CENTRE FOR MARINE APPLIED RESEARCH

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WIND AND WAVE CONDITIONS – WHYCOCOMAGH BAY – MARINE FINFISH LEASES 0814X, 0814, 0600, 1431, 5010, 1430

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Engineering Review Status Acronyms
IFI – Issued for information
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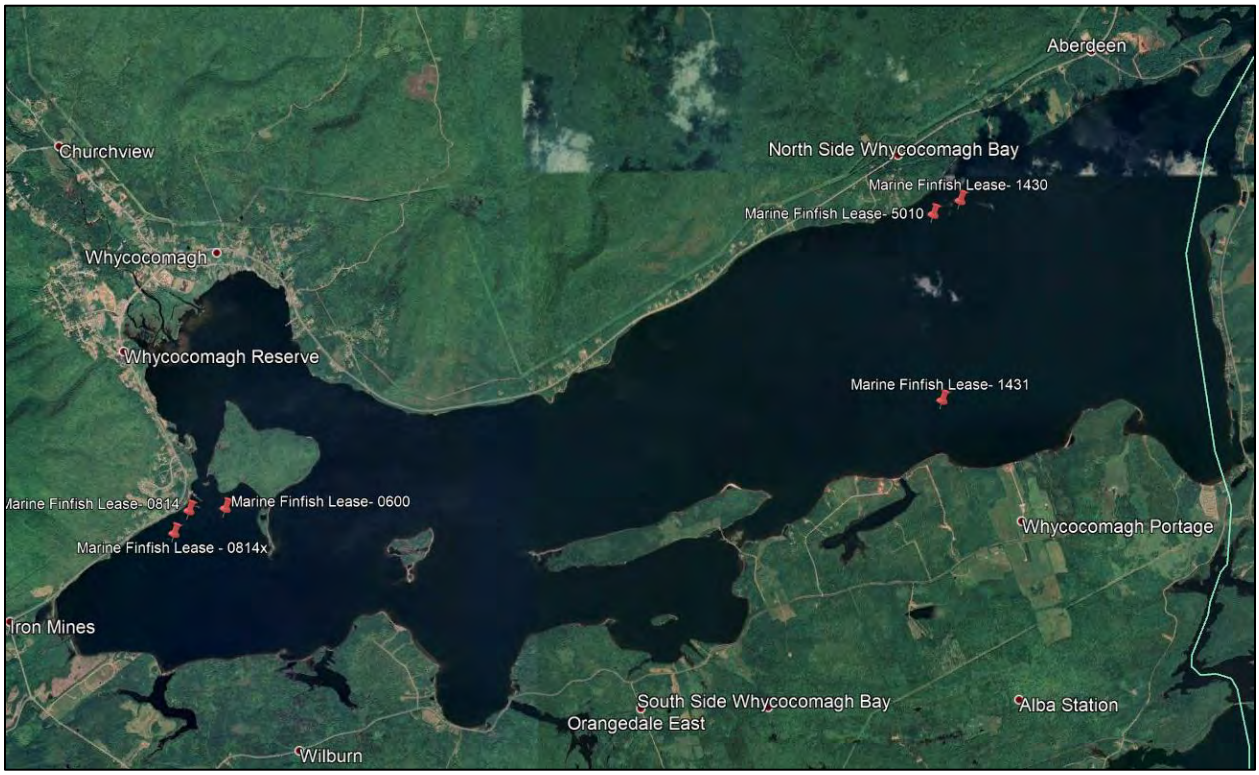
Executive Summary

In support of Centre for Marine Applied Research (CMAR), the following report presents wind and wave conditions at six marine finfish leases near Whycocomagh Bay in the Bras d'Or Lake on Cape Breton Island in Nova Scotia, Canada.

In this report, wave and wind conditions are presented for 6 locations:

- Proposed Marine Finfish Lease - 0814x: 45° 56.927'N, 61° 7.675'W.
- Marine Finfish Lease - 0814: 45° 57.050'N, 61° 7.555'W.
- Marine Finfish Lease - 0600: 45° 57.061'N, 61° 7.270'W.
- Marine Finfish Lease - 1431: 45° 57.611'N, 61° 1.630'W.
- Marine Finfish Lease - 5010: 45° 58.626'N, 61° 1.685'W.
- Marine Finfish Lease - 1430: 45° 58.699'N, 61° 1.472'W.



To determine the wave field evolution closer to shore at a specific site, and to determine more accurate 10- and 50- year return period wave data, near shore wave modelling can be used. For the Whycocomagh Bay sites, STWave was used to model the wind-driven wave conditions inside the area. The results are based on wind conditions from a weather station located near Eskasoni which is located outside of the Whycocomagh Bay area. The STWave model results are determined using only wind boundary condition. The extreme wind-driven waves at the lease locations are presented in this report.

Contents

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1 Introduction

1.1 Overview

For the finfish lease locations in the Whycocomagh Bay area in the Bras d'Or Lake shown in Figure 1, wind and wave conditions have been estimated. The following presents data on the predicted 10- and 50- year wind and wave conditions at six locations.

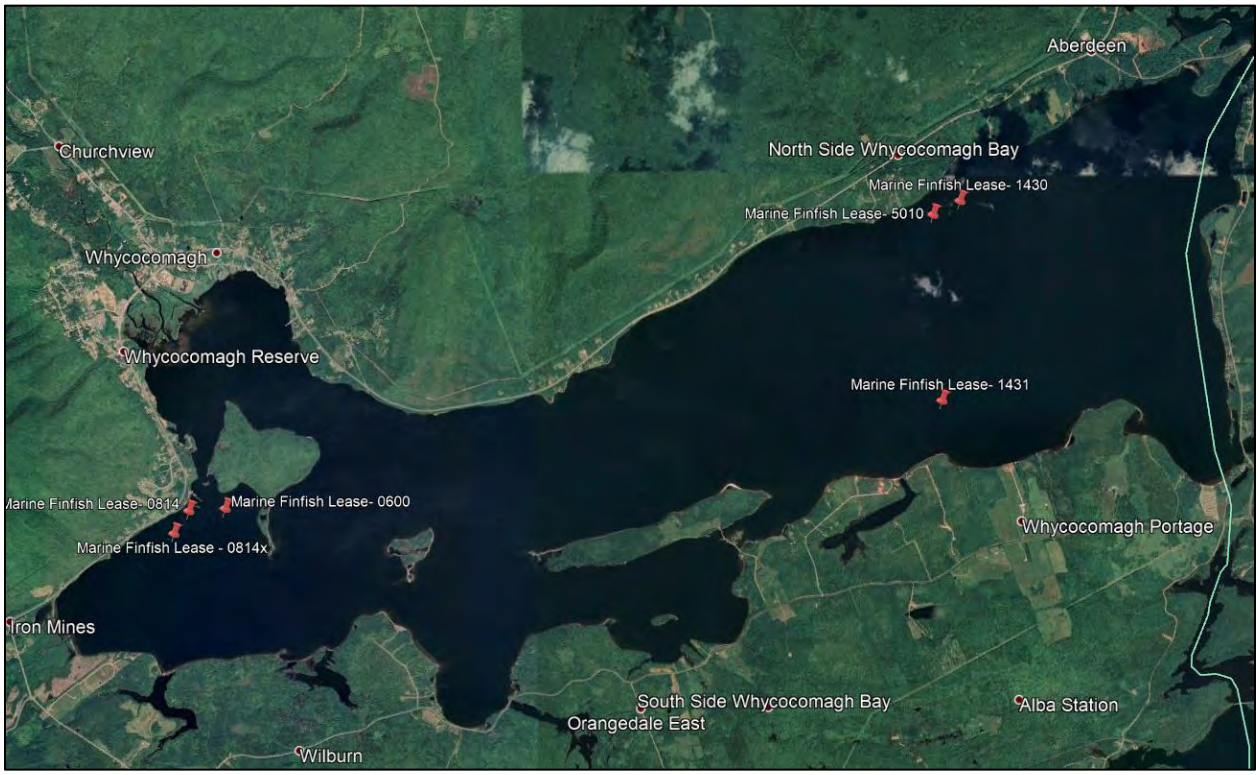


Figure 1 Six (6) site locations near Whycocomagh Bay in the Bras d'Or Lake [4]

The area is overall fully protected from offshore waves by surrounding lands as can be seen in Figure 2. Due to the nature of the region, wind-driven waves are calculated for the finfish leases in the bay. However, as waves will lose energy by travelling into shallower waters, detailed wave modelling is required to determine the amount of energy lost and wave height reduction.

Figure 2 Whycocomagh Bay, Nova Scotia, Canada- Source Point is the closest weather station to Whycocomagh Bay with hourly wind data for 10 years

The context of this project is that extreme wind and wave conditions are needed to select engineering load cases for those wishing to install finfish or shellfish farms in the area. For example, extreme environmental conditions with minimum 10- year and 50- year return periods are required for the design of a marine fish farm site, as per guidance in the Scottish technical standard [2] and NS9415 [3]. While the locations assessed as part of this modeling exercise are actual aquaculture site locations (with the exception of 0814x), the data produced for these locations is useful for understanding the approximate wave climate in the region and can be used to evaluate any proposals for sites in the area. Understanding the wind and wave climates at aquaculture sites is important for mitigating risks.

1.2 Objective(s)

- Determine wave/wind conditions at six locations near Whycocomagh Bay and find the conditions with 10- and 50- year return periods.

