CENTRE FOR MARINE APPLIED RESEARCH

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WIND AND WAVE CONDITIONS – DENAS POND & NYANZA BAY – MARINE FINFISH LEASES 0193, 0745

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Executive Summary

In support of Centre for Marine Applied Research (CMAR), the following report presents wind and wave conditions at two marine finfish leases at Denas Pond and Nyanza Bay in the Bras d'Or Lake, Nova Scotia, Canada.

In this report, wave and wind conditions are presented for 2 locations:

- Marine Finfish Lease - 0193: 46° 0.459'N, 60° 59.305'W.
- Marine Finfish Lease - 0745: 46° 5.155'N, 60° 53.548'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 Denas Pond and Nyanza Bay sites, a simple fetch calculator was used to model the wind-driven wave conditions inside the area, as compared with other sites in the province these locations are not exposed to ocean swell or extreme fetch. The results are based on wind conditions from a weather station located near Eskasoni which is located outside of the Denas Pond and Nyanza Bay area. The extreme wind-driven waves at the lease locations are presented in this report.

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1 Introduction

1.1 Overview

For the finfish lease locations in the Denas Pond and Nyanza 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 two locations.

Figure 1 Two (2) site locations near Denas Pond and Nyanza 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, a wave modelling is required to determine the amount of energy lost and wave height reduction. Note that a detailed wave modeling is not possible due to the lack of bathymetric data for the selected locations.

Figure 2 Denas Pond and Nyanza Bay, Nova Scotia, Canada- Source Point is the closest weather station to Denas Pond and Nyanza 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, 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 two locations near Denas Pond and Nyanza Bay Bay and find the conditions with 10- and 50- year return periods.

2 Abbreviations and acronyms

DSA	Dynamic Systems Analysis Ltd.
CMAR	Centre for Marine Applied Research

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

Only wind-driven waves considered for the wave modeling using the Norwegian fish farm standard NS9415.E:2009 [3]. Waves are assumed to fetch limited. Current-wave interaction was not included because local flow velocities are very small.

4.2 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 Denas Pond and Nyanza Bay fish farm sites. The scatter plot of wind speeds versus wind directions for the source point is also shown in Figure 3. Extreme winds at the Source Point appear to originate more frequently from the northeast and east.

