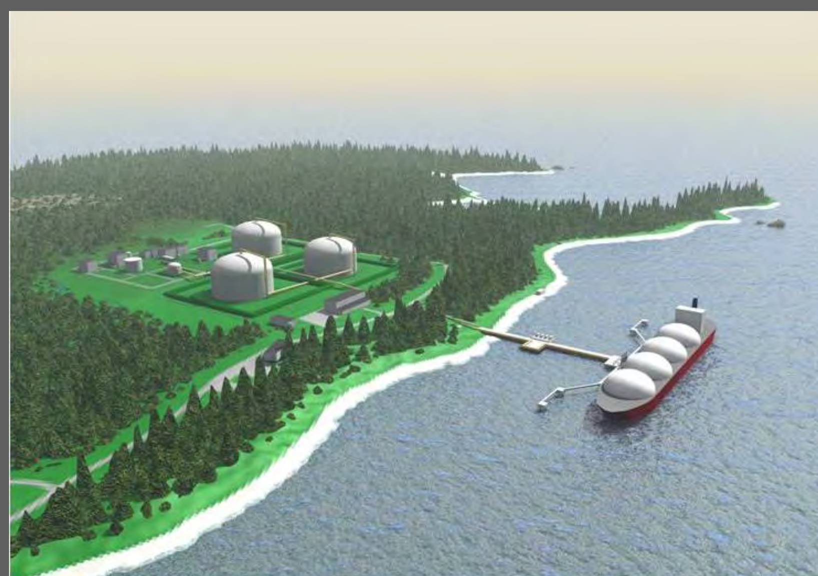
APPENDIX D

Metocean Study (CBCL 2015)

Bear Head LNG Terminal

2015 Metocean Study



140672.00 ● Draft Report ● January 2015

ISO 9001
Registered Company

Prepared for:
Bear Head LNG

Prepared by:
CBCL LIMITED
Consulting Engineers

CRRC

622560-0001-EXT-REP-0019

Draft Report	Randy Thorpe	01/09/2015	Vincent Leys
Issue or Revision	***Reviewed By:***	***Date***	***Issued By:***

CBCL LIMITED
Consulting Engineers

ISO 9001
Registered Company

Contents

CHAPTER 1 INTRODUCTION

This report presents the updated metocean study at the proposed Bear Head LNG Terminal in support of detailed engineering design. The project area is shown in Figure 1. The initial metocean study and design was conducted in 2006.

A description of wind, wave, current and water level parameters is given in sections 2 to 5. Recommended design current velocities are as per the 2006 study. Extreme water levels, wind and wave parameters were revised based on updated datasets and numerical models. The methodology is based on a combination of historical observations, site-specific observations and modeling. For each metocean parameter, the methodology for deriving extremes and associated results are described in the following chapters.

We note that this report gives extreme values for various return periods. Probability of occurrence for various return periods and design life is shown on Table 1. It is assumed that the choice of a particular return period if applicable will be made during the following design iterations. In the 2006 design iteration it was assumed that the project lifetime would be 30 years.

Table 1: Probability of occurrence for various return periods and design life

Return period [years]	Design life [years]		
	30	50	100
10	96%	99%	100%
50	45%	64%	87%
100	26%	39%	63%
200	14%	22%	39%

CHAPTER 2 WINDS

2.1 Historical Observations

Available wind data for the Project area are comprised of measurements obtained from Environment Canada at several sites in the Strait of Canso area, a long-term wind-wave offshore hindcast ('MSC50' covering years 1954 to 2013), and design parameters from the National Building Code in Port Hawkesbury. Location and time duration of the datasets are listed in Table 2.1. A comparison of MSC50, the longest dataset available, vs. Eddy Point, the dataset closest to the project site, is shown on Figure 2.1 (directional statistics) and Figure 2.2. The datasets are well correlated in speed and direction. As expected, extreme wind speeds at Eddy Point are somewhat weaker than those offshore from MSC50. However the Eddy Point dataset may not exhibit the influence of the funneling effect of the Strait, which may increase wind speeds and would likely be felt at the Project site.

Table 2.1: Available Wind Data

Type / Source of Data	Site	Distance from Project Site, km	Length of Record, Years
MSC50 Offshore model hindcast	Lat. 45.5 N Lon. 61.1 W	15	59 (1954-2013)
National Building Code (NRC) extreme winds (100, 50 and 10-year return)	Port Hawkesbury	9	N/A
Hourly observations from Environment Canada weather stations	Port Hawkesbury	9	2.2
	Hart Island	40	18.8
	Eddy Point	6	13.3
	Port Hastings Canal	14	11.2
	Canso	35	1

2.2 2006 Observations during Field Program

Available wind observations concurrent to the winter wave and current data collection program were obtained from two local sources: (1) the anemometer from Statia Terminals 3.5 km from the Project site, and (2) the Environment Canada weather station at Hart Island near Canso. Hourly wind data from both sources is presented in Figure 2.3. Maximum hourly speed observed during the monitoring program occurred on the 22 January 2006 storm, when recorded winds peaked at 22 and 25 m/s at Hart Island and Statia Terminals, respectively. The two datasets are generally consistent.

2.3 Extreme Values for Design

All wind speed values given in the present section are at 10m elevation.

2.3.1 Mooring Design

A design hourly wind speed of 23.3 m/s (equivalent to a 30-sec gust of 30.9 m/s or 60 kts) was specified in the design basis addendum A-5 as the maximum wind condition for berthing. This design parameter was subsequently used to derive wave conditions for mooring design.

2.3.2 Marine Structure Design

The NBC extreme values for Port Hawkesbury were deemed the most appropriate design parameters for the site after consultation with Environment Canada. Notably, it is expected the values account for potential local funneling effects along the Strait. The NBC values are higher than extremes that would be obtained from extreme value analyses on either the MSC50 (offshore) or the Eddy Point dataset, and are therefore believed to be conservative enough. These values were subsequently used to derive extreme wave conditions for design.

Table 2.2: Extreme Wind Speeds at Port Hawkesbury – Source: National Building Code

Return period, years	100	50	10
Hourly wind speed, m/s	35.2	33.8	29.7
30-second gust speed, m/s	46.6	44.7	39.3

CHAPTER 3 CURRENTS

3.1 Historical Observations

Local data was collected by DFO in the 1970's and early 1980's at several sites including in Chedabucto Bay, in the Strait entrance between Bear Head and Melford Point, and up the Strait past Wright Point. Less data was acquired during the winter months, when the strongest storm-driven currents are most likely to be observed.

Directional statistics for a 40 m-deep site in the Strait entrance are presented in Figure 3.1. As expected, current direction is generally aligned with the Strait. The data indicates peak values at 8 m depth of 0.3 to 0.6 m/s, with typical values from 0.1 to 0.2 m/s. Measured current strength decreases with depth, with peak values at 23 m deep from 0.1 to 0.3 m/s and typical values from 0.05 to 0.1 m/s. In addition, residual current values indicate a weak estuarine circulation pattern, with a down-strait mean surface drift of 0.08 m/s and a mean up-strait drift near the bottom of 0.01 m/s approximately.

Tidal analyses conducted on the above dataset reveal that the tide accounts for only 10 to 20% of the total variance, the remainder of the energy being due to winds and low-frequency coastal circulation patterns. The maximum current due to tides only is expected to be 0.2 m/s. Time-series analyses of de-tided current vs. winds measured at Eddy Point show significant correlation, as illustrated in Figure 3.2. Notably, the analysis suggest that the generally accepted practice to represent wind-induced surface currents as 3% of the wind speed is appropriate for the present analyses (UK HSE, 2001).

3.2 2006 ADCP Observations

3.2.1 General Description

Current, wave and wind data were collected at the site from 16 December 2005 to 16 March 2006. An Acoustic Doppler Current Profiler (ADCP) covering the whole water column was deployed at the unloading platform site in 20.5 m water depth (rel. to Chart Datum). The instrument used was a RD Instruments 600 kHz ADCP Waves Array set on a bottom mount frame. The 600 kHz Waves Array is capable of collecting water level, wave and current data simultaneously. Importantly, current data was captured throughout the complete water column and averaged every 15 minutes in 1 m bins, which allow for the derivation of site-specific current profiles. A first dataset was recovered on 25 January 2006, and the instrument was serviced and redeployed for a 2-month duration until 16 March 2006. The instrument performed to expectations and 100 % of the data was recovered. The dataset was used to calibrate the wave model and establish design parameters developed for the mooring and structural components.

The data was found to be of very good quality. A summary of the complete current speed and direction dataset is shown on Figure 3.3. The plot shows current distribution and variability with depth. Currents below 5 m depth are generally weak, i.e. less than 0.1 m/s. The maximum surface current observed was 0.65 m/s. Directional statistics ('current roses') are shown in Figure 3.4 at four representative depths. As expected, currents are generally aligned with the coastline, particularly in the deeper sections where the wind influence is less.

3.2.2 Tidal Analyses

Tidal analyses were conducted on the data and confirmed tidal currents are weak, accounting for less than 30 % of the total energy. The maximum near-surface tidal current was estimated at 0.17 m/s which is consistent with the 0.2 m/s observation from historical DFO data. The maximum tidal current to be expected at each depth is listed in Table 3.1.

3.2.3 Wind-driven Currents

As expected, surface currents are mostly wind-driven and tidal currents are weak. The assumed "3%-of-the-wind" correlation between surface currents and local winds was confirmed particularly for along-strait velocities (Figure 3.5), and the rule is conservative enough when applied to the ADCP dataset using the winds from MSC50.

3.2.4 Current Profiles

Statistics for each depth are presented in Table 3.1, and shown graphically in Figure 3.6. In general, near-surface currents (typically around 0.2 m/s) drop to less than half of their value below mid depth, where typical current speed is less than 0.1 m/s. However on one occasion (January 27th 2006), stronger-than-average (0.15 to 0.2 m/s) depth-uniform northwestward currents were observed. The event is visible on Figure 3.3, and corresponded to a strong southeasterly wind (~15 to 20 m/s hourly speed) which did not have much influence on the near-surface currents. This type of event is typically due to a wind-driven large-scale coastal circulation pattern that cannot be predicted or modelled with confidence.

