 0.25	129.1	160.5	36.9	74.9	29.2	5.6	16.0	4.4	456.6
0.25 - 0.5	110.0	27.1	34.5	77.4	17.5	7.3	28.0	1.5	303.3
0.5 - 0.75	39.4	8.4	25.2	44.7	1.2	0.0	6.8	0.1	125.8
0.75 - 1	23.7	4.6	15.9	12.7	0.1	0.0	0.5	0.0	57.5
1 - 1.25	19.7	2.9	5.2	1.8	0.0	0.0	0.0	0.0	29.6
1.25 - 1.5	11.9	1.4	0.8	0.4	0.0	0.0	0.0	0.0	14.5
1.5 - 1.75	6.6	0.4	0.3	0.1	0.0	0.0	0.0	0.0	7.4
1.75 - 2	3.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.2
2 - 2.25	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
2.25 - 2.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
2.5 - 2.75	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2.75 - 3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	345.7	205.4	118.8	212.0	48.0	12.9	51.3	6.0	1000.0

Table 6.24 Annual joint probability distribution (parts per thousand) of the significant wave height and mean wave direction at peak energy at P6.

H_s (m)	Mean wave direction at peak energy, θ_p (from, degT)								
	337.5 -22.5	22.5 -67.5	67.5 -112.5	112.5 -157.5	157.5 -202.5	202.5 -247.5	247.5 -292.5	292.5 -337.5	Total
0 - 0.25	120.4	199.4	37.8	57.1	56.3	4.5	17.4	1.5	494.4
0.25 - 0.5	114.4	31.9	40.5	40.3	43.3	6.7	13.1	0.9	291.1
0.5 - 0.75	64.4	12.5	20.1	13.9	4.0	0.0	0.1	0.0	115.0
0.75 - 1	37.2	6.1	4.6	3.7	0.1	0.0	0.0	0.0	51.7
1 - 1.25	19.5	3.7	1.6	0.9	0.0	0.0	0.0	0.0	25.7
1.25 - 1.5	10.5	1.3	0.7	0.1	0.0	0.0	0.0	0.0	12.6
1.5 - 1.75	5.3	0.4	0.2	0.0	0.0	0.0	0.0	0.0	5.9
1.75 - 2	2.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2.2
2 - 2.25	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
2.25 - 2.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
2.5 - 2.75	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	375.2	255.4	105.5	116.0	103.7	11.2	30.6	2.4	1000.0

Table 6.25 Annual joint probability distribution (parts per thousand) of the significant wave height and mean wave direction at peak energy at P7.

H_s (m)	Mean wave direction at peak energy, θ_p (from, degT)								
	337.5 -22.5	22.5 -67.5	67.5 -112.5	112.5 -157.5	157.5 -202.5	202.5 -247.5	247.5 -292.5	292.5 -337.5	Total
0 - 0.25	110.8	208.7	23.7	81.0	27.0	42.3	2.7	19.4	515.6
0.25 - 0.5	127.0	37.8	19.9	58.2	11.9	21.4	1.1	2.0	279.3
0.5 - 0.75	70.2	15.1	9.7	15.1	0.5	0.4	0.0	0.0	111.0
0.75 - 1	35.4	6.8	4.0	3.0	0.0	0.0	0.0	0.0	49.2
1 - 1.25	18.5	3.8	1.6	0.7	0.0	0.0	0.0	0.0	24.6
1.25 - 1.5	9.9	1.4	0.6	0.1	0.0	0.0	0.0	0.0	12.0
1.5 - 1.75	4.9	0.4	0.2	0.0	0.0	0.0	0.0	0.0	5.5
1.75 - 2	1.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2.0
2 - 2.25	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
2.25 - 2.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Total	379.5	274.1	59.7	158.1	39.4	64.1	3.8	21.4	1000.0

Table 6.26 Annual joint probability distribution (parts per thousand) of the significant wave height and mean wave direction at peak energy at P8.

H_s (m)	Mean wave direction at peak energy, θ_p (from, degT)								
	337.5 -22.5	22.5 -67.5	67.5 -112.5	112.5 -157.5	157.5 -202.5	202.5 -247.5	247.5 -292.5	292.5 -337.5	Total
0 - 0.25	130.8	225.3	19.7	49.5	37.8	4.6	4.7	22.6	495.0
0.25 - 0.5	111.4	81.4	18.6	32.5	20.3	7.5	4.7	14.8	291.2
0.5 - 0.75	59.8	30.4	9.6	13.5	1.1	0.0	0.0	0.5	114.9
0.75 - 1	37.0	7.1	3.9	3.7	0.0	0.0	0.0	0.0	51.7
1 - 1.25	19.5	3.7	1.5	0.9	0.0	0.0	0.0	0.0	25.6
1.25 - 1.5	10.4	1.4	0.6	0.1	0.0	0.0	0.0	0.0	12.5
1.5 - 1.75	5.2	0.4	0.2	0.0	0.0	0.0	0.0	0.0	5.8
1.75 - 2	2.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2.2
2 - 2.25	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
2.25 - 2.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
2.5 - 2.75	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	377.4	349.8	54.1	100.2	59.2	12.1	9.4	37.9	1000.0

Table 6.27 Annual joint probability distribution (parts per thousand) of the significant wave height and mean wave direction at peak energy at P9.

H_s (m)	Mean wave direction at peak energy, θ_p (from, degT)								
	337.5 -22.5	22.5 -67.5	67.5 -112.5	112.5 -157.5	157.5 -202.5	202.5 -247.5	247.5 -292.5	292.5 -337.5	Total
0 - 0.25	128.2	172.2	15.8	56.2	58.3	8.9	28.6	29.1	497.3
0.25 - 0.5	133.1	25.8	16.2	30.4	52.5	5.2	22.3	4.9	290.4
0.5 - 0.75	74.7	9.8	9.1	12.4	7.6	0.1	1.0	0.1	114.8
0.75 - 1	37.9	5.8	3.8	3.3	0.2	0.0	0.0	0.0	51.0
1 - 1.25	19.2	3.7	1.5	0.8	0.0	0.0	0.0	0.0	25.2
1.25 - 1.5	10.3	1.4	0.6	0.1	0.0	0.0	0.0	0.0	12.4
1.5 - 1.75	5.1	0.4	0.2	0.0	0.0	0.0	0.0	0.0	5.7
1.75 - 2	2.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2.1
2 - 2.25	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
2.25 - 2.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
2.5 - 2.75	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	411.6	219.2	47.2	103.2	118.6	14.2	51.9	34.1	1000.0

Table 6.28 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P1. The grey cells indicate "surfable conditions".

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	43.3	23.9	35.5	23.0	70.4	115.6	43.0	20.4	9.3	3.0	387.4
0.25 - 0.5	108.4	30.1	38.6	30.5	19.1	49.7	32.2	19.4	6.3	1.5	335.8
0.5 - 0.75	59.8	26.8	11.2	13.9	5.3	4.4	3.6	2.2	0.7	0.2	128.1
0.75 - 1	13.8	27.5	7.8	4.4	2.9	1.0	0.5	0.3	0.1	0.0	58.3
1 - 1.25	0.6	19.6	5.0	1.6	1.3	0.4	0.2	0.1	0.0	0.0	28.8
1.25 - 1.5	0.0	10.8	3.8	0.8	0.7	0.3	0.1	0.1	0.0	0.0	16.6
1.5 - 1.75	0.0	3.6	3.1	0.4	0.3	0.1	0.1	0.0	0.0	0.0	7.6
1.75 - 2	0.0	1.1	2.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	3.6
2 - 2.25	0.0	0.2	1.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.4
2.25 - 2.5	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.6
2.5 - 2.75	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2.75 - 3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	225.9	143.6	108.5	75.5	100.1	171.6	79.7	42.5	16.4	4.7	1000.0

Table 6.29 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P2. The grey cells indicate "surfable conditions".

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	44.2	20.7	29.3	21.2	61.6	90.6	32.6	14.6	7.4	2.2	324.4
0.25 - 0.5	100.2	45.4	45.0	32.3	27.8	58.7	33.9	20.0	6.1	1.4	370.8
0.5 - 0.75	57.9	32.6	19.1	17.8	6.1	6.2	4.2	2.3	1.0	0.2	147.4
0.75 - 1	12.8	31.8	9.9	8.1	3.6	1.5	0.5	0.3	0.1	0.0	68.6
1 - 1.25	0.5	21.7	6.5	3.0	1.7	0.5	0.2	0.1	0.0	0.0	34.2
1.25 - 1.5	0.0	10.6	5.4	1.4	1.1	0.3	0.1	0.1	0.0	0.0	19.0
1.5 - 1.75	0.0	2.6	5.7	0.5	0.5	0.2	0.1	0.0	0.0	0.0	9.6
1.75 - 2	0.0	0.4	3.5	0.4	0.2	0.1	0.0	0.0	0.0	0.0	4.6
2 - 2.25	0.0	0.0	1.2	0.5	0.1	0.0	0.0	0.0	0.0	0.0	1.8
2.25 - 2.5	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.4
Total	215.6	165.8	125.7	85.4	102.8	158.1	71.6	37.4	14.6	3.8	1000.0

Table 6.30 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P3. The grey cells indicate "surfable conditions".

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	62.5	54.6	48.1	34.3	72.2	114.5	44.3	20.8	9.3	2.8	463.4
0.25 - 0.5	77.3	65.1	48.7	29.4	17.0	28.5	18.7	12.0	3.5	0.8	301.0
0.5 - 0.75	43.6	38.5	17.9	13.4	4.6	2.7	1.4	0.8	0.3	0.1	123.3
0.75 - 1	8.1	30.9	8.7	5.3	2.2	0.6	0.2	0.1	0.0	0.0	56.1
1 - 1.25	0.4	19.1	5.3	1.8	1.2	0.3	0.1	0.1	0.0	0.0	28.3
1.25 - 1.5	0.0	7.9	5.3	0.6	0.5	0.1	0.0	0.0	0.0	0.0	14.4
1.5 - 1.75	0.0	1.9	4.2	0.3	0.2	0.1	0.0	0.0	0.0	0.0	6.7
1.75 - 2	0.0	0.2	2.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	2.9
2 - 2.25	0.0	0.0	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1.2
2.25 - 2.5	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Total	191.9	218.2	141.5	86.0	98.0	146.8	64.7	33.8	13.1	3.7	1000.0

Table 6.31 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P4. The grey cells indicate "surfable conditions".

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	111.7	38.7	43.7	22.7	51.2	71.8	30.9	13.9	5.1	1.5	391.2
0.25 - 0.5	164.7	41.7	53.8	16.0	9.2	10.7	7.0	3.5	1.4	0.2	308.2
0.5 - 0.75	73.9	34.2	18.5	8.3	2.2	0.7	0.3	0.2	0.0	0.0	138.3
0.75 - 1	18.0	35.1	8.3	3.1	0.9	0.2	0.1	0.1	0.0	0.0	65.8
1 - 1.25	1.9	26.1	4.8	1.0	0.3	0.1	0.0	0.0	0.0	0.0	34.2
1.25 - 1.5	0.0	14.3	3.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	18.0
1.5 - 1.75	0.0	5.5	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0
1.75 - 2	0.0	1.4	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4
2 - 2.25	0.0	0.3	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
2.25 - 2.5	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
2.5 - 2.75	0.0	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5
2.75 - 3	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Total	370.2	197.3	141.9	51.5	63.9	83.5	38.3	17.7	6.5	1.7	1000.0

Table 6.32 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P5. The grey cells indicate "surfable conditions".

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	117.2	50.8	52.8	29.1	48.2	73.4	32.3	14.9	5.6	1.6	425.9
0.25 - 0.5	153.7	48.5	54.1	16.5	6.9	6.9	4.7	2.4	1.1	0.1	294.9
0.5 - 0.75	63.9	36.1	16.7	6.5	1.8	0.4	0.2	0.2	0.0	0.0	125.8
0.75 - 1	16.0	31.7	7.0	2.0	0.6	0.2	0.1	0.0	0.0	0.0	57.6
1 - 1.25	2.0	23.1	4.0	0.4	0.1	0.0	0.1	0.0	0.0	0.0	29.7
1.25 - 1.5	0.0	11.3	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.4
1.5 - 1.75	0.0	4.1	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3
1.75 - 2	0.0	1.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4
2 - 2.25	0.0	0.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
2.25 - 2.5	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
2.5 - 2.75	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Total	352.8	206.7	145.3	54.5	57.6	80.9	37.4	17.5	6.7	1.7	1000.0

Table 6.33 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P6. The grey cells indicate "surfable conditions".

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	116.0	56.2	74.6	26.4	50.2	79.5	35.3	16.1	6.3	1.8	462.4
0.25 - 0.5	140.2	48.6	54.4	17.4	5.0	5.5	4.1	2.0	1.0	0.2	278.4
0.5 - 0.75	57.9	33.5	15.7	5.7	1.6	0.4	0.2	0.2	0.0	0.0	115.2
0.75 - 1	14.9	28.5	6.4	1.2	0.4	0.2	0.1	0.0	0.0	0.0	51.7
1 - 1.25	1.5	20.1	3.7	0.2	0.1	0.0	0.0	0.0	0.0	0.0	25.6
1.25 - 1.5	0.0	9.1	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6
1.5 - 1.75	0.0	2.9	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9
1.75 - 2	0.0	0.5	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
2 - 2.25	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
2.25 - 2.5	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
2.5 - 2.75	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	330.5	199.4	164.2	50.9	57.3	85.6	39.7	18.3	7.3	2.0	1000.0

Table 6.34 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P7. The grey cells indicate "surfable conditions".