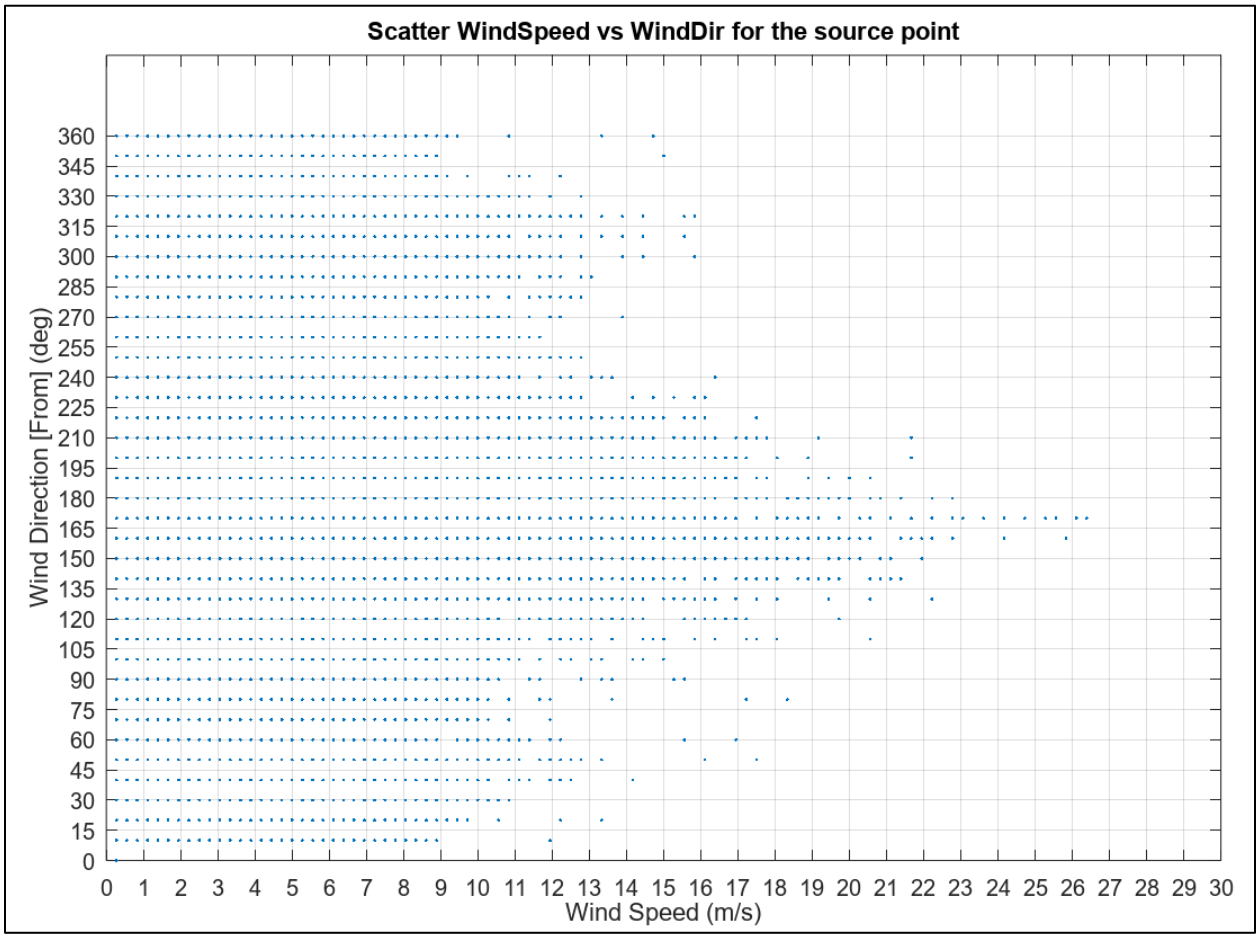