Table 3.1: Current Statistics for each Depth Bin – Based on Complete Dataset from 16 Dec 2005 to 16 March 2006

Measurements																Max. tidal current from tidal analyses
Depth rel to CD	Average speed	Max current		Mean current		Most frequent direction	Frequency of occurrence, %									
		Speed	Direc To	Speed	Direc To	To	Current speed bins, m/s									
m	m/s	m/s	deg.	m/s	deg.		0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	0.5-0.6	0.6-0.7	missing		m/s
0.5	0.18	0.65	308	0.071	89.2	SE	24.3	14.5	8.1	3.0	1.8	0.8	0.10	47.3		0.17
1.5	0.10	0.66	120	0.029	105	SE	55.9	24.9	4.4	1.0	0.4	0.1	0.02	13.2		0.16
2.5	0.07	0.35	290	0.018	70.2	SE	68.8	17.7	0.8	0.01	0	0	0	12.6		0.14
3.5	0.07	0.31	103	0.012	80.4	SE	77.6	18.6	1.3	0.01	0	0	0	2.5		0.13
4.5	0.06	0.30	104	0.009	102	SE	83.6	15.4	0.9	0	0	0	0	0.05		0.13
5.5	0.06	0.29	104	0.009	86.6	SE	85.9	13.4	0.7	0	0	0	0	0.03		0.13
6.5	0.05	0.28	104	0.007	84.6	SE	87.9	11.6	0.5	0	0	0	0	0.02		0.11
7.5	0.05	0.26	104	0.005	80.3	SE	88.8	10.8	0.4	0	0	0	0	0.01		0.11
8.5	0.05	0.25	282	0.004	67.3	SE	89.5	10.2	0.4	0	0	0	0	0.01		0.11
9.5	0.05	0.24	112	0.003	40.5	NW	90.1	9.6	0.3	0	0	0	0	0.01		0.11
10.5	0.05	0.25	285	0.003	6.32	NW	90.7	9.0	0.3	0	0	0	0	0.01		0.11
11.5	0.05	0.25	284	0.004	348	NW	90.9	8.7	0.3	0	0	0	0	0.01		0.11
12.5	0.05	0.26	287	0.005	335	NW	91.0	8.7	0.3	0	0	0	0	0.01		0.10
13.5	0.05	0.26	287	0.007	327	NW	91.0	8.6	0.4	0	0	0	0	0		0.10
14.5	0.05	0.25	289	0.008	318	NW	91.0	8.5	0.4	0	0	0	0	0		0.10
15.5	0.05	0.25	290	0.010	314	NW	91.3	8.2	0.5	0	0	0	0	0		0.09
16.5	0.05	0.26	291	0.011	309	NW	91.3	8.1	0.6	0	0	0	0	0		0.09
17.5	0.05	0.24	294	0.013	306	NW	91.2	8.4	0.4	0	0	0	0	0		0.09
18.5	0.05	0.25	300	0.014	303	NW	91.6	8.0	0.4	0	0	0	0	0		0.08
19.5	0.05	0.25	300	0.022	299	NW	88.4	11.0	0.6	0	0	0	0	0		0.07
20.5	0.05	0.24	301	0.022	296	NW	88.2	11.3	0.5	0	0	0	0	0		0.08
21.5	0.05	0.25	303	0.022	294	W	88.6	10.9	0.5	0	0	0	0	0		0.08
22.5	0.05	0.25	305	0.022	292	W	88.7	11.0	0.3	0	0	0	0	0		0.08
23.5	0.05	0.24	96.6	0.021	289	W	89.6	10.2	0.2	0	0	0	0	0		0.08
24.5	0.05	0.24	98.6	0.020	284	W	90.5	9.4	0.1	0	0	0	0	0		0.07

3.3 Extreme Values for Design

Extreme values for current velocities are listed in Table 3.2, for both mooring and marine structure design purposes. The values are broken down by component.

Table 3.2: Extreme Current Velocities for Design

	Mooring Design	Marine Structure Design	Source /Methodology
Surface to mid-depth			
Maximum tidal current	0.2		DFO historical observations in Strait entrance confirmed by 2006 ADCP data
Extreme storm surge current	N/A (no berthing during extreme storm)	0.14	Estimated as the max. tidal current weighed by the ratio of extreme surge level over maximum tidal level. The assumed extreme surge level is 1.5 m, i.e. the storm surge level measured in Halifax Harbour during Hurricane Juan which is thought to be representative of 100-year event.
Mean current	0.08		DFO historical observations in Strait entrance confirmed by 2006 ADCP data
100-year extreme tidal + wind-driven current	0.75	0.75	For design purposes, a 50-year time-series of hindcast currents was constructed as the vector sum of [tidal current + 3% wind component from MSC50]. Extreme value analyses were conducted on the current hindcast.
Total extreme velocity	0.83	0.97	= Extreme surge + Mean + [Extreme tidal+wind]
1 m above bottom	0.65	0.70	Based on the 1/7th power law profile (UK HSE, OTO 2001/010 guidelines) by fitting a profile to the extreme near-surface surface current made of wind, tidal, mean and surge component. This conservative approach is warranted by the complexity of the processes shaping vertical current structure. Under average conditions, currents in the Strait vary vertically and form a 2 to 3-layer structure due to density differences and relatively weak tides. During the Jan. 27th 2006 storm the current at 20 m deep peaked at 0.25 m/s.

CHAPTER 4 **WAVES**

4.1 Offshore Wave Climate

The proposed terminal site is sheltered from much of the ocean wave activity, and exposed to local wind-wave growth from the Southeast (the longest fetch direction being 5.5 km), and to a lesser extent, the Northwest. Offshore wave climate from an MSC50 hindcast point outside Chedabucto Bay is presented in Figure 4.1, showing offshore height vs. period.

4.2 2006 ADCP Observations

Summary data plots are presented in Figure 4.2. The results confirm that the site is very well sheltered from long period swells and the local wave climate is predominantly wind-driven. The maximum significant wave height 'Hsig' measured was 0.87 m during the 22 January storm, when hourly winds recorded at Statia Terminals peaked at 25 m/s. Maximum peak periods measured at the site for heights greater than 0.3 m are close to 4 seconds. Summary statistics on significant wave height (Hs) and peak period (Tp) are presented in Table 4.1.

Table 4.1 Hs-Tp Joint Occurrence Statistics – 16 Dec 2005 to 16 March 2006
Values are given as %.

	Tp bins, sec						
Hs bins, m	2-3	3-4	4-6	6-8	8-10	>10	Total
0.8-0.9	0	0.11	0	0	0	0	0.11
0.7-0.8	0	0.03	0	0	0	0	0.03
0.6-0.7	0	0.22	0	0	0	0	0.22
0.5-0.6	0.03	0.40	0	0	0	0	0.43
0.4-0.5	0.05	0.49	0	0	0	0	0.54
0.3-0.4	0.35	1.00	0.03	0.03	0	0	1.40
0.2-0.3	1.94	1.46	0.54	0.08	0	0	4.02
0.1-0.2	8.10	6.23	3.05	0.78	0.11	0.08	18.35
0-0.1	25.24	24.97	4.18	1.81	8.39	10.09	74.68
Total	35.71	34.90	7.80	2.70	8.50	10.18	100

4.3 Numerical Modeling

The 2006 observations were used to calibrate a numerical wave model driven by MSC50 data at the open ocean boundary and Hart Island wind observations. We used the 2014 version of MIKE21 SW, which is an industry-standard near-shore spectral wave propagation model available from the Danish Hydraulic Institute. The model uses a finite element mesh (Figure 4.3) to simulate the effects of depth-induced wave refraction and shoaling, depth- and steepness-induced wave breaking, diffraction, wind-wave growth, and wave-wave interaction and white capping that redistribute and dissipate energy in a growing wave field.

Modeled vs. observed significant wave heights are shown on Figure 4.4. The best fit for storm peaks was obtained by adjusting the wind drag coefficient, using an uncoupled air-sea interaction with a Charnock parameter of 0.01 (DHI 2014, MIKE21 SW Technical Documentation).

4.4 Extreme Values for Design

Extreme wave parameters at the site were developed using the calibrated model run in steady state mode for a set of case-specific wind speeds. Sample model results are shown on Figure 4.5.

Case	Wind Speed [m/s]	Hsig [m]	Tp [s]
Mooring design	23.3	1.1	3.9
Marine structure design			
10-year return	29.7	1.6	4.4
50-year return	33.8	1.9	4.7
100-year return	35.2	2.1	4.8

CHAPTER 5 WATER LEVELS

The extreme water level was estimated as the sum of high tide, storm surge, wave crest height and sea level rise, as detailed below.

5.1 Highest High Water Large Tide (HHWLT)

At Point Tupper, HHWLT = 2.0 m above Chart Datum (source: CHS Chart 4302). Hydrodynamic modeling using DHI MIKE21 HD confirms that the Point Tupper value is applicable to Bear Head.

5.2 2006 ADCP Observations

Instrument depth below surface was recorded by the instrument's pressure sensor. Results are shown on Figure 5.1. Tidal analyses on the data confirm a 2.0 m tidal range, and therefore the 2.0 m value adopted for Higher High Water Large Tide.

5.3 Storm Surge

For Canso Harbour and adjacent areas, Richards and Daigle (2011) recommend using 0.95 m (± 0.20 m) for the 100-year storm surge residual on top of the HHWLT.

5.4 Sea Level Rise

Sea Level Rise (SLR) along eastern Canada's coast has been occurring since the end of the last ice age, about 10,000 years ago. The rate of global mean SLR is accelerating in the 21st century due to global warming impacts, notably the melting of polar ice caps. The Intergovernmental Panel on Climate Change (IPCC AR5, 2013) indicates that the current consensus is as follows:

- The *likely* range of global mean SLR for 2081-2100 relative to 1986-2005 was estimated from 0.26 m (lower bound value for low emission scenario) to 0.98 m (higher bound estimate for high emission scenario);
- There is currently insufficient evidence to evaluate the probability of specific levels above the assessed *likely* range; and
- There will be regional differences, with the northeastern coast of North America potentially experiencing a SLR rate higher than the global average.

Site-specific sea level rise allowances were recently developed by DFO based on emissions scenarios from IPCC AR5 (Zhai et al 2014). For an assumed project life of 30 years, we used the high emissions scenario ('RCP 8.5') to year 2050, which results in a recommended sea level rise allowance of 0.38 m for Halifax and 0.41 m for North Sydney, rounded to 0.4 m for the present project.

5.5 Design Still Water Level (SWL)

The design SWL was calculated as:
HHWLT + storm surge + 30-year sea level rise = 2.0 + 1.15 + 0.4 = 3.55 m.

5.6 Extreme Wave Crest Height

Estimating crest heights in coastal areas is hindered by the fact that shallow water causes significant asymmetry in the wave profiles. Coastal field measurements indicate that maximum crest height above the still water level can be up to 80% of the maximum wave height (USACE Coastal Engineering Manual, 2002). The stream function wave theory is commonly used to provide an estimate of asymmetric wave profiles in shallow water. The method for deriving extreme crest heights was as follows:

1. The 100-year maximum wave height at the unloading platform in 20 m depth was using the relationship Hmax = 1.96*Hsig (inferred from an assumed Rayleigh wave height distribution over a 3-hour duration with peak period of 4.8 s). For shallower bent sites along the trestle, Hmax was taken as the breaking wave height calculated using the Fenton breaking criteria that accounts for both wave steepness and water depth (USACE 2012).