2 Abbreviations and acronyms

DSA	Dynamic Systems Analysis Ltd.
SMS	Surface-water Modeling System
CMAR	Centre for Marine Applied Research

CHS	Canadian Hydrographic Services

3 Reference documents and drawings

[1]	https://weather.gc.ca/
[2]	Marine Scotland. (2015). A Technical Standard for Scottish Finfish Aquaculture. Ministerial Group for Sustainable Aquaculture's Scottish Technical Standard Steering Group
[3]	Norge, S. (2009). Norwegian Standard NS 9415. E: 2009. Marine Fish Farms—Requirements for Site Survey, Risk Analyses, Design, Dimensioning, Production, Installation and Operation. *Standard Norge, Lysaker*.
[4]	CMAR approved sites -RevB.kmz

4 Wave conditions

4.1 Overview

SMS version 12.2.13 was used to setup the bathymetric and computational grid. This section provides a description of the grid size, mesh size and offshore environmental conditions. Site bathymetry is provided in Figure 3. Note that a CHS hydrographic chart is used to generate the bathymetric data for wave modeling.

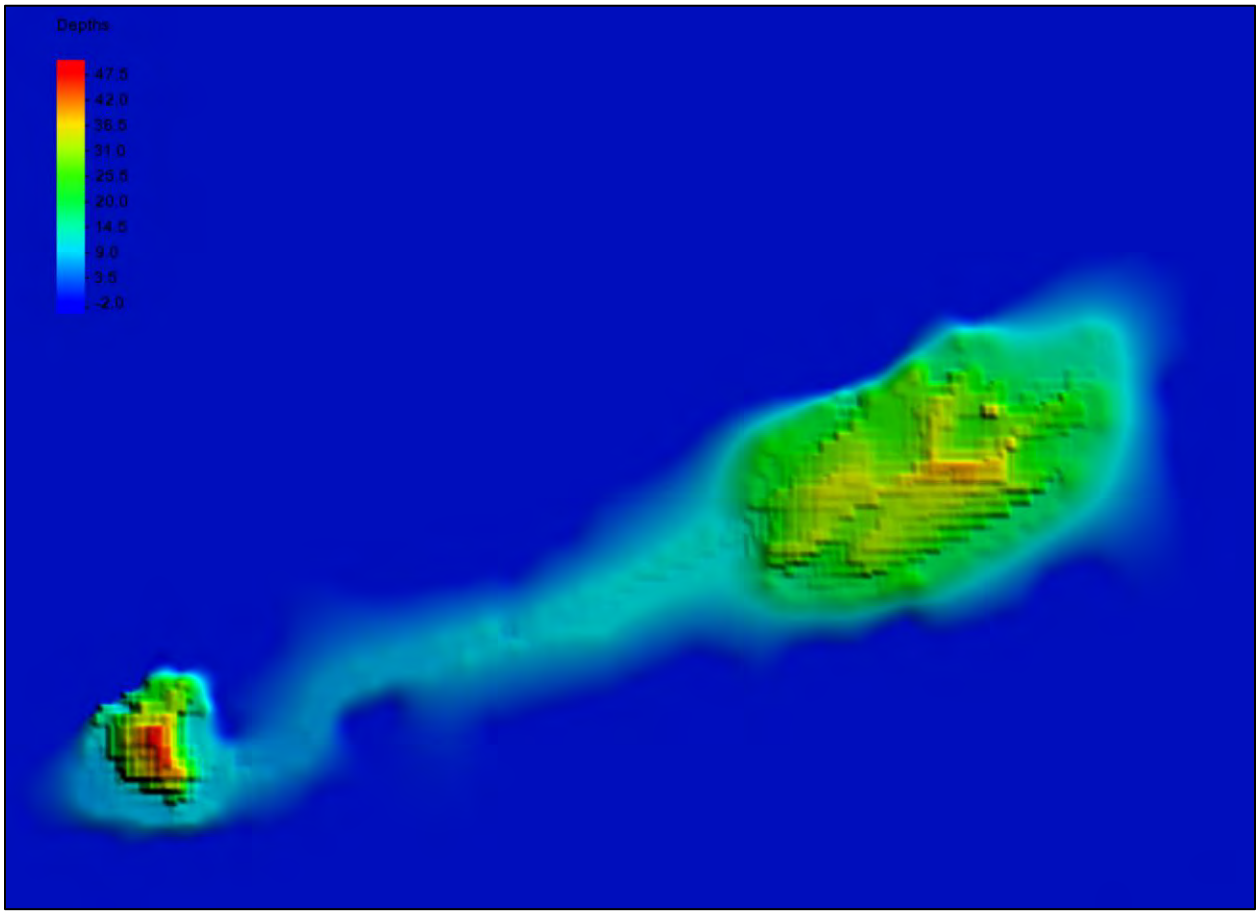


Figure 3 Bathymetry at site on hydrographic charts- Depth reported in meters

4.2 Wave Model Description

SMS, created by Aquaveo, is a modelling suite in which various water surface modelling tools, like wave and flow models, can be used. For this analysis SMS in combination with STWave is used. STWave is a nearshore spectral Hydraulics model, developed by U.S. Army Engineer Research and Development Center (ERDC) and Coastal and Hydraulics Laboratory (CHL). It is capable of modelling accurately wave transformation and propagation.

Two grids were setup, computational grid and spectral grid. The computational grid and its mesh sizes are mainly defined by the bathymetry. The bathymetry in SMS is presented in Figure 4. For this analysis, the computational grid size was 12.1 km x 6.7 km. The mesh size was 10 m x 10 m, resulting in 1211 x 668 = 808,948 grid cells. The spectral domain was divided into 72 directions and 50 frequencies, with a minimum frequency of 0.03 Hz and a maximum frequency of 1.01 Hz.

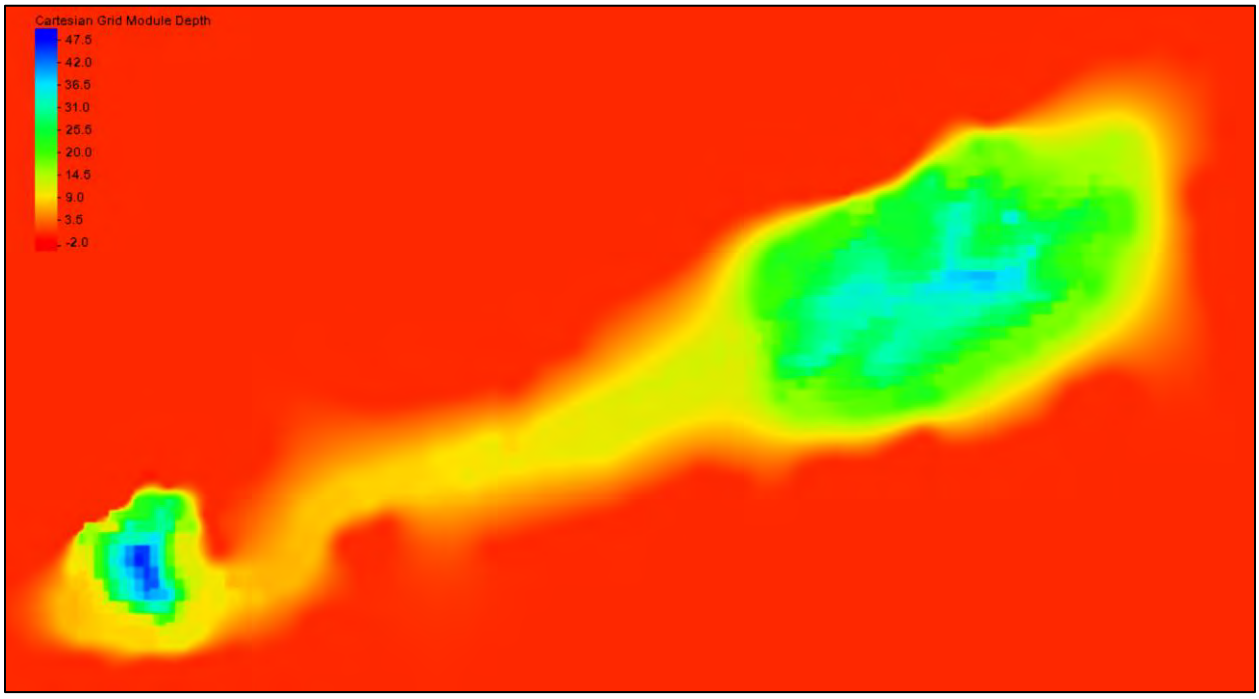


Figure 4 Bathymetry at site on STWave. Note the Source Point indicated at 45° 55.125'N, 60° 38.616'W Boundary conditions – wind conditions

4.3 Boundary conditions – Wind and wave conditions

Environment Canada wind data [1] from a weather station located near Eskasoni (45° 55.125'N, 60° 38.616'W) was used to determine the 10- and 50- year return periods for wind and wave of the Whycocomagh Bay fish farm sites. The scatter plot of wind speeds versus wind directions for the source point is also shown in Figure 5. Extreme winds at the source point appear to originate more frequently from the northeast and east.