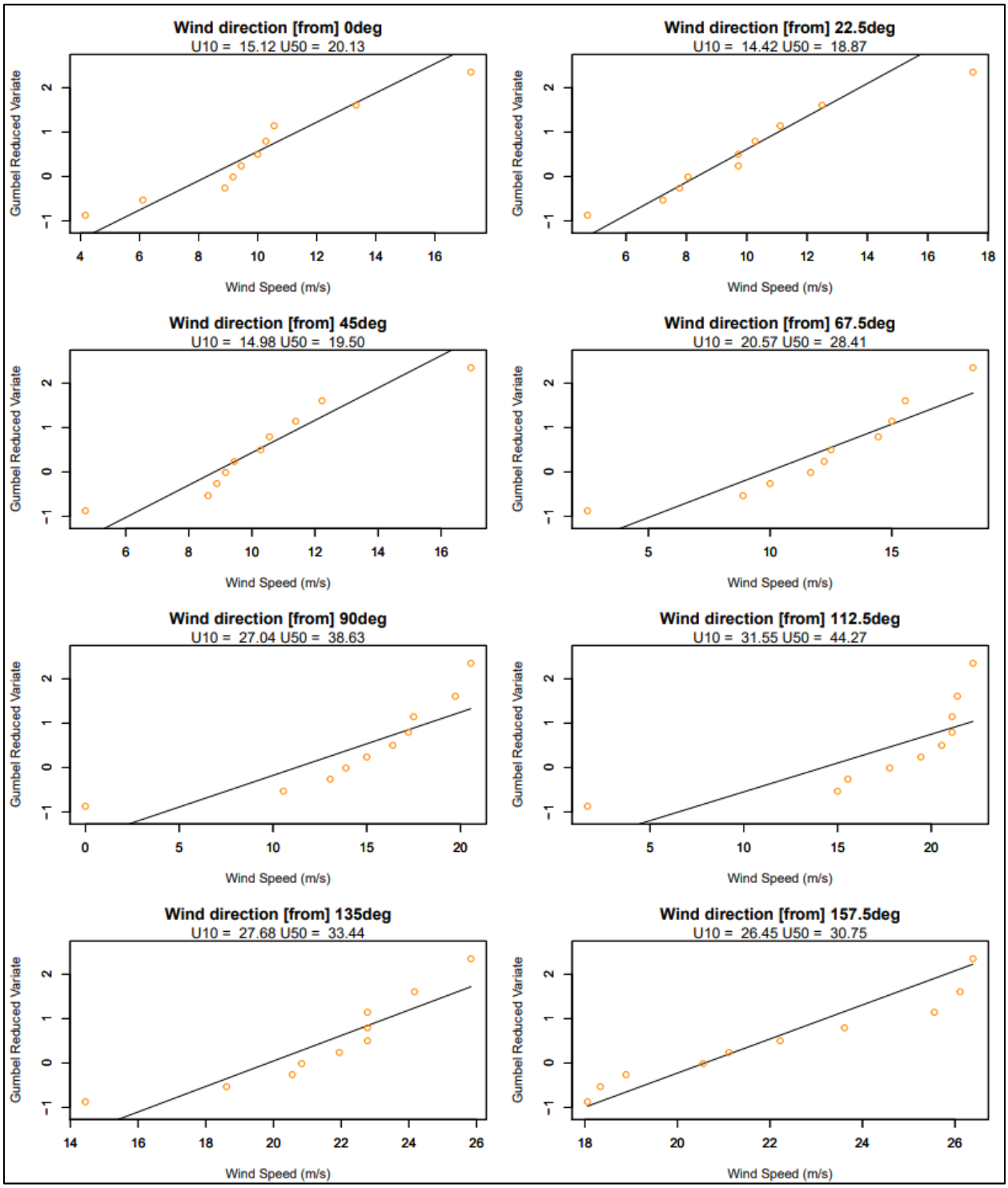