2. The 100-year crest height was derived using the stream function wave theory applied to selected bent sites along the trestle of varying water depth. Inputs to the stream function calculation include: Hmax, T=4.8s, and water depth = depth CD + design SWL

Table 5.1: 100-Year Extreme Waves and Water Levels at Selected Bent Sites Along the Trestle

Site	Unloading platform	Bent 5	Bent 4	Bent 3	Bent 2	Bent 1 (abutment)
100-year Hmax [m]	4.1	4.0	3.9	3.8	3.7	2.4
Waves breaking?	no	no	no	no	yes	yes
Water depth [m CD]	17	15	8	6	3	0
Extreme still water depth [m]	20.6	18.6	11.6	9.6	6.6	3.6
100-yr Hcrest [m]	2.5	2.4	2.4	2.4	2.4	1.7
Extreme water level [m CD] = SWL + Hcrest	5.9	5.8	5.8	5.7	5.8	5.0

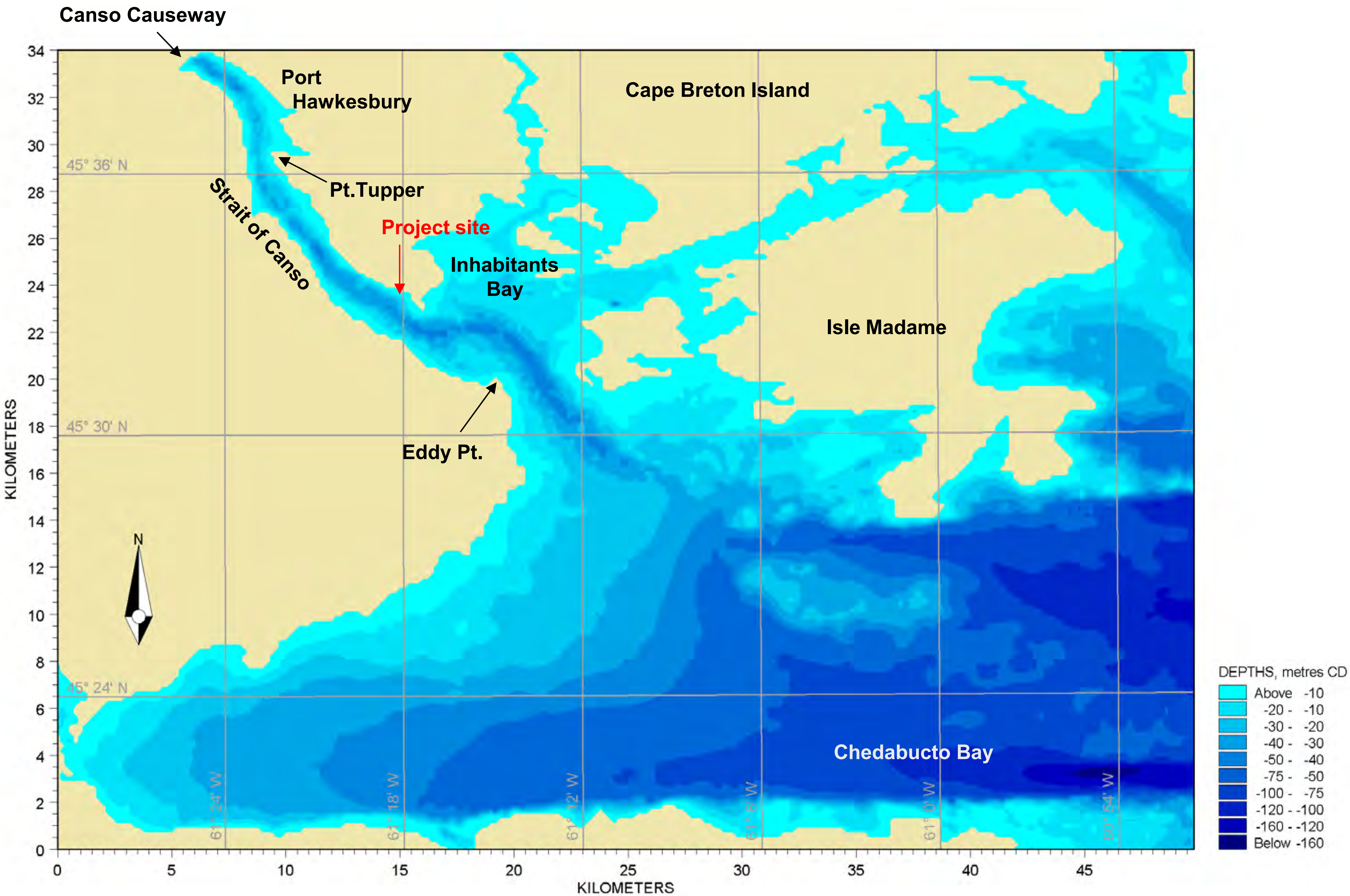
Draft Report *Draft Report*

Prepared by:
Vincent Leys, M.Sc., P.Eng.
Coastal Engineer

Reviewed by:
Randy Thorpe, P.Eng.
Senior Electrical Engineer

APPENDIX A

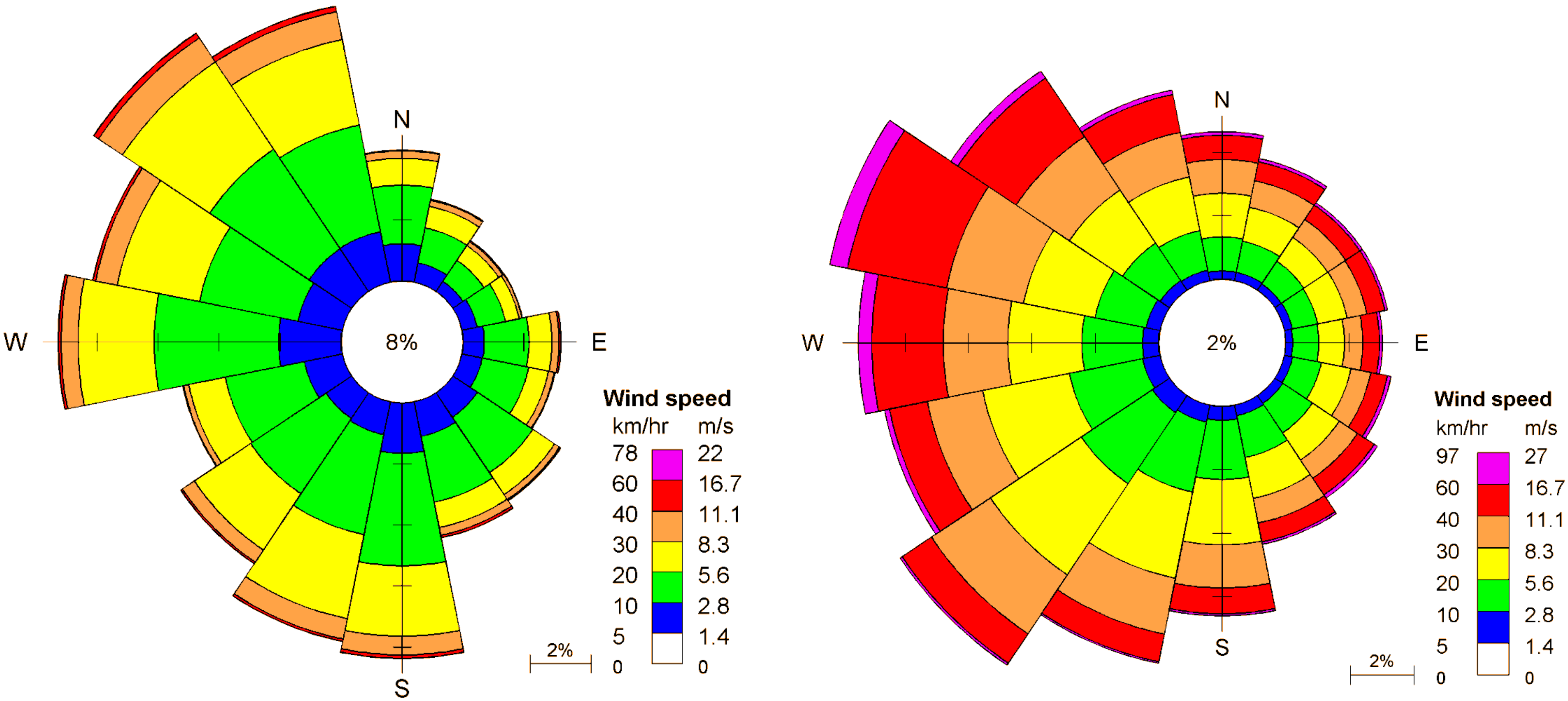
Figures



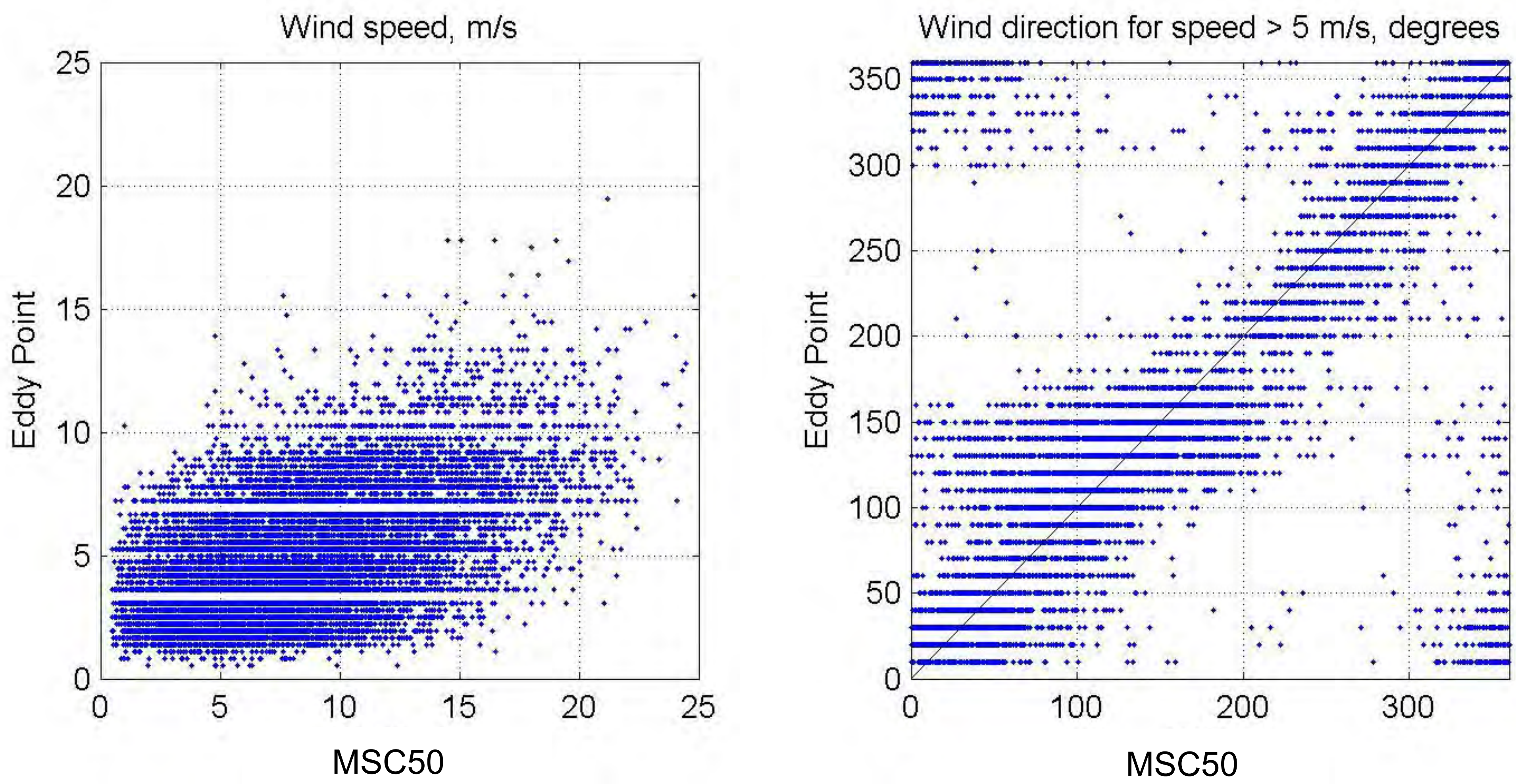
CBCL LIMITED Consulting Engineers	140672.00 - Bear Head Metocean Study	Jan. 2015
	Bathymetry of Chedabucto Bay and Project area	**Fig. 1**