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	127.4	73.9	76.2	24.4	49.0	82.1	36.6	16.7	6.6	2.0	494.9
0.25 - 0.5	137.4	54.7	53.6	16.3	4.8	4.7	3.9	1.9	1.0	0.2	278.5
0.5 - 0.75	54.3	34.4	14.6	5.5	1.5	0.4	0.2	0.2	0.0	0.0	111.1
0.75 - 1	14.0	27.5	6.0	1.0	0.4	0.2	0.1	0.0	0.0	0.0	49.2
1 - 1.25	1.4	19.2	3.7	0.1	0.1	0.0	0.0	0.0	0.0	0.0	24.5
1.25 - 1.5	0.0	8.6	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0
1.5 - 1.75	0.0	2.6	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4
1.75 - 2	0.0	0.4	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
2 - 2.25	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
2.25 - 2.5	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Total	334.5	221.3	162.8	47.3	55.8	87.4	40.8	18.8	7.6	2.2	1000.0

Table 6.35 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P8. The grey cells indicate "surfable conditions".

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	132.7	51.9	56.4	19.6	53.2	80.9	35.7	16.4	6.3	1.8	454.9
0.25 - 0.5	149.2	47.7	50.9	14.4	4.9	6.2	4.4	2.0	1.0	0.1	280.8
0.5 - 0.75	60.3	33.1	14.1	5.3	1.5	0.4	0.2	0.2	0.0	0.0	115.1
0.75 - 1	16.1	28.3	5.6	1.1	0.4	0.2	0.1	0.0	0.0	0.0	51.8
1 - 1.25	1.8	20.4	3.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	25.6
1.25 - 1.5	0.0	9.4	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4
1.5 - 1.75	0.0	3.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7
1.75 - 2	0.0	0.5	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
2 - 2.25	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
2.25 - 2.5	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
2.5 - 2.75	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	360.1	194.3	138.8	40.6	60.0	87.7	40.4	18.6	7.3	1.9	1000.0

Table 6.36 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P9. The grey cells indicate "surfable conditions".

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	136.3	71.5	58.2	19.5	44.8	77.6	34.7	16.0	6.4	1.8	466.8
0.25 - 0.5	152.4	57.0	49.4	14.2	4.5	4.9	4.0	2.1	1.0	0.1	289.6
0.5 - 0.75	59.5	35.2	13.0	5.0	1.5	0.4	0.2	0.1	0.0	0.0	114.9
0.75 - 1	16.2	28.2	5.3	0.9	0.3	0.2	0.1	0.0	0.0	0.0	51.2
1 - 1.25	1.9	20.2	2.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	25.1
1.25 - 1.5	0.0	9.7	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4
1.5 - 1.75	0.0	3.1	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6
1.75 - 2	0.0	0.6	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1
2 - 2.25	0.0	0.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
2.25 - 2.5	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Total	366.3	225.6	136.5	39.7	51.1	83.1	39.0	18.2	7.4	1.9	1000.0

Table 6.37 Probability of surfable conditions (%) at surf spots corresponding to sites P1-P9 for the conservative threshold of $H_s \geq 0.5$ and $T_p \geq 6$ s, the threshold used by Mead et al. (2004) and Black et al. (2004) of $H_s \geq 0.75$ and $T_p \geq 6$ s, and for average to good conditions ($H_s \geq 0.75$ and $T_p \geq 8$ s).

	Probability of surfable conditions (%)		
	$H_s \geq 0.5$ and $T_p \geq 6$ s	$H_s \geq 0.75$ and $T_p \geq 6$ s	$H_s \geq 0.75$ and $T_p \geq 8$ s
Site P1	8.2	4.0	1.7
Site P2	11.5	5.8	2.6
Site P3	8.3	4.2	1.5
Site P4	6.3	3.2	0.7
Site P5	5.1	2.5	0.4
Site P6	4.6	2.2	0.2
Site P7	4.3	2.1	0.2
Site P8	4.1	1.9	0.2
Site P9	3.8	1.8	0.2

Table 6.38 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P1. The grey cells indicate "surfable conditions". The incident frequency dependency of Plew et al. (2005) has been applied to incident waves with peak periods less than 10 seconds.

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	56.2	28.1	40.9	25.0	70.4	115.6	43.0	20.4	9.3	3.0	411.9
0.25 - 0.5	113.3	32.4	35.8	30.6	19.1	49.7	32.2	19.4	6.3	1.5	340.3
0.5 - 0.75	49.8	29.2	11.0	13.1	5.3	4.4	3.6	2.2	0.7	0.2	119.5
0.75 - 1	6.6	28.5	7.5	3.5	2.9	1.0	0.5	0.3	0.1	0.0	50.9
1 - 1.25	0.1	16.5	4.9	1.4	1.3	0.4	0.2	0.1	0.0	0.0	24.9
1.25 - 1.5	0.0	6.6	3.7	0.6	0.7	0.3	0.1	0.1	0.0	0.0	12.1
1.5 - 1.75	0.0	1.7	2.8	0.3	0.3	0.1	0.1	0.0	0.0	0.0	5.3
1.75 - 2	0.0	0.3	1.3	0.3	0.1	0.1	0.0	0.0	0.0	0.0	2.1
2 - 2.25	0.0	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.7
2.25 - 2.5	0.0	0.0	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.5
2.5 - 2.75	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	226.0	143.3	108.6	75.4	100.1	171.6	79.7	42.5	16.4	4.7	1000.0

Table 6.39 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P2. The grey cells indicate "surfable conditions". The incident frequency dependency of Plew et al. (2005) has been applied to incident waves with peak periods less than 10 seconds.

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	56.7	25.8	34.1	22.9	61.6	90.6	32.6	14.6	7.4	2.2	348.5
0.25 - 0.5	104.5	48.1	44.3	33.1	27.8	58.7	33.9	20.0	6.1	1.4	377.9
0.5 - 0.75	48.7	35.9	18.0	17.0	6.1	6.2	4.2	2.3	1.0	0.2	139.6
0.75 - 1	5.7	32.0	9.6	7.3	3.6	1.5	0.5	0.3	0.1	0.0	60.6
1 - 1.25	0.0	17.3	6.3	2.6	1.7	0.5	0.2	0.1	0.0	0.0	28.7
1.25 - 1.5	0.0	5.9	6.4	1.1	1.1	0.3	0.1	0.1	0.0	0.0	15.0
1.5 - 1.75	0.0	0.8	4.5	0.5	0.5	0.2	0.1	0.0	0.0	0.0	6.6
1.75 - 2	0.0	0.0	2.0	0.4	0.2	0.1	0.0	0.0	0.0	0.0	2.7
2 - 2.25	0.0	0.0	0.4	0.5	0.1	0.0	0.0	0.0	0.0	0.0	1.0
2.25 - 2.5	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.2
Total	215.6	165.8	125.6	85.5	102.8	158.1	71.6	37.4	14.6	3.8	1000.0

Table 6.40 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P3. The grey cells indicate "surfable conditions". The incident frequency dependency of Plew et al. (2005) has been applied to incident waves with peak periods less than 10 seconds.

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	72.1	63.6	54.5	36.8	72.2	114.5	44.3	20.8	9.3	2.8	490.9
0.25 - 0.5	81.9	66.1	46.8	28.9	17.0	28.5	18.7	12.0	3.5	0.8	304.2
0.5 - 0.75	33.9	39.8	16.3	12.6	4.6	2.7	1.4	0.8	0.3	0.1	112.5
0.75 - 1	4.0	29.4	7.9	4.5	2.2	0.6	0.2	0.1	0.0	0.0	48.9
1 - 1.25	0.0	14.8	5.7	1.5	1.2	0.3	0.1	0.1	0.0	0.0	23.7
1.25 - 1.5	0.0	3.8	5.4	0.5	0.5	0.1	0.0	0.0	0.0	0.0	10.3
1.5 - 1.75	0.0	0.6	3.3	0.2	0.2	0.1	0.0	0.0	0.0	0.0	4.4
1.75 - 2	0.0	0.0	1.3	0.3	0.1	0.0	0.0	0.0	0.0	0.0	1.7
2 - 2.25	0.0	0.0	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.7
2.25 - 2.5	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	191.9	218.1	141.5	85.8	98.0	146.8	64.7	33.8	13.1	3.7	1000.0

Table 6.41 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P4. The grey cells indicate "surfable conditions". The incident frequency dependency of Plew et al. (2005) has been applied to incident waves with peak periods less than 10 seconds.

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	135.6	44.5	50.6	23.8	51.2	71.8	30.9	13.9	5.1	1.5	428.9
0.25 - 0.5	163.9	43.6	51.1	16.1	9.2	10.7	7.0	3.5	1.4	0.2	306.7
0.5 - 0.75	60.8	38.2	17.1	7.8	2.2	0.7	0.3	0.2	0.0	0.0	127.3
0.75 - 1	9.6	36.6	7.5	2.8	0.9	0.2	0.1	0.1	0.0	0.0	57.8
1 - 1.25	0.3	22.4	4.5	0.7	0.3	0.1	0.0	0.0	0.0	0.0	28.3
1.25 - 1.5	0.0	9.2	3.9	0.2	0.1	0.0	0.0	0.0	0.0	0.0	13.4
1.5 - 1.75	0.0	2.5	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9
1.75 - 2	0.0	0.4	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
2 - 2.25	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
2.25 - 2.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
2.5 - 2.75	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Total	370.2	197.4	141.9	51.5	63.9	83.5	38.3	17.7	6.5	1.7	1000.0

Table 6.42 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P5. The grey cells indicate "surfable conditions". The incident frequency dependency of Plew et al. (2005) has been applied to incident waves with peak periods less than 10 seconds.

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	140.1	57.9	59.9	30.3	48.2	73.4	32.3	14.9	5.6	1.6	464.2
0.25 - 0.5	151.3	49.9	51.3	16.5	6.9	6.9	4.7	2.4	1.1	0.1	291.1
0.5 - 0.75	51.8	38.7	14.8	5.9	1.8	0.4	0.2	0.2	0.0	0.0	113.8
0.75 - 1	9.3	31.9	6.2	1.5	0.6	0.2	0.1	0.0	0.0	0.0	49.8
1 - 1.25	0.3	19.4	3.9	0.2	0.1	0.0	0.1	0.0	0.0	0.0	24.0
1.25 - 1.5	0.0	7.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7
1.5 - 1.75	0.0	1.6	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5
1.75 - 2	0.0	0.2	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7
2 - 2.25	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
2.25 - 2.5	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
2.5 - 2.75	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	352.8	206.6	145.3	54.4	57.6	80.9	37.4	17.5	6.7	1.7	1000.0

Table 6.43 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P6. The grey cells indicate "surfable conditions". The incident frequency dependency of Plew et al. (2005) has been applied to incident waves with peak periods less than 10 seconds.

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	136.4	62.8	82.1	27.7	50.2	79.5	35.3	16.1	6.3	1.8	498.2
0.25 - 0.5	138.2	50.3	50.9	17	5	5.5	4.1	2	1	0.2	274.2
0.5 - 0.75	47.1	34.9	13.9	5.2	1.6	0.4	0.2	0.2	0	0	103.5
0.75 - 1	8.7	28.8	5.8	0.9	0.4	0.2	0.1	0	0	0	44.9
1 - 1.25	0.1	16.1	4	0.1	0.1	0	0	0	0	0	20.4
1.25 - 1.5	0	5.3	3.6	0	0	0	0	0	0	0	8.9
1.5 - 1.75	0	1.1	2.3	0	0	0	0	0	0	0	3.4
1.75 - 2	0	0.1	1.1	0	0	0	0	0	0	0	1.2
2 - 2.25	0	0	0.5	0	0	0	0	0	0	0	0.5
2.25 - 2.5	0	0	0.1	0	0	0	0	0	0	0	0.1
Total	330.5	199.4	164.3	50.9	57.3	85.6	39.7	18.3	7.3	2	1000

Table 6.44 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P7. The grey cells indicate "surfable conditions". The incident frequency dependency of Plew et al. (2005) has been applied to incident waves with peak periods less than 10 seconds.

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	152.7	81.7	84.1	25.7	49	82.1	36.6	16.7	6.6	2	537.2
0.25 - 0.5	129.9	55.2	49.7	15.9	4.8	4.7	3.9	1.9	1	0.2	267.2
0.5 - 0.75	43.7	35.7	12.9	4.9	1.5	0.4	0.2	0.2	0	0	99.5
0.75 - 1	8.2	27.8	5.5	0.8	0.4	0.2	0.1	0	0	0	43
1 - 1.25	0.1	15.2	3.9	0	0.1	0	0	0	0	0	19.3
1.25 - 1.5	0	4.8	3.5	0	0	0	0	0	0	0	8.3
1.5 - 1.75	0	0.9	2.1	0	0	0	0	0	0	0	3
1.75 - 2	0	0	0.9	0	0	0	0	0	0	0	0.9
2 - 2.25	0	0	0.4	0	0	0	0	0	0	0	0.4
2.25 - 2.5	0	0	0.1	0	0	0	0	0	0	0	0.1
Total	334.6	221.3	163.1	47.3	55.8	87.4	40.8	18.8	7.6	2.2	1000

Table 6.45 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P8. The grey cells indicate "surfable conditions". The incident frequency dependency of Plew et al. (2005) has been applied to incident waves with peak periods less than 10 seconds.

