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Task 4: Environmental Impact Monitoring at WETS

WETS Acoustic Doppler Current Profiler (ADCP) Data Report

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Kaneohe Wave Energy Test Site Acoustic Doppler Current Profiler Data Report

**Kaneohe Bay Marine Corps Base
Oahu, Hawaii**

June, 2012

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1. INTRODUCTION

The OPT Acoustic Doppler Current Profiler (ADCP) collected data off of Kaneohe Marine Corps Base in 31 meter water depth at Lat 21° 27' 56.33"N, Lon 157° 45' 2.34"W. The location of the ADCP is shown in Figure 1 below. The ADCP measurements start June 20th, 2010 and end May 26th, 2011. Waves and currents were measured using a Teledyne RD Instruments acoustic Doppler current profilers ADCP's equipped with wave measurement capabilities. The ADCP's radiate four acoustic beam patterns and measure the resulting back-scatter from small particles in the water. The discrete frequencies of the acoustic signals are shifted higher or lower in accordance with the Doppler effect when the reflecting particles have a velocity relative to the ADCP beam. Water motion due to currents and waves is calculated by the relative values measured by the four acoustic beams. The entire water column is measured in discrete 0.75m intervals. There were numerous measurement gaps during the deployment period, resulting in a total of approximately 5 months of recorded data. Currents were measured from a depth of 2.1m to 27.6m. This depth range allowed accurate measurement without side lobe contamination that can result from using a 20 degree beam angle. OPT stated that when changing the battery on the ADCP, the internal compass was not always recalibrated. According to RDI the difference in voltage in batteries results in a 10-15% error in direction if the ADCP was not recalibrated, however this error would not be compounded for consecutive battery changes. Any error in direction did not affect current magnitudes, wave heights or wave periods.

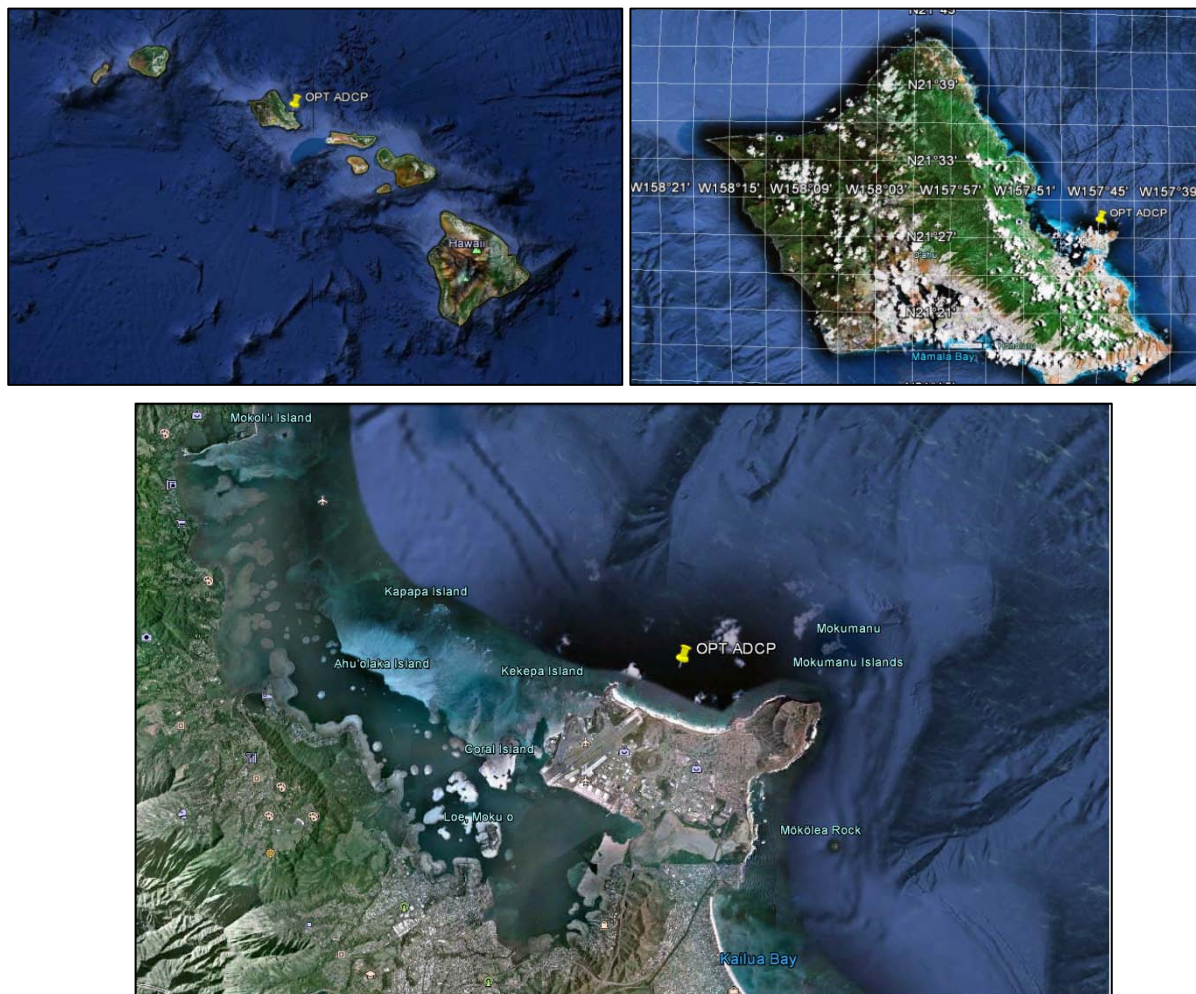


Figure 1 Location of the OPT ADCP.

2. CURRENT DATA

The current and wave data is provided in an excel csv file containing the wave and current data collected every twenty minutes from the ADCP. The data consists of time in a serial date number format, year, month, day, hour, minute, and second, Significant wave height (H_s), peak period (T_p), mean period (T_{mean}), peak direction (D_p), mean direction (D_{mean}), current speed, current direction, northing current velocity, and easting current velocity as labeled by column headers. Above each column of current data is the corresponding depth from which the measurement was taken.

Figure 2 below shows three different current speed and direction profiles recorded on June 22 and 23, 2012. The profiles show the variability of current speed and directions at different times and depths in the water column. The convention for current direction is the direction to which the current is travelling.

To better describe the characteristics of the current, three sections of the water column were selected: a surface current shown by the blue band in Figure 2 (-2.1300m to -3.6300m), a mid water column current shown by the black band in Figure 2 (-8.1300m to -16.3800m), and a bottom current shown by the red band in Figure 2 (-23.8800 to -26.8800). Each section consists of multiple bins that were average together to eliminate noise. The three sections were chosen to capture distinct flow components that exist at different depths.

Figures 3-5 present scatter plots of current speed, direction and velocity components during the measurement period for surface, mid and bottom depths.

