Appendix A

Sea Cage Site Water Quality Data:

Water Temperature and Dissolved Oxygen

Appendix A-Sea Cage Site: Iona Island

Grieg NL Seafarms Ltd - Environmental Data													
Sea Cage Site: Iona Island													
Temperature							Dissolved Oxygen						
Date	Temperature (˚C) - Surf	Temperature (˚C) - 3r	Temperature (˚C)- 10r	Temperature (˚C) - 25r	Temperature (˚C) - 35r	Temperature (˚C) - 50r	Date:2	DO (%L) - 3n	DO (mg/L)-3n	DO (%L) - 15n	DO (mg/L)-15n	DO (%L) - 35n	DO (mg/L)-35n
June 25,2016		8.40	8.40	8.40	8.10	1.10	June 25,2016	106.80	10.28	106.60	10.25	106.50	10.25
July 8,2016		10.00	5.20	5.00	3.00	1.10	July 8,2016	106.30	9.82	106.10	11.75	99.60	11.60
July 20,2016		12.20	12.20	10.90	7.40	1.40	July 20,2016	111.60	9.76	110.60	9.70	113.50	11.03
July 26,2016		13.70	13.30	12.90	2.70	1.10	July 26,2016	114.30	9.72	112.00	9.63	114.50	12.49
August 3,2016		15.90	13.90	5.20	3.80	1.60	Aug. 3,2016	111.80	9.17	114.60	10.32	116.50	12.34
August 10,2016	16.00	16.00	16.00	15.00	2.60	0.90	Aug. 10,2016	111.90	9.13	110.00	9.01	116.40	12.80
August 20,2016	16.30	16.30	13.90	6.40	4.90	2.30	Aug. 20,2016	109.10	8.94	122.90	11.57	117.70	12.22
September 4,2016	15.40	15.40	15.30	7.00	5.90	5.00	Sept 4,2016	108.20	8.93	113.00	10.18	115.50	11.78
September 8,2016	14.50	14.50	14.30	13.00	8.90	2.30	Sept 9,2016	112.60	9.45	114.10	9.73	116.70	10.97
September 23,2016	13.00	13.00	13.00	13.00	10.70	5.40	Sept 23,2016	104.60	9.05	103.30	8.93	103.10	9.36
September 27,2016	12.80	12.80	12.80	11.70	10.00	5.60	Sept 27,2016	102.10	8.79	99.90	8.62	101.60	9.30
September 30,2016	12.20	12.20	11.60	8.20	5.10	4.00	Sept 30,2016	102.20	9.06	101.40	9.26	103.20	10.65
October 6,2016	11.70	11.70	11.70	11.10	8.70	5.80	Oct 6,2016	105.80	9.45	102.50	9.17	100.00	9.34
October 12,2016	11.40	11.30	11.20	11.10	10.60	8.00	Oct 12,2016	107.00	9.70	105.10	9.53	103.10	9.49
October 16,2016	10.60	10.60	10.50	8.00	6.80	5.40	Oct 16,2016	110.60	10.08	106.70	9.78	108.10	10.71
October 21,2016	10.60	10.60	10.60	10.60	10.60	7.80	Oct 21,2016	99.60	9.19	99.20	9.15	98.90	9.13
October 26,2016	10.00	10.00	10.00	10.00	10.00	9.70	Oct 26,2016	107.20	9.87	106.40	9.79	104.90	9.66
October 31,2016	9.90	9.90	9.90	10.00	9.90	9.10							
November 4,2016	9.60	9.60	9.60	9.00	8.70	8.50							
November 8,2016	9.60	9.60	9.60	9.50	9.30	8.60							
November 15,2016	8.90	8.90	8.90	9.00	9.00	5.70	Nov 15,2016	91.90	8.75	92.20	8.78	91.00	8.66
November 23,2016	8.80	8.80	8.70	8.40	8.20	7.40	Nov 23,2016	97.30	9.13	96.60	9.12	95.20	9.04
November 30,2016	7.20	7.20	7.20	6.70	6.40	6.10	Nov 30,2016	95.20	9.36	92.40	9.12	92.70	9.27
December 8,2016	6.30	6.20	6.20	5.90	5.90	5.80	Dec 8,2016	98.90	9.81	97.60	9.74	95.90	9.64
December 14,2016	4.70	4.70	4.70	4.60	4.50	3.20							
December 31,2016	2.00	2.00	2.00	1.90	1.90	1.90	Dec 31,2016	101.50	11.22	99.80	11.03	88.10	10.86
May 23,2017	2.70	2.60	2.40	1.20	0.70	0.40	May 23,2017	99.00	13.50	102.00	14.30	101.00	14.60
June 3,2017	4.10	4.10	4.00	3.70	3.40	2.80	June 3,2017	104.00	13.60	103.00	13.40	104.00	13.80
June 7,2017	5.10	5.00	4.50	3.60	2.60	1.40	June 7,2017	107.00	13.70	105.00	13.70	105.00	14.20
June 16,2017	6.60	6.40	6.10	2.90	1.10	0.40	June 16,2017	104.00	12.90	105.00	13.60	102.00	14.50
June 23, 2017	6.40	6.40	6.40	6.30	5.80	5.00	June 23, 2017	96.00	11.90	96.00	11.80	96.00	11.90
June 30, 2017	8.00	7.90	7.90	6.90	6.30	5.60	June 30, 2017	110.00	13.20	108.00	13.10	109.00	13.60
July 21, 2017	12.80	12.80	12.80	7.70	3.50	2.50	July 21, 2017	105.00	11.10	104.00	11.10	108.00	14.30
July 27, 2017	11.90	11.90	11.30	5.50	3.50	1.90	July 27, 2017	105.00	11.40	107.00	11.80	104.00	12.60
August 3, 2017	15.90	15.90	15.40	6.10	4.30	3.10	August 3, 2017	109.00	10.90	117.00	13.30	115.00	15.20
August 11, 2017	16.10	16.10	15.90	11.10	6.30	3.40	August 11, 2017	106.00	10.50	106.00	10.50	116.00	14.40
August 19, 2017	14.90	14.80	6.80	1.40	0.80	0.20	August 19, 2017	95.00	9.70	104.00	14.00	96.00	13.80
August 26, 2017	15.70	15.20	14.50	12.20	2.60	1.90							
September 3, 2017	13.80	13.60	12.10	11.10	8.30	2.40							
September 9, 2017	13.50	13.40	13.40	13.30	12.50	1.00	September 9, 2017	100.00	10.50	98.00	10.30	98.00	10.50
September 15, 2017	13.70	13.70	13.10	12.30	10.90	3.60	September 15, 2017	104.00	10.90	101.00	10.70	99.00	11.00
September 22, 2017	14.00	14.00	13.80	13.50	7.50	3.00	September 22, 2017	99.00	10.30	98.00	10.20	101.00	12.50
September 30, 2017	13.20	13.10	13.00	10.00	4.40	1.50	September 30, 2017	93.00	9.90	93.00	10.10	98.00	12.80
October 7, 2017	12.00	12.00	12.00	11.90	9.90	8.10	October 7, 2017	97.00	10.50	96.00	10.40	95.00	10.80
October 13, 2017	11.60	11.60	11.60	10.90	7.00	4.10	October 13, 2017	96.00	10.60	94.00	10.40	96.00	11.90
October 19, 2017	11.00	11.00	11.00	11.00	10.90	6.70	October 19, 2017	97.00	10.80	96.00	10.70	96.00	10.70
October 28, 2017	10.30	10.30	10.30	9.60	8.30	6.60	October 28, 2017	97.00	10.90	96.00	10.80	95.00	11.20
November 2, 2017	9.90	9.90	9.90	9.80	9.60	8.10	November 2, 2017	99.00	11.50	99.00	11.50	98.00	11.50
November 13, 2017	8.50	8.50	8.50	7.80	6.90	5.80	November 13, 2017	92.00	11.00	92.00	11.00	91.00	11.30
November 19, 2017	7.90	7.90	7.90	7.70	7.00	5.80	November 19, 2017	88.00	10.60	88.00	10.50	87.00	10.40
November 29, 2017	6.40	6.40	6.40	6.50	6.60	6.30	November 29, 2017	94.00	11.70	92.00	11.50	92.00	11.30
December 6, 2017	5.90	5.90	6.00	6.10	6.00	5.30	December 6, 2017	94.00	11.70	94.00	11.70	89.00	11.20
December 11, 2017	5.50	5.50	5.50	5.50	5.50	5.50	December 11, 2017	99.00	12.60	99.00	12.60	99.00	12.50
January 4, 2018	2.40	2.50	2.60	3.50	3.60	2.90	January 4, 2018						

Appendix A-Sea Cage Site: Brine Island

Grieg NL Seafarms Ltd - Environmental Data

Sea Cage Site: Brine Island

Temperature							Dissolved Oxygen						
Date	Temperature (˚C) - Surface	Temperature (˚C) - 3m	Temperature (˚C)- 10m	Temperature (˚C) - 25m	Temperature (˚C) - 35m	Temperature (˚C) - 50m	Date:2	DO (%L) - 3m	DO (mg/L)-3m	DO (%L) - 15m	DO (mg/L)-15m	DO (%L) - 35m	DO (mg/L)-35m
June 25,2016		8.40	8.40	8.40	8.40	1.60	June 25,2016	111.90	10.74	109.40	10.53	107.80	10.38
July 8,2016		9.60	6.20	6.00	3.00	1.20	July 8,2016	112.50	10.49	108.90	12.08	102.30	11.90
July 20,2016		12.10	12.00	11.50	5.40	2.00	July 20,2016	111.90	9.81	110.00	9.67	115.80	11.81
July 26,2016		13.60	12.40	8.10	2.50	1.20	July 26,2016	113.00	9.63	110.50	9.47	113.00	12.39
August 3,2016		15.70	14.20	5.60	3.50	2.00	Aug. 3,2016	114.50	9.43	115.20	10.44	116.30	12.46
August 10,2016	16.05	16.05	16.00	14.80	2.75	0.50	Aug. 10,2016	109.70	8.95	108.70	8.87	116.50	12.75
August 20,2016	16.40	16.40	13.50	6.60	4.00	3.00	Aug. 20,2016	113.90	9.14	125.00	12.21	117.80	12.54
September 4,2016	15.40	15.40	13.00	6.70	5.30	4.80	Sept 4,2016	107.20	8.88	112.40	10.00	114.80	11.86
September 8,2016	14.60	14.60	14.40	12.00	8.20	2.20	Sept 8,2016	114.40	9.61	112.30	9.54	115.50	11.05
September 23,2016	13.20	13.20	13.20	13.00	9.90	5.50	Sept 23,2016	103.80	8.92	100.90	8.69	101.70	9.38
September 27,2016	13.00	13.00	13.00	11.70	9.80	6.40	Sept 27,2016	102.10	8.78	100.10	8.60	102.00	9.39
September 30,2016	11.30	11.30	11.00	7.80	6.10	4.00	Sept 30,2016	109.20	9.41	100.20	9.19	103.30	10.51
October 6,2016	11.70	11.70	11.50	11.60	10.00	6.40	Oct 6,2016	105.80	9.45	102.50	9.17	100.00	9.34
October 12,2016	11.40	11.40	11.40	11.00	10.20	7.00	Oct 12,2016	105.00	9.52	103.80	9.42	102.80	9.56
October 16,2016	10.90	10.90	11.00	8.00	6.80	6.60							
October 21,216	10.50	10.50	10.60	10.60	10.40	8.80	Oct 21,2016	104.40	9.65	102.00	9.39	100.40	9.31
October 26,2016	10.00	10.10	10.10	10.10	10.20	9.10	Oct 26,2016	102.40	9.42	101.70	9.36	101.40	9.30
October 31,2016	9.90	9.90	9.80	9.80	9.60	8.80							
November 4,2016	9.70	9.70	9.80	9.80	9.70	9.10							
November 8,2016	9.50	9.50	9.50	9.40	9.40	8.80							
November 15,2016	9.00	9.00	9.00	9.00	9.00	9.00	Nov 15,2016	90.70	8.63	90.10	8.57	90.90	8.64
November 23,2016	9.40	9.10	8.90	8.70	8.60	7.40	Nov 23,2016	97.00	9.03	94.80	8.87	93.20	8.78
November 30,2016	7.60	7.60	7.60	7.10	6.70	6.70	Nov 30,2016	94.20	9.18	93.40	9.11	93.60	9.33
December 8,2016	6.10	6.10	6.10	6.00	5.90	5.70	Dec 8,2016	98.10	9.79	97.10	9.68	96.10	9.64
December 14,2016	4.80	4.80	4.80	4.80	4.10	3.40	Dec 14,2016	97.30	10.16	95.60	9.99	94.10	9.99
December 31,2016	2.00	2.10	2.00	2.00	2.00	2.00	Dec 31,2016	102.10	11.26	101.40	11.19	99.40	10.98
May 23,2017	2.70	2.70	2.60	1.10	0.40	0.20	May 23,2017	100.00	13.60	101.00	14.00	99.00	14.40
June 3,2017	4.10	4.10	4.10	3.58	3.60	2.10	June 3,2017	103.00	13.50	102.00	13.40	103.00	13.60
June 7,2017	5.20	5.00	4.30	3.00	2.30	1.60	June 7,2017	108.00	13.80	107.00	14.00	106.00	14.50
June 16,2017	6.30	6.30	5.70	5.20	5.30	5.30	June 16,2017	104.00	12.90	105.00	13.40	103.00	13.30
June 23, 2017	7.00	7.00	6.70	6.40	6.30	4.70	June 23, 2017	96.00	11.60	95.00	11.70	95.00	11.80
June 30, 2017	8.20	8.10	7.90	6.70	6.30	5.50	June 30, 2017	108.00	12.90	108.00	13.00	107.00	13.30
July 21, 2017	13.00	13.00	12.50	8.20	3.60	2.00	July 21, 2017	105.00	11.00	104.00	11.20	105.00	14.00
July 27, 2017	12.00	11.90	11.50	5.50	3.40	2.00	July 27, 2017	111.00	12.00	113.00	13.20	110.00	14.60
August 3, 2017	15.90	15.90	14.60	7.00	4.70	2.90	August 3, 2017	108.00	10.80	114.00	12.60	115.00	15.00
August 11, 2017	16.10	16.00	15.90	13.10	6.10	3.30	August 11, 2017	106.00	10.50	106.00	10.60	117.00	14.70
August 19, 2017	15.10	15.10	6.80	2.80	1.50	0.90	August 19, 2017	96.00	9.70	107.00	14.20	100.00	14.20
August 26, 2017	16.00	15.70	14.30	11.10	2.10	1.70							
September 3, 2017	14.20	14.20	12.90	10.60	9.00	3.20							
September 9, 2017	13.60	13.50	13.50	13.20	11.30	1.90	September 9, 2017	100.00	10.60	96.00	10.10	99.00	10.90
September 15, 2017	13.40	13.40	12.90	12.20	9.50	4.20	September 15, 2017	103.00	10.80	100.00	10.70	100.00	11.40
September 22, 2017	13.80	13.80	13.80	13.00	10.00	2.70	September 22, 2017	99.00	10.30	98.00	10.30	97.00	11.00
September 30, 2017	13.10	13.10	13.10	9.40	3.70	1.70	September 30, 2017	93.00	9.80	93.00	9.80	99.00	13.10
October 7, 2017	12.00	12.00	12.00	12.10	11.20	8.30	October 7, 2017	97.00	10.50	96.00	10.40	95.00	10.40
October 13, 2017	11.80	11.80	11.60	11.10	7.60	7.00	October 13, 2017	94.00	10.40	94.00	10.40	95.00	11.60
October 19, 2017	11.00	11.00	11.00	11.00	10.70	6.60	October 19, 2017	98.00	10.80	95.00	10.60	94.00	10.90
October 28, 2017	10.30	10.30	10.10	9.50	9.20	9.10	October 28, 2017	97.00	10.90	96.00	11.00	94.00	10.90
November 2, 2017	10.00	10.00	10.00	9.90	8.90	7.40	November 2, 2017	100.00	11.60	99.00	11.50	97.00	11.50
November 13, 2017	8.60	8.60	8.60	7.70	6.60	5.20	Noveber 13, 2017	92.00	11.00	91.00	10.80	92.00	11.50
November 19, 2017	7.90	7.90	8.00	7.70	7.20	6.80	November 19, 2017	87.00	10.30	88.00	10.40	89.00	10.60
November 29, 2017	6.60	6.60	6.60	6.60	6.60	6.10	November 29, 2017	92.00	11.40	92.00	11.40	92.00	11.40
December 6, 2017	6.00	6.00	6.10	6.10	6.10	5.40	December 6, 2017	94.00	11.80	92.00	11.60	90.00	11.40
December 11, 2017	5.50	5.50	5.50	5.60	5.50	5.50	December 11, 2017	100.00	12.70	97.00	112.20	99.00	12.50
January 4, 2018	2.60	2.60	2.60	3.40	3.60	3.10	January 4, 2018						

Appendix A-Sea Cage Site: Ship Island

Grieg NL Seafarms Ltd - Environmental Data

Sea Cage Site: Ship Island

Temperature							Dissolved Oxygen						
Date	Temperature (˚C) - Surface	Temperature (˚C) - 3m	Temperature (˚C) - 10m	Temperature (˚C) - 25m	Temperature (˚C) - 35m	Temperature (˚C) - 50m	Date:2	DO (%L) - 3m	DO (mg/L)-3m	DO (%L) - 15m	DO (mg/L)-15m	DO (%L) - 35m	DO (mg/L)-35m
Feb. 24, 2016		0.10	0.70	0.90	0.90	1.00	Feb. 24, 2016	107.60	12.88	103.20	12.15	102.70	12.03
Mar. 7, 2016		0.30	0.60	0.60	0.70	0.80	Mar. 7, 2016	n/a	n/a	n/a	n/a	n/a	n/a
Mar.16, 2016		0.20	0.40	0.40	0.50	0.80	Mar.16, 2016	118.20	13.64	113.50	13.12	111.60	12.88
Mar. 27, 2016		0.50	0.30	0.30	0.30	0.40	Mar. 27, 2016	111.50	13.08	108.00	12.70	106.90	12.48
Apr. 12, 2016		1.20	0.90	0.90	0.90	0.60	Apr. 12, 2016	114.00	13.07	107.40	12.51	104.60	12.22
Apr. 17, 2016		3.90	1.80	0.90	0.50	0.40	Apr. 17, 2016	118.90	12.76	122.40	13.86	105.30	12.23
Apr. 28, 2016		1.90	1.50	0.60	0.40	0.30	Apr. 28, 2016	123.50	13.64	116.30	13.12	107.10	12.30
May 5, 2016		3.30	2.10	1.70	1.40	1.30	May 5, 2016	120.50	12.87	121.70	13.66	117.00	13.23
May 12,2016		3.80	3.30	2.40	2.00	1.00	May 12,2016	116.70	12.18	113.60	12.24	112.00	12.24
May 20,2016		5.40	4.80	3.50	2.50	1.60	May 20,2016	115.20	11.85	113.60	11.95	115.30	12.71
May 26,2016		5.40	3.50	2.20	1.20	0.50	May 26,2016	117.40	12.00	117.10	12.61	109.00	12.64
June 3,2016		6.70	6.20	3.20	1.60	0.80	June 3,2016	111.30	11.15	111.60	11.34	108.80	12.24
June 11,2016		7.90	7.40	1.90	1.40	0.90	June 11,2016	113.80	10.87	113.70	11.26	106.30	11.90
June 25,2016		9.60	9.00	7.50	4.30	0.80	June 25,2016	109.50	10.30	109.50	10.57	119.10	12.11
July 8,2016		11.10	10.80	7.50	4.70	0.10	July 8,2016	108.50	9.77	108.30	9.85	103.50	11.92
July 20,2016		9.90	9.40	7.50	5.20	2.30	July 20,2016	116.20	10.70	113.30	10.50	113.00	11.55
July 26,2016		13.10	12.60	11.50	3.50	1.00	July 26,2016	114.50	9.87	109.30	9.54	111.60	11.94
August 3,2016		16.00	15.20	12.20	3.10	1.90	Aug. 3,2016	112.30	9.21	115.20	10.02	108.70	11.78
August 10,2016	16.60	16.50	16.10	5.20	2.50	1.70	Aug. 10,2016	112.00	9.05	111.50	9.21	113.00	12.47
August 20,2016	17.30	17.30	17.10	3.90	2.40	1.10	Aug. 20,2016	109.90	8.78	116.80	10.18	110.60	12.25
September 4,2016	15.70	15.40	15.40	5.10	3.10	1.90	Sept 4,2016	105.40	8.77	105.10	8.75	111.80	12.21
September 9,2016	16.00	16.00	16.00	10.70	6.30	5.00	Sept 9,2016	110.30	8.99	105.90	8.97	115.40	11.56
September 23,2016	14.00	14.00	14.10	13.80	12.80	6.10	Sept 23,2016	101.90	8.64	102.90	8.72	100.10	8.71
September 27,2016	13.50	13.50	13.60	13.60	12.90	7.80	Sept 27,2016	99.00	8.44	97.80	8.30	96.20	8.29
October 1,2016	12.40	13.00	13.00	12.10	6.60	4.90	Oct 1,2016	101.20	8.83	98.70	8.60	104.00	10.44
October 6,2016	12.60	12.60	12.40	12.30	11.90	10.40	Oct 6,2016	109.70	9.56	106.40	9.34	102.00	9.06
October 13,2016	11.70	11.80	11.90	12.00	12.00	11.20	Oct 13,2016	102.20	9.18	100.70	9.03	99.50	8.91
October 16,2016	11.30	11.30	11.50	11.60	11.30	5.90	Oct 16,2016	104.00	9.21	104.20	9.27	103.50	9.24
October 21,2016	10.90	10.90	10.90	11.00	11.10	11.00	Oct 21,2016	100.20	9.20	100.20	9.19	99.80	9.13
October 25,2016	10.80	10.80	10.90	10.90	10.80	10.20	Oct 25,2016	108.20	9.77	105.10	9.47	103.40	9.33
October 31,2016	10.30	10.30	10.20	10.20	10.20	10.00							
November 4,2016	10.10	10.00	10.00	9.90	9.90	7.80							
November 8,2016	9.80	9.80	9.80	9.40	9.20	8.30							
November 15,2016	9.20	9.20	9.20	9.30	9.30	9.00	Nov 15,2016	90.00	8.50	90.10	8.50	87.20	8.22
November 23,2016	9.60	9.20	9.10	9.00	8.90	7.70	Nov 23,2016	95.30	88.20	93.10	8.63	91.60	8.54
November 30,2016	7.50	7.60	7.60	8.10	8.20	8.00	Nov 30,2016	93.90	9.18	93.20	9.09	91.60	8.92
December 8,2016	6.00	6.00	6.70	6.60	6.40	5.40	Dec 8,2016	98.30	9.88	95.20	9.44	92.40	9.20
December 14,2016	5.20	5.20	5.20	5.20	5.20	5.50	Dec 14,2016	92.40	9.57	91.20	9.44	89.70	9.27
December 23, 2016	4.30	4.30	4.30	4.30	4.10	3.90	Dec 22,2016	91.40	9.90	90.10	9.58	89.90	9.55
December 31,2016	2.50	3.10	3.20	3.30	3.30	3.40	Dec 31,2016	96.70	10.46	96.50	10.41	96.10	10.55
January 6,2017	3.00	3.00	3.00	3.30	3.40	3.30	Jan 6,2017	100.30	10.89	98.60	10.62	96.20	10.33
January 31,2017	1.00	1.00	1.00	1.10	1.10	1..4							
February 4,2017	0.20	0.20	0.50	1.20	1.40	1.40							
February 19,2017	0.80	0.70	0.70	0.80	0.90	0.80	Feb 19,2017	91.00	12.90	91.00	12.90	90.00	12.70
February 25,2017	0.60	0.60	0.50	0.50	0.30	0.20	Feb 25,2017	93.00	13.40	92.00	13.30	92.00	13.40
March 8,2017	-0.20	-0.20	0.00	0.10	0.10	0.40	Mar 8,2017	95.00	14.10	94.00	13.90	93.00	13.80
March 14,2017	-0.10	0.00	0.00	0.10	0.10	0.20	Mar 14,2017	96.00	14.40	96.00	14.30	95.00	14.20
March 19,2017	-0.20	-0.10	0.20	0.10	0.10	0.10	Mar 19,2017	99.00	14.80	97.00	14.40	95.00	14.20
March 25,2017	-0.20	-0.10	0.20	0.10	0.10	0.10	Mar 25,2017	93.00	13.70	92.00	13.50	90.00	13.20
April 6,2017	0.00	0.00	0.00	-0.10	-0.10	-0.10	Apr 6,2017	87.00	13.00	87.00	12.90	87.00	12.90
April 12,2017	0.70	0.70	0.40	0.00	0.00	-0.10	Apr 12,2017	91.00	13.20	92.00	13.60	91.00	13.40
April 23,2017	1.20	1.20	1.00	0.70	0.60	0.00	Apr 23,2017	90.00	12.80	90.00	12.90	90.00	12.90
April 26,2017	0.70	0.70	0.50	0.00	-0.10	-0.20	Apr 26,2017	90.00	13.10	88.00	13.10	85.00	12.80
May 3,2017	2.10	2.10	1.50	0.80	0.70	0.30	May 4,2017	112.00	15.30	110.00	15.40	105.00	15.00
May 13,2017	3.90	3.90	3.00	0.60	0.30	-0.10	May 13,2017	102.00	13.50	102.00	13.80	93.00	13.60
May 18,2017	3.00	3.00	1.60	0.40	0.20	0.00	May 18,2017	98.00	13.20	100.00	14.10	92.00	13.40
May 23,2017	3.60	3.50	2.80	2.50	1.60	0.10	May 23,2017	100.00	13.30	99.00	13.60	98.00	13.50
June 3,2017	5.10	4.70	4.60	3.00	2.60	1.80	June 3,2017	102.00	13.20	103.00	13.40	102.00	13.90
June 7,2017	6.90	6.30	5.10	3.60	2.20	1.30	June 7,2017	109.00	13.30	109.00	14.00	107.00	14.60
June 16,2017	7.10	6.90	6.80	4.90	2.80	1.20	June 16,2017	106.00	13.00	104.00	12.80	105.00	14.40
June 23, 2017	7.70	7.70	7.60	6.20	5.20	1.50	June 23, 2017	95.00	11.30	97.00	11.70	97.00	112.30
June 30, 2017	9.10	9.10	8.10	7.60	6.40	3.10	June 30, 2017	107.00	12.40	107.00	12.80	106.00	13.20
July 8, 2017	10.30	10.30	9.30	8.50	7.40	3.50	July 8, 2017	98.00	10.90	98.00	11.40	97.00	11.70
July 21, 2017	13.70	13.60	12.20	8.10	4.20	2.10	July 21, 2017	105.00	10.80	106.00	11.70	105.00	13.60
July 27, 2017	13.50	13.50	11.90	5.20	2.90	1.60	July 27, 2017	110.00	11.50	111.00	12.30	106.00	14.30
August 3, 2017	16.40	16.40	16.30	9.30	2.50	1.40	August 3, 2017	105.00	10.40	108.00	11.10	109.00	15.10
August 11, 2017	17.10	17.10	16.50	9.80	4.80	2.80	August 11, 2017	105.00	10.20	106.00	10.40	113.00	14.60
August 19, 2017	16.40	16.30	16.10	2.40	1.20	0.60	August 19, 2017	89.00	8.80	91.00	9.10	100.00	14.30
August 26, 2017	15.40	15.40	15.40	9.30	2.30	1.30							
September 3, 2017	14.40	14.50	14.30	9.40	7.00	2.00							
September 9, 2017	14.70	14.70	14.50	13.90	13.90	5.30	September 9, 2017	98.00	10.10	97.00	10.00	95.00	10.00
September 15, 2017	14.70	14.60	13.90	11.60	10.30	7.30	September 15, 2017	99.00	10.20	97.00	10.10	98.00	11.10
September 22, 2017	14.10	14.10	14.10	12.80	10.10	5.10	September 22, 2017	100.00	10.30	98.00	10.20	100.00	10.50
September 30, 2017	13.50	13.50	13.50	13.40	12.30	4.30	Septmeber 30, 2017	95.00	10.00	93.00	9.70	91.00	9.80
October 7, 2017	12.10	12.10	12.00	11.20	10.70	8.60	October 7, 2017	97.00	10.50	94.00	10.30	94.00	10.50
October 13, 2017	11.80	11.80	11.80	11.70	11.10	6.30	October 13, 2017	95.00	10.50	94.00	10.30	91.00	10.20
October 19, 2017	11.20	11.10	11.10	10.70	8.40	5.30	October 19, 2017	95.00	10.60	95.00	10.50	94.00	11.20
October 28, 2017	10.70	10.50	10.50	10.40	9.80	6.10	October 28, 2017	99.00	11.20	96.00	10.80	92.00	10.50
November 2, 2017	10.30	10.30	10.30	10.30	9.90	7.10	November 2, 2017	99.00	11.40	98.00	11.20	95.00	11.00
November 13, 2017	8.70	8.80	8.80	9.10	9.10	8.50	November 13, 2017	90.00	10.70	90.00	10.60	89.00	10.50
November 17, 2017	8.20	8.20	8.40	8.40	8.40	4.50	November 17, 2017	96.00	11.30	95.00	11.10	95.00	11.10
November 24, 2017	7.00	7.00	7.10	6.90	6.50	5.50	November 24, 2017	88.00	10.80	87.00	10.50	88.00	10.80
December 2, 2017	6.20	6.40	6.60	6.70	6.70	6.40	December 2, 2017	92.00	11.40	89.00	10.90	89.00	11.00
December 12, 2017	5.60	5.60	5.70	5.70	5.70	5.40	December 12, 2017	98.00	12.40	98.00	12.30	97.00	12.20
January 3, 2018	3.10	3.10	3.20	3.20	3.40	3.50	January 3, 2018	91.00	12.50	91.00	12.50	90.00	12.20
January 17, 2018	1.60	1.60	1.90	2.20	2.30	2.50	January 17, 2018	93.00	13.20	91.00	12.80	90.00	12.60
January 27, 2018	1.00	1.00	1.00	1.80	2.00	2.10	January 27, 2018	76.00	11.00	75.00	10.90	76.00	10.80
February 15, 2018	1.60	1.70	1.60	1.70	1.70	1.70	February 15, 2018	90.00	12.60	89.00	12.40	87.00	12.10
February 26, 2018	0.60	0.60	0.50	1.00	1.20	1.20	February 26, 2018	94.00	13.80	94.00	13.70	92.00	13.20

Appendix A-Sea Cage Site: Chamber's Island

Grieg NL Seafarms Ltd - Environmental Data

Sea Cage Site: Chamber's Island

Temperature							Dissolved Oxygen						
Date	Temperature (˚C) - Surface	Temperature (˚C) - 3m	Temperature (˚C) - 10m	Temperature (˚C) - 25m	Temperature (˚C) - 35m	Temperature (˚C) - 50m	Date:2	DO (%L) - 3m	DO (mg/L)-3m	DO (%L) - 15m	DO (mg/L)-15m	DO (%L) - 35m	DO (mg/L)-35m
Feb. 24, 2016		0.30	0.60	0.90	0.90	0.80	Feb. 24, 2016	104.10	12.26	101.20	11.86	108.60	12.86
Mar. 7, 2016		0.30	0.60	0.60	0.70	0.80	Mar. 7, 2016	n/a	n/a	n/a	n/a	n/a	n/a
Mar. 16, 2016		0.30	0.30	0.60	0.70	0.60	Mar. 16, 2016	118.20	13.64	113.50	13.12	111.60	12.88
Mar. 27, 2016		0.80	0.30	0.40	0.30	0.40	Mar. 27, 2016	113.50	13.17	108.20	12.72	105.20	12.39
Apr. 12, 2016		1.20	1.00	0.80	0.70	0.50	Apr. 12, 2016	115.80	13.34	109.70	12.77	104.30	12.22
Apr. 17, 2016		3.60	2.10	0.90	0.70	0.60	Apr. 17, 2016	122.70	13.16	121.50	13.86	108.20	12.51
Apr. 28, 2016		1.70	1.30	0.70	0.30	0.20	Apr. 28, 2016	127.30	13.96	120.50	13.50	108.50	12.47
May 5, 2016		3.40	2.50	1.80	1.20	1.10	May 5, 2016	125.20	13.37	122.30	13.76	112.90	12.90
May 12,2016		3.30	2.80	2.10	1.80	1.30	May 12,2016	114.30	12.11	112.70	12.24	111.20	12.28
May 20,2016		4.80	4.30	3.10	2.80	1.30	May 20,2016	118.40	12.33	115.30	12.25	115.40	12.65
May 26,2016		4.80	3.30	2.00	1.20	0.60	May 26,2016	120.50	12.53	116.40	12.61	109.90	12.46
June 3,2016		6.70	6.30	4.40	2.40	1.00	June 3,2016	119.50	11.99	114.10	11.55	114.20	12.67
June 11,2016		8.00	7.90	2.10	1.60	0.90	June 11,2016	115.90	11.07	111.10	10.96	106.60	11.87
June 25,2016		9.40	8.50	6.90	5.30	1.80	June 25,2016	110.60	10.41	110.70	10.66	111.80	11.58
July 8,2016		10.80	10.50	5.60	4.70	1.00	July 8,2016	111.80	10.17	108.90	9.95	103.10	11.87
July 20,2016		10.20	8.40	7.20	4.00	1.10	July 20,2016	113.70	10.34	111.20	10.61	108.90	11.45
July 26,2016		13.30	12.60	11.90	4.10	1.00	July 26,2016	114.80	9.85	111.40	9.75	103.70	11.42
August 3,2016		16.40	16.10	11.80	5.20	1.50	Aug. 3,2016	114.50	9.31	115.60	9.92	110.90	11.47
August 10,2016	16.20	16.10	14.80	5.50	2.70	1.70	Aug. 10,2016	13.50	9.47	13.70	9.74	108.50	11.90
August 20,2016	17.10	17.10	16.90	4.20	2.60	1.30	Aug. 20,2016	111.40	8.91	109.00	8.71	109.90	12.10
September 4,2016	15.30	15.30	15.20	4.70	3.10	1.70	Sept 4,2016	105.20	8.76	105.20	8.78	105.50	11.83
September 9,2016	15.60	15.60	15.50	11.10	7.10	5.10	Sept 9,2016	109.60	9.00	109.30	9.03	117.30	11.52
September 23,2016	14.10	14.00	13.90	13.70	13.10	7.10	Sept 23,2016	102.50	8.70	99.00	8.42	97.10	8.39
September 27,2016	13.50	13.50	13.50	13.60	12.50	8.00	Sept 27,2016	99.70	8.99	97.90	8.33	96.60	8.40
October 1,2016	13.10	13.00	13.10	13.10	7.90	3.40	Oct 1,2016	100.90	8.79	98.20	8.53	98.60	9.62
October 6,2016	12.50	12.40	12.20	11.90	11.00	10.40	Oct 6,2016	106.20	9.31	101.80	8.98	102.50	9.24
October 13,2016	11.90	11.90	12.00	11.90	11.80	11.10	Oct 13,2016	100.70	9.04	100.20	8.97	99.10	8.91
October 16,20164	11.30	11.50	11.60	11.50	11.50	8.20	Oct 16,2016	107.60	9.58	105.50	9.37	104.90	9.35
Octobe 21,2016	10.80	10.90	11.00	11.30	11.20	10.80	Oct 21,2016	101.70	9.34	100.20	9.16		
October 25,2016	10.90	10.90	10.90	10.90	10.80	10.50	Oct 25,2016	107.60	9.70	105.30	9.48	103.40	9.33
October 31,2016	10.20	10.20	10.10	10.00	9.80	9.40							
November 4,2016	10.00	10.10	10.00	10.00	9.80	7.90							
November 8,2016	9.60	9.60	9.60	9.30	8.90	7.50							
November 15,2016	9.10	9.10	9.10	9.00	9.00	8.90	Nov 15,2016	92.60	8.76	90.10	8.53	90.20	8.55
November 23,2016	9.20	9.20	9.10	9.00	8.90	8.40	Nov 23,2016	94.10	8.71	93.70	8.71	93.00	8.65
November 30,2016	7.40	7.40	7.60	8.20	8.20	8.20	Nov 30,2016	93.00	9.11	93.00	9.06	92.50	8.90
December 8,2016	6.40	6.40	6.40	6.40	6.50	5.40	Dec 8,2016	93.40	9.31	93.90	9.35	90.80	9.03
December 14,2016	5.30	5.30	5.30	5.30	5.30	5.50	Dec 14,2016	97.00	9.94	95.10	9.81	93.90	9.71
December 22,2016	4.30	4.30	4.30	4.20	4.20	4.40	Dec 22,2016	94.00	9.91	91.40	9.68	91.00	9.63
December 31,2016	2.90	3.00	3.30	3.30	3.30	3.30	Dec 31,2016	95.30	10.37	93.10	10.03	93.50	10.09
January 6,2017	3.00	3.00	3.00	3.00	3.30	3.20	Jan 6,2017	102.20	11.09	99.20	10.77	94.50	10.16
January 31,2017	1.00	1.10	1.10	1.40	1.50	1.50							
February 4,2017	0.30	0.30	0.40	1.00	1.40	1.60							
February 19,2017	0.70	0.70	0.70	0.80	0.80	0.70	Feb 19,2017	93.00	13.20	92.00	13.00	91.00	12.80
February 25,2017	0.60	0.60	0.60	0.60	0.50	0.80	Feb 25,2017	92.00	13.30	91.00	13.20	90.00	13.10
March 8,2017	0.00	0.10	0.30	0.30	0.30	0.30	Mar 8,2017	96.00	14.20	94.00	13.90	94.00	13.80
March 14,2017	-0.10	-0.10	0.00	0.10	0.10	0.10	Mar 14,2017	97.00	14.60	95.00	14.20	94.00	14.10
March 19,2017	0.00	0.00	0.10	0.10	0.10	0.10	Mar 19,2017	95.00	14.20	94.00	14.00	93.00	13.80
March 25,2017	0.00	0.10	0.20	0.10	0.10	0.00	Mar 25,2017	95.00	14.00	91.00	13.50	89.00	13.20
April 6,2017	0.10	0.10	0.10	0.00	0.00	-0.10	Apr 6,2017	89.00	13.10	87.00	12.90	87.00	12.90
April 12,2017	0.30	0.30	0.30	0.20	0.10	-0.10	Apr 12,2017	92.00	13.50	92.00	13.60	92.00	13.60
April 23,2017	1.60	1.50	0.90	0.60	0.40	0.00	Apr 23,2017	92.00	12.90	90.00	12.90	88.00	12.80
April 26,2017	1.20	1.10	0.50	0.10	0.00	-0.20	Apr 26,2017	95.00	13.80	90.00	13.30	87.00	13.10
May 3,2017	2.10	2.00	1.40	0.60	0.30	0.10	May 3,2017	113.00	15.50	108.00	15.30	101.00	14.60
May 13, 2017	4.30	4.30	3.30	1.20	0.50	0.10	May 13,2017	101.00	13.20	102.00	13.90	95.00	13.80
May 18,2017	2.40	2.40	1.80	0.70	0.20	-0.10	May 18,2017	101.00	13.80	100.00	14.00	94.00	13.60
May 23.2017	4.20	4.10	3.20	2.60	2.30	0.60	May 23,2017	100.00	13.20	99.00	13.60	98.00	13.50
June 3,2017	4.60	4.40	3.90	2.80	2.20	1.70	June 3,2017	103.00	13.40	104.00	13.80	102.00	14.00
June 7,2017	6.50	6.50	5.30	3.20	2.50	1.20	June 7,2017	108.00	13.30	108.00	13.90	107.00	14.50
June 16,2017	7.40	7.30	7.30	4.60	2.70	2.20	June 16,2017	105.00	12.90	102.00	12.60	104.00	14.40
June 23, 2017	7.40	7.20	6.90	5.90	5.10	1.60	June 23, 2017	97.00	11.80	97.00	11.90	98.00	12.40
June 30, 2017	8.00	8.00	7.60	7.00	6.30	2.10	June 30, 2017	108.00	12.90	106.00	12.90	105.00	13.20
July 8, 2017	9.40	9.40	9.10	7.70	6.40	4.20	July 8, 2017	99.00	11.40	98.00	11.50	97.00	12.00
July 21, 2017	13.80	13.00	10.60	8.20	4.10	2.90	July 21, 2017	105.00	11.10	104.00	11.70	104.00	13.60
July 27, 2017	12.80	12.80	11.40	4.80	2.40	1.30	July 27, 2017	111.00	11.80	111.00	12.20	106.00	14.50
August 3, 2017	15.90	15.90	15.30	5.40	1.90	1.00	August 3, 2017	106.00	10.60	108.00	11.20	108.00	15.20
August 11, 2017	16.30	16.30	15.30	9.90	4.30	3.30	August 11, 2017	106.00	10.50	110.00	11.70	111.00	14.50
August 19, 2017	16.60	16.20	15.90	3.30	1.90	1.30	August 19, 2017	86.00	8.50	86.00	8.60	99.00	13.80
August 26, 2017	15.30	15.30	15.10	14.80	3.50	1.20							
September 3, 2017	14.80	14.80	14.70	10.10	6.20	2.20							
September 9, 2017	14.60	14.60	14.50	14.40	14.20	9.80	September 9, 2017	98.00	10.00	97.00	10.00	97.00	10.00
September 15, 2017	14.60	14.60	14.00	12.00	9.20	4.80	September 15, 2017	98.00	10.00	97.00	10.10	99.00	11.40
September 22, 2017	14.10	14.10	13.80	12.60	11.40	5.20	September 22, 2017	100.00	10.30	98.00	10.20	96.00	10.50
September 30, 2017	13.60	13.60	13.50	13.50	13.50	3.40	September 30, 2017	93.00	9.80	92.00	9.60	92.00	9.60
October 7, 2017	12.30	12.30	12.30	11.70	10.90	8.30	October 7, 2017	96.00	10.10	93.00	10.00	94.00	10.40
October 13, 2017	11.70	11.70	11.70	11.60	10.60	6.70	October 13, 2017	95.00	10.50	94.00	10.40	91.00	10.30
October 19, 2017	11.30	11.30	11.20	11.00	8.70	4.80	October 19, 2017	96.00	10.70	95.00	10.60	95.00	11.20
October 28, 2017	10.60	10.50	10.50	10.40	9.60	6.80	October 28, 2017	98.00	11.10	94.00	10.60	91.00	10.50
November 2, 2017	10.50	10.30	10.20	10.30	9.90	9.50	November 2, 2017	100.00	11.60	97.00	11.20	96.00	11.00
November 13, 2017	8.90	8.90	8.90	9.00	9.00	9.10	November 13, 2017	91.00	10.80	89.00	10.50	88.00	10.40
November 17, 2017	8.20	8.20	8.30	8.30	8.30	8.50	November 17, 2017	95.00	11.20	95.00	11.20	95.00	11.20
November 24, 2017	7.00	7.00	6.90	6.40	6.20	5.50	November 24, 2017	89.00	10.60	88.00	10.70	88.00	10.90
December 2, 2017	6.30	6.30	6.60	6.60	6.70	6.80	December 2, 2017	90.00	11.20	90.00	11.10	89.00	11.00
December 12, 2017	5.70	5.70	5.70	5.80	5.80	5.50	December 12, 2017	98.00	12.30	97.00	12.20	97.00	12.20
January 3, 2018	3.30	3.30	3.30	3.50	3.60	3.50	January 3, 2018	89.00	12.10	84.00	11.40	78.00	10.60
January 17, 2018	1.80	1.90	2.20	2.30	2.30	2.50	January 17, 2018	92.00	12.10	90.00	12.60	89.00	12.50
January 27, 2018	1.10	1.00	1.30	2.00	2.00	2.10	January 27, 2018	80.00	11.60	79.00	11.20	77.00	10.80
February 15, 2018	1.40	1.40	1.50	1.70	1.50	1.70	February 15, 2018	91.00	12.60	89.00	12.40	88.00	12.40
February 26, 2018	0.40	0.40	0.40	1.00	1.50	1.50	February 26, 2018	96.00	14.10	94.00	13.60	91.00	13.00