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	155.4	58.3	63.5	20.6	53.2	80.9	35.7	16.4	6.3	1.8	492.1
0.25 - 0.5	145.7	49.7	47.4	14.2	4.9	6.2	4.4	2	1	0.1	275.6
0.5 - 0.75	49.2	34.4	12.4	4.8	1.5	0.4	0.2	0.2	0	0	103.1
0.75 - 1	9.5	28.7	5.1	0.8	0.4	0.2	0.1	0	0	0	44.8
1 - 1.25	0.2	16.5	3.5	0.1	0	0	0	0	0	0	20.3
1.25 - 1.5	0	5.5	3.2	0	0	0	0	0	0	0	8.7
1.5 - 1.75	0	1.2	2.1	0	0	0	0	0	0	0	3.3
1.75 - 2	0	0.1	1	0	0	0	0	0	0	0	1.1
2 - 2.25	0	0	0.5	0	0	0	0	0	0	0	0.5
2.25 - 2.5	0	0	0.1	0	0	0	0	0	0	0	0.1
2.5 - 2.75	360	194.4	138.8	40.5	60	87.7	40.4	18.6	7.3	1.9	1000
Total	155.4	58.3	63.5	20.6	53.2	80.9	35.7	16.4	6.3	1.8	492.1

Table 6.46 Annual joint probability distribution (parts per thousand) of the significant wave height and peak wave period at P9. The grey cells indicate "surfable conditions". The incident frequency dependency of Plew et al. (2005) has been applied to incident waves with peak periods less than 10 seconds.

H_s (m)	Peak wave period T_p (s)										
	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0 - 0.25	161.8	80	65.5	20.4	44.8	77.6	34.7	16	6.4	1.8	509
0.25 - 0.5	146.4	57.7	45.6	14.1	4.5	4.9	4	2.1	1	0.1	280.4
0.5 - 0.75	48.2	36	11.4	4.5	1.5	0.4	0.2	0.1	0	0	102.3
0.75 - 1	9.7	28.5	4.5	0.7	0.3	0.2	0.1	0	0	0	44
1 - 1.25	0.3	16.6	3.1	0	0	0	0	0	0	0	20
1.25 - 1.5	0	5.6	2.9	0	0	0	0	0	0	0	8.5
1.5 - 1.75	0	1.2	2	0	0	0	0	0	0	0	3.2
1.75 - 2	0	0.1	0.9	0	0	0	0	0	0	0	1
2 - 2.25	0	0	0.4	0	0	0	0	0	0	0	0.4
2.25 - 2.5	0	0	0.1	0	0	0	0	0	0	0	0.1
Total	366.4	225.7	136.4	39.7	51.1	83.1	39	18.2	7.4	1.9	1000

Table 6.47 *Probability of surfable conditions (%) at surf spots corresponding to sites P1-P9 at the conservative threshold of Hs ≥ 0.5 and Tp ≥ 6 s, the threshold used by Mead et al. (2004) and Black et al. (2004) of Hs ≥ 0.75 and Tp ≥ 6 s, and for average to good conditions (Hs ≥ 0.75 and Tp ≥ 8 s). Surf sites potentially impacted by the proposed aquaculture areas (P6-P9) are highlighted. The incident frequency dependency of Plew et al. (2005) has been applied to incident waves with peak periods less than 10 seconds. Bracketed values are representative of surfable conditions without the presence of the mussel farms.*

	Probability of surfable conditions (%)		
	$H_s \geq 0.5$ and $T_p \geq 6$ s	$H_s \geq 0.75$ and $T_p \geq 6$ s	$H_s \geq 0.75$ and $T_p \geq 8$ s
Site P1	7.7 *(8.2)*	3.6 *(4.0)*	1.6 *(1.7)*
Site P2	10.8 *(11.5)*	5.3 *(5.8)*	2.4 *(2.6)*
Site P3	7.6 *(8.3)*	3.8 *(4.2)*	1.4 *(1.5)*
Site P4	5.7 *(6.3)*	2.9 *(3.2)*	0.6 *(0.7)*
Site P5	4.6 *(5.1)*	2.2 *(2.5)*	0.3 *(0.4)*
Site P6	4.1 *(4.6)*	1.9 *(2.2)*	0.2 *(0.2)*
Site P7	3.8*(4.3)*	1.8 *(2.1)*	0.2 *(0.2)*
Site P8	3.7*(4.1)*	1.7 *(1.9)*	0.2 *(0.2)*
Site P9	3.3 *(3.8)*	1.5 *(1.8)*	0.1 *(0.2)*

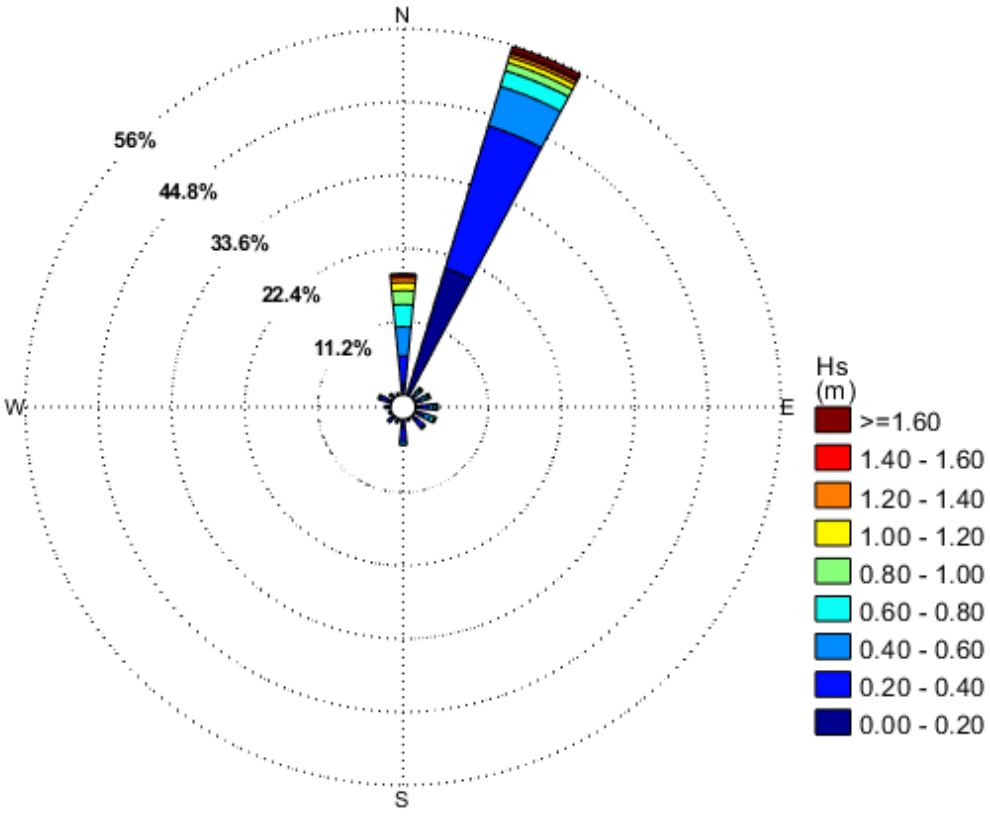

Figure 6.1 Annual wave rose plot for the significant wave height at P1.

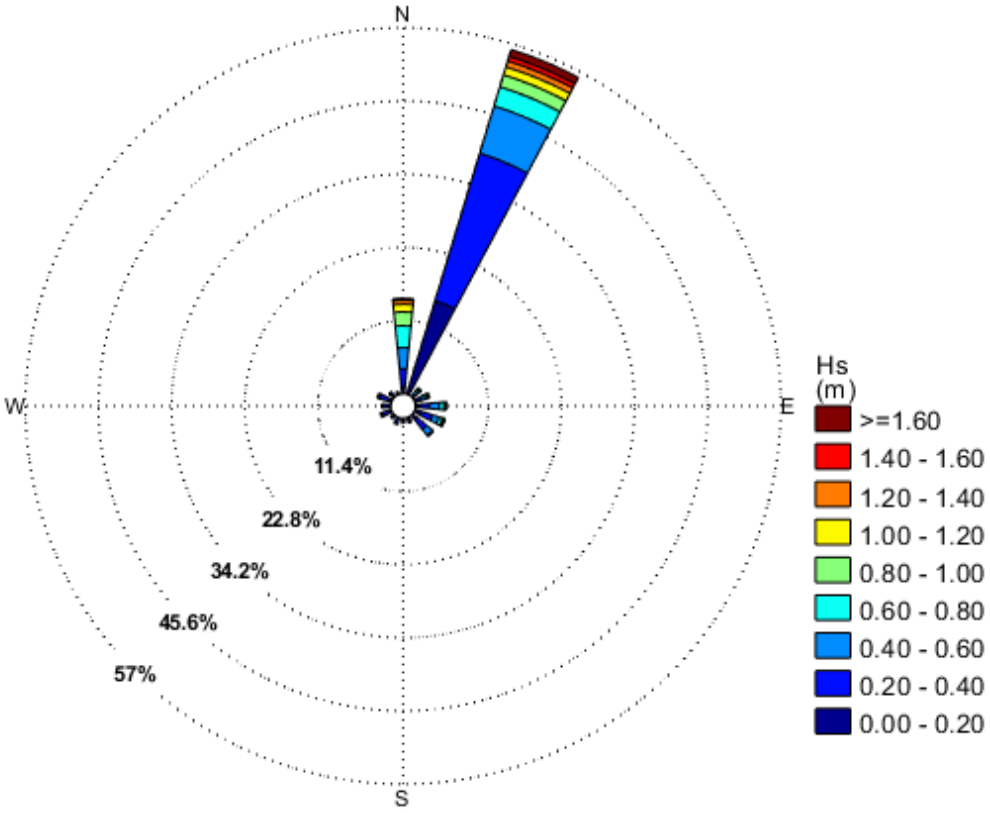

Figure 6.2 Annual wave rose plot for the significant wave height at P2.

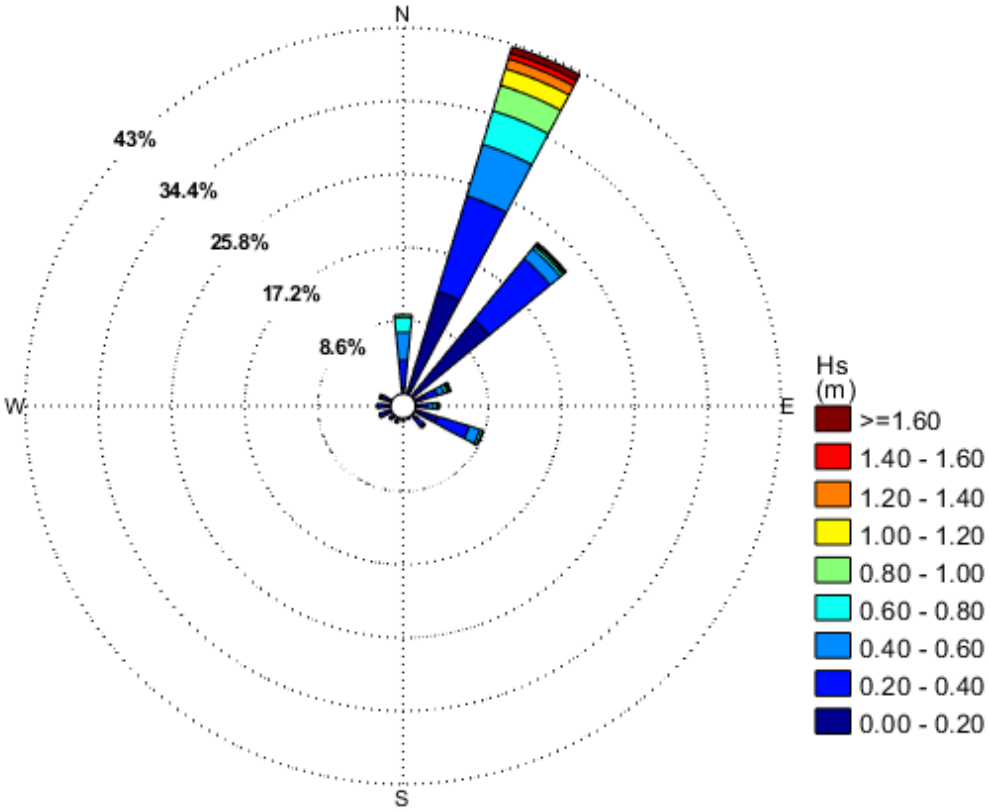

Figure 6.3 Annual wave rose plot for the significant wave height at P3.