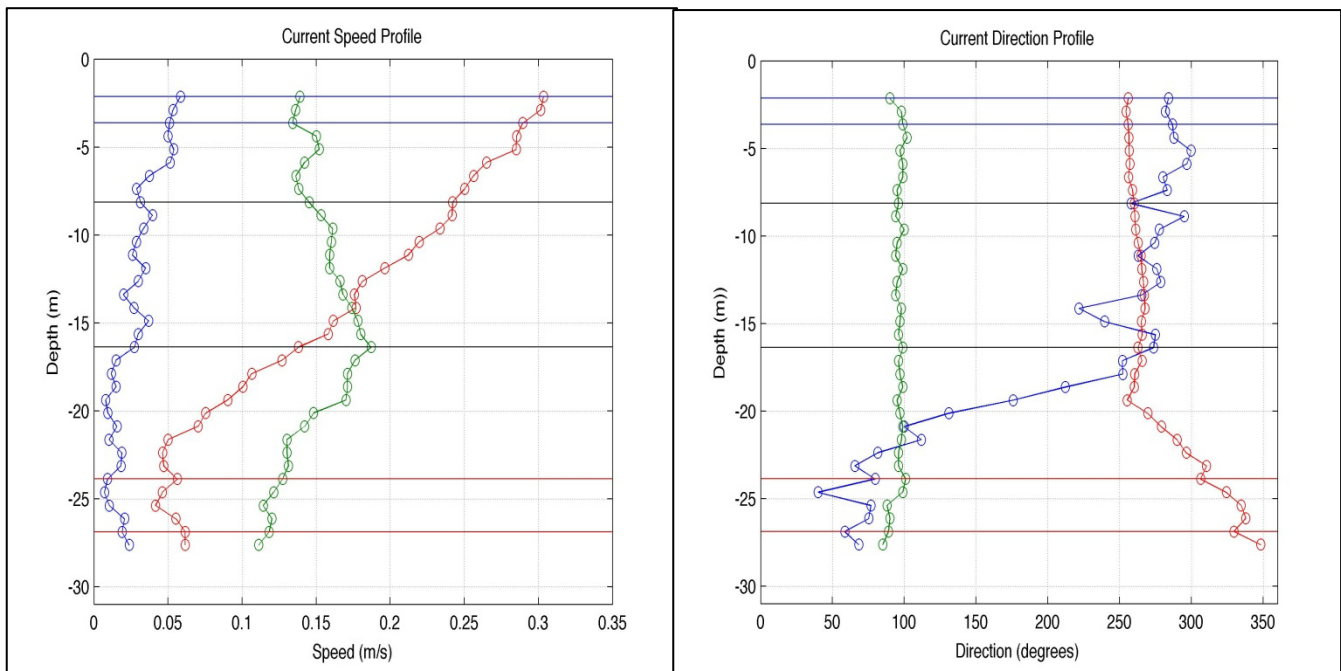


Figure 2 Current Speed and Direction Profiles. Circles mark the recorded values.

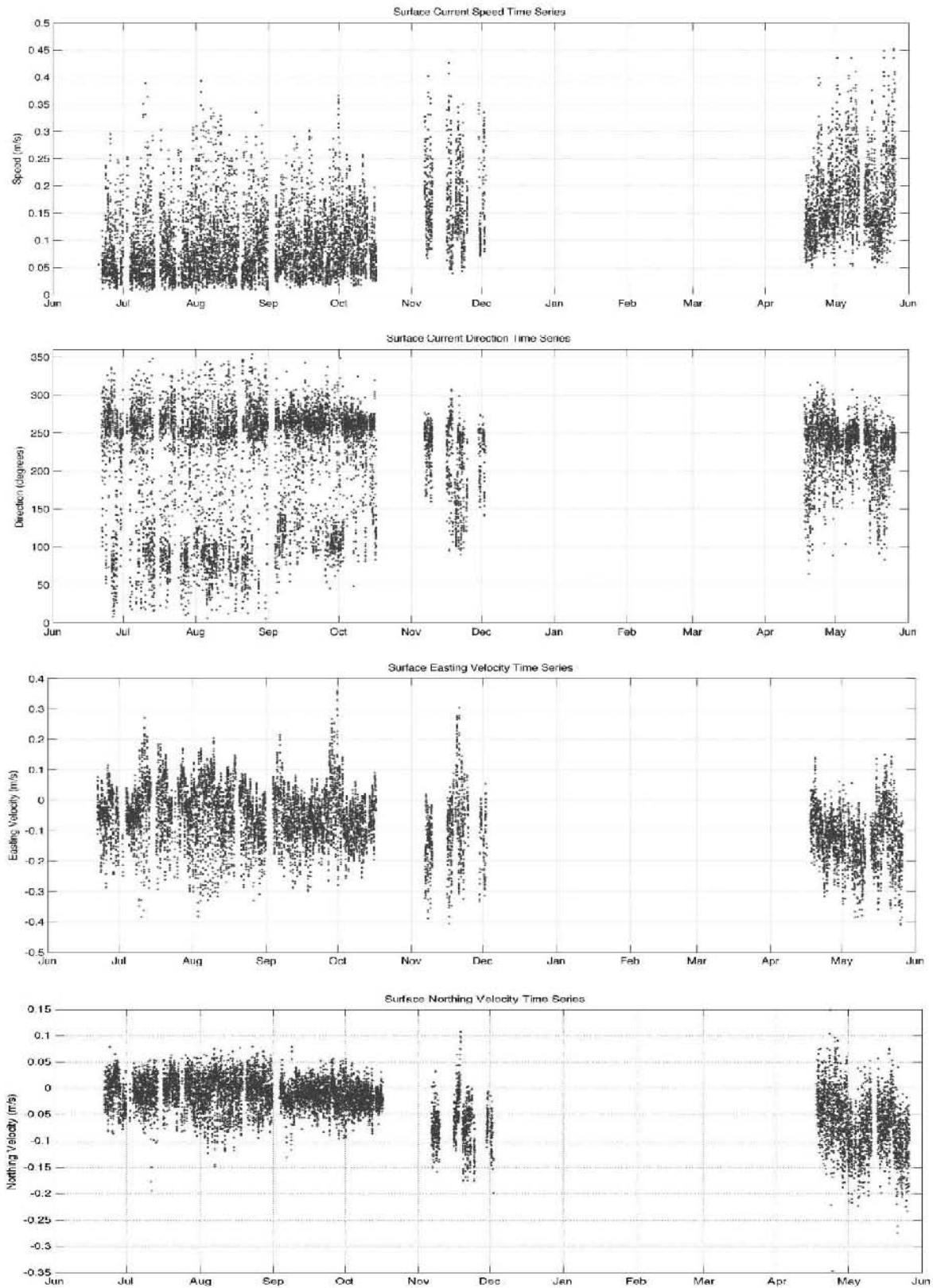


Figure 3 Current speed, current direction, northing component, and easting component for the surface current.