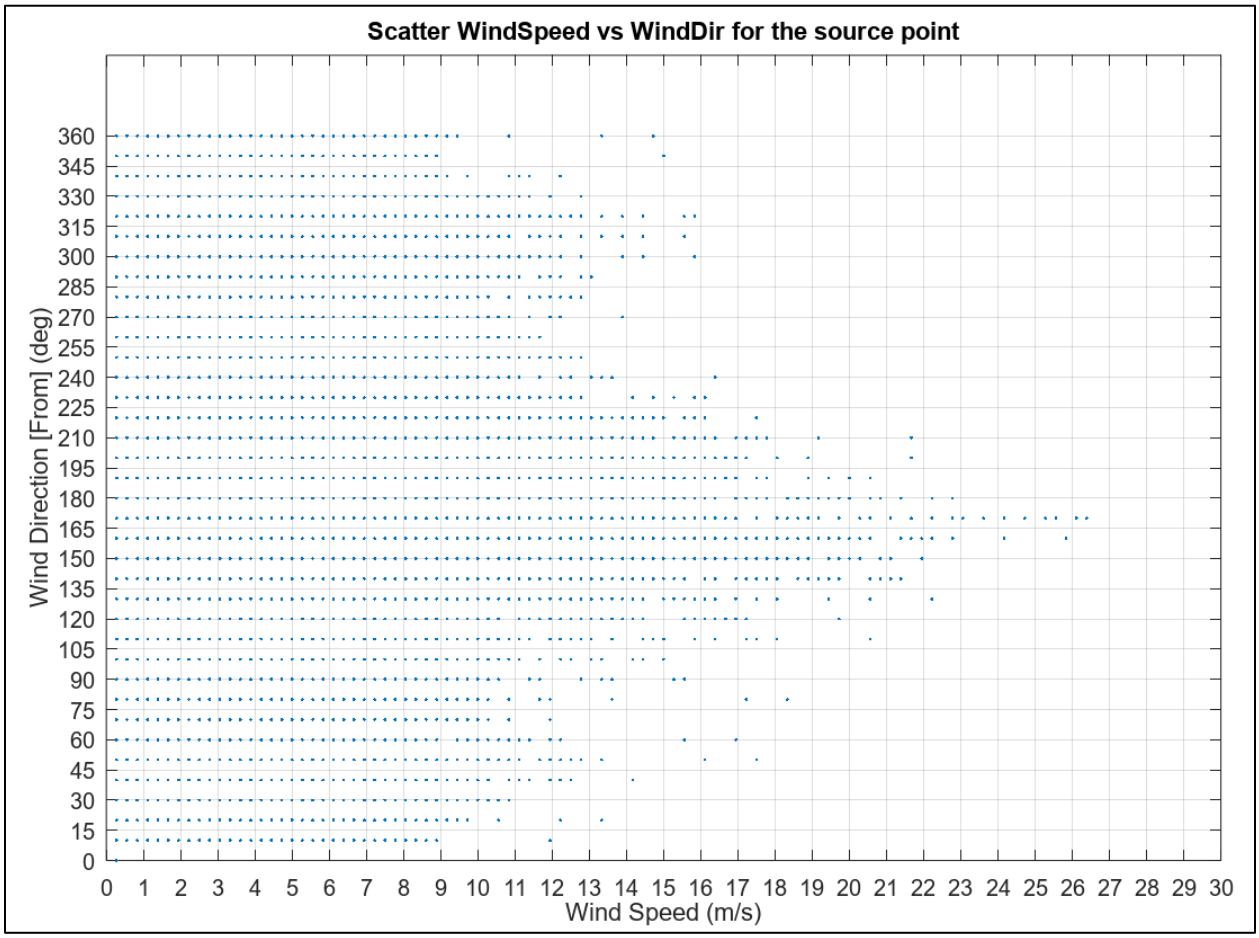
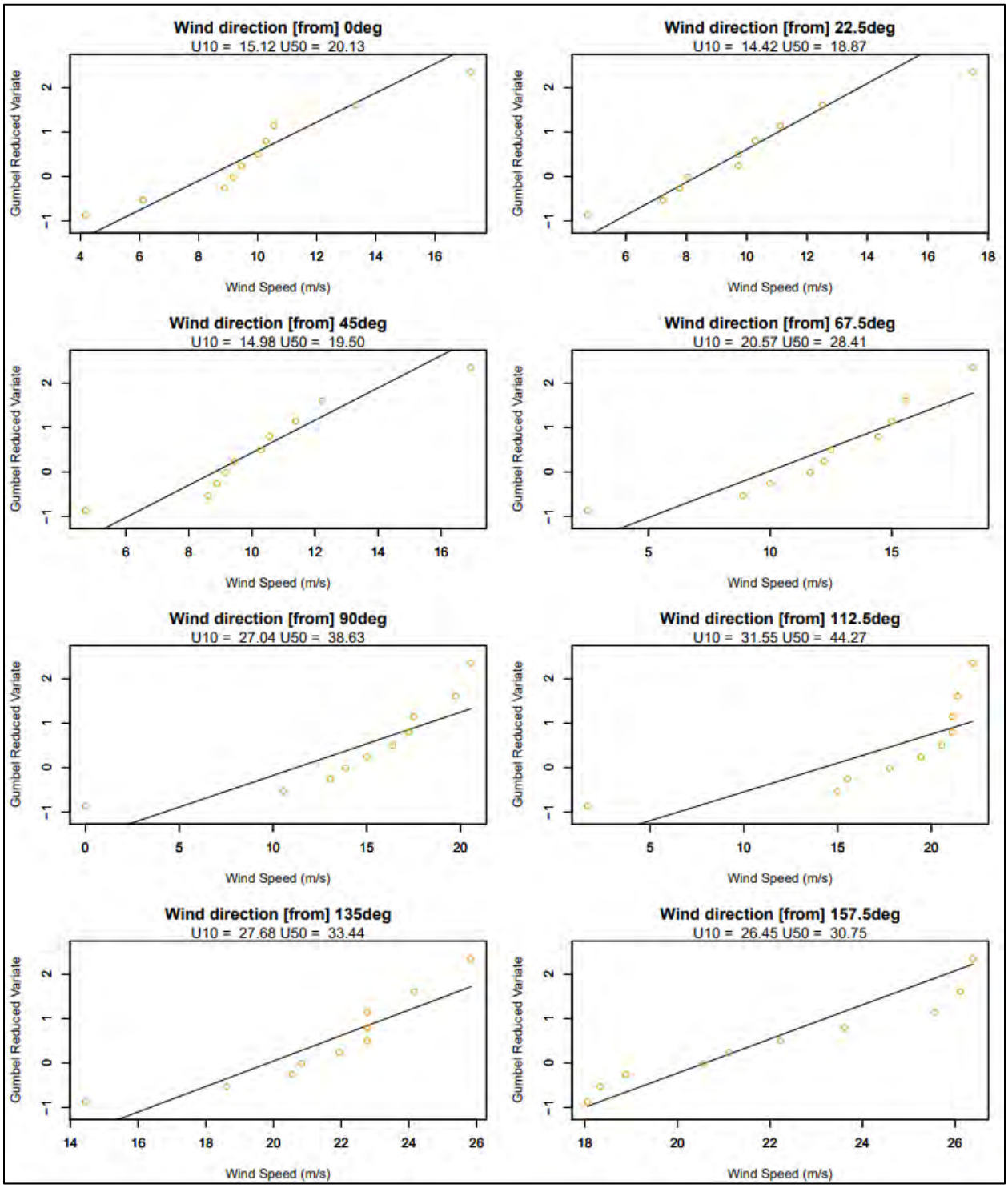


Figure 5 Wind speed versus wind direction plot for the Source Point

10- and 50- year return period conditions are in general achieved by:

- Obtaining measured or hindcast data for parameter in question
- For each parameter, bin data by direction
- Perform extreme value analysis.
    - Extract annual maxima
    - Fit Gumbel or Weibull distribution to this data
    - Use fitted distribution to calculate values corresponding to 10- and 50- year return period

The extreme value analysis of the wind velocities is presented in Figure 6. U10 and U50 represent the 10- and 50- year return period wind velocities, respectively.


Wind direction [from] 0deg
U10 = 15.12 U50 = 20.13
Wind direction [from] 22.5deg
U10 = 14.42 U50 = 18.87
Wind direction [from] 45deg
U10 = 14.98 U50 = 19.50
Wind direction [from] 67.5deg
U10 = 20.57 U50 = 28.41
Wind direction [from] 90deg
U10 = 27.04 U50 = 38.63
Wind direction [from] 112.5deg
U10 = 31.55 U50 = 44.27
Wind direction [from] 135deg
U10 = 27.68 U50 = 33.44
Wind direction [from] 157.5deg
U10 = 26.45 U50 = 30.75
Gumbel Reduced Variate
Wind Speed (m/s)