Figure 3 Wind speed versus wind direction plot for the Source Point

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 4. 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)

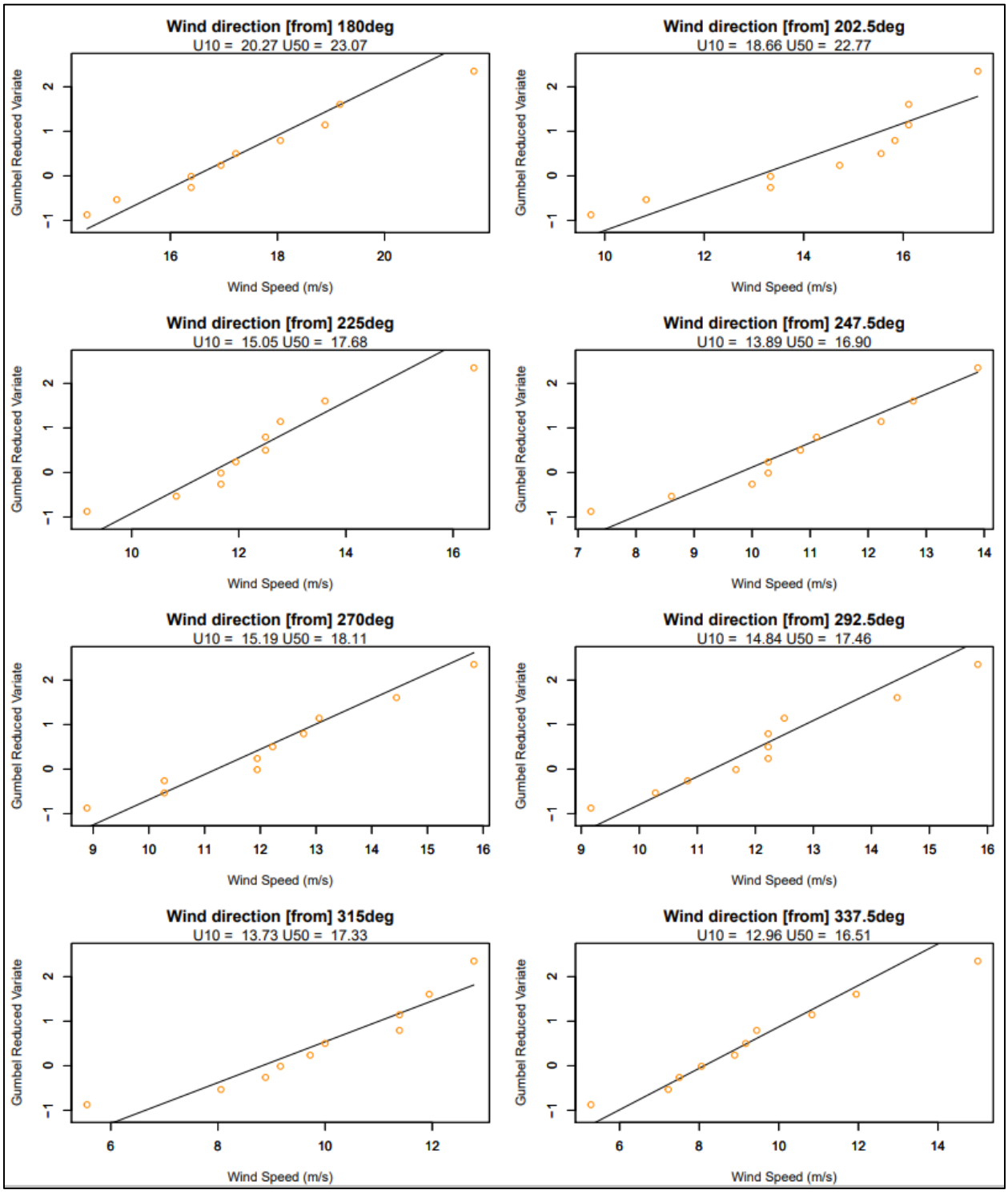


Figure 4: Extreme value analysis on wind data – for the Source Point [1]

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 5 and Figure 6, respectively.

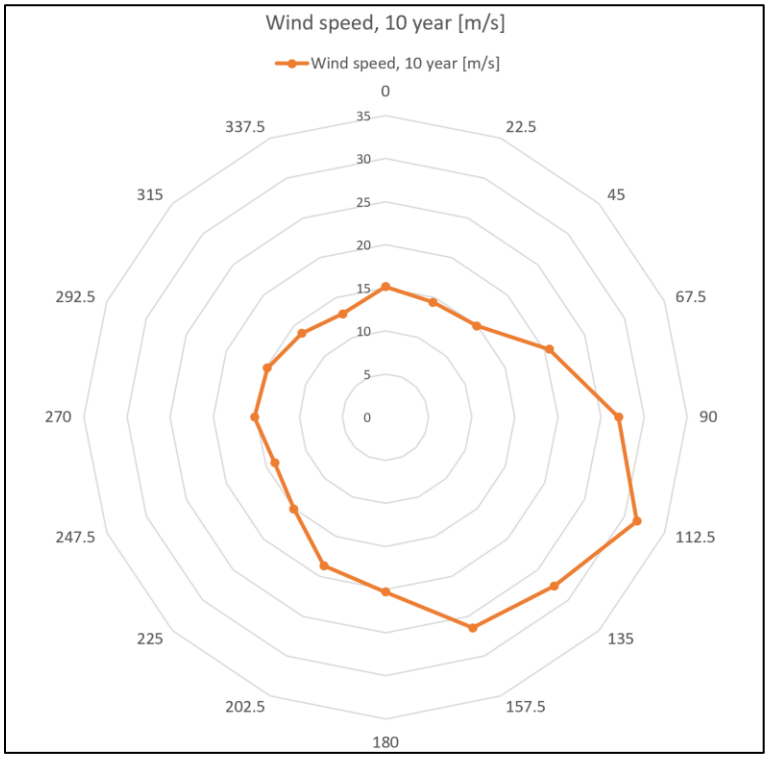


Figure 5 Maximum wind speed at 10- year return period and direction [from]- for Source Point location [1]