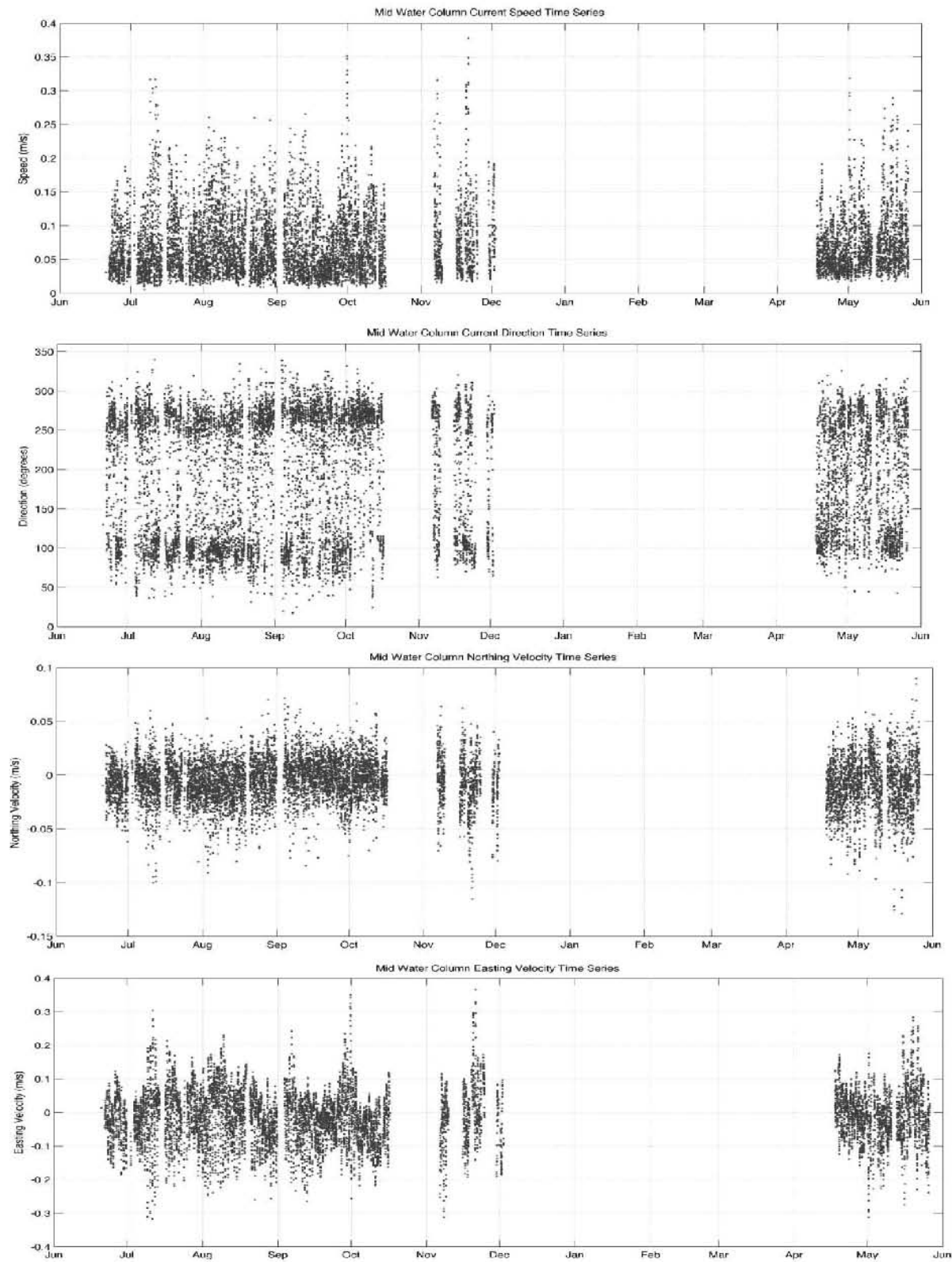


Figure 4 Current speed, current direction, northing component, and easting component for the surface current.

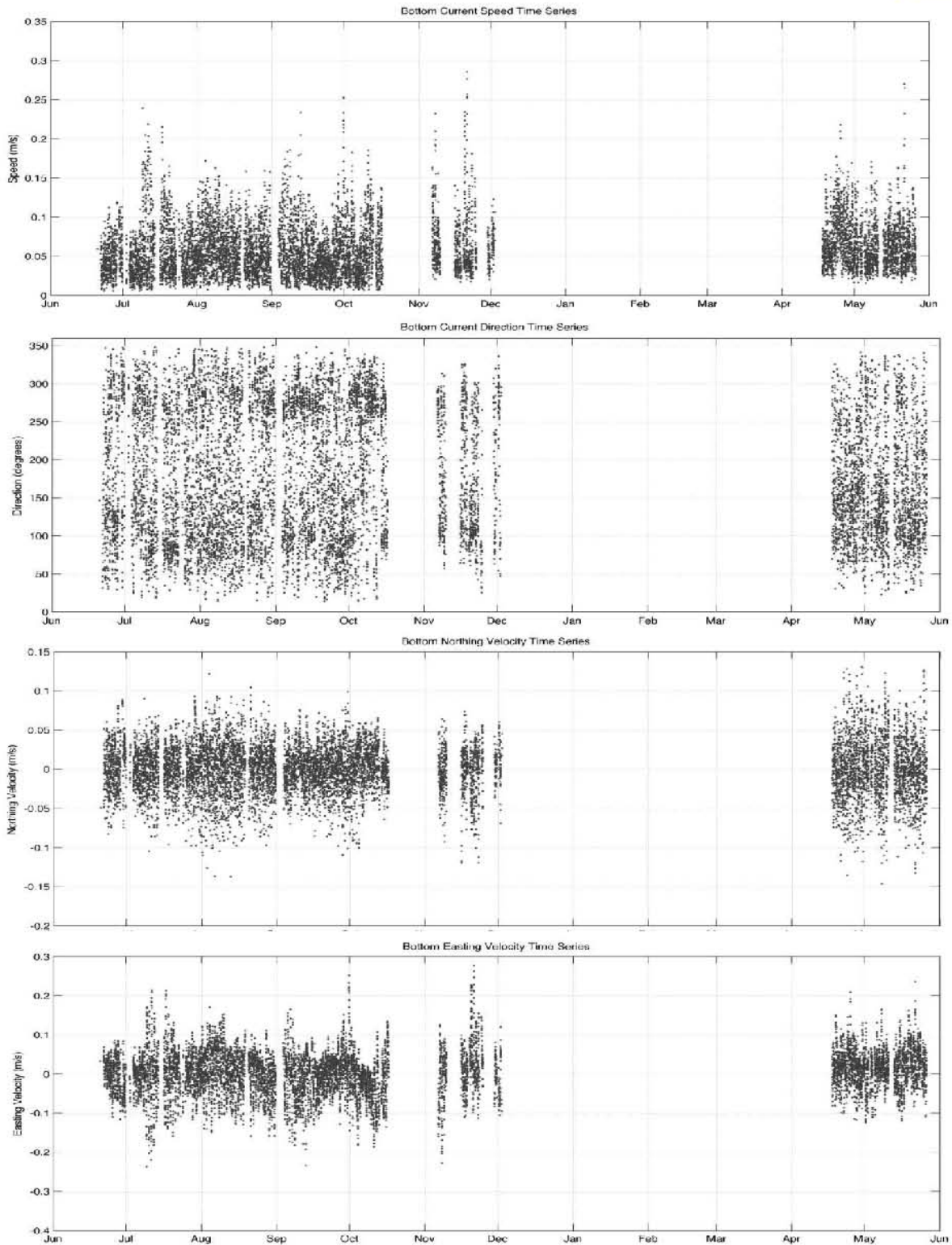


Figure 5 Current speed, current direction, northing component, and easting component for the surface current.