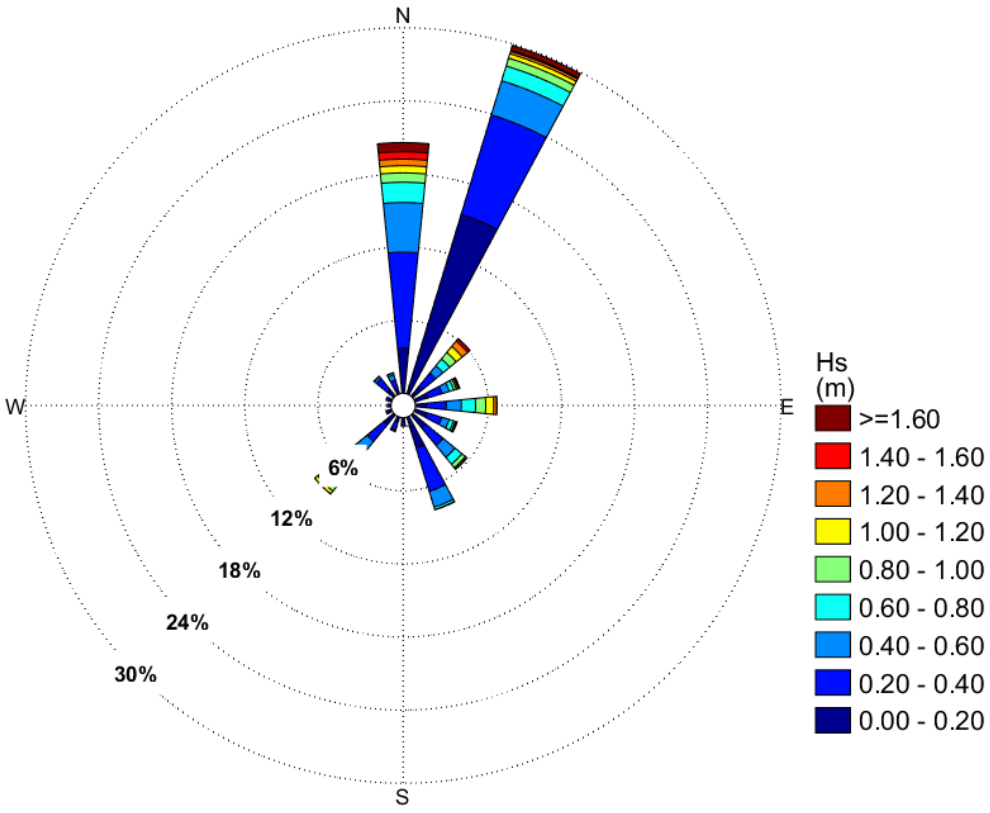

Figure 6.4 Annual wave rose plot for the significant wave height at P4.

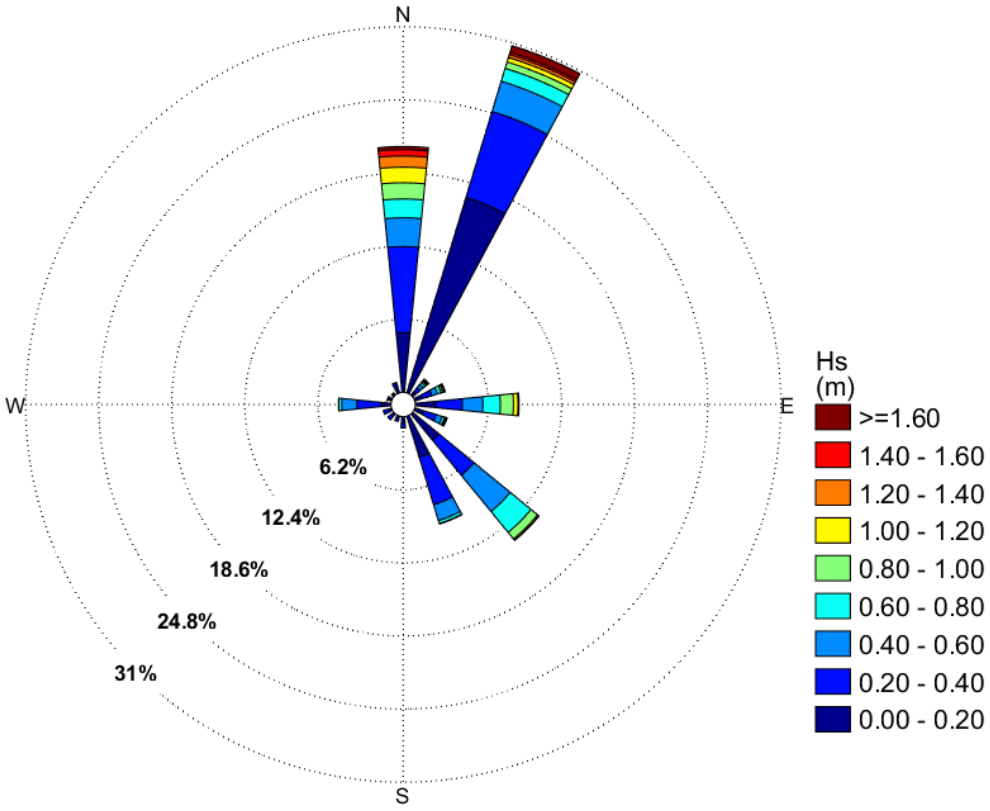

Figure 6.5 Annual wave rose plot for the significant wave height at P5.

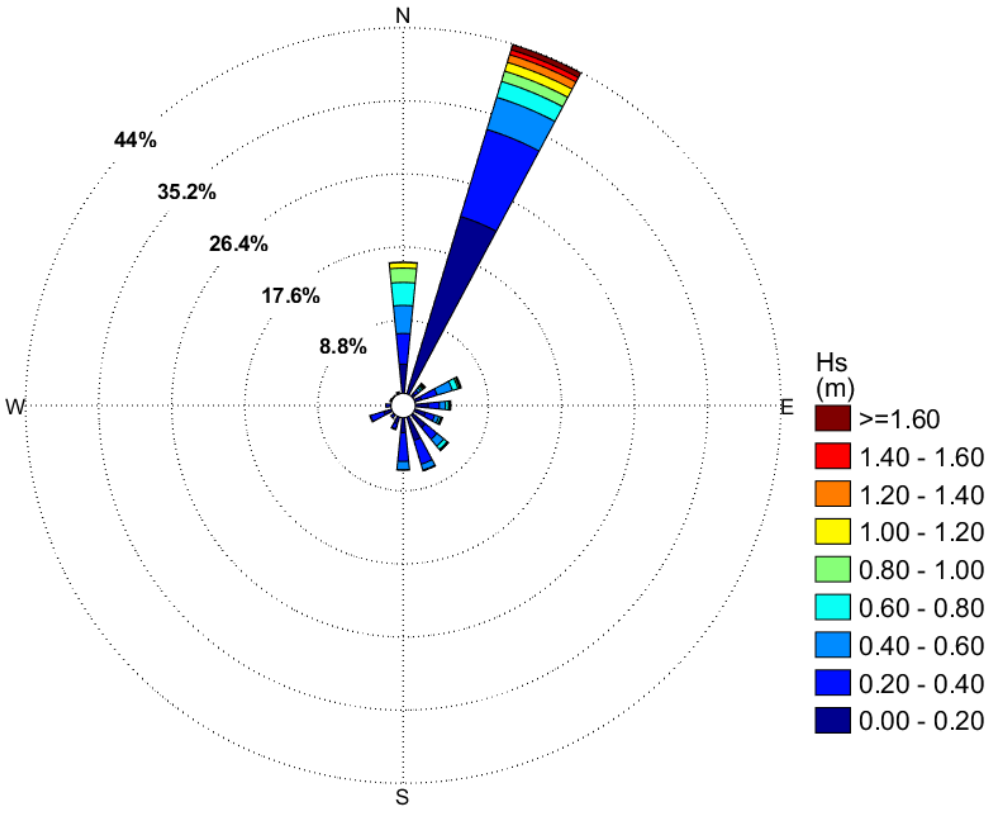

Figure 6.6 Annual wave rose plot for the significant wave height at P6.

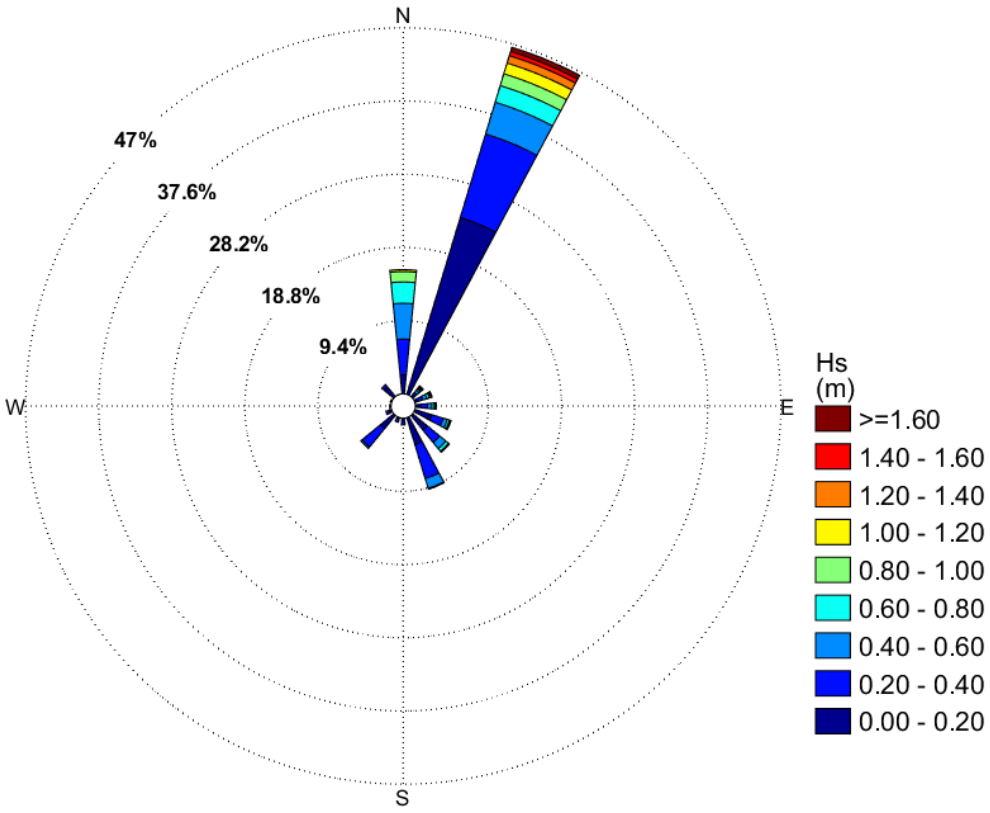

Figure 6.7 Annual wave rose plot for the significant wave height at P7.

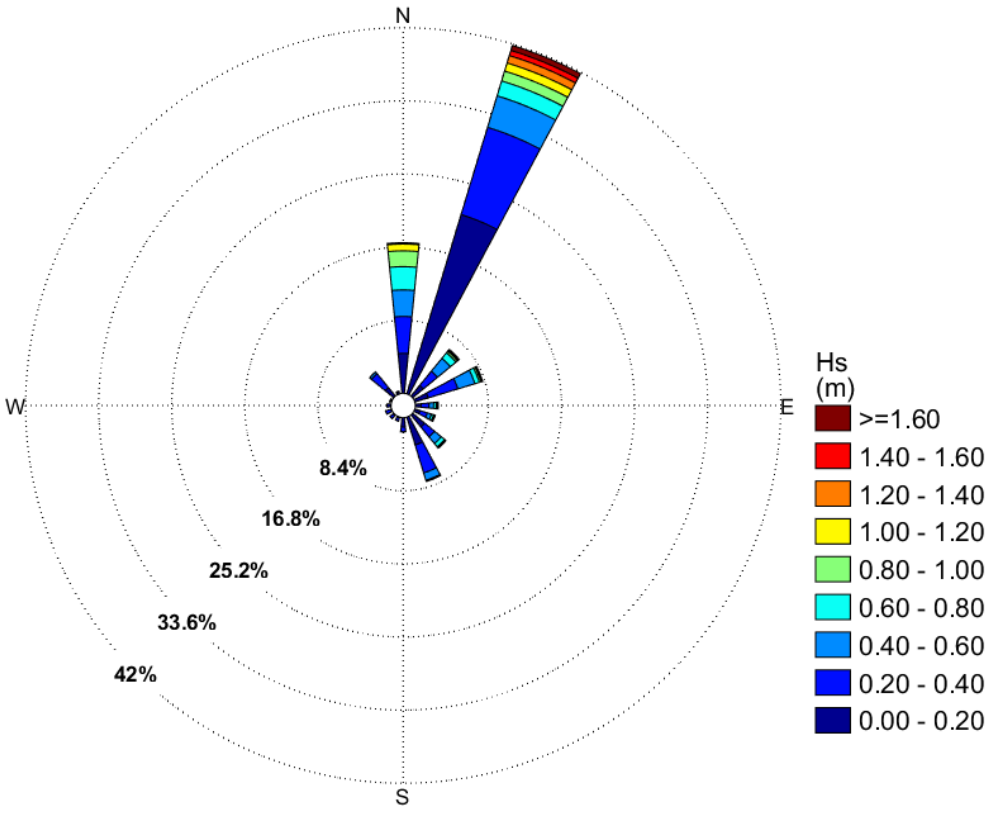

Figure 6.8 Annual wave rose plot for the significant wave height at P8.