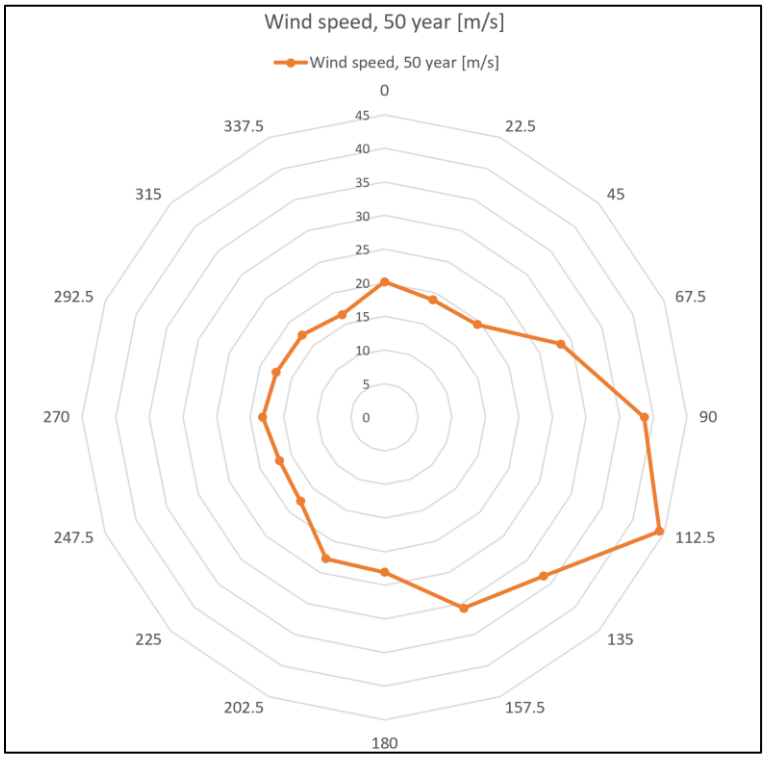


Figure 6 Maximum wind speed at 50- year return period and direction [from]- for Source Point location [1]

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 locations. This will provide reasonable design conditions; however, they cannot be linked directly to a return period at the site.

4.3 Wind/wave conditions for Denas Pond- Marine Finfish Lease- 0193

The wave and wind results from the wind generated waves, for the Marine Finfish Lease – 0193 at the Denas Pond, 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: 46° 0.459'N, 60° 59.305'W.

Table 2 Estimated wave and wind design conditions for Denas Pond– Marine Finfish Lease - 0193

Wave/Wind conditions	Direction [from] [°]		Wind (m/s)	Fetch (km)	Hs (m)	Tp (s)
10yr wave/wind	*0*	N	15.12	0.14	0.12	0.88
	23	NNE	14.42	0.27	0.16	1.07
	45	NE	14.98	0.32	0.18	1.15