Figure 6, 7, and 8 below show the current roses and histograms calculated from each corresponding time series. Tables 1, 2 and 3 contain the percent occurrence binned by direction and current speed illustrated by the corresponding rose and current statistics binned by direction.

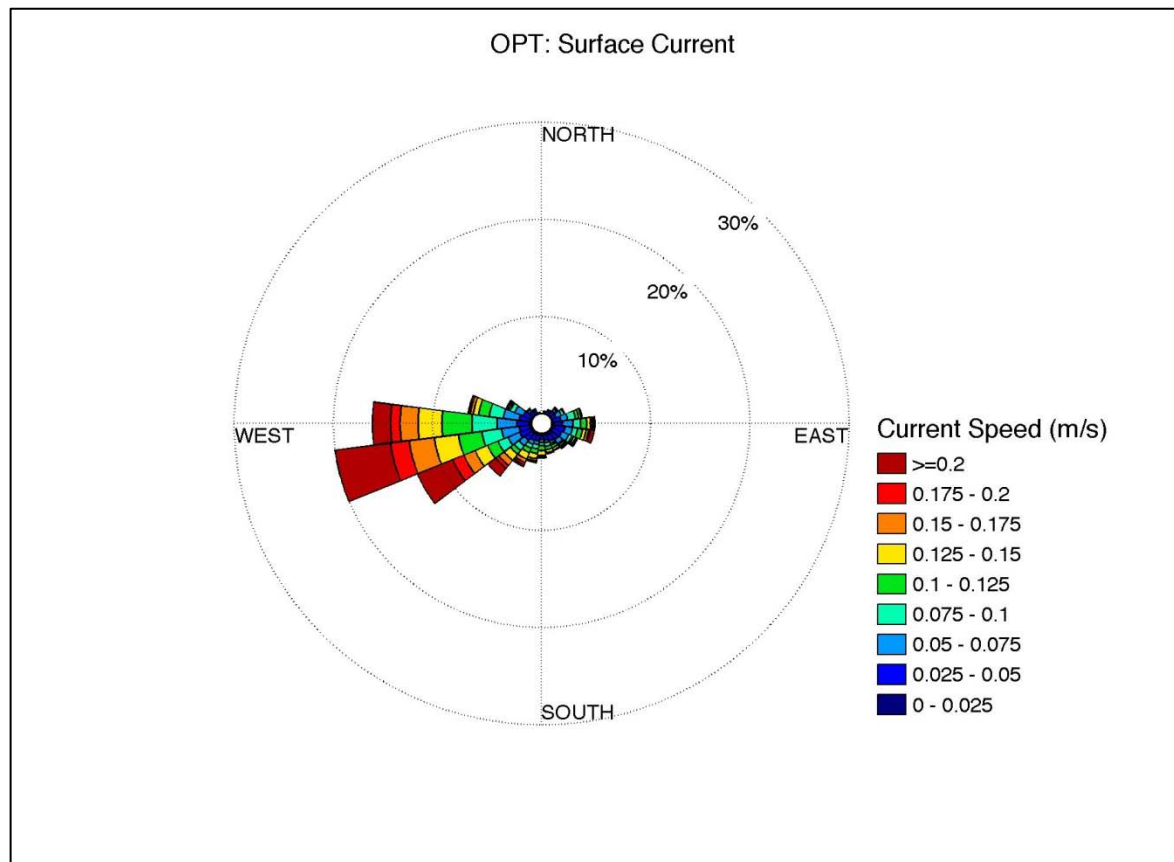


Figure 6 Surface current rose.

Table 1 Surface current direction (degrees from north)

Current Speed (m/s)	0	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	Total %
0.000-0.025	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.2	0.1	0.1	0.1	0.0	4.0
0.025-0.050	0.0	0.2	0.4	0.6	0.5	0.8	0.9	1.0	1.0	0.8	0.7	0.4	0.5	0.6	0.7	0.9	1.1	1.1	1.2	1.1	0.9	0.5	0.4	0.1	16.5
0.050-0.075	0.0	0.1	0.1	0.3	0.6	0.7	1.0	0.8	0.8	0.5	0.3	0.3	0.3	0.4	0.4	0.7	1.3	1.8	2.0	1.6	0.9	0.3	0.2	0.1	15.3
0.075-0.100	0.0	0.0	0.0	0.1	0.3	0.8	0.8	0.5	0.3	0.1	0.2	0.4	0.3	0.5	0.4	0.6	1.1	2.0	2.5	1.4	0.5	0.0	0.0	0.0	13.1
0.100-0.125	0.0	0.0	0.0	0.0	0.1	0.3	0.6	0.5	0.2	0.2	0.3	0.3	0.5	0.5	0.5	0.5	1.1	2.4	3.0	1.1	0.2	0.0	0.0	0.0	12.3
0.125-0.150	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.4	0.2	0.2	0.2	0.3	0.5	0.5	0.7	0.8	1.4	2.5	2.4	0.5	0.2	0.0	0.0	0.0	11.4
0.150-0.175	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.2	0.2	0.4	0.7	1.2	2.6	1.8	0.3	0.1	0.0	0.0	0.0	8.4
0.175-0.200	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.3	0.4	1.2	1.9	1.0	0.2	0.1	0.0	0.0	0.0	5.5
0.200-0.225	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.5	1.0	1.7	0.8	0.1	0.0	0.0	0.0	0.0	4.4
0.225-0.250	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.8	1.1	0.5	0.0	0.0	0.0	0.0	0.0	2.8
0.250-0.300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.2	1.7	0.4	0.0	0.0	0.0	0.0	0.0	3.7
0.300-0.400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.8	1.0	0.2	0.0	0.0	0.0	0.0	0.0	2.3
0.400-0.500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
0.500-1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total %	0.0	0.3	0.6	1.1	1.5	3.1	4.4	4.3	2.9	2.3	2.1	2.2	2.6	3.1	3.8	5.8	12.6	20.0	16.1	6.5	2.9	1.0	0.6	0.2	100.0
	0	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	Overall
Mean	0.05	0.05	0.04	0.05	0.06	0.08	0.09	0.10	0.07	0.06	0.07	0.08	0.09	0.09	0.11	0.12	0.16	0.16	0.12	0.09	0.07	0.05	0.04	0.04	0.12
StDev	0.00	0.01	0.01	0.02	0.03	0.04	0.05	0.07	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.07	0.09	0.08	0.06	0.04	0.04	0.03	0.02	0.01	0.07
Min	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
Max	0.06	0.08	0.08	0.10	0.16	0.21	0.36	0.37	0.26	0.18	0.19	0.23	0.23	0.24	0.39	0.45	0.45	0.43	0.37	0.22	0.21	0.23	0.09	0.06	0.45