Eddy Point Wind Observations, 1971 to 1985
5 km from project site

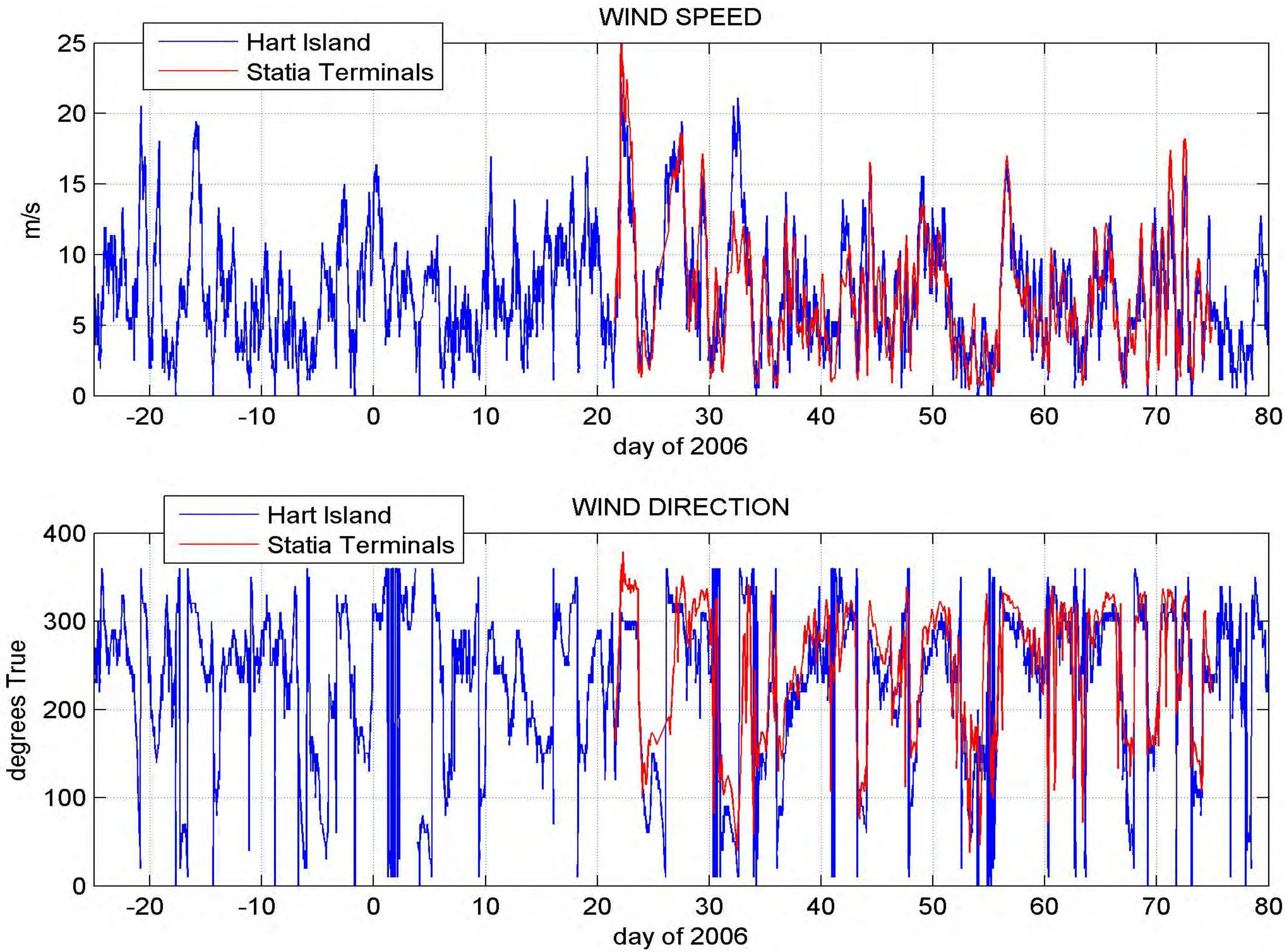
MSC50 Hindcast, 1954 to 2013
Lat 45.5 N, Lon 61.1 W
15 km from project site



CBCL LIMITED Consulting Engineers	140672.00 - Bear Head Metocean Study	Jan. 2015
	Annual directional wind speed statistics - Eddy Point and MSC50 offshore hindcast	**Fig. 2.1**



CBCL LIMITED Consulting Engineers	140672.00 - Bear Head Metocean Study	Jan. 2015
	Comparison of winds from Eddy Point vs. MSC50 offshore hindcast	**Fig. 2.2**