	68	ENE	20.57	0.29	0.26	1.27
	90	E	27.04	0.28	0.35	1.41
	113	ESE	31.55	0.29	0.43	1.52
	135	SE	27.68	0.29	0.37	1.44
	158	SSE	26.45	0.42	0.42	1.60
	180	S	20.27	0.55	0.35	1.57
	203	SSW	18.66	1.25	0.47	1.99
	225	SW	15.05	1.26	0.36	1.83
	248	WSW	13.89	0.42	0.19	1.23
	270	W	15.19	0.10	0.10	0.79
	293	WNW	14.84	0.09	0.10	0.75
	315	NW	13.73	0.12	0.10	0.80
	338	NNW	12.96	0.14	0.10	0.83
50yr wave/wind	*0*	N	20.13	0.14	0.17	0.99
	23	NNE	18.87	0.27	0.22	1.20
	45	NE	19.50	0.32	0.25	1.29
	68	ENE	28.41	0.29	0.38	1.45
	90	E	38.63	0.28	0.54	1.63
	113	ESE	44.27	0.29	0.65	1.74
	135	SE	33.44	0.29	0.46	1.55
	158	SSE	30.75	0.42	0.50	1.70
	180	S	23.07	0.55	0.40	1.65
	203	SSW	22.77	1.25	0.60	2.16
	225	SW	17.68	1.26	0.44	1.95
	248	WSW	16.90	0.42	0.24	1.33
	270	W	18.11	0.10	0.13	0.85
	293	WNW	17.46	0.09	0.12	0.81
	315	NW	17.33	0.12	0.13	0.88
	338	NNW	16.51	0.14	0.14	0.91

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 7 and Figure 8.

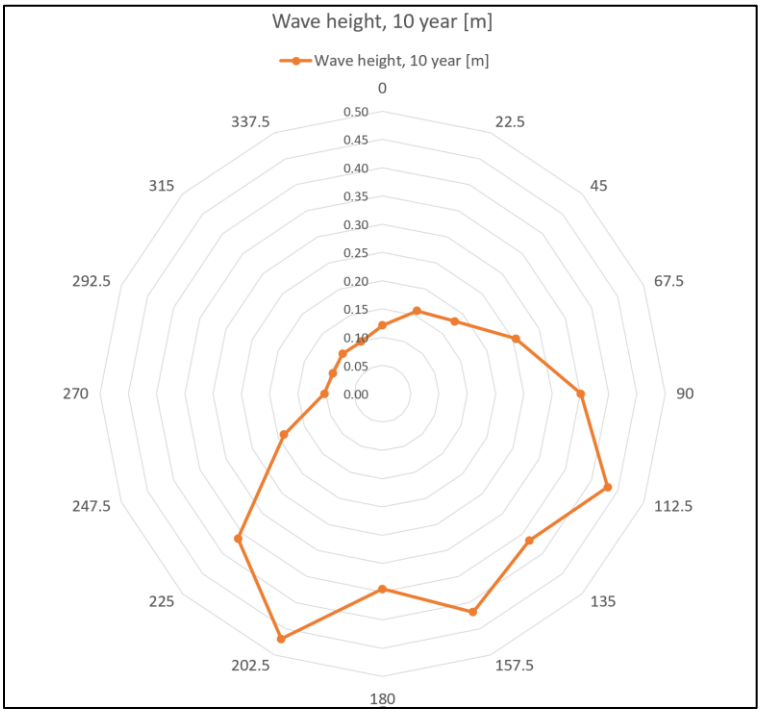


Figure 7 Maximum wave height at 10- year return period and direction [from]- Denas Pond–Marine Finfish Lease - 0193