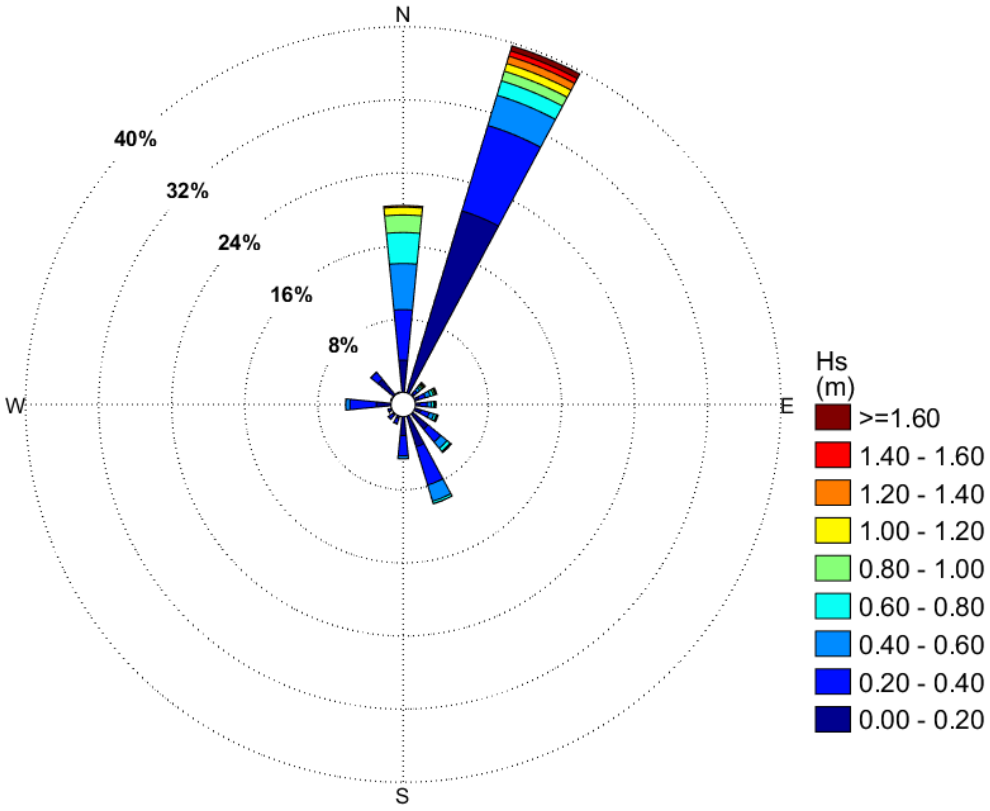

Figure 6.9 Annual wave rose plot for the significant wave height at P9.

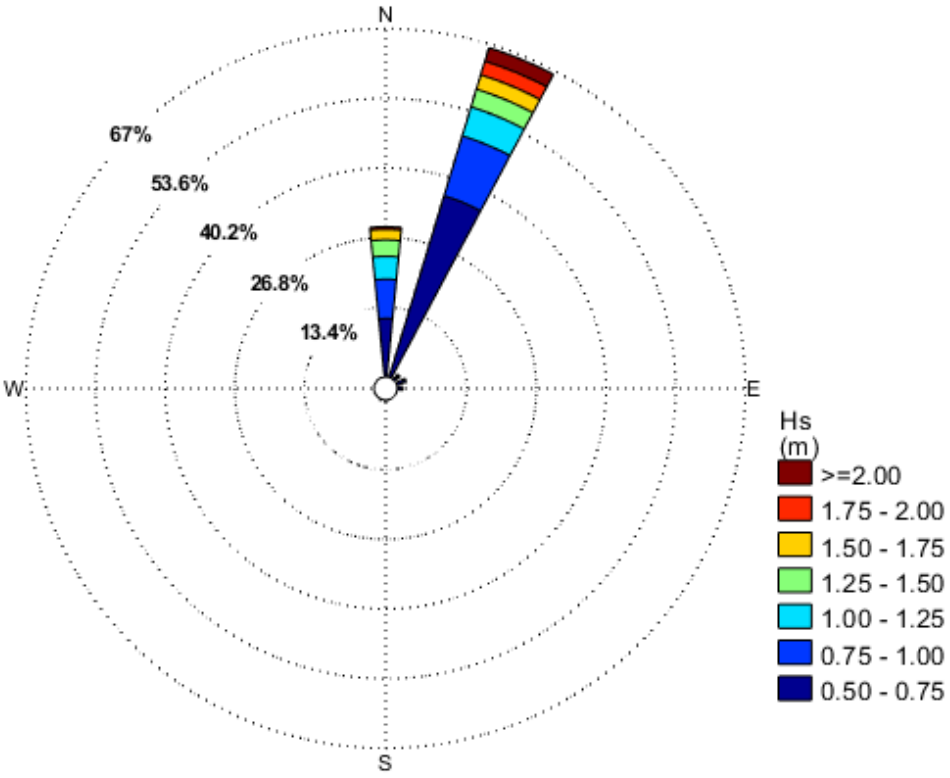

Figure 6.10 Annual wave rose plot for the significant wave height at P1 for "surfable" events (i.e. $H_s \geq 0.5$ m and $T_p \geq 6$ s).

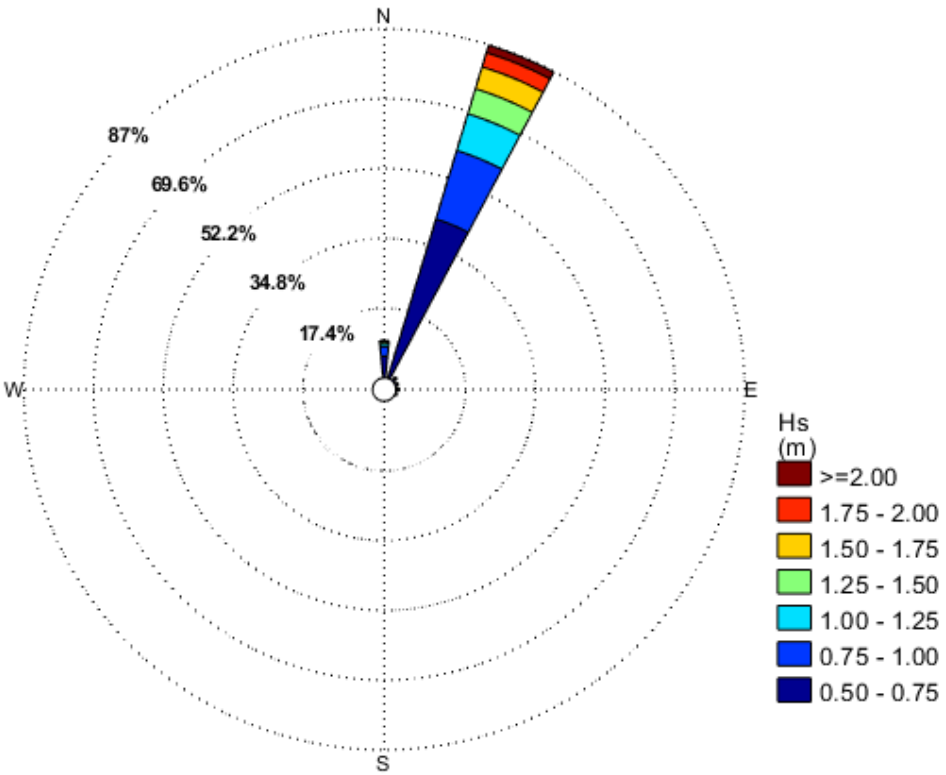

Figure 6.11 Annual wave rose plot for the significant wave height at P2 for "surfable" events (i.e. $H_s \geq 0.5$ m and $T_p \geq 6$ s).

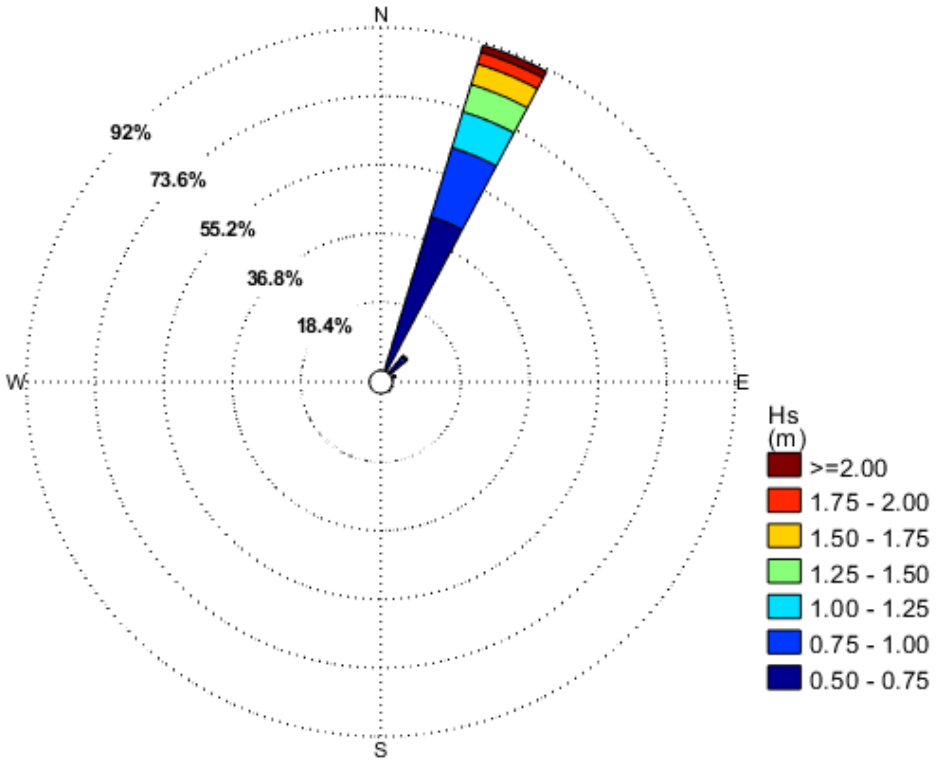

Figure 6.12 Annual wave rose plot for the significant wave height at P3 for "surfable" events (i.e. $H_s \geq 0.5$ m and $T_p \geq 6$ s).

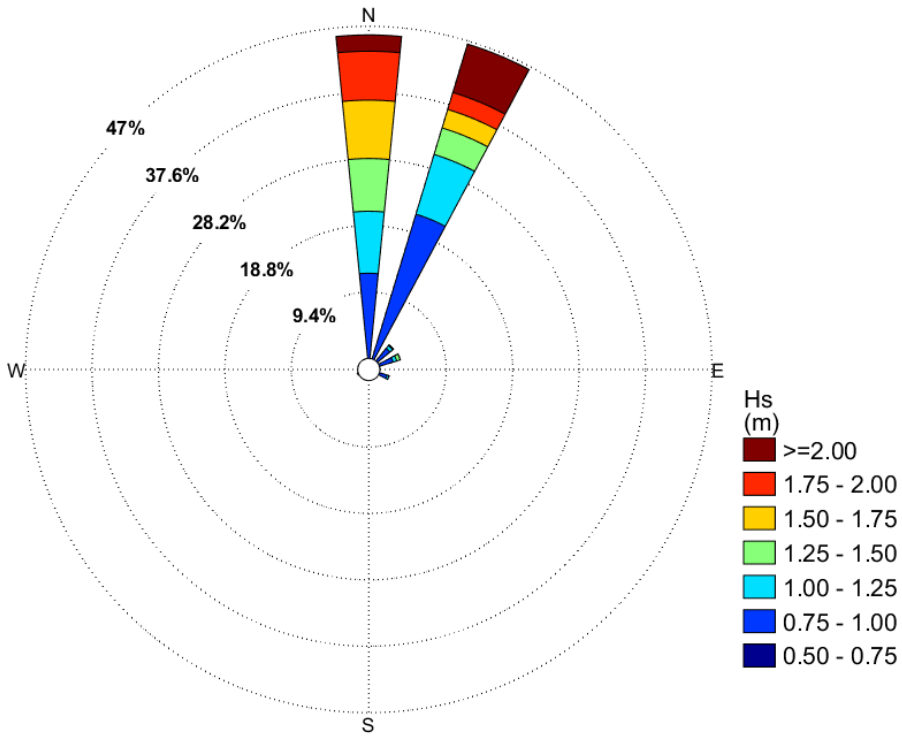

Figure 6.13 Annual wave rose plot for the significant wave height at P4 for "surfable" events (i.e. $H_s \geq 0.5$ m and $T_p \geq 6$ s).