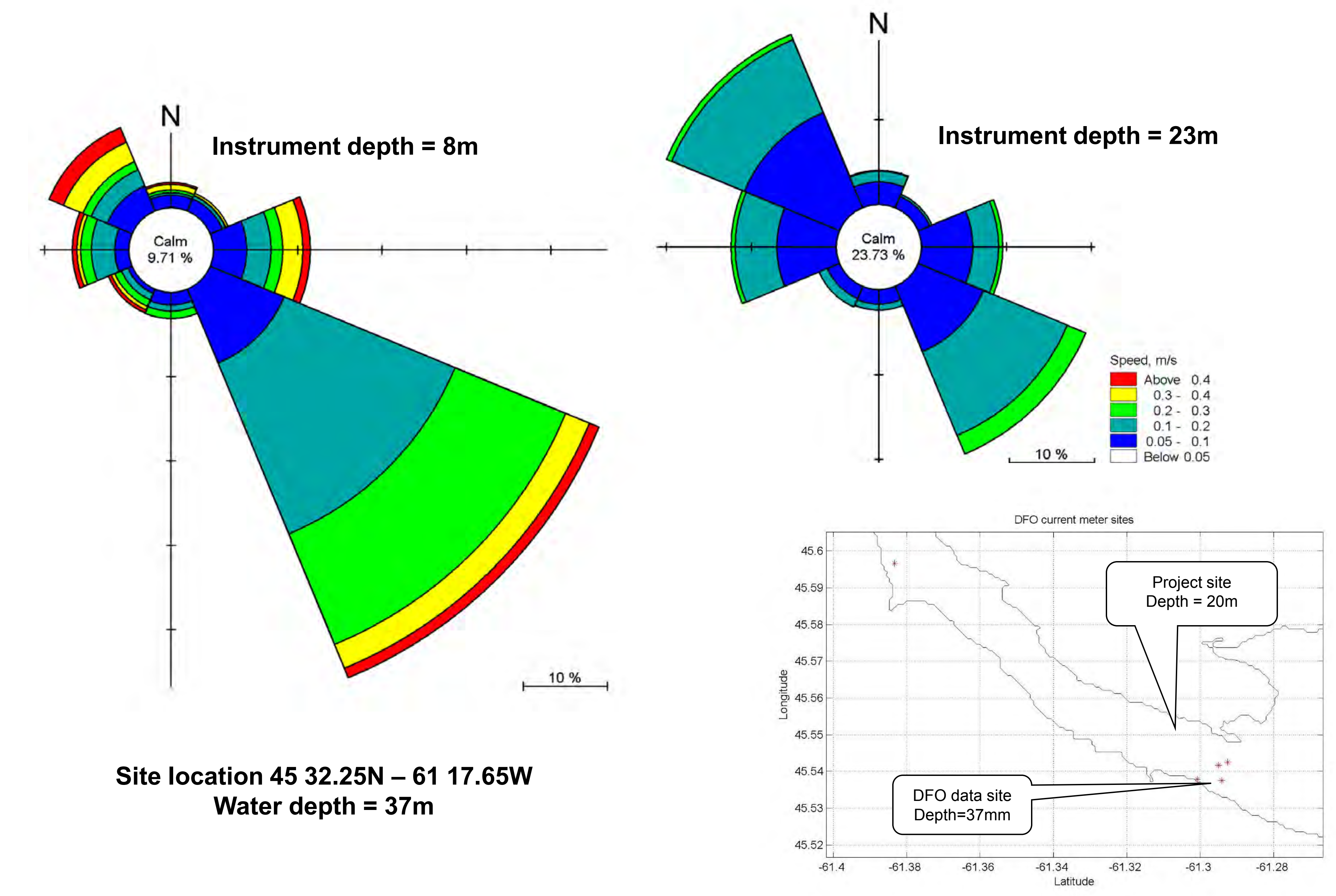
CBCL LIMITED
Consulting Engineers

140672.00 - Bear Head Metocean Study

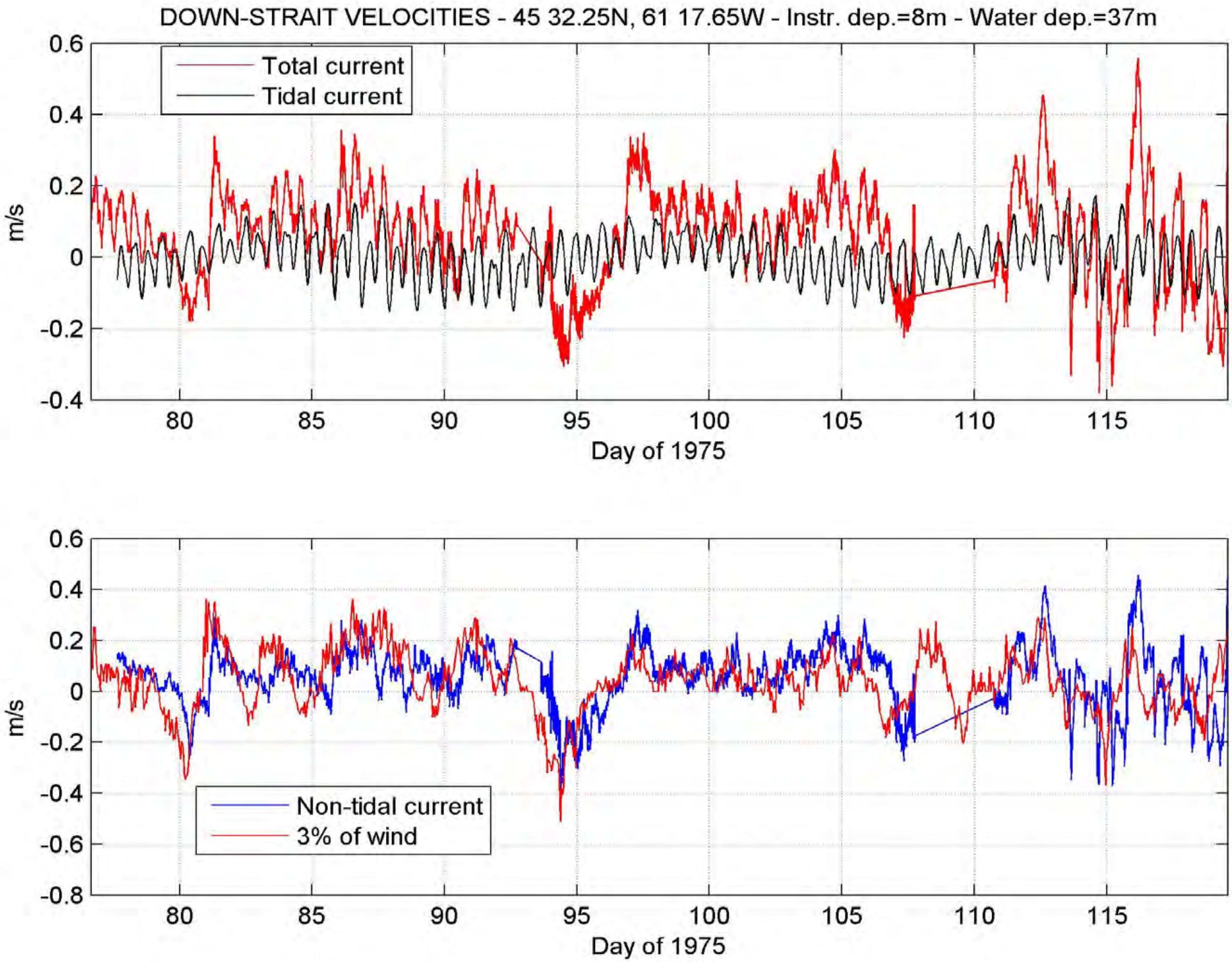
Jan. 2015

Hourly wind data concurrent to the field program

Fig. 2.3

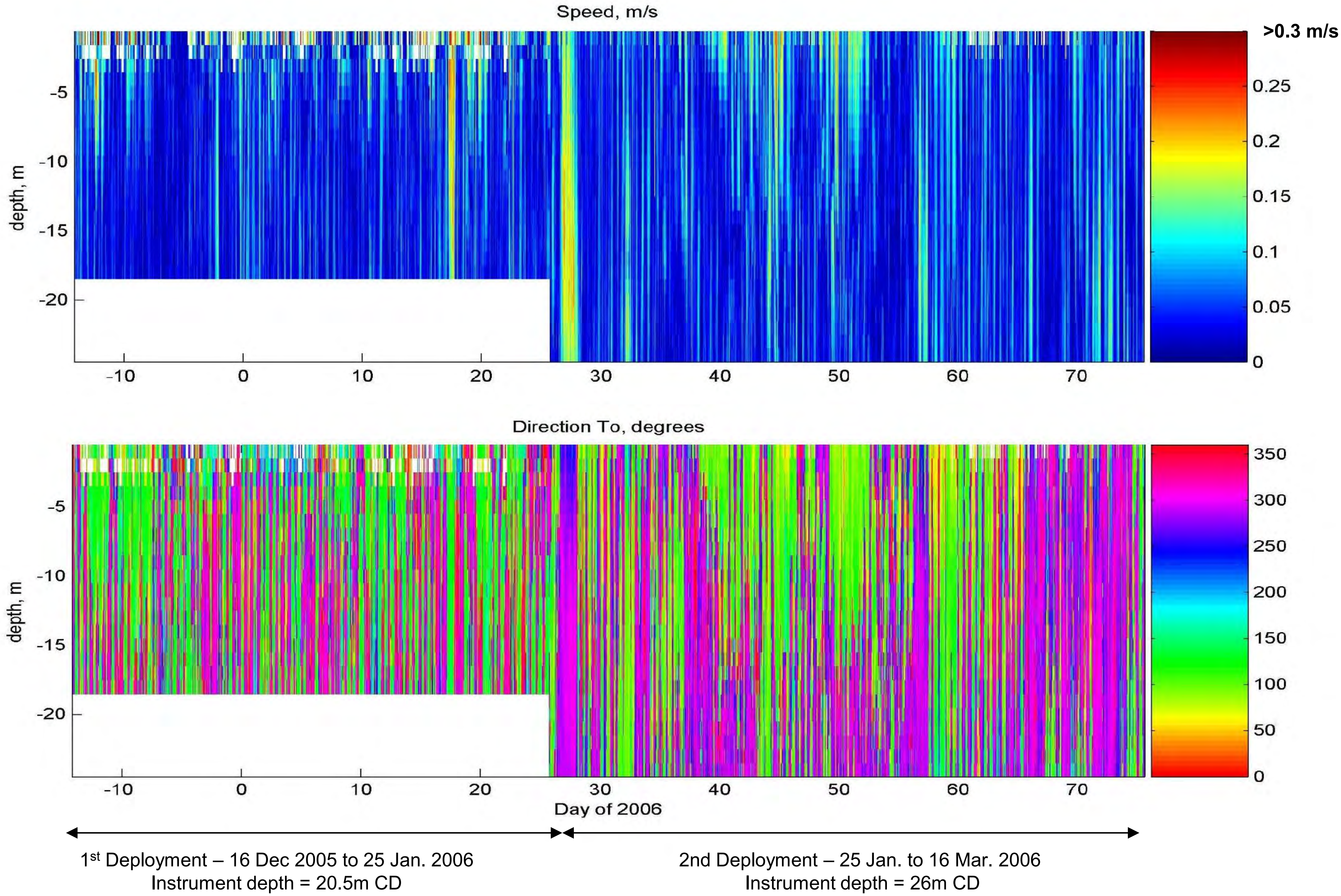


CBCL LIMITED Consulting Engineers	140672.00 - Bear Head Metocean Study	Jan. 2015
	Directional current statistics from DFO current data at Strait entrance	**Fig. 3.1**