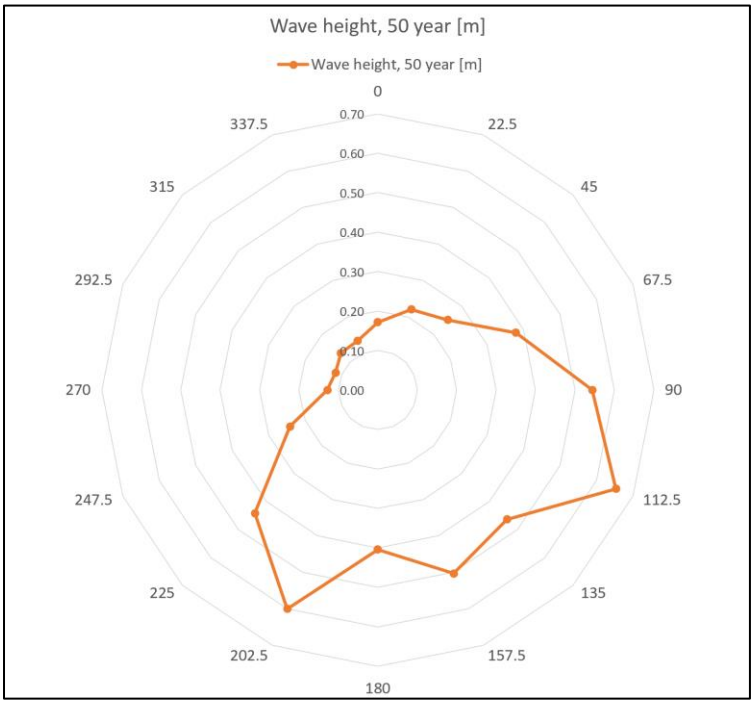


Figure 8 Maximum wave height at 50- year return period and direction [from]- Denas Pond–Marine Finfish Lease – 0193

4.4 Wind/wave conditions for Nyanza Bay- Marine Finfish Lease- 0745

The wave and wind results from the wind generated waves, for the Marine Finfish Lease – 0745 at the Nyanza Bay, 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: 46° 5.155'N, 60° 53.548'W.

Table 3 Estimated wave and wind design conditions for Nyanza Bay - Marine Finfish Lease – 0745

Wave/Wind conditions	Direction [from] [°]		Wind (m/s)	Fetch (km)	Hs (m)	Tp (s)
10yr wave/wind	*0*	N	15.12	0.43	0.213	1.28
	23	NNE	14.42	0.58	0.233	1.39
	45	NE	14.98	1.51	0.394	1.94
	68	ENE	20.57	2.06	0.679	2.45
	90	E	27.04	2.44	1.035	2.9
	113	ESE	31.55	1.5	0.981	2.62
	135	SE	27.68	1.22	0.753	2.32
	158	SSE	26.45	1.75	0.853	2.57
	180	S	20.27	4.53	0.989	3.16
	203	SSW	18.66	5.37	0.973	3.23
	225	SW	15.05	1.97	0.452	2.12
	248	WSW	13.89	1.45	0.352	1.85
	270	W	15.19	0.75	0.282	1.54
	293	WNW	14.84	0.45	0.212	1.29
	315	NW	13.73	0.41	0.184	1.21
	338	NNW	12.96	0.43	0.176	1.2
50yr wave/wind	*0*	N	20.13	0.43	0.302	1.44
	23	NNE	18.87	0.58	0.324	1.55
	45	NE	19.50	1.51	0.545	2.16
	68	ENE	28.41	2.06	1.011	2.79
	90	E	38.63	2.44	1.605	3.35
	113	ESE	44.27	1.5	1.488	3.01
	135	SE	33.44	1.22	0.95	2.51
	158	SSE	30.75	1.75	1.027	2.73
	180	S	23.07	4.53	1.16	3.33
	203	SSW	22.77	5.37	1.243	3.51
	225	SW	17.68	1.97	0.551	2.27
	248	WSW	16.90	1.45	0.448	2.01

	270	W	18.11	0.75	0.35	1.66
	293	WNW	17.46	0.45	0.26	1.38
	315	NW	17.33	0.41	0.245	1.33
	338	NNW	16.51	0.43	0.237	1.33

It should be noted that the return periods indicated for each wave parameter in The wave and wind results from the wind generated waves, for the Marine Finfish Lease – 0745 at the Nyanza Bay, 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: 46° 5.155'N, 60° 53.548'W.

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 9 and Figure 10.