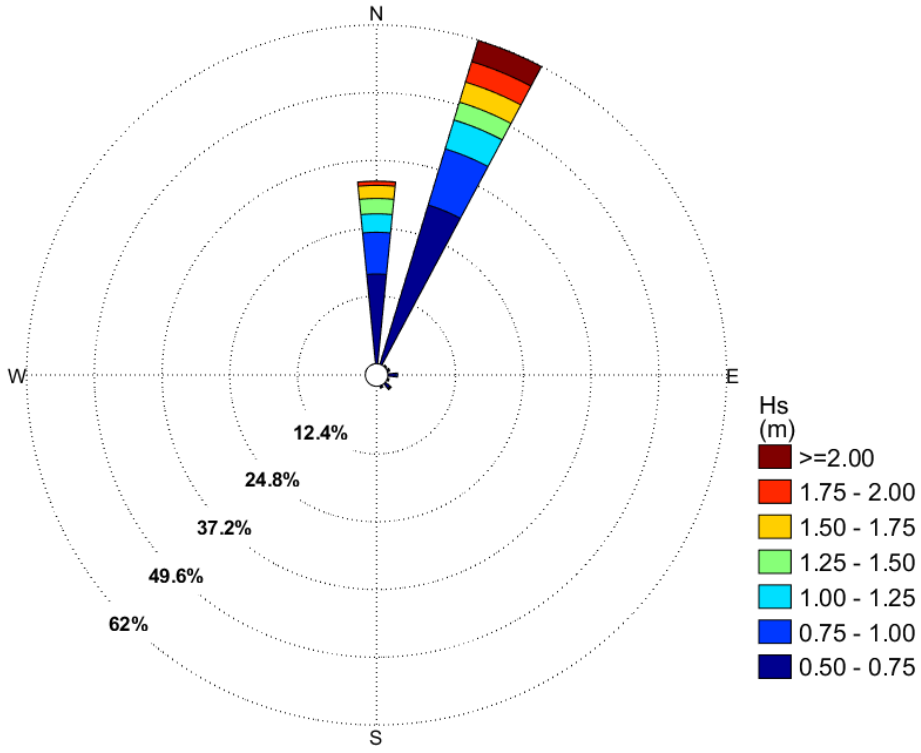

Figure 6.14 Annual wave rose plot for the significant wave height at P5 for "surfable" events (i.e. $H_s \geq 0.5$ m and $T_p \geq 6$ s).

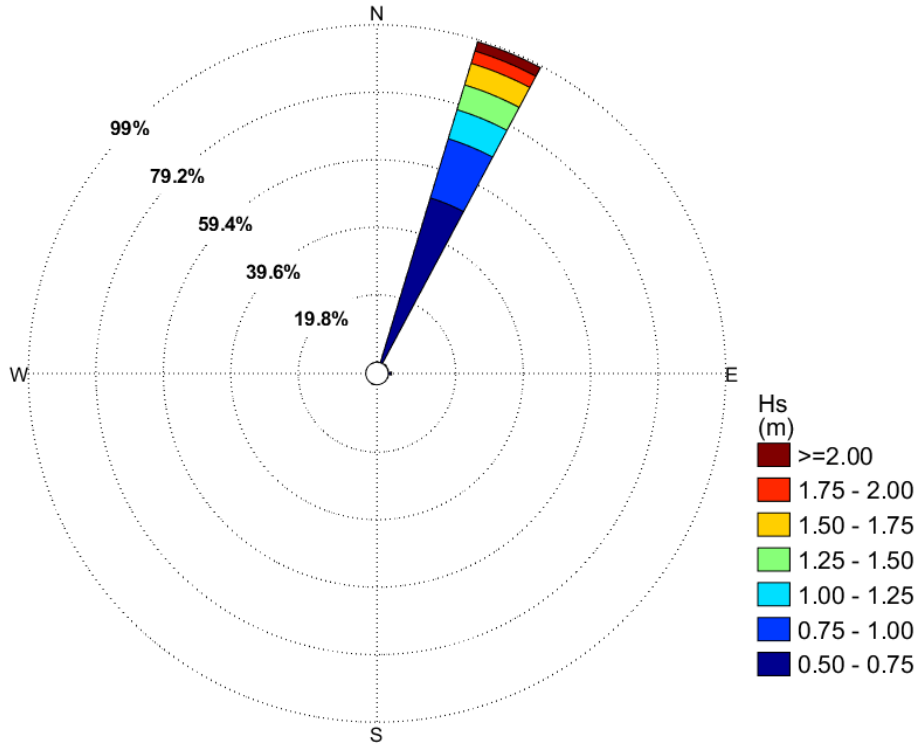

Figure 6.15 Annual wave rose plot for the significant wave height at P6 for "surfable" events (i.e. $H_s \geq 0.5$ m and $T_p \geq 6$ s).

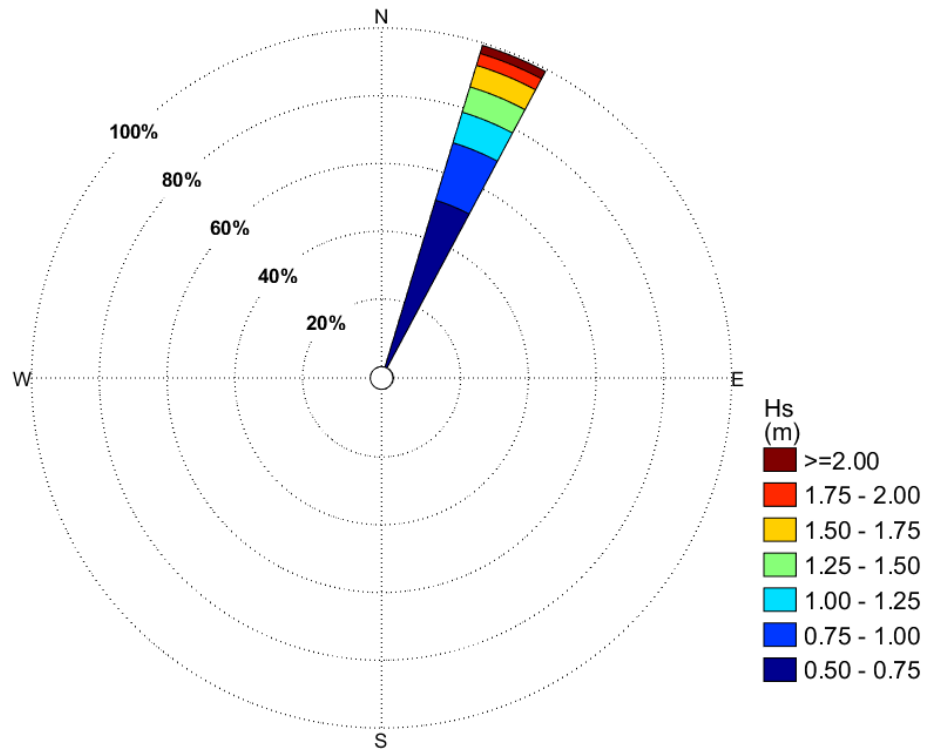

Figure 6.16 Annual wave rose plot for the significant wave height at P7 for "surfable" events (i.e. $H_s \geq 0.5$ m and $T_p \geq 6$ s).

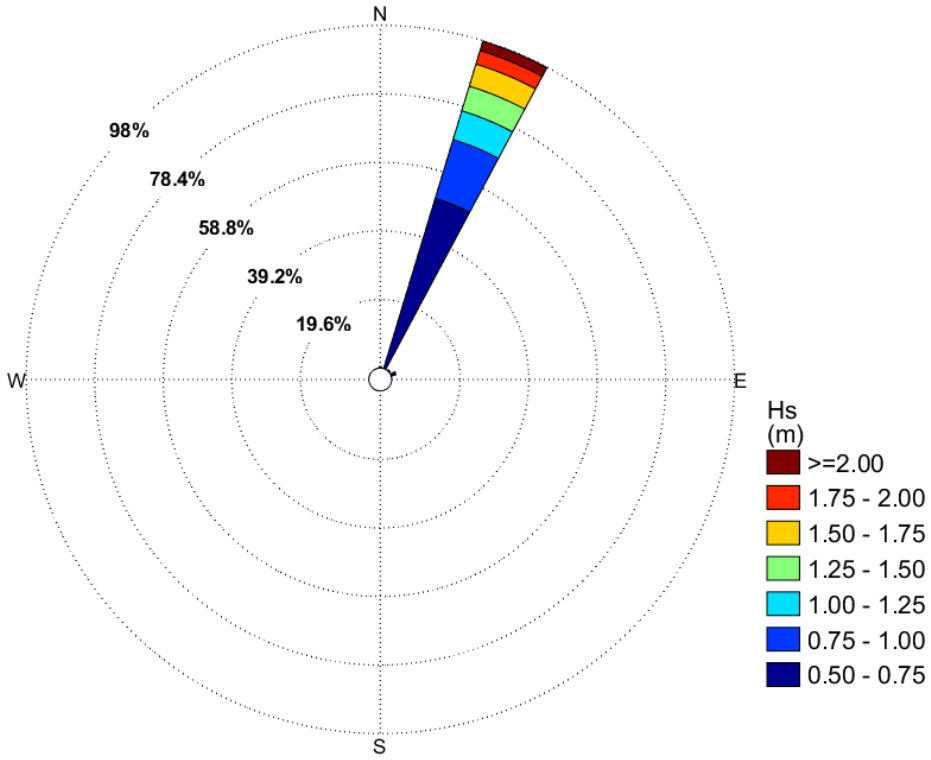

Figure 6.17 Annual wave rose plot for the significant wave height at P8 for "surfable" events (i.e. $H_s \geq 0.5$ m and $T_p \geq 6$ s).

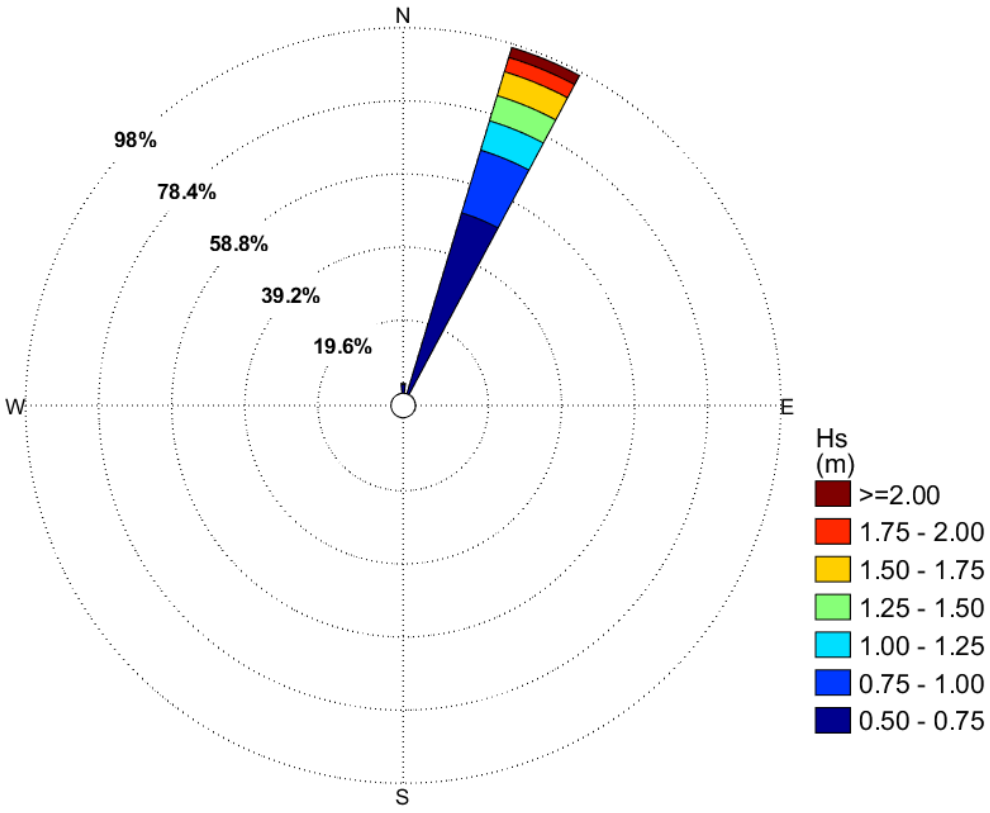

Figure 6.18 Annual wave rose plot for the significant wave height at P9 for "surfable" events (i.e. $H_s \geq 0.5$ m and $T_p \geq 6$ s).

6.2 Wave fields for typical surfing events

Five events with large H_s and $T_p > 6$ s were selected to illustrate typical wave field and refraction patterns in the area of interest. Time series of H_s and T_p at sites P1-P9 during these events are shown in Figure 6.19 and Figure 6.20, respectively. Note that "surfable" events exhibit a wide range of T_p values (i.e. 6 – 18 s).

Wave height and direction distributions are presented for the 5 events in Figure 6.21 to Figure 6.25, showing that surf breaks corresponding to P3, P4 and P5 are unlikely to be affected by the proposed mussel farms (FARM3) during typical surfing days with incoming N/NNE waves, while Sites P1 and P2 may be affected. The consented FARM1 is expected to have very minor effects on wave attenuation at all sites, while the consented FARM2 may have larger impacts[4]. The area travelled by typical N/NNE waves over the proposed farm and consented farms is in the same order of magnitude as the farm described in Plew et al. (2005). Therefore up to 10% wave dissipation may occur during "surfable"

[4] See MetOcean Solutions 2018 report No. P0389-01 entitled "POTENTIAL EFFECTS OF MUSSEL FARMS ON SURF BREAKS. Hindcast wave statistics at several surf breaks in the Firth of Thames". Prepared for Westpac Mussels.

events for peak periods between 6 - 10 s at sites P6-P9. Note this assumption is conservative as the proposed farm is situated relatively far from the 9 surfing breaks while Plew et al. (2005)'s results are more relevant for describing the sea-state to the immediate south of the farm.