Sample time-series of DFO current data at Strait entrance vs. Eddy Point winds

Fig. 3.2



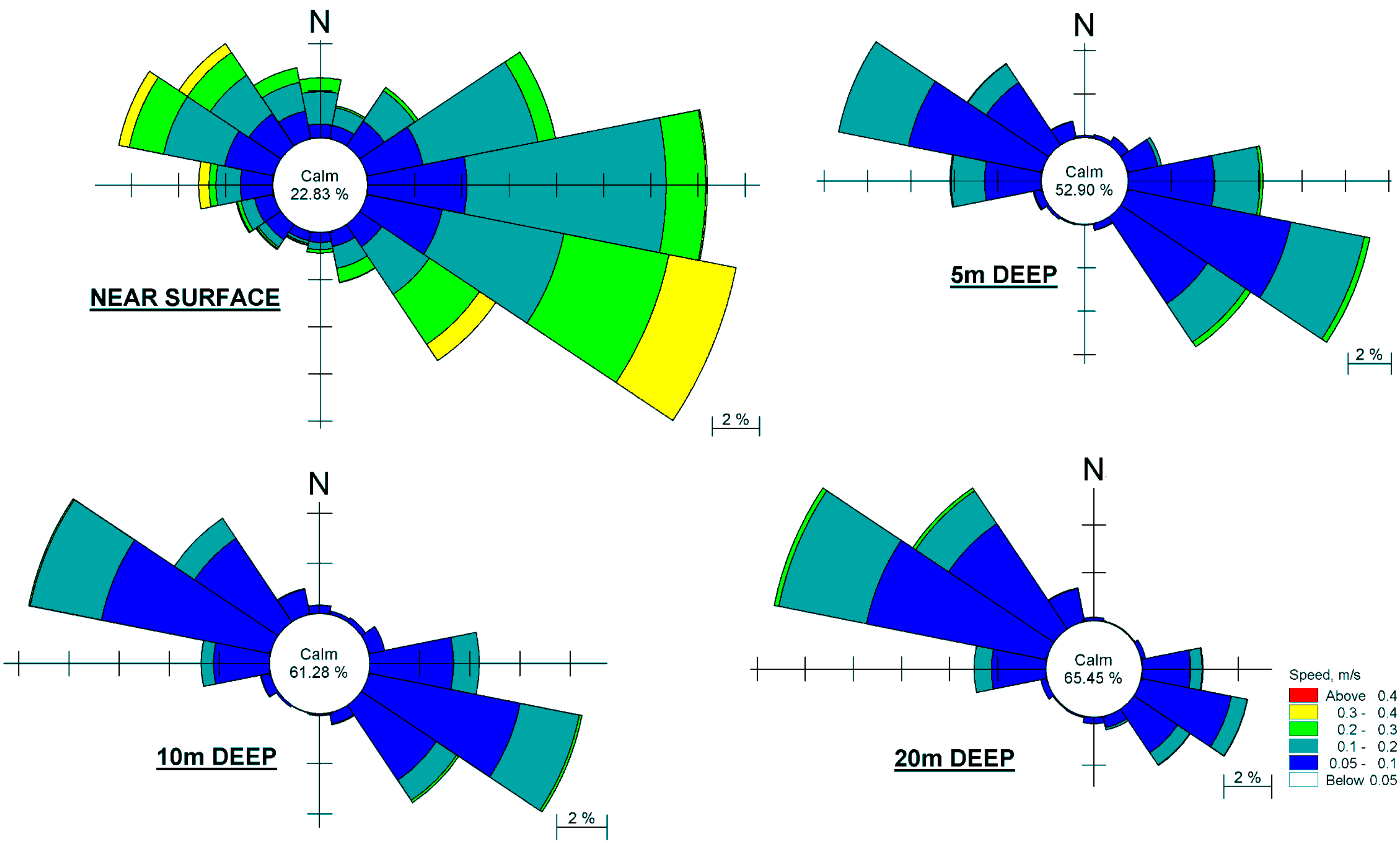
CBCL LIMITED
Consulting Engineers

140672.00 - Bear Head Metocean Study

Jan. 2015

Winter 2005-2006 current data (speed and direction) collected at the site

Fig. 3.3



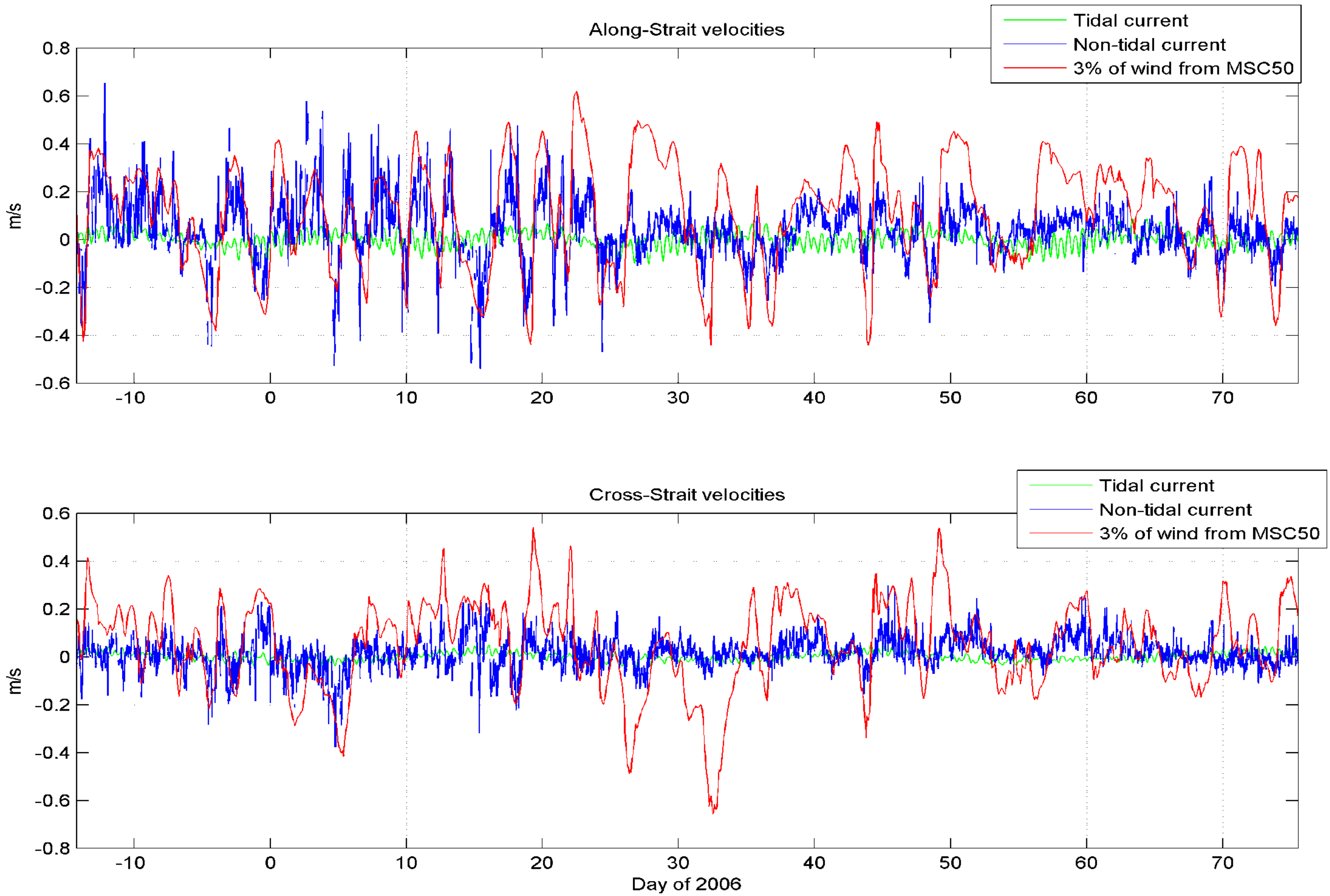
CBCL LIMITED
Consulting Engineers

140672.00 - Bear Head Metocean Study

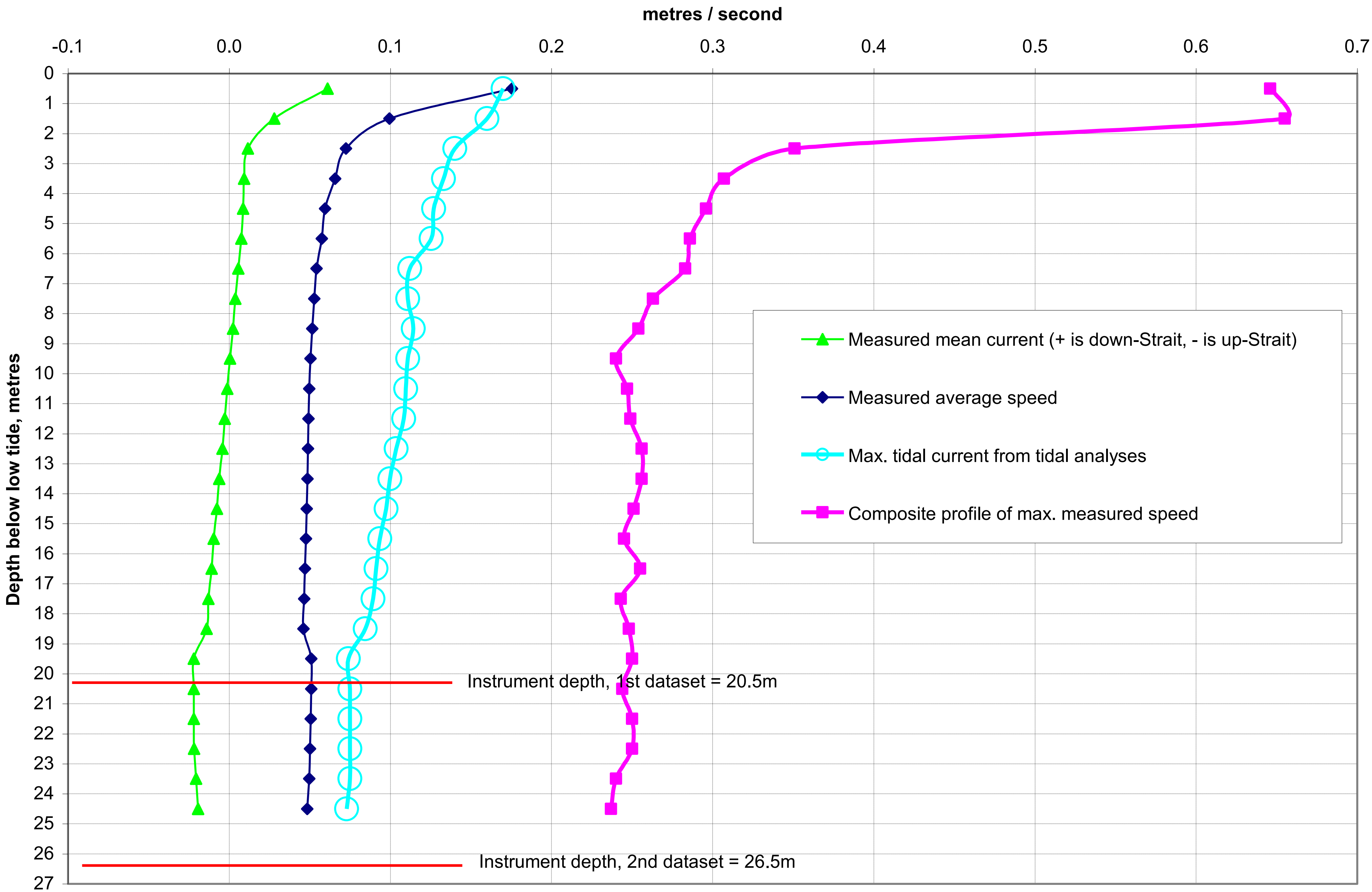
Jan. 2015

Directional statistics on current data collected at the site

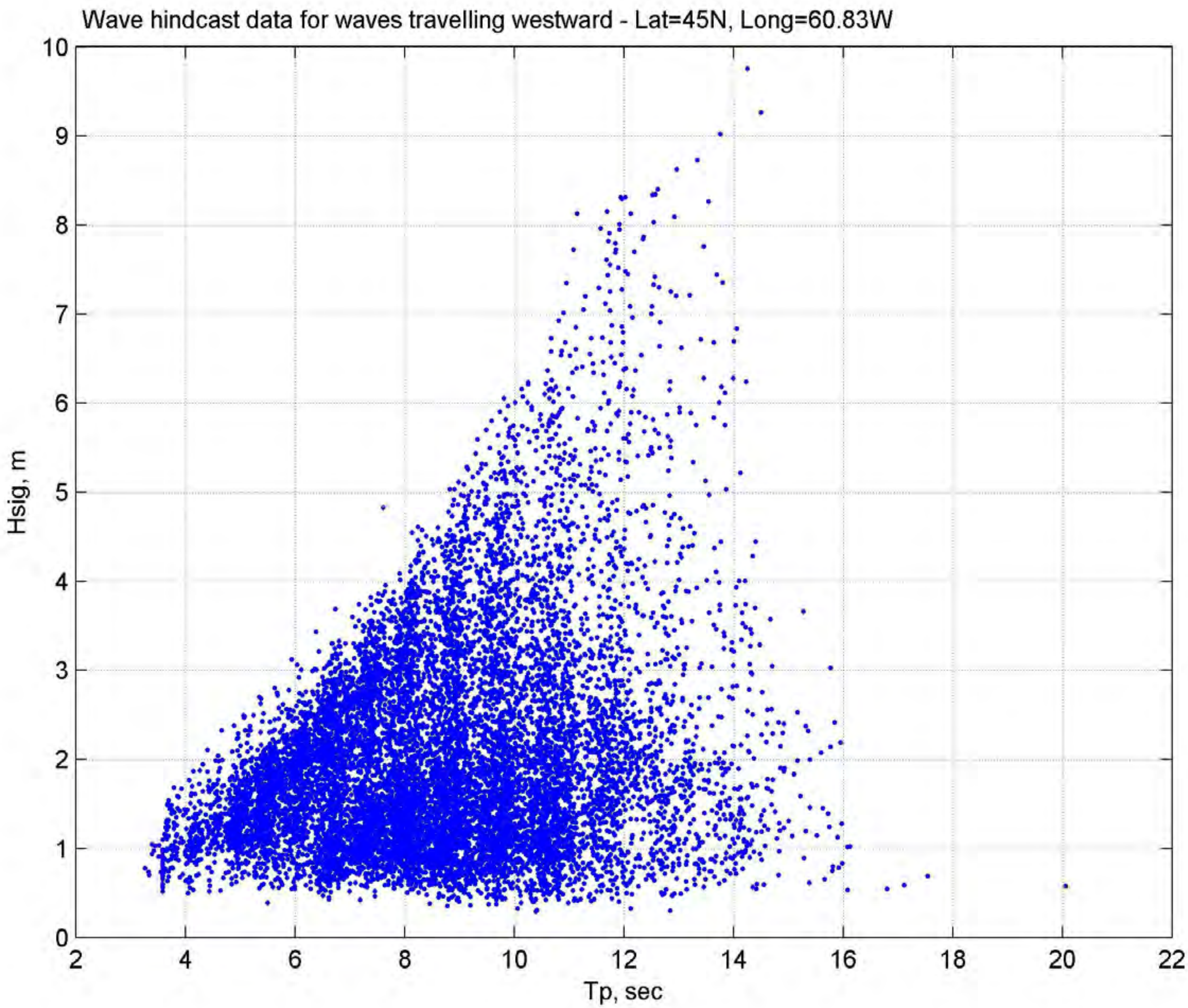
Fig. 3.4



CBCL LIMITED Consulting Engineers	140672.00 - Bear Head Metocean Study	Jan. 2015
	Time-series of near surface currents vs. local winds	**Fig. 3.5**



CBCL LIMITED Consulting Engineers	140672.00 - Bear Head Metocean Study	Jan. 2015
	Measured current profiles	**Fig. 3.6**



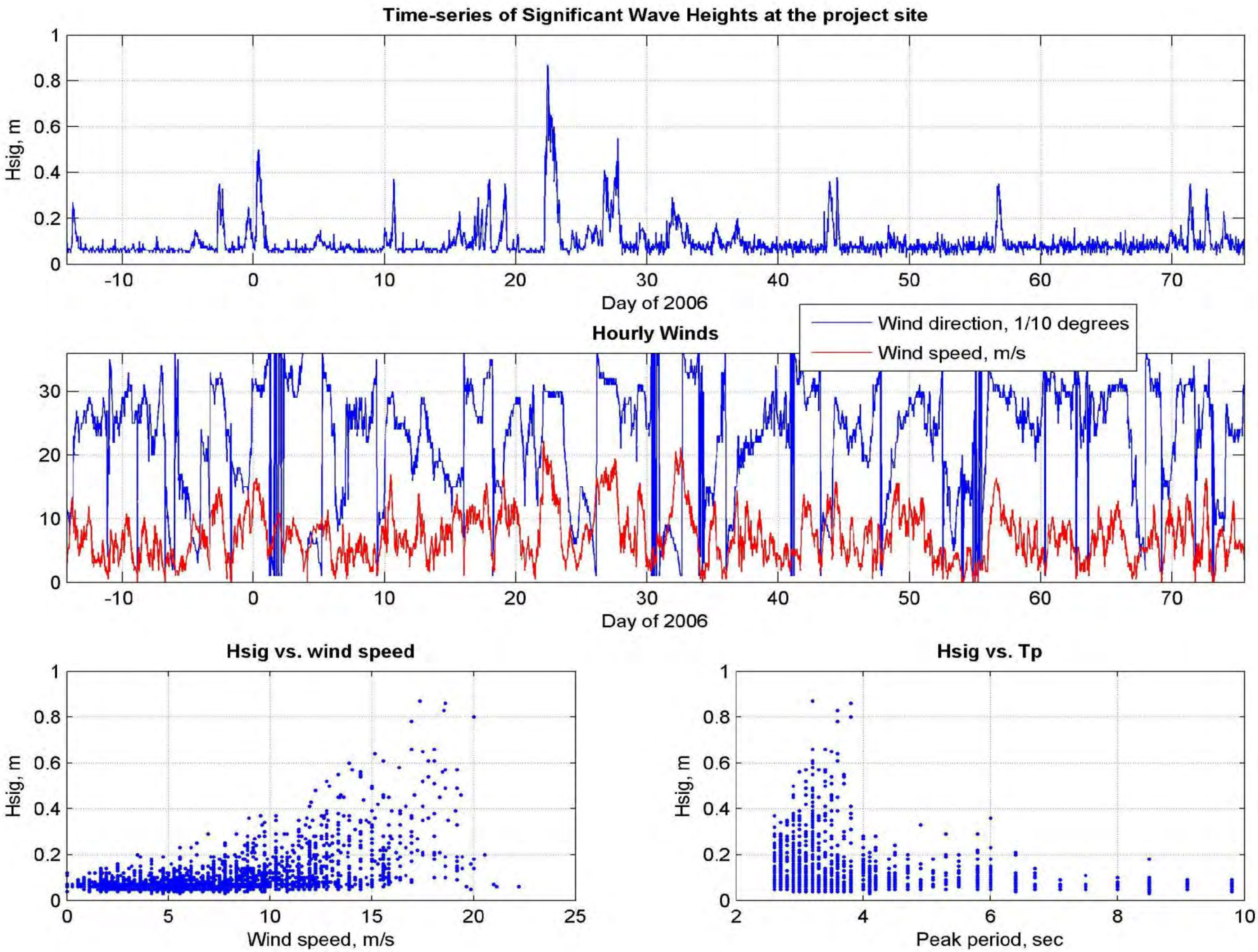
CBCL LIMITED
Consulting Engineers

140672.00 - Bear Head Metocean Study

Jan. 2015

Wave significant height vs. peak period distribution from MSC50 offshore hindcast