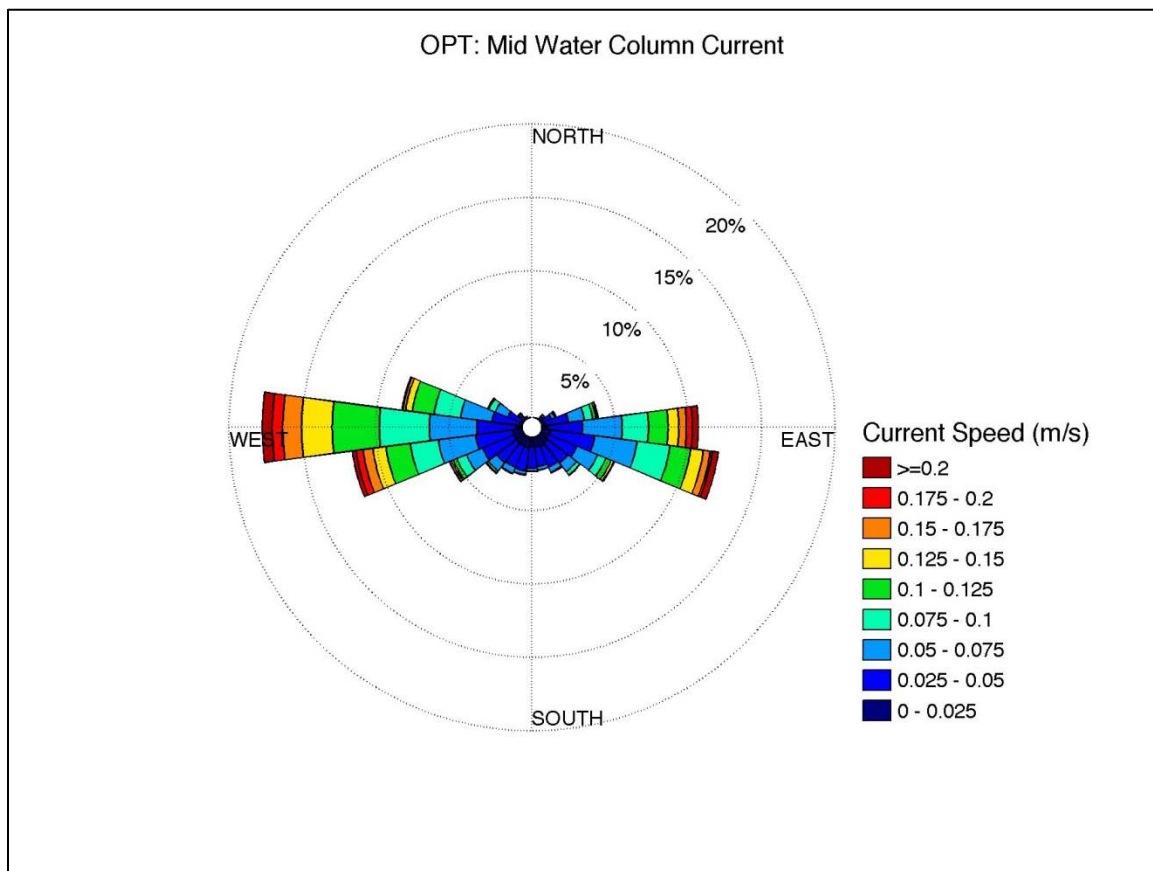


Figure 7 Mid water column current rose.

Table 2 Mid water column current rose (degrees from north)

Current Speed (m/s)	0	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	Total %
0.000-0.025	0.0	0.0	0.0	0.0	0.2	0.2	0.4	0.6	0.6	0.6	0.8	0.7	0.6	0.7	0.7	0.6	0.7	0.7	0.3	0.2	0.1	0.0	0.0	0.0	8.9
0.025-0.050	0.0	0.0	0.0	0.3	0.6	1.6	2.4	3.1	2.1	1.8	1.5	1.3	1.5	1.6	1.6	1.7	2.3	2.6	2.7	1.9	1.0	0.3	0.1	0.0	31.9
0.050-0.075	0.0	0.0	0.0	0.2	0.3	1.1	2.7	2.9	1.5	0.7	0.4	0.3	0.2	0.3	0.4	0.7	1.2	2.6	3.2	2.2	0.9	0.1	0.1	0.0	22.0
0.075-0.100	0.0	0.0	0.0	0.0	0.1	0.6	1.8	2.3	0.6	0.3	0.1	0.0	0.0	0.0	0.0	0.1	0.7	1.9	3.4	1.8	0.5	0.0	0.0	0.0	14.3
0.100-0.125	0.0	0.0	0.0	0.0	0.0	0.2	1.3	1.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	1.7	3.2	1.5	0.1	0.0	0.0	0.0	10.2
0.125-0.150	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	2.1	0.5	0.0	0.0	0.0	0.0	5.5
0.150-0.175	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	1.3	0.2	0.0	0.0	0.0	0.0	3.3
0.175-0.200	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.7	0.1	0.0	0.0	0.0	0.0	1.9
0.200-0.225	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.9
0.225-0.250	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.4
0.250-0.300	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.4
0.300-0.400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
0.400-0.500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.500-1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total %	0.0	0.0	0.1	0.4	1.1	3.9	10.7	12.2	5.4	3.5	2.7	2.3	2.4	2.6	2.8	3.3	5.4	11.7	17.7	8.3	2.6	0.6	0.2	0.0	99.9
	0	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	Overall
Mean	0.00	0.06	0.05	0.05	0.04	0.06	0.09	0.08	0.06	0.04	0.04	0.03	0.03	0.03	0.04	0.04	0.06	0.09	0.10	0.08	0.06	0.05	0.05	0.05	0.07
StdDev	0.00	0.00	0.01	0.01	0.02	0.03	0.05	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.03	0.05	0.05	0.04	0.02	0.02	0.02	0.02	0.05
Min	0.00	0.05	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.01
Max	0.00	0.06	0.07	0.09	0.12	0.20	0.35	0.38	0.22	0.19	0.15	0.08	0.10	0.10	0.12	0.13	0.22	0.32	0.32	0.32	0.15	0.15	0.09	0.06	0.38