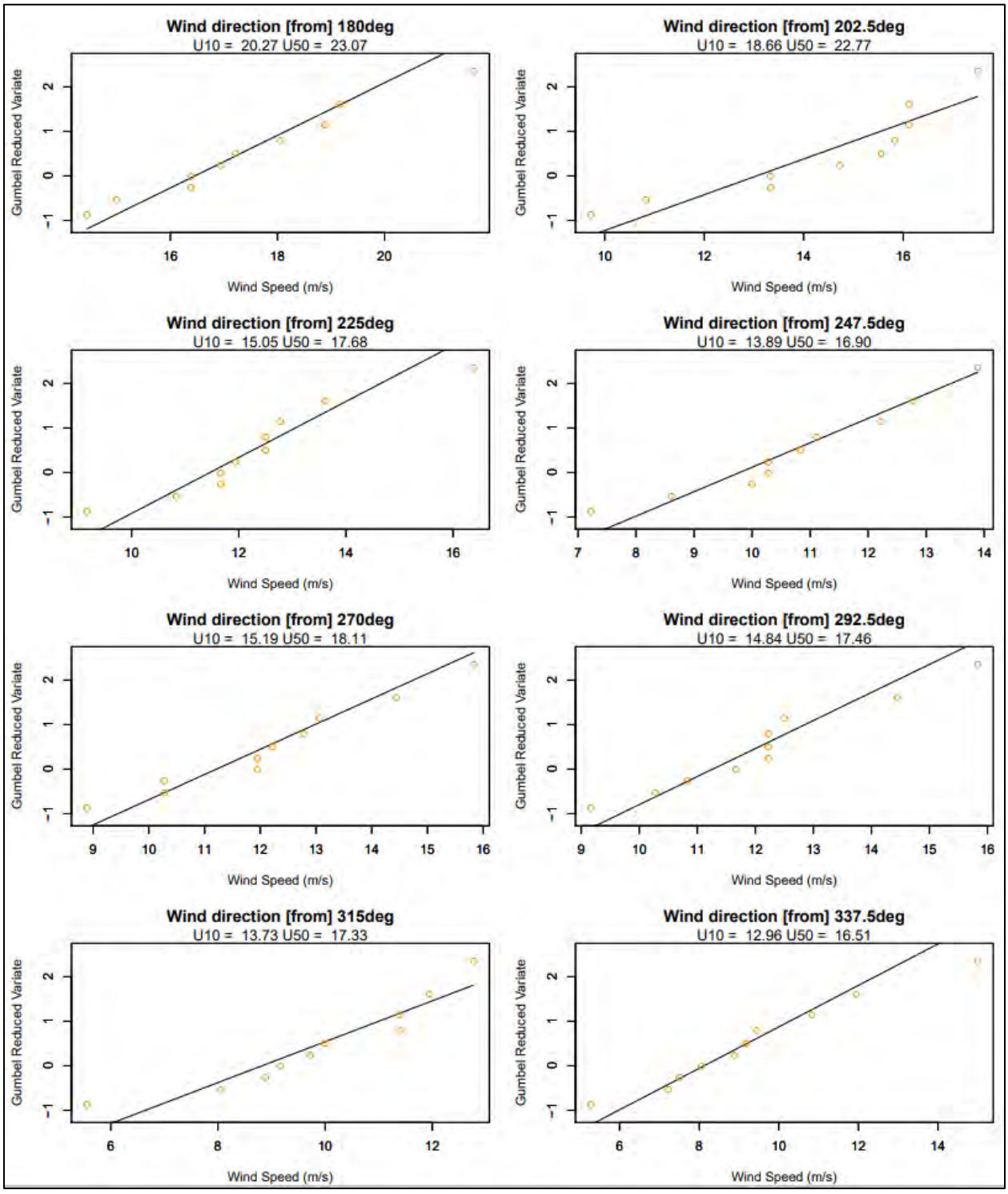


Figure 6: Extreme value analysis on wind data – for the Source Point [1]

In summary, the following data was obtained from the extreme value analysis:

Table 1 Results extreme value analysis for wind at the Source Point locations in Figure 4

Direction [from] [°]		$U_{wind,10year}$ [m/s]	$U_{wind,50year}$ [m/s]
0	N	15.12	20.13
23	NNE	14.42	18.87
45	NE	14.98	19.5
68	ENE	20.57	28.41
90	E	27.04	38.63
113	ESE	31.55	44.27
135	SE	27.68	33.44
158	SSE	26.45	30.75
180	S	20.27	23.07
203	SSW	18.66	22.77
225	SW	15.05	17.68
248	WSW	13.89	16.9
270	W	15.19	18.11
293	WNW	14.84	17.46
315	NW	13.73	17.33
338	NNW	12.96	16.51

Polar plots for maximum wind speeds at 10- year and 50- year return periods are shown in Figure 7 and Figure 8, respectively.

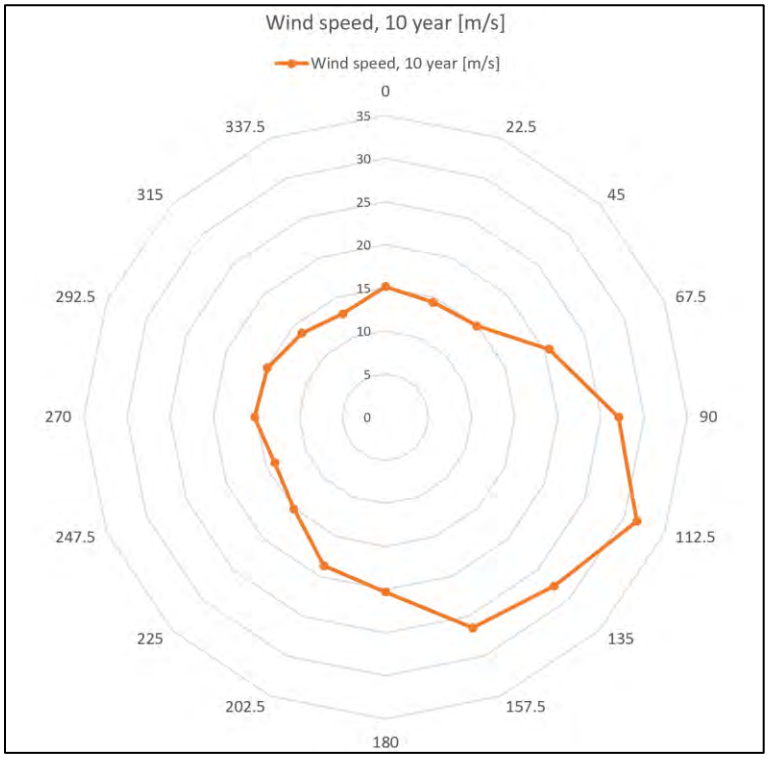


Figure 7 Maximum wind speed at 10- year return period and direction [from]- for Source location [1]

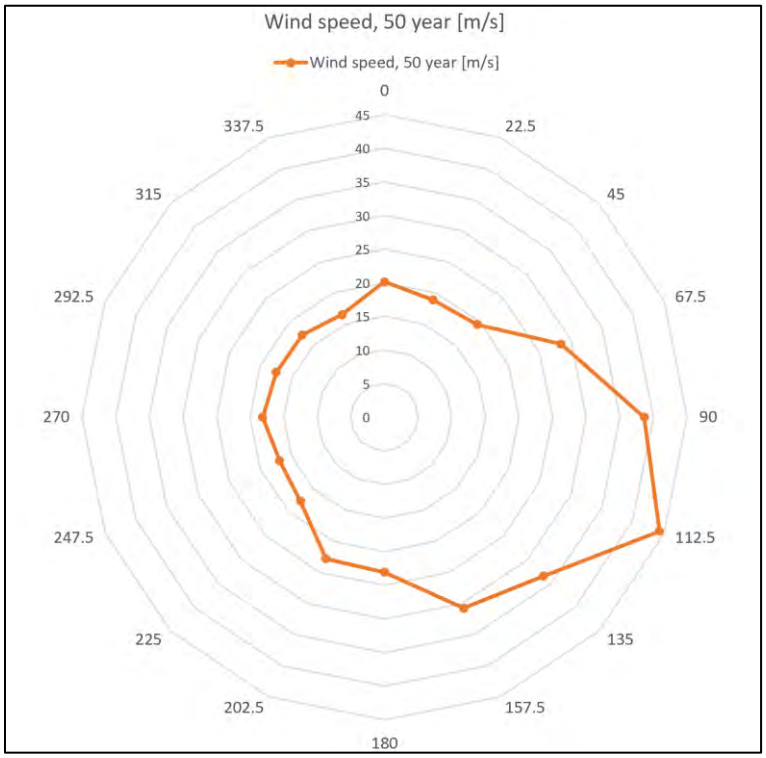


Figure 8 Maximum wind speed at 50- year return period and direction [from]- for Source Point location [1]

Only wind-driven waves considered for the wave modeling. Current-wave interaction was not included because local flow velocities are very small.

16 headings were used, the wind direction was kept constant within its directional bin.

In this method, wave design conditions for the project location are based on 10- and 50- year return period winds for a nearby weather station, which have subsequently been transferred to the project location. This will provide reasonable design conditions; however, they cannot be linked directly to a return period at the site.

4.4 Wave modeling results

The results of the wave modeling are presented in Figure 9 and Figure 10 for directions from East and Southeast, respectively for two key wave headings with the highest wave heights. As stated in the previous section, the wind conditions are assumed to stay constant for the region. The results from STWave represent the maximum significant wave height value at the region including its spectral peak period and wave direction.

The location of sites at the Whycocomagh Bay are presented in Figure 1. The estimated wave and wind conditions for each site based on the STWave modeling are presented in the following sections.