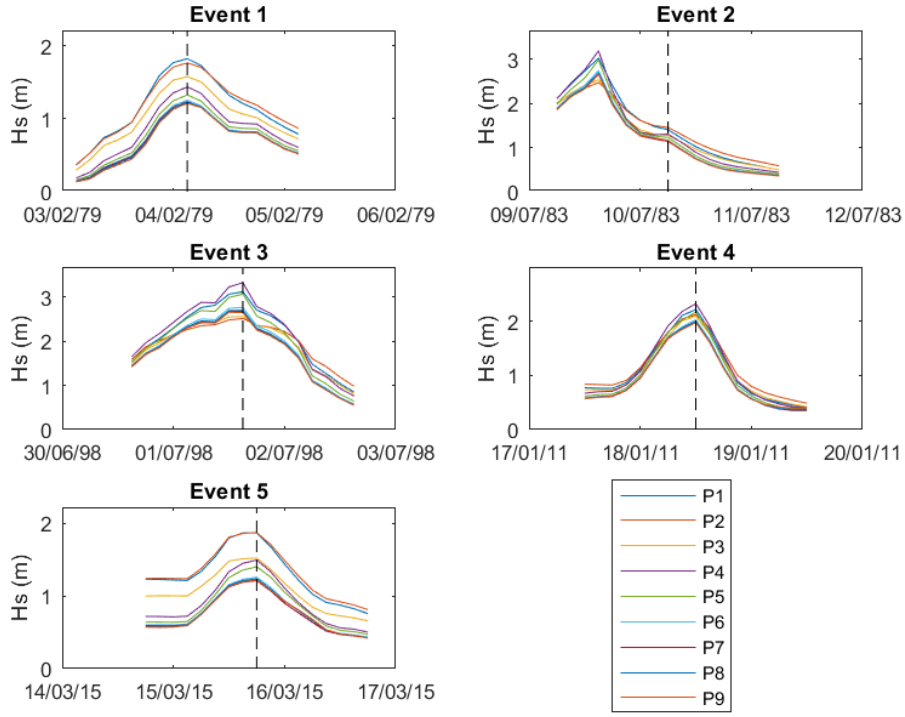

Figure 6.19 Significant wave height time series for the 5 selected events at sites P6-P9. The dashed vertical lines indicate the time (UTC) corresponding to the wave fields provided in Figure 6.21 to Figure 6.25.

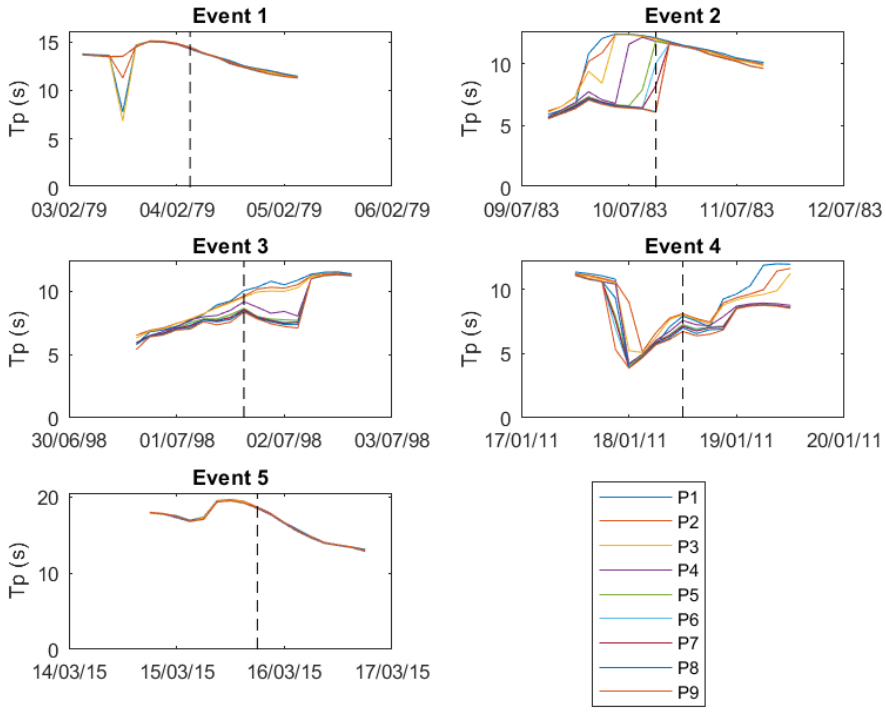

Figure 6.20 Peak wave period time series for the 5 selected events at sites P1-P9. The dashed vertical lines indicate the time (UTC) corresponding to the wave fields provided in Figure 6.21 to Figure 6.25.

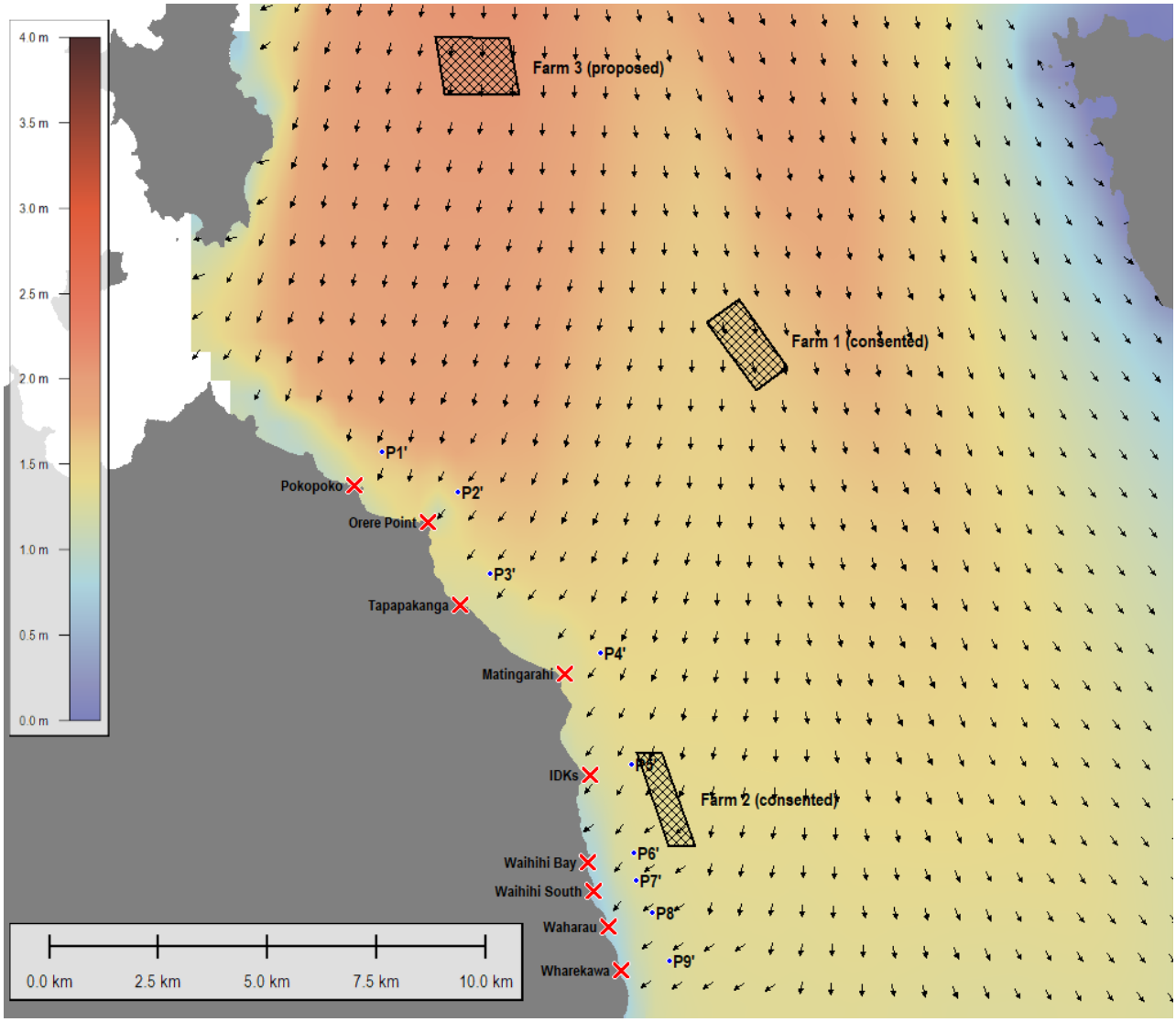

Figure 6.21 Significant wave height and wave direction distribution in the Firth of Thames during Event 1 (04/02/1979 3:00 UTC).

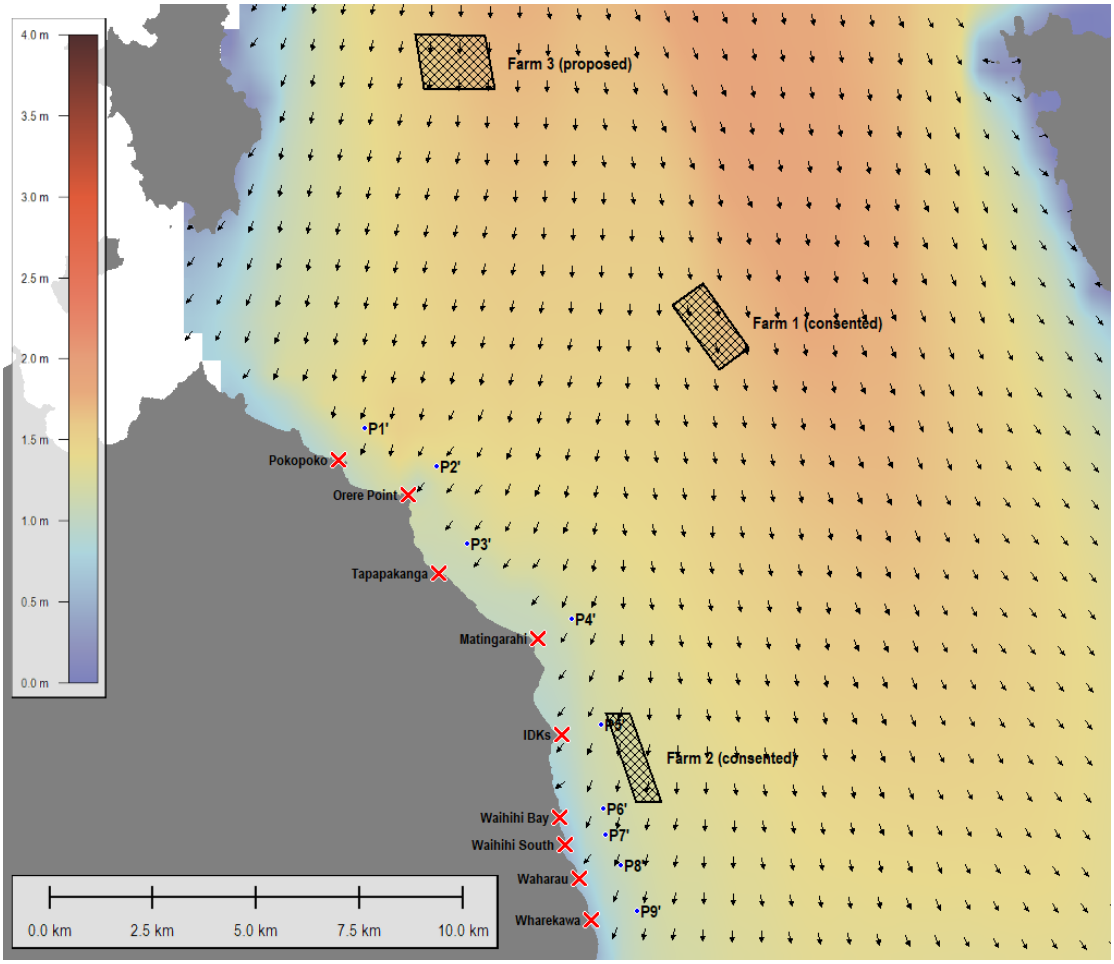

Figure 6.22 Significant wave height and wave direction distribution in the Firth of Thames during Event 2 (10/07/1983 6:00 UTC).