Fig. 4.1



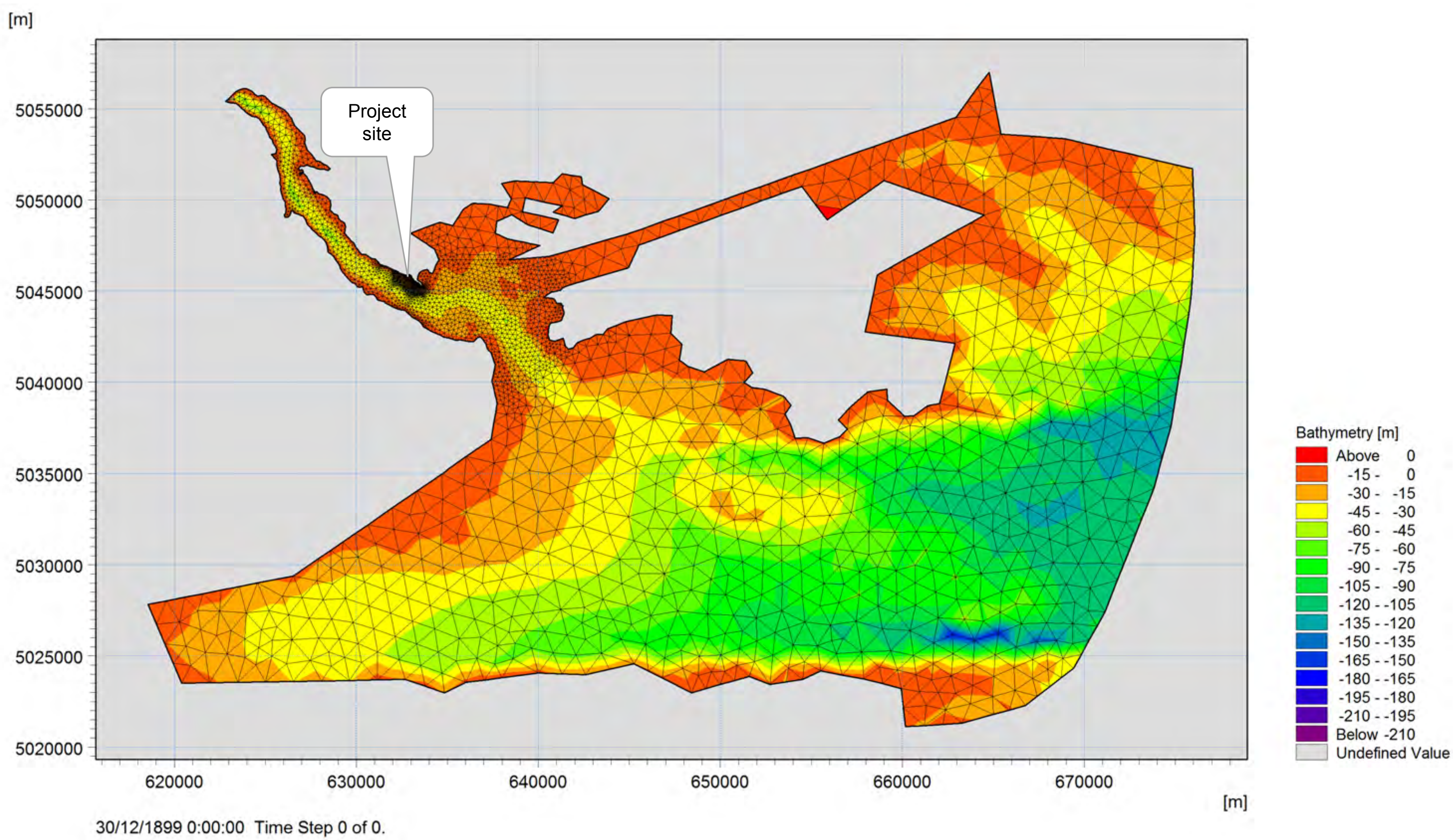
CBCL LIMITED
Consulting Engineers

140672.00 - Bear Head Metocean Study

Jan. 2015

Summary wave data plots

Fig. 4.2



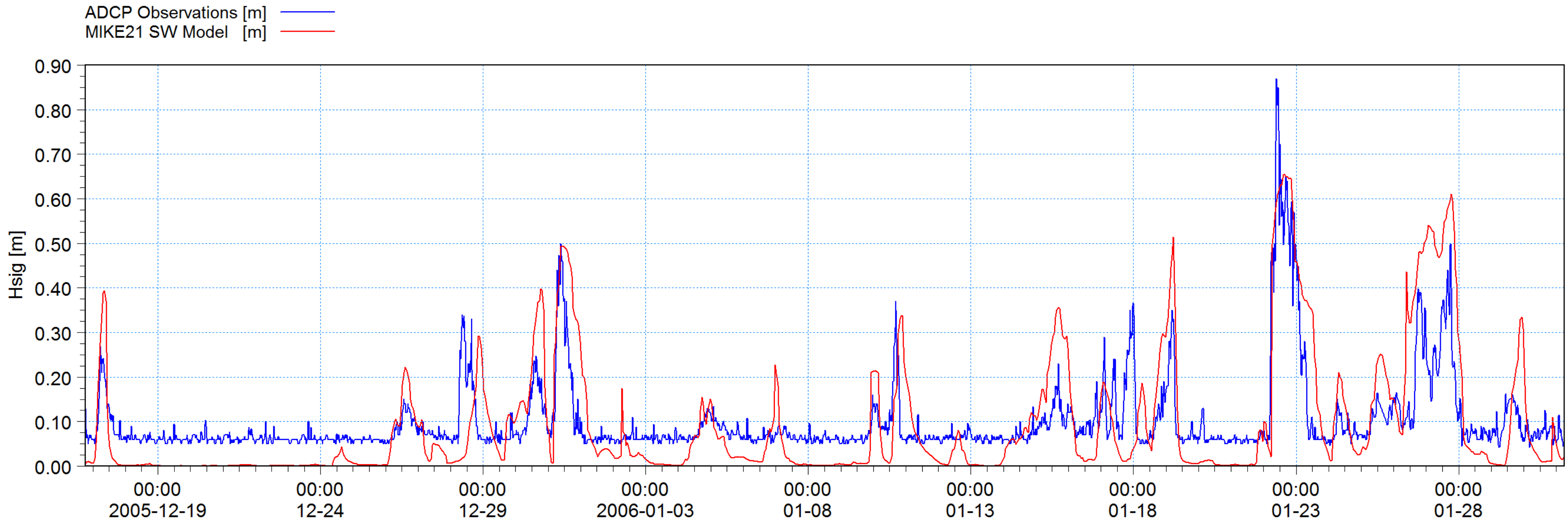
CBCL LIMITED
Consulting Engineers

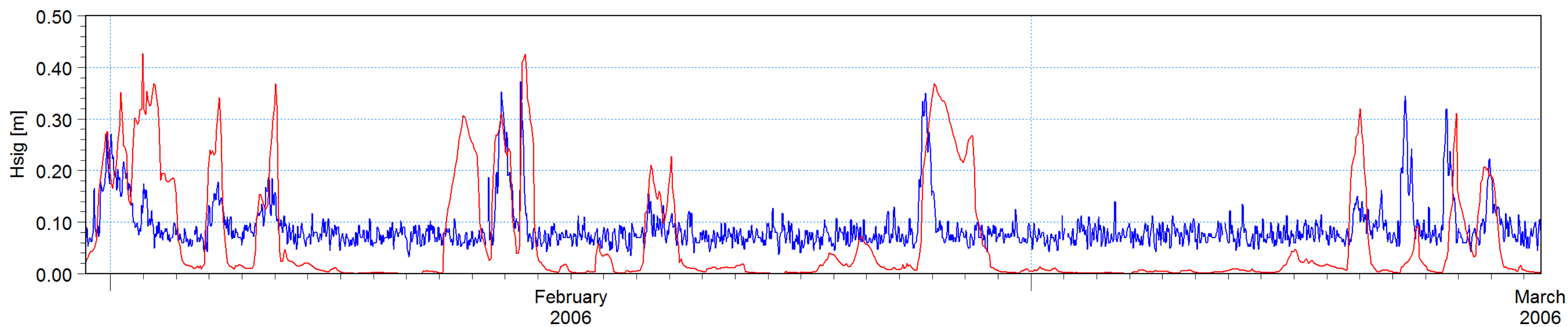
140672.00 - Bear Head Metocean Study

Jan. 2015

MIKE21 SW Model Domain

Fig. 4.3

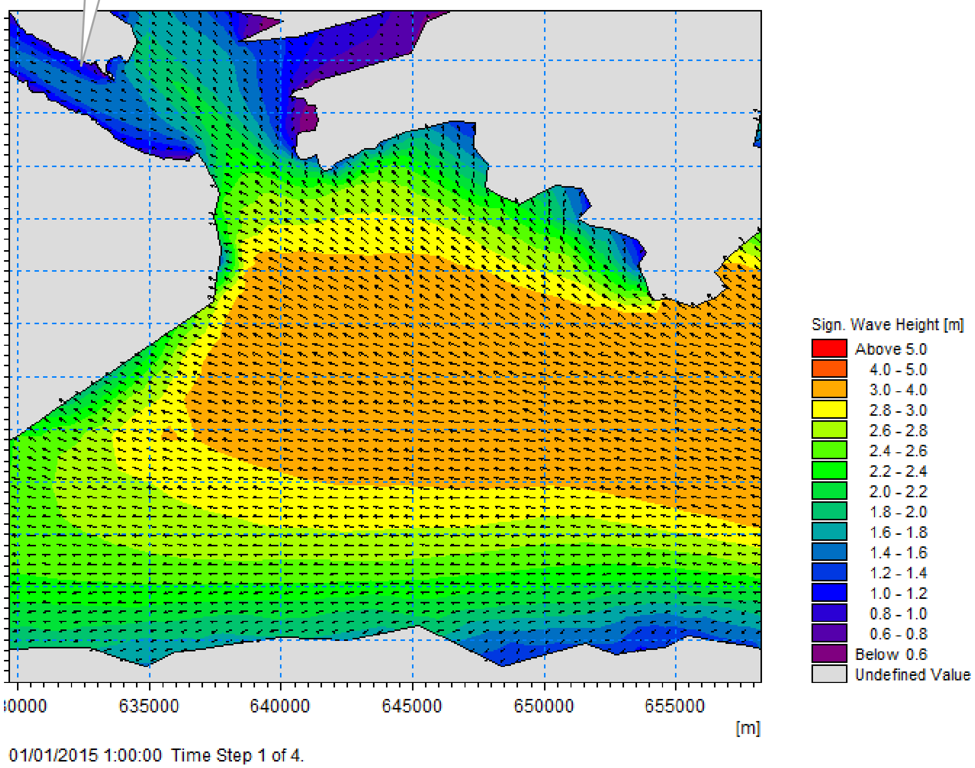




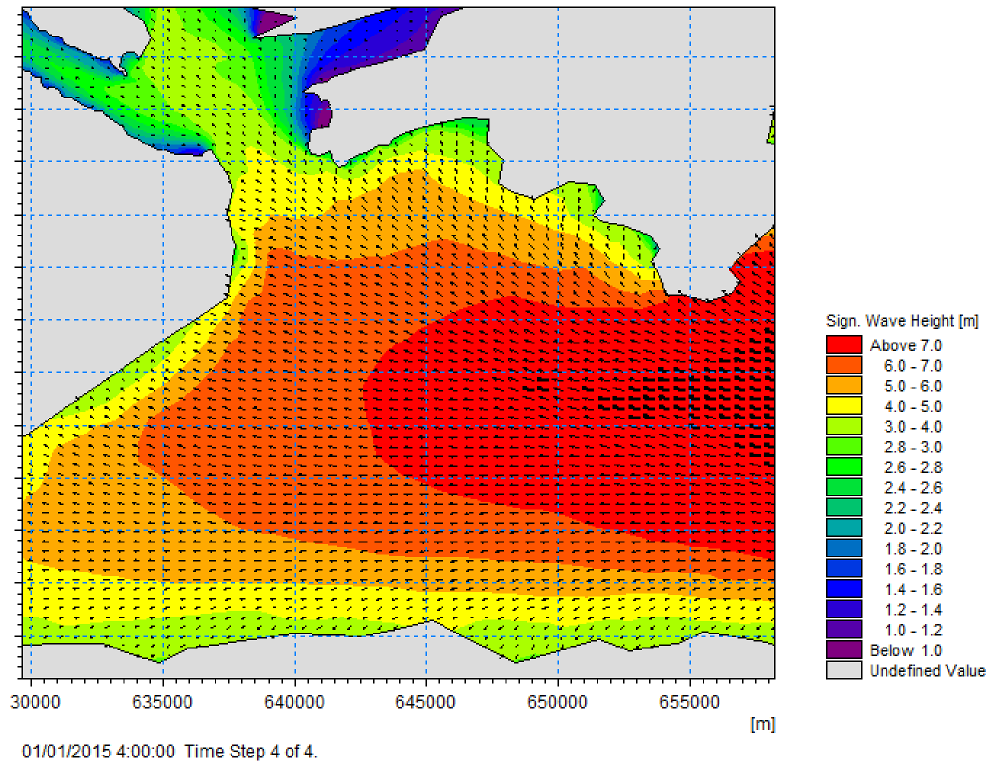
CBCL LIMITED Consulting Engineers	140672.00 - Bear Head Metocean Study	Jan. 2015
	MIKE21 SW Model Calibration Plot	**Fig. 4.4**

Project site

Mooring design
Wind speed = 23.3 m/s



Extreme 100-year storm conditions
Wind speed = 35.2 m/s



CBCL LIMITED
Consulting Engineers

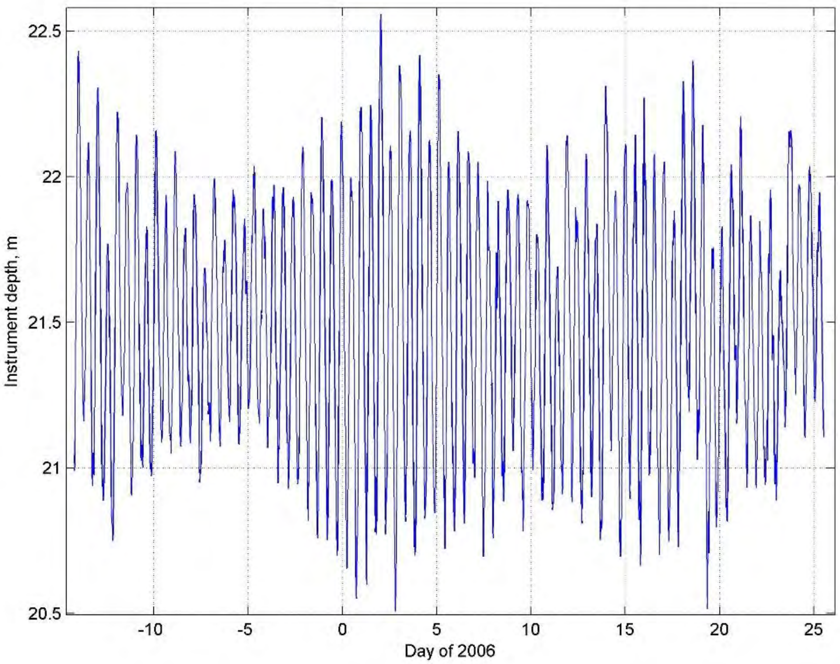
140672.00 - Bear Head Metocean Study

Jan. 2015

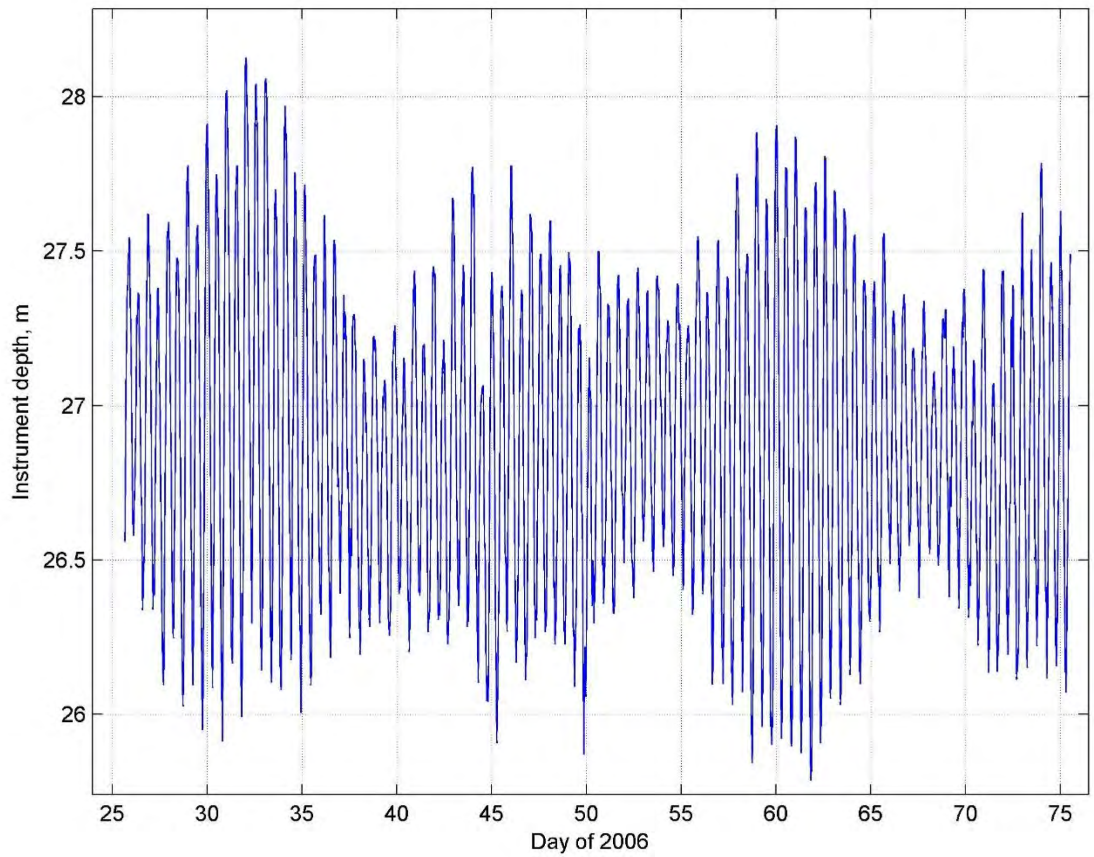
Sample modelled extreme wave heights

Fig. 4.5

1st deployment
Deployment depth = 20.5m CD



2nd deployment
Deployment depth = 26m CD



CBCL LIMITED Consulting Engineers	140672.00 - Bear Head Metocean Study	Jan. 2015
	ADCP instrument depth below surface	**Fig. 5.1**

APPENDIX B

Summary Design Parameters Table

2015 Bear Head LNG - Final metocean criteria					
Summary of parameters at the unloading platform - Water depth = 20m CD					
MOORING DESIGN			**MARINE STRUCTURE DESIGN**		
Parameter	**Value**	**Reference/Methodology**	**Parameter**	**Value**	**Reference/Methodology**
Wind speed	*Values at 10m height - Unit = m/s*		**Wind speed**	*Values at 10m height - Unit = m/s*	
	30-sec gust	Required max. for berthing	Hourly values		
	30.8	= 60 kts	100-year	35.2	NBC - Port Hawkesbury