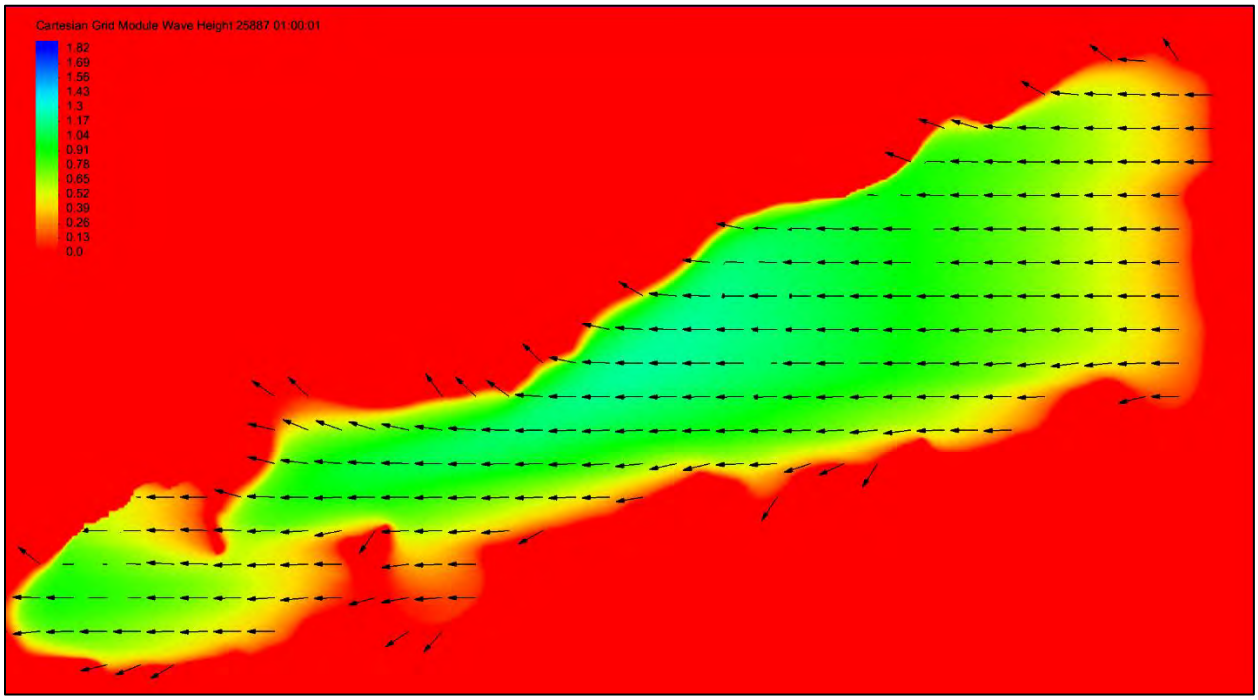


Figure 9 Wave modeling results for direction [From] 90 deg- E

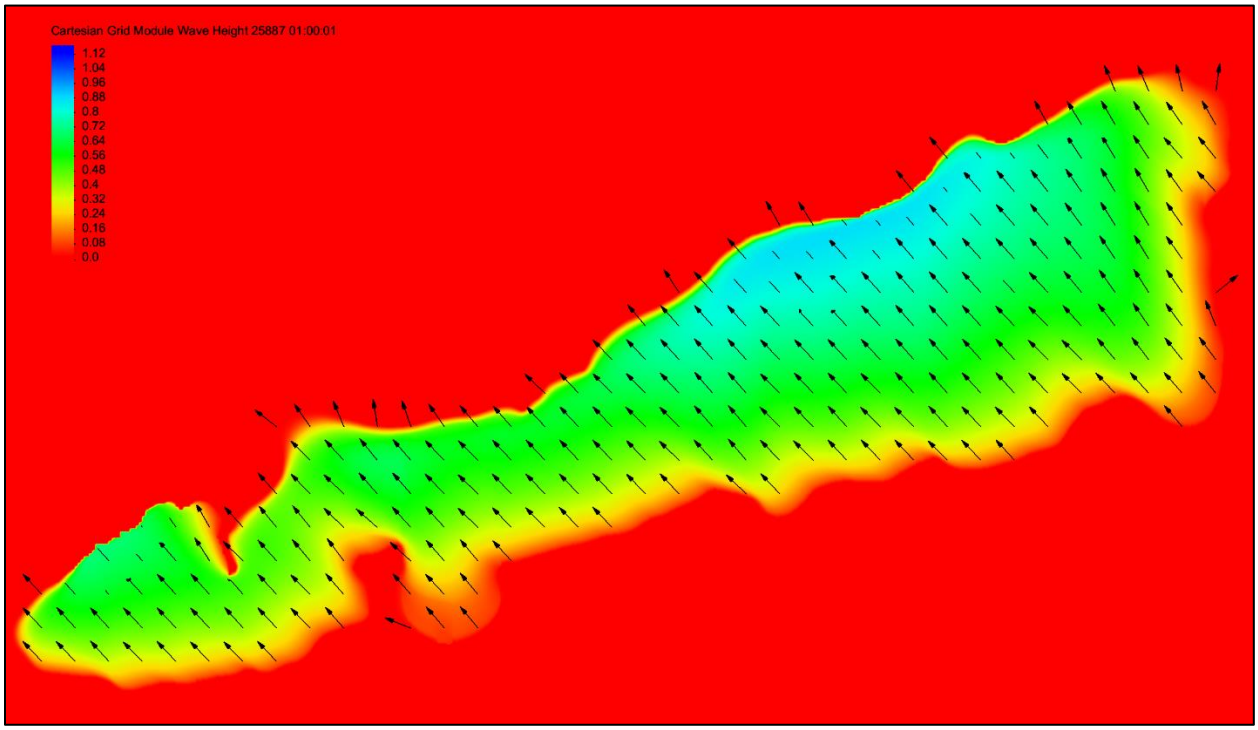


Figure 10 Wave modeling results for direction [From] 135 deg- SE

4.4.1 Wave/wind conditions for Whycocomagh Bay – Proposed Marine Finfish Lease – 0814x

The wave and wind results from the STWave model, for the proposed Marine Finfish Lease – 0814x at the Whycocomagh Bay, are summarized in Table 2. Note that the results in Table 2 indicate significant wave height (Hs) and peak period (T_P) for the selected site. These represent the extreme wave conditions at this coordinate: 45° 56.927'N, 61° 7.675'W.

Table 2 Estimated wave and wind design conditions for Whycocomagh Bay – Proposed Marine Finfish Lease - 0814x

Wave/Wind conditions	Direction [from] [°]		Wind (m/s)	Hs (m)	Tp (s)
10yr wave/wind	*0*	N	15.12	0.15	1.27
	23	NNE	14.42	0.1	1.22
	45	NE	14.98	0.21	1.83
	68	ENE	20.57	0.37	1.91
	90	E	27.04	0.61	2.15
	113	ESE	31.55	0.69	2.51
	135	SE	27.68	0.65	2.36
	158	SSE	26.45	0.61	2.17
	180	S	20.27	0.44	1.92
	203	SSW	18.66	0.27	1.8
	225	SW	15.05	0.28	1.65
	248	WSW	13.89	0.23	1.4
	270	W	15.19	0.18	1.4
	293	WNW	14.84	0.07	1.1
	315	NW	13.73	0.1	1.22
	338	NNW	12.96	0.1	1.2
50yr wave/wind	*0*	N	20.13	0.21	1.42
	23	NNE	18.87	0.16	1.41
	45	NE	19.5	0.29	2
	68	ENE	28.41	0.54	2.16
	90	E	38.63	0.91	2.51
	113	ESE	44.27	1.05	2.95
	135	SE	33.44	0.82	2.57
	158	SSE	30.75	0.73	2.32
	180	S	23.07	0.51	2.01
	203	SSW	22.77	0.37	1.92
	225	SW	17.68	0.34	1.73

	248	WSW	16.9	0.3	1.52
	270	W	18.11	0.23	1.5
	293	WNW	17.46	0.1	1.37
	315	NW	17.33	0.1	1.2
	338	NNW	16.51	0.15	1.32

It should be noted that the return periods indicated for each wave parameter in Table 2 are representative of the boundary condition used to derive that value, not the value itself. Polar plots for maximum wave heights are presented in Figure 11 and Figure 12.

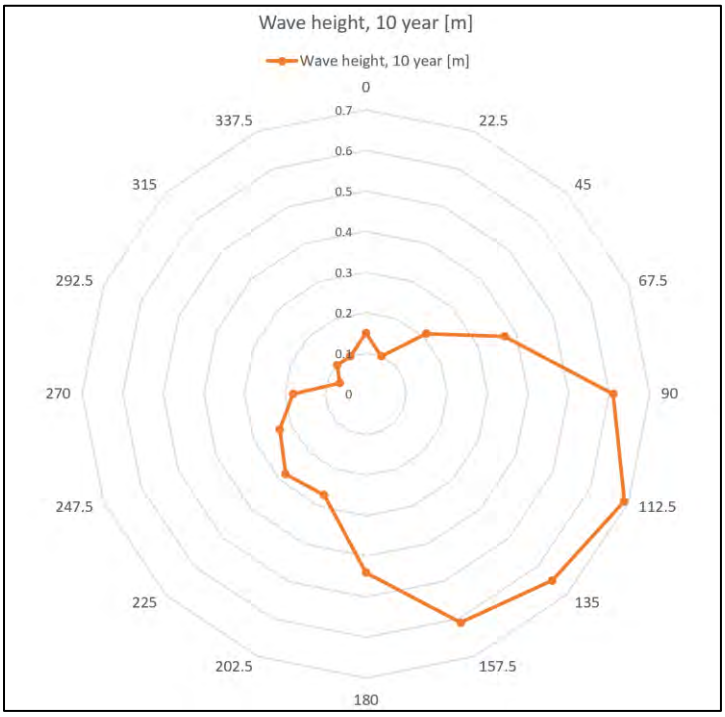


Figure 11 Maximum wave height at 10- year return period and direction [from]- Whycocomagh Bay – Proposed Marine Finfish Lease - 0814x

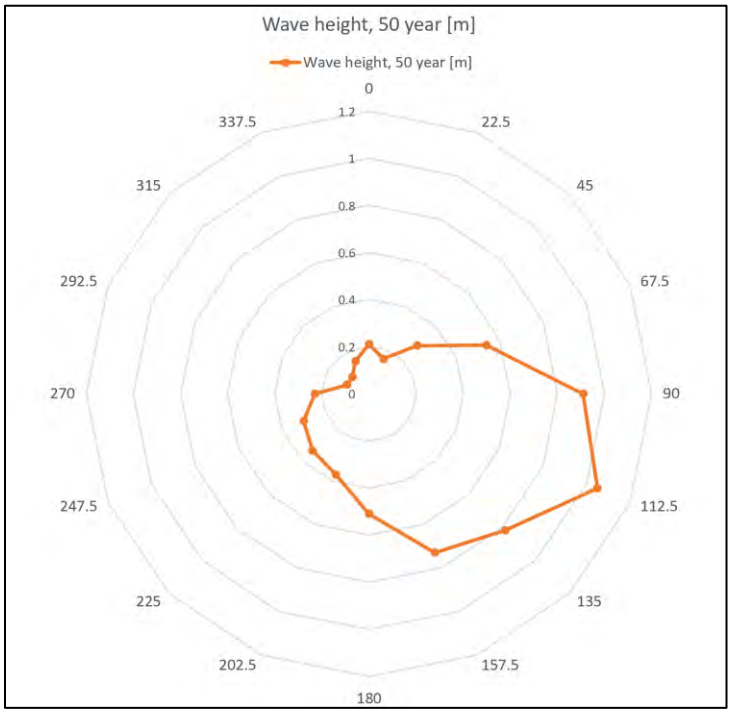


Figure 12 Maximum wave height at 50- year return period and direction [from]- Whycocomagh Bay – Proposed Marine Finfish Lease - 0814x

4.4.2 Wave/wind conditions for Whycocomagh Bay - Marine Finfish Lease - 0814

The wave and wind results from the STWave model, for the Whycocomagh Bay - Marine Finfish Lease - 0814, are summarized in Table 3. Note that the results in Table 3 indicate significant wave height (Hs) and peak period (T_P) for the selected site. These represent the extreme wave conditions at this coordinate: 45° 57.050'N, 61° 7.555'W.