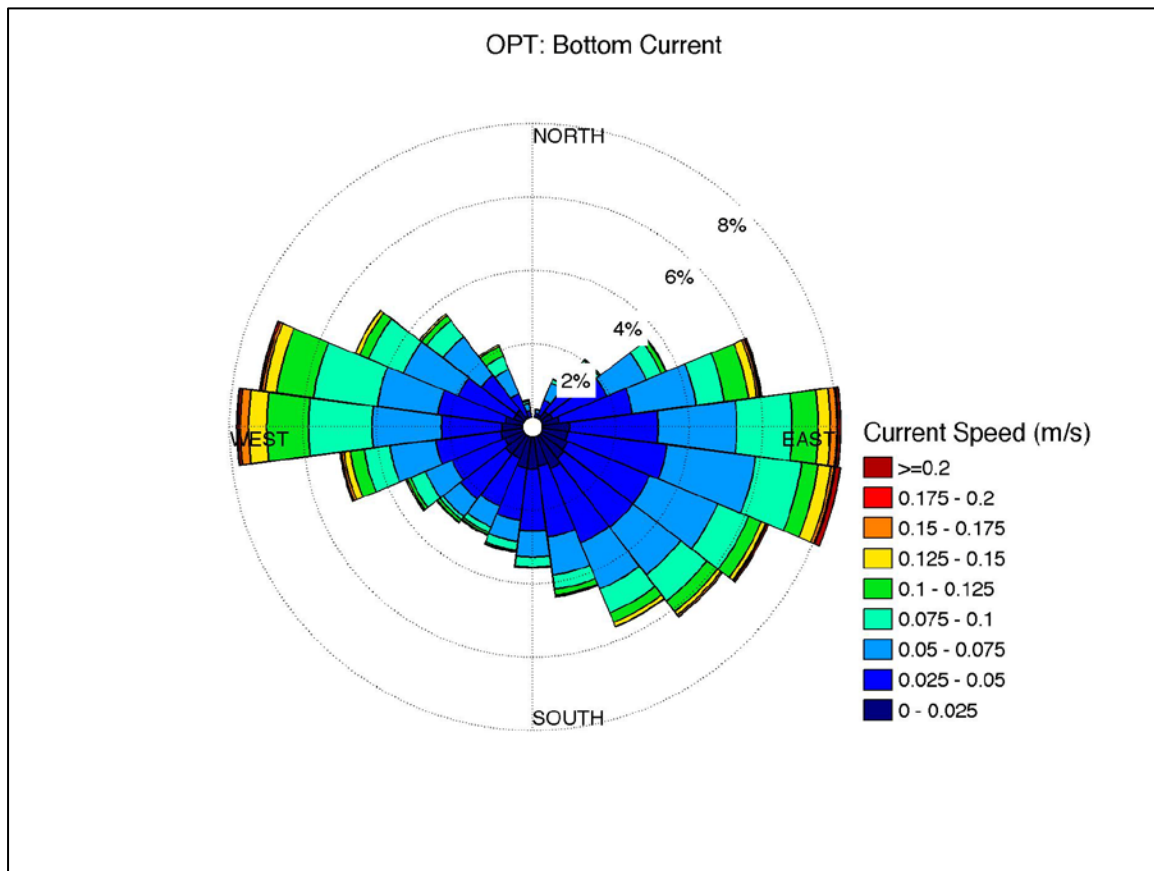


Figure 8 Bottom current rose

Table 3 Bottom current direction (degrees from north)

Current Speed (m/s)	0	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	Total %
0.000-0.025	0.0	0.0	0.1	0.3	0.3	0.5	0.7	0.7	0.8	0.8	1.0	0.8	0.9	0.9	0.6	0.7	0.6	0.6	0.6	0.5	0.3	0.3	0.1	0.0	11.9
0.025-0.050	0.0	0.1	0.4	0.9	1.6	2.0	2.4	2.7	2.4	2.4	2.2	1.9	1.7	1.4	1.4	1.6	1.6	1.8	1.6	1.8	1.6	1.2	0.6	0.2	35.7
0.050-0.075	0.0	0.1	0.5	0.6	1.2	1.8	2.1	2.4	2.0	1.6	1.4	1.0	0.7	0.6	0.6	0.6	0.8	1.3	1.9	1.7	1.6	1.3	0.7	0.2	26.8
0.075-0.100	0.0	0.0	0.1	0.2	0.4	0.8	1.5	1.3	0.9	0.9	0.7	0.4	0.3	0.2	0.2	0.1	0.4	0.7	1.7	1.7	1.0	0.6	0.4	0.1	14.6
0.100-0.125	0.0	0.0	0.0	0.0	0.1	0.7	0.7	0.5	0.4	0.4	0.3	0.2	0.0	0.0	0.1	0.1	0.1	0.4	1.1	1.0	0.3	0.2	0.3	0.0	6.8
0.125-0.150	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.4	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.3	0.1	0.1	0.1	0.0	2.7
0.150-0.175	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.8
0.175-0.200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.3
0.200-0.225	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
0.225-0.250	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
0.250-0.300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
0.300-0.400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.400-0.500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.500-1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total %	0.0	0.2	1.2	2.1	3.7	6.0	8.1	8.2	6.7	6.3	5.6	4.4	3.6	3.2	2.9	3.0	3.5	5.0	7.8	7.3	5.0	3.6	2.2	0.5	100.0
Mean	0.00	0.05	0.05	0.05	0.05	0.06	0.07	0.06	0.06	0.06	0.05	0.05	0.04	0.04	0.04	0.04	0.05	0.06	0.08	0.07	0.06	0.06	0.07	0.06	0.06
StDev	0.00	0.02	0.02	0.02	0.02	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.03
Min	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01
Max	0.00	0.08	0.10	0.11	0.14	0.22	0.25	0.29	0.27	0.20	0.17	0.16	0.14	0.15	0.13	0.14	0.16	0.21	0.24	0.21	0.16	0.15	0.14	0.14	0.29

3. WAVE DATA

Wave data was recorded as significant wave height (Hs), peak period (Tp), and peak direction (Dp). Mean period and mean direction were recorded but not used. Significant wave height is defined as $H_s = 4 \cdot \sqrt{\text{area under the power spectrum}}$. Peak period is defined as the wave period associated with the largest peak in the power spectrum. Peak Direction is defined as the peak direction at the peak period. Wave direction is defined as the direction from which the waves approach. The data was filtered such that wave heights less than 0m and greater than 10m were discarded and wave periods less than 0s were discarded as bad data. Figure 9 below show the time series for Hs, Tp, and Dp.