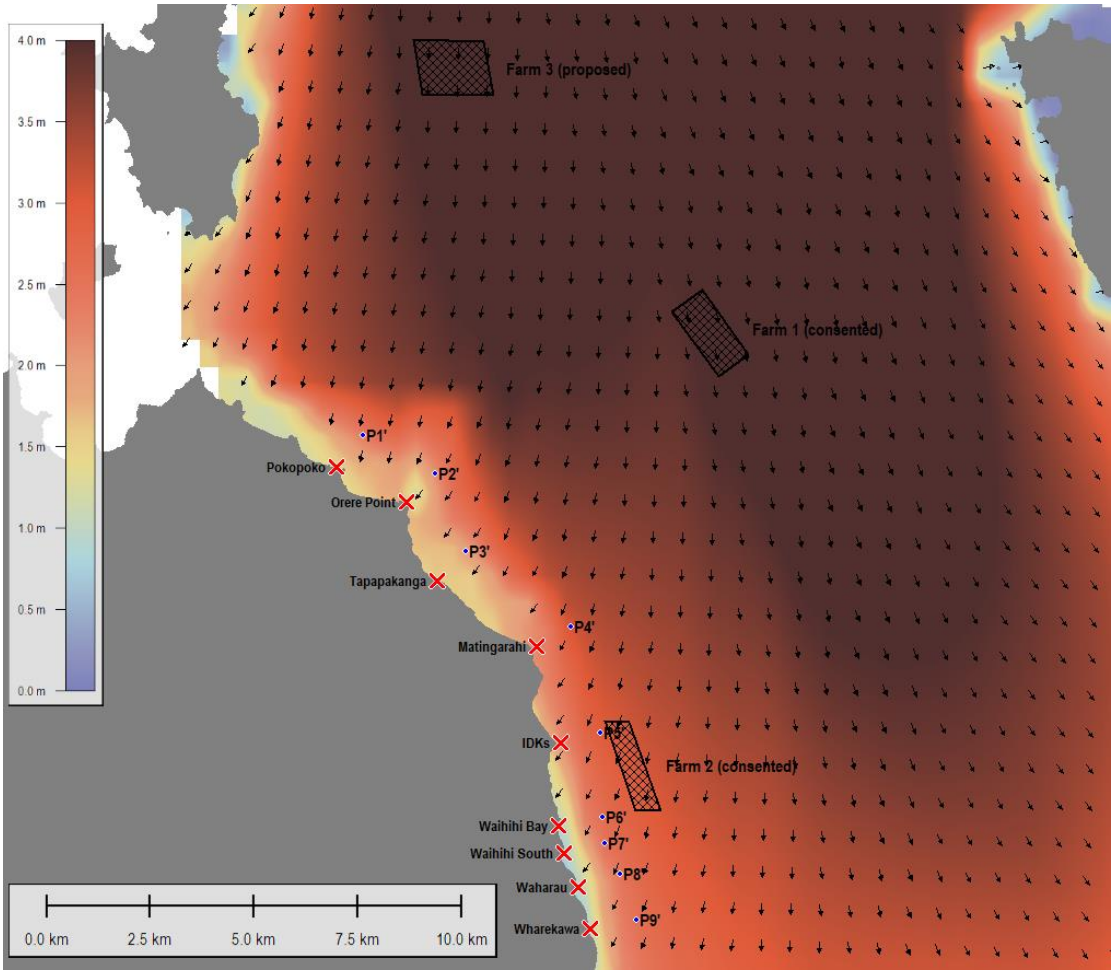

Figure 6.23 Significant wave height and wave direction distribution in the Firth of Thames during Event 3 (01/07/1998 15:00 UTC).

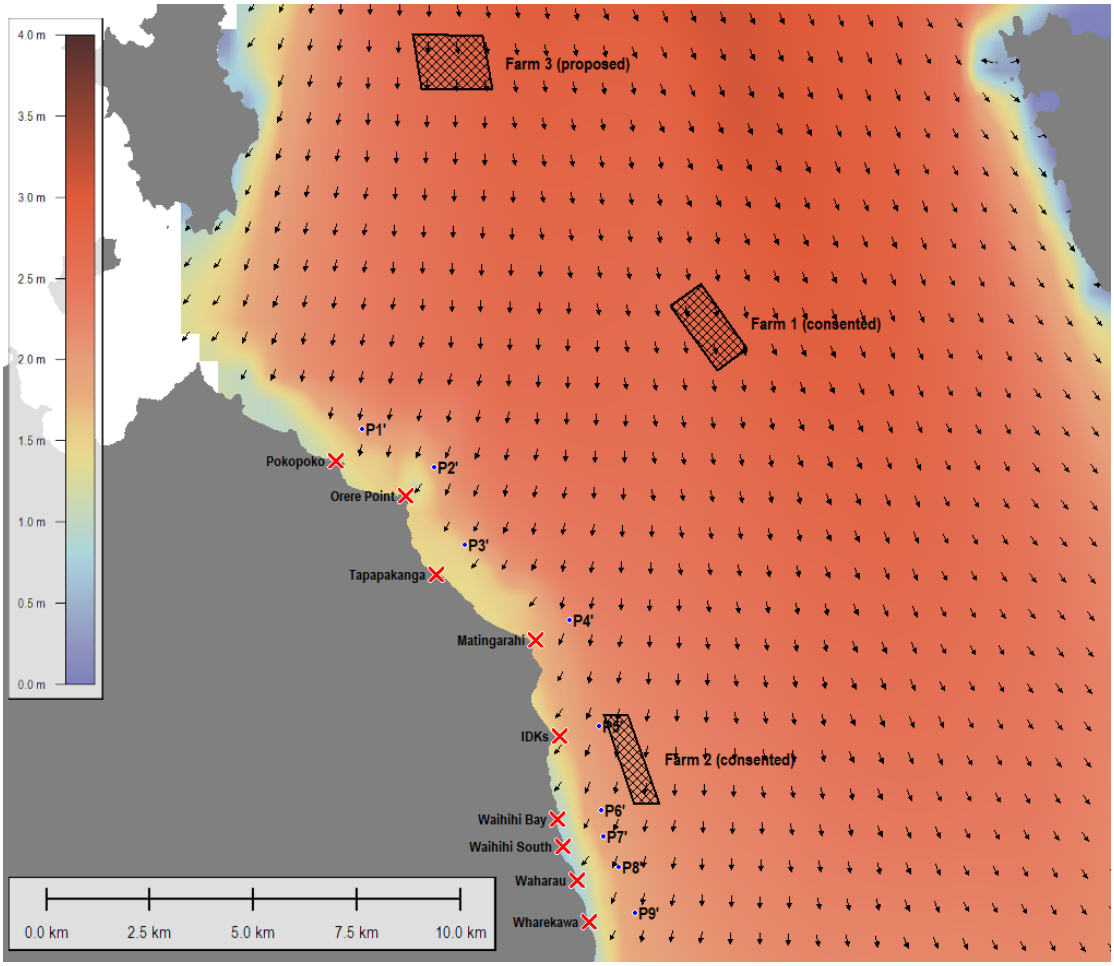

Figure 6.24 Significant wave height and wave direction distribution in the Firth of Thames during Event 4 (18/01/2011 12:00 UTC).

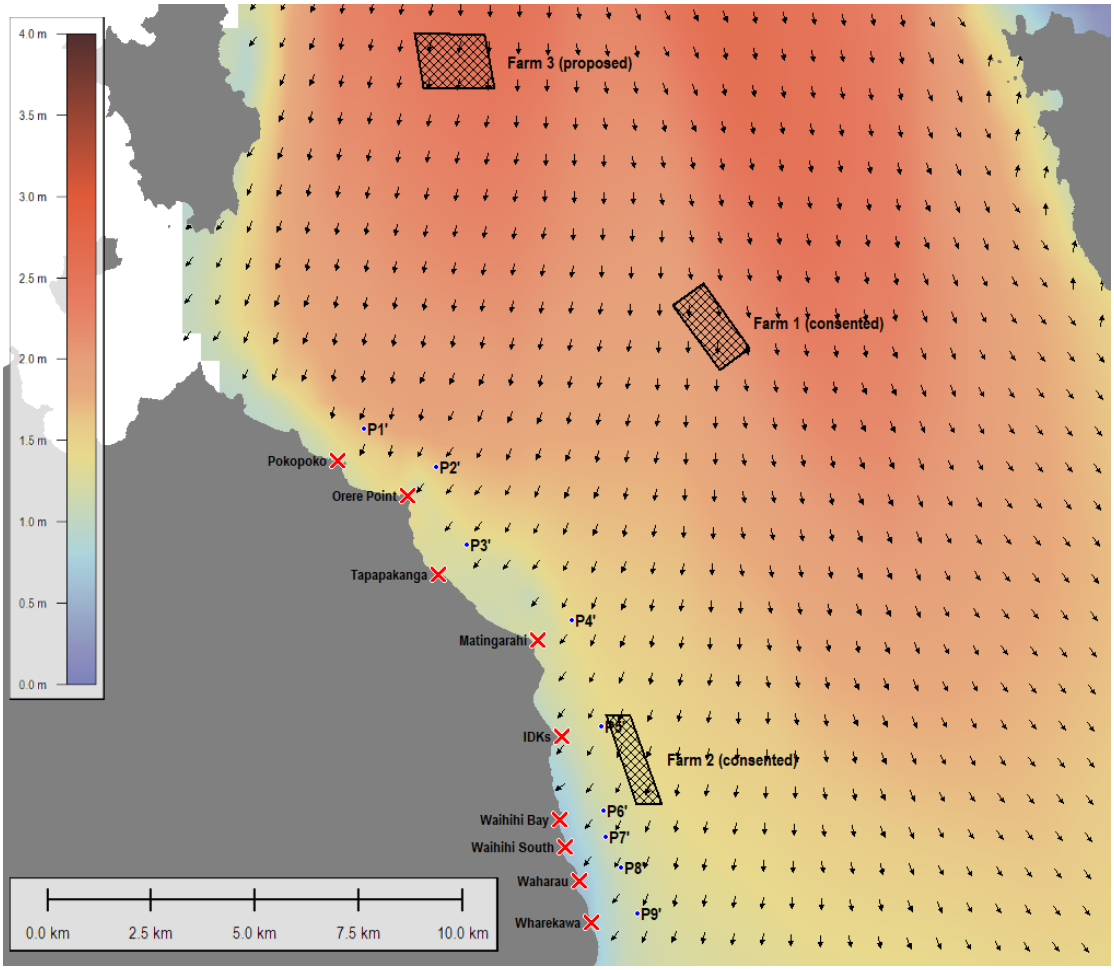

Figure 6.25 Significant wave height and wave direction distribution in the Firth of Thames during Event 5 (15/03/2015 18:00 UTC).

7. Conclusions

The "Surfability" of 9 surf breaks on the western shoreline of the Firth of Thames has been examined (P1-P9), while the proposed new aquaculture area is expected to be in the swell corridor for only sites P1-P2. Long term hindcast wind and wave data (1979-2015) have been used to characterise the metocean conditions at the surf breaks.

None of the surfbreaks identified are listed as either nationally significant as set out in the New Zealand Coastal Policy Statement, 2010[5], or regionally significant as defined by Atkin et al. (2015) and Atkin and Mead (2016). Further, none are listed in either the online New Zealand Surfing Guide (http://www.nzsurfguide.co.nz/) or the Wavetrack New Zealand Surfing Guide Book (Morse and Brunskill, 2004), nor are the surfbreaks identified in either of the two primary New Zealand surf forecast sites (Swellmap.com or Marineweather.co.nz).

Winds predominantly come from the SW quadrant (i.e. good wind direction for surf breaks P1-P9). However, strong onshore N and NE sector winds often occur due to the passage of frontal systems or ex-tropical storms/cyclones; which tend to be conducive to generating conditions suitable for surfing.

Conservative "Surfable" conditions (inclusive of poor conditions) are arbitrary defined as $H_s \geq 0.5$ m and $T_p \geq 6$ s at the offshore sites P1-P9, occurring annually between 11.5% and 3.8% of the time. These H_s and T_p thresholds are considered conservative, while applying less conservative thresholds as used by Mead et al. (2004) and Black et al. (2004) (i.e. $H_s >$ 0.75, and $T_p > 6$ s) suggest surfable conditions occur approximately 5.8% of the time at site P2 and only 1.8% of the time at site P9 (Table 6.37).

Average to good surfable conditions (i.e. $H_s \geq 0.75$ m and $T_p \geq 8$ s) are expected to occur on average 9-10 days per year at P2, decreasing to ~1 day every 2-3 years at sites P6-P9 (

[5] http://www.doc.govt.nz/Documents/conservation/marine-and-coastal/coastal-management/nz-coastal-policy-statement-2010.pdf

Table 6.37).

Plew et al. (2005) found that the wave dissipation due to mussel farms is frequency dependent, from which a conservative interpretation of the results was applied in this study: 10% decrease in wave amplitudes for incident wave conditions with peak periods of 7 seconds or less and a 5% decrease in wave amplitudes for incident waves with peak periods of 7-10 s. Higher period incident waves were not significantly affected by the presence of the mussel farms.

While it is recognised that there is uncertainty as to the applicability of the findings of Plew et al. (2005) to wave conditions outside those measured in his assessment; applying the frequency dependency to the hindcast and assessing the effect on surfability provide some context as to the potential of the marine farm to effect the inshore surfability.

Importantly, it is noted that these frequencies are representative of the component of the complete sea state that is locally wind generated. Given that the proposed farm is approximately 10 km from the nearest surf site (P1), removal of these frequencies completely from the analysis is considered highly conservative as in reality these frequency components will be generated/added to between the farm location and the surf breaks, particularly for events with onshore directed winds from the N-NE.

The effect of the conservative frequency dependent wave height attenuation is to reduce the number of surfable days by between 0.7% to 0.0% (depending on the surfability threshold considered, see Table 6.37 and Table 6.47). Note surf breaks corresponding to P3, P4 and P5 are unlikely to be affected by the proposed mussel farms (FARM3) during typical surfing days with incoming N/NNE waves, while Sites P1 and P2 are more likely to be affected, with a reduction in the number of surfable days predicted of the order ~0.75-0.4 days respectively (under worst case, conservative assumptions); that is the effect is expected to be minor to less than minor. Similarly, the combined effect of the proposed mussel farm (FARM3) and the existing consented farms (as illustrated in Figure 1.2) are expected to be less than minor for the surf breaks within the inner Firth (i.e. sites P3-P9).

Note wind data were not included in the estimation of “surfable” conditions. However strong wind events from the N, E or S octants may deteriorate the surf quality, therefore further decreasing the percentage “surfable” conditions.

Field measurements and additional numerical modelling would be required to better quantify the wave energy attenuation due to the proposed mussel farms and possible resonance at particular frequencies and amplitudes.

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