Table 3 Estimated wave and wind design conditions for Whycocomagh Bay - Marine Finfish Lease - 0814

Wave/Wind conditions	Direction [from] [°]		Wind (m/s)	Hs (m)	Tp (s)
10yr wave/wind	*0*	N	15.12	0.11	1.16
	23	NNE	14.42	0.07	1.1
	45	NE	14.98	0.16	1.7
	68	ENE	20.57	0.32	1.79
	90	E	27.04	0.48	1.9
	113	ESE	31.55	0.6	2.54
	135	SE	27.68	0.66	2.47
	158	SSE	26.45	0.65	2.27
	180	S	20.27	0.48	2

	203	SSW	18.66	0.31	1.88
	225	SW	15.05	0.28	1.6
	248	WSW	13.89	0.2	1.31
	270	W	15.19	0.14	1.26
	293	WNW	14.84	0.03	1.1
	315	NW	13.73	0.06	1.12
	338	NNW	12.96	0.07	1.1
50yr wave/wind	*0*	N	20.13	0.16	1.28
	23	NNE	18.87	0.11	1.2
	45	NE	19.5	0.22	1.93
	68	ENE	28.41	0.47	1.97
	90	E	38.63	0.73	2.2
	113	ESE	44.27	0.91	2.99
	135	SE	33.44	0.83	2.7
	158	SSE	30.75	0.78	2.42
	180	S	23.07	0.56	2.1
	203	SSW	22.77	0.41	2.02
	225	SW	17.68	0.34	1.7
	248	WSW	16.9	0.25	1.42
	270	W	18.11	0.18	1.35
	293	WNW	17.46	0.05	1.1
	315	NW	17.33	0.05	1.11
	338	NNW	16.51	0.1	1.2

It should be noted that the return periods indicated for each wave parameter in Table 3 are representative of the boundary condition used to derive that value, not the value itself. Polar plots for maximum wave heights are presented in Figure 13 and Figure 14.

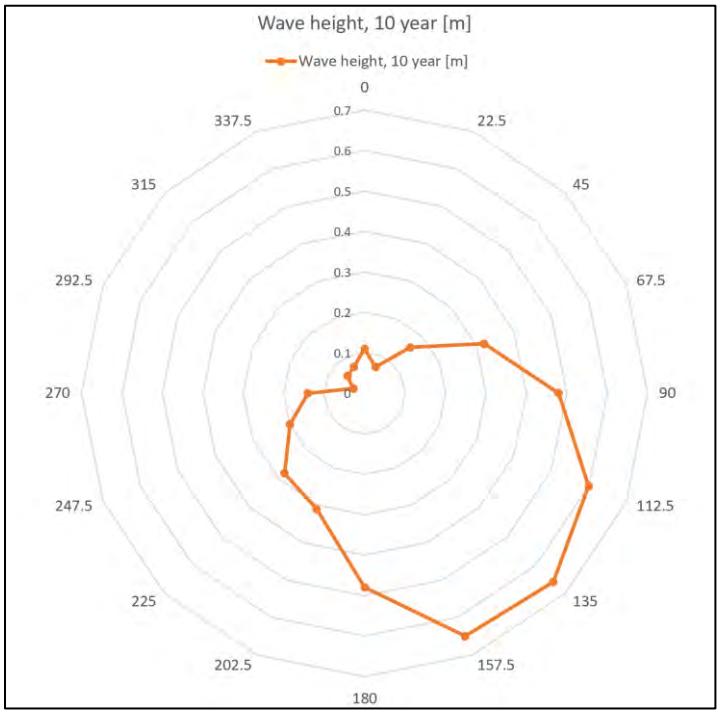


Figure 13 Maximum wave height at 10- year return period and direction [from]- Whycocomagh Bay - Marine Finfish Lease – 0814

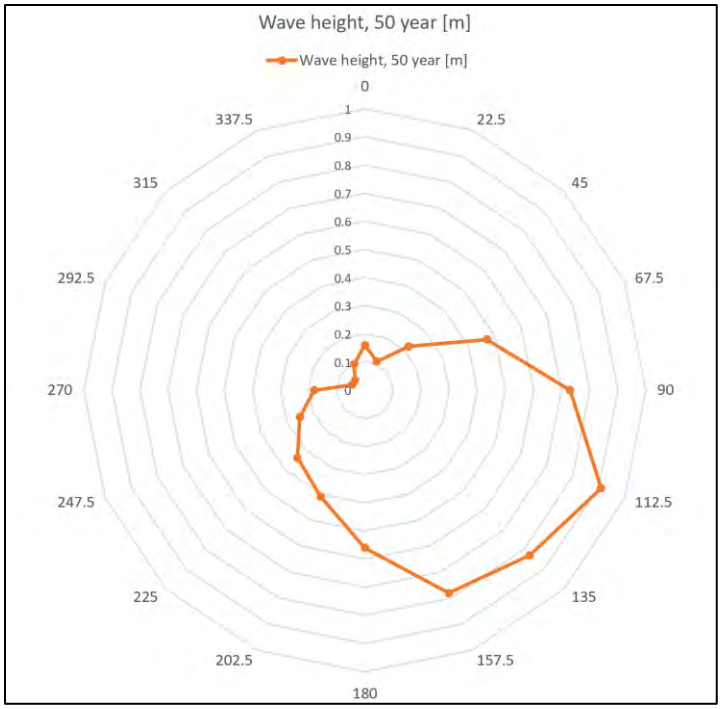


Figure 14 Maximum wave height at 50- year return period and direction [from]- Whycocomagh Bay - Marine Finfish Lease – 0814

4.4.3 Wave/wind conditions for Whycocomagh Bay - Marine Finfish Lease - 0600

The wave and wind results from the STWave model, for the Whycocomagh Bay - Marine Finfish Lease - 0600, are summarized in Table 4. Note that the results in Table 4 indicate significant wave height (Hs) and peak period (T_P) for the selected site. These represent the extreme wave conditions at this coordinate: 45° 57.061'N, 61° 7.270'W.

Table 4 Estimated wave and wind design conditions for Whycocomagh Bay - Marine Finfish Lease - 0600

Wave/Wind conditions	Direction [from] [°]		Wind (m/s)	Hs (m)	Tp (s)
10yr wave/wind	*0*	N	15.12	0.13	1.22
	23	NNE	14.42	0.07	1.1
	45	NE	14.98	0.14	1.34
	68	ENE	20.57	0.24	1.5
	90	E	27.04	0.33	1.65
	113	ESE	31.55	0.33	2.1
	135	SE	27.68	0.54	2.51
	158	SSE	26.45	0.62	2.28
	180	S	20.27	0.48	1.99
	203	SSW	18.66	0.31	1.9
	225	SW	15.05	0.32	1.78
	248	WSW	13.89	0.28	1.54
	270	W	15.19	0.21	1.5
	293	WNW	14.84	0.08	1.12
	315	NW	13.73	0.12	1.21
	338	NNW	12.96	0.12	1.16
50yr wave/wind	*0*	N	20.13	0.2	1.36
	23	NNE	18.87	0.11	1.18
	45	NE	19.5	0.2	1.56
	68	ENE	28.41	0.36	1.71
	90	E	38.63	0.52	1.84
	113	ESE	44.27	0.53	2.26
	135	SE	33.44	0.67	2.75
	158	SSE	30.75	0.75	2.43
	180	S	23.07	0.55	2.1
	203	SSW	22.77	0.41	2.1
	225	SW	17.68	0.38	1.84
	248	WSW	16.9	0.35	1.66

	270	W	18.11	0.26	1.6
	293	WNW	17.46	0.11	1.17
	315	NW	17.33	0.11	1.2
	338	NNW	16.51	0.16	1.27

It should be noted that the return periods indicated for each wave parameter in Table 4 are representative of the boundary condition used to derive that value, not the value itself. Polar plots for maximum wave heights are presented in Figure 15 and Figure 16.

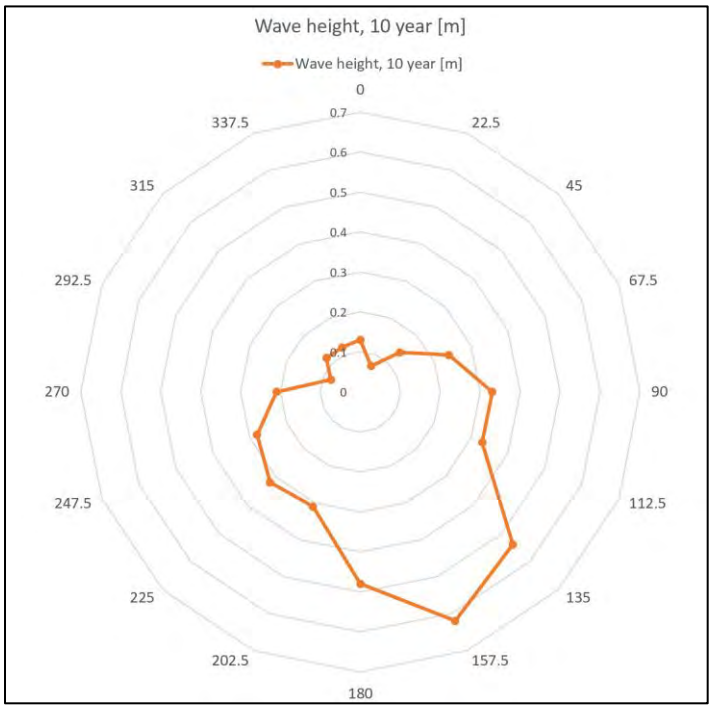


Figure 15 Maximum wave height at 10- year return period and direction [from]- Whycocomagh Bay - Marine Finfish Lease – 0600