		Design Basis Add. Exh. A-5	50-year	33.8	
			10-year	29.7	
	Hourly value		30-sec gust		
	23.3		100-year	46.6	Converted from hourly values
			50-year	44.7	
			10-year	39.3	
Waves			**Waves**		
Hs, m	1.1	Based on 23.3 m/s hourly wind	100-year Hs, m	2.1	
Tp, m	3.9	and MIKE21 SW model	Tp, s	4.8	
			50-year Hs, m	1.9	Based on hourly extreme winds and
			Tp, s	4.7	MIKE21 SW model
			10-year Hs, m	1.6	
			Tp, s	4.4	
Currents			**Currents**		
Surface to mid-depth			*Surface to mid-depth*		
Max tidal current	0.20	DFO Strait entrance data confirmed by 2006 Bear Head ADCP data	Max tidal current	0.20	DFO Strait entrance data confirmed by 2006 Bear Head ADCP data
			Extreme surge current	0.14	=1.5/2.1= 0.71 ratio applied to max. tidal current.
Mean current	0.08	DFO Strait entrance data confirmed by 2006 Bear Head ADCP data	Mean current	0.08	DFO Strait entrance data confirmed by 2006 Bear Head ADCP data
Extreme wind + tidal current	0.75	Analysis on 50-year time-series of [tides + 3% wind]	Extreme wind + tidal current	0.75	Analysis on 50-year time series of [tides + 3% wind]
Total extreme	0.83	=mean + [wind + tide]	Total extreme	0.97	=surge + mean + [wind + tide]
1m above bottom	0.65	Based on a 1/7th power law profile - UK HSE, OTO 2001/010	*1m above bottom*	0.70	Based on a 1/7th power law profile - UK HSE, OTO 2001/010
			Water levels at unloading platform		
			HHWLT	2.0	Chart Datum - Based on PointTupper (CHS)
			Surge	0.95	Richards and Daigle 2011
			Sea level rise	0.40	SLR to 2050, based on Zhai et al 2014
			Hcrest	2.5	From 100-year Hsig
			Total	5.9	
			See report for water levels along trestle and at abutment.		