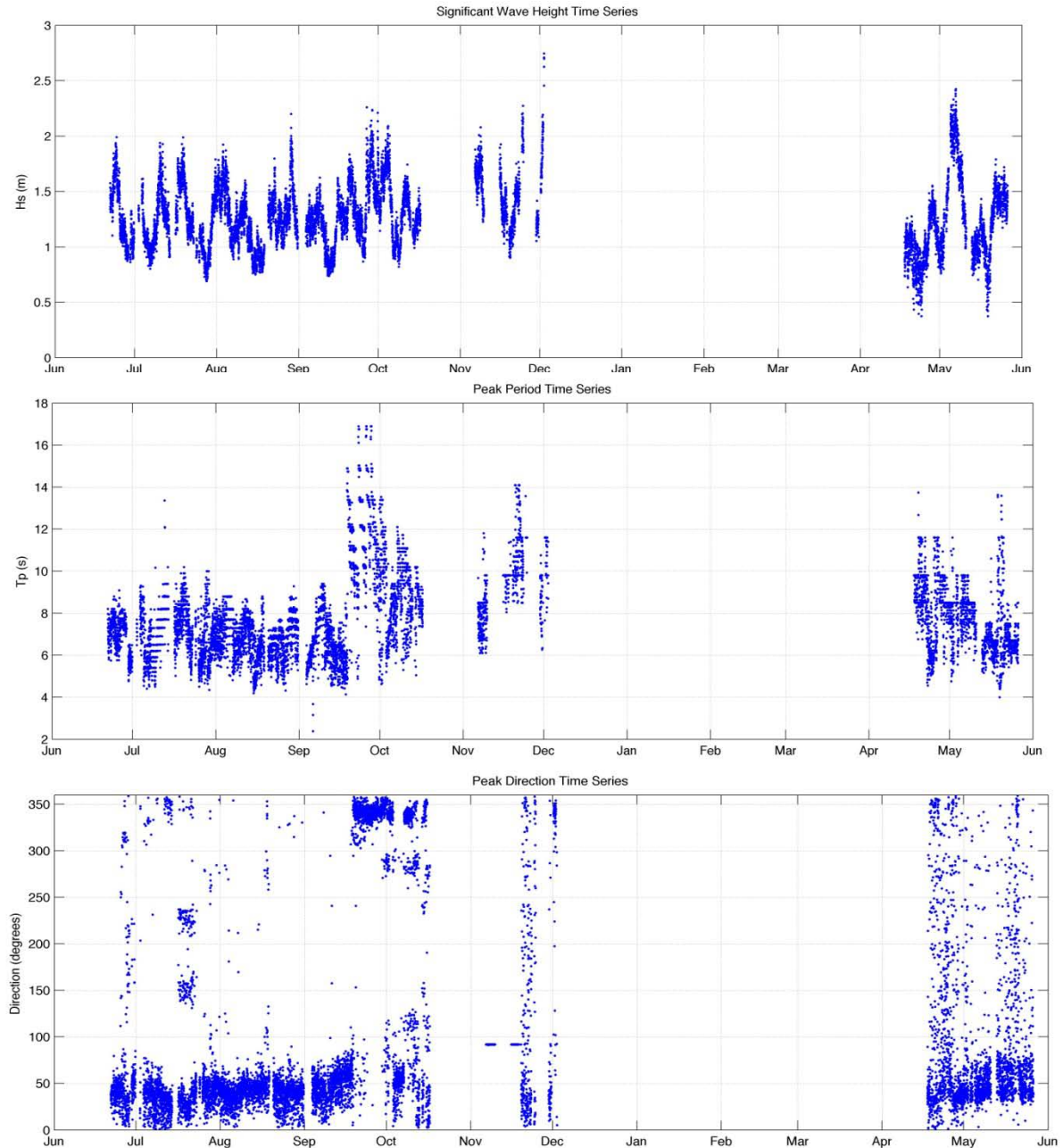


Figure 9 Time series of significant wave heights (hs), peak period (Tp), and peak direction (Dp).

Figure 10 and Figure 11 below show the wave and period roses and histograms calculated from each corresponding time series. Tables 4-5 contain the percent occurrence binned by direction and wave Hs/Tp respectively illustrated by the corresponding rose and wave statistics binned by direction.

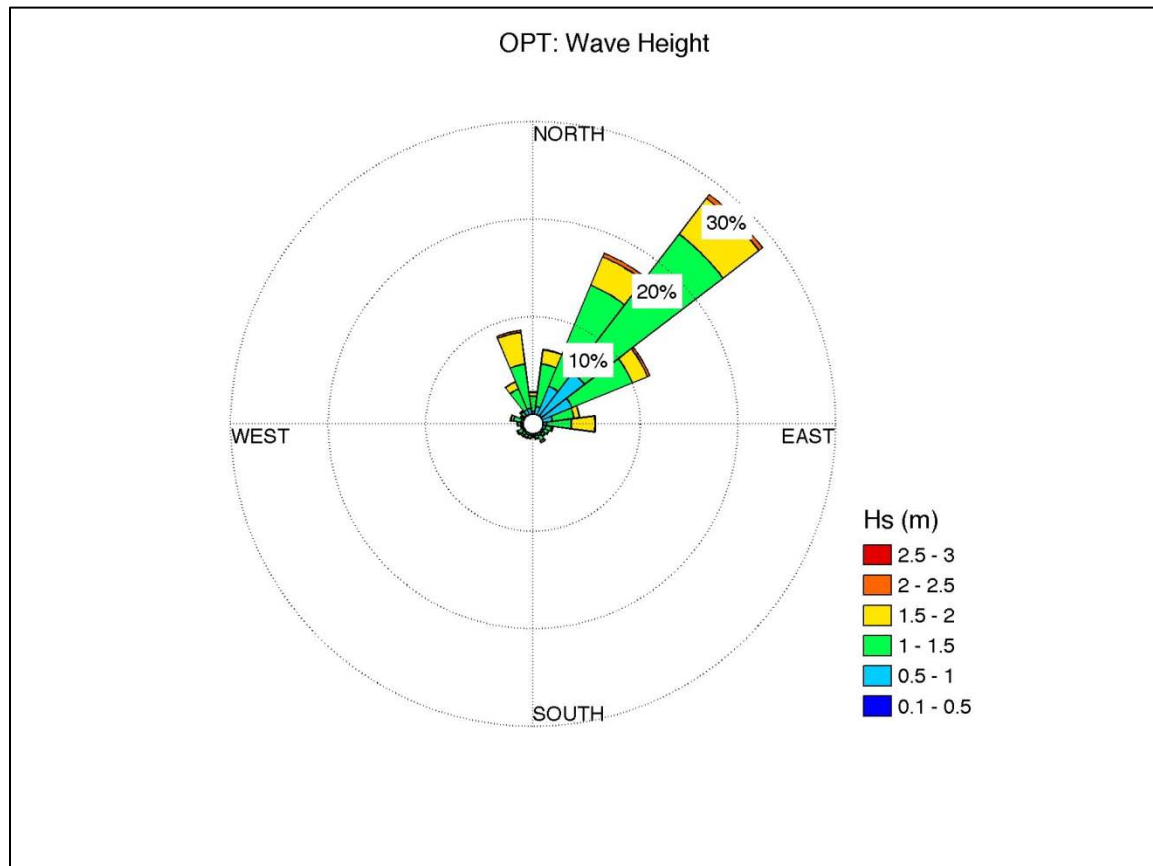


Figure 10 Significant wave height rose.