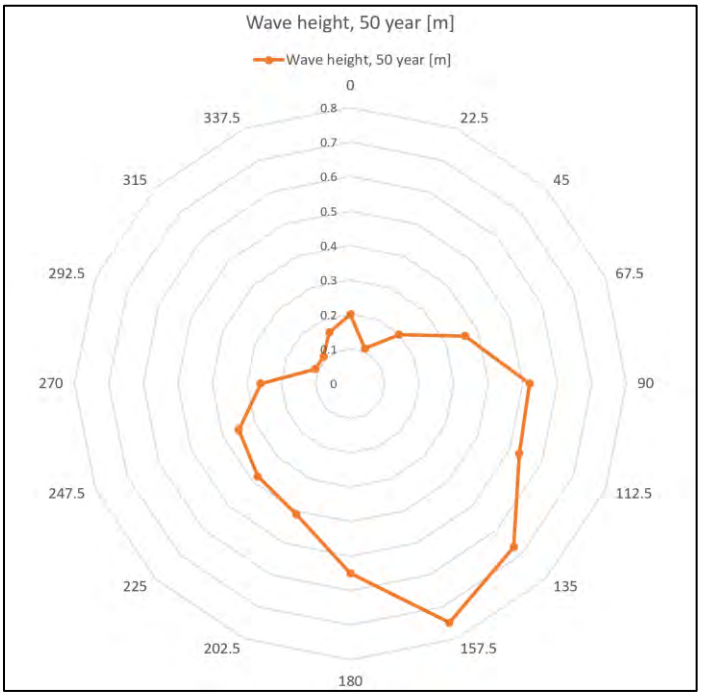


Figure 16 Maximum wave height at 50- year return period and direction [from]- Whycocomagh Bay - Marine Finfish Lease – 0600

4.4.4 Wave/wind conditions for Whycocomagh Bay - Marine Finfish Lease - 1431

The wave and wind results from the STWave model, for the Whycocomagh Bay - Marine Finfish Lease - 1431, are summarized in Table 5. Note that the results in Table 5 indicate significant wave height (Hs) and peak period (T_P) for the selected site. These represent the extreme wave conditions at this coordinate: 45° 57.611'N, 61° 1.630'W.

Table 5 Estimated wave and wind design conditions for Whycocomagh Bay - Marine Finfish Lease - 1431

Wave/Wind conditions	Direction [from] [°]		Wind (m/s)	Hs (m)	Tp (s)
10yr wave/wind	*0*	N	15.12	0.44	2.1
	23	NNE	14.42	0.35	2.1
	45	NE	14.98	0.48	2.17
	68	ENE	20.57	0.69	2.32
	90	E	27.04	0.75	2.35
	113	ESE	31.55	0.53	2.1
	135	SE	27.68	0.47	1.84
	158	SSE	26.45	0.4	1.73
	180	S	20.27	0.26	1.56
	203	SSW	18.66	0.16	1.44

	225	SW	15.05	0.25	2.82
	248	WSW	13.89	0.45	2.41
	270	W	15.19	0.56	2.4
	293	WNW	14.84	0.3	1.93
	315	NW	13.73	0.34	2.1
	338	NNW	12.96	0.33	1.91
50yr wave/wind	*0*	N	20.13	0.61	2.27
	23	NNE	18.87	0.49	2.33
	45	NE	19.5	0.65	2.42
	68	ENE	28.41	1	2.66
	90	E	38.63	1.36	2.75
	113	ESE	44.27	0.83	2.44
	135	SE	33.44	0.6	1.97
	158	SSE	30.75	0.49	1.81
	180	S	23.07	0.31	1.64
	203	SSW	22.77	0.23	1.67
	225	SW	17.68	0.3	3
	248	WSW	16.9	0.55	2.61
	270	W	18.11	0.68	2.58
	293	WNW	17.46	0.4	2.1
	315	NW	17.33	0.32	2
	338	NNW	16.51	0.44	2.1

It should be noted that the return periods indicated for each wave parameter in Table 5 are representative of the boundary condition used to derive that value, not the value itself. Polar plots for maximum wave heights are presented in Figure 17 and Figure 18.

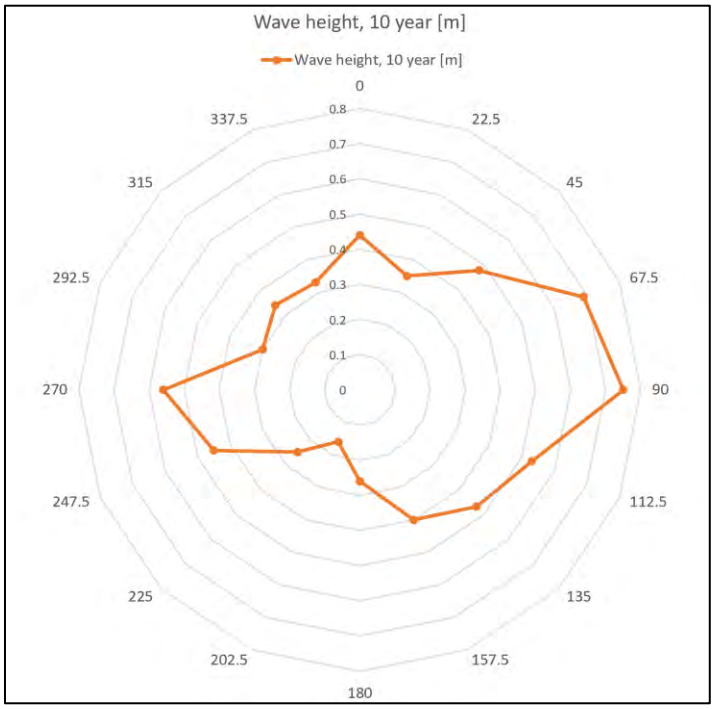


Figure 17 Maximum wave height at 10- year return period and direction [from]- Whycocomagh Bay - Marine Finfish Lease – 1431

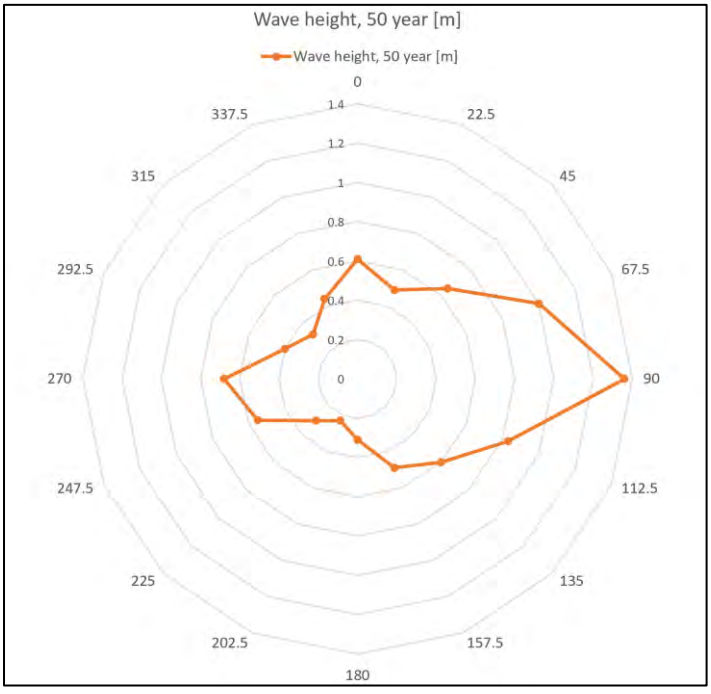


Figure 18 Maximum wave height at 50- year return period and direction [from]- Whycocomagh Bay - Marine Finfish Lease – 1431

4.4.5 Wave/wind conditions for Whycocomagh Bay - Marine Finfish Lease - 5010

The wave and wind results from the STWave model, for the Whycocomagh Bay - Marine Finfish Lease - 5010, are summarized in Table 6. Note that the results in Table 6 indicate significant wave height (Hs) and peak period (T_P) for the selected site. These represent the extreme wave conditions at this coordinate: 45° 58.626'N, 61° 1.685'W.

Table 6 Estimated wave and wind design conditions for Whycocomagh Bay - Marine Finfish Lease - 5010

Wave/Wind conditions	Direction [from] [°]		Wind (m/s)	Hs (m)	Tp (s)
10yr wave/wind	*0*	N	15.12	0.15	1.29
	23	NNE	14.42	0.12	1.3
	45	NE	14.98	0.29	2.35
	68	ENE	20.57	0.62	2.45
	90	E	27.04	0.91	2.69
	113	ESE	31.55	0.88	2.9
	135	SE	27.68	0.84	2.85
	158	SSE	26.45	0.84	2.61
	180	S	20.27	0.62	2.3
	203	SSW	18.66	0.45	2.26
	225	SW	15.05	0.44	2.1
	248	WSW	13.89	0.41	1.91
	270	W	15.19	0.24	1.63
	293	WNW	14.84	0.07	1.1
	315	NW	13.73	0.1	1.23
	338	NNW	12.96	0.1	1.25
50yr wave/wind	*0*	N	20.13	0.22	1.44
	23	NNE	18.87	0.18	1.58
	45	NE	19.5	0.39	2.62
	68	ENE	28.41	0.9	2.82
	90	E	38.63	1.4	3.17
	113	ESE	44.27	1.32	3.4
	135	SE	33.44	1.1	3.1
	158	SSE	30.75	1	2.79
	180	S	23.07	0.72	2.41
	203	SSW	22.77	0.57	2.48
	225	SW	17.68	0.53	2.2
	248	WSW	16.9	0.52	2.1

	270	W	18.11	0.3	1.72
	293	WNW	17.46	0.1	1.13
	315	NW	17.33	0.1	1.2
	338	NNW	16.51	0.14	1.33

It should be noted that the return periods indicated for each wave parameter in Table 6 are representative of the boundary condition used to derive that value, not the value itself. Polar plots for maximum wave heights are presented in Figure 19 and Figure 20.