Appendix A-Sea Cage Site: Valen Island

Grieg NL Seafarms Ltd - Environmental Data

Sea Cage Site: Valen Island

Temperature							Dissolved Oxygen						
Date	Temperature (˚C) - Surface	Temperature (˚C) - 3m	Temperature (˚C) - 10m	Temperature (˚C) - 25m	Temperature (˚C) - 35m	Temperature (˚C) - 50m	Date:2	DO (%L) - 3m	DO (mg/L)-3m	DO (%L) - 15m	DO (mg/L)-15m	DO (%L) - 35m	DO (mg/L)-35m
Feb. 24, 2016		0.50	0.60	0.80	0.70	0.60	Feb. 24, 2016	107.60	12.76	103.90	12.30	102.70	12.10
Mar. 7, 2016		0.10	0.70	0.60	0.70	0.70	Mar. 7, 2016	n/a	n/a	n/a	n/a	n/a	n/a
Mar. 16, 2016		0.40	0.30	0.50	0.50	0.60	Mar. 16, 2016	119.10	13.74	115.00	13.32	112.00	12.92
Mar. 27, 2016		0.40	0.30	0.30	0.20	0.30	Mar. 27, 2016	115.20	13.23	107.50	12.66	105.00	12.36
Apr. 12, 2016		1.30	0.90	0.80	0.80	0.50	Apr. 12, 2016	114.30	13.15	107.50	12.56	103.80	12.14
Apr. 17, 2016		2.50	2.00	0.90	0.70	0.60	Apr. 17, 2016	122.50	13.25	122.70	13.88	105.90	12.29
Apr. 28, 2016		1.60	1.40	0.60	0.40	0.20	Apr. 28, 2016	125.00	13.71	117.90	13.36	108.40	12.45
May 5, 2016		3.20	1.90	1.40	1.00	0.80	May 5, 2016	129.00	13.46	122.60	13.78	111.00	12.74
May 12,2016		3.40	2.40	1.70	1.50	1.40	May 12,2016	114.60	12.19	112.80	12.39	109.10	12.19
May 20,2016		5.10	3.90	2.90	2.30	1.70	May 20,2016	115.40	11.93	114.60	12.24	113.30	12.53
May 26,2016		4.40	3.30	1.80	1.20	0.50	May 26,2016	118.80	12.50	114.40	12.38	109.00	12.34
June 3,2016		6.50	6.10	5.50	2.00	0.40	June 3,2016	112.80	11.89	114.30	11.61	111.90	12.46
June 11,2016		7.70	7.40	2.00	1.40	0.90	June 11,2016	113.20	10.88	112.80	11.14	107.70	12.03
June 25,2016		9.80	9.00	7.00	6.10	1.60	June 25,2016	113.40	10.58	111.30	10.78	111.60	11.33
July 8,2016		10.70	10.40	7.80	5.30	1.20	July 8,2016	114.50	10.41	107.20	9.83	104.10	11.79
July 20,2016		10.70	9.70	7.30	4.50	1.90	July 20,2016	115.10	10.39	112.20	10.74	109.70	11.42
July 26,2016		13.20	12.70	10.80	6.00	4.00	July 26,2016	114.40	9.84	110.70	9.87	109.70	11.05
August 3,2016		16.40	15.60	11.80	6.10	1.70	Aug. 3,2016	112.4	9.18	114.3	9.58	112	11.34
August 10,2016	16.20	16.00	15.10	8.50	2.90	1.80	Aug. 10,2016	113.1	9.17	114.6	9.9	111.3	12.17
August 20,2016	17.10	17.00	16.70	3.80	2.20	1.10	Aug. 20,2016	112.3	9.01	109.8	8.87	111	12.3
September 4,2014	15.30	15.30	15.20	5.40	3.40	2.10	Sept 4,2016	107.5	8.97	105.4	8.84	111.5	12.07
September 9,2016	15.80	15.80	15.80	11.60	7.70	5.20	Sept 9,2016	110.5	9.03	110.6	9.22	116.3	11.26
September 23,2016	14.40	14.20	14.00	13.90	12.60	7.70	Sept 23,2016	100.8	8.51	98	8.29	97.2	8.46
September 27,2016	13.80	13.80	13.70	13.60	11.80	6.30	Sept 27,2016	98.2	8.29	95.6	8.11	96.2	8.5
October 1,2016	13.10	13.40	13.10	13.00	10.20	5.80	Oct 1,2016	101.3	8.82	95.9	8.35	96.7	8.99
October 6,2016	12.50	12.50	12.40	11.90	11.20	9.10	Oct 6,2016	106.7	9.34	103.2	9.08	102.4	9.2
October 13,2016	11.80	11.80	11.80	11.60	11.60	11.60	Oct 13,2016	100.9	9.06	98.8	8.97	98.5	8.89
October 16,2016	11.40	11.40	11.40	11.40	11.50	7.10	Oct 16,2016	105.8	9.43	103.7	9.23	103	9.18
October 21,2016	10.90	11.00	11.00	11.10	11.00	10.90	Oct 21,2016	104.1	9.55	101.3	9.29	100.5	9.22
October 25,2016	10.70	10.70	10.80	10.80	10.50	10.40	Oct 25,2016	99.2	8.97	98.4	8.88	99	8.98
October 31,2016	10.20	10.20	10.20	9.60	9.50	9.60							
November 4,2016	9.90	10.00	9.90	9.90	9.80	8.70							
November 8,2016	9.20	9.20	9.50	9.20	8.90	7.80							
November 15,2016	8.90	8.90	8.90	8.90	8.90	8.20	Nov 15,2016	89.3	8.5	89.7	8.51	89.6	8.51
November 23,2016	9.30	9.20	9.10	9.00	8.90	8.20	Nov 23,2016	92.1	8.51	90.7	8.42	91	8.47
November 30,2016	7.50	7.50	7.60	7.90	8.10	8.10	Nov 30,2016	94	9.2	93.6	9.11	92.7	8.94
December 8,2016	6.30	6.30	6.50	6.60	6.40	5.00	Dec 9,2016	94.3	9.41	93.5	9.28	91.9	9.14
December 14,2016	5.30	5.30	5.30	5.30	5.40	5.50	Dec 14,2016	93.2	9.6	91.6	9.43	90.3	9.28
December 22,2016	4.30	4.30	4.30	4.30	4.00	3.70							
December 31,2016	3.00	3.00	3.30	3.30	3.40	3.20	Dec 31,2016	97.9	10.65	95.4	10.3	94.1	10.15
January 6,2017	2.50	2.60	2.60	2.50	2.70	2.70	Jan 6,2017	99.7	10.89	100.1	10.98	98.7	10.77
January 31,2017	1.00	1.00	1.00	1.10	1.30	1.60							
February 4,2017	0.50	0.60	0.70	0.70	1.30	1.60							
February 19,2017	0.60	0.60	0.60	0.70	0.80	0.60	Feb 19,2017	96	13.6	94	13.3	92	12.9
February 25,2017	0.60	0.60	0.70	0.70	0.60	0.50	Feb 25,2017	93	13.4	92	13.3	90	13.1
March 8,2017	0.20	0.20	0.20	0.30	0.30	0.30	Mar 8,2017	96	14.1	93	13.7	93	13.6
March 14,2017	-0.10	-0.10	0.00	0.00	0.10	0.10	Mar 14,2017	97	14.5	95	14.2	95	14.1
March 19,2017	0.00	0.00	0.20	0.10	0.10	0.10	Mar 19,2017	97	14.4	95	14.1	93	13.8
March 25,2017	0.00	0.00	0.20	0.10	0.10	0.00	Mar 25,2017	93	13.8	91	13.5	90	13.2
April 6,2017	0.20	0.10	0.10	0.00	0.00	-0.10	Apr 6,2017	90	13.3	88	13	88	13
April 12,2017	0.30	0.30	0.20	0.00	-0.10	-0.10	Apr 12,2017	92	13.6	92	13.6	91	13.5
April 23,2017	1.40	1.40	1.20	1.00	0.20	-0.10	Apr 23,2017	91	12.9	92	12.9	88	12.9
April 26,2017	1.50	1.40	0.70	0.10	-0.10	-0.20	Apr 26,2017	96	13.8	92	13.6	86	13
May 3,2017	2.30	2.50	1.60	0.60	0.40	0.20	May 3,2017	116	15.7	111	15.5	103	14.7
May 13,2017	4.60	4.60	3.60	1.00	0.50	0.10	May 13,2017	100	13.9	101	13.6	93	13.6
May 18,2017	2.80	2.80	1.80	0.20	0.00	0.00	May 18,2017	102	13.7	104	14.6	91	13.3
May 23,2017	4.10	3.90	3.10	3.00	2.40	0.70	May 23,2017	100	13.2	98	13.3	99	13.6
June 3,2017	4.20	3.80	3.60	2.40	1.90	1.50	June 3,2017	103	13.6	102	13.6	101	14
June 7,2017	7.00	5.80	5.20	2.70	2.00	1.80	June 7,2017	108	13.6	107	13.7	105	14.4
June 16,2017	7.40	7.40	6.60	4.80	3.20	1.60	June 16,2017	105	12.7	104	12.9	105	14.3
June 23, 2017	7.50	7.40	7.20	5.40	5.10	2.40	June 23, 2017	97	11.7	98	11.9	98	12.5
June 30, 2017	9.00	8.20	7.80	6.80	6.80	6.70	June 30, 2017	107	12.7	107	13	105	13
July 8, 2017	9.10	9.10	8.30	6.70	6.00	3.70	July 8, 2017	97	11.2	97	11.5	95	12
July 21, 2017	13.50	12.50	10.60	8.80	4.90	2.00	July 21, 2017	109	11.4	105	11.9	106	13.6
July 27, 2017	13.80	13.80	12.10	6.20	2.90	1.60	July 27, 2017	111	11.5	112	12.8	107	14.4
August 3, 2017	15.60	15.60	15.40	4.00	1.90	1.10	August 3, 2017	106	10.8	107	11.2	107	15.1
August 11, 2017	16.20	16.20	14.80	7.70	5.20	2.80	August 11, 2017	108	10.7	110	11.7	109	14.1
August 19, 2017	16.20	16.10	15.60	8.90	2.00	0.90	August 19, 2017	83	8.2	87	8.8	103	19.3
August 26, 2017	15.50	15.50	15.30	14.30	8.30	2.10							
September 3, 2017	15.00	15.00	14.90	9.00	4.90	2.90							
September 9, 2017	14.60	14.40	14.20	13.90	13.50	11.30	September 9, 2017	100	10.3	97	10.1	97	10.2
September 15, 2017	14.50	14.30	14.20	12.80	10.50	9.70	September 15, 2017	98	10.1	95	9.9	98	11
September 22, 2017	14.00	14.00	14.00	13.10	10.90	3.30	September 22, 2017	100	10.4	99	10.2	96	10.6
September 30, 2017	13.60	13.60	13.60	13.50	13.00	3.60	September 30, 2017	94	9.8	89	9.3	90	9.5
October 7, 2017	12.40	12.40	12.40	12.20	11.80	8.00	October 7, 2017	95	10.2	94	10.1	92	10
October 13, 2017	11.80	11.80	11.70	11.60	11.00	5.50	October 13, 2017	93	10.2	94	10.3	92	10.3
October 19, 2017	11.40	11.20	11.20	11.10	8.20	4.40	October 19, 2017	97	10.8	96	10.6	95	11.3
October 28, 2017	10.40	10.30	10.40	10.40	9.00	6.60	October 28, 2017	97	10.9	94	10.6	93	10.8
November 2, 2017	10.50	10.50	10.40	10.20	9.70	8.90	November 2, 2017	98	11.2	98	11.2	96	11.1
November 13, 2017	8.60	8.60	8.60	9.00	9.00	8.30	November 13, 2017	90	10.7	90	10.6	89	10.5
November 17, 2017	8.30	8.30	8.30	8.30	8.30	7.10	November 17, 2017	95	11.2	95	11.2	95	11.2
November 24, 2017	6.90	6.90	6.90	6.50	6.00	5.40	November 24, 2017	88	10.7	88	10.7	88	11
December 2, 2017	6.50	6.50	6.50	6.50	6.60	6.60	December 2, 2017	87	10.8	88	10.9	89	10.7
December 12, 2017	5.70	5.70	5.70	5.70	5.70	5.40	December 12, 2017	100	12.6	98	12.3	97	12.2
January 3, 2018	3.30	3.40	3.40	3.50	3.60	3.60	January 3, 2018	92	12.6	92	12.5	91	12.3
January 17, 2018	1.90	2.00	2.20	2.30	2.30	2.40	January 17, 2018	91	12.9	90	12.6	89	12.4
January 27, 2018	1.20	1.20	1.50	2.20	2.20	2.80	January 27, 2018	81	11.6	77	10.9	76	10.6
February 15, 2018	1.40	1.50	1.50	1.60	1.50	1.60	February 15, 2018	91	12.7	89	12.5	88	12.3
February 26, 2018	0.50	0.50	0.60	0.90	1.20	1.60	February 26, 2018	96	14.1	93	13.5	92	13.2

Appendix A-Sea Cage Site: Darby Harbour

Grieg NL Seafarms Ltd - Environmental Data													
Sea Cage Site: Darby Harbour													
Temperature							Dissolved Oxygen						
Date	Temperature (˚C) - Surface	Temperature (˚C) - 3m	Temperature (˚C)- 10m	Temperature (˚C) - 25n	mperature (˚C) -	Temperature (˚C) - 50m	Date:2	DO (%L) - 3m	DO (mg/L)-3m	DO (%L) - 15m	DO (mg/L)-15m	DO (%L) - 35m	DO (mg/L)-35m
Mar. 11, 2016		0.40	0.40	0.50	0.50	0.40	Mar. 11, 2016	115.4	13.36	113.40	13.10	109.10	12.59
Mar. 16, 2016		0.30	0.20	0.20	0.20	0.30	Mar. 16, 2016	118.8	13.80	116.60	13.62	114.60	13.36
Mar. 27, 2016		0.20	0.30	0.20	0.20	0.20	Mar. 27, 2016	112.2	13.12	108.80	12.84	107.00	12.65
Apr. 12, 2016		1.10	1.10	1.00	0.80	0.50	Apr. 12, 2016	117.4	13.57	113.70	13.17	109.20	12.70
Apr. 17, 2016		2.50	2.40	1.20	0.80	0.40	Apr. 17, 2016	123.1	13.74	122.80	13.69	108.50	12.55
Apr. 28, 2016		1.40	1.00	0.90	0.80	0.30	Apr. 28, 2016	122.3	13.67	117.00	13.28	111.20	12.70
May 5, 2016		3.00	2.10	1.20	0.90	0.50	May 5, 2016	124.8	13.33	123.10	13.64	109.60	12.57
May 12, 2016		2.90	2.60	2.30	1.90	1.20	May 12,2016	116.3	12.50	114.80	12.49	113.60	12.50
May 20,2016		5.30	4.50	3.80	3.00	1.60	May 20,2016	115.3	11.83	113.70	11.20	115.30	12.57
May 26,2016		6.20	5.10	2.80	1.80	0.60	May 26,2016	115.6	11.60	115.60	12.05	114.00	12.74
June 3,2016		5.90	5.70	4.70	2.20	1.10	June 3, 2016	113.3	11.57	111.30	11.44	111.70	12.40
June 11,2016		7.70	7.60	3.30	1.70	1.00	June 11,2016	113.6	11.22	110.80	10.94	112.40	12.44
June 25,2016		7.40	7.20	6.10	3.80	1.80	June 25,2016	116.0	11.40	112.20	11.17	111.20	11.95
July 8,2016		11.00	10.90	5.00	3.20	1.60	July 8,2016	111.9	10.00	109.60	10.01	103.30	12.05
July 20,2016		10.20	9.50	6.90	4.30	1.60	July 20,2016	114.8	10.50	114.80	10.97	115.70	12.02
July 26,2016		12.80	11.70	9.90	4.40	1.30	July 26,2016	113.5	9.85	113.00	10.08	115.90	12.08
August 3,2016		15.20	15.00	10.90	3.50	1.40	Aug. 3,2016	113.6	9.46	113.50	9.58	115.50	12.43
August 10,2016	14.00	13.90	13.80	6.70	3.30	1.40	Aug. 10,2016	112.4	9.58	112.00	9.66	110.00	11.91
August 20,2016	17.00	17.00	16.90	6.00	3.00	1.30	Aug. 20,2016	112.3	9.00	110.70	8.92	115.50	12.57
September 4,2016	15.30	15.40	15.40	9.90	3.30	1.70	Sept 4,2016	106.6	8.86	105.20	8.74	112.20	12.20
September 9,2016	15.60	15.60	15.60	10.90	8.50	5.00	Sept 9,2016	109.0	8.95	109.60	9.05	112.50	10.71
September 23,2016	13.20	13.20	13.20	13.00	11.80	5.90	Sept 23,2016	102.3	8.81	99.30	8.59	98.20	8.73
September 27,2016	13.20	13.20	13.20	13.10	12.90	7.10	Sept 27,2016	103.8	8.88	9.99	8.56	97.00	8.35
October 1,2016	12.30	12.30	12.30	12.10	8.50	4.50	Oct 1,2016	102.0	9.03	101.20	8.95	103.60	9.95
October 6,2016	11.90	11.90	11.70	11.70	11.70	11.00	Oct 6,2016	110.5	9.80	104.70	9.33	102.00	9.08
October 12,2016	11.60	11.50	11.50	11.60	11.60	11.20	Oct 12,2016	103.9	9.39	102.90	9.29	100.50	9.08
October 16,2016	11.30	11.30	11.40	11.40	11.40	6.80	Oct 16,2016	109.2	9.77	106.90	9.56	105.80	9.46
October 21,2016	10.90	10.90	10.90	10.90	10.80	10.80	Oct 21,2016	103.6	9.51	102.50	9.41	102.00	9.38
October 25,2016	10.40	10.50	10.60	10.70	10.70	9.80	Oct 25,2016	105.1	9.55	104.10	9.46	102.00	9.25
October 31,2016	10.10	10.10	9.70	9.60	9.60	9.20							
November 4,2016	10.00	10.00	9.90	9.80	9.60	9.50							
November 8,2016	9.50	9.40	9.40	9.30	9.10	8.70							
November 15,2016	9.00	9.00	9.10	9.00	9.00	7.90	Nov 15,2016	91.7	8.71	88.20	8.35	88.90	8.44
November 23,2016	9.20	9.30	9.10	8.90	8.80	7.40	Nov 23,2016	96.4	8.94	93.90	8.75	92.90	8.70
November 30,2016	8.10	8.10	8.10	8.10	8.00	6.70	Nov 30,2016	91.1	8.79	89.80	8.66	91.20	8.82
December 8,2016	6.60	6.60	6.60	6.60	6.60	6.60	Dec 8,2016	93.4	9.24	92.80	9.18	93.30	9.22
December 14,2016	5.50	5.40	5.40	5.40	5.40	5.50	Dec 14,2016	93.9	9.67	93.10	9.59	92.40	9.52
December 26,2016	3.70	3.70	3.70	3.70	3.80	3.80	Dec 26,2016	90.7	9.78	89.70	9.66	89.80	9.66
December 31,2016	3.10	3.00	3.30	3.30	3.80	2.50	Dec 31,2016	101.2	10.41	98.40	10.54	96.90	10.49
January 6,2017	2.50	2.50	2.50	2.50	2.50	2.60	Jan 6,2017	101.6	11.18	100.40	11.05	98.60	10.83
January 30,2017	1.30	1.40	1.40	1.40	1.40	1.50							
February 4,2017	0.60	0.60	0.70	0.90	1.00	1.20							
February 19,2017	0.60	0.60	0.60	0.60	0.60	0.30	Feb 19,2017	92.0	13.10	90.00	12.90	90.00	12.60
February 25,2017	0.40	0.40	0.20	0.00	0.00	0.00	Feb 25,2017	94.0	13.60	93.00	13.50	91.00	13.40
March 8,2017	0.10	0.20	0.20	0.10	0.00	0.00	Mar 8,2017	95.0	14.10	95.00	13.90	94.00	13.80
March 14,2017	-0.20	-0.20	-0.10	-0.10	-0.10	-0.10	Mar 14,2017	99.0	14.90	99.00	14.80	98.00	14.60
March 19,2017	0.00	0.00	0.10	0.10	0.00	-0.10	Mar 19,2017	95.0	14.20	95.00	14.10	94.00	14.00
March 24,2017	0.20	0.20	0.20	0.10	-0.10	-0.20	Mar 24,2017	95.0	13.90	94.00	13.90	91.00	13.60
April 6,3017	-0.10	-0.10	-0.10	-0.10	-0.20	-0.20	Apr 6,2017	91.0	13.50	90.00	13.40	89.00	13.20
April 12,2017	0.10	0.10	0.10	-0.10	-0.10	-0.20	Apr 12,2017	94.0	13.80	94.00	13.80	92.00	13.60
April 22,2017	1.00	1.00	1.00	0.70	0.70	0.00	Apr 22,2017	98.0	14.00	97.00	13.90	93.00	13.30
April 26,2017	0.70	0.70	0.50	0.00	-0.20	-0.40	Apri 26,2017	95.0	13.90	91.00	13.50	86.00	13.00
May 3,2017	1.50	1.50	1.40	1.00	0.90	0.10	May 3,2017	112.0	15.70	108.00	15.30	107.00	15.20
May 13,2017	3.40	3.40	3.30	3.10	0.40	0.20	May 13,2017	104.0	14.00	104.00	14.00	104.00	15.10
May 19,2017	2.00	1.90	1.50	0.60	0.30	0.10	May 19,2017	104.0	14.40	105.00	14.90	100.00	14.40
May 23,2017	3.50	3.40	3.40	2.90	2.40	1.70	May 23,2017	100.0	13.40	99.00	13.40	99.00	13.70
June 3,2017	3.80	3.60	3.40	2.80	2.20	1.40	June 3,2017	103.0	13.70	102.00	13.70	102.00	14.00
June 7,2017	5.80	5.00	4.40	2.20	1.40	1.00	June 7,2017	107.0	13.70	107.00	14.00	102.00	14.50
June 16,2017	6.60	6.60	6.50	4.60	2.90	1.70	June 16,2017	106.0	13.10	104.00	13.10	103.00	14.10
June 23, 2017	5.80	5.80	5.40	4.50	3.90	2.70	June 23, 2017	97.0	12.10	98.00	12.40	98.00	12.80
July 1, 2017	7.70	7.70	6.40	5.80	5.30	3.10	July 1, 2017	109.0	13.10	109.00	13.70	108.00	13.90
July 9, 2017	8.30	8.30	7.80	6.90	6.40	4.60	July 9, 2017	98.0	11.60	98.00	11.60	98.00	12.10
July 21, 2017	11.70	10.90	10.40	7.50	4.30	2.20	July 21, 2017	108.0	11.90	107.00	12.20	105.00	13.60
July 27, 2017	12.20	12.20	10.20	4.90	2.30	1.20	July 27, 2017	111.0	11.90	113.00	12.90	105.00	14.50
August 3, 2017	15.70	15.70	15.10	6.00	2.50	1.50	August 3, 2017	108.0	10.80	111.00	11.70	109.00	15.00
August 11, 2017	16.70	16.70	15.50	10.20	4.80	2.90	August 11, 2017	105.0	10.30	111.00	11.60	110.00	14.20
August 19, 2017	15.80	15.80	15.60	6.60	1.60	1.10	August 19, 2017	95.0	9.50	97.00	9.70	105.00	15.10
August 26, 2017	15.70	15.20	14.60	9.60	3.00	2.20							
September 3, 2017	13.90	13.90	13.70	13.30	7.50	2.50							
September 9, 2017	13.20	13.10	13.00	12.80	11.80	4.70	September 9, 2017	100.0	10.60	98.00	10.40	96.00	10.50
September 16, 2017	13.60	13.60	13.00	11.80	9.70	5.70	September 16, 2017	101.0	10.50	99.00	10.50	99.00	11.30
September 22, 2017	13.40	13.40	13.40	12.00	9.90	4.20	September 22, 2017	99.0	10.40	98.00	10.30	96.00	11.00
September 30, 2017	13.20	13.20	13.10	13.10	9.60	3.10	September 30, 2017	95.0	10.10	93.00	9.90	93.00	10.70
October 7, 2017	12.10	12.10	11.90	10.00	8.40	5.30	October 7, 2017	94.0	10.20	94.00	10.30	96.00	11.30
October 13, 2017	11.80	11.80	11.60	11.50	10.60	6.10	October 13, 2017	94.0	10.40	94.00	10.40	91.00	10.30
October 19, 2017	11.00	11.00	11.00	10.70	8.90	5.30	October 19, 2017	95.0	10.60	96.00	10.60	95.00	11.10
October 28, 2017	10.30	10.30	10.30	10.10	8.20	4.80	October 28, 2017	97.0	10.90	93.00	10.60	95.00	11.20
November 2, 2017	10.20	10.20	10.20	10.10	9.10	6.70	November 2, 2017	98.0	11.30	97.00	11.20	96.00	11.30
November 13, 2017	8.70	8.70	8.70	8.70	8.70	8.50	November 13, 2017	92.0	10.90	92.00	10.90	91.00	10.80
November 19, 2017	7.80	7.90	7.90	7.80	7.20	6.80	November 19, 2017	89.0	10.60	88.00	10.40	88.00	10.70
November 28, 2017	6.80	6.80	6.80	6.80	6.70	6.50	November 28, 2017	92.0	11.40	92.00	11.30	89.00	11.00
December 6, 2017	6.00	6.00	6.10	6.10	6.10	5.50	December 6, 2017	95.0	11.90	92.00	11.50	92.00	11.50
December 12, 2017	5.70	5.70	5.80	5.80	5.80	5.70	December 12, 2017	99.0	12.50	99.00	12.40	98.00	12.30
January 4, 2018	2.90	2.90	3.00	3.60	3.70	3.30	January 4, 2018						
January 17, 2018	1.90	2.00	2.10	2.20	2.20	2.10	January 17, 2018	90.0	12.70	90.00	12.70	89.00	12.60
January 27, 2018	1.30	1.30	1.30	1.50	1.50	1.80	January 27, 2018	79.0	11.30	78.00	11.30	78.00	11.10
February 15, 2018	1.10	1.10	1.00	1.20	1.30	1.30	February 15, 2018	93.0	13.20	92.00	13.00	90.00	12.80
February 26, 2018	0.40	0.40	0.40	0.40	0.50	0.60	February 26, 2018	93.0	13.60	92.00	13.60	92.00	13.30

Appendix A-Sea Cage Site: Red Island

Grieg NL Seafarms Ltd - Environmental Data													
Sea Cage Site: Red Island													
Temperature								Dissolved Oxygen					
Date	Temperature (˚C) - Surface	Temperature (˚C) - 3m	Temperature (˚C)- 10m	Temperature (˚C) - 25m	Temperature (˚C) - 35m	Temperature (˚C) - 50m	Date:2	DO (%L) - 3m	DO (mg/L)-3m	DO (%L) - 15m	DO (mg/L)-15m	DO (%L) - 35m	DO (mg/L)-35m
Mar.11, 2016		0.30	0.40	0.50	0.50	0.50	Mar. 11, 2016	113.20	13.09	110.50	12.78	106.30	12.24
Mar. 16, 2016		0.20	0.30	0.30	0.30	0.30	Mar. 16, 2016	123.00	14.30	118.50	13.74	115.20	13.39
Mar. 27, 2016		0.20	0.20	0.30	0.30	0.30	Mar. 27, 2016	113.50	13.37	109.60	12.95	105.60	12.40
Apr. 12, 2016		1.30	1.20	1.10	0.90	0.30	Apr. 12, 2016	118.40	13.56	113.30	13.02	107.50	12.54
Apr. 17, 2016		2.30	1.80	0.70	0.50	0.30	Apr. 17, 2016	126.00	14.12	120.30	13.77	104.60	12.25
Apr. 28, 2016		2.00	1.90	1.00	0.50	0.20	Apr. 28, 2016	125.50	13.87	123.00	13.67	106.90	12.27
May 5, 2016		2.90	2.20	1.00	0.80	0.40	May 5, 2016	124.80	13.52	122.80	13.82	114.40	12.62
May 12,2016		3.80	3.30	2.80	2.10	0.50	May12,2016	115.00	12.20	114.90	12.33	113.90	12.52
May 20,2016		5.30	5.40	4.30	1.90	0.90	May 20,2016	114.10	11.71	112.50	11.72	113.90	12.69
May 26,2016		6.90	6.00	3.20	1.80	0.50	May 26,2016	117.40	11.51	116.50	12.01	111.50	12.43
June 3,2016		6.20	6.10	2.80	1.70	0.90	June 3,2016	117.00	11.87	118.30	11.70	111.20	12.60
June 11,2016		8.00	8.00	2.70	1.80	0.90	June 11,2016	113.60	10.85	110.80	10.59	111.70	12.38
June 25,2016		8.50	8.10	6.00	3.50	1.80	June 25,2016	114.40	11.00	111.70	10.95	111.30	12.02
July 8,2016		11.00	10.50	4.60	3.50	1.20	July 8,2016	109.00	9.85	109.40	10.10	106.50	12.03
July 20,2016		11.20	10.60	6.00	3.50	1.20	July 20,2016	113.90	10.19	112.50	10.51	111.40	11.88
July 26,2016		12.80	12.20	11.40	5.10	2.20	July 26,2016	114.10	9.87	112.80	10.01	115.10	11.83
August 3,2016		15.30	15.30	7.20	2.70	1.40	Aug. 3,2016	115.20	9.57	117.30	10.12	111.40	12.26
August 10,2016	15.50	15.30	14.70	9.20	2.50	1.10	Aug. 10,2016	113.50	9.40	111.60	9.38	110.30	12.17
August 20,2016	17.20	17.20	17.20	5.10	2.60	1.00	Aug. 20,2016	112.50	8.98	110.30	10.05	111.60	12.27
September 4,2016	15.40	15.40	15.40	6.30	2.80	1.60	Sept 4,2016	107.40	8.92	105.80	8.78	109.10	11.97
September 9,2016	15.80	15.90	15.90	10.20	6.70	4.70	Sept 9,2016	106.50	8.95	110.00	8.99	116.20	11.54
September 23,2016	13.70	13.70	13.70	13.30	13.00	6.00	Sept 23,2016	102.90	8.76	100.60	8.62	98.50	8.53
September 27,2016	13.50	13.50	13.50	13.50	11.40	5.30	Sept 27,2016	98.50	8.38	97.90	8.33	97.70	8.62
October 1,2016	13.00	13.00	12.90	12.70	8.20	3.10	Oct 1,2016	101.70	8.88	97.90	8.57	101.80	9.83
October 6,2016	12.20	12.20	11.90	11.90	11.90	11.30	Oct 6,2016	107.00	9.43	103.40	9.17	101.00	8.95
October 12,2016	11.90	11.90	11.90	11.80	11.50	7.30	Oct 12,2016	104.50	9.37	102.00	9.17	100.30	9.07
October 16,2016	11.50	11.50	11.50	11.60	9.70	5.80	Oct 16,2016	106.30	9.48	105.70	9.42	104.30	9.64
October 21,2016	11.00	11.00	11.00	11.10	11.10	11.00	Oct 21,2016	103.40	9.47	101.30	9.26	100.20	9.17
October 25,2016	10.80	10.80	10.80	10.90	10.80	10.30	Oct 25,2016	106.90	9.66	102.90	9.30	99.60	9.00
October 31,2016	10.00	10.00	9.90	9.90	9.80	9.20							
November 4,2016	10.10	10.00	9.90	9.80	9.70	9.10							
November 8,2016	9.30	9.30	9.50	9.50	9.50	8.80							
November 15,2016	9.00	9.00	9.00	9.00	9.10	6.80	Nov 15,2016	92.40	8.77	88.30	8.38	86.50	8.20
November 23,2016	9.20	9.20	9.20	9.00	8.80	7.50	Nov 23,2016	94.40	8.75	91.40	8.51	90.00	8.42
November 30,2016	8.00	7.90	8.00	8.00	7.90	5.90	Nov 30,2016	94.10	9.12	92.10	8.91	90.70	8.79
December 8,2016	6.60	6.60	6.60	6.70	6.80	6.70	Dec 8,2016	93.50	9.25	92.50	9.14	92.10	9.08
December 14,2016	5.50	5.50	5.50	5.50	5.40	5.10	Dec 14,2016	91.70	9.44	89.00	9.17	90.60	9.33
December 26,2016	3.60	3.60	3.60	3.70	3.70	3.70	Dec 26,2016	90.10	9.72	88.90	9.58	88.50	9.53
December 31,2016	2.90	3.00	3.20	3.30	3.10	3.10	Dec 31,2016	96.70	10.46	97.40	10.45	95.70	10.32
January 6,2017	2.60	2.60	2.60	2.60	2.60	2.60	Jan 6,2017	100.80	11.07	99.30	10.90	99.10	10.88
January 30,2017	1.20	1.20	1.20	1.20	1.30	1.60							
February 4,2017	0.30	0.40	0.50	0.60	1.30	1.20							
February 19,2017	0.50	0.50	0.50	0.50	0.50	0.70	Feb 19,2017	93.00	13.20	92.00	13.00	91.00	12.80
February 25,2017	0.50	0.50	0.50	0.30	0.20	0.30	Feb 25,2017	94.00	13.60	91.00	13.30	91.00	13.30
March 8,2017	0.10	0.10	0.20	0.20	0.10	0.10	Mar 8,2017	93.00	13.70	93.00	13.70	92.00	13.60
March 14,2017	-0.10	-0.10	0.00	0.00	0.00	0.00	Mar 14,2017	97.00	14.50	97.00	14.40	97.00	14.50
March 19,2017	0.00	0.00	0.10	0.10	0.10	-0.20	Mar 19,2017	96.00	14.40	95.00	14.10	95.00	14.20
March 24,2017	0.20	0.20	0.30	0.00	-0.20	-0.20	Mar 24,2017	93.00	13.90	91.00	13.50	90.00	13.40
April 6,2017	-0.10	-0.10	-0.10	-0.10	-0.20	-0.20	Apr 6,2017	88.00	13.20	88.00	13.00	88.00	13.10
April 12,2017	0.80	0.60	0.60	0.40	0.10	-0.20	Apr 12,2017	93.00	13.60	92.00	13.40	91.00	13.50
April 22,2017	0.70	0.70	0.60	0.60	0.40	-0.30	Apr 22,2017	92.00	13.30	91.00	13.20	91.00	13.20
April 26,2017	1.40	1.40	0.80	0.30	0.20	-0.30	Apr 26,2017	95.00	13.60	93.00	13.70	90.00	13.30
May 3,2017	1.50	1.50	1.30	1.00	0.80	0.20	May 3,2017	114.00	15.90	107.00	15.20	107.00	15.20
May 13,2017	3.00	3.00	2.90	2.10	0.50	0.20	May 13,2017	106.00	14.40	105.00	14.30	100.00	14.60
May 19.2017	2.80	2.70	2.70	1.20	0.60	0.10	May 19,2017	103.00	13.90	105.00	14.30	103.00	14.80
May 23,2017	3.30	2.80	2.70	1.80	1.40	0.90	May 23,2017	102.00	13.80	101.00	13.80	101.00	14.20
June 3,2017	4.30	4.30	4.20	3.00	1.90	1.30	June 3,2017	103.00	13.50	102.00	13.50	102.00	14.30
June 7,2017	6.50	5.60	4.70	2.10	1.40	1.10	June 7,2017	112.00	14.00	110.00	14.20	107.00	14.90
June 16,2017	7.20	7.00	6.80	3.50	2.20	1.60	June 16,2017	105.00	12.90	105.00	13.20	105.00	14.50
June 23, 2017	6.40	6.40	6.40	5.30	3.60	1.90	June 23,2 017	99.00	12.20	97.00	12.10	98.00	13.00
July 1, 2017	7.80	7.80	7.60	6.10	5.60	3.00	July 1, 2017	109.00	13.10	108.00	13.30	108.00	13.70
July 9, 2017	9.00	9.00	8.10	7.80	6.20	3.30	July 9, 2017	98.00	11.30	99.00	11.70	99.00	12.20
July 21, 2017	12.50	12.50	10.40	7.50	7.10	2.10	July 21, 2017	106.00	11.30	108.00	12.10	105.00	12.70
July 27, 2017	14.50	14.50	12.30	5.80	2.70	0.80	July 27, 2017	110.00	11.20	114.00	12.80	106.00	14.40
August 3, 2017	16.00	16.00	14.60	5.40	2.50	1.60	August 3, 2017	106.00	10.60	113.00	12.40	108.00	15.00
August 11, 2017	17.30	17.20	16.50	11.40	4.80	2.90	August 11, 2017	105.00	10.30	111.00	11.60	110.00	14.20
August 19, 2017	15.80	15.70	15.50	6.60	2.60	1.90	August 19, 2017	97.00	9.70	99.00	10.10	101.00	13.90
August 26, 2017	15.00	15.00	14.70	9.50	4.80	2.20							
September 3, 2017	15.20	15.20	14.90	14.00	6.70	2.70							
September 9, 2017	13.30	13.20	13.20	13.30	13.20	4.60	September 9, 2017	99.00	10.50	97.00	10.30	94.00	9.90
September 16, 2017	13.80	13.60	13.30	11.60	10.70	4.30	September 16, 2017	101.00	10.50	99.00	10.50	98.00	11.00
September 22, 2017	13.80	13.80	13.70	12.40	10.00	4.90	September 22, 2017	100.00	10.40	99.00	10.30	96.00	11.00
September 30, 2017	13.40	13.30	13.30	13.20	6.40	2.80	September 30, 2017	94.00	9.90	93.00	9.80	96.00	11.90
October 7, 2017	12.10	12.10	12.10	12.10	10.40	7.30	October 7, 2017	96.00	10.40	94.00	10.60		
October 13, 2017	12.00	12.00	11.90	11.80	8.30	5.30	October 13, 2017	94.00	10.40	94.00	10.30	95.00	11.30
October 19, 2017	11.30	11.30	11.30	11.30	8.30	5.40	October 19, 2017	98.00	10.80	95.00	10.50	95.00	11.20
October 28, 2017	10.40	10.30	10.30	10.30	10.10	5.90	October 28, 2017	98.00	11.00	93.00	10.50	92.00	10.50
November 2, 2017	10.40	10.40	10.30	10.30	9.60	9.60	November 2, 2017	99.00	11.40	98.00	11.20	95.00	11.10
November 13, 2017	8.80	8.80	8.80	8.80	8.90	6.50	November 13, 2017	91.00	10.80	91.00	10.70	89.00	10.50
November 19, 2017	8.00	8.00	8.00	8.00	7.90	6.40	November 19, 2017	99.00	10.60	98.00	10.40	95.00	10.40
November 28, 2017	6.90	6.90	6.90	6.90	6.90	6.90	November 28, 2017	90.00	11.10	91.00	11.10	90.00	11.10
December 6, 2017	6.00	6.00	6.00	6.00	6.00	5.30	December 6, 2017	94.00	11.90	91.00	11.40	90.00	11.40
December 12, 2017	5.80	5.80	5.80	5.80	5.70	5.80	December 12, 2107	100.00	12.60	98.00	12.30	98.00	12.30
January 4, 2018	2.90	2.90	3.00	3.80	3.80	3.40	January 4, 2018						
January 17, 2018	2.00	2.00	2.10	2.20	2.20	2.20	January 17, 2018	92.00	13.00	91.00	12.80	89.00	12.50
January 27, 2018	1.40	1.40	1.40	1.40	1.60	2.10	January 27, 2018	80.00	11.50	78.00	11.20	77.00	11.10
February 15, 2018	1.20	1.10	1.00	1.20	1.30	1.40	February 15, 2018	93.00	13.10	91.00	12.00	90.00	12.70
February 26, 2018	0.30	0.40	0.40	0.40	0.80	1.00	February 26, 2018	93.00	13.60	92.00	13.60	92.00	13.30

Appendix A-Sea Cage Site: Butler Island

Grieg NL Seafarms Ltd - Environmental Data

Sea Cage Site: Butler Island

Temperature							Dissolved Oxygen						
Date	Temperature (˚C) - Surface	Temperature (˚C) - 3m	Temperature (˚C)- 10m	Temperature (˚C) - 25m	Temperature (˚C) - 35m	Temperature (˚C) - 50m	Date:	DO (%L) - 3m	DO (mg/L)-3m	DO (%L) - 15m	DO (mg/L)-15m	DO (%L) - 35m	DO (mg/L)-35m
Mar.11, 2016		0.40	0.50	0.50	0.50	0.50	Mar. 11, 2016	115.90	13.38	114.60	13.23	107.80	12.47
Mar. 16, 2016		0.20	0.30	0.40	0.40	0.30	Mar. 16, 2016	1118.10	13.70	115.10	13.38	113.20	13.14
Mar. 27, 2016		0.10	0.20	0.20	0.20	0.20	Mar. 27, 2016	112.90	13.27	110.30	12.90	106.60	12.56
Apr. 12, 2016		1.40	1.00	0.50	0.40	0.40	Apr. 12, 2016	117.10	13.46	108.30	12.63	103.50	12.22
Apr. 17, 2016		2.10	1.70	1.00	0.70	0.30	Apr. 17, 2016	126.30	14.17	120.20	14.72	107.30	12.48
Apri. 28, 2016		2.10	1.90	0.80	0.40	0.20	Apr. 28, 2016	127.20	14.03	125.70	13.89	108.40	12.43
May 5, 2016		2.60	2.30	1.20	0.90	0.40	May 5, 2016	125.70	13.80	123.20	13.86	110.80	12.70
May 12,2016		4.20	3.10	2.40	1.80	0.90	May 12,2016	116.80	12.21	116.00	12.46	113.10	12.50
May 20,2016		5.20	4.50	3.10	2.30	1.40	May 20,2016	117.50	11.97	114.70	12.20	113.70	12.60
May 26,2016		7.20	7.10	2.80	1.70	0.70	May 26,2016	115.40	11.32	118.20	12.47	112.90	12.64
June 3,2016		6.00	5.60	4.10	1.50	0.90	June 3,2016	113.70	11.60	112.30	11.61	110.30	12.55
June 11,2016		6.60	5.50	3.30	1.80	1.00	June 11,2016	116.00	11.41	115.80	11.83	111.40	12.84
June 25,2016		8.70	8.30	6.20	4.70	1.60	June 25,2016	112.10	10.71	110.20	10.70	111.90	11.83
July 8,2016		10.60	10.10	6.90	4.10	1.30	July 8,2016	110.30	10.06	108.70	10.07	106.40	12.04
July 20,2016		11.40	11.00	6.00	3.30	1.40	July 20,2016	110.90	9.85	109.70	9.86	110.00	11.77
July 26,2016		13.10	12.60	10.00	5.40	2.00	July 26,2016	114.20	9.84	111.00	9.73	113.50	11.62
August 3,2016		15.00	14.00	7.20	2.90	1.20	Aug. 3,2016	114.6	9.59	115.5	10.02	112.6	12.32
August 10,2016	16.00	15.90	15.70	7.90	2.80	1.20	Aug. 10,2016	113.8	9.32	113.1	9.67	111.9	12.23
August 20,2016	17.20	17.20	16.40	4.80	2.50	1.00	Aug. 20,2016	110.5	8.82	115	9.49	112.4	12.38
September 4,2016	15.30	15.30	15.30	6.50	2.80	1.50	Sept 4,2016	106.4	8.85	106	8.92	112.5	12.36
September 9,2016	16.00	16.00	15.60	10.40	7.10	5.60	Sept 9,2016	108.9	8.88	112.5	9.66	114.8	11.27
September 23,2016	13.90	13.90	13.50	13.00	12.60	6.20	Sept 23,2016	101.1	8.59	98.6	8.47	97.1	8.48
September 27,2016	13.50	13.50	13.40	13.10	11.70	6.10	Sept 27,2016	98.2	8.38	96.3	8.22	96.4	8.52
October 1,2016	12.80	12.80	12.80	12.50	8.70	4.70	Oct 1,2016	101	8.84	98.8	8.66	102.4	9.79
October 6,2016	12.40	12.30	12.20	12.10	11.80	11.30	Oct 6,2016	106.2	9.32	102.3	9.01	100.7	8.93
October 12,2016	11.90	11.90	11.90	11.90	11.30	7.00	Oct 13,2016	104.3	9.36	102.8	9.22	100.4	9.12
October 16,2016	11.40	11.40	11.40	11.40	9.70	5.70	Oct 16,2016	105.7	9.44	104.7	9.36	104.6	9.7
October 21,2016	11.00	11.00	11.10	11.10	11.00	10.90	Oct 21,2016	100.7	9.23	100.8	9.21	99.8	9.14
October 25,2016	10.70	10.70	10.50	10.60	10.60	9.50	Oct 25,2016	106.3	9.63	104.8	9.53	102.8	9.34
October 31,2016	10.00	10.00	9.90	9.90	9.80	9.20							
November 4,2016	10.00	10.00	9.80	9.70	9.50	8.90							
November 8,2016	9.50	9.50	9.50	9.50	9.50	9.50							
November 15,2016	9.00	9.00	9.00	9.10	9.10	7.30	Nov 15,2016	91.9	8.73	89.2	8.47		
November 23,2016	9.40	9.40	9.40	9.20	8.80	7.40							
November 30,2016	7.70	7.80	7.90	8.10	8.00	7.20	Nov 30,2016	93	9.04	92	8.88	92.9	9
December 8,2016	6.60	6.60	6.60	6.60	6.60	6.70	Dec 8,2016	97	9.6	94.8	9.37	93.7	9.27
December 14,2016	5.30	5.30	5.30	5.30	5.40	5.10	Dec 14,2016	92	9.51	92.6	9.57	91.9	9.47
December 26,2016	3.60	3.60	3.70	3.70	3.70	3.70	Dec 26,2016	91	9.81	90	9.7	89.2	9.61
December 31,2016	2.90	3.10	3.30	3.10	3.10	2.70	Dec 31,2016	97.1	10.42	95.5	10.28	94.9	10.24
January 30,2017	1.10	1.10	1.10	1.20	1.30	1.00							
February 4,2017	0.30	0.40	0.50	1.00	1.00	1.00							
Febraury 19,2017	0.50	0.50	0.40	0.50	0.30	0.00	Feb 19,2017	92	13.2	91	13.1	90	13
February 25,3017	0.50	0.50	0.50	0.40	0.40	0.10	Feb 25,2017	93	13.5	92	13.3	92	13.3
March 8,2017	0.00	0.00	1.00	1.00	1.00	1.00	Mar 8,2017	97	14.3	94	13.8	93	13.8
March 14,2017	-0.20	-0.10	-0.10	0.00	0.10	-0.20	Mar 14,2017	99	14.8	97	14.5	95	14.1
March 19,2017	0.00	0.00	0.20	0.00	-0.10	-0.20	Mar 19,2017	99	14.3	95	14.1	94	14
March 24,2017	0.20	0.20	0.20	-0.10	-0.10	-0.20	Mar 24,2017	93	13.8	92	13.6	90	13.4
April 6,2017	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	Apr 6,2017	88	13.2	88	13.1	88	13.2
April 12,2017	0.80	0.80	0.80	0.60	0.10	-0.10	Apr 12,2017	93	13.5	93	13.5	92	13.6
April 22,2017	0.40	0.40	0.40	0.30	0.10	-0.20	Apr 22,2017	88	12.8	89	12.9	88	12.9
April 26,2017	1.40	1.50	0.90	-0.10	-0.30	-0.50	Apr 26,2017	94	13.4	92	13.8	87	13.7
May 3,2016	1.50	1.50	1.40	1.00	0.90	0.10	May 3,2017	112	15.7	108	15.3	107	15.2
May 13,2017	1.70	1.70	1.70	0.60	0.40	0.20	May 13,2017	106	14.8	105	14.8	102	14.8
May 19,2017	3.50	3.50	3.40	0.90	0.30	0.10	May 19,2017	101	13.4	102	13.5	99	14.4
May 23,2017	3.20	2.60	2.60	2.60	2.50	1.40	May 23,2017	101	13.8	99	13.6	99	13.6
June 3,2017	4.60	4.60	4.40	2.60	1.80	1.40	June 3,2017	104	13.5	102	13.3	102	14.3
June 7,2017	7.80	5.50	4.70	3.00	1.70	1.10	June 7,2017	110	13.8	110	14.3	107	14.8
June 16,2017	6.50	6.30	5.00	4.40	3.40	1.80	June 16,2017	104	13	105	13.6	104	14
June 23, 2017	6.40	6.40	6.40	5.80	3.70	2.40	June 23, 2017	97	11.9	97	11.9	98	12.9
June 30, 2017	8.70	8.70	8.70	6.20	5.70	3.90	June 30, 2017	107	12.6	107	12.6	108	13.9
July 9, 2017	9.30	9.30	9.30	8.90	7.70	5.20	July 9, 2017	97	11.1	97	11.3	98	11.5
July 21, 2017	13.40	13.30	11.30	7.00	4.10	1.70	July 21, 2017	104	10.8	109	12.2	108	14.1
July 27, 2017	14.80	14.80	14.70	4.60	2.60	1.40	July 27, 2017	108	11	108	11	106	14.4
August 3, 2017	15.60	15.60	15.10	7.30	3.00	1.20	August 3, 2017	108	10.9	110	11.5	107	14.6
August 11, 2017	17.40	17.30	16.80	9.80	4.40	2.10	August 11, 2017	106	10.3	105	10.4	111	14.5
August 19, 2017	16.00	15.70	14.50	10.40	3.20	2.00	August 19, 2017	97	9.7	99	10.2	107	14.5
August 26, 2017	14.60	14.60	14.20	11.30	5.80	2.20							
September 3, 2017	15.20	15.10	14.70	12.40	6.60	2.50							
September 9, 2017	13.30	13.30	13.20	13.20	13.20	5.00	September 9, 2017	100	10.6	98	10.4	96	10.2
September 16, 2017	13.60	13.50	13.20	12.30	9.40	4.60	September 16, 2017	101	10.5	99	10.4	100	11.5
September 22, 2017	13.90	13.90	13.70	12.30	10.90	4.50	September 22, 2017	100	10.3	98	10.3	95	10.5
September 30, 2017	13.50	13.50	13.40	12.60	9.50	7.90	September 30, 2017	95	10	93	9.8	93	10.7
October 7, 2017	12.20	12.20	12.20	11.90	9.80	5.70	October 7, 2017	92	9.9	93	10.1	94	10.7
October 13, 2017	11.90	11.90	11.70	11.50	10.20	5.40	October 13, 2017	95	10.4	94	10.3	93	10.6
October 19, 2017	11.30	11.30	11.30	11.30	8.40	5.50	October 19, 2017	97	10.7	96	10.6	96	11.3
October 28, 2017	10.50	10.50	10.50	10.20	8.70	6.10	October 28, 2017	98	11	94	10.6	94	11
November 2, 2017	10.50	10.40	10.30	10.10	8.90	6.90	November 2, 2017	99	11.3	98	11.2	95	11.4
November 13, 2017	8.80	8.80	8.80	8.80	8.80	8.80	November 13, 2017	91	10.8	90	10.7	90	10.6
November 19, 2017	8.00	8.00	8.00	7.80	7.10	6.90	November 19, 2017	8	8	8	7.8	7.1	6.9
November 28, 2017	6.80	6.80	6.80	6.38	6.70	6.50	November 28, 2017	91	11.2	90	11.1	91	11.2
December 6, 2017	5.70	5.80	5.80	5.90	5.90	5.90	December 6, 2017	81	10.3	83	10.5	80	10.11
December 12, 2017	5.80	5.80	5.80	5.80	5.70	5.60	December 12, 2017	100	12.5	99	12.4	98	12.3
January 4, 2018	2.30	3.00	3.00	3.40	3.50	3.20	January 4, 2018						
January 17, 2018	2.00	2.00	2.20	2.20	2.20	2.20	January 17, 2018	91	12.8	90	12.6	89	12.5
January 27, 2018	1.30	1.30	1.30	1.60	2.00	2.10	January 27, 2018	82	11.7	79	11.3	77	10.8
February 15, 2018	0.80	0.80	0.90	1.30	1.40	1.40	February 15, 2018	93	13.3	91	13	90	12.6
February 26, 2018	0.40	0.40	0.40	0.70	0.80	0.90	February 26, 2018	93	13.7	92	13.6	92	13.4

Appendix A-Sea Cage Site: Oderin Island

Grieg NL Seafarms Ltd - Environmental Data

Sea Cage Site: Oderin Island

Temperature							Dissolved Oxygen Readings						
Date	Temperature (˚C) - Surface	Temperature (˚C) - 3m	Temperature (˚C) - 10m	Temperature (˚C) - 25m	Temperature (˚C) - 35m	Temperature (˚C) - 50m	Date:2	DO (%L) - 3m	DO (mg/L)-3m	DO (%L) - 15m	DO (mg/L)-15m	DO (%L) - 35m	DO (mg/L)-35m
Feb. 5, 2016		1.3	1.2	1.1	1.2	1.2	Feb. 5	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 7, 2016		1.2	1.2	1.2	1.2	1.0	Feb. 7	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 11, 2016		1.0	1.0	1.0	1.0	1.0	Feb. 11	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 14, 2016		0.7	0.7	0.7	0.8	0.9	Feb. 14	n/a	n/a	n/a	n/a	n/a	n/a
Feb.18, 2016		0.8	0.7	0.7	0.7	0.8	Feb. 18	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 20, 2016		0.6	0.7	0.7	0.7	0.7	Feb. 20	105.50	12.20	102.90	11.92	101.00	11.68
Feb. 24, 2016		0.3	0.6	0.6	0.8	0.8	Feb. 24	100.40	11.91	97.10	11.43	94.00	11.04
Feb. 29, 2016		0.6	0.6	0.5	0.6	0.6	Feb. 29	103.30	11.89	99.80	11.46	97.00	11.18
Mar. 2, 2016		0.7	0.6	0.7	0.7	0.6	Mar. 2	113.00	13.01	109.70	12.76	105.80	12.28
Mar. 7, 2016		0.1	0.5	0.4	0.5	0.5	Mar. 7	n/a	n/a	n/a	n/a	n/a	n/a
Mar. 9, 2016		0.4	0.5	0.5	0.5	0.5	Mar. 9	111.50	12.99	107.30	12.47	103.50	12.01
Mar. 15, 2016		0.3	0.3	0.3	0.3	0.5	Mar. 15	117.00	13.54	111.70	13.10	110.00	12.89
Mar. 21, 2016		0.3	0.4	0.4	0.5	0.5	Mar. 21	115.30	13.22	109.80	12.70	106.40	12.26
Mar. 25, 2016		0.2	0.1	0.0	0.0	0.0	Mar. 25	114.40	13.35	110.30	12.95	108.00	12.74
Mar. 27, 2016		0.6	0.3	0.1	0.2	0.1	Mar. 27	115.90	13.37	109.70	12.91	105.80	12.49
Apr. 1, 2016		0.7	0.4	0.2	0.1	0.1	Apr. 1	113.10	12.95	107.60	12.43	103.60	12.04
Apr. 12, 2016		0.9	0.8	0.7	0.2	0.1	Apr. 12	114.90	13.13	107.50	12.59	102.10	12.16
Apr. 17, 2016		1.5	1.1	0.6	0.3	0.4	Apr. 17	105.50	12.08	103.00	11.91	99.60	11.66
Apr. 21, 2016		1.4	1.4	1.3	1.3	1.2	Apr. 21	121.80	13.50	118.40	13.16	116.00	12.90
Apr. 28, 2016		2.3	2.2	1.7	0.7	0.5	Apr. 28	124.10	13.51	122.10	13.30	109.20	12.41
May 5, 2016		2.2	2.1	1.4	0.7	0.4	May 5, 2016	126.20	13.98	124.70	14.02	111.20	12.83
May 9, 2016		3.6	2.8	1.2	1.0	0.5	May 9, 2016	108.50	11.50	108.90	11.91	101.30	11.48
May 12, 2016		3.6	2.2	1.3	0.7	0.5	May 12, 2016	118.20	12.50	115.80	12.77	103.40	12.76
May 20,2016		4.1	2.3	1.1	0.9	0.5	May 20,2016	120.70	12.78	119.00	13.27	110.80	12.71
May 26,2016		7.3	4.6	1.9	1.4	1.0	May 26,2016	117.40	11.53	117.40	12.81	112.10	12.64
June 3,2016		6.9	6.3	2.4	1.9	1.3	June 3,2016	117.80	11.71	116.40	11.87	111.40	12.49
June 11,2016		8.2	8.0	5.4	3.7	1.0	June 11,2016	113.00	10.68	112.00	11.05	113.40	11.96
June 19,2016		8.7	7.9	4.0	2.5	0.9	June 19,2016	112.20	10.69	114.20	11.38	111.10	12.26
June 25, 2016		9.1	8.0	2.5	1.6	0.8	June 25,2016	115.40	10.96	112.30	11.43	107.70	12.20
July 8,2016		10.8	9.9	8.5	5.2	2.4	July 8,2016	113.10	10.27	112.00	10.48	114.40	11.78
July 20,2016		12.6	10.1	6.7	3.8	0.6	July 20,2016	113.50	9.82	115.00	10.78	109.70	11.61
July 26,2016		12.8	10.5	7.5	6.2	3.2	July 26,2016	118.40	10.27	116.70	10.76	114.00	11.43
August 3,2016		14.7	14.4	10.1	7.7	2.2	Aug 3,2016	118.5	9.95	118.3	10.2	112.6	11
August 20,2016	17.2	17.0	15.6	11.2	4.3	1.4	Aug 20.2016	112.3	9.06	112.6	9.31	106.8	11.26
September 4,2016	14.70	14.6	14.3	12.1	6.6	2.4	Sept 4,2016	114.5	9.65	110.6	9.4	110.8	11.13
September 9,2016	14.60	14.5	14.5	11.7	8.8	4.2	Sept 9,2016	114.5	9.57	112.5	9.42	113.2	10.69
September 17,2016	12.90	12.9	12.8	9.3	7.7	5.3	Sept 17,2016	107.3	9.33	105	9.19	105	10.24
September 23,2016	12.40	12.4	12.1	11	9.5	5.2	Sept 23,2016	102.4	8.96	101	8.9	99.2	9.25
September 27,2016	12.50	12.5	12.4	12	10.8	4.7	Sept 27,2016	101.7	8.84	100.4	8.79	96.7	8.71
October 1,2016	12.50	12.5	12.5	12.3	12.1	7	Oct 1,2016	103.1	9.08	99.8	8.79		
October 6, 2016	12.10	12.1	12.1	11.2	10.8	6.5	Oct 6,2016	103.9	9.18	100.6	8.9	97.5	8.85
October 13,2016	11.60	11.6	11.4	11	11	10.3	Oct 13,2016			101.3	9.24	99.4	9.09
October 17,2016	10.60	10.6	10.9	10.9	10.8	10.2	Oct 17,2016	106.9	9.63	105.8	9.51	104.1	9.37
October 21,2016	10.50	10.5	10.4	10.4	10.3	10.1	Oct 21,2016	106.6	9.76	103.4	9.59	100.9	9.38
October 26,2016	10.10	10.1	10.2	10	10.1	9.3	Oct 26,2016	101.7	9.38	100.2	9.24	101.1	9.34
November 2,2016	9.40	9.4	9.3	9.3	9.3	9.3							
November 4,2016	9.60	9.5	9.5	9.3	9.3	9.3							
November 8,2016	9.20	9.2	9.3	9.3	9	9							
November 15,2016	8.70	8.6	8.6	8.7	7.7	6.3	Nov 15,2016	92.1	8.84	90.4	8.66	86.9	8.52
November 23,2016	9.40	9.1	9	8.8	8.7	7.6	Nov 23,2016	96.4	8.44	93.4	8.68	92.6	8.64
December 1,2016	7.90	7.9	8	8	8.1	8	Dec 1,2016	94.8	9.21	93.2	8.99	91.8	8.89
December 8,2016	6.70	6.7	6.7	6.9	6.8	6.8	Dec 8,2016	93.4	9.26	93.7	9.27	92.6	9.15
December 15,2016	5.10	5.1	5.1	5.1	5.1	5.1	Dec 15,2016	100.1	10.19	100.1	10.17	99.4	10.12
December 27,2016	2.90	2.9	3.3	3.5	3.2	3.2	Dec 27,2016	90.8	98.9	89.2	9.7	86.3	9.38
January 31,2017	1.00	1	1	1	1.3	1.7							
February 4,2017	0.30	0.3	0.4	0.9	1.3	1.4							
February 16,2017	0.40	0.3	0.4	0.4	0.4	0.4	Feb 16,2017	95	13.5	94	13.6	95	13.6
February 20,2017	0.20	0.2	0.2	0.3	0.3	0.3	Feb 20,2017	93	13.4	92	13.3	91	13.2
February 25,2017	0.70	0.5	0.4	0.4	0.5	0.3	Feb 25,2017	96	14	94	13.7	92	13.3
March 8,2017	0.50	0.4	0.3	0.1	0.1	0.1	Mar 8,2017	97	14.3	93	13.7	91	13.4
March 14,2017	-0.20	-0.2	-0.2	-0.5	-0.5	-0.4	Mar 14,2017	100	15	98	14.8	98	14.8
March 19,2017	0.70	0	-0.2	-0.3	-0.3	-0.2	Mar 19,2107	98	14.6	97	14.4	96	14.3
March 29,2017	0.50	0.4	0.1	-0.1	-0.1	-0.1	Mar 29,2017	91	13.2	89	13.1	87	12.9
April 6,2017	0.40	0.4	0.3	0.1	0	0	Apr 6,2017	92	13.5	91	13.4	90	13.3
April 12,2017	1.10	1.1	0.5	0	0	0	Apr 12,2017	96	13.9	94	13.9	92	13.7
April 23,2017	0.80	0.8	0.8	0.3	0.1	0	Apr 23,2017	92	13.2	92	13.1	89	13
April 26,2017	1.20	1.2	1.1	0.3	0.2	-0.1	Apr 26,2017	95	13.7	95	13.9	92	13.6
May 4,2017	1.90	1.8	1.6	0.2	-0.1	-0.2	May 4,2017	112	15.4	111	15.6	101	14.7
May 14,2017	3.90	4	3.5	3	0.6	0.1	May 14,2017	100	13.2	101	13.6	99	14.3
May 18,2017	5.00	4.9	3	0.9	0.2	0.1	May 18,2017	104	13.5	103	14.4	94	13.6
May 23,2017	3.40	3.4	2.6	1.8	1.1	0.6	May 23,2017	101	13.4	99	13.7	96	13.7
June 3,2017	5.40	5.1	4.3	2.9	1.6	0.9	June 3,2017	108	13.7	107	14	101	14.2
June 8,2017	6.10	6.1	6	3.2	2.5	1.8	June 8,2017	108	13.4	107	13.8	105	14.4
June 16,2017	6.40	6.4	6	3.6	3.3	2.1	June 16, 2017	105	13.1	104	13.4	105	14.1
June 23, 2017	7.20	7	4.5	2.5	1.9	1.6	June 23, 2017	103	12.4	102	13.5	98	13.7
July 1, 2017	10.00	9.8	6.5	3.9	2.7	1.6	July 1, 2017	109	12.5	112	14.2	109	15
July 9, 2017	11.40	10.9	7.6	5.6	4.4	2	July 9, 2017	96	10.6	101	12.3	100	13
July 20, 2017	14.40	14.4	9.2	6.8	5.6	4.2	July 20, 2017	109	11.1	115	13.7	114	13.9
July 28, 2017	12.40	12.2	8.2	5.2	3.5	1.9	July 28, 2017	110	11.8	113	13.7	104	13.8
August 4, 2017	14.50	14.5	10.8	7.3	3.5	1.9	August 4, 2017	105	10.8	114	13.4	108	14.5
August 11, 2017	15.70	15.7	14.2	6.6	2.8	1.5	August 11, 2017	105	10.5	114	12.8	105	14.4
August 19, 2107	13.80	13.8	13.7	9.3	4.5	2.5	August 19, 2017	63	6.5	65	6.9	73	9.6
August 27, 2017	14.50	14.5	13.7	9.1	5.4	2.3							
September 3, 2017	14.70	14.7	14.5	5.5	2.6	0.8							
September 9, 2017	14.80	14.8	14.1	11.3	8.5	4.7	September 9, 2017	100	10.2	99	10.4	101	12
September 16, 2017	14.20	14.2	13.4	12	7.5	2.1	September 16, 2017	98	10.1	95	10	99	12
September 22, 2017	13.90	13.9	13.9	12	10.5	5.3	September 22, 2017	99	10.3	97	10.1	94	10.6
September 30, 2017	13.10	13.1	13	11.9	10.6	6.1	September 30, 2017	94	10	93	9.9	90	10.1
October 7, 2017	12.00	12.0	11.9	11.5	9.4	3.9	October 7, 2017	96	10.4	94	10.3	97	10.7
October 13, 2017	11.40	11.4	11.4	10.3	9.1	7.3	October 13, 2017	11.4	11.4	11.4	10.3	9.1	7.3
October 19, 2017	10.60	10.6	10.5	9.6	8.8	5.9	October 19, 2017	99	11.2	96	10.9	95	11.1
Ocotber 28, 2017	10.20	10.2	10	9.7	9.3	6.8	October 28, 2017	98	11.1	95	10.8	92	10.7
November 2, 2017	9.90	9.9	9.9	9.8	8.6	6.2	November 7, 2017	100	11.5	97	11.3	95	11.4
November 13, 2017	8.10	8.1	8	7.7	6.6	5.3	November 13, 2017	94	11.3	92	11	91	11.3
November 17, 2017	7.50	7.6	7.7	7.7	7.7	7.4	November 17, 2017	94	11.3	95	11.3	95	11.4
November 24, 2017	6.90	6.9	6.8	6.6	6	5.2	November 24, 2017	88	10.7	88	10.5	87	10.7
December 2nd, 2017	5.90	6	6	6.2	5.7	5.2	December 2, 2017	89	11.3	91	11.5	90	11.5
December 12, 2017	5.40	5.4	5.4	5.6	5.5	5.3							
January 4, 2018	2.50	2.5	2.6	2.8	2.8	2.5							
January 17, 2018	1.60	1.6	1.8	2.1	2	1.8	January 17, 2018	92	13.1	91	12.7	90	12.6
January 27, 2018	0.70	0.8	1.5	1.6	1.7	1.7	January 27, 2018	82	12.2	80	11.5	79	11.3
February 7, 2018	1.10	1.1	1.3	1.4	1.4	1.5	February 7, 2018	92	13.1	91	12.7	90	12.6
February 15, 2018	1.10	1.1	1.2	1.4	1.3	1.3	February 15, 2018	90	12.7	89	12.6	87	12.3
February 26, 2018	0.50	0.4	0.4	0.5	1.1	1.3	February 26, 2018	100	14.4	97	14.1	94	13.4

Appendix A-Sea Cage Site: Gallows Harbour

Grieg NL Seafarms Ltd - Environmental Data

Sea Cage Site: Gallows Harbour

Temperature							Dissolved Oxygen						
Date	Temperature (˚C) - Surface	Temperature (˚C) - 3m	Temperature (˚C) - 10m	Temperature (˚C) - 25m	Temperature (˚C) - 35m	Temperature (˚C) - 50m	Date:2	DO (%L) - 3m	DO (mg/L)-3m	DO (%L) - 15m	DO (mg/L)-15m	DO (%L) - 35m	DO (mg/L)-35m
Feb. 5, 2016		1.20	1.20	1.20	1.20	1.10	Feb. 5	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 7, 2016		1.00	1.20	1.20	1.20	1.10	Feb. 7	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 11, 2016		1.00	0.90	0.90	0.90	0.80	Feb. 11	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 14, 2016		0.80	0.70	0.80	0.80	0.80	Feb. 14	n/a	n/a	n/a	n/a	n/a	n/a
Feb.18, 2016		0.80	0.80	0.80	0.80	0.80	Feb. 18	120.10	14.02	122.00	14.05	119.10	13.72
Feb. 20, 2016		0.50	0.90	0.70	0.70	0.70	Feb. 20	110.20	13.00	103.90	11.97	104.30	12.06
Feb. 24, 2016		0.70	0.70	0.70	0.70	0.60	Feb. 24	111.20	13.11	108.30	12.80	105.20	12.38
Feb. 29, 2016		0.60	0.60	0.60	0.70	0.60	Feb. 29	107.20	12.36	104.70	12.09	102.00	11.77
Mar. 2, 2016		0.70	0.60	0.60	0.60	0.60	Mar. 2	103.70	12.09	102.60	11.95	101.40	11.80
Mar. 7, 2016		0.30	0.40	0.40	0.50	0.50	Mar. 7	n/a	n/a	n/a	n/a	n/a	n/a
Mar. 9, 2016		0.50	0.40	0.40	0.40	0.50	Mar. 9	106.90	12.37	105.00	12.22	102.90	11.97
Mar. 15, 2016		0.30	0.30	0.40	0.30	0.40	Mar. 15	118.30	13.75	113.00	13.32	111.20	12.97
Mar. 21, 2016		0.50	0.40	0.50	0.50	0.30	Mar. 21	109.00	12.59	104.50	12.05	104.30	12.07
Mar. 25, 2016		0.20	0.30	0.30	0.10	0.10	Mar. 25	117.90	13.69	110.30	12.94	109.50	12.87
Mar. 27, 2016		0.90	0.40	0.20	0.10	0.10	Mar. 27	112.80	12.87	107.40	12.59	105.30	12.46
Apr. 1, 2016		0.50	0.40	0.10	0.10	0.10	Apr. 1	101.30	11.69	101.30	11.70	94.10	11.56
Apr. 12, 2016		1.30	0.90	0.70	0.30	0.10	Apr. 12	111.90	12.78	107.60	12.56	103.60	12.26
Apr. 17, 2016		1.50	0.80	0.60	0.40	0.30	Apr. 17	112.00	12.70	109.20	12.63	104.30	12.22
Apr. 21, 2016		1.50	1.40	1.40	1.40	1.40	Apr. 21	113.30	12.52	113.00	12.52	111.20	12.33
Apr. 28, 2016		2.30	2.20	1.00	0.60	0.10	Apr. 28	121.30	13.24	120.40	13.24	108.20	2.34
May 5, 2016		2.50	2.30	1.80	0.80	0.40	May 5, 2016	124.10	13.70	122.30	13.63	110.10	12.70
May 9, 2016		3.10	2.60	1.50	1.30	1.00	May 9, 2016	98.40	10.53	101.20	11.16	97.10	10.94
May 12, 2016		3.90	3.20	1.80	1.00	0.30	May 12, 2016	114.10	12.41	115.30	12.57	105.30	12.89
May 20,2016		4.10	3.00	1.20	0.70	0.40	May 20,2016	118.10	12.51	118.20	13.10	107.20	12.38
May 26,2016		7.40	4.60	2.30	1.90	1.10	May 26,2016	119.70	11.63	117.80	12.37	116.80	12.92
June 3,2016		6.10	5.20	3.90	2.00	0.70	June 3,2016	115.70	11.78	113.80	11.87	113.00	12.63
June 11, 2016		7.90	7.00	4.50	3.10	1.60	June 11,2016	118.30	11.24	114.40	11.15	113.50	12.16
June 19, 2016		8.00	7.60	6.10	3.10	1.60	June 19,2016	106.40	10.30	106.80	10.58	106.80	11.63
June 25,2016		9.40	7.90	5.70	3.20	1.90	June 25,2016	116.20	10.97	114.60	11.38	112.80	12.30
July 8,2016		10.80	9.90	9.30	7.30	2.20	July 8,2016	114.90	10.44	111.50	10.32	111.90	10.99
July 20,2016		11.30	10.20	5.20	3.30	1.70	July 20,2016	116.10	10.34	115.20	10.99	109.10	11.67
July 26,2016		12.50	11.30	10.40	7.40	5.20	July 26,2016	115.80	10.10	114.30	10.30	112.90	11.02
August 3,2016		15.90	15.40	10.50	6.20	1.60	Aug. 3,2016	117.00	9.58	119.50	10.50	114.20	11.50
August 10,2016	15.30	15.30	13.60	10.80	6.30	3.10	Aug. 10,2016	115.40	9.54	116.90	10.20	119.70	12.07
August 20,2016	17.10	16.60	16.30	7.10	2.70	0.80	Aug 20,2016	109.90	8.88	110.80	9.23	112.10	12.31
September 4,2016	15.00	14.90	14.60	9.90	6.20	1.80	Sept 4,2016	110.90	9.30	110.40	9.53	110.50	11.20
September 9,2016	14.60	14.60	14.40	12.20	7.40	4.60	Sept 9,2016	113.90	9.53	112.30	9.42	116.10	11.33
September 17,2016	12.80	12.80	12.60	10.00	7.60	3.30	Sept 17,2016	99.10	8.71	99.40	8.87	101.90	9.99
September 23,2016	12.70	12.70	12.30	12.10	11.80	8.90	Sept 23,2016	104.90	9.13	104.00	9.14	100.90	8.94
September 27,2016	12.70	12.70	13.10	12.00	10.40	4.50	Sept 27,2016	101.80	8.82	99.80	8.66	97.50	8.87
October 1,2016	12.40	12.40	12.60	12.50	12.30	6.20	Oct 1,2016	99.70	8.80	99.00	8.71	96.40	8.53
October 6,2016	11.70	11.70	11.70	11.40	10.60	6.00	Oct 6,2016	104.50	9.30	103.00	9.18	100.90	9.19
October 13,2016	11.30	11.70	11.20	11.00	10.50	9.90	Oct 13,2016	101.80	9.18	100.00	9.14	99.50	9.19
October 17,2016	10.70	11.10	11.00	10.80	10.70	10.20	Oct 17,2016	104.50	9.36	103.70	9.28	102.20	9.23
October 21,2016	10.30	10.30	10.30	10.40	10.40	10.20	Oct 21,2016	108.80	10.11	104.10	9.69	101.50	9.43
October 26,2016	9.90	9.90	10.30	10.20	10.20	9.40	Oct 26,2016	104.90	9.69	104.20	9.57	103.10	9.49
November 2,2016	9.40	9.40	9.40	9.30	9.30	9.30							
November 4,2016	9.70	9.60	9.40	9.30	9.30	9.10							
November 8,2016	9.30	9.30	9.40	9.30	9.20	8.40							
November 15,2016	9.00	9.00	8.90	8.90	8.80	8.80	Nov 15,2016	93.00	8.86	91.50	8.73	89.90	8.58
November 23,2016	9.20	9.10	8.90	8.80	8.80	8.70	Nov 23,2016	96.40	8.93	96.00	8.95	95.10	8.87
December 1,2016	7.40	7.50	7.80	8.00	7.70	7.60	Dec 1,2016	92.30	9.24	92.80	8.99	94.80	9.22
December 8,2016	5.30	6.00	6.30	7.30	7.10	6.30	Dec 8,2016	93.00	9.34	91.00	8.98	88.40	8.66
December 15,2016	5.00	5.00	5.10	5.10	5.10	5.20	Dec 15,2016	103.70	10.43	101.60	10.34	99.20	10.08
December 27,2016	2.40	2.80	3.40	3.30	3.20	3.10	Dec 27,2016	89.10	9.81	88.00	9.57	86.70	9.40
January 1,2017	2.90	2.90	2.90	2.90	2.90	3.10	Jan 1,2017	97.70	10.70	97.30	10.64	96.10	10.51
January 31,2017	0.90	1.00	1.10	1.20	1.40	1.60							
February 4,2017	0.30	0.40	0.90	1.10	1.10	1.10							
February 16,2017	0.40	0.40	0.40	0.40	0.30	0.30	Feb 16,2017	96.00	13.70	95.00	13.60	95.00	13.60
February 20,2017	0.40	0.40	0.40	0.50	0.50	0.60	Feb 20,2017	92.00	13.20	92.00	13.20	91.00	12.90
February 25,2017	0.60	0.50	0.40	0.30	0.40	0.30	Feb 25,2017	96.00	13.90	94.00	13.70	93.00	13.50
March 8,2017	0.40	0.40	0.20	0.10	0.10	0.00	Mar 8,2017	96	14	94	13.9	93	13.8
March 14, 2017	0.40	0.40	0.10	0.00	-0.10	-0.10	Mar 14,2017	99.00	14.70	98.00	14.60	98.00	14.60
March 19,2017	0.80	0.40	0.10	0.10	0.10	0.10	Mar 19,2017	97.00	14.40	96.00	14.30	94.00	14.10
March 29,2017	0.60	0.50	0.30	0.10	0.00	-0.10	Mar 29,2017	92.00	13.30	90.00	13.10	89.00	13.10
April 6,2017	0.40	0.40	0.00	0.00	0.00	-0.10	Apr 6,2017	94.00	13.70	92.00	13.60	91.00	13.50
April 12,2017	1.60	1.20	1.10	0.10	0.00	-0.10	Apr 12,2017	95.00	13.70	94.00	13.90	93.00	14.10
April 23,2017	1.00	1.10	0.40	0.70	0.50	0.30	Apr 23,2017	89.00	12.70	90.00	12.80	90.00	13.00
April 26,2017	1.00	1.00	0.50	0.30	0.10	-0.10	Apr 26,2017	95.00	13.80	94.00	13.90	91.00	13.50
May 4,2017	1.90	1.70	1.10	0.70	0.40	0.30	May 4,2017	111.00	15.60	111.00	15.60	105.00	15.10
May 14,2017	3.70	3.60	3.40	2.10	0.80	0.10	May 14,2017	101.00	13.40	101.00	13.50	99.00	14.30
May 18,2017	4.70	4.10	2.50	0.60	-0.10	-0.30	May 18,2017	105.00	13.60	104.00	14.50	92.00	13.50
May 23,2017	3.20	3.20	2.50	2.20	1.90	1.90	May 23,2017	100.00	13.50	99.00	13.60	99.00	13.70
June 3,2017	5.80	5.00	3.80	2.30	1.60	1.30	June 3,2017	106.00	13.50	105.00	14.00	99.00	13.80
June 8,2017	6.20	6.10	4.80	3.90	2.60	1.80	June 8,2017	109.00	13.50	107.00	13.80	106.00	14.40
June 16,2017	7.10	7.10	5.90	4.60	3.30	2.70	June 16,2017	106.00	12.90	105.00	13.40	103.00	14.10
June 23,2017	7.20	7.00	5.90	2.90	2.00	1.40	June 23, 2017	102.00	12.30	100.00	13.00	96.00	13.30
July 1, 2017	9.00	8.00	7.60	5.00	4.60	2.40	July 1, 2017	110.00	13.10	109.00	13.50	110.00	14.30
July 9, 2017	10.60	9.90	8.80	7.20	3.50	1.40	July 9, 2017	97.00	11.10	98.00	11.70	97.00	13.10
July 20, 2017	15.70	15.70	10.10	7.40	6.30	4.50	July 20, 2017	107.00	10.70	115.00	13.40	111.00	13.80
July 28, 2017	10.80	10.80	9.10	5.80	2.90	1.50	July 28, 2017	110.00	12.30	110.00	13.10	105.00	14.20
August 4, 2017	14.80	14.80	13.20	7.80	3.40	1.90	August 4, 2017	106.00	10.90	111.00	12.30	108.00	14.60
August 11, 2017	15.70	15.70	13.20	4.50	2.00	0.80	August 11, 2017	98.00	9.90	99.00	11.20	101.00	14.20
August 19, 2017	14.40	14.40	13.80	10.60	8.90	4.00	August 19, 2017	80.00	8.20	63.00	6.70	67.00	7.90
August 27, 2017	15.00	15.00	14.90	12.90	9.50	2.90							
September 3, 2017	14.60	14.60	13.80	6.20	2.30	1.10							
September 9, 2017	14.50	14.40	14.10	9.50	8.40	7.80	September 9, 2017	101.00	10.40	98.00	10.30	97.00	11.70
September 16, 2017	14.00	14.20	13.10	12.30	8.50	1.80	September 16, 2017	97.00	10.00	94.00	9.90	95.00	11.30
September 22, 2017	14.00	14.00	14.00	11.90	10.40	6.70	September 22, 2017	98.00	10.20	97.00	10.10	96.00	10.80
September 30, 2017	12.80	12.90	12.80	12.40	11.20	7.70	September 30, 2017	94.00	10.00	93.00	9.90	91.00	10.10
October 7, 2017	11.60	11.60	11.30	10.90	10.30	4.30	October 7, 2017	98.00	10.80	97.00	10.80	96.00	10.80
October 13, 2017	11.30	11.30	11.40	10.10	9.20	5.90	October 13, 2017	95.00	10.60	94.00	10.40	93.00	10.90
October 19, 2017	10.70	10.70	10.40	8.90	6.80	4.40	October 19, 2017	99.00	11.10	96.00	10.90	96.00	11.90
October 27, 2017	10.30	10.30	9.90	9.70	9.00	7.10	October 28, 2017	98.00	11.10	94.00	10.70	93.00	10.80
November 2, 2017	9.90	10.00	9.90	9.90	9.30	6.80	November 2, 2017	97.00	11.20	97.00	11.20	94.00	11.00
November 13, 2017	7.70	7.80	8.10	8.10	7.80	5.60	November 13, 2017	91.00	11.00	91.00	10.90	90.00	10.90
November 17, 2017	7.70	7.70	7.80	7.90	7.80	7.50	November 17, 2017	92.00	11.00	95.00	11.30	93.00	11.20
November 24, 2017	6.70	6.70	6.70	6.80	5.90	5.50	November 24, 2017	87.00	10.60	88.00	10.70	89.00	10.90
December 2, 2017	5.90	5.90	6.20	6.20	6.10	6.00	Decemebr 2, 2017	93.00	11.90	92.00	11.40	91.00	11.40
December 12, 2017	5.50	5.60	5.70	5.70	5.47	5.70	December 12, 2017	89.00	11.30	91.00	11.50	93.00	11.70
January 4, 2018	2.10	2.50	2.60	3.00	3.00	2.90							
January 17, 2018	1.90	1.90	2.20	2.10	1.90	2.00	Janurary 17, 2018	94.00	13.20	91.00	12.80	90.00	12.70
January 27, 2018	1.40	1.50	1.70	1.70	1.80	1.80	January 27, 2018	85.00	12.30	83.00	11.70	81.00	11.40
February 7, 2018	1.30	1.30	1.50	1.50	1.60	1.60	February 7, 2018	100.00	14.50	98.00	14.20	95.00	13.60
Febraury 15, 2018	0.80	1.20	1.30	1.20	1.20	1.40	Febraury 15, 2018	90.00	12.70	90.00	12.70	89.00	12.50
February 26, 2018	0.60	0.50	0.50	0.60	0.90	1.00	February 26, 2018	99.00	14.40	96.00	14.00	94.00	13.60

Appendix A-Sea Cage Site: Long Island

Grieg NL Seafarms Ltd - Environmental Data													
Sea Cage Site: Long Island													
Temperature							Dissolved Oxygen						
Date	Temperature (˚C) - Surface	Temperature (˚C) - 3m	Temperature (˚C) - 10m	Temperature (˚C) - 25	Temperature (˚C) - 35m	Temperature (˚C) - 50m	Date:2	DO (%L) - 3m	DO (mg/L)-3m	DO (%L) - 15m	DO (mg/L)-15m	DO (%L) - 35m	DO (mg/L)-35m
Feb. 5, 2016		1.20	1.20	1.10	1.00	0.80	Feb. 5	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 7, 2016		1.00	1.20	1.20	1.00	0.80	Feb. 7	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 11, 2016		0.90	0.90	0.90	0.80	0.80	Feb. 11	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 14, 2016		0.70	0.80	0.80	0.80	0.80	Feb. 14	n/a	n/a	n/a	n/a	n/a	n/a
Feb.18, 2016		0.70	0.70	0.70	0.70	0.70	Feb. 18	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 20, 2016		0.70	0.80	0.80	0.80	0.80	Feb. 20	103.90	12.06	102.40	11.84	101.10	11.69
Feb. 24, 2016		0.60	0.60	0.60	0.50	0.50	Feb. 24	102.30	12.06	97.90	11.56	95.30	11.27
Feb. 29, 2016		0.60	0.60	0.60	0.50	0.60	Feb. 29	106.00	12.23	104.40	12.04	102.80	11.89
Mar. 2, 2016		0.60	0.60	0.50	0.50	0.40	Mar. 2	108.70	12.62	105.10	12.23	102.40	11.92
Mar. 7, 2016		0.40	0.40	0.40	0.40	0.40	Mar. 7	n/a	n/a	n/a	n/a	n/a	n/a
Mar.9, 2016		0.30	0.30	0.40	0.40	0.40	Mar. 9	102.40	11.97	101.70	11.83	101.50	11.78
Mar. 15, 2016		0.30	0.30	0.30	0.30	0.40	Mar. 15	116.70	13.62	113.00	13.27	111.30	13.05
Mar. 21, 2016		0.40	0.30	0.30	0.30	0.30	Mar. 21	114.00	13.21	109.50	12.73	105.20	12.22
Mar. 25, 2016		0.10	0.00	0.10	0.00	0.00	Mar. 25	114.40	13.43	110.30	13.02	107.00	12.52
Mar. 27, 2016		0.80	0.20	0.10	0.10	0.10	Mar. 27	111.70	12.86	108.40	12.80	105.90	12.52
Apr. 1, 2016		0.60	0.50	0.10	0.00	0.00	Apr. 1	101.30	11.64	100.60	11.57	99.80	11.63
Apr. 12, 2016		1.00	0.80	0.70	0.20	0.10	Apr. 12	114.90	13.13	107.50	12.59	102.10	12.16
Apr. 17, 2016		1.50	1.00	0.40	0.40	0.20	Apr. 17	113.30	12.87	109.80	12.70	105.00	12.27
Apr. 21, 2016		1.60	1.60	1.60	1.50	1.50	Apr. 21	124.20	13.61	119.60	13.17	117.10	12.85
Apr. 28, 2016		2.40	2.10	1.20	0.70	0.30	Apr. 28	120.80	13.14	119.10	13.15	107.80	12.23
May 5, 2016		2.40	1.90	1.20	0.80	0.50	May 5, 2016	126.60	13.94	124.80	14.02	113.20	13.01
May 9, 2016		3.00	2.60	1.70	1.30	0.60	May 9, 2016	99.00	10.65	101.10	11.09	96.50	10.81
May 12, 2016		3.70	3.30	1.10	0.90	0.50	may 12,2016	114.60	12.19	114.00	12.61	105.20	11.92
May 20,2016		4.20	3.80	1.00	0.90	0.80	May 20,2016	120.20	12.74	118.50	13.37	109.70	12.60
May 26,2016		5.20	3.90	2.20	1.60	1.00	May 26,2016	119.20	12.29	118.60	12.73	113.20	12.70
June 3,2016		6.40	6.20	3.20	1.90	1.00	June 3,2016	116.70	11.75	113.90	11.61	112.10	12.63
June 11,2016		7.80	6.90	6.50	4.80	1.00	June 11,2016	116.60	11.16	113.20	11.13	113.10	11.62
June 19,2016		7.90	7.90	7.50	4.40	2.10	June 19,2016	110.90	10.76	109.50	10.67	110.60	11.63
June 25,2016		8.30	8.20	5.10	3.90	2.00	June 25,2016	115.90	11.21	112.00	10.91	113.90	12.18
July 8,2016		10.40	10.10	9.40	7.80	1.50	July 8,2016	114.20	10.45	111.60	10.30	111.80	10.83
July 20,2016		12.40	8.30	5.20	4.10	0.60	July 20,2016	115.60	10.12	114.90	10.99	113.50	11.90
July 26,2016		12.30	10.90	9.80	8.90	8.90	July 26,2016	116.80	10.25	114.40	10.47	111.80	10.55
August 3,2016		14.80	14.70	10.00	5.80	1.60	Aug. 3,2016	117.60	9.85	116.80	10.06	112.60	11.47
August 10,2016	14.70	14.80	13.50	10.40	5.70	2.90	Aug. 10,2016	110.30	9.26	115.90	10.17	117.30	11.92
August 20,2016	16.70	16.40	16.00	9.50	2.60	0.70	Aug.20,2016	110.70	8.99	113.20	9.38	109.30	12.02
September 4,2016	14.80	14.80	14.70	10.70	4.50	1.60	Sept 4,2016	115.00	9.66	110.40	9.42	112.30	11.83
September 9,2016	14.90	14.90	14.40	11.70	7.00	4.60	Sept 9,2016	116.10	9.63	115.40	9.74	118.90	11.71
September 17,2016	12.90	12.90	12.90	10.00	6.50	3.60	Sept 17,2016	99.40	8.67	99.70	8.69	101.30	10.17
September 23,2016	12.60	12.60	12.30	12.20	10.70	7.50	Sept 23,2016	105.50	9.20	102.80	9.01	100.30	9.11
September 27,2016	12.80	12.80	12.80	12.40	11.20	5.30	Sept 27,2016	100.80	8.72	100.10	8.66	96.30	8.60
October 1,2016	12.50	12.50	12.50	12.50	12.50	5.50	Oct 1,2016	106.50	9.38	101.90	8.87	98.30	8.67
October 6,2016	12.00	12.00	12.00	11.40	10.10	6.40	Oct 6,2016	108.00	9.56	104.60	9.25	101.70	9.37
October 13,2016	11.10	11.10	10.90	10.90	11.00	10.70	Oct 13,2016	102.40	9.34	100.90	9.25	99.80	9.12
October 17,2016	10.60	10.60	10.80	10.70	10.10	10.30	Oct 17,2016	106.00	9.59	105.70	9.54	105.30	9.61
Octobre 21,2016	10.40	10.40	10.40	10.50	10.50	9.70	Oct 21,2016	104.10	9.67	102.60	9.63	100.40	9.32
October 26,2016	10.10	10.10	10.30	10.00	9.70	9.30	Oct 26,2016	102.90	9.50	104.60	9.60	104.80	9.76
November 2,2016	9.30	9.30	9.30	9.30	9.30	9.30							
November 4,2016	9.50	9.50	9.40	9.40	9.40	9.40							
November 8,2016	9.20	9.20	9.20	9.30	9.20	9.30							
November 15,2016	8.80	8.80	8.80	8.80	8.50	6.90							
November 23,2016	9.10	9.10	8.90	8.80	8.70	8.50	Nov 23,2016	97.40	9.04	96.60	9.01	96.60	9.02
December 1,2016	7.60	7.60	7.70	7.70	7.80	7.60	Dec 1,2016	95.20	9.30	93.50	9.12	93.80	9.14
December 8,2016	5.70	5.70	7.00	6.80	6.70	5.80	Dec 8,2016	92.30	9.36	91.90	9.04	90.50	8.98
December 15,2016	5.00	5.00	5.00	5.00	5.00	4.20	Dec 15,2016	105.30	10.53	103.90	10.56	102.20	10.40
December 27,2016	2.80	2.80	3.30	3.30	3.20	3.10	Dec 27,2016	91.60	10.07	89.90	9.77	86.10	9.48
January 31, 2017	0.80	0.80	1.00	0.90	1.40	0.90							
February 4,2017	0.30	0.30	0.40	0.90	0.90	1.00							
February 16,2017	0.30	0.30	0.30	0.40	0.40	0.30	Feb 16,2017	96.00	13.50	95.00	13.60		
February 20,2017	0.40	0.40	0.30	0.30	0.30	0.60	Feb 20,2017	93.00	13.40	92.00	13.20	91.00	13.20
February 25,2017	0.50	0.50	0.40	0.40	0.30	0.20	feb. 25,2017	96.00	13.90	94.00	13.70	93.00	13.60
March 8,2017	0.50	0.50	0.20	0.10	0.10	0.10	Mar 8,2017	96.00	14.00	94.00	13.80	93.00	13.70
March 14,2017	0.20	0.20	-0.10	-0.20	-0.20	-0.10	Mar 14,2017	100.00	14.80	96.00	14.60	97.00	14.60
March 19,2017	0.80	0.30	0.10	0.00	-0.10	-0.20	Mar 19,2017	98.00	14.50	96.00	14.30	94.00	14.10
March 29,2017	0.30	0.20	0.10	-0.10	-0.10	-0.10	Mar 29,2017	93.00	13.60	92.00	13.50	91.00	13.40
April 6,2017	0.30	0.30	0.00	-0.10	-0.10	-0.10	Apr 6,2017	93.00	13.70	90.00	13.40	90.00	13.40
April 12,2017	0.70	0.70	0.40	0.00	-0.10	-0.10	Apr 12,2017	96.00	13.90	94.00	13.90	92.00	13.70
April 23,2017	1.00	1.00	0.90	0.80	0.50	0.50	Apr 23,2017	92.00	13.10	92.00	13.20	92.00	13.30
April 26,2017	1.20	1.20	1.00	0.40	0.10	-0.10	Apr 26,2017	98.00	14.10	96.00	14.10	92.00	13.70
May 4,2017	1.10	1.10	1.10	1.00	0.90	0.20	May 4,2017	110.00	15.50	111.00	15.60	110.00	15.60
May 14,2017	3.40	3.40	3.40	2.90	1.60	0.20	May 14,2017	101.00	13.50	101.00	13.60	100.00	14.00
May 18,2017	4.80	4.80	2.90	0.80	0.20	0.00	May 18,2017	104.00	13.60	103.00	14.20	93.00	13.50
May 23,2017	3.30	3.30	3.10	2.80	2.70	2.70	May 23,2017	101.00	13.50	100.00	13.50	100.00	13.60
June 3,2017	5.40	5.10	3.40	2.70	2.00	1.60	June 3,2017	106.00	13.60	105.00	14.00	100.00	13.70
June 8,2017	5.80	5.80	5.40	4.30	3.30	2.20	June 8,2017	108.00	13.50	107.00	13.80	106.00	14.20
June 16,2017	6.40	6.40	5.90	5.10	4.60	3.40	June 16,2017	105.00	13.10	105.00	13.40	104.00	13.50
June 23, 2017	7.20	7.10	5.60	3.60	2.20	1.60	June 23, 2017	101.00	12.20	100.00	12.50	97.00	13.30
July 1, 2017	9.90	9.00	7.30	5.50	4.00	2.30	July 1, 2017	110.00	12.80	111.00	13.70	111.00	14.70
July 9, 2017	11.80	10.90	7.10	5.50	3.90	1.70	July 9, 2017	96.00	10.50	99.00	12.30	97.00	12.70
July 20, 2017	14.90	14.90	9.80	8.00	6.20	3.70	July 20, 2017	107.00	10.80	113.00	13.10	112.00	13.80
July 28, 2017	12.50	12.40	8.70	5.90	3.20	0.90	July 28, 2017	110.00	11.70	113.00	13.40	105.00	14.10
August 4, 2017	14.90	14.90	14.80	6.60	3.50	1.50	August 4, 2017	106.00	10.90	111.00	12.00	107.00	14.60
August 11, 2017	16.20	16.20	14.00	6.80	3.70	1.00	August 11, 2017	103.00	10.30	113.00	13.10	107.00	14.60
August 19, 2017	14.00	13.80	13.50	13.10	8.00	2.60	August 19, 2017	71.00	7.50	71.00	7.60	78.00	9.30
August 27, 2017	14.30	14.30	14.30	13.00	8.00	2.70							
September 3, 2017	14.60	14.60	14.60	7.10	2.70	1.10							
September 9, 2017	14.60	14.60	14.10	10.30	8.50	5.10	September 9, 2017	99.00	10.30	98.00	10.40	100.00	11.90
September 16, 2017	14.40	14.20	13.60	12.70	7.30	2.00	September 16, 2017	99.00	10.20	96.00	10.10	99.00	12.00
September 22, 2017	14.00	14.00	14.00	11.80	8.40	5.70	September 22, 2017	99.00	10.30	98.00	10.20	99.00	11.80
September 30, 2017	12.90	12.90	12.60	12.30	11.80	9.30	September 30, 2017	94.00	10.00	93.00	9.90	91.00	9.90
October 7, 2017	12.00	12.00	11.90	11.60	9.60	3.70	October 7, 2017	98.00	10.60	95.00	10.30	94.00	10.80
October 13, 2017	11.50	11.50	11.50	11.00	9.70	8.00	October 13, 2017	96.00	10.60	94.00	10.50	93.00	10.70
October 19, 2017	10.60	10.60	10.60	9.10	8.00	5.20	October 19, 2017	100.00	11.20	98.00	10.00	97.00	11.60
October 28, 2017	10.10	10.10	10.00	9.80	9.40	6.80	October 28, 2017	99.00	11.30	94.00	10.70	93.00	10.70
November 2, 2017	10.00	10.00	9.90	9.90	9.10	6.80	November 2, 2017	100.00	11.60	98.00	11.40	94.00	11.20
November 13, 2017	8.20	8.10	8.00	7.80	7.60	6.20	November 13, 2017	93.00	11.20	91.00	11.00	91.00	11.00
November 17, 2017	7.80	7.80	7.80	7.80	7.80	7.80	November 17, 2017	98.00	11.70	96.00	11.50	96.00	11.40
November 24, 2017	6.90	6.90	6.90	6.30	6.00	5.10	November 24, 2017	88.00	10.80	88.00	10.70	89.00	10.90
December 2, 2017	5.90	6.00	6.00	6.00	6.00	6.00	December 2, 2017	89.00	11.20	88.00	11.00	90.00	11.30
December 12, 2017	5.60	5.60	5.60	5.70	5.70	4.90	December 12, 2017	95.00	12.10	95.00	12.50	96.00	12.20
Januray 4, 2018	2.50	2.50	2.50	3.00	2.90	2.90							
January 17, 2018	1.90	1.80	2.10	2.20	2.20	2.20	January 17, 2018	94.00	13.30	92.00	12.80	91.00	12.70
January 27, 2018	0.80	1.60	1.70	1.60	1.80	1.80	January 27, 2018	83.00	11.80	81.00	11.40	79.00	11.10
February 7, 2018	1.10	1.10	1.30	1.50	1.60	1.40	February 7, 2018	99.00	14.30	98.00	14.20	95.00	13.70
February 15, 2018	1.00	1.00	1.10	1.20	1.30	1.30	February 15, 2018	91.00	12.90	90.00	12.70	88.00	12.40
Febraury 26, 2018	0.80	0.80	0.70	0.60	0.70	0.80	February 26, 2018	98.00	14.20	96.00	13.90	94.00	13.60

Appendix B

Application of Available Multibeam Acoustic and Seascape Data to Map Proposed Marine Finfish Production Locations in Placentia Bay, Newfoundland

FINAL

Application of available multibeam acoustic and seascape data to map proposed marine finfish production locations in Placentia Bay, Newfoundland

Submitted to:

Knut Skeidsvoll, General Manager
Grieg NL Seafarms Ltd.
205 McGettigan Blvd.
P.O. Box 457
Marystown NL A0E 2MO

Submitted by:

Amec Foster Wheeler Environment & Infrastructure,

a Division of Amec Foster Wheeler Americas Limited

133 Crosbie Road
PO Box 13216
St. John's, NL Canada A1B 4A5

16 June 2017

Amec Foster Wheeler Project #: TF1791503

IMPORTANT NOTICE

This report was prepared exclusively for Grieg NL Seafarms Ltd. by Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler). The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in Amec Foster Wheeler's services and based on: i) information available at the time of preparation, ii) data supplied by outside sources and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by Grieg NL Seafarms Ltd. only, subject to the terms and conditions of its contract with Amec Foster Wheeler. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

TABLE OF CONTENTS

LIST OF TABLES

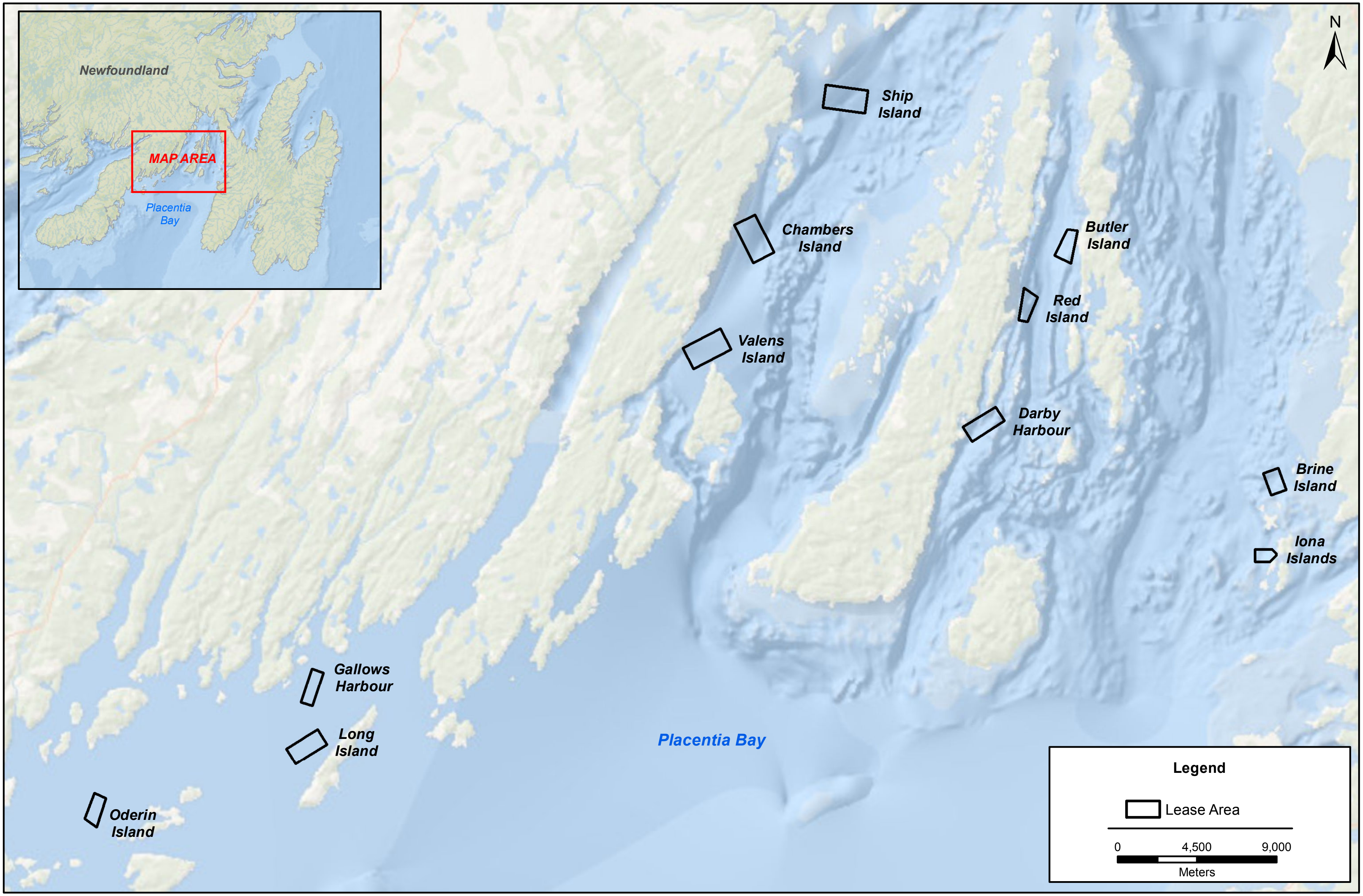
LIST OF FIGURES

LIST OF APPENDICES

1.0 CONTEXT

Amec Foster Wheeler, Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler) is pleased to submit this report of benthic mapping and characterization at your proposed marine production sites in Placentia Bay, Newfoundland for the purpose of supporting your approval process with the federal Department of Fisheries and Oceans (DFO) Aquaculture Activities Regulations (AAR) permitting requirements (AAR, 2015). This report summarizes benthic habitat types according to AAR classification requirements to facilitate consistent interpretation of all production sites as hard or soft bottom for future operational monitoring programs at the eleven proposed marine production sites in Placentia Bay, Newfoundland (Figure 1).

Figure 1 Proposed Grieg NL lease site locations in Placentia Bay, Newfoundland



NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT: GRIEG NL

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

amec foster wheeler

DWN BY:	JA
CHK'D BY:	AE
DATUM	NAD83
PROJECTION	ZONE 21N (M)
SCALE:	As Shown

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION

TITLE: LEASE AREAS

DATE	May 2017
PROJECT No.	TF1791503
REV No.	0
FIGURE No.	1

2.0 BACKGROUND

An essential step toward implementing effective management strategies for ocean systems is to identify biophysical patterns and processes that delineate benthic system functions (reviewed by Brown et al., 2011). The process of producing seafloor habitat maps incorporates disparate datasets from biological, geological, hydrographical and geophysical inputs to produce simplified spatial representation of the seafloor relating to the distribution of biological characteristics (Brown et al., 2011).

However, in the sublittoral environment, limitations of conventional *in situ* sampling methods (such as benthic grabs, dredges, video, etc.) impair the ability to synthesize the complexities of benthic system interactions as they provide detailed information on the seafloor that they sample, but on a very localized/small scale; therefore, it remains challenging to derive accurate representation of the biophysical characteristics of the seafloor in an area without extensive survey designs and tightly spaced sampling station transects (reviewed by Brown et al., 2011). Therefore, application of acoustic survey techniques such as side-scan sonar systems and multibeam echo sounders provide tools that enable wide-scale reconnaissance style surveying to produce accurate, aerial-like images of the seafloor (reviewed by Brown et al., 2011).

Multibeam echosounders are able to provide bathymetric data detailing the terrain and structure (e.g., rugosity and/or steepness) of the seafloor in addition to information that can provide an indication of sediment grain size and hardness (Dolan et al., 2009; Kaplan et al., 2010). The latter is derived from acoustic response (reflection) of the seafloor to the multibeam acoustic waves, this data, called backscatter, can be used for interpretation of some aspects of the physical habitat such as morphological structures and slopes (Dolan et al., 2009; Kaplan et al., 2010). However, interpretation of backscatter data also requires supportive *in situ* observations using conventional benthic survey methods to validate the interpretations and ground-truth the data (Dolan et al., 2009; Kaplan et al., 2010). The combination of multibeam acoustic survey data with conventional *in situ* sampling can be reconciled with a Geographic Information System (GIS) to synthesize seafloor habitat characterization maps (seascapes) according to geomorphology, texture and biota (Dolan et al., 2009; Brown et al., 2011; Shaw et al., 2011; 2011; Todd and Greene, 2007; Whitmire et al., 2007).

3.0 APPROACH

The Geologic Survey of Canada (GSC) and Canadian Hydrographic Service (CHS) conducted systematic mapping of Placentia Bay, Newfoundland using multibeam sonar and surveyed with sub-bottom profilers (Shaw et al., 2011). Interpretation of the multibeam data was supported by seismic data, sidescan sonograms, bottom photographs, video, submersible observations and grab samples to generate a high-resolution seascape dataset (Shaw et al., 2011). The output was georeferenced spatially using GIS software (ESRI's ArcGIS Software Package) and then digitized and coded. High-resolution outputs (5m grid resolution GIS Shapefiles) and graphical outputs have been generated according to referenced coordinates.

Proposed lease site area coverage represented by multibeam data was calculated and the non-surveyed areas were composited with CHS bathymetric data when both sources were in alignment where they interfaced. For each site the percentage represented by multibeam data is reported, as is the percentage for each habitat type defined therein.

Lease areas with less than 90% multibeam survey coverage were composited with CHS 10m resolution bathymetry data and surveyed using drop video at 100 m grid intervals by Grieg NL personnel. The video survey locations are indicated in this report and results of the video surveys are reported separately by Grieg NL.

All sites are depicted with corresponding carbon depositional contours previously calculated using DEPOMOD software (Appendix A) and represented at the same spatial scale as the multibeam outputs.

The baseline site characterization data was used to designate potential lease sites as hard bottom according to the *Monitoring Protocol for Hard Bottom Benthic Substrates under Marine Finfish Farms in Newfoundland and Labrador (NL)* under Annex 9 of the AAR if “more than 50% of the lease area is hard bottom composed of rockwall, bedrock, boulders, rubble, cobble, gravel, or hard packed finer substrates” (Annex 9; AAR, 2015).

4.0 RESULTS

Four of the proposed lease sites (Oderin Island, Valens Island, Ship Island, and Red Island) had 100% site coverage with the multibeam data (Table 1). An additional four sites had greater than 90% site coverage, including Chambers Island, Butler Island, Darby Harbour and Iona Island (Table 1). For the remaining sites, Long Island had 69.34% multibeam survey coverage, Gallows Harbour had 15.71% survey coverage, and Brine Island was represented by 1.71% survey coverage.

Table 1 Grieg NL lease site coverage with CHS or Multibeam bathymetry

Lease Area Name	Total Lease Area (km^2)	Area multibeam (km^2)	Area CHS Area (km^2)	% Canadian Hydrographic Service	% Multibeam
Gallows Harbour	1.40	0.22	1.18	84.29	15.71
Long Island	2.12	1.47	0.65	30.48	69.34
Oderin Island	1.22	1.22	0.00	0.00	100.00
Valens Island	3.17	3.17	0.00	0.00	100.00
Chambers Island	3.15	3.09	0.05	1.59	98.10
Ship Island	3.13	3.13	0.00	0.00	100.00
Butler Island	1.39	1.37	0.02	1.44	98.56
Red Island	1.19	1.19	0.00	0.00	100.00
Darby Harbour	2.08	1.94	0.15	7.08	93.27
Brine Island	1.17	0.02	1.15	98.29	1.71
Iona Islands	0.66	0.63	0.03	4.55	95.45

4.1 Benthic Habitat Types in Proposed Grieg NL Marine Production Lease Areas

Use of the Shaw et al. (2011) seascape dataset for benthic habitat mapping reveals up to three benthic habitat types at the proposed production lease sites, two are consistent with hard bottom classification: sub-littoral bedrock and deep-water bedrock, and one is consistent with soft-bottom classification: deep-water muddy.

The predominant hard bottom seascape type among lease areas is **deep-water bedrock**. This seascape is characterized as having high-relief ridges, ledges, and pinnacles; however the topographic relief of these features is more subdued compared to those in shallower regions (Shaw et al., 2011). The sediment is composed of rock, muddy gravel, and gravelly mud and is relatively barren of biota, other than anemones (*Hormathia nodosa*) and tube burrow openings in sediment (Shaw et al., 2011). The depth ranges for this habitat type vary depending on the sites, and these are discussed separately for each lease area below.

The balance of hard-bottom areas among lease areas is **sub-littoral bedrock** seascape, which is characterized as being composed of rock (high backscatter) and gravel (high backscatter) with morphology of high relief ridges, ledges and pinnacles (Shaw et al., 2011). There is commonly a veneer of sand and gravel, with thicker sediments in pockets (Shaw et al., 2011). Associated biota include attached fauna such as encrusting red algae (*Lithothamnion sp.*) and seaweeds on rocks (Shaw et al., 2011).

The only soft-bottom type among the proposed lease areas is **deep-water muddy** seascape. This habitat is characterized as having very low relief (flat) except in areas of "pockmarks" and being composed of mud, silty mud, and sandy mud (low backscatter) (Shaw et al., 2011). Biota that may be associated with this habitat include infaunal annelids and bivalves, gastropods, crustaceans, including snow crabs (*Chionoecetes opilio*), and shrimps (*Pandalus sp.*) (Shaw et al., 2011).

4.2 Benthic habitat type per individual lease area

The habitat types, depths and depositional contours for each lease site are described below. An overall site designation as hard or soft bottom is proposed according to the data available.

4.2.1 Oderin Island

Oderin Island is located in the southwest region of Placentia Bay (Figure 1), in the Rushoon Bay Management Area (BMA). This site ranges in depth from 39 in the southeast corner of the lease area to 98 m in the northeast and southern regions of the lease area (Figure 2). The entirety (100%) of this proposed lease site is represented by the multibeam survey data. The predominant (61.26%) seascape type is **deep-water bedrock (Table 2)**. This habitat type spans from the southwest corner of the lease area across the majority of the northern half (Figure 2) and includes several slight pinnacle formations not exceeding this depth range.

The remaining hard-bottom regions of this lease area are **sub-littoral bedrock** seascape (4.70%). This habitat type is confined to the southernmost corner of the proposed Oderin Island lease site at a depth range of approximately 35-70m.

The soft-bottom area of the lease site (34.24%) is **deep-water muddy** seascape. This seascape type is located primarily in the bottom half of the proposed lease site and ranges in depth from approximately 72 to 98m (which includes the deepest region of this proposed lease area). In the northernmost region of the proposed lease area there is an additional deep (95m) area of this seascape type.

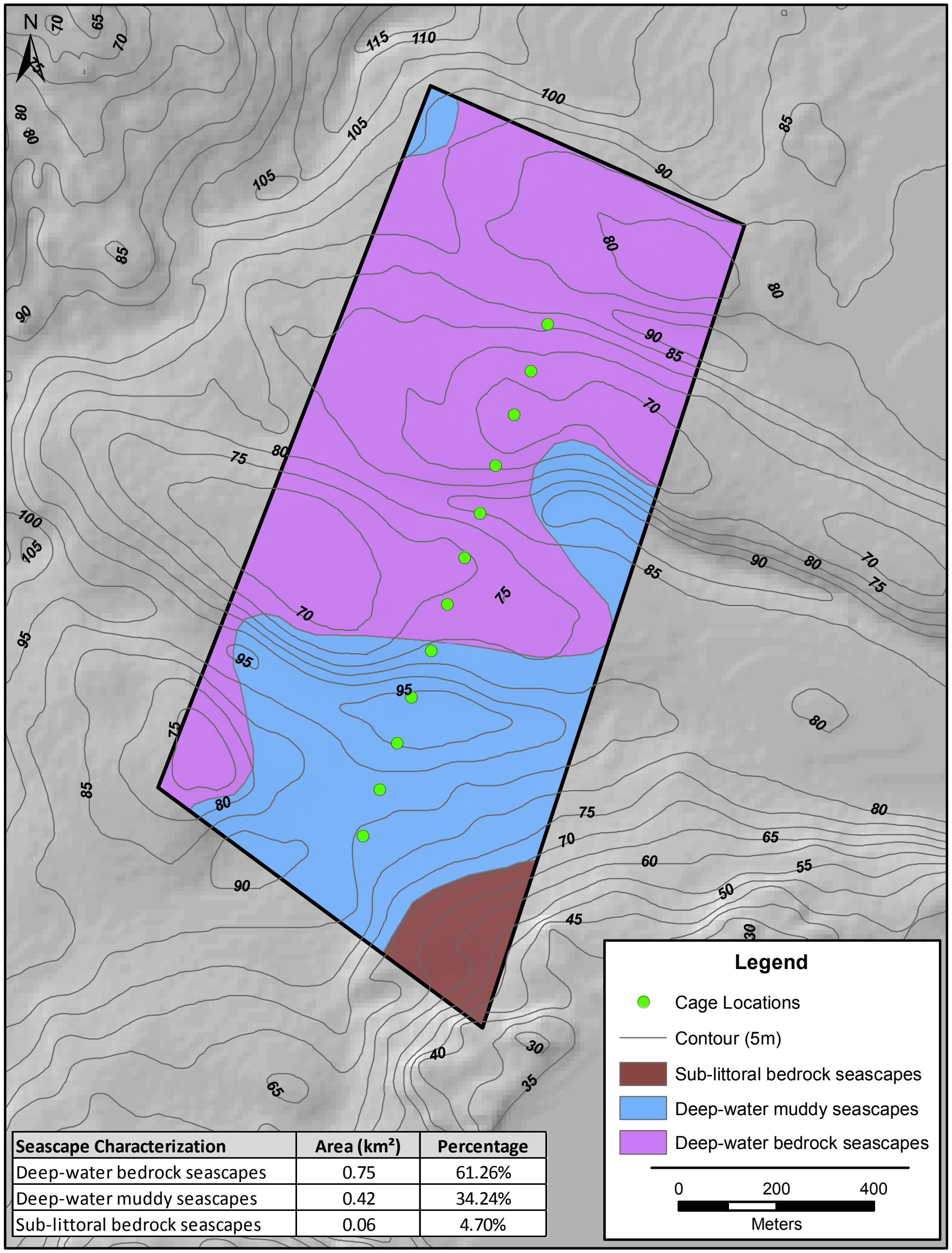
Table 2 Summary of Oderin Island benthic habitat types by spatial coverage.

Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Oderin Island	Deep-water bedrock seascapes	0.75	61.26	61.26
	Sub-littoral bedrock seascapes	0.06	4.70	4.70
	Deep-water muddy seascapes	0.42	34.24	
Total		**1.22**		**65.96**

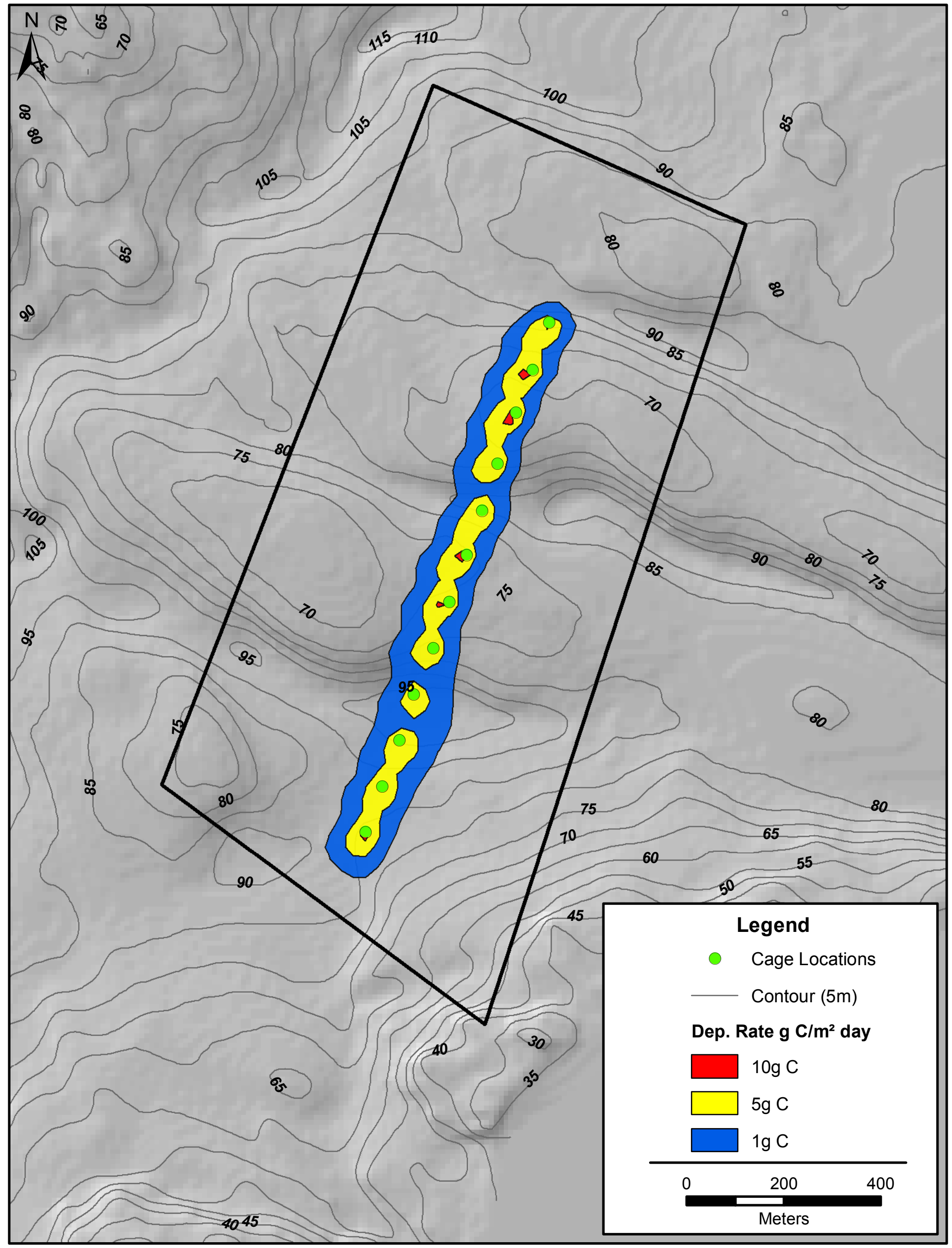
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)

Overall, the majority (65.96%) of the Oderin Island lease area is hard-bottom (Table 2) and the 1 g depositional contour is primarily over deep-water bedrock seascape (Figure 2).

Figure 2 Oderin Lease Site



Seascape Characterization	Area (km²)	Percentage
Deep-water bedrock seascapes	0.75	61.26%
Deep-water muddy seascapes	0.42	34.24%
Sub-littoral bedrock seascapes	0.06	4.70%



NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT: GRIEG NL

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

amec foster wheeler

DWN BY:	JA
CHK'D BY:	AE
DATUM	NAD83
PROJECTION	ZONE 21N (M)
SCALE:	1:15,000

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION

TITLE: SUB-LITTORAL SEASCAPE ODERIN ISLAND

DATE	May 2017
PROJECT No.	TF1791503
REV No.	0
FIGURE No.	2

4.2.2 Long Island

Long Island is located in the southwest region of Placentia Bay (Figure 1), also in the Rushoon Bay Management Area (BMA). In the area represented by the seascape data, this site ranges in depth from 75 m near the northern corner of the lease area to 180 m in the southwest region of the lease area (Figure 3). The majority (69.34%) of this proposed lease site is represented by the multibeam survey data. The predominant (47.70%) seascape type is **deep-water bedrock (Table 3)**. This habitat type spans between the northern corner and southern corners of the lease area and bifurcates towards the west around a deep-water muddy seascape in the middle of the western half of the lease area (Figure 3), representing 22.68% of the lease area seascape composition.

The remaining hard-bottom region of this lease area that has been characterized by the seascape data is **sub-littoral bedrock** (2.36%). This habitat type is confined towards the northern shallower region of the lease area.

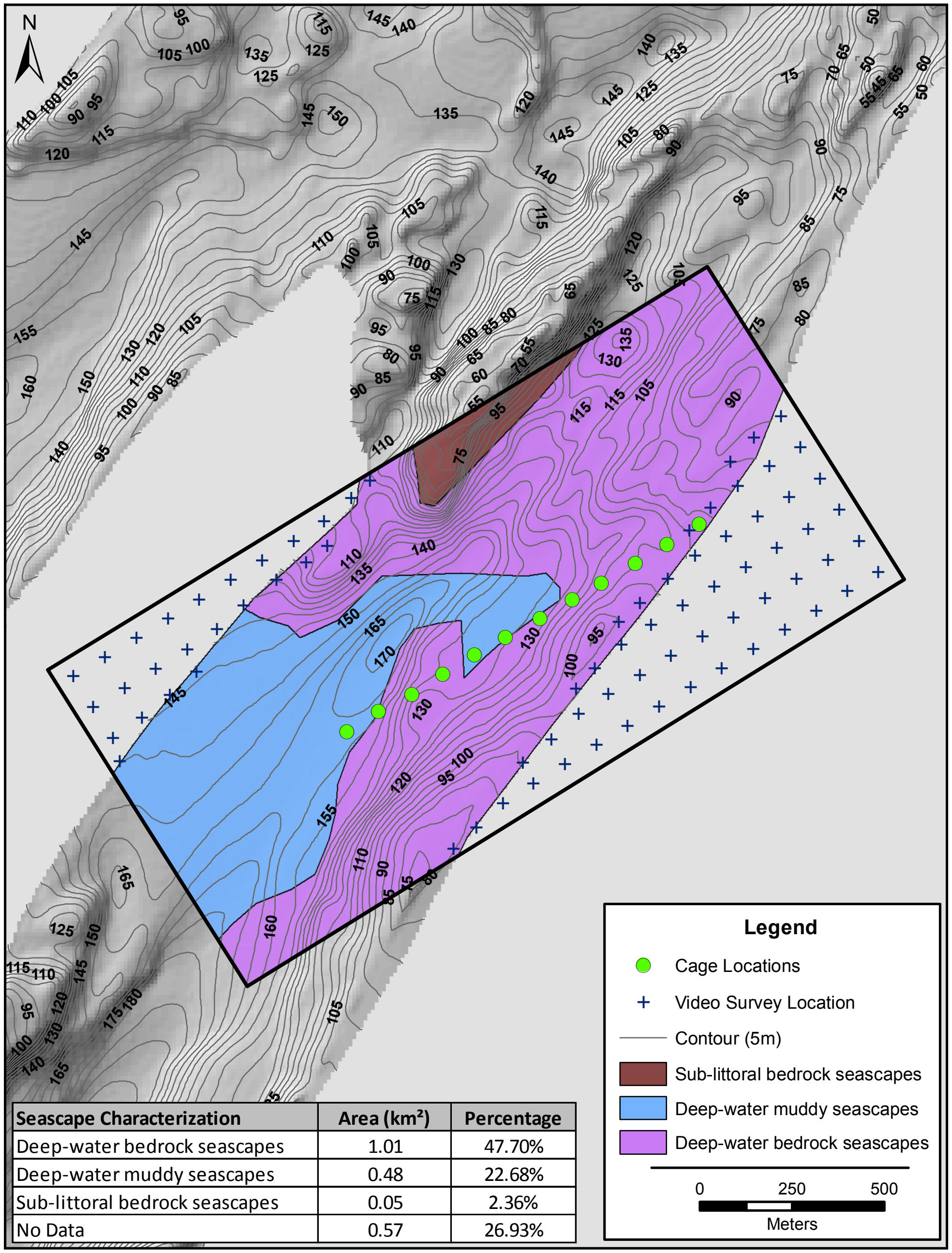
The remainder of this lease area (26.93%) is not represented by the seascape survey and this area was instead surveyed by Grieg NL using drop video at the station locations illustrated in Figure 3. Those survey results are reported separately.

Overall, according to the multibeam data the majority (50.60%) of the Oderin Island lease area is hard-bottom (Table 3) and the 1 g depositional contour is primarily over deep-water bedrock seascape (Figure 3).

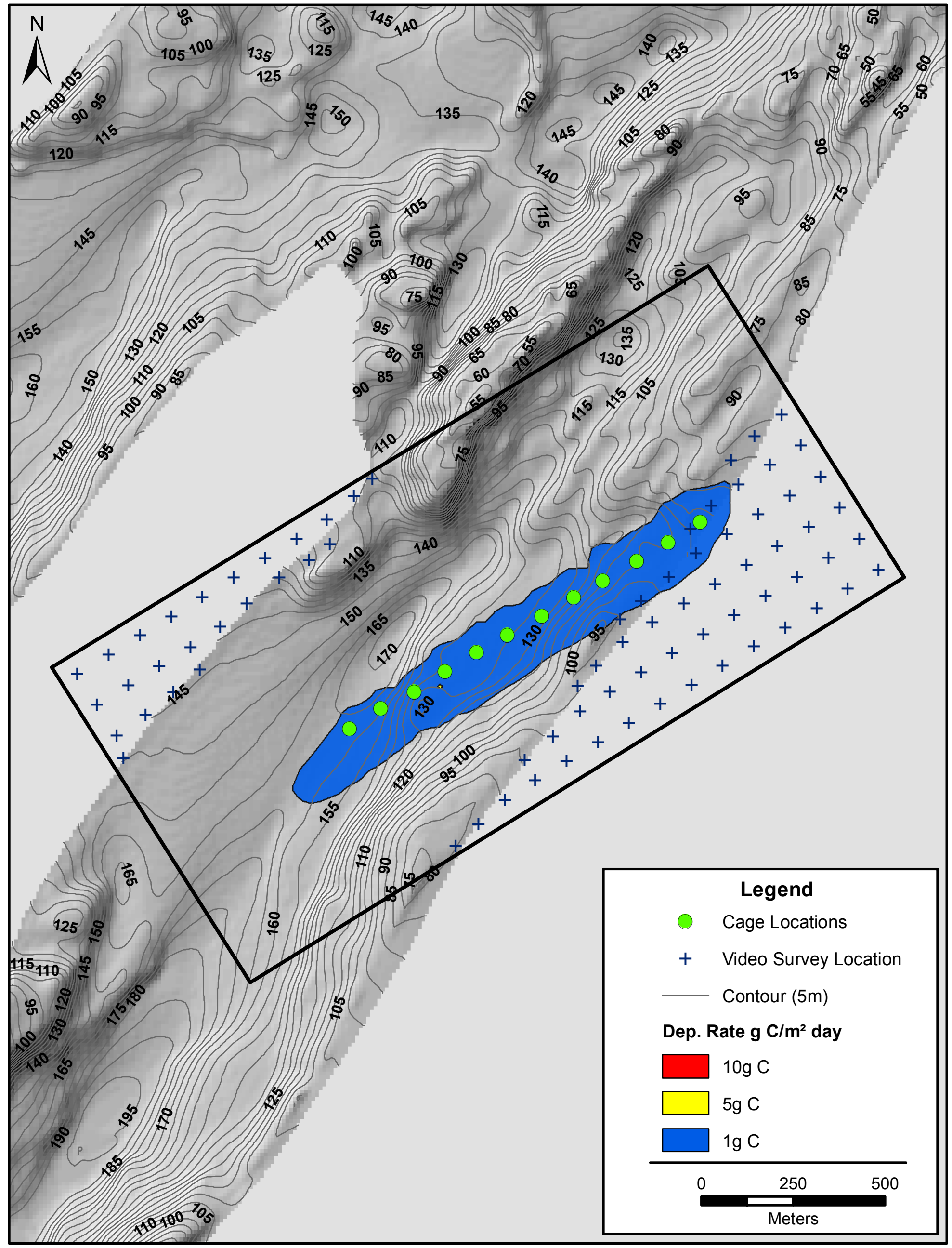
Table 3 Summary of Long Island benthic habitat types by spatial coverage.

Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Long Island	Deep-water bedrock seascapes	1.01	47.70	47.70
	Sub-littoral bedrock seascapes	0.05	2.36	2.36
	Deep-water muddy seascapes	0.48	22.68	
	No multibeam data	0.57	26.93	
Total				**50.60**
*The AAR definition of hard bottom is "substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines." (AAR, 2015)				

Figure 3 Long Island Site



Seascape Characterization	Area (km²)	Percentage
Deep-water bedrock seascapes	1.01	47.70%
Deep-water muddy seascapes	0.48	22.68%
Sub-littoral bedrock seascapes	0.05	2.36%
No Data	0.57	26.93%



NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT: GRIEG NL

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

amec foster wheeler

DWN BY:	JA
CHK'D BY:	AE
DATUM	NAD83
PROJECTION	ZONE 21N (M)
SCALE:	1:20,000

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION

TITLE: SUB-LITTORAL SEASCAPE LONG ISLAND

DATE	May 2017
PROJECT No.	TF1791503
REV No.	0
FIGURE No.	1

4.2.3 Gallows Harbour

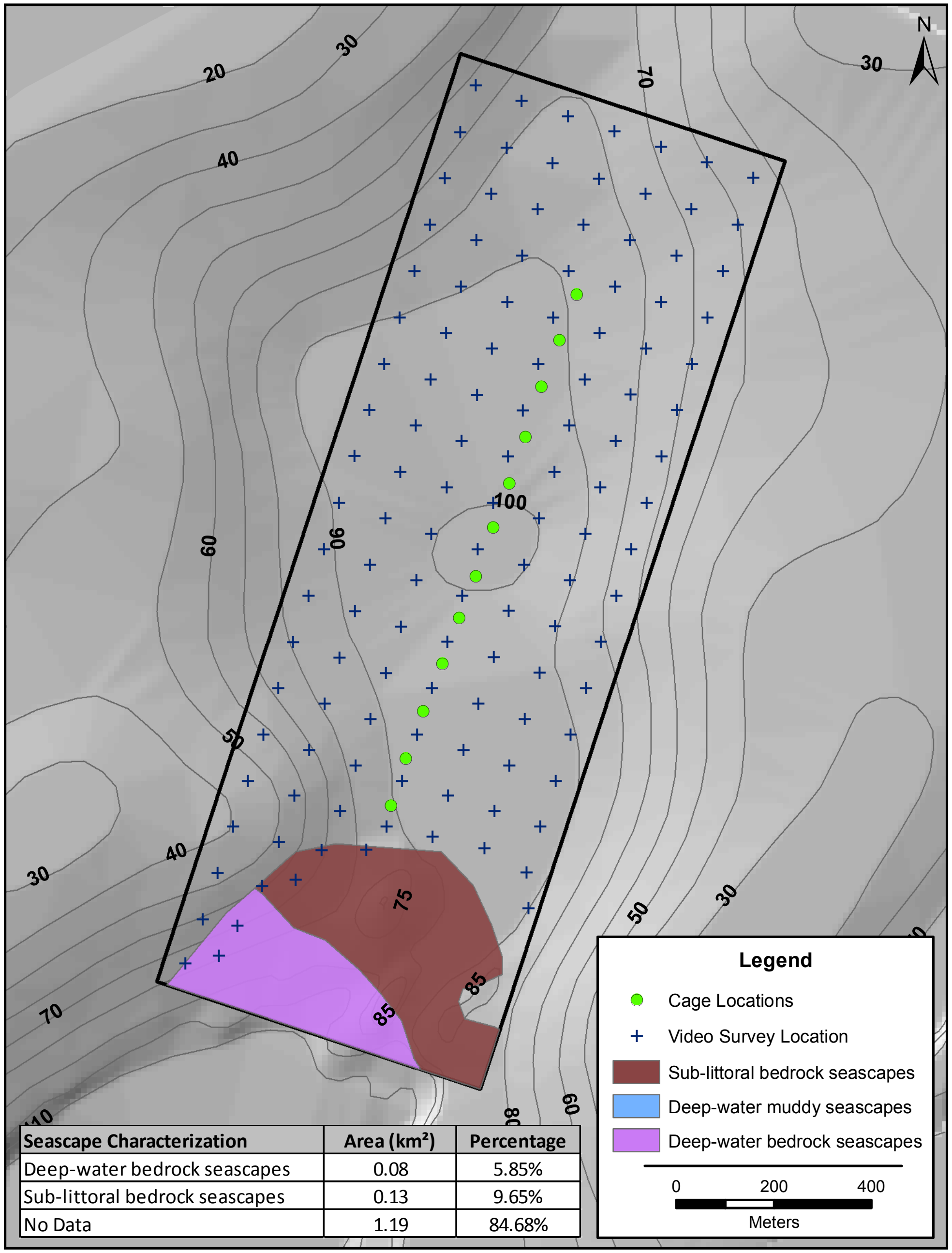
Gallows Harbour is also located in the southwest region of Placentia Bay (Figure 1), in the Rushoon BMA. This site ranges in depth from 40 m in the southwest corner of the lease area to 100 m in the centre of the lease area (Figure 4). Only a portion (15.50%) of this proposed lease site is represented by the multibeam survey data, of this 9.65% of the lease area is **sub-littoral bedrock** (Table 4**)**. This habitat type spans from the southeast corner of the lease area towards the centre (Figure 4) and south of this is a region of deep-water bedrock. The majority of this sight required conventional video survey at 100m grid intervals (video locations indicated in Figure 4). That survey information is provided in a separate report from Grieg NL.

The characterization of the Gallows Harbour Lease Area will depend on the results of the video survey of the remaining 85% of the lease area including in the area of the predicted 1 g/ day depositional contour.

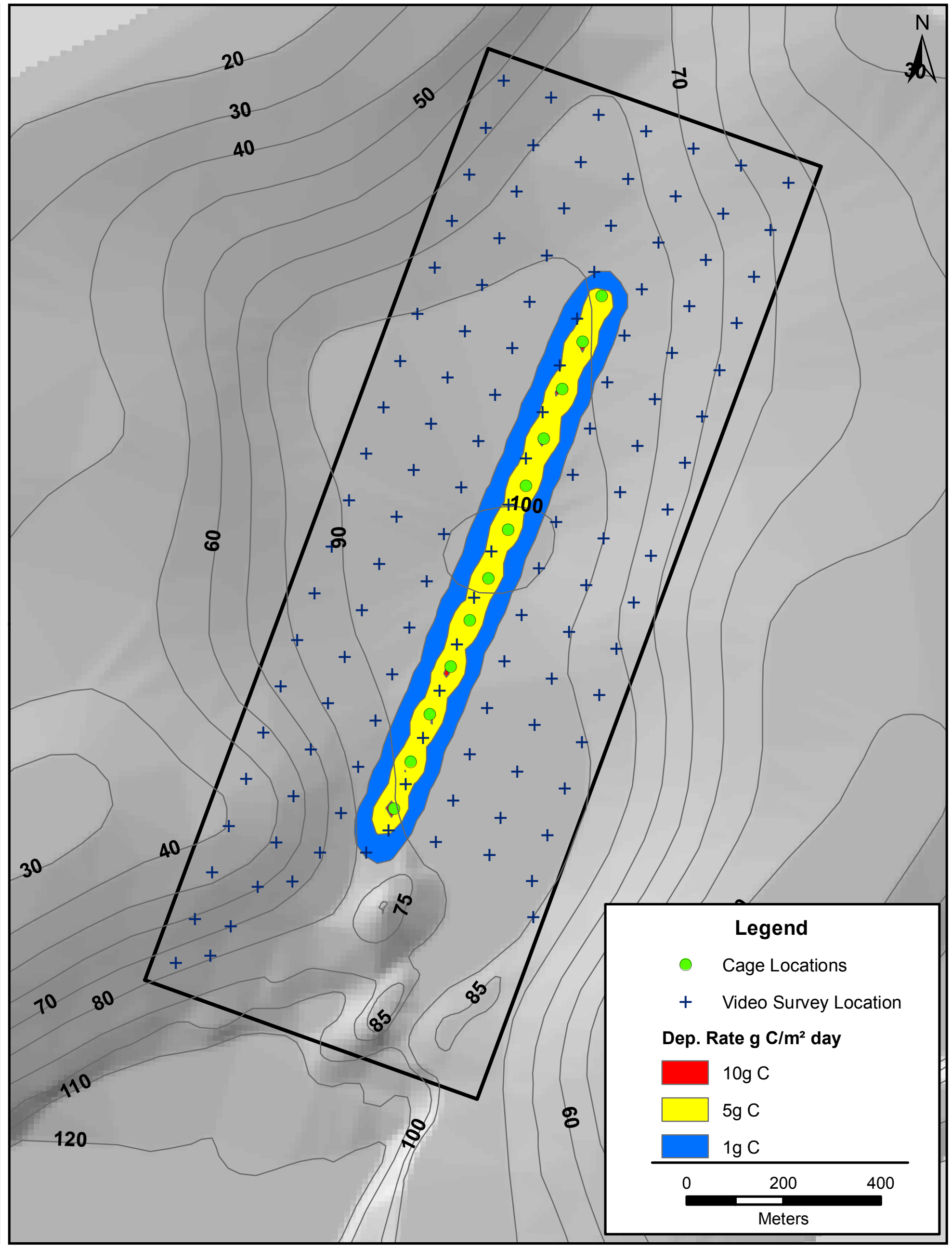
Table 4 Summary of Gallows Harbour Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Gallows Harbour	Deep-water bedrock seascapes	0.08	5.85	5.85
	Sub-littoral bedrock seascapes	0.13	9.65	9.65
	No multibeam data	1.19	84.50	
Total		**1.40**		**15.50**
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)				

Figure 4 Gallows Harbour



Seascape Characterization	Area (km²)	Percentage
Deep-water bedrock seascapes	0.08	5.85%
Sub-littoral bedrock seascapes	0.13	9.65%
No Data	1.19	84.68%



NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT: GRIEG NL

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

amec foster wheeler

DWN BY:	JA
CHK'D BY:	AE
DATUM	NAD83
PROJECTION	ZONE 21N (M)
SCALE:	As Shown

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION

TITLE: SUB-LITTORAL SEASCAPE GALLOWS HARBOUR

DATE	May 2017
PROJECT No.	TF1791503
REV No.	0
FIGURE No.	4

4.2.4 Valens Island

Valens Island is located towards the inland region of Placentia Bay (Figure 1), in the southwest region of the Merasheen BMA. This site ranges in depth from 58 m in the westernmost corner of the lease area to 308 m in the centre of the northeastern half of the lease area (Figure 5). The entirety (100%) of this proposed lease site is represented by the multibeam survey data. The predominant (53.80%) seascape type is **deep-water bedrock (Table 5)**. This habitat type undulates around the perimeter of the lease area and is continuous across the northeast margin of the lease area (Figure 5) there are several slopes and pinnacle formations in these habitat areas.

The remaining hard-bottom regions of this lease area are **sub-littoral bedrock** seascape (0.20%). This habitat type is confined to the western-most corner of the proposed Valens Island lease area projecting towards the coastal shoreline.

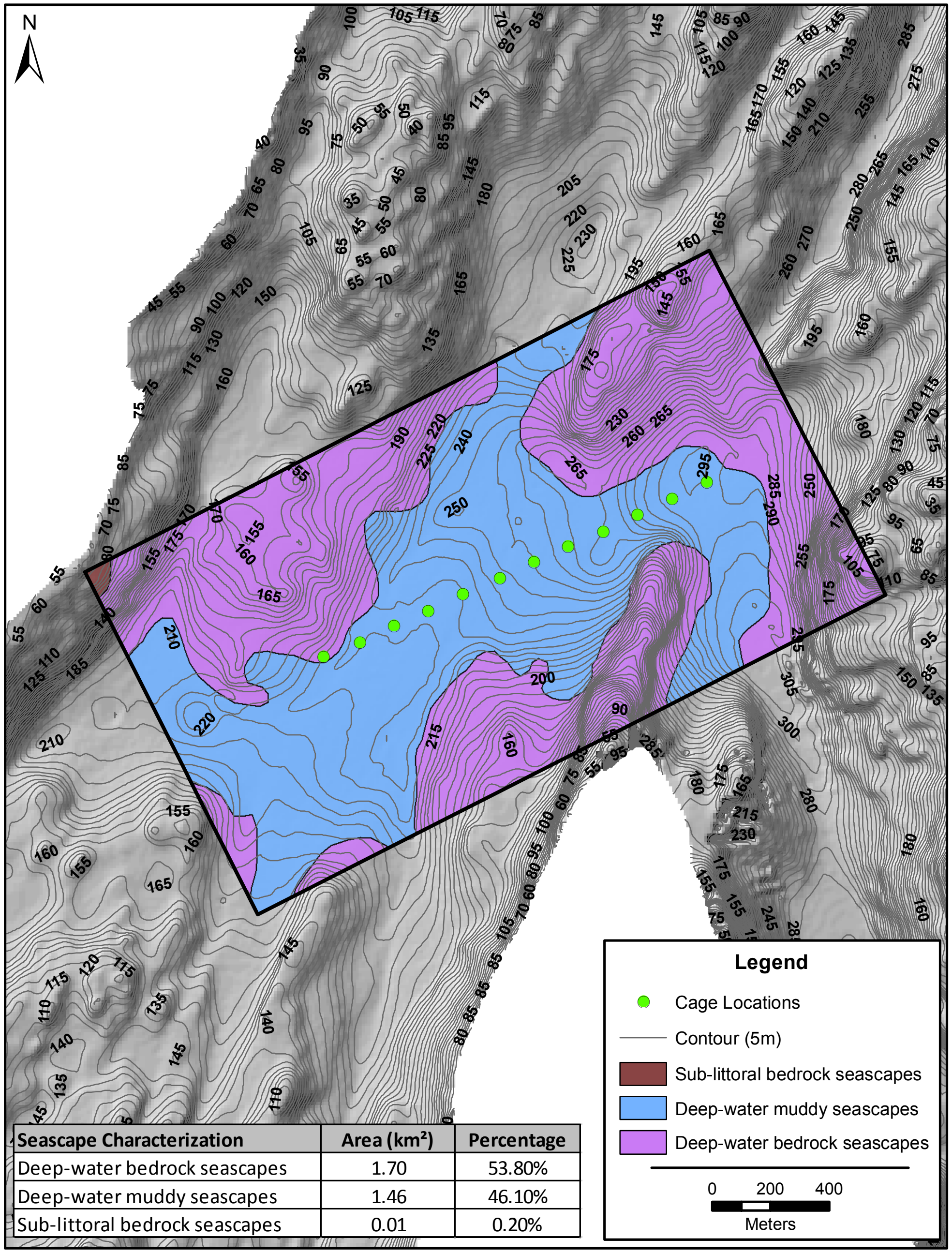
The soft-bottom area of the lease site (46.10%) is **deep-water muddy** seascape. This seascape type is located primarily along the centre of the proposed lease site and diverges out in north and south projections around deep-water bedrock seascapes.

Overall, the majority (54.00%) of the Valens Island lease area is hard-bottom (Table 5) and the 1 g depositional contour is primarily over deep-water muddy seascape (Figure 5).

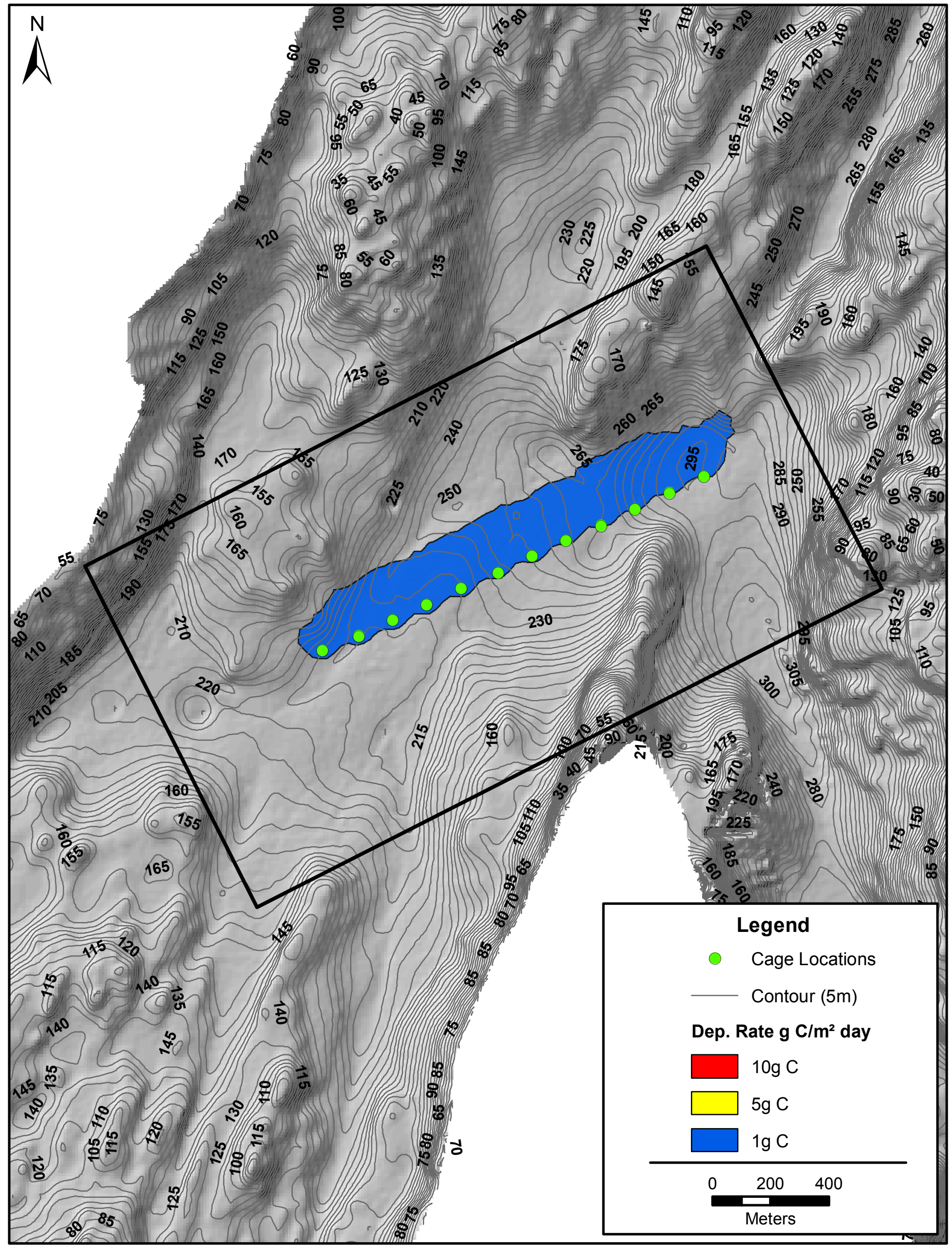
Table 5 Summary of Valens Island Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Valens Island	Deep-water bedrock seascapes	1.70	53.80	53.80
	Sub-littoral bedrock seascapes	0.01	0.20	0.20
	Deep-water muddy seascapes	1.46	46.10	
Total		**3.17**		**54.00**
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)				

Figure 5 Valens Island Site



Seascape Characterization	Area (km²)	Percentage
Deep-water bedrock seascapes	1.70	53.80%
Deep-water muddy seascapes	1.46	46.10%
Sub-littoral bedrock seascapes	0.01	0.20%



NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT: GRIEG NL

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

amec foster wheeler

DWN BY:	JA
CHK'D BY:	AE
DATUM	NAD83
PROJECTION	ZONE 21N (M)
SCALE:	1:25,000

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION

TITLE: SUB-LITTORAL SEASCAPE VALENS ISLAND

DATE	May 2017
PROJECT No.	TF1791503
REV No.	0
FIGURE No.	5

4.2.5 Chambers Island

Chambers Island is located towards the inland region of Placentia Bay (Figure 1), in the western region of the Merasheen BMA. This site ranges in depth from 16 m in the westernmost corner of the lease area to 308 m in the western-most corner of the lease area (Figure 6). The majority (99.95%) of this proposed lease site is represented by the multibeam survey data. The predominant (51.70%) seascape type is **deep-water bedrock (Table 6)**. This habitat type extends across the northern region of the lease area as well as along the majority of the southern perimeter of the lease area continuous across the northeast margin of the lease area (Figure 6).

The remaining hard-bottom region of this lease area is **sub-littoral bedrock** seascape (3.10%). This habitat type is confined to the western-most corner of the proposed Valens Island lease area and ascending towards the coastal shoreline.

The soft-bottom area of the lease site (43.20%) is **deep-water muddy** seascape. This seascape type transverses the southern mid-section of the proposed lease site.

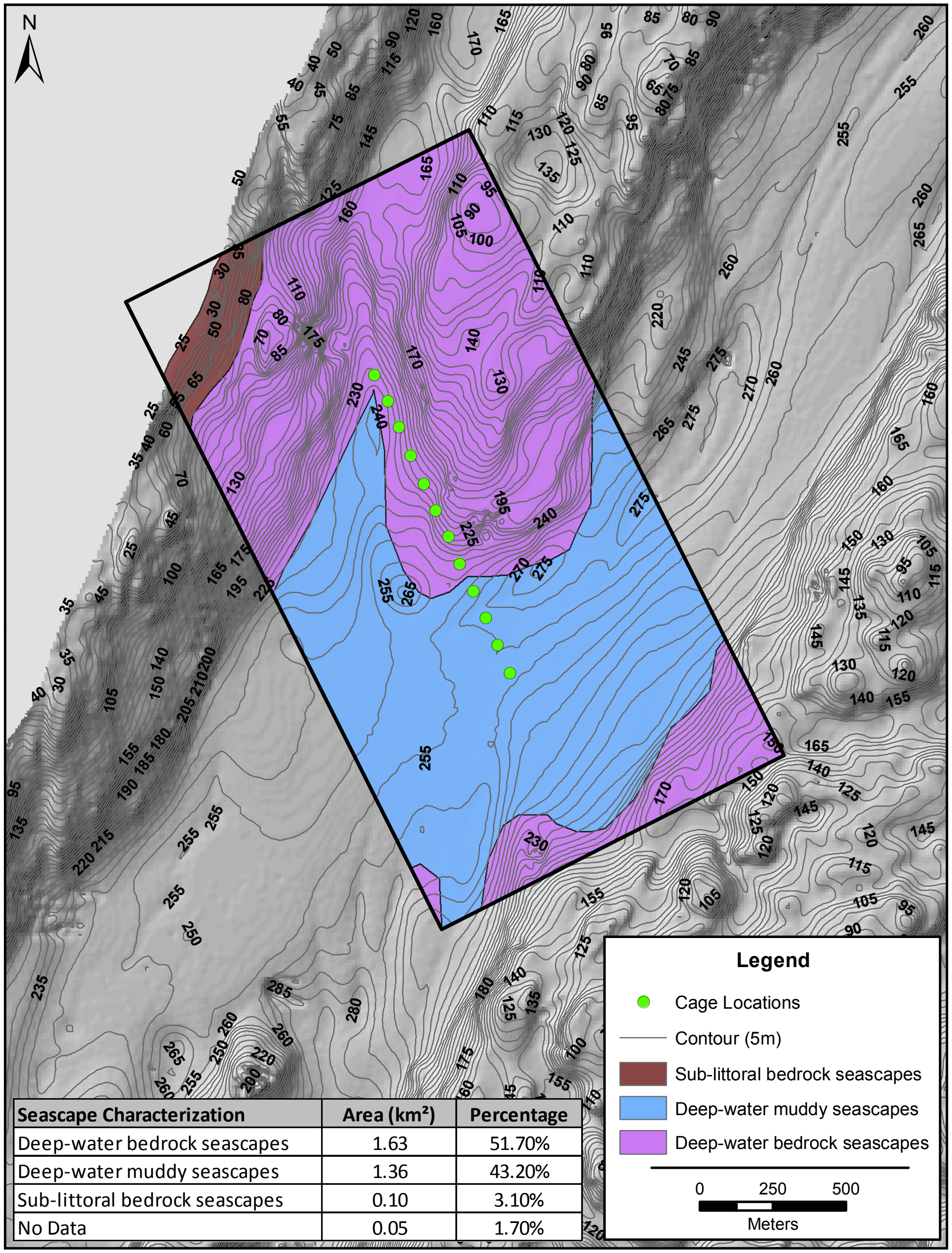
Overall, the majority (54.80%) of the Valens Island lease area is hard-bottom (Table 6) and the 1 g depositional contour is over deep-water bedrock and deep-water muddy seascapes (Figure 6).

Table 6 Summary of Chambers Island Benthic Habitat Types by Spatial Coverage.

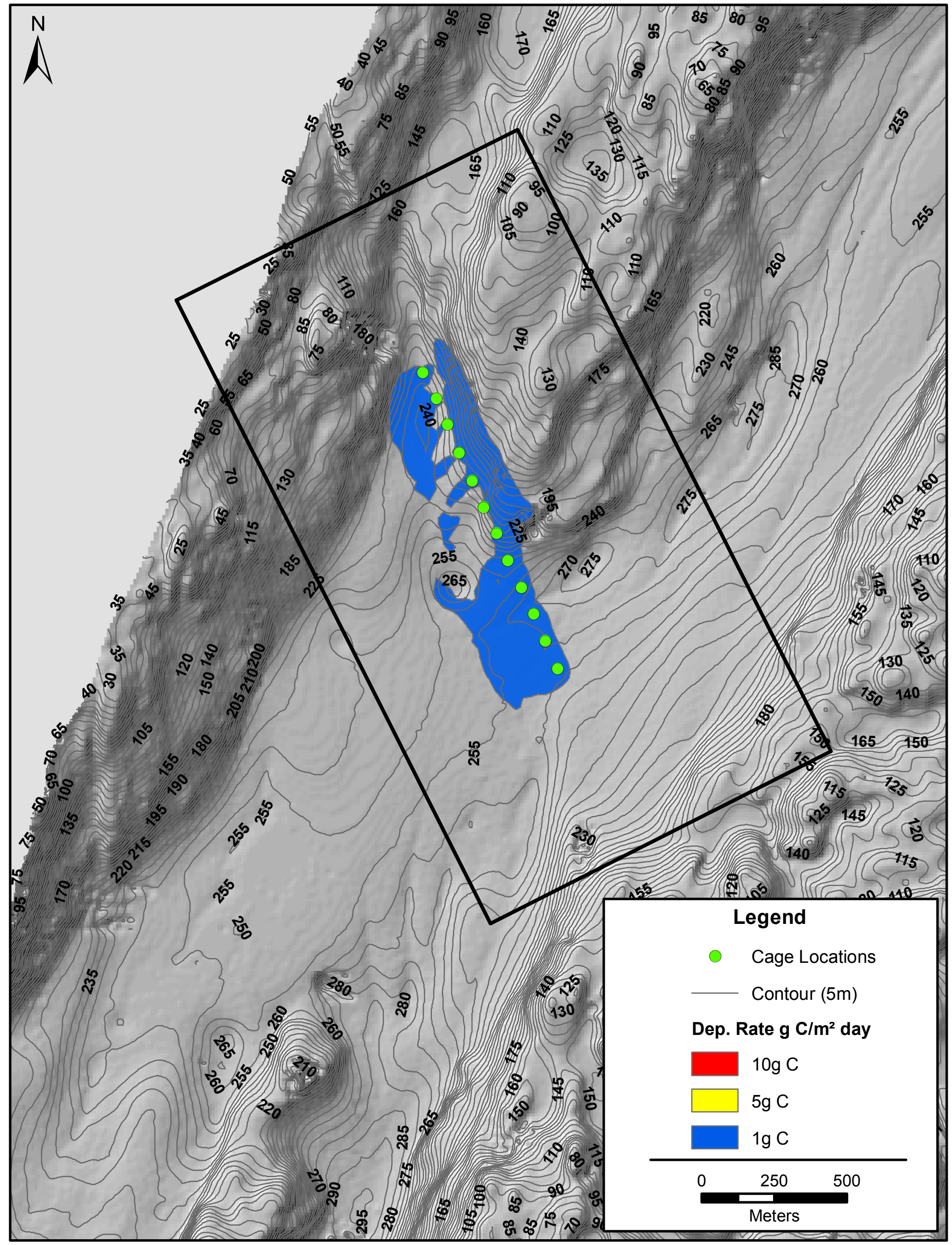
Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Chambers Island	Deep-water bedrock seascapes	1.63	51.70	51.70
	Sub-littoral bedrock seascapes	0.10	3.10	3.10
	Deep-water muddy seascapes	1.36	43.20	
	No multibeam data	0.05	1.70	
Total		**3.15**		**54.80**

*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)

Figure 6 Chambers Island Site



Seascape Characterization	Area (km²)	Percentage
Deep-water bedrock seascapes	1.63	51.70%
Deep-water muddy seascapes	1.36	43.20%
Sub-littoral bedrock seascapes	0.10	3.10%
No Data	0.05	1.70%



NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT: GRIEG NL

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

DWN BY:	JA
CHK'D BY:	AE
DATUM	NAD83
PROJECTION	ZONE 21N (M)
SCALE:	1:25,000

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION

TITLE: SUB-LITTORAL SEASCAPE CHAMBERS ISLAND

DATE	May 2017
PROJECT No.	TF1791503
REV No.	0
FIGURE No.	6

4.2.6 Ship Island

Ship Island is also located towards the inland region of Placentia Bay (Figure 1), in the northwestern region of the Merasheen BMA. This site ranges in depth from 41 m in the northwestern-most corner of the lease area to 223 m in the southeastern-most corner of the lease area (Figure 7). The entirety (100%) of this proposed lease site is represented by the multibeam survey data. The predominant (61.40%) seascape type is **deep-water muddy** (Table 7). This habitat type represents the eastern half of the lease area and extends upwards along the central and northern regions of the lease area an additional small section near the southwestern corner (Figure 7).

The hard-bottom region of this lease area is predominantly deep-water bedrock seascape (36.90%).. This seascape type spans across the western half of the lease area adjacent to the deep-water muddy seascape (Figure 7).

The remaining hard-bottom area of the lease site (1.70%) is **sub-littoral bedrock** seascape. This habitat type is confined to the northwestern corner of the proposed Ship Island lease area and ascends steeply towards the nearest small island (Figures 1 and 7).

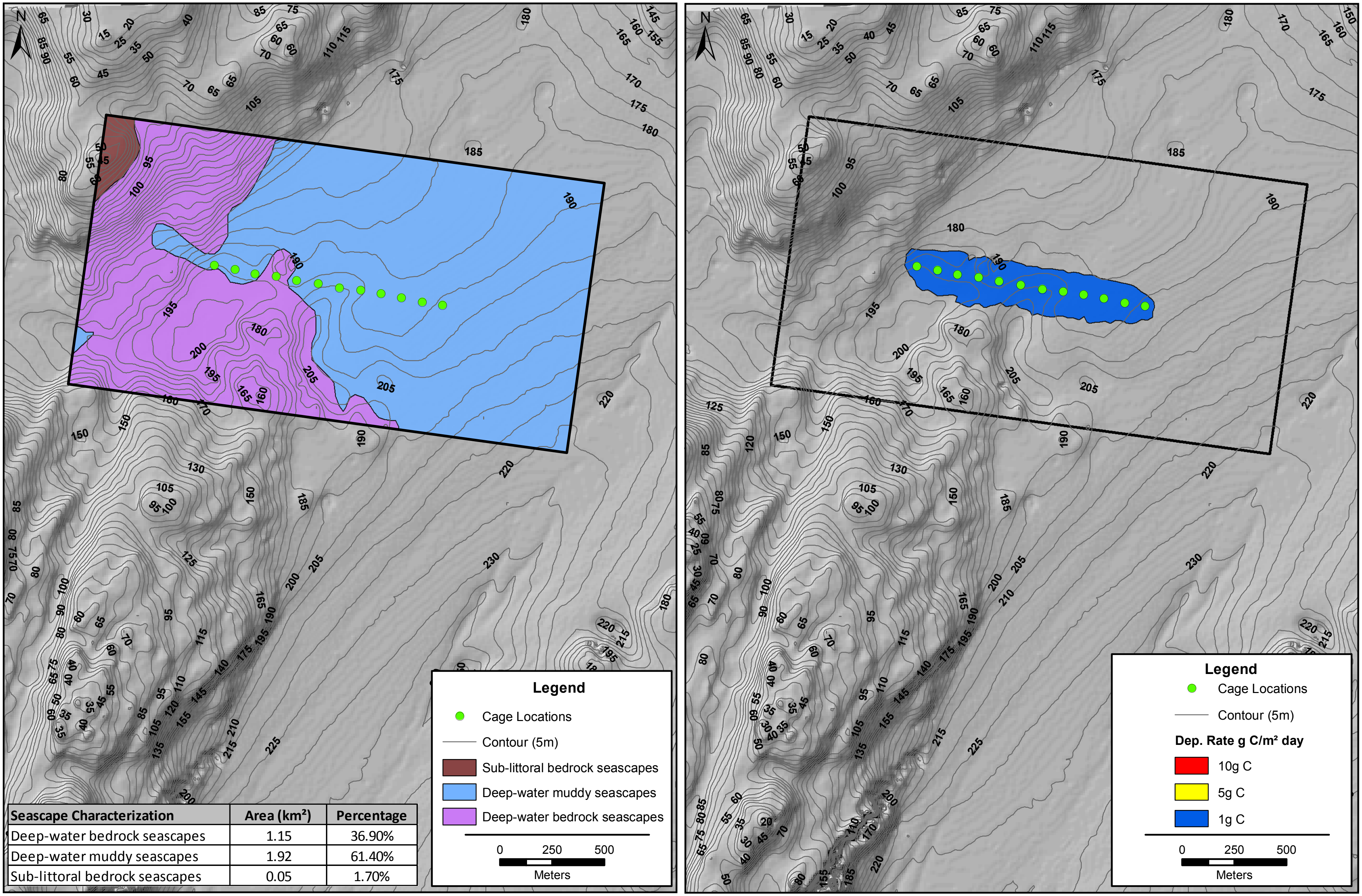
Overall, the majority (61.40%) of the Ship Island lease area is soft-bottom (Table 7) and the 1 g depositional contour is predominantly over deep-water muddy seascape with some bedrock overlap (Figure 7).

Table 7 Summary of Ship Island Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Ship Island	Deep-water bedrock seascapes	1.15	36.90	36.90
	Sub-littoral bedrock seascapes	0.05	1.70	1.70
	Deep-water muddy seascapes	1.92	61.40	
Total		**3.13**		**38.50**

*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)

Figure 7 Ship Island Site



Seascape Characterization	Area (km²)	Percentage
Deep-water bedrock seascapes	1.15	36.90%
Deep-water muddy seascapes	1.92	61.40%
Sub-littoral bedrock seascapes	0.05	1.70%

NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT: GRIEG NL

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

amec foster wheeler

DWN BY: JA	PROJECT: BENTHIC SEASCAPE CHARACTERIZATION	DATE May 2017
CHK'D BY: AE		PROJECT No. TF1791503
DATUM NAD83	TITLE: SUB-LITTORAL SEASCAPE SHIP ISLAND	REV No. 0
PROJECTION ZONE 21N (M)		
SCALE: 1:25,000		FIGURE No. 7

4.2.7 Butler Island

Butler Island is also located towards the inland region of Placentia Bay (Figure 1), in the northwestern region of the Red Island BMA. This site ranges in depth from 10 m in the northeastern-most corner of the lease area to 143 m along the southwestern perimeter of the lease area (Figure 8). The entirety (100%) of this proposed lease site is represented by the multibeam survey data. The predominant (79.90%) seascape type is **deep-water bedrock** (Table 8). This habitat type represents almost the entire western half of the lease area as well as the centre region of the eastern half (Figure 8).

The predominant hard-bottom habitat type of this lease area is **deep-water bedrock** seascape (79.85%). This habitat type is located in the western half of the proposed lease area and ascends towards the coastal shoreline. The remaining 20.01% of the lease area that comprises hard-bottom is sub-littoral bedrock, this is confined to the northwest corner of the lease area nearest the coastal shoreline (Figure 8).

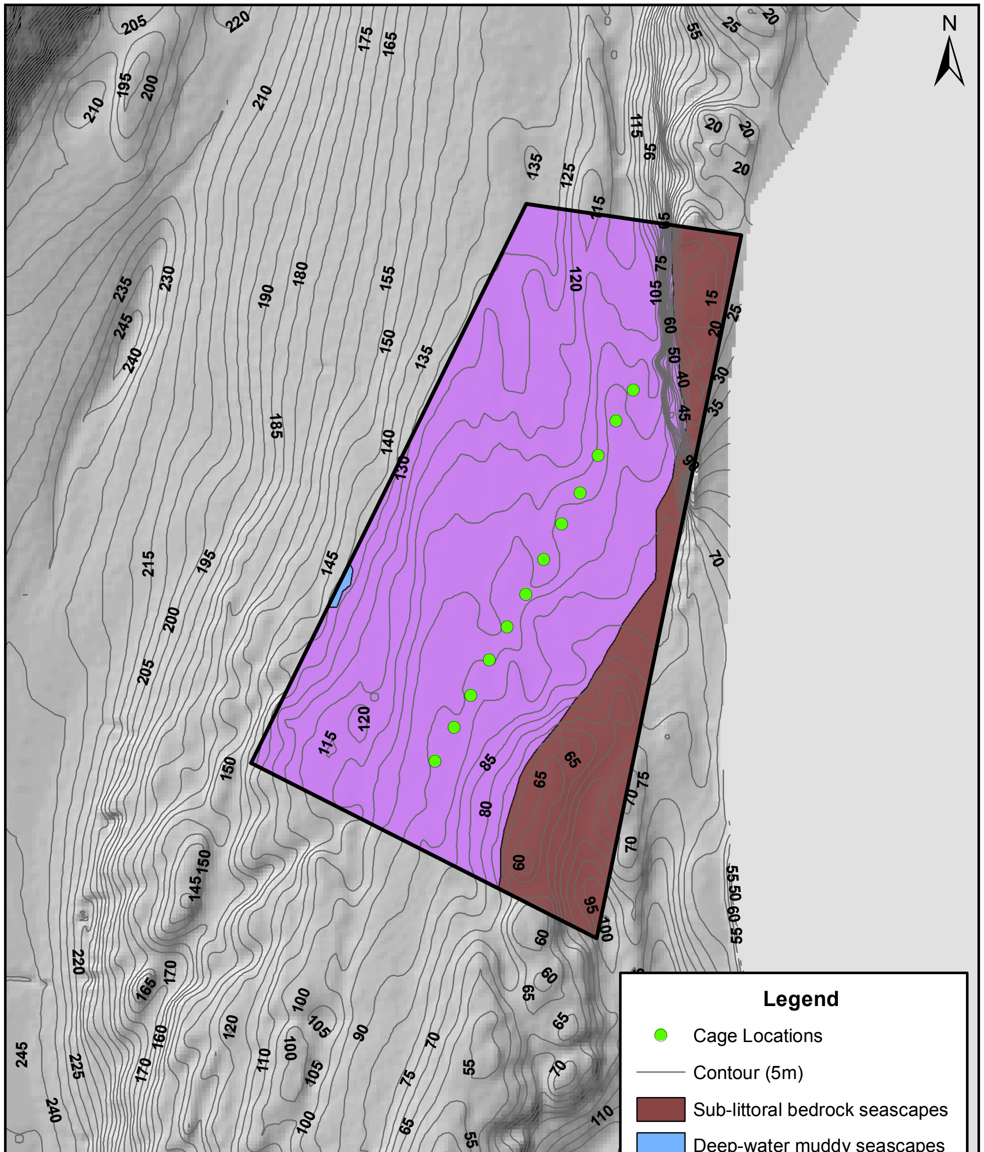
Overall, the majority (99.86%) of the Butler Island lease area is hard-bottom (Table 8) and the 1 g depositional contour is predominantly over this habitat type as well with some overlapping deep-water bedrock areas (Figure 8).

Table 8 Summary of Butler Island Benthic Habitat Types by Spatial Coverage

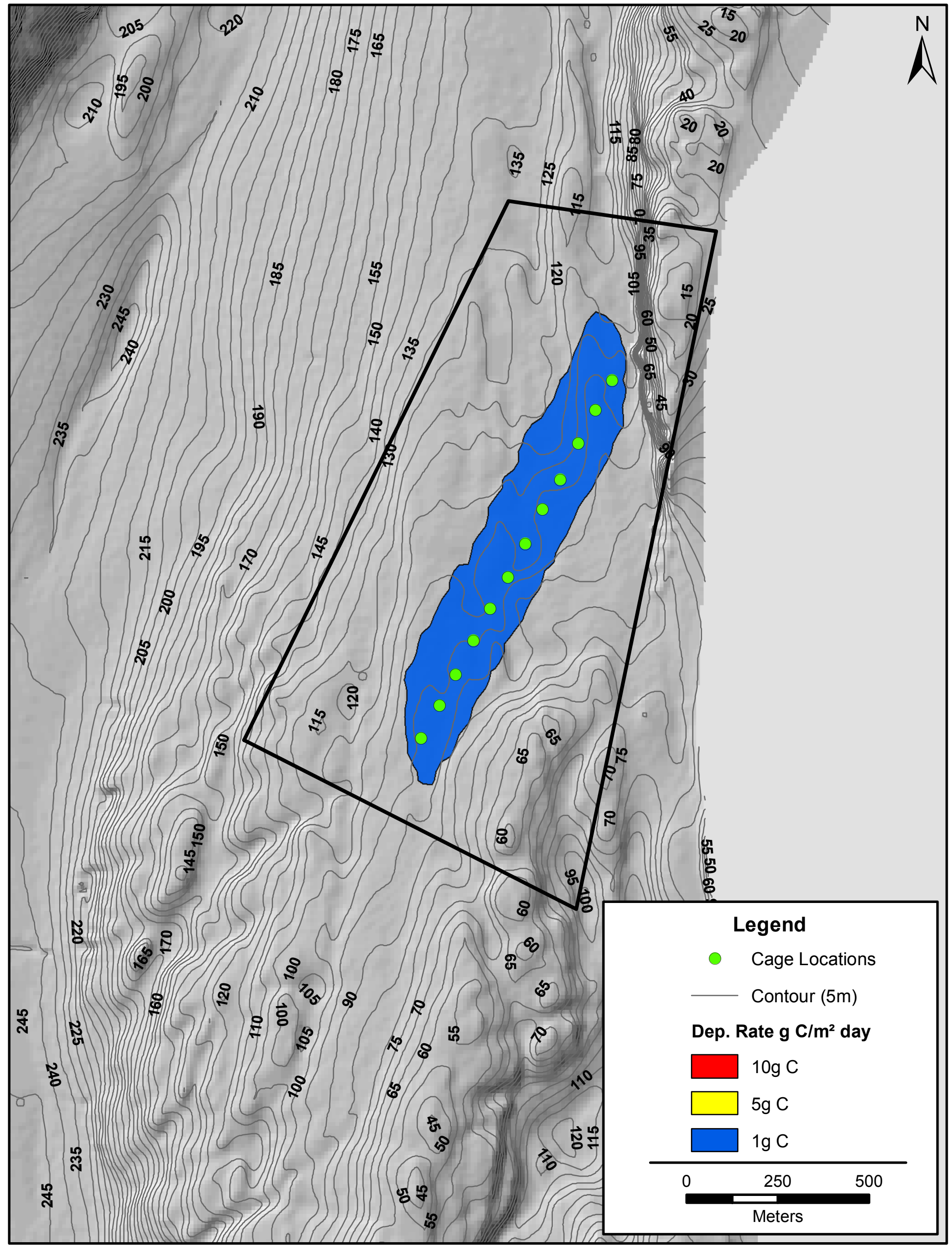
Proposed Marine Site	Seascape Characterization	Area (km²)*	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification**
Butler Island	Deep-water bedrock seascapes	1.111	79.85	79.85
	Sub-littoral bedrock seascapes	0.278	20.01	20.01
	Deep-water muddy seascapes	0.002	0.14	
Total		**1.39**		**99.86**

*Three significant digits are shown to capture the portion of the lease area that is soft-bottom.
**The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015);

Figure 8 Butler Island Site



Seascape Characterization	Area (km²)	Percentage
Deep-water bedrock seascapes	1.111	79.85%
Deep-water muddy seascapes	0.002	0.14%
Sub-littoral bedrock seascapes	0.278	20.01%



NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT:

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

DWN BY: JA
CHK'D BY: AE
DATUM: NAD83
PROJECTION: ZONE 21N (M)
SCALE: 1:20,000

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION

TITLE: SUB-LITTORAL SEASCAPE BUTLER ISLAND

DATE: May 2017
PROJECT No. TF1791503
REV No. 0
FIGURE No. 8

4.2.8 Red Island

Red Island is located towards the central region of Placentia Bay (Figure 1), also in the northwestern region of the Red Island BMA. This site ranges in depth from 18 m along the western margin of the lease area to 250 m along the southeastern perimeter of the lease area (Figure 9). The entirety (100%) of this proposed lease site is represented by the multibeam survey data. The predominant (69.23%) seascape type is **deep-water bedrock** (Table 9). This habitat type represents the majority of the western half and central region of the lease area (Figure 9).

The remaining hard-bottom seascape of this lease area is sub-littoral bedrock (23.53%). This seascape type is largely confined along the Eastern slope section of the proposed lease area running parallel to the nearest shoreline. There is an additional small section of sub-littoral bedrock in the middle of the southern perimeter of the lease area nearest the coastal shoreline (Red Island) (Figure 9).

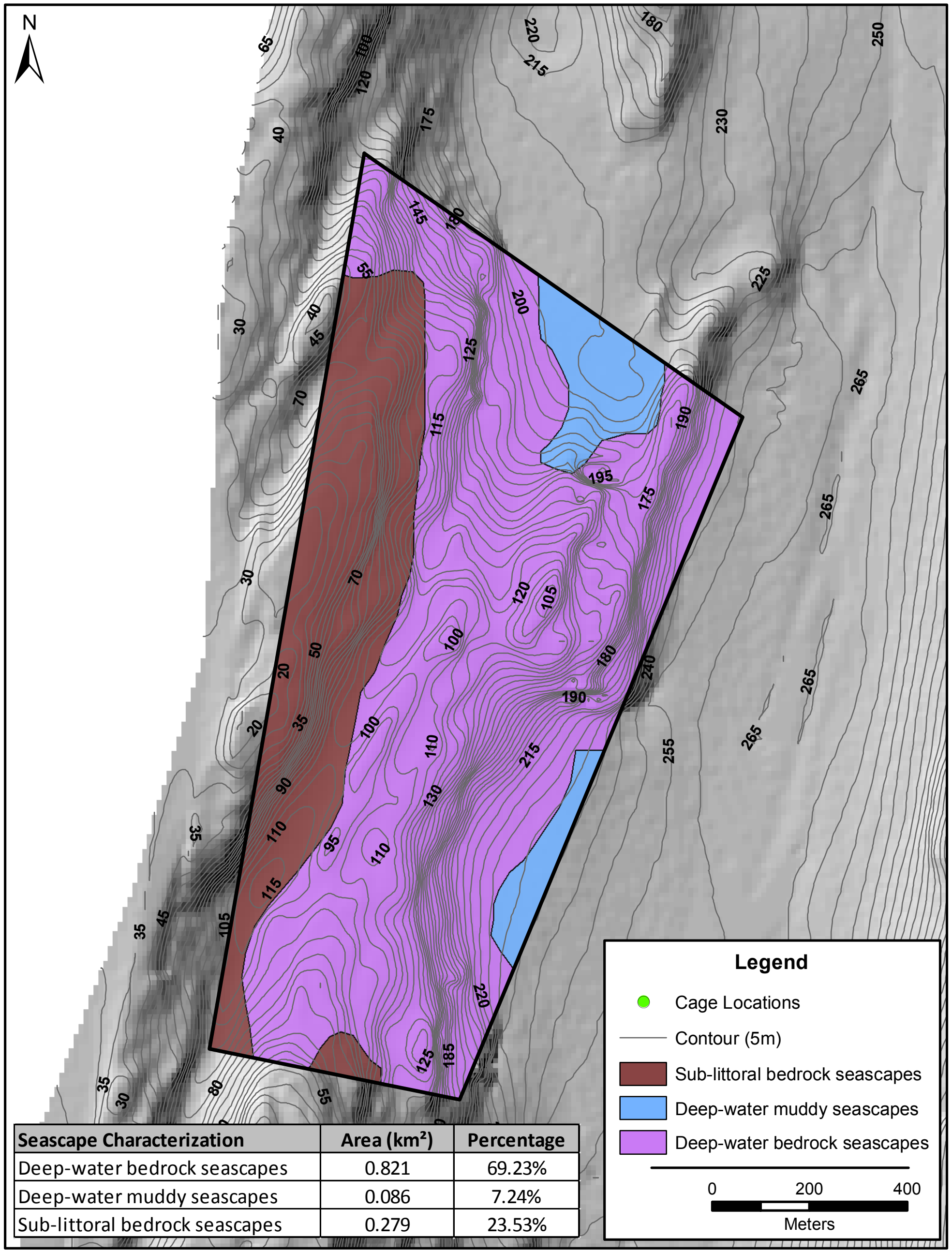
The soft-bottom habitat type of this lease area is **deep-water muddy** seascape (7.24%). This habitat type is located as two patches in the proposed lease area, one along the northern margin and a second along the southeastern boundary of the lease area.

Overall, the majority (92.76%) of the Red Island lease area is hard-bottom (Table 9) and the 1 g depositional contour is predominantly over deep-water bedrock habitat type (Figure 9).

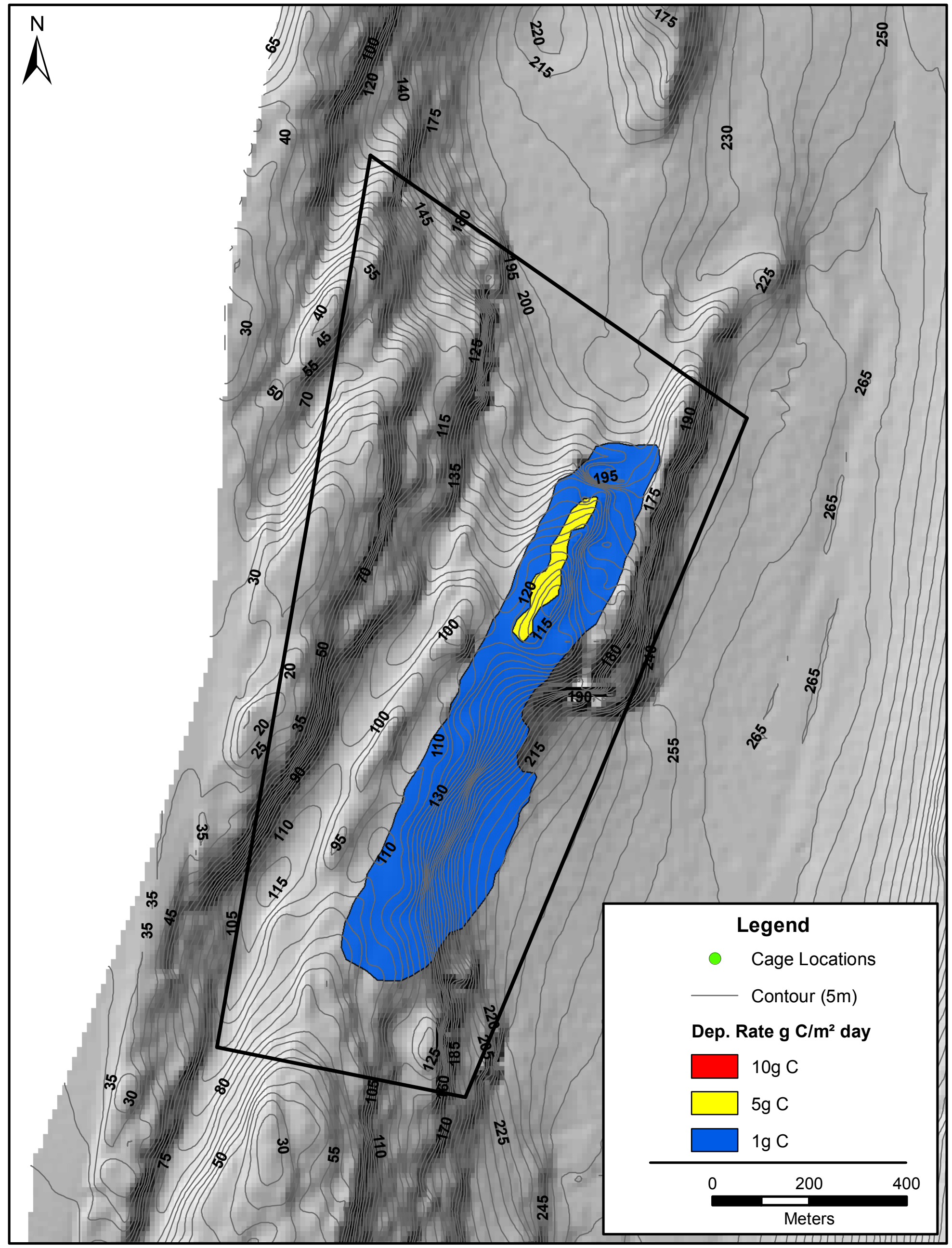
Table 9 Summary of Red Island Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km^2)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Red Island	Deep-water bedrock seascapes	0.821	69.23	69.23
	Sub-littoral bedrock seascapes	0.279	23.53	23.53
	Deep-water muddy seascapes	0.086	7.24	
Total				**92.76**
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)				

Figure 9 Red Island Site



Seascape Characterization	Area (km²)	Percentage
Deep-water bedrock seascapes	0.821	69.23%
Deep-water muddy seascapes	0.086	7.24%
Sub-littoral bedrock seascapes	0.279	23.53%



NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT: GRIEG NL

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

amec foster wheeler

DWN BY:	JA
CHK'D BY:	AE
DATUM	NAD83
PROJECTION	ZONE 21N (M)
SCALE:	1:15,000

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION

TITLE: SUB-LITTORAL SEASCAPE RED ISLAND

DATE	May 2017
PROJECT No.	TF1791503
REV No.	0
FIGURE No.	9

4.2.9 Darby Harbour

Darby Harbour is located centrally in Placentia Bay (Figure 1), in the Red Island BMA. This site ranges in depth from 16 m in the centre of the northeastern margin of the lease area to 147 m in the southwestern region of the lease area (Figure 10). The majority (93.27%) of this proposed lease site is represented by the multibeam survey data. The predominant (35.80%) seascape type is **sub-littoral bedrock** (Table 10). This habitat type nearly encircles the lease area around the west, north and eastern regions representing the site location in proximity island shorelines in each of these areas (Figure 1).

In almost equal proportion, the remaining hard-bottom region of this lease area seascape is **deep-water bedrock** (34.80%). This habitat type extends from the northernmost corner towards the southeastern region of the lease area and also represents to easternmost corner of the lease area (Figure 10).

The soft-bottom area of the lease site (23.10%) is **deep-water muddy** seascape. This seascape type transverses north to south in the mid-section of the proposed lease site.

The remaining 6.50% of the Darby Harbour lease area is not represented by multibeam survey data. This is distributed in two regions of the lease site, in the northwestern region and the southwestern corner and both areas are in proximity to island shorelines.

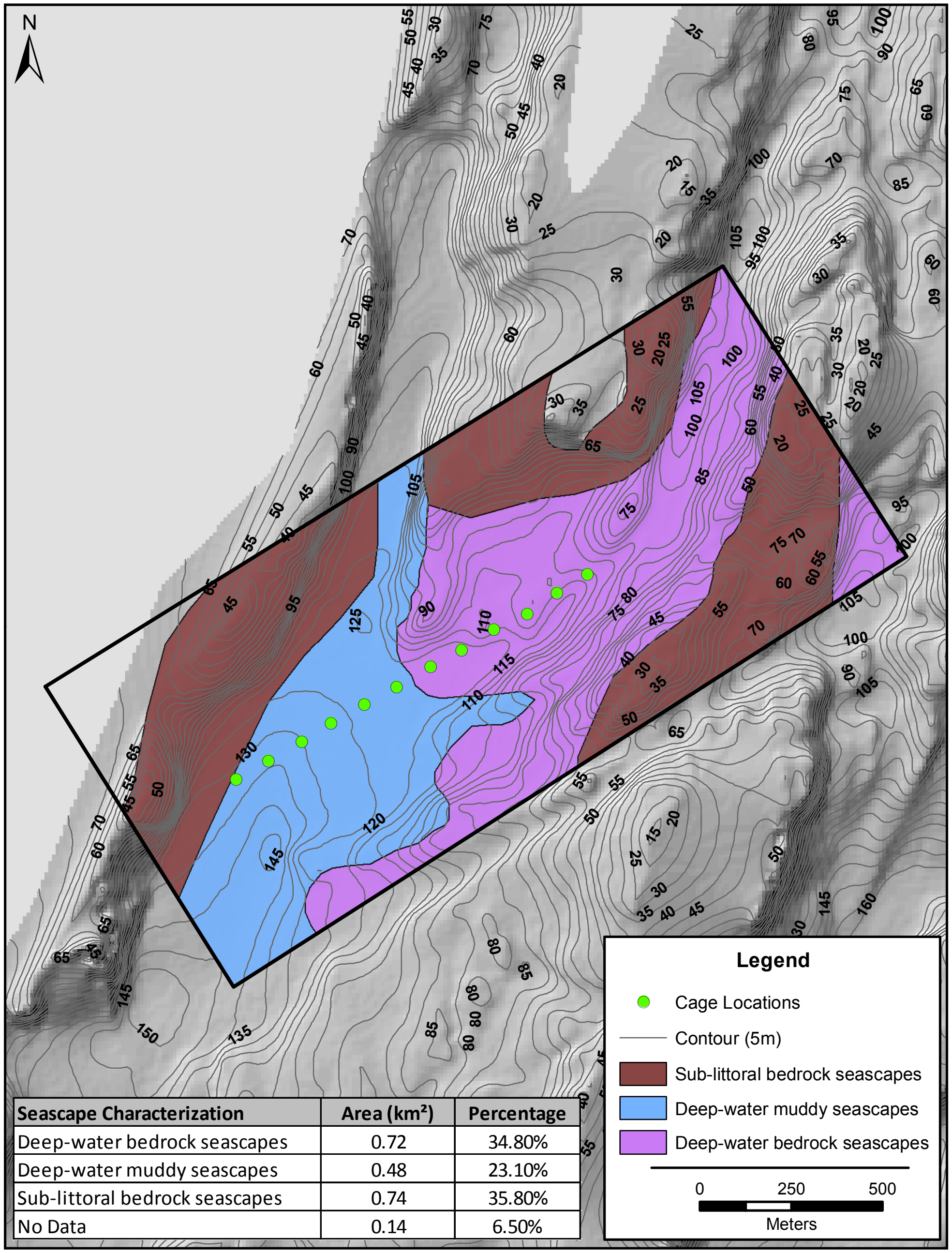
Overall, the majority (70.60%) of the Darby Harbour lease area is hard-bottom (Table 10) and the 1 g depositional contour is predominantly over both deep-water bedrock and deep-water muddy seascapes (Figure 10).

Table 10 Summary of Darby Harbour Benthic Habitat Types by Spatial Coverage

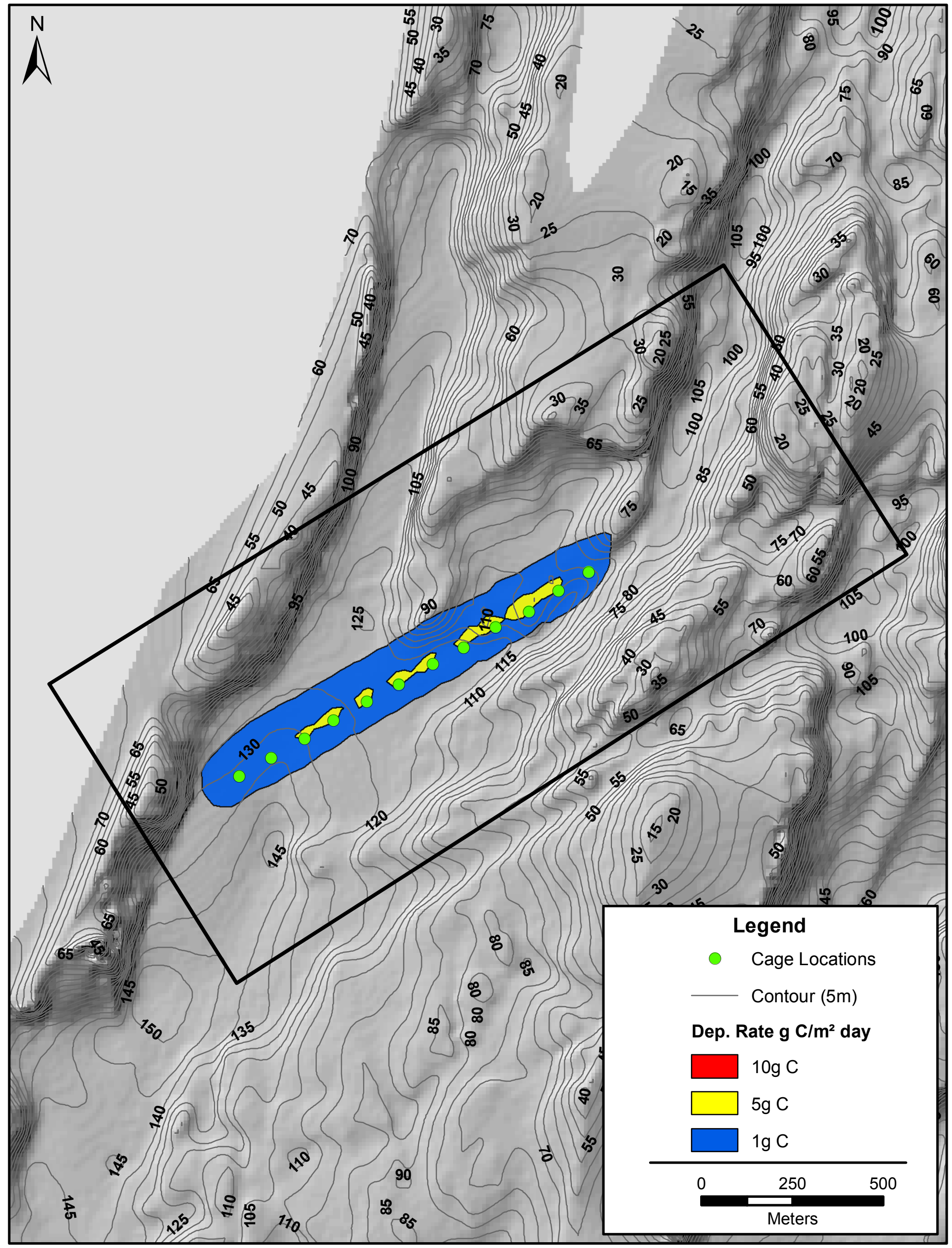
Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Darby Harbour	Deep-water bedrock seascapes	0.72	34.80	34.80
	Sub-littoral bedrock seascapes	0.74	35.80	35.80
	Deep-water muddy seascapes	0.48	23.10	
	No multibeam data	0.14	6.50	
Total				**70.60**

*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)

Figure 10 Darby Island Site



Seascape Characterization	Area (km²)	Percentage
Deep-water bedrock seascapes	0.72	34.80%
Deep-water muddy seascapes	0.48	23.10%
Sub-littoral bedrock seascapes	0.74	35.80%
No Data	0.14	6.50%



NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT: GRIEG NL

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

amec foster wheeler

DWN BY:	JA
CHK'D BY:	AE
DATUM	NAD83
PROJECTION	ZONE 21N (M)
SCALE:	1:20,000

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION

TITLE: SUB-LITTORAL SEASCAPE DARBY HARBOUR

DATE	May 2017
PROJECT No.	TF1791503
REV No.	0
FIGURE No.	10

4.2.10 Brine Island

Brine Island is located in the southeast region of Placentia Bay (Figure 1), in the Red Island BMA. This site ranges in depth from 40 m in the southeast region of the lease area to 100 m in the centre of the lease area (Figure 11). Only a portion (1.71%) of this proposed lease site is represented by the multibeam survey data, however it is represented by seascape characterization (identifying areas according to their habitat types). According to which, the predominant habitat type (55.5%) of this this lease area is **deep-water bedrock** (Table 11). This habitat type spans across the majority of the Northern half as well as the central and western regions of this lease area (Figure 11). The remaining (22.8%) of hard-bottom areas are sub-littoral bedrock seascape bordering the southeast, southern and northwest corners of the lease area.

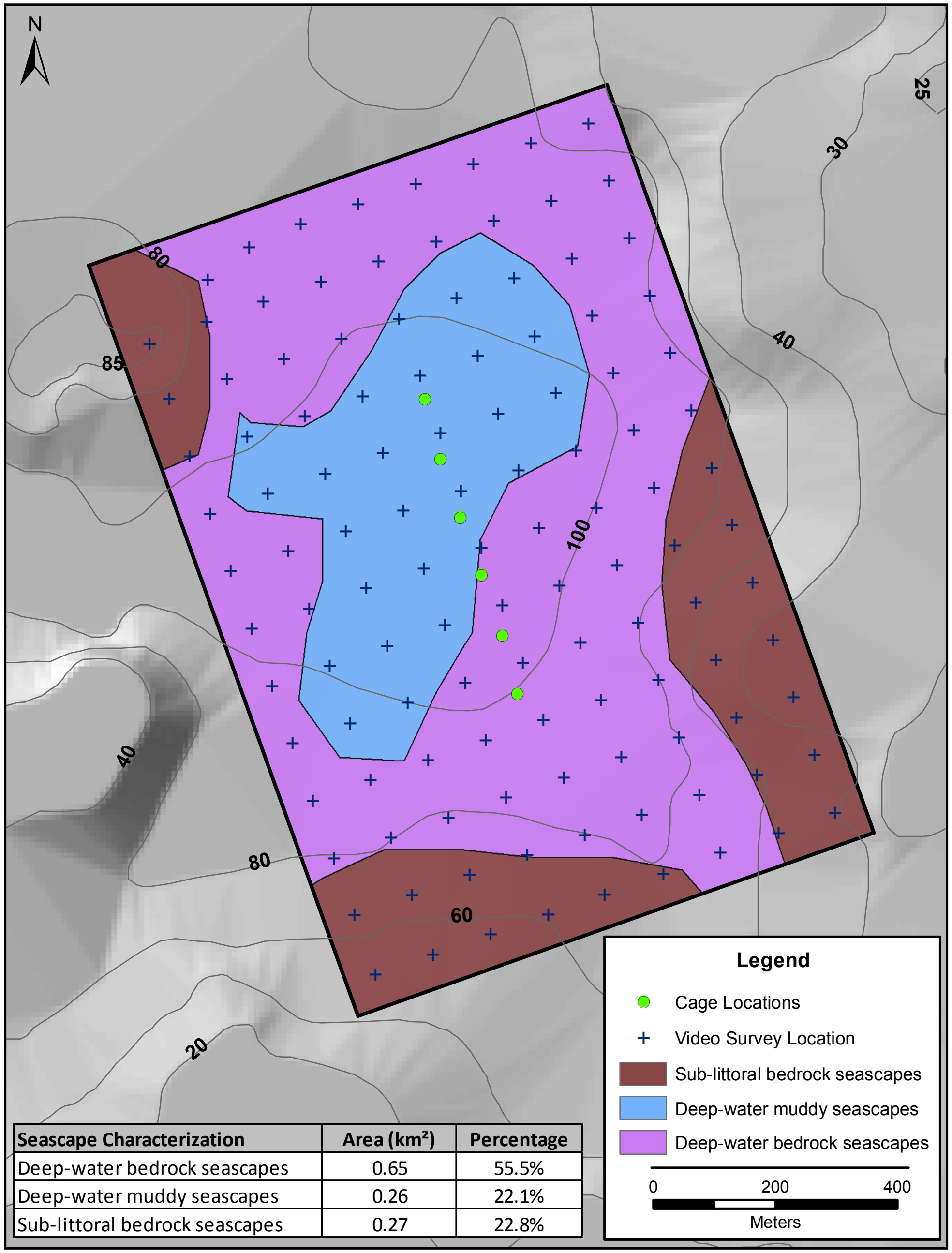
The soft-bottom area of this lease area is centralized in the north and western regions of the (Figure 11) and south of this is a region of deep-water bedrock. According to the seacape classification alone, the majority (78.3%) is hard-bottom and the 1 g depositonal contour spans both deep-water hard and soft bottom areas. However, as only lower resolution CHS benthic survey data was available for the bathymetry at this lease area, this characterization should be confirmed using conventional video survey at 100m grid intervals (video locations indicated in Figure 11). That survey information can be used to ground-truth the benthic characterization projection for this lease area (provided in a separate report from Grieg NL).

Table 11 Summary of Brine Island Benthic Habitat Types by Spatial Coverage According to Seascape Characterization.

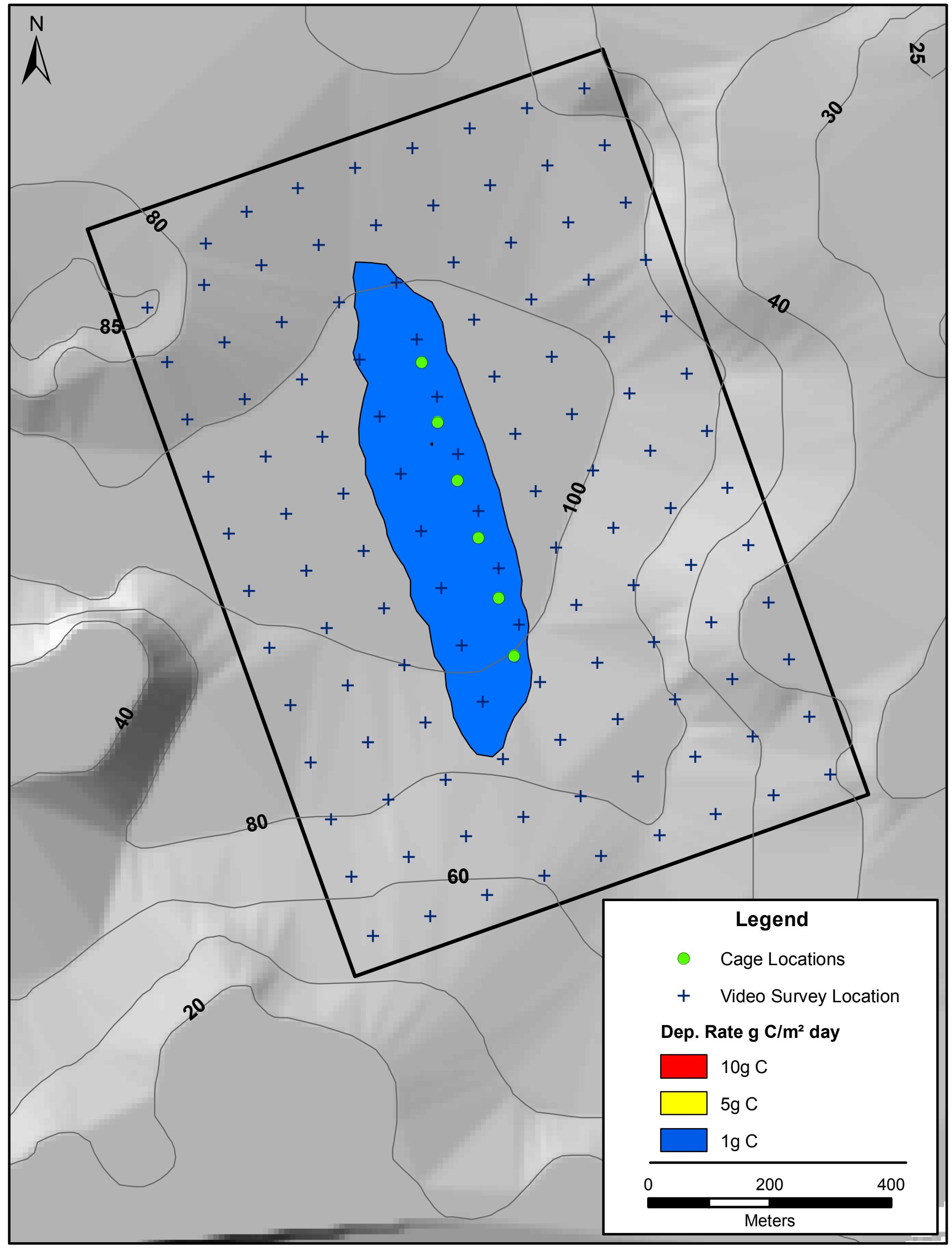
Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Brine Island	Deep-water bedrock seascapes	0.65	55.5	55.5
	Sub-littoral bedrock seascapes	0.27	22.8	22.8
	Deep-water muddy seascapes	0.28	22.1	
	No multibeam data	0.02	98.29	
Total				**78.3****

*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015);
**Based on seascape characterization map and not multibeam survey area.

Figure 11 Brine Island Site



Seascape Characterization	Area (km²)	Percentage
Deep-water bedrock seascapes	0.65	55.5%
Deep-water muddy seascapes	0.26	22.1%
Sub-littoral bedrock seascapes	0.27	22.8%



NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT: GRIEG NL

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

amec foster wheeler

DWN BY:	JA
CHK'D BY:	AE
DATUM	NAD83
PROJECTION	ZONE 21N (M)
SCALE:	1:12,000

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION

TITLE: SUB-LITTORAL SEASCAPE BRINE ISLAND

DATE	May 2017
PROJECT No.	TF1791503
REV No.	0
FIGURE No.	1

4.2.11 Iona Islands

The Iona Islands lease area is located near the southeast coast of Placentia Bay (Figure 1), in the Red Island BMA. This site ranges in depth from 54 m in the eastern most corner of the of the lease area to 108 m in the northwest corner of the lease area (Figure 12). The majority (95.45%) of this proposed lease site is represented by the multibeam survey data. The predominant (70.20%) seascape type is deep-water **bedrock** (Table 12), this represents the only hard-bottom type in this lease area and covers the majority of the western and southern regions of this lease area (Figure 12).

The soft-bottom area of the lease site (26.10%) is **deep-water muddy** seascape. This seascape extends from the northeast region of the lease area to the centre with an additional soft-bottom area in the northwest corner of the lease area (Figure 12).

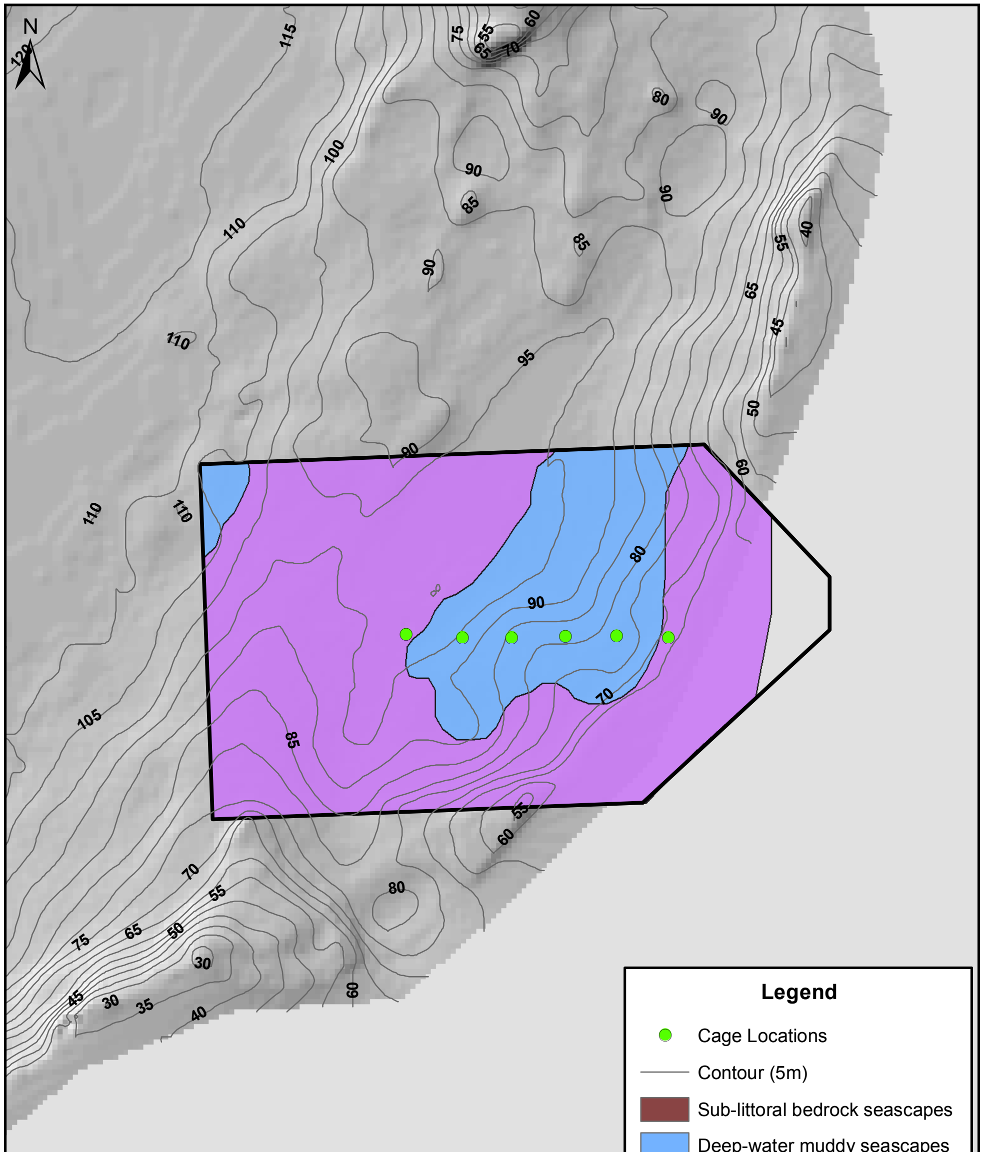
The remaining 3.80% of the Iona Islands lease area is not represented by multibeam survey data. This is localized in the easternmost corner of the lease area projecting towards the adjacent shoreline.

Overall, the majority (70.20%) of the Iona Islands lease area is hard-bottom (Table 12) and the 1 g depositional contour is predominantly over deep-water muddy with some overlap of boon deep-water bedrock and seascapes (Figure 12).

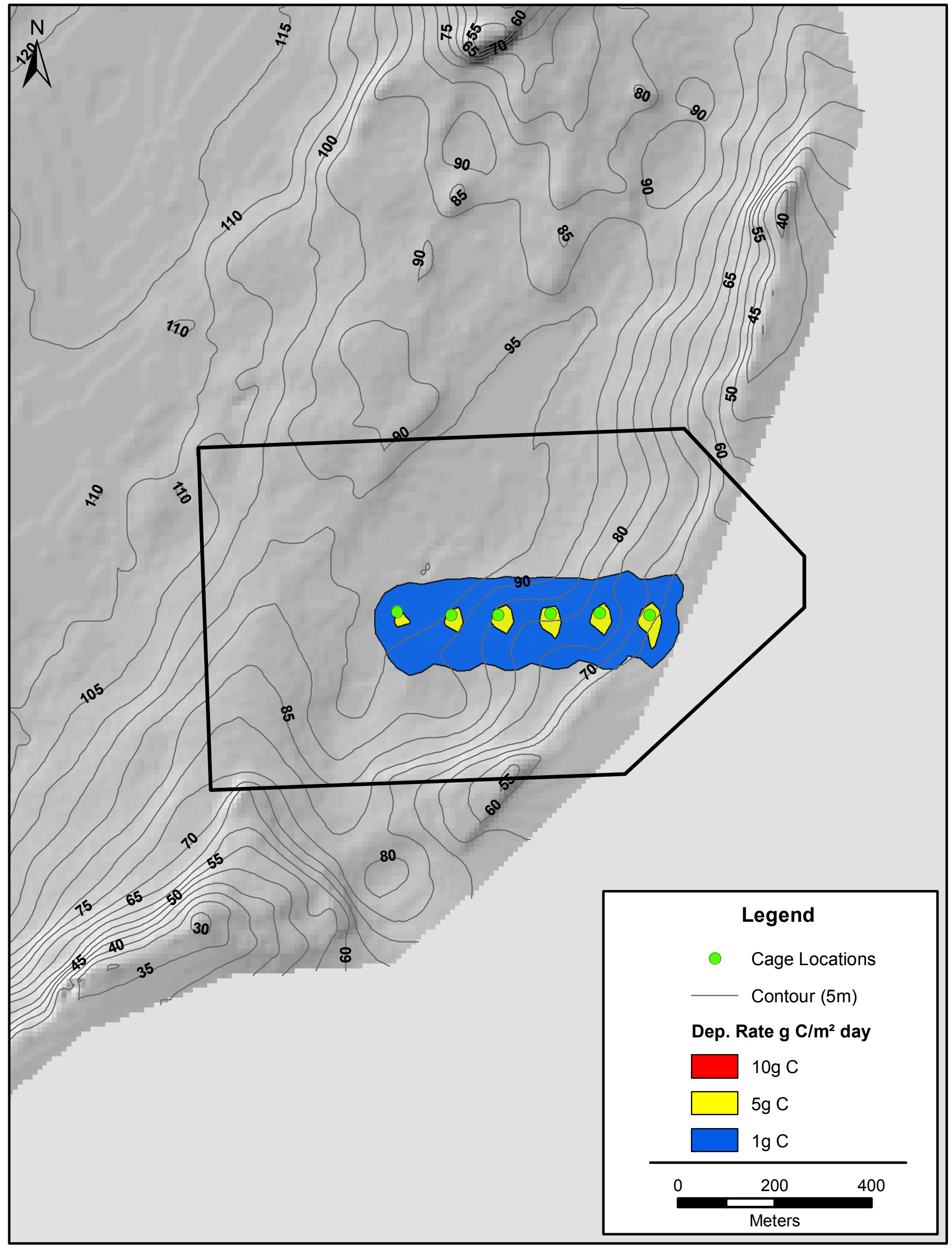
Table 12 Summary of Iona Island Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Iona Island	Deep-water bedrock seascapes	0.55	70.20	70.20
	Sub-littoral bedrock seascapes	0.00	0.00	
	Deep-water muddy seascapes	0.20	26.10	
	No multibeam data	0.03	3.80	
Total				**70.20**
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)				

Figure 12 Iona Island Site



Seascape Characterization	Area (km²)	Percentage
Deep-water bedrock seascapes	0.55	70.20%
Deep-water muddy seascapes	0.20	26.10%
No Data	0.03	3.80%



NOTE:
1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

CLIENT: GRIEG NL

AMEC Foster Wheeler
133 Crosbie Road
St. John's, NL
A1B 4A5
(709) 722-7023

amec foster wheeler

DWN BY: JA	PROJECT: BENTHIC SEASCAPE CHARACTERIZATION		DATE: May 2017
CHK'D BY: AE			PROJECT No. TF1791503
DATUM: NAD83	TITLE: SUB-LITTORAL SEASCAPE IONA ISLAND		REV No. 0
PROJECTION: ZONE 21N (M)			
SCALE: 1:15,000			FIGURE No. 1

5.0 SUMMARY

The majority of Grieg NL's proposed marine production sites in Placentia Bay had more than 90% lease area represented by multibeam bathymetry and seascape mapping (Table 1). Among these, 7 out of 8 sites are characterized as hard-bottom according to the AAR definition, only Ship Island appears to be a soft-bottom site. Although, only 69.34% of Long Island was surveyed, more than half this lease area is characterized as hard-bottom. Brine Island is tentatively characterized as hard-bottom, but requires evaluation of complimentary field survey data to confirm. Gallows Harbor had insufficient data and requires field survey results.

Table 13. Summary of Grieg NL Production Site Classification According to >50 of the Lease Area Being Characterized as Hard or Soft Bottom

Lease Area Name	Hard-Bottom	Soft-Bottom	Field Survey Required	Comments
Gallows Harbour			■	Insufficient spatial coverage
Long Island	■			69.34% multibeam coverage
Oderin Island	■			
Valens Island	■			
Chambers Island	■			
Ship Island		■		
Butler Island	■			
Red Island	■			
Darby Harbour	■			
Brine Island	■		■	Requires ground-truthing to confirm
Iona Islands	■			

*The AAR definition of hard bottom is "substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines." (AAR, 2015).

6.0 CLOSURE

Amec Foster Wheeler has prepared this benthic seascape characterization for Grieg NL Seafarms Ltd. as part of their Aquaculture Activities Regulations permitting requirements. Any questions associated with this report should be directed to the undersigned and we appreciate the opportunity to conduct this work on your behalf.

Yours sincerely,

Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited

Prepared by:

Alexandra Eaves, Ph.D.
Senior Scientist
Tel: 709-722-7023
Fax: 709-722-7353
E-mail: alexandra.eaves@amecfw.com

Reviewed by:

James McCarthy, M.Sc., CFP
Senior Biologist/Aquatics Group Lead
Tel: 709-722-7023
Fax: 709-722-7353
E-mail: james.mccarthy@amecfw.com

cc: Candice Way, Grieg NL

7.0 REFERENCES

AAR, 2015. Aquaculture Activities Regulations guidance document. Available from: http://www.dfo-mpo.gc.ca/aquaculture/management-gestion/aar-raa-gd-eng.htm#section1.

Brown, C.J., Smith, S.J., Lawton, P. and Anderson, J.T., 2011. Benthic habitat mapping: a review of progress towards improved understanding of the spatial ecology of the seafloor using acoustic techniques. Estuarine, Coastal and Shelf Science, 92(3), pp.502-520.

Dolan, M.F., Buhl-Mortensen, P., Thorsnes, T., Buhl-Mortensen, L., Bellec, V.K. and Bøe, R., 2009. Developing seabed nature-type maps offshore Norway: initial results from the MAREANO programme. Norwegian Journal of Geology, 89(1-2), pp.17-28.

Kaplan, D.M., Planes, S., Fauvelot, C., Brochier, T., Lett, C., Bodin, N., Le Loc'h, F., Tremblay, Y. and Georges, J.Y., 2010. New tools for the spatial management of living marine resources. Current Opinion in Environmental Sustainability, 2(1), pp.88-93.

Shaw, J., Potter, D.P. and Kostylev, V.E., 2011. Seascapes, Placentia Bay, Newfoundland and Labrador. Geological Survey of Canada, Open File, 6683.

Todd, B.J. and Greene, H.G., 2007. Mapping the seafloor for habitat characterization. Geological Association of Canada Special Paper 47, 519pp.

Whitmire, C.E., Embley, R.W., Wakefield, W.W., Merle, S.G., and Tissot, B.N., 2007. A quantitative approach for using multibeam sonar data to map benthic habitats, in Todd, B.J., and Greene, H.G., eds., Mapping the Seafloor for Habitat Characterization: Geological Association of Canada, Special Paper 47, p. 111-126

Appendix A

Grieg NL Benthic Depositional Modeling Report

133 Crosbie Road
PO Box 13216
St. John's, NL A1B 4A5
Tel +1 709 722 7023
amecfw.com

Amec Foster Wheeler Environment & Infrastructure
Registered office:
2020 Winston Park Drive, Suite 700, Oakville, ON L6H 6X7
Registered in Canada
No. 773289-9; GST: 899879050 RT0008; DUNS: 25-362-6642

FINAL

Benthic Depositional Modelling for Grieg Seafarms in Placentia Bay

Submitted to:

Grieg NL Seafarms Ltd.
P.O. Box 457
205 McGettigan Blvd.
Marystown, NL, A0E 2M0
709-279-7226

Submitted by:

Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited
133 Crosbie Road
PO Box 13216
St. John's, NL A1B 4A5

29 July 2016
Amec Foster Wheeler Project #: TF1691501

IMPORTANT NOTICE

This report was prepared exclusively for Grieg by Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler). The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in Amec Foster Wheeler's services and based on: i) information available at the time of preparation, ii) data supplied by outside sources and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by Grieg only, subject to the terms and conditions of its contract with Amec Foster Wheeler. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

EXECUTIVE SUMMARY

To address the federal Department of Fisheries and Oceans (DFO) Aquaculture Activities Regulations (AAR) permitting requirements condition 8.1a the 1, 5 and 10 grams of carbon per meter squared per day depositional contours are calculated for each marine production site using a specified daily quantity of feed usage. Overall the majority of depositional contours predicted from the model will not exceed 1g C/ m2 /day with minimal exceptions at shallower sites.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler) is pleased to provide the required Benthic Depositional Modeling at the proposed marine production sites in Placentia Bay for the purpose of satisfying the federal Department of Fisheries and Oceans (DFO) Aquaculture Activities Regulations (AAR) permitting requirements specific to:

"Predicted Contours [AAR paragraph 8(1)(a)]

1. (1) Calculate the rate of deposition of biochemical oxygen demanding (BOD) matter from the facility during maximum daily quantity of feed usage, using an aquaculture waste deposition model, and map the 1, 5, and 10 g C/m^2/day depositional contours."

This work was conducted using the commercially available aquaculture industry benthic depositional modeling software DEPOMOD (version 2.4.1) (Cromey et al 2002) using the methods and settings defined in "DEPOMOD Canada Methods and Settings v1.6" and provided by DFO (DFO 2016), and the output calculations were plotted using MATLAB (version 7.12.0.635 R2011a) software.

2.0 INPUT DATA

Information regarding the locations and production capacity of Grieg NL Seafarms Ltd. marine sites was obtained from the "Placentia Bay Atlantic Salmon Aquaculture Project" Environmental Assessment Registration (Grieg NL 2016) and in consultation with Grieg NL Seafarms Ltd. personnel.

2.1 Bathymetry

A 2400x2400 m bathymetric grid was created around each farm site using data obtained from the Canadian Hydrographic service.

2.2 Currents

Current data was recorded at the 11 sites of interest during the winter of 2015-2016 by DHI (see Appendix A). The deployments ranged from ~12 hours to several days. The 20-minute averaged data was looped on itself to create 1-month long timeseries for each site.

Other assumptions used for setting up the current velocity data:

- ADCP moored ~3m above anchor (seafloor)
- No magnetic correction applied to raw data, we apply this inside DEPOMOD
- Use the same 3 depth layers defined in the DHI report (Appendix A)
- Mean tidal range is 1m above chart datum

2.3 DEPOMOD Inputs

Grid Generation Module (values set by user)	
Major grid cell dimensions	40 x 40 m
Number of major grid cells	60
Minor grid cell dimensions	25 x 25 m
Number of minor grid cells	90
Particle Tracking Module	
Material type	Carbon
Feed release type	Continuous release of food
Particle Information (defaults)	
Feed water content	9%
Feed digestibility	85%
Feed wasted as % of feed pellets (dry weight)	3%
Carbon as % of feed pellets (dry weight)	49%
Carbon as % of feces (dry weight)	30%
Settling velocity of feed pellets (mean)	9.5 cm/s
Settling velocity of feces (mean)	3.2 cm/s
Current velocity data (see Appendix A for Current information)	
Current velocity layers	3: near-surface, mid-depth, near-bottom

Grid Generation Module (values set by user)	
Current velocity time step	1200 s (20 minutes)
Turbulence model (default values)	
Random walk model	Yes
Dispersion coefficient (x)	0.100 m^{-2} s^{-1}
Dispersion coefficient (y)	0.100 m^{-2} s^{-1}
Dispersion coefficient (z)	0.001 m^{-2} s^{-1}
Particle trajectory model (default values)	
Number of particles released	10
Trajectory evaluation accuracy (model time step)	High (60 s)
Resuspension module	Turned off

2.4 CAGE INFORMATION

Number of Cages	12 per site (6 at Brine island and Iona island)
Cage Circumference	160 m
Cage diameter	51 m
Cage depth (below water surface)	30 m
Feed input	1,124 kg/cage/day

3.0 FARM SITE RESULTS

Below are the depth layers used, maps of the lease area, and depositional contours generated using DEPOMOD for 1, 5 and 10 grams of carbon per meter squared per day calculated for each marine production site based on the specified daily quantity of feed input. Depths depicted in all figures are in meters.

3.1 Gallows Harbour

Table 3-1: Gallows Harbour depth layer information

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Gallows Harbour (47.3588N, 54.6942W)	113 m	Near-Surface	2159	20	83 m above bottom
		Mid-Depth	2159	20	43 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-1: Gallows Harbour Map

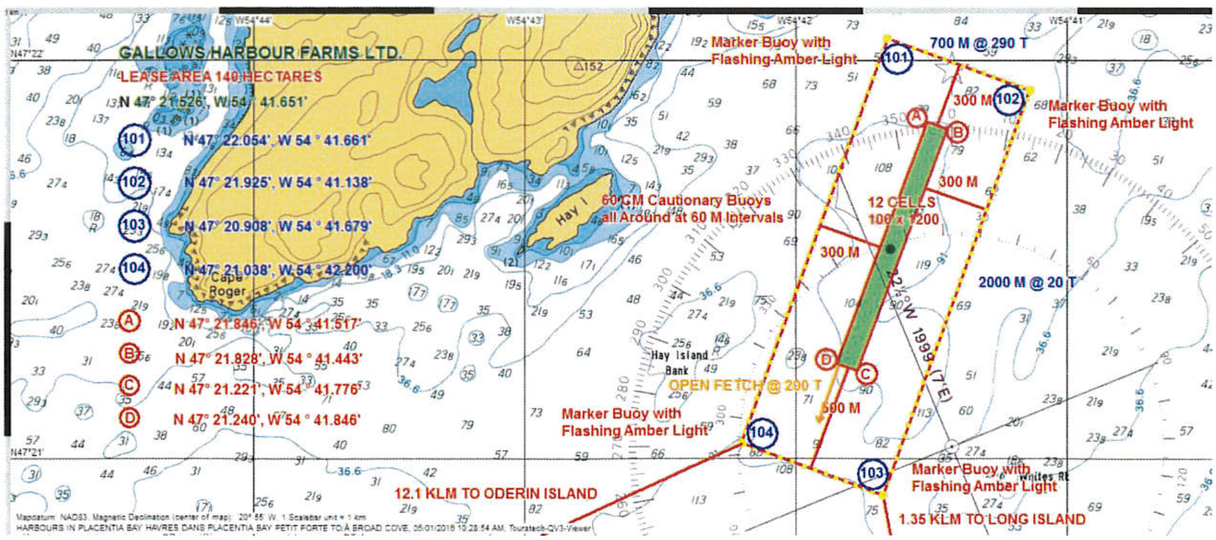
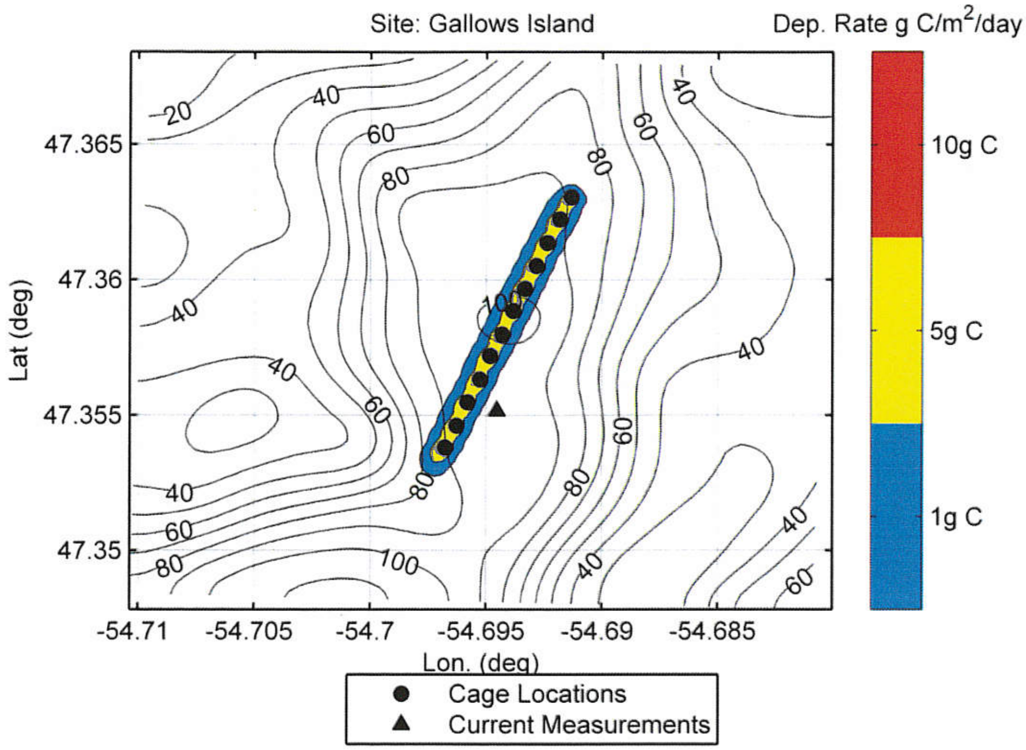


Figure 3-2: Gallows Harbour depositional contours



3.2 Long Island

Table 3-2: Long Island depth layer information

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Long Island (47.3283N, 54.6979W)	137 m	Near-Surface	2159	20	107 m above bottom
		Mid-Depth	2159	20	50 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-3: Long Island map

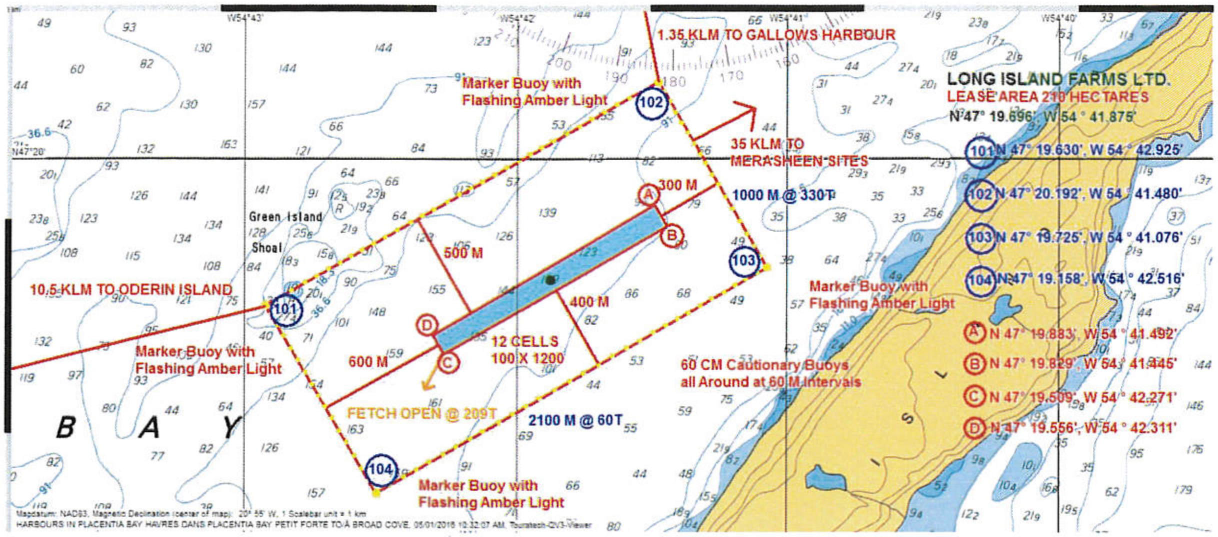
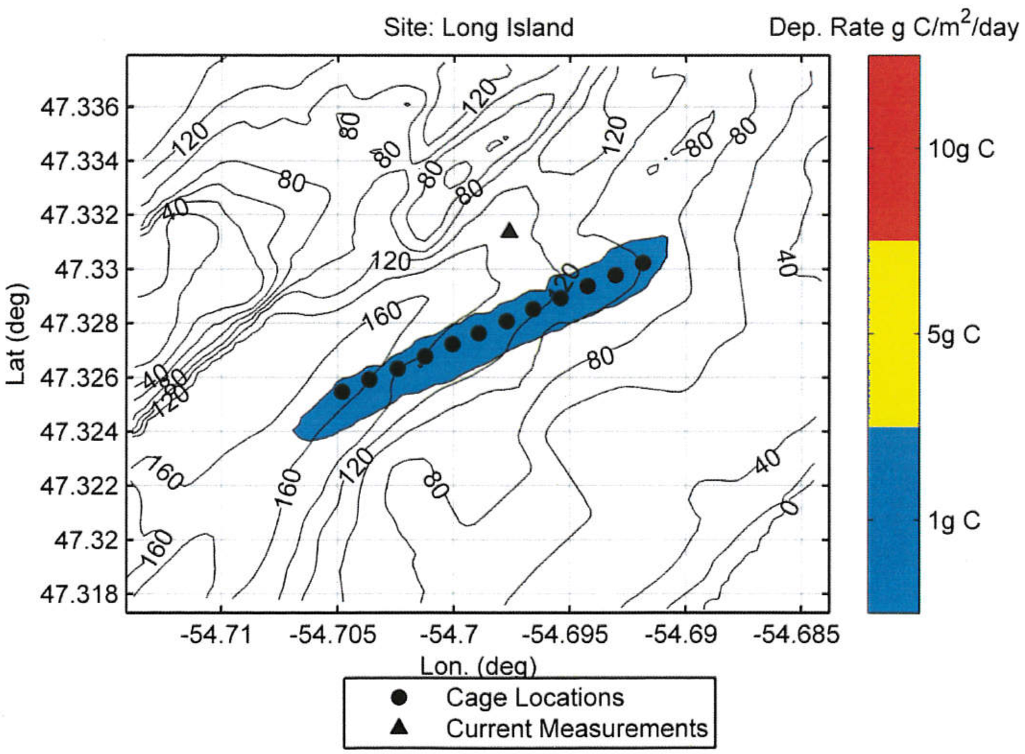


Figure 3-4: Long Island depositional contours



3.3 Oderin Island

Table 3-3: Oderin Island depth layer information

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Oderin Island (47.2983, 54.8595W)	83 m	Near-Surface	2159	20	53 m above bottom
		Mid-Depth	2159	20	25 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-5: Oderin Island map

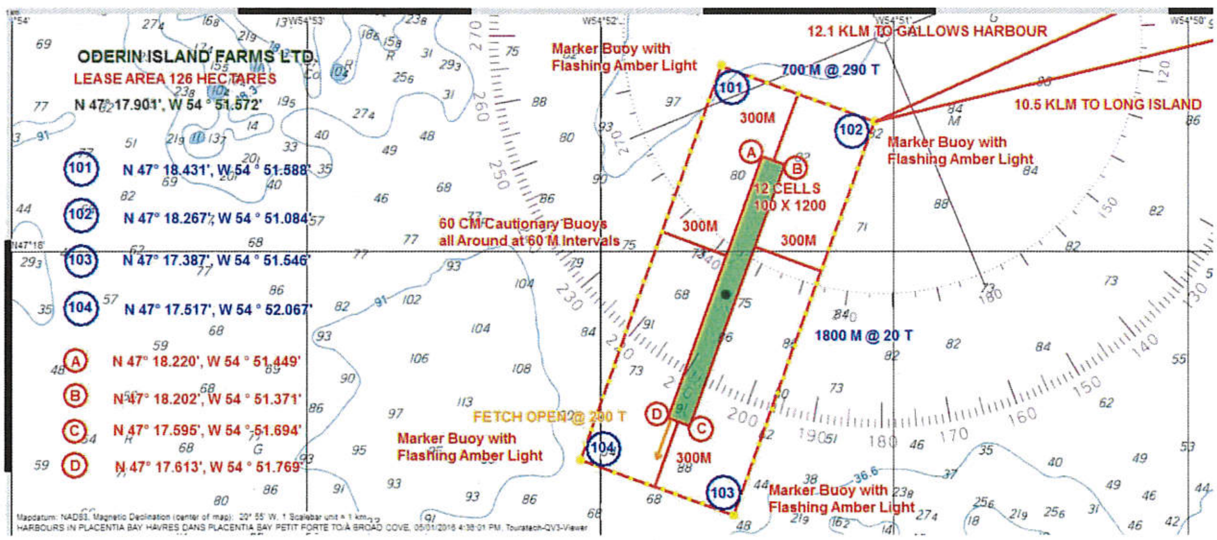
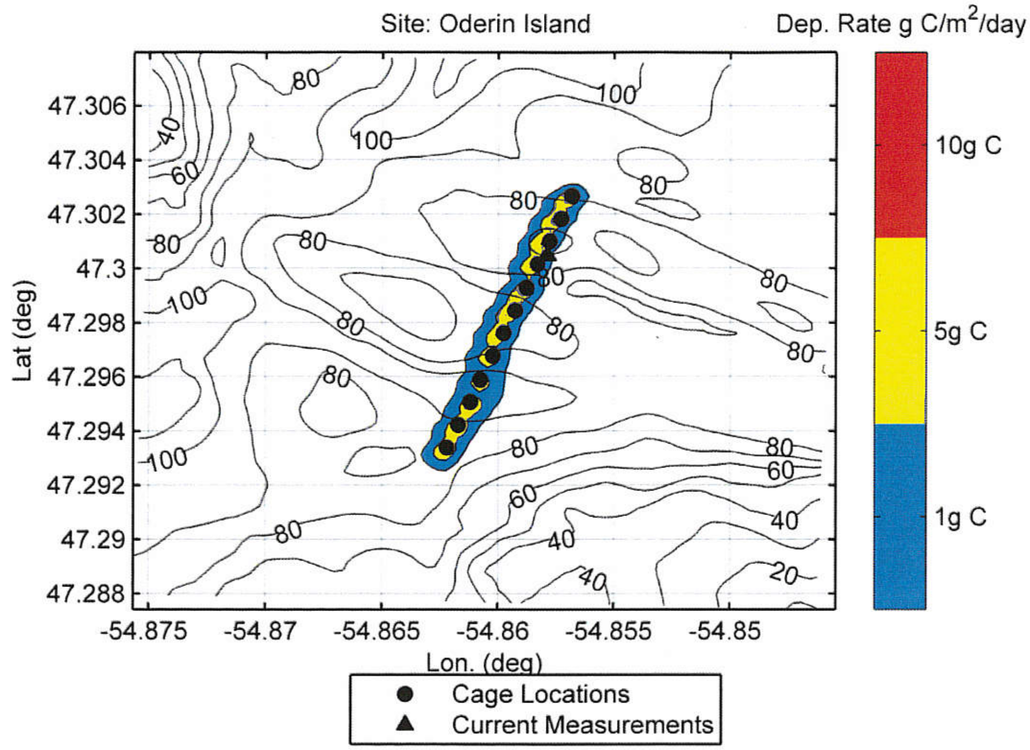


Figure 3-6: Oderin island depositional contours



3.4 Valens Island

Table 3-4: Valens Island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Valens island (47.5243N, 54.3901W)	238 m	Near-Surface	2159	20	213 m above bottom
		Mid-Depth	2159	20	108 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-7: Valens Island map

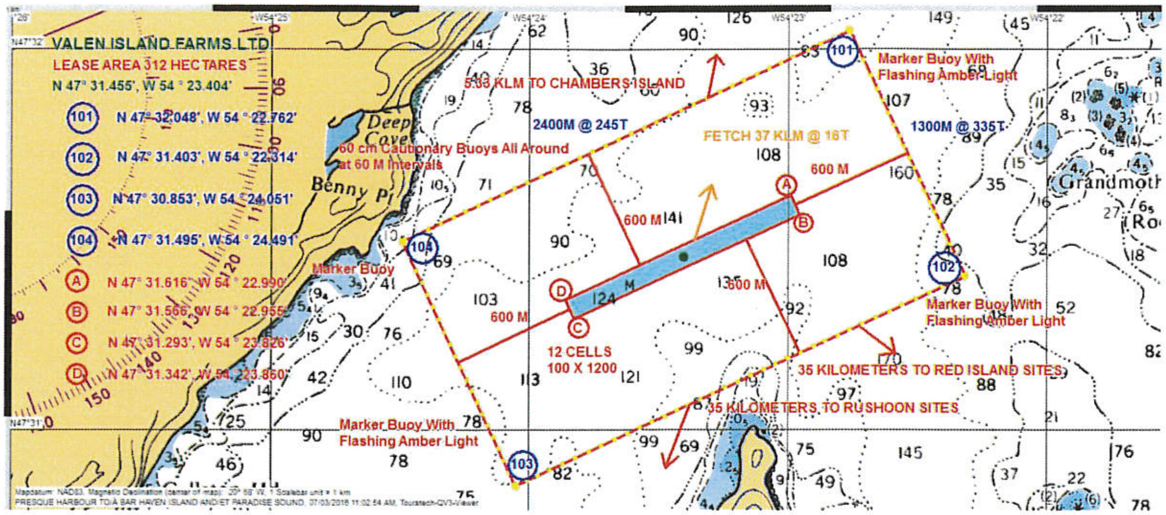
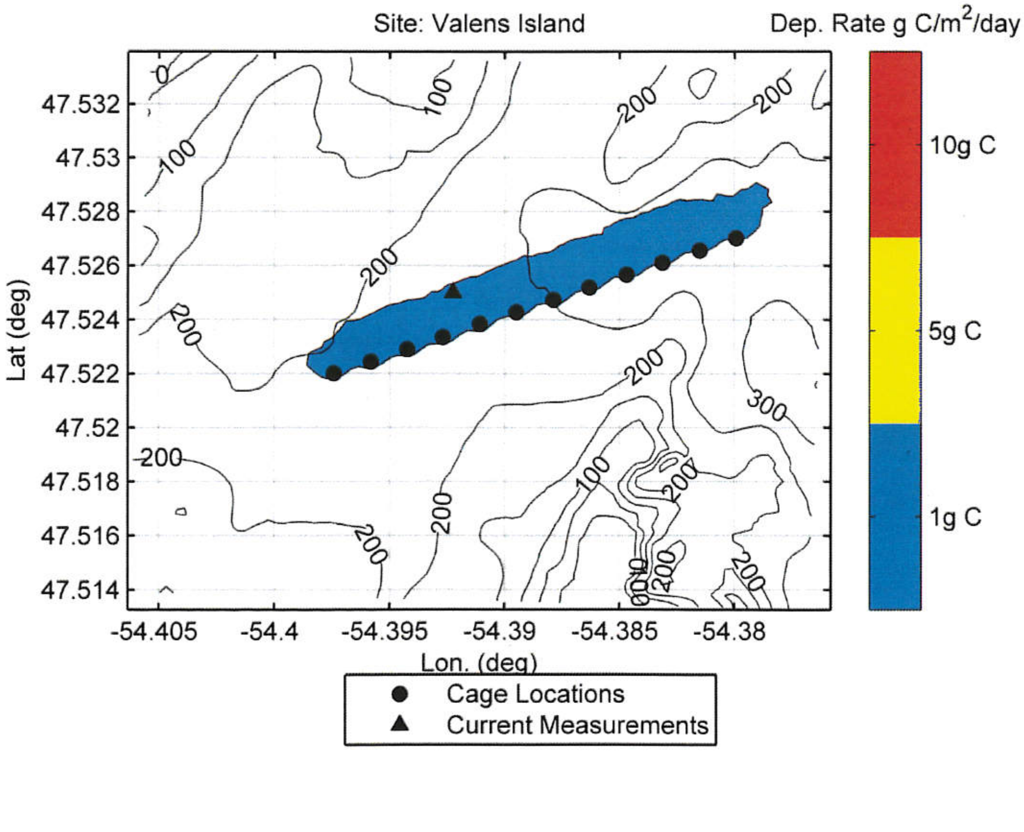


Figure 3-8: Valens Island depositional contours



3.5 Chambers Island

Table 3-5: Chambers Island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Chambers Island (47.5795N, 54.3520W)	268 m	Near-Surface	2159	20	238 m above bottom
		Mid-Depth	2159	20	108 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-9: Chambers Island map

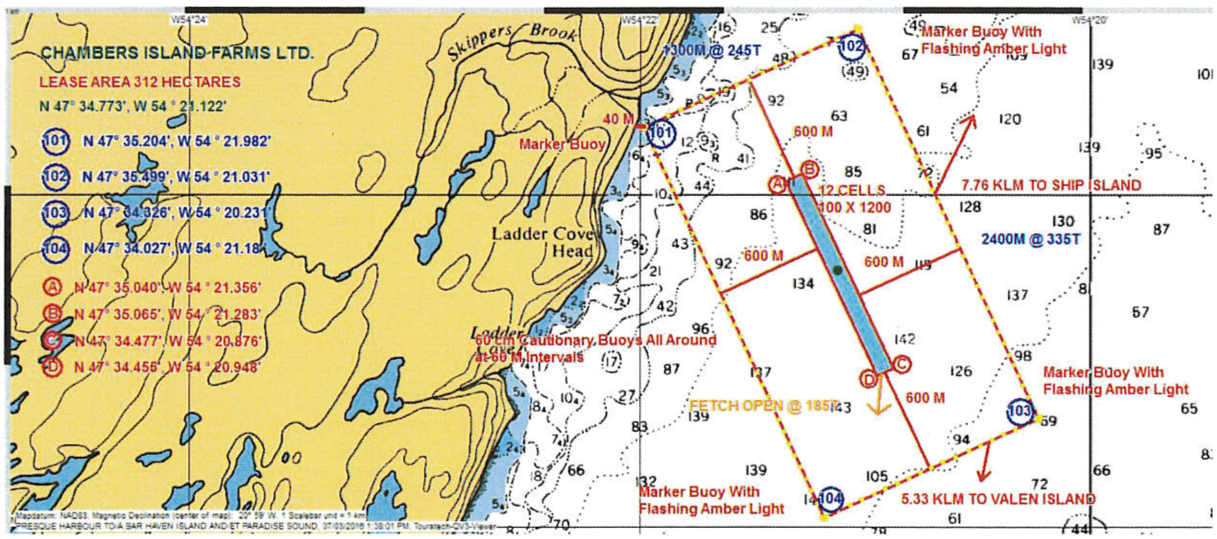
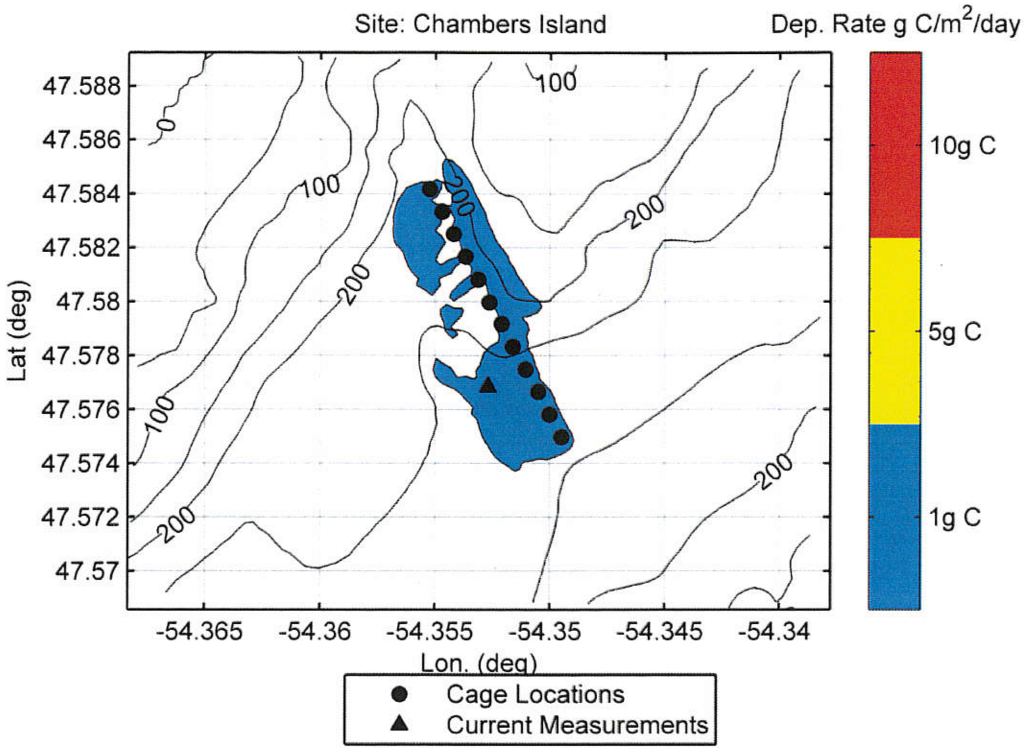


Figure 3-10: Chambers island depth contours



3.6 Ship Island

Table 3-6: Ship island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Ship Island (47.6490N, 54.2794W)	203 m	Near-Surface	2159	20	173 m above bottom
		Mid-Depth	2159	20	88 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-11: Ship Island map

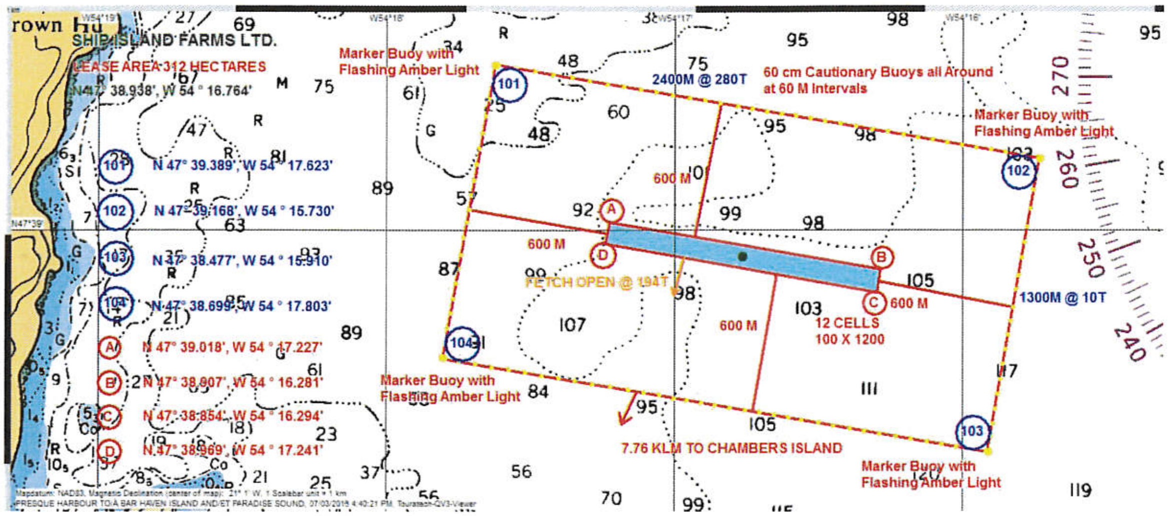
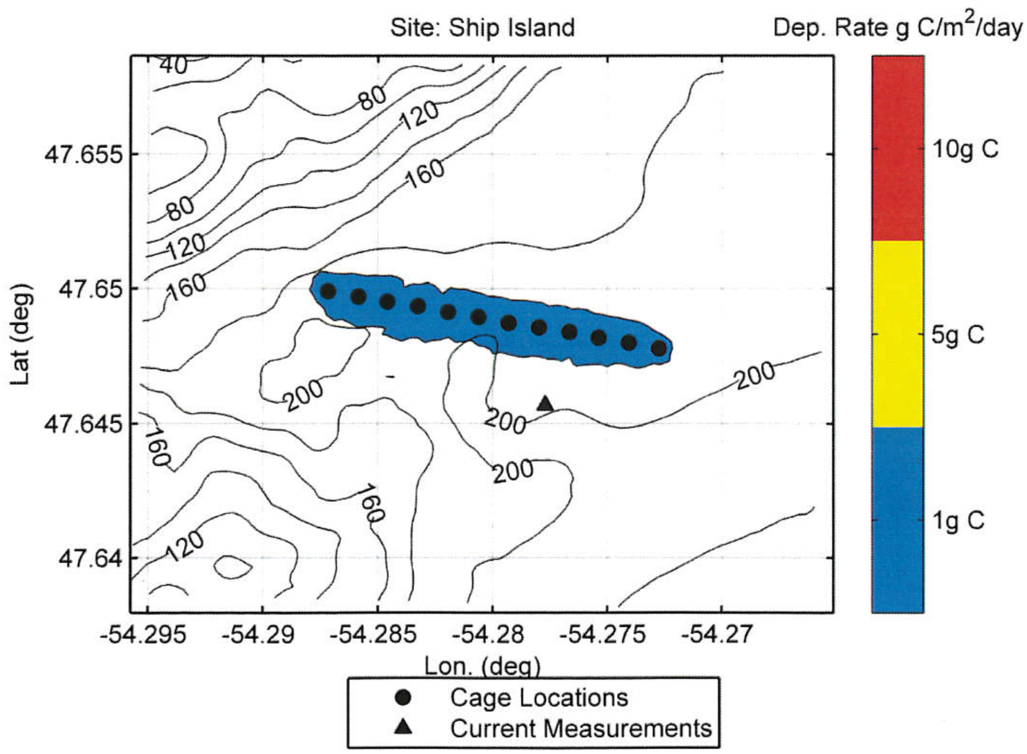


Figure 3-12: Ship Island depositional contours



3.7 Butler Island

Table 3-7: Butler Island depositional contours

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Butler Island (47.5700N, 54.1159W)	103 m	Near-Surface	2159	20	73 m above bottom
		Mid-Depth	2159	20	33 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-13: Butler Island map

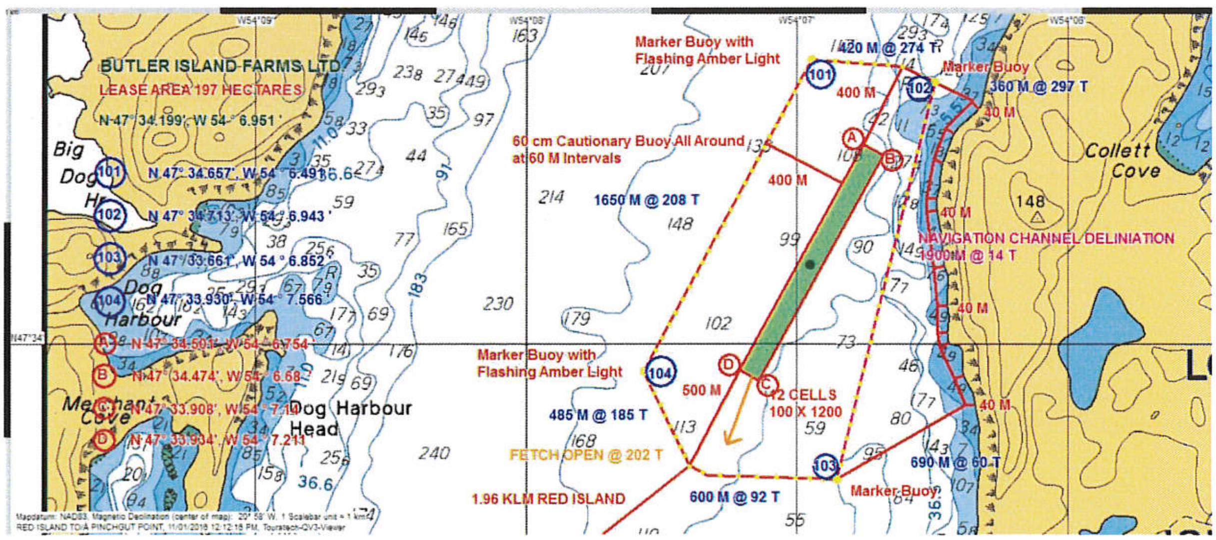
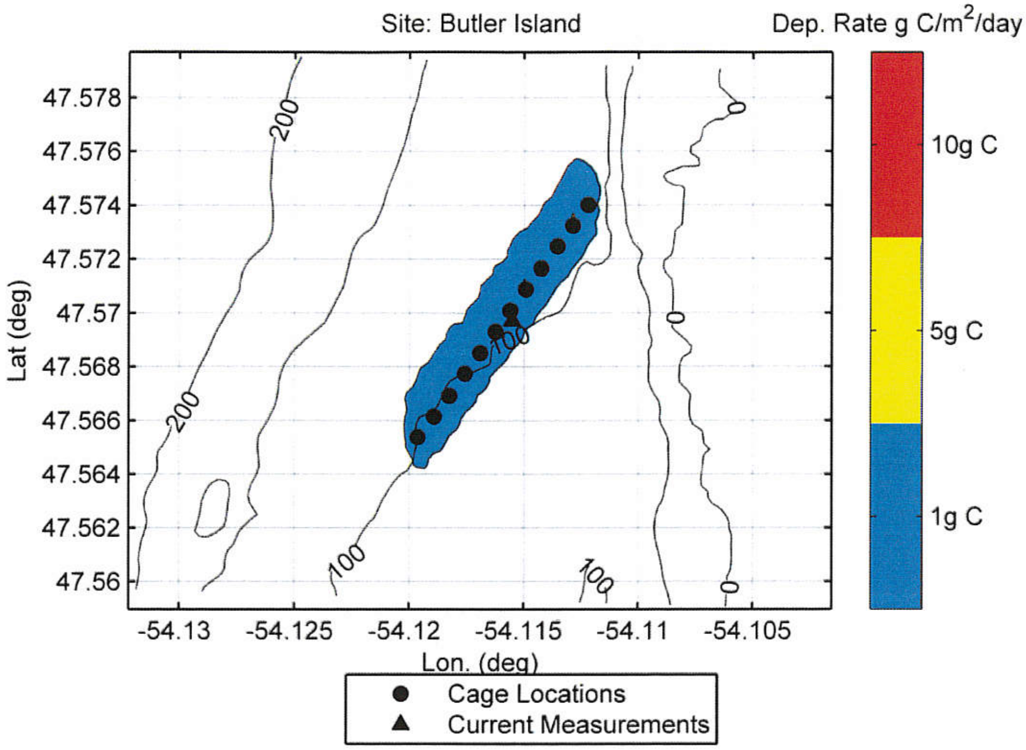


Figure 3-14: Butler Island depositional contours



3.8 Red Island

Table 3-8: Red Island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Red Island (47.5404N, 54.1489W)	108 m	Near-Surface	2159	20	78 m above bottom
		Mid-Depth	2159	20	33 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-15: Red Island map

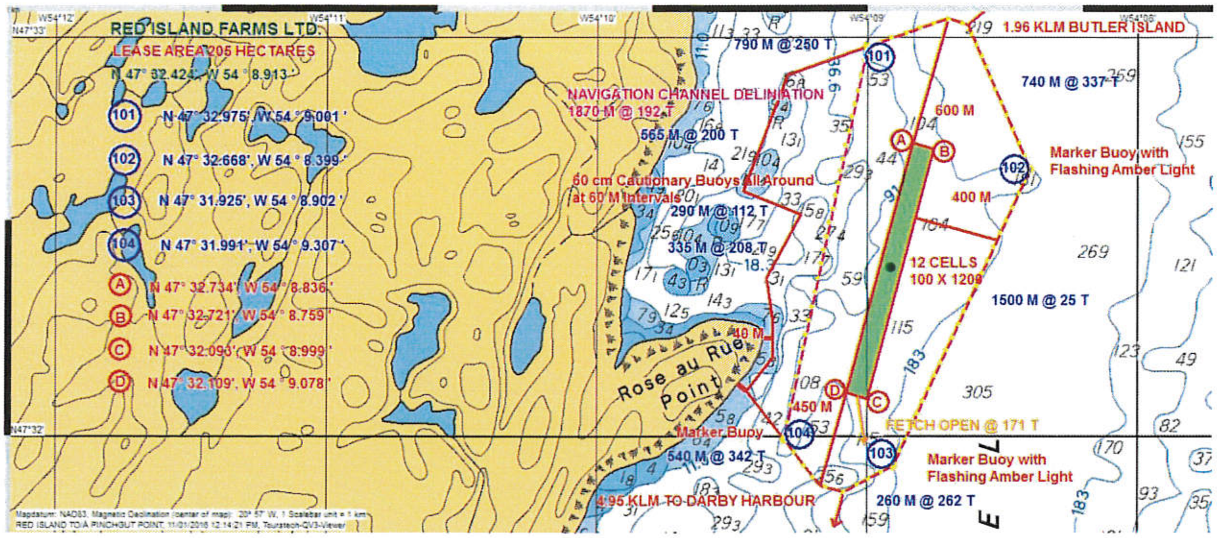
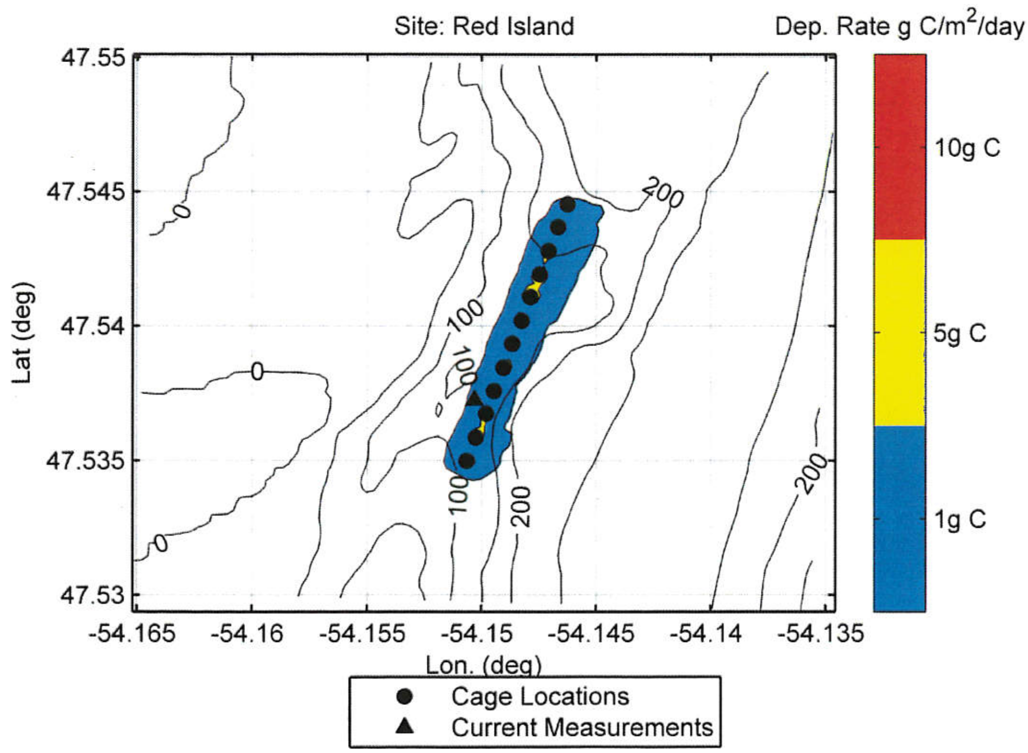


Figure 3-16: Red Island depositional contours



3.9 Darby Harbour

Table 3-9: Darby harbour depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Darby Harbour (47.4798N, 54.1863W)	125 m	Near-Surface	2159	20	95 m above bottom
		Mid-Depth	2159	20	45 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-17: Darby Harbour map

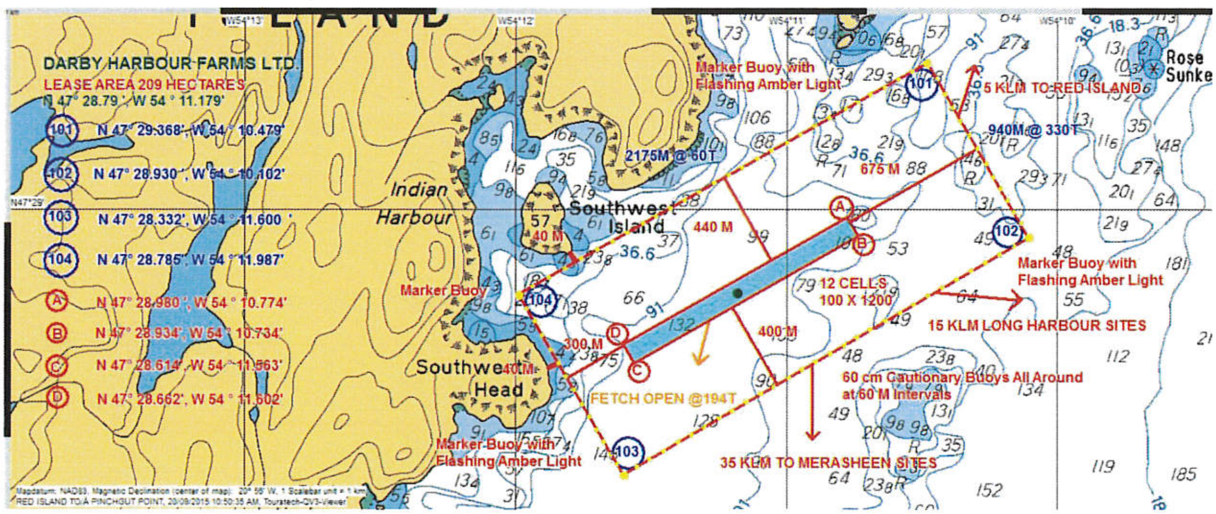
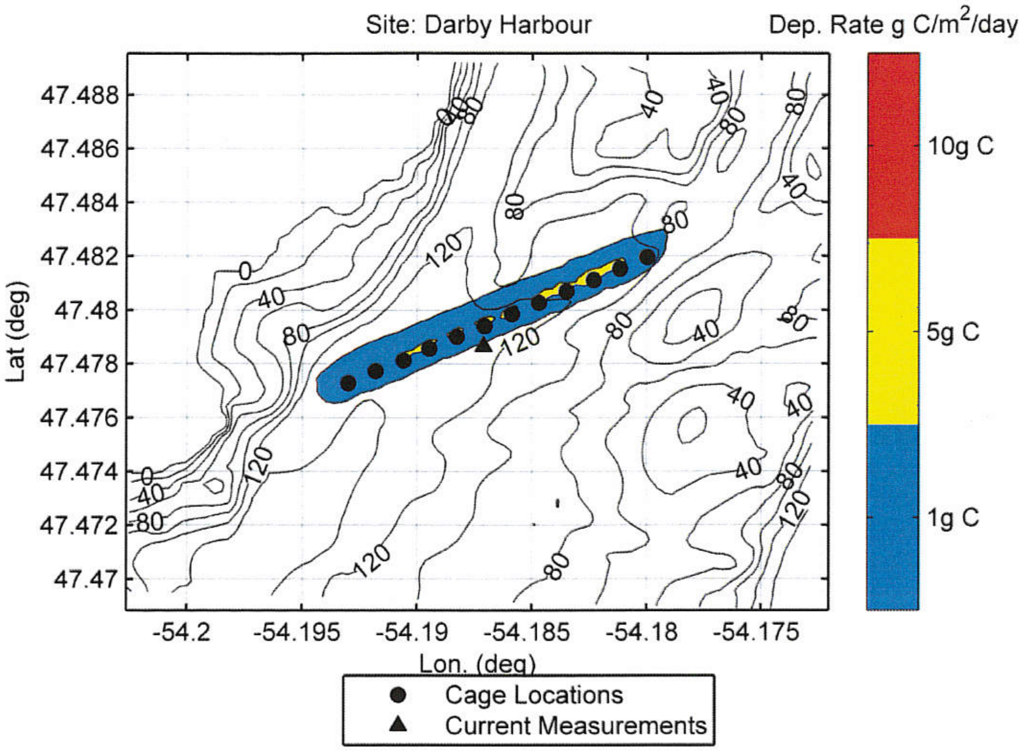


Figure 3-18: Darby Harbour depositional contours



3.10 Brine Islands

Table 3-10: Brine Island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Brine Islands (47.4455N, 53.9671W)	118 m	Near-Surface	2159	20	88 m above bottom
		Mid-Depth	2159	20	42 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-19: Brine island map

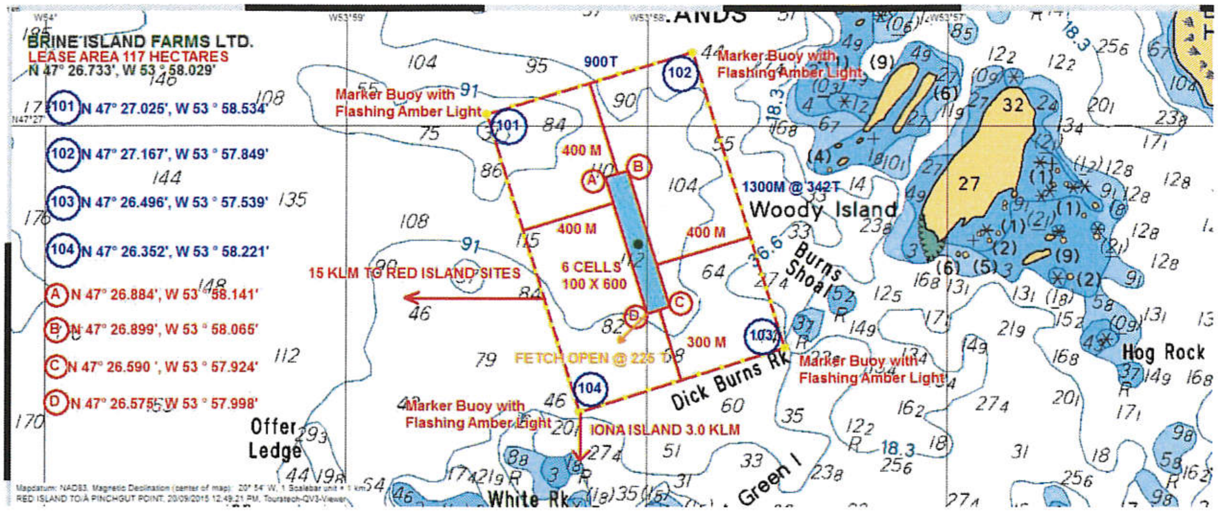
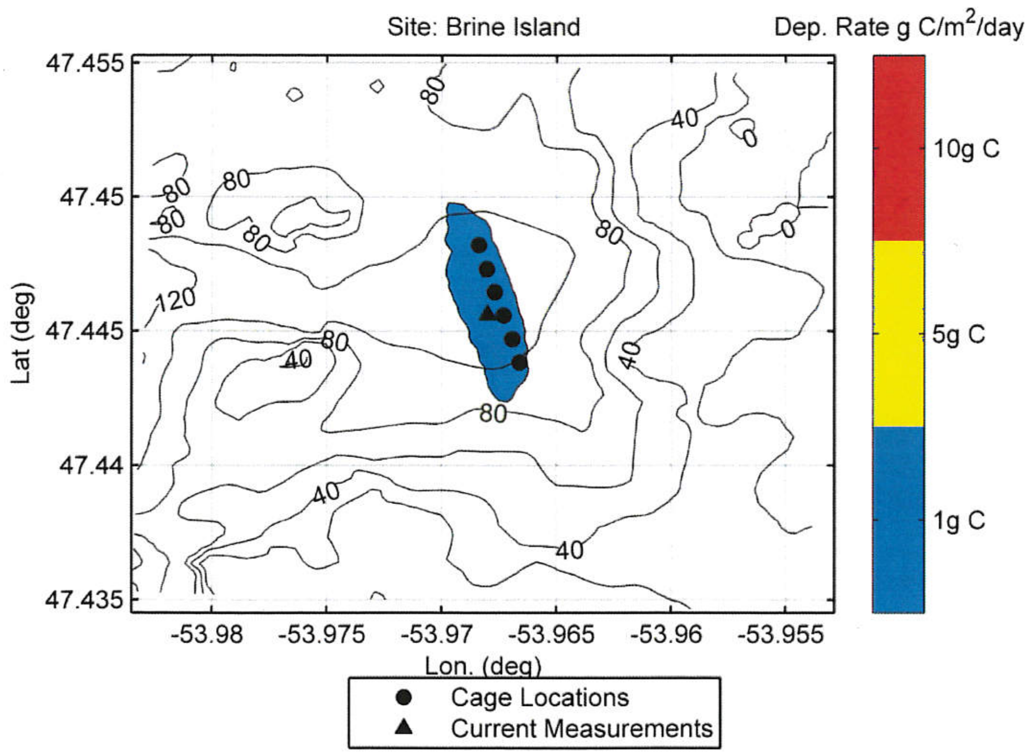


Figure 3-20: Brine Island depositional contours



3.11 Iona Islands

Table 3-11: Iona Island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Iona Islands (47.4086N, 53.9750W)	98 m	Near-Surface	2159	20	68 m above bottom
		Mid-Depth	2159	20	33 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-21: Iona Islands map

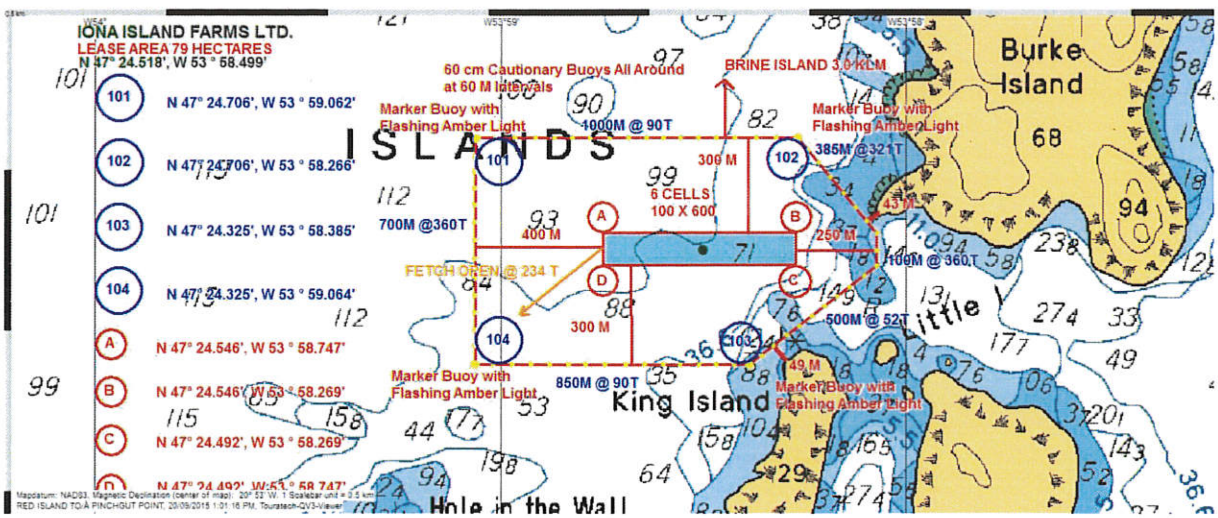
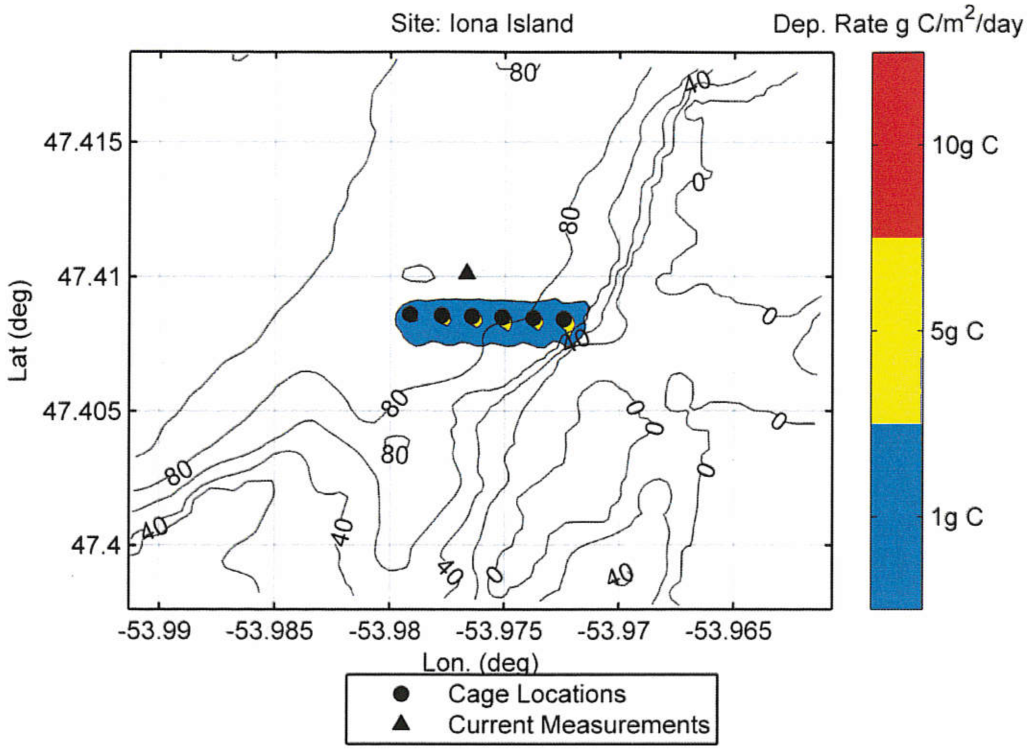


Figure 3-22: Iona Islands depositional contours



4.0 CLOSURE

Amec Foster Wheeler has prepared this Aquaculture Benthic Depositional Modeling Report for Grieg NL Seafarms Ltd. as part of their Aquaculture Activities Regulations permitting requirements. Any questions associated with this report should be directed to the undersigned and we appreciate the opportunity to conduct this work on your behalf.

Yours sincerely,

Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited

Prepared by:

Charlie Bishop

Charlie Bishop, M.Sc
Oceanographer
Tel: 709-722-7023
Fax: 709-722-7353
E-mail: charlie.bishop@amecfw.com

Prepared by:

Alexandra Eaves

Alexandra Eaves, Ph.D.
Senior Scientist
Tel: 709-722-7023
Fax: 709-722-7353
E-mail: alexandra.eaves@amecfw.com

Reviewed by:

P. R.

Patrick Roussel, M.Sc., M.Eng.
Senior Oceanographer
Tel: 902-468-2848
Fax: 902-4681314
E-mail: patrick.roussel@amecfw.com

5.0 REFERENCES

Cromey, C.J., Nickell, T.D. and Black, K.D., 2002. DEPOMOD—modelling the deposition and biological effects of waste solids from marine cage farms. Aquaculture, 214(1), pp.211-239.

Fisheries and Oceans Canada (DFO). 2016. Annex A DEPOMOD Canada Methods and Settings v1.6. Stucchi, D. and Chamberlain J. (eds) Canadian Science Advisory Secretariat (CSAS) Publication. 29 pp.

Grieg NL. 2016. Placentia Bay Atlantic salmon aquaculture project (Part 1 & Part 2), Registration of an Undertaking under the Environmental Assessment Regulations, 203, Section 29. Prepared by Grieg NL Nurseries Ltd. And Grieg NL Seafarms Ltd. 559 pp.

APPENDIX A: DHI Hydrographic Report

Grieg Seafarms, Newfoundland

Hydrographic surveys

Grieg Seafood BC Ltd

Report

March 2016

The expert in **WATER ENVIRONMENTS**

This report has been prepared under the DHI Business Management System
certified by Bureau Veritas to comply with ISO 9001 (Quality Management)

ISO 9001
Management System Certification
BUREAU VERITAS
Certification Denmark A/S

Grieg Seafarms, Newfoundland

Placentia Bay, current measurements

Prepared for	Grieg Seafood BC Ltd
Represented by	Knut Skeidsvoll

View of Placentia Bay

Project manager	Lindsey Aies
Quality supervisor	Ulrik Lumborg

Project number	11819009
Approval date	11 March 2016
Revision	1.0
Classification	Confidential

DHI • Agern Alle 5 • • DK-2970 Hørsholm • Denmark
Telephone: +45 4516 9200 • Telefax: +45 4516 9292 • dhi@dhigroup.com • www.dhigroup.com

CONTENTS

1 Introduction

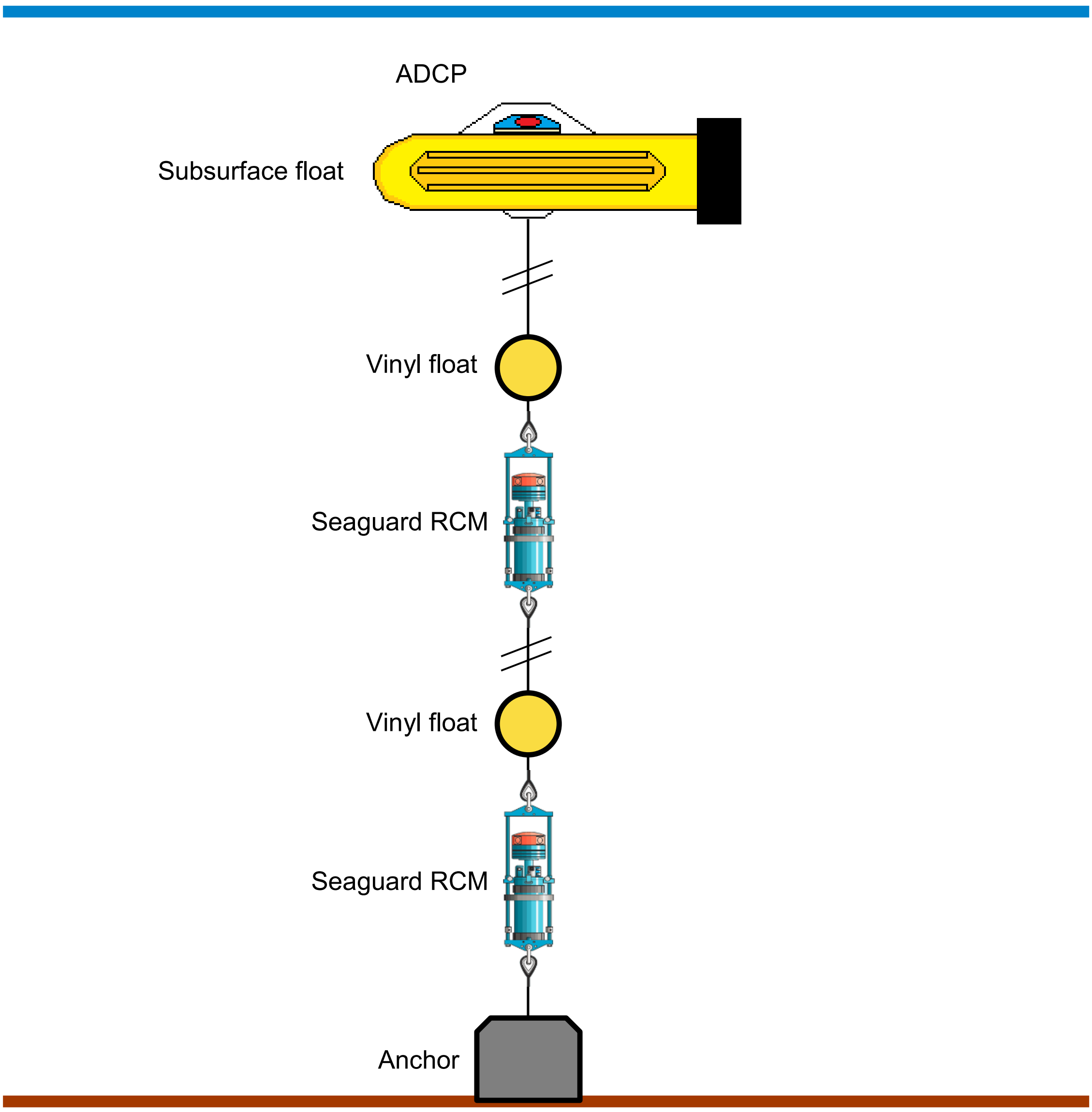
Grieg Seafarms has contracted with DHI to undertake hydrographic surveys in connection with application for establishment of new sites in Placentia Bay, Canada.

This report covers task undertaken from January to March 2016 and includes current measurements at 11 locations. Current measurements are taken at 3 points in the water column.

At all locations the aim was to document current speed and –direction during a period of 1 tidal period. Due to the rough weather during the survey period the total length of each deployment varies. The majority of deployment was over 24 hours where in three instances the deployment was only slightly less than 24 hours.

The system was compromised of two Aanderaa Seaguard RCMs and a RDI 600 kHz Workhorse Sentinel ADCP in conjunction with a subsurface float.

The system deployment is illustrated in the figure below.



Schematic view of the deployed system. The deployment was similar for all survey sites

2 Current Data

2.1 Rushoon BMA

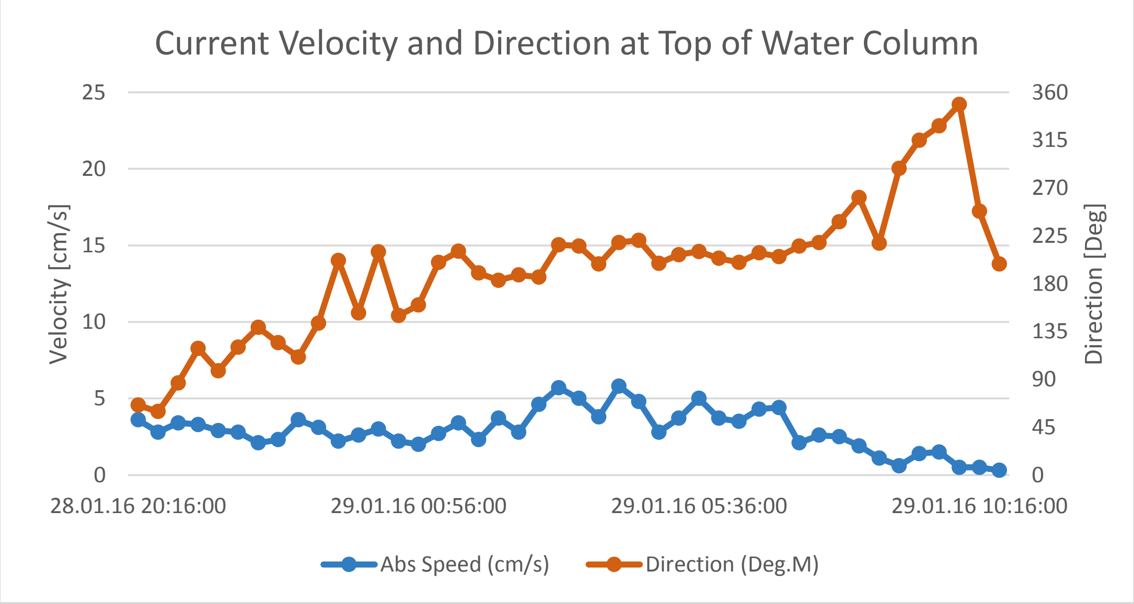
2.1.1 Gallows Harbour

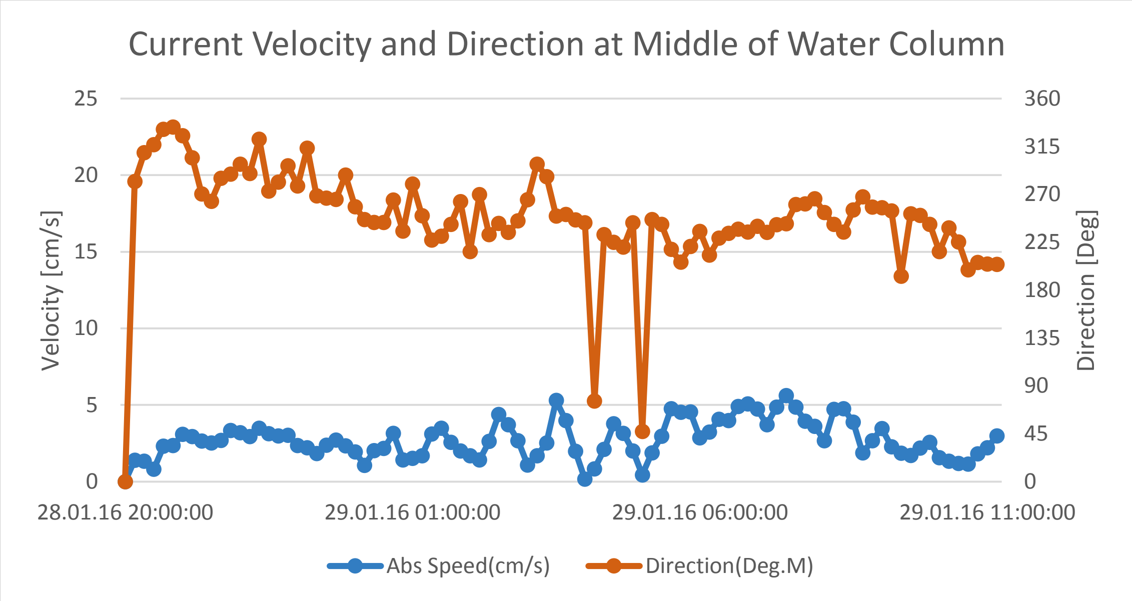
The system was placed at the follow coordinates:

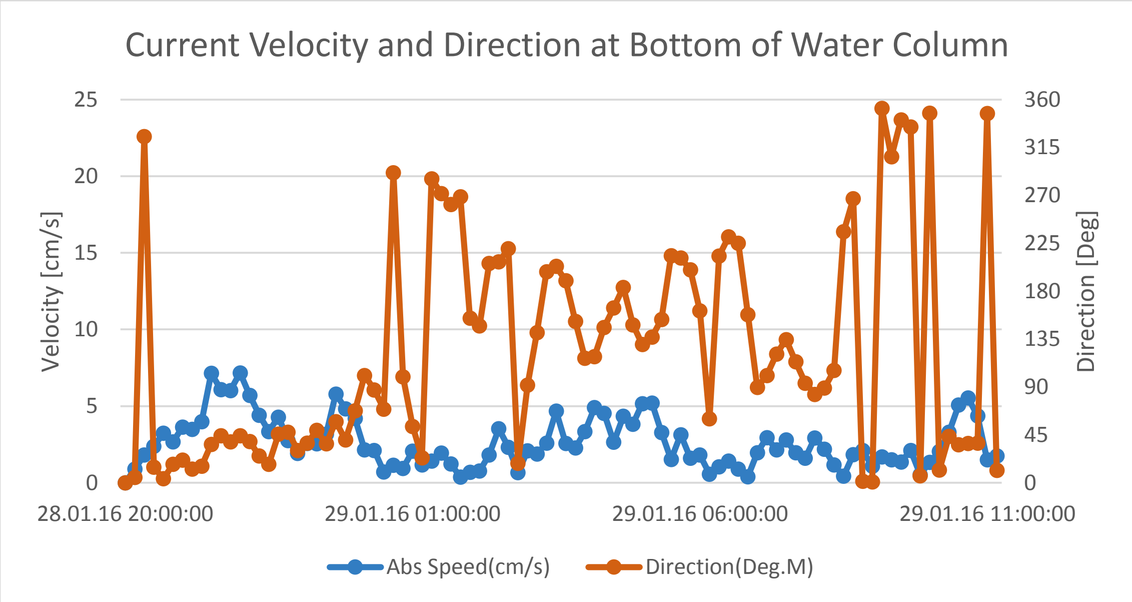
Latitude: 47º 21.311' N
Longitude: 54º 41.673' W

The system was deployed on the 28th of January 2016 at 20:00 UTC and recovered on the 29th of January 2016 at 11:00 UTC.

Displayed current measurements were taken at the following depths:
Top: 30 m
Middle: 70 m
Bottom: 110 m







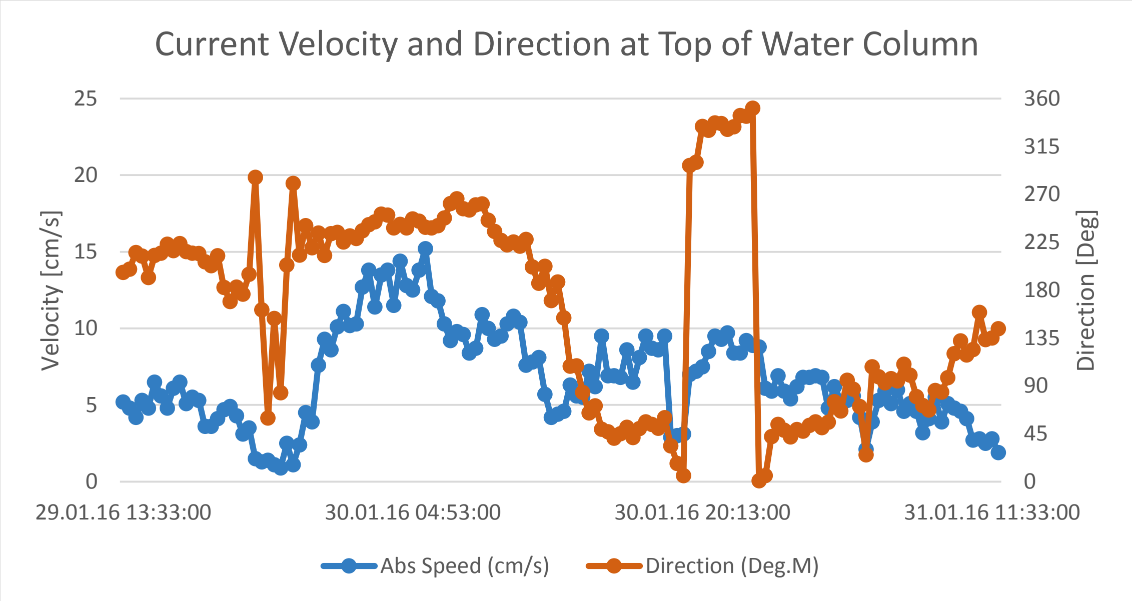
2.1.2 Long Island

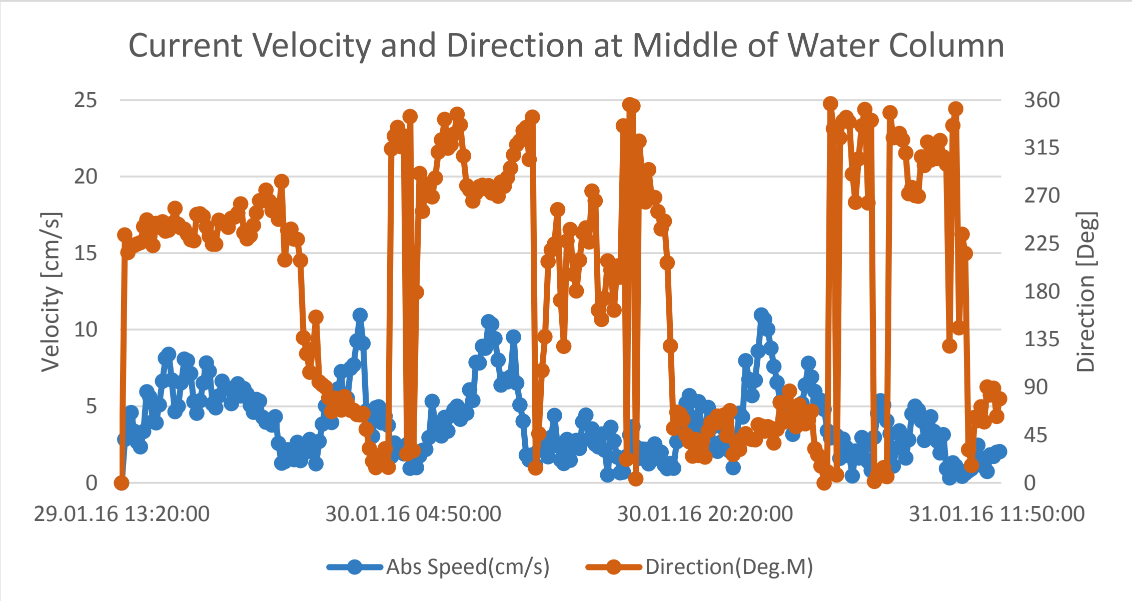
The system was placed at the following coordinates:

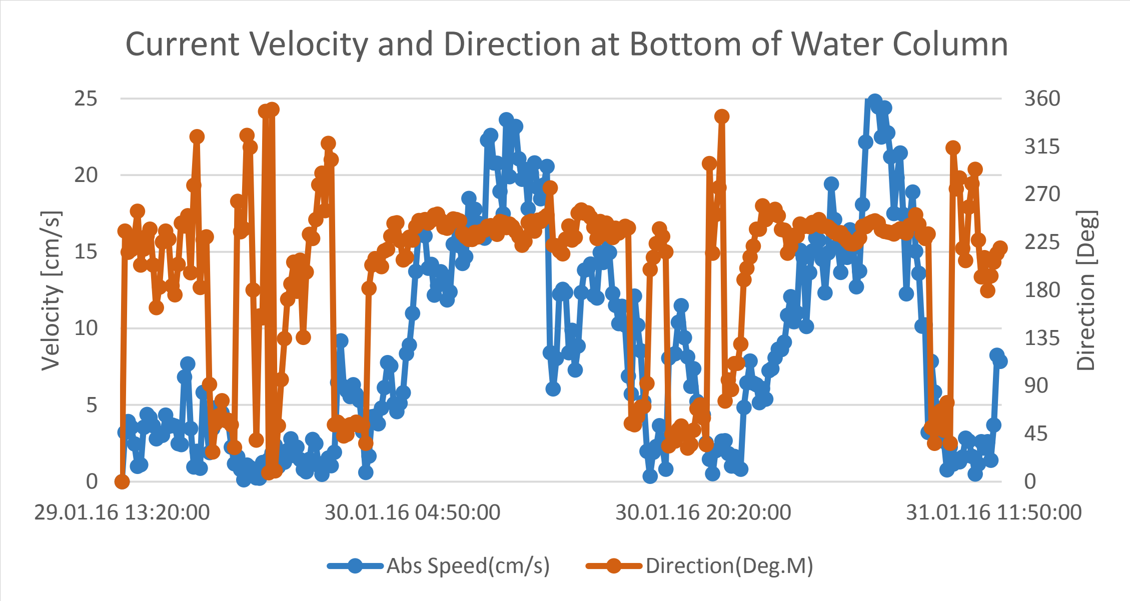
Latitude: 47º 19.881’ N
Longitude: 54º 41.858’ W

The system was deployed on the 29th of January 2016 at 13:20 UTC and recovered on the 31st of January 2016 at 12:00 UTC.

Displayed current measurements were taken at the following depths:
Top: 30 m
Middle: 87 m
Bottom: 135 m


Current Velocity and Direction at Top of Water Column
Velocity [cm/s]
Direction [Deg]
25
20
15
10
5
0
360
315
270
225
180
135
90
45
0
29.01.16 13:33:00
30.01.16 04:53:00
30.01.16 20:13:00
31.01.16 11:33:00
Abs Speed (cm/s)
Direction (Deg.M)


Current Velocity and Direction at Middle of Water Column
Velocity [cm/s]
Direction [Deg]
25
20
15
10
5
0
360
315
270
225
180
135
90
45
0
29.01.16 13:20:00
30.01.16 04:50:00
30.01.16 20:20:00
31.01.16 11:50:00
Abs Speed(cm/s)
Direction(Deg.M)



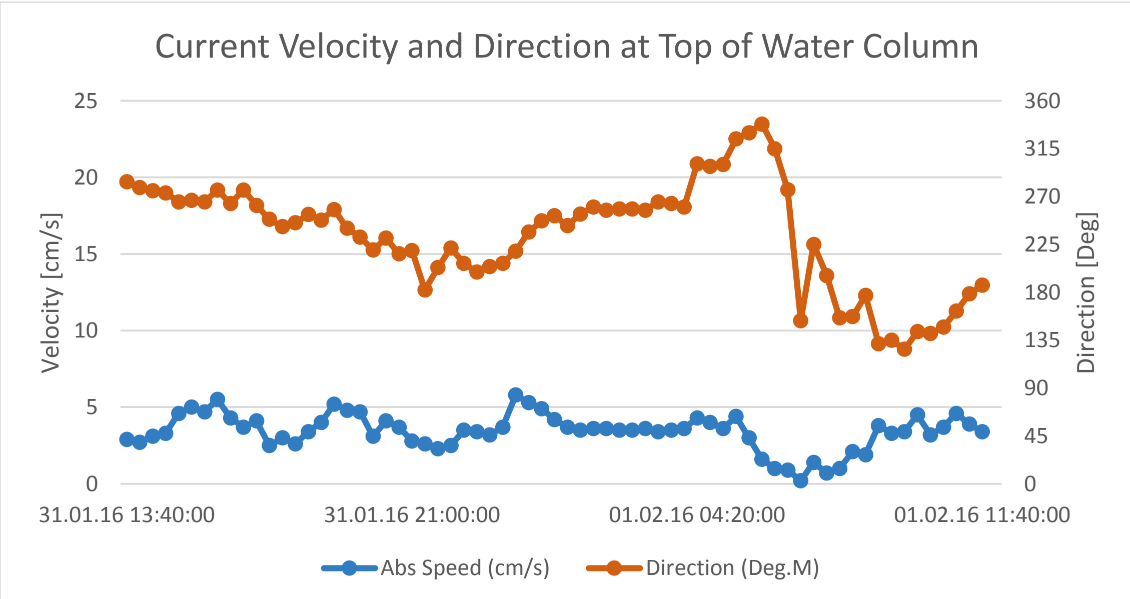
2.1.3 Oderin Island

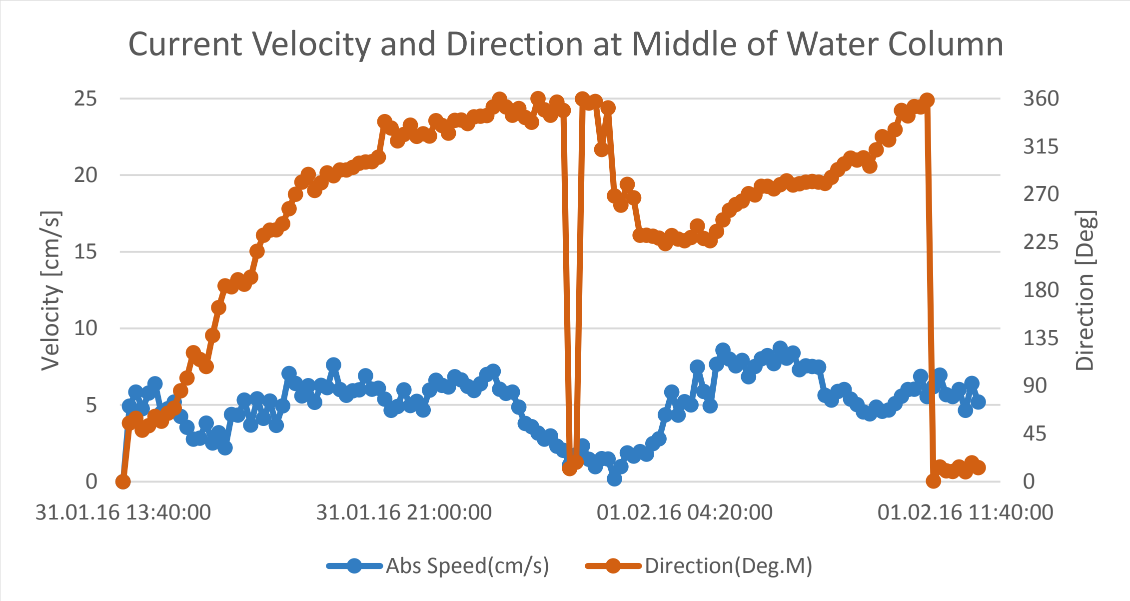
The system was placed at the follow coordinates:

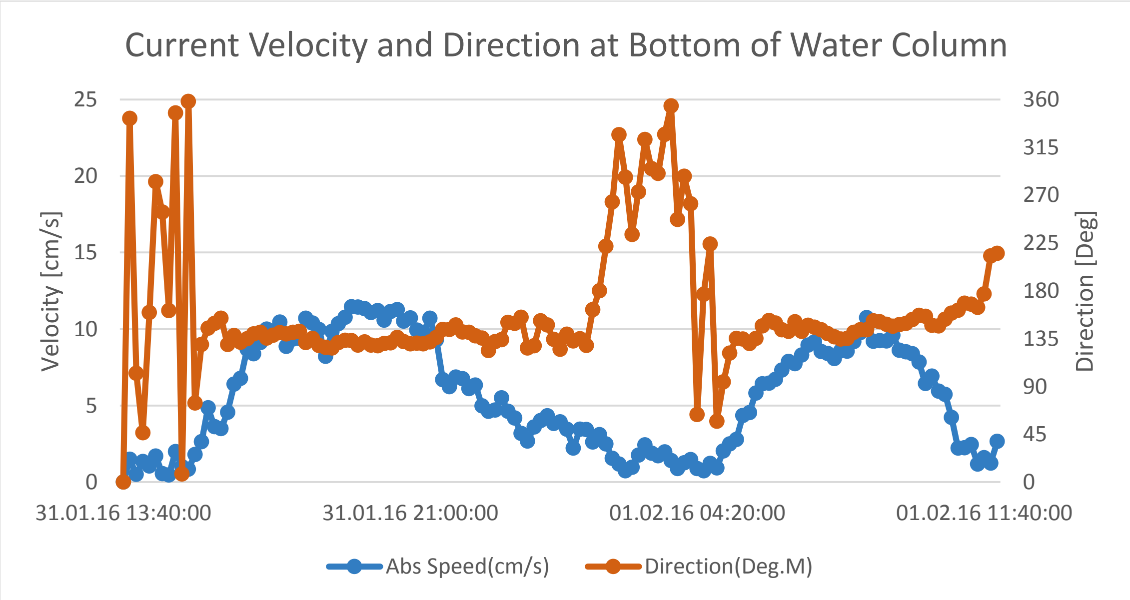
Latitude: 47° 18.030' N
Longitude: 54° 51.470' W

The system was deployed on the 31st of January 2016 at 13:30 UTC and recovered on the 1st of February 2016 at 11:45 UTC.

Displayed current measurements were taken at the following depths:
Top: 30 m
Middle: 58 m
Bottom: 80 m







2.2 Merasheen BMA

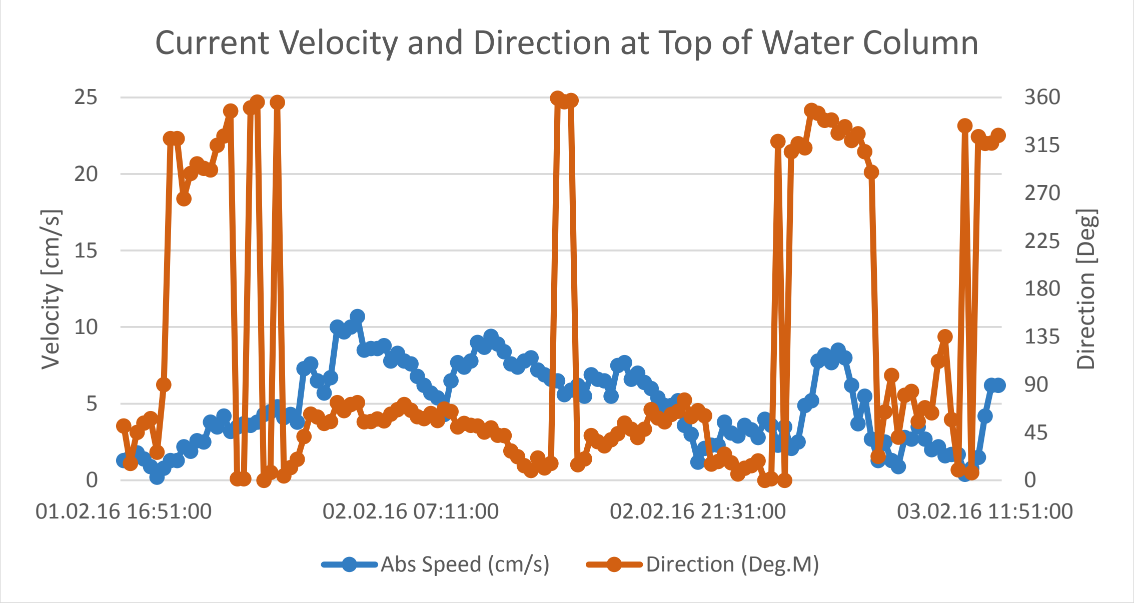
2.2.1 Valen Island

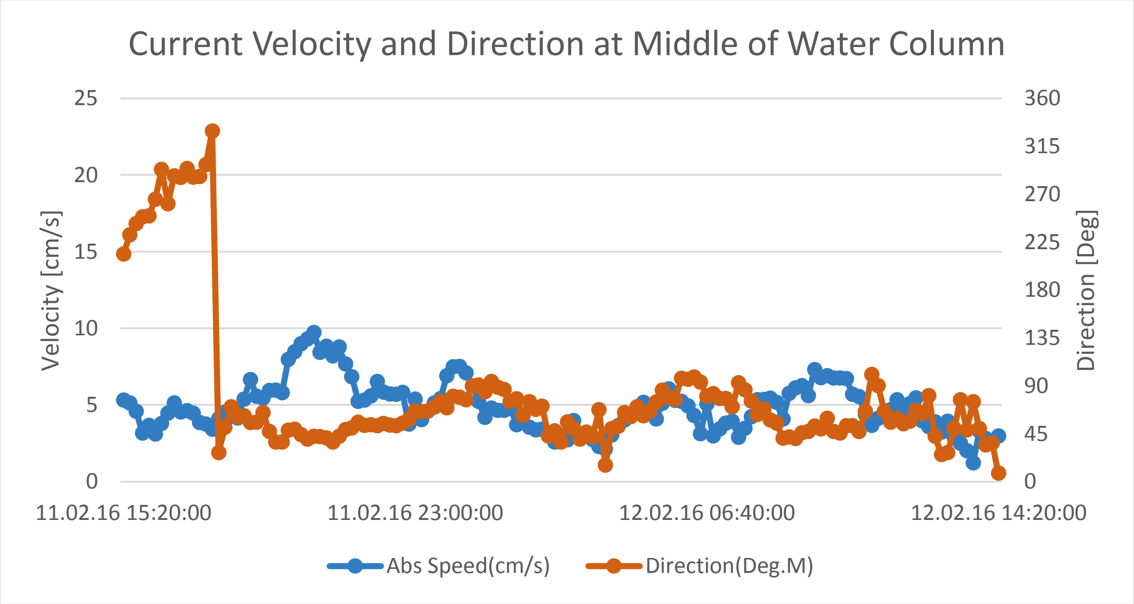
The system was placed at the follow coordinates:

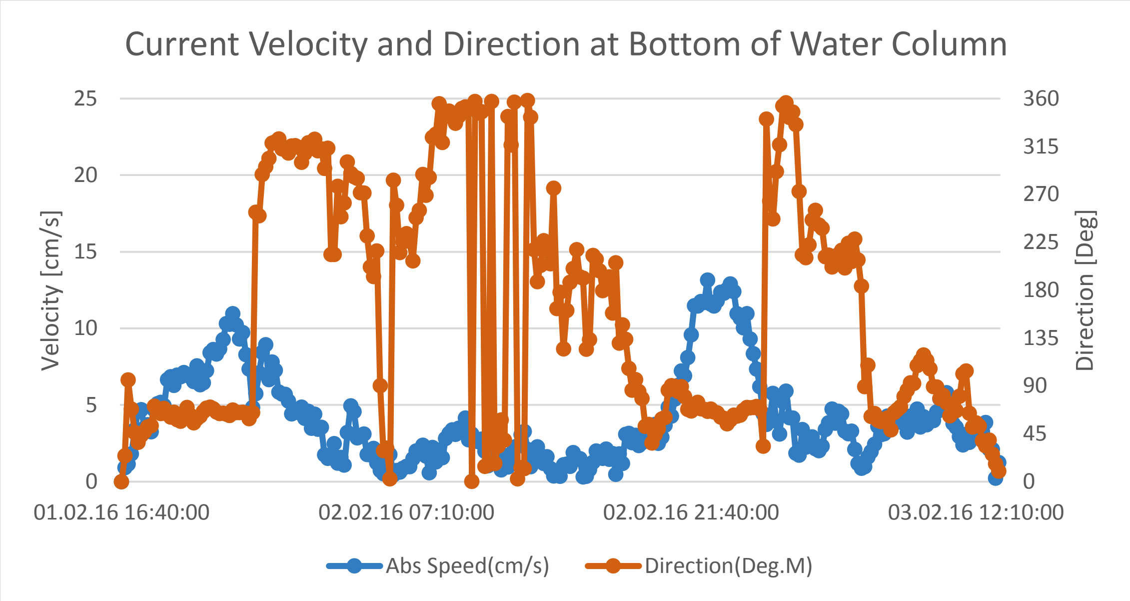
Latitude: 47º 31.500' N
Longitude: 54º 23.533' W

The system was deployed on the 1st of February 2016 at 16:30 UTC and recovered on the 3rd of February 2016 at 13:30 UTC.

Displayed current measurements were taken at the following depths:
Top: 25 m
Middle: 130 m
Bottom: 235 m







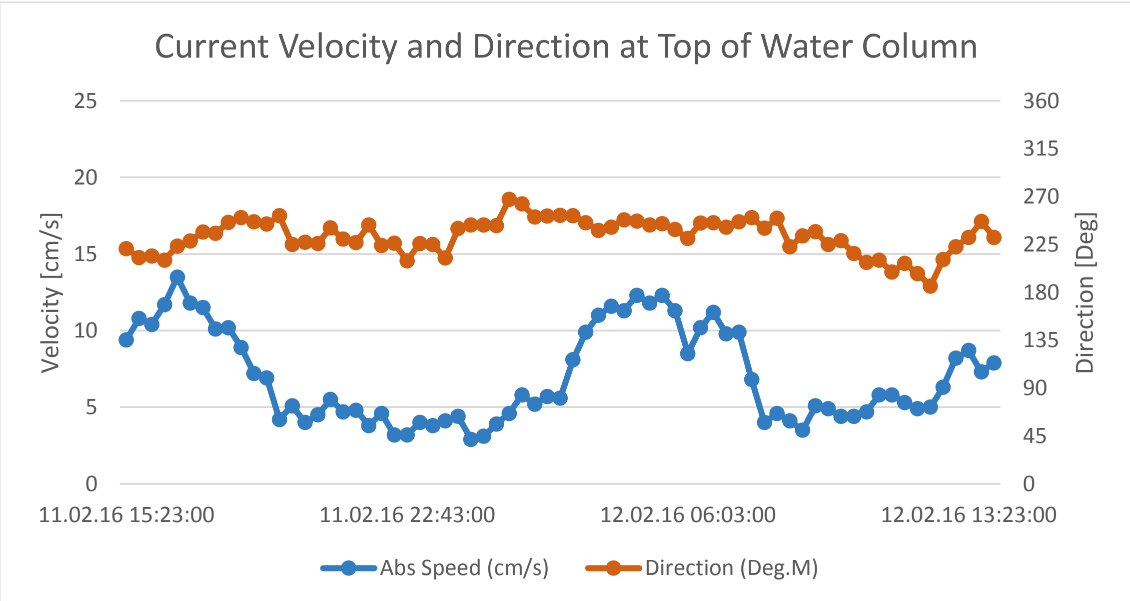
2.2.2 Chambers Island

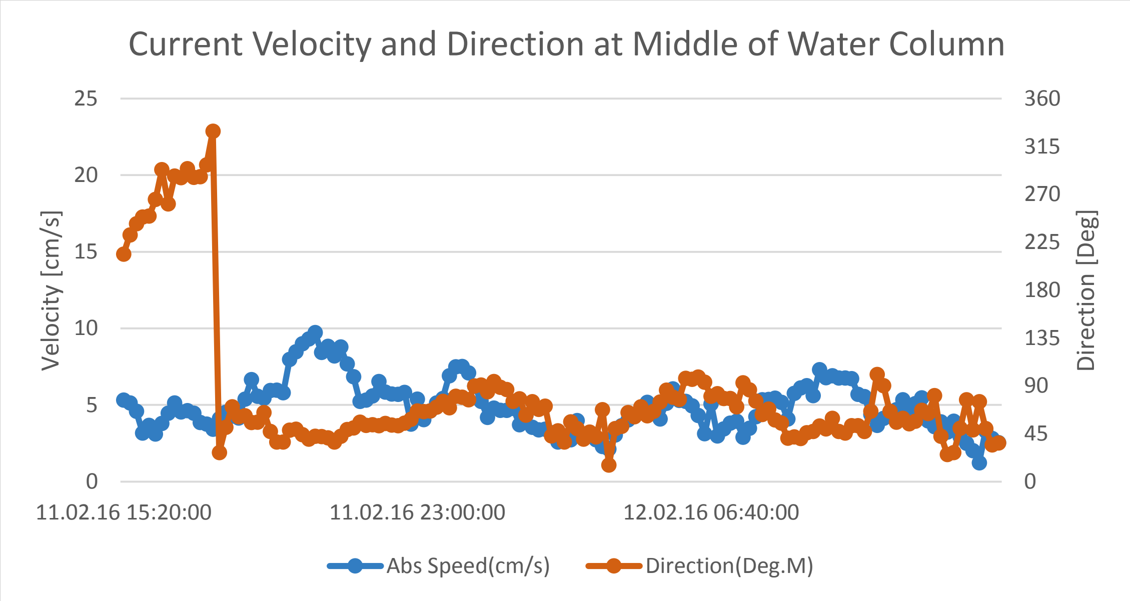
The system was placed at the follow coordinates:

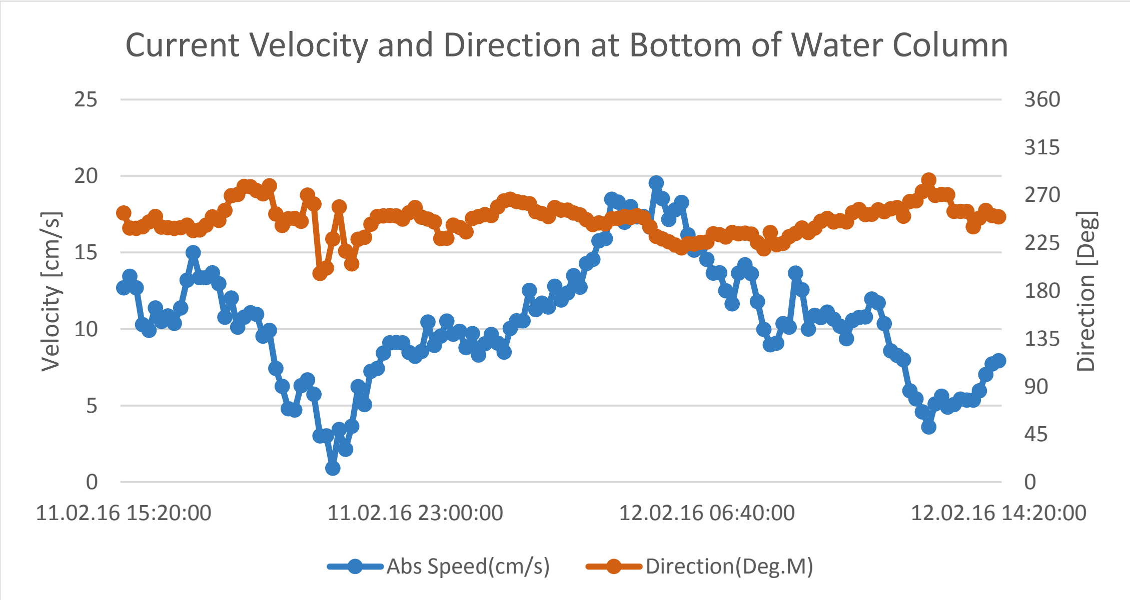
Latitude: 47° 34.728' N
Longitude: 54° 20.926' W

The system was deployed on the 11th of February 2016 at 15:00 UTC and recovered on the 12th of February 2016 at 14:30 UTC.

Displayed current measurements were taken at the following depths:
Top: 30 m
Middle: 160 m
Bottom: 265 m







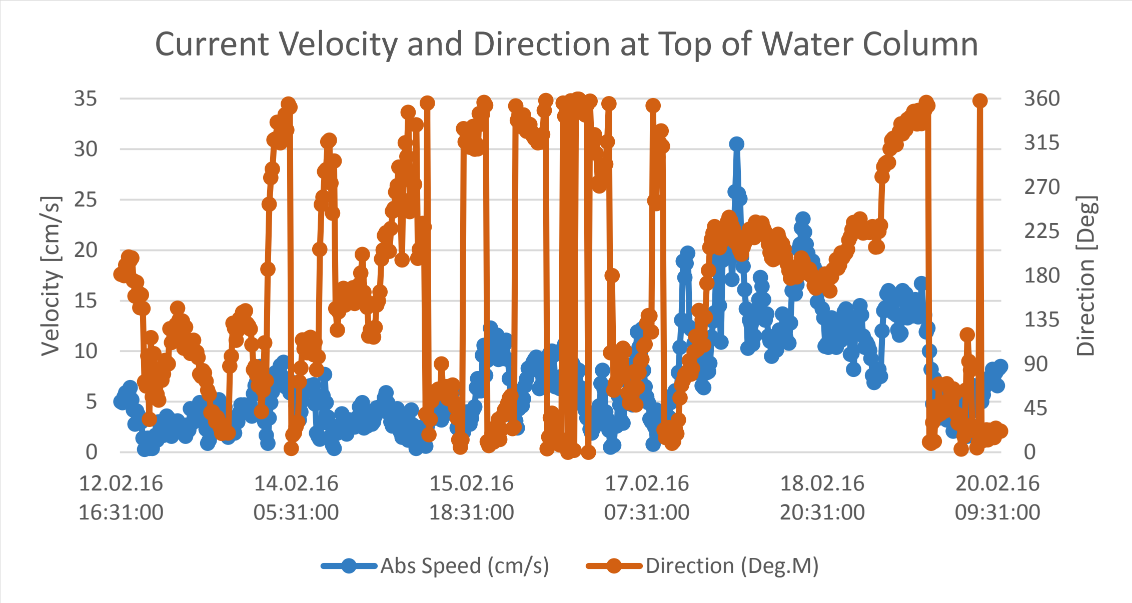
2.2.3 Ship Island

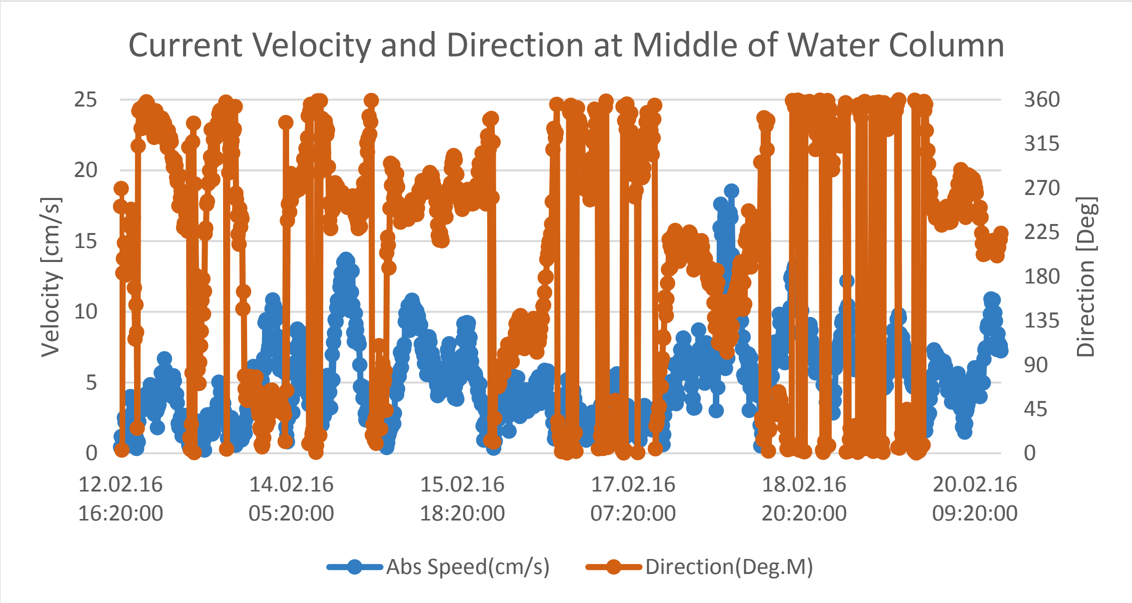
The system was placed at the following coordinates:

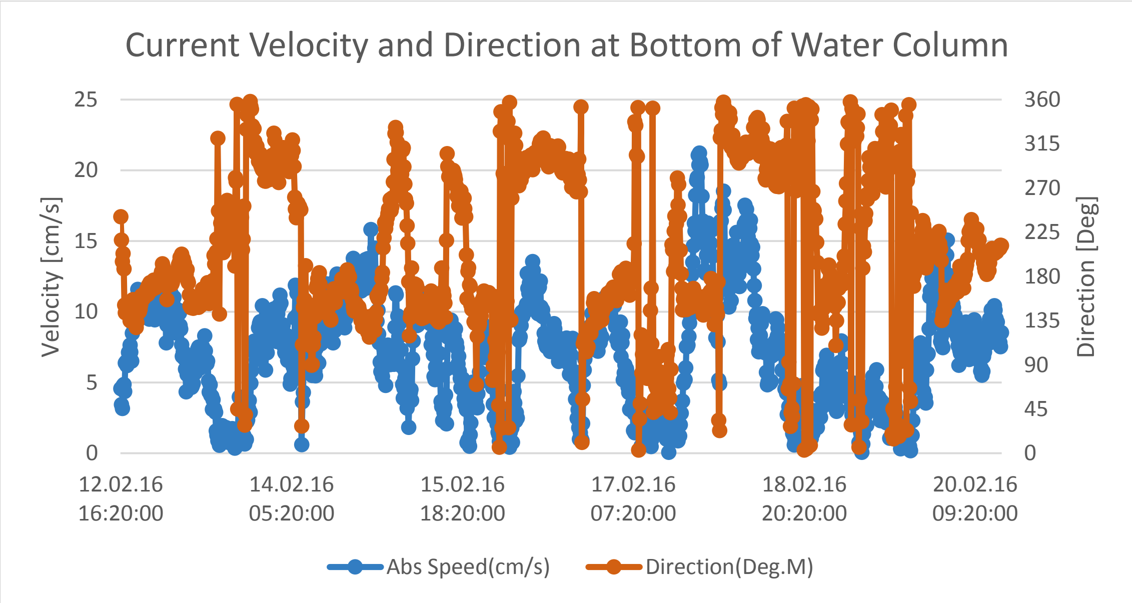
Latitude: 47° 38.740’ N
Longitude: 54° 16.662’ W

The system was deployed on the 12th of February 2016 at 16:15 UTC and recovered on the 20th of February 2016 at 15:00 UTC.

Displayed current measurements were taken at the following depths:
Top: 30 m
Middle: 115 m
Bottom: 200 m


Current Velocity and Direction at Top of Water Column
Velocity [cm/s]
Direction [Deg]
35
30
25
20
15
10
5
0
360
315
270
225
180
135
90
45
0
12.02.16 16:31:00
14.02.16 05:31:00
15.02.16 18:31:00
17.02.16 07:31:00
18.02.16 20:31:00
20.02.16 09:31:00
Abs Speed (cm/s)
Direction (Deg.M)


Current Velocity and Direction at Middle of Water Column
Velocity [cm/s]
Direction [Deg]
25
20
15
10
5
0
360
315
270
225
180
135
90
45
0
12.02.16 16:20:00
14.02.16 05:20:00
15.02.16 18:20:00
17.02.16 07:20:00
18.02.16 20:20:00
20.02.16 09:20:00
Abs Speed(cm/s)
Direction(Deg.M)



2.3 Red Island BMA

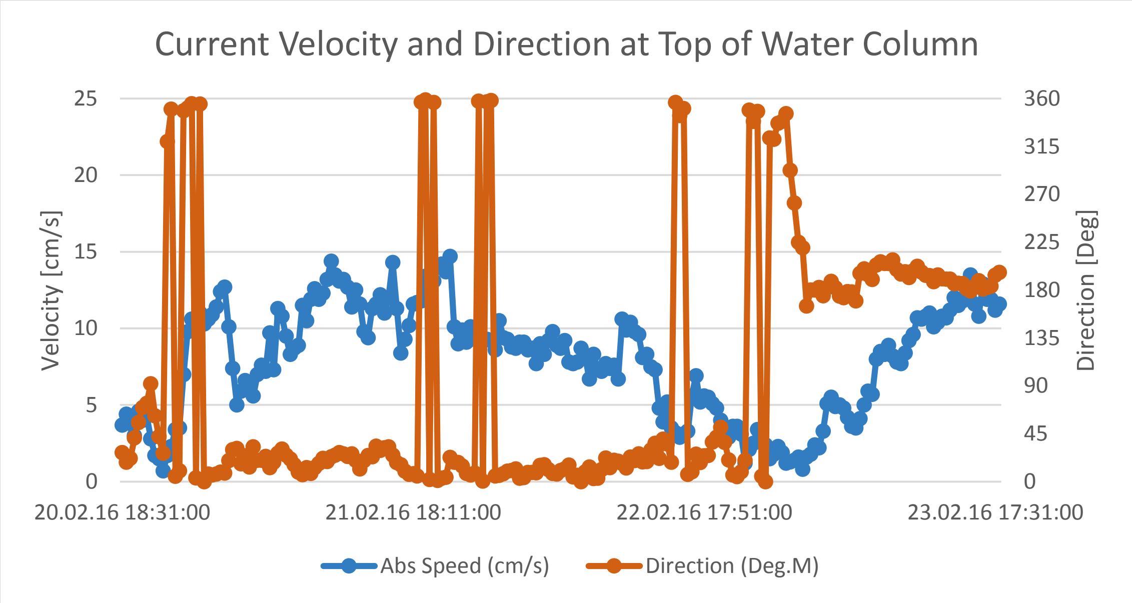
2.3.1 Butler Island

The system was placed at the follow coordinates:

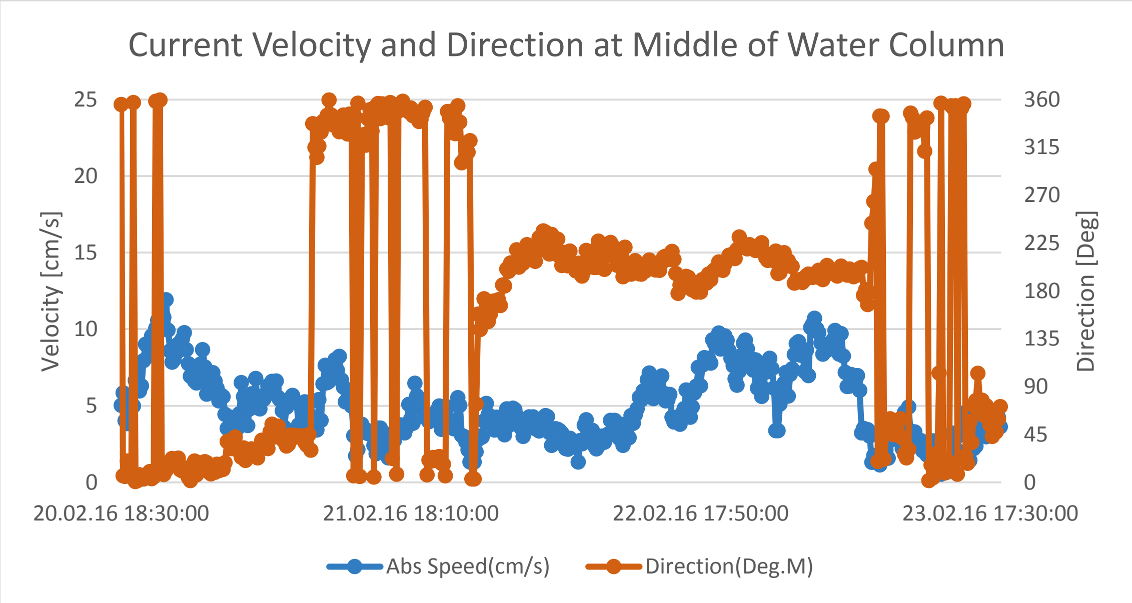
Latitude: 47° 34.183’ N
Longitude: 54° 06.930’ W

The system was deployed on the 20th of February 2016 at 18:00 UTC and recovered on the 23rd of February 2016 at 19:00 UTC.

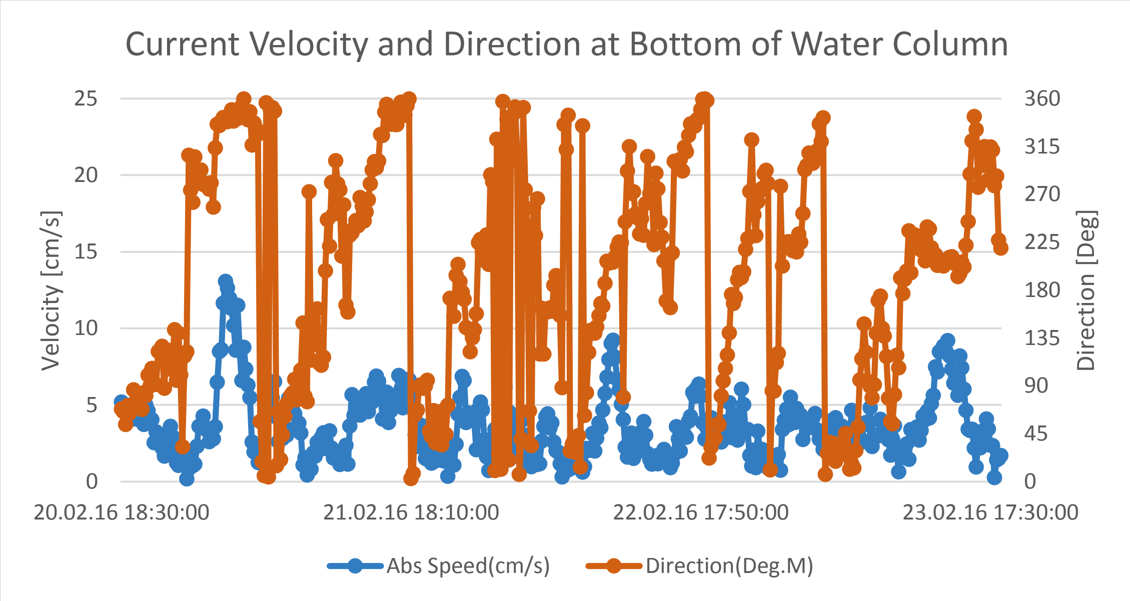
Displayed current measurements were taken at the following depths:
Top: 30 m
Middle: 70 m
Bottom: 100 m



Current Velocity and Direction at Top of Water Column
Velocity [cm/s]
Direction [Deg]
25
20
15
10
5
0
360
315
270
225
180
135
90
45
0
20.02.16 18:31:00
21.02.16 18:11:00
22.02.16 17:51:00
23.02.16 17:31:00
Abs Speed (cm/s)
Direction (Deg.M)



Current Velocity and Direction at Middle of Water Column
Velocity [cm/s]
Direction [Deg]
25
20
15
10
5
0
360
315
270
225
180
135
90
45
0
20.02.16 18:30:00
21.02.16 18:10:00
22.02.16 17:50:00
23.02.16 17:30:00
Abs Speed(cm/s)
Direction(Deg.M)



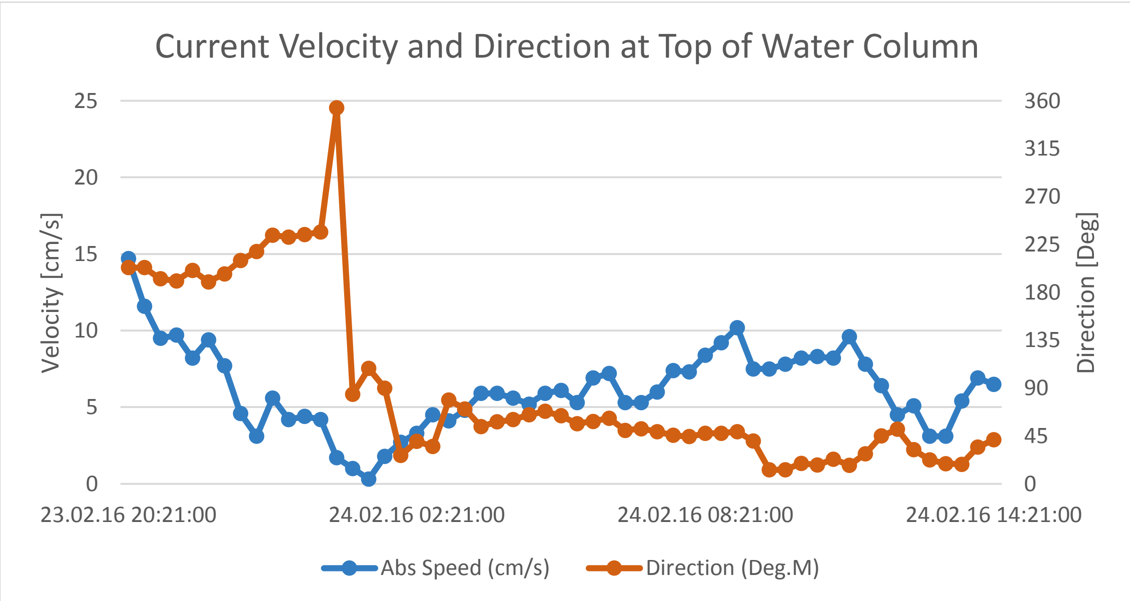
2.3.2 Red Island

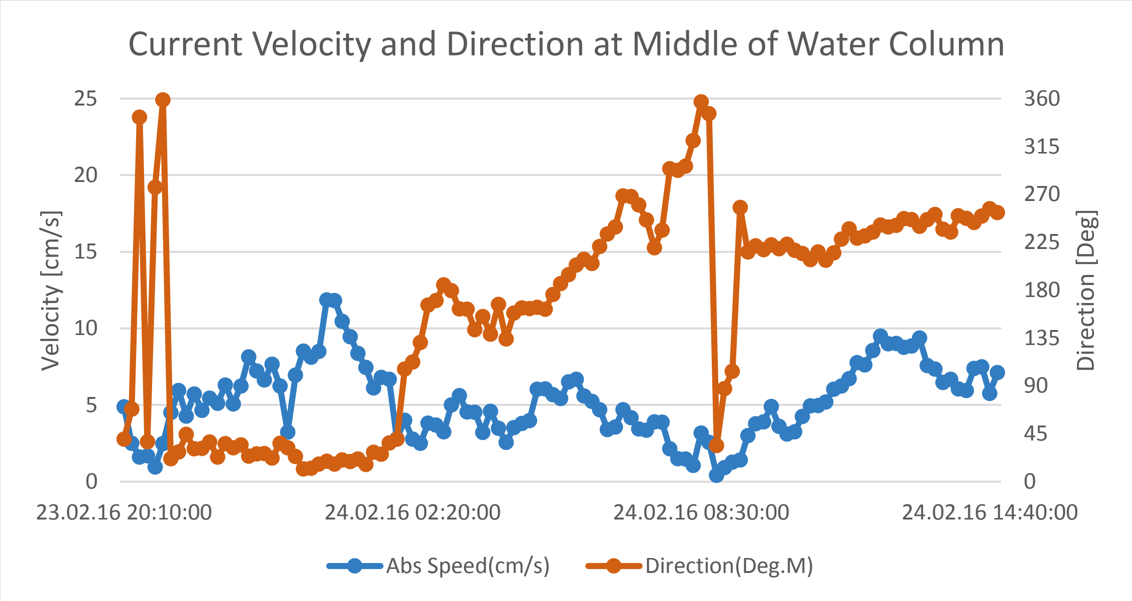
The system was placed at the following coordinates:

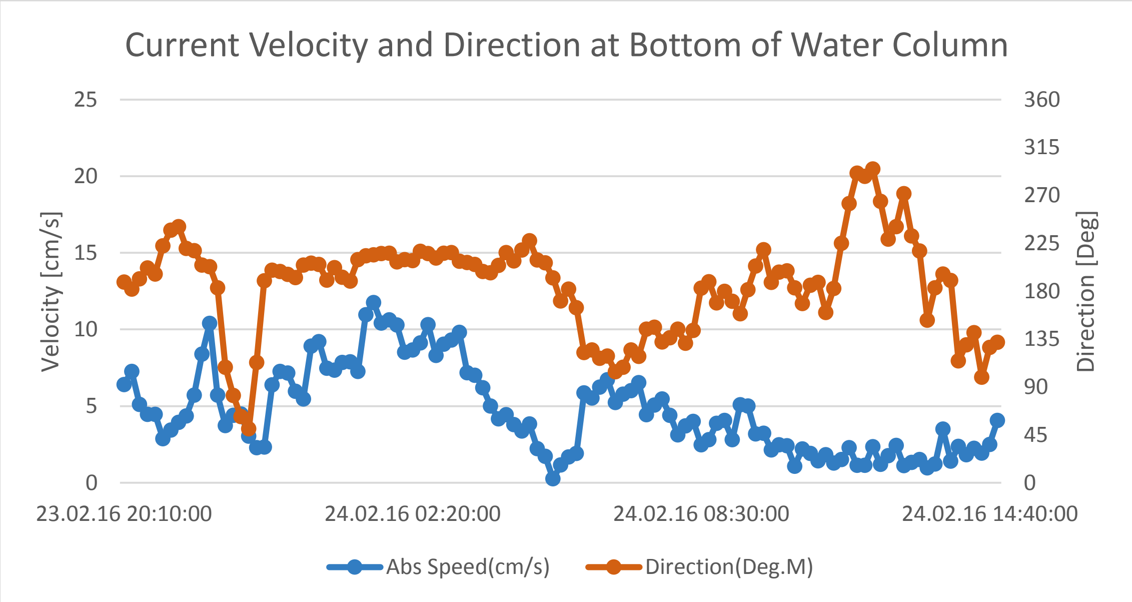
Latitude: 47º 32.237' N
Longitude: 54º 09.019' W

The system was deployed on the 23rd of February 2016 at 20:00 UTC and recovered on the 24th of February 2016 at 15:00 UTC.

Displayed current measurements were taken at the following depths:
Top: 30 m
Middle: 75 m
Bottom: 105 m







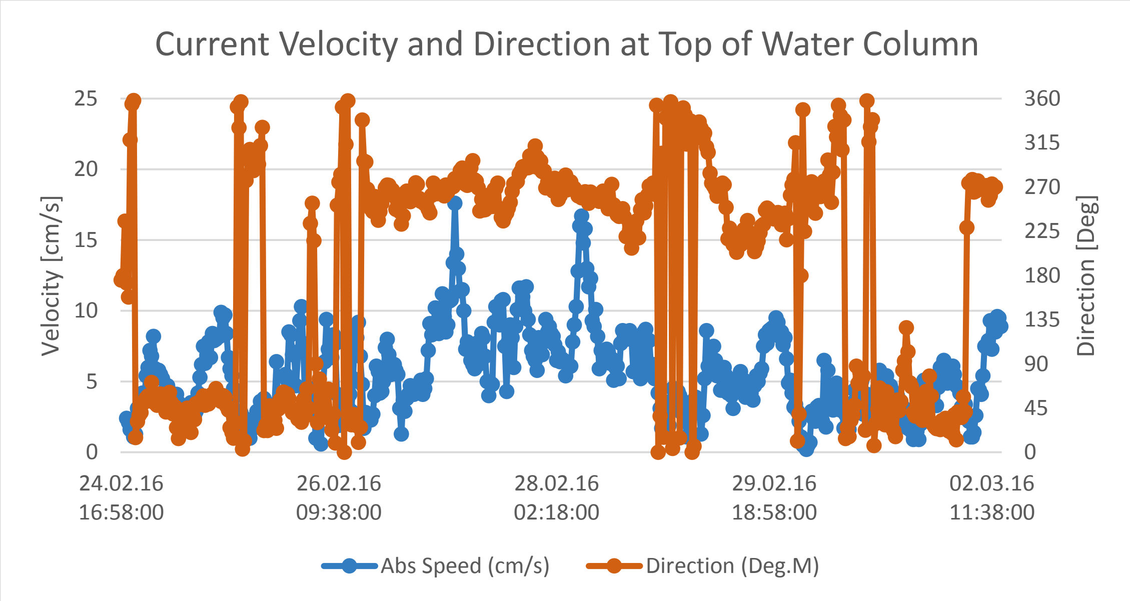
2.3.3 Darby Harbour

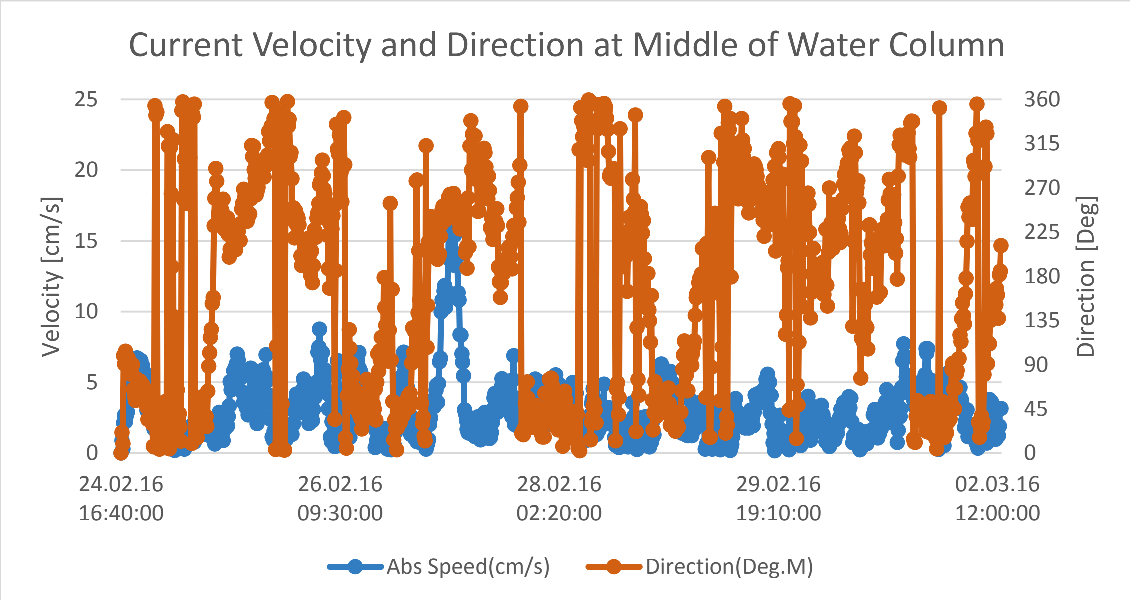
The system was placed at the following coordinates:

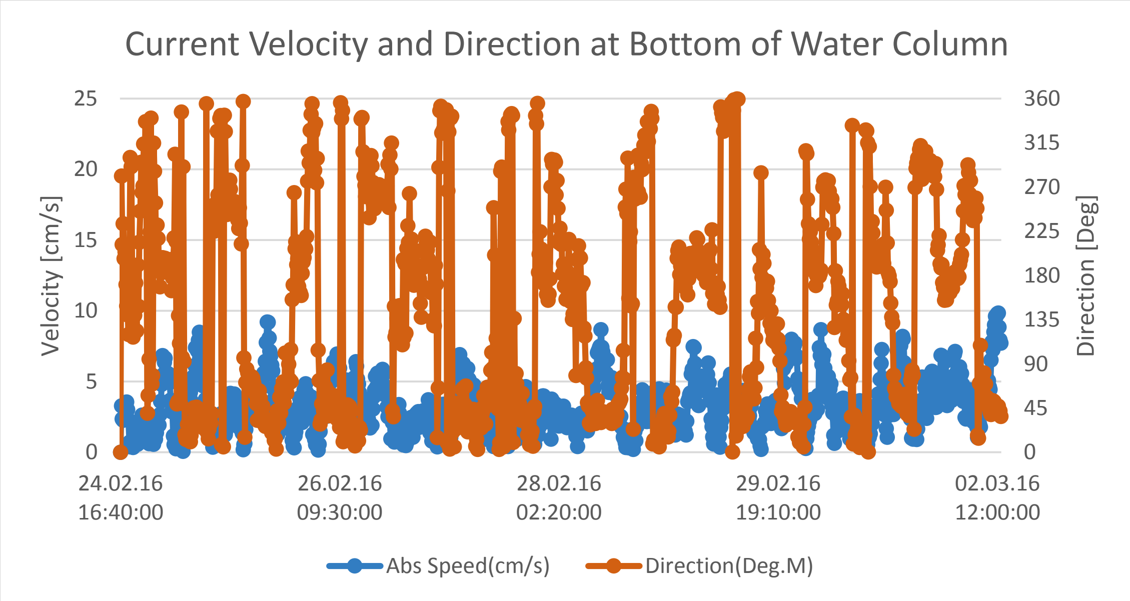
Latitude: 47° 28.720’ N
Longitude: 54° 11.227’ W

The system was deployed on the 24th of February 2016 at 15:30 UTC and recovered on the 2nd of March 2016 at 12:30 UTC.

Displayed current measurements were taken at the following depths:
Top: 30 m
Middle: 80 m
Bottom: 122 m


Current Velocity and Direction at Top of Water Column
Velocity [cm/s]
Direction [Deg]
0
5
10
15
20
25
0
45
90
135
180
225
270
315
360
24.02.16 16:58:00
26.02.16 09:38:00
28.02.16 02:18:00
29.02.16 18:58:00
02.03.16 11:38:00
Abs Speed (cm/s)
Direction (Deg.M)


Current Velocity and Direction at Middle of Water Column
Velocity [cm/s]
Direction [Deg]
0
5
10
15
20
25
0
45
90
135
180
225
270
315
360
24.02.16 16:40:00
26.02.16 09:30:00
28.02.16 02:20:00
29.02.16 19:10:00
02.03.16 12:00:00
Abs Speed(cm/s)
Direction(Deg.M)



2.4 Long Harbour BMA