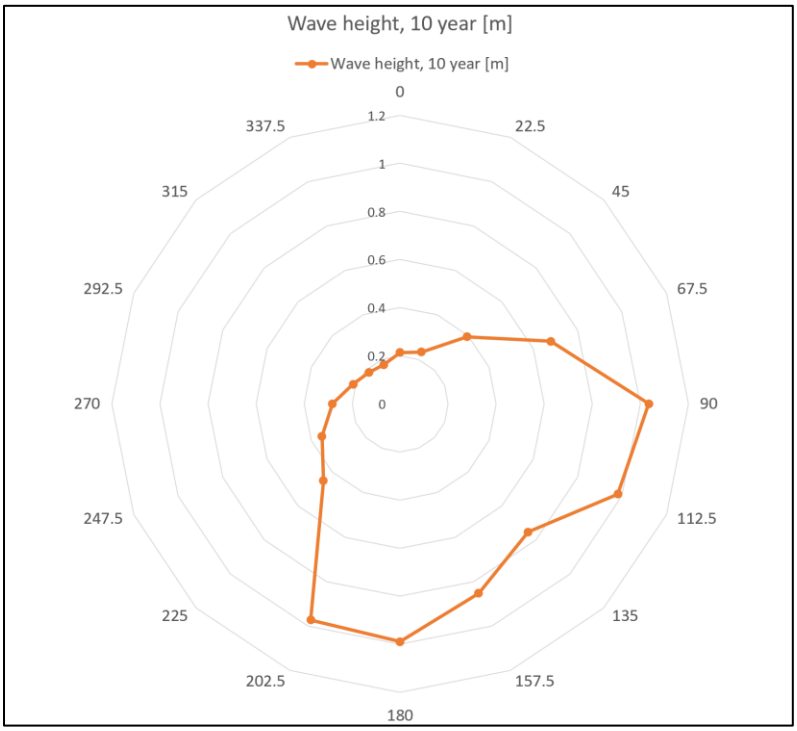


Figure 9 Maximum wave height at 10- year return period and direction [from]- Nyanza Bay - Marine Finfish Lease – 0745

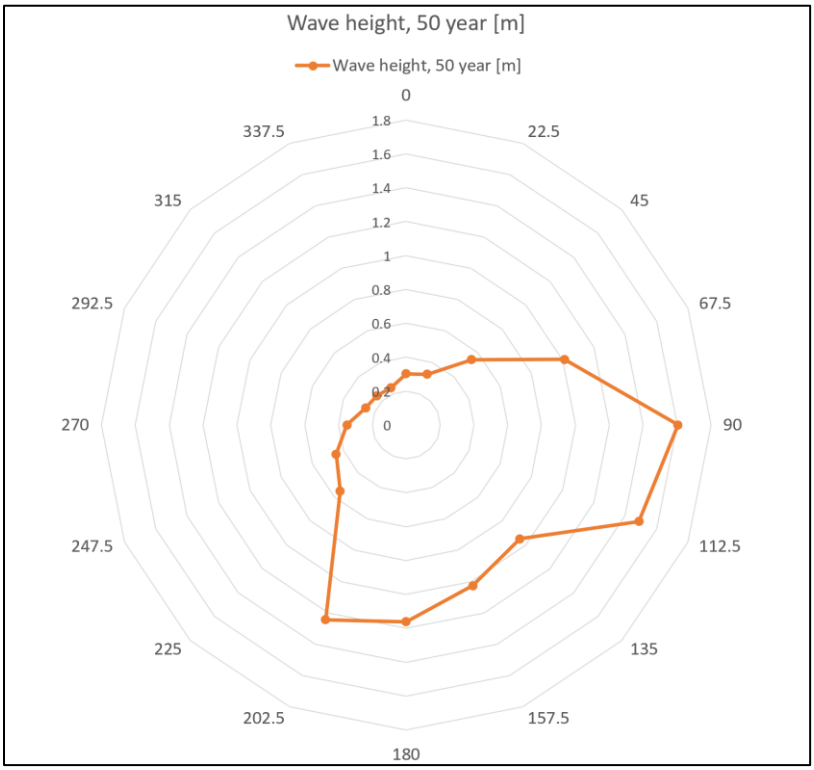


Figure 10 Maximum wave height at 50- year return period and direction [from]- Nyanza Bay - Marine Finfish Lease – 0745