Table 4 Wave direction (degrees from north)

Hs (m)	0	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	Total %
<0.5	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
0.5-1.0	0.3	0.8	3.2	5.5	3.3	1.0	0.4	0.3	0.2	0.2	0.3	0.2	0.1	0.2	0.2	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.6	0.6	18.6
1.0-1.5	1.6	4.4	11.2	17.9	6.7	2.2	2.5	0.6	0.5	0.3	0.6	0.3	0.2	0.3	0.3	0.4	0.5	0.2	0.4	0.8	0.2	0.5	2.3	4.6	59.2
1.5-2.0	0.4	1.5	3.1	4.6	1.7	0.6	2.4	0.2	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.1	0.3	0.1	0.2	0.8	3.3	20.2
2.0-2.5	0.1	0.0	0.4	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	1.7
2.5-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0-3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.5-4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0-4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.5-5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0-7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.5-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total %	2.3	6.7	18.0	28.6	11.9	3.8	5.4	1.1	0.8	0.6	1.1	0.6	0.4	0.5	0.6	0.7	0.8	0.3	0.7	1.4	0.4	0.8	3.7	8.7	100.0
Hs (m)	0	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	Overall
Mean	1.3	1.3	1.3	1.2	1.2	1.2	1.4	1.2	1.1	1.2	1.2	1.1	1.2	1.1	1.1	1.3	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.3
StDev	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.3
Min	0.6	0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.5	0.6	0.5	0.7	0.6	0.7	0.5	0.5	0.7	0.6	0.6	0.5	0.7	0.4	0.7	0.4
Max	2.5	2.7	2.4	2.4	2.4	2.2	2.7	2.0	2.1	1.9	1.9	1.7	1.9	1.7	1.8	2.0	2.0	2.2	1.7	2.6	2.7	2.0	2.1	2.3	2.7

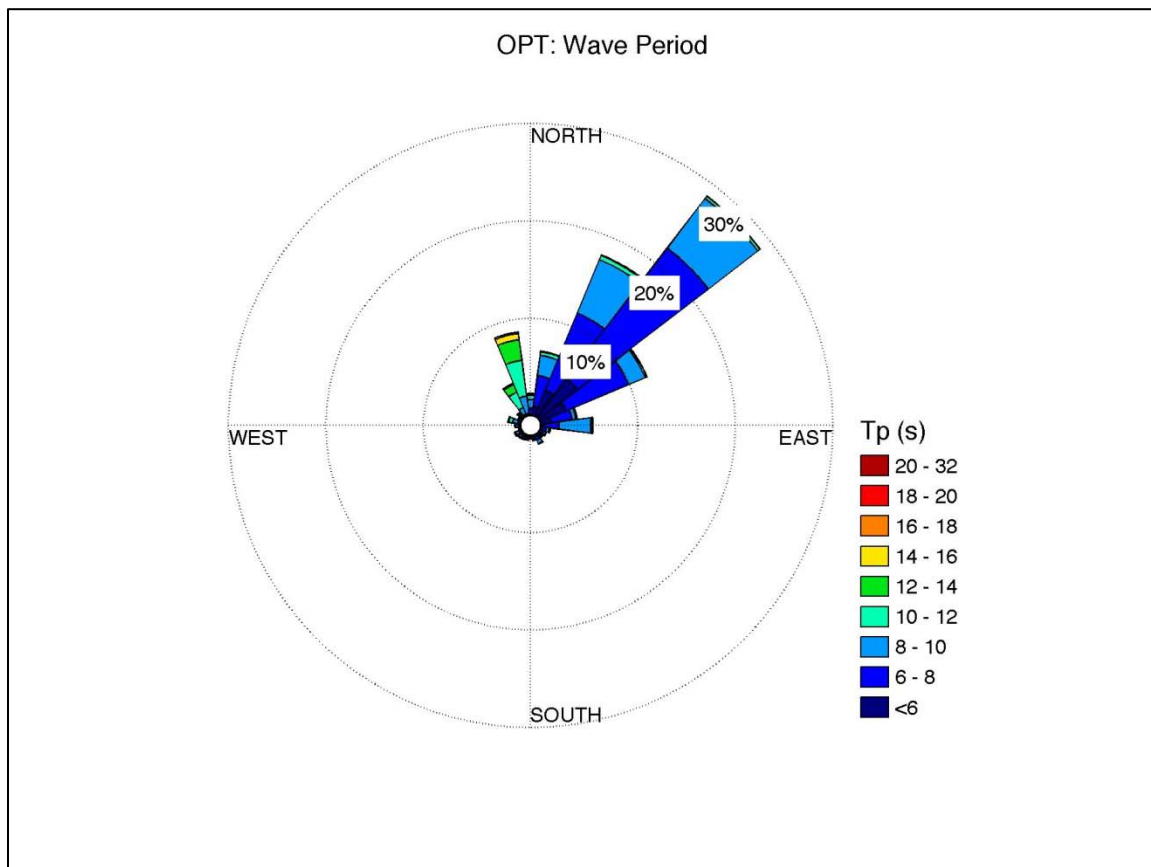


Table 5 Wave direction (degrees from north)

Tp (s)	0	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	Total %
4-6	0.1	1.0	2.9	5.0	2.9	1.1	0.2	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.0	15.2
6-8	0.6	3.2	8.6	16.9	7.0	2.2	1.7	0.5	0.4	0.2	0.4	0.3	0.1	0.1	0.3	0.2	0.2	0.1	0.1	0.3	0.1	0.2	0.2	0.2	44.0
8-10	0.9	2.1	5.9	6.4	1.8	0.4	3.3	0.3	0.2	0.1	0.4	0.1	0.1	0.1	0.1	0.3	0.3	0.1	0.3	0.6	0.2	0.2	0.7	1.8	26.8
10-12	0.4	0.4	0.5	0.3	0.2	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.4	0.1	0.1	1.7	3.7	9.2
12-14	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.8	2.1	3.6
14-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.9
16-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3
18-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total %	2.3	6.7	18.0	28.6	11.9	3.8	5.4	1.1	0.8	0.6	1.1	0.6	0.4	0.5	0.6	0.7	0.8	0.3	0.7	1.4	0.4	0.8	3.7	8.7	100.0
	0	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	Overall
Mean	9.1	7.7	7.5	7.1	6.8	6.7	8.5	7.9	7.8	7.9	7.7	7.0	8.3	8.4	7.3	8.3	8.4	8.0	8.6	9.2	8.9	9.2	10.8	11.3	7.9
StDev	2.4	1.6	1.4	1.2	1.3	1.4	1.4	1.9	1.8	2.2	1.7	1.7	2.5	2.3	2.1	1.8	2.0	2.3	2.0	1.9	2.1	2.4	2.1	2.0	2.1
Min	4.7	4.4	4.3	2.4	4.1	4.0	4.7	4.6	5.5	4.8	4.4	4.6	5.2	4.5	4.5	4.4	4.4	4.6	4.4	5.5	4.7	4.7	5.0	5.6	2.4
Max	16.9	14.1	16.4	14.5	14.1	13.6	14.1	14.1	14.1	14.1	13.6	11.6	14.1	11.9	14.1	12.5	13.0	11.6	13.5	14.1	13.9	16.1	16.9	16.9	16.9