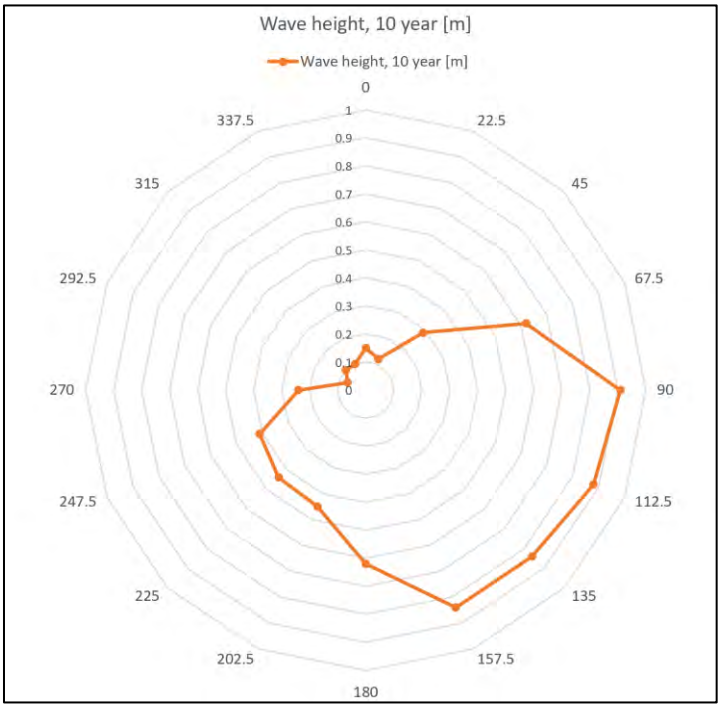


Figure 19 Maximum wave height at 10- year return period and direction [from]- Whycocomagh Bay - Marine Finfish Lease – 5010

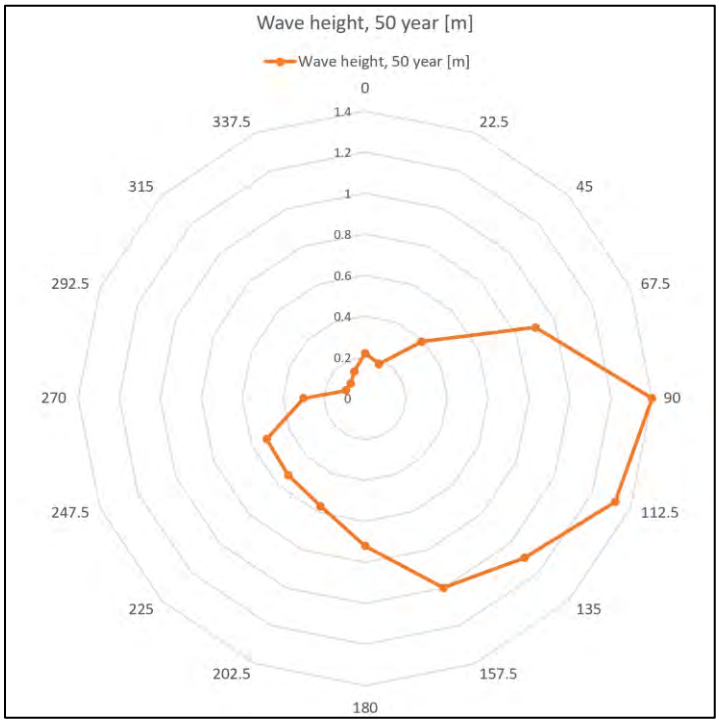


Figure 20 Maximum wave height at 50- year return period and direction [from]- Whycocomagh Bay - Marine Finfish Lease – 5010

4.4.6 Wave/wind conditions for Whycocomagh Bay - Marine Finfish Lease - 1430

The wave and wind results from the STWave model, for the Whycocomagh Bay - Marine Finfish Lease - 1430, are summarized in Table 7. Note that the results in Table 7 indicate significant wave height (Hs) and peak period (T_P) for the selected site. These represent the extreme wave conditions at this coordinate: 45° 58.699'N, 61° 1.472'W.

Table 7 Estimated wave and wind design conditions for Whycocomagh Bay - Marine Finfish Lease - 1430

Wave/Wind conditions	Direction [from] [°]		Wind (m/s)	Hs (m)	Tp (s)
10yr wave/wind	*0*	N	15.12	0.19	1.42
	23	NNE	14.42	0.11	1.24
	45	NE	14.98	0.27	2.33
	68	ENE	20.57	0.59	2.4
	90	E	27.04	0.87	2.63
	113	ESE	31.55	0.82	2.81
	135	SE	27.68	0.83	2.92
	158	SSE	26.45	0.85	2.66
	180	S	20.27	0.64	2.32

	203	SSW	18.66	0.45	2.3
	225	SW	15.05	0.42	2.1
	248	WSW	13.89	0.4	1.88
	270	W	15.19	0.22	1.52
	293	WNW	14.84	0.07	1.1
	315	NW	13.73	0.11	1.37
	338	NNW	12.96	0.13	1.35
50yr wave/wind	*0*	N	20.13	0.27	1.59
	23	NNE	18.87	0.18	1.5
	45	NE	19.5	0.36	2.59
	68	ENE	28.41	0.85	2.76
	90	E	38.63	1.34	3.1
	113	ESE	44.27	1.25	3.3
	135	SE	33.44	1.03	3.2
	158	SSE	30.75	1	2.84
	180	S	23.07	0.74	2.45
	203	SSW	22.77	0.58	2.5
	225	SW	17.68	0.51	2.2
	248	WSW	16.9	0.5	2
	270	W	18.11	0.27	1.61
	293	WNW	17.46	0.1	1.14
	315	NW	17.33	0.1	1.34
	338	NNW	16.51	0.18	1.5

It should be noted that the return periods indicated for each wave parameter in Table 7 are representative of the boundary condition used to derive that value, not the value itself. Polar plots for maximum wave heights are presented in Figure 21 and Figure 22.

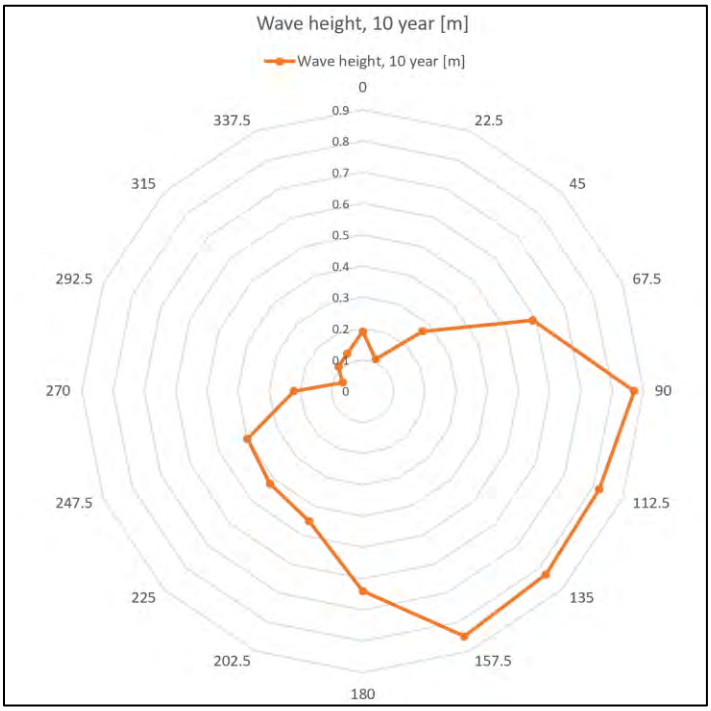


Figure 21 Maximum wave height at 10- year return period and direction [from]- Whycocomagh Bay - Marine Finfish Lease – 1430

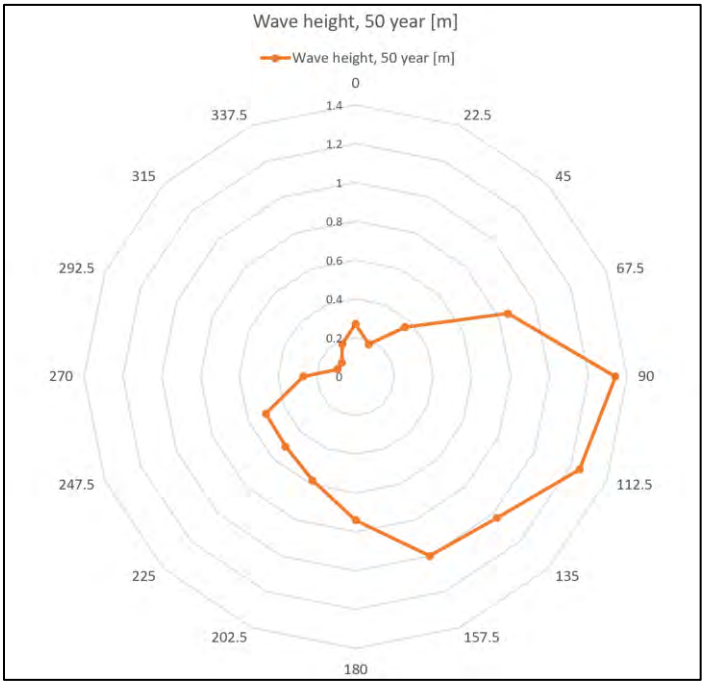


Figure 22 Maximum wave height at 50- year return period and direction [from]- Whycocomagh Bay - Marine Finfish Lease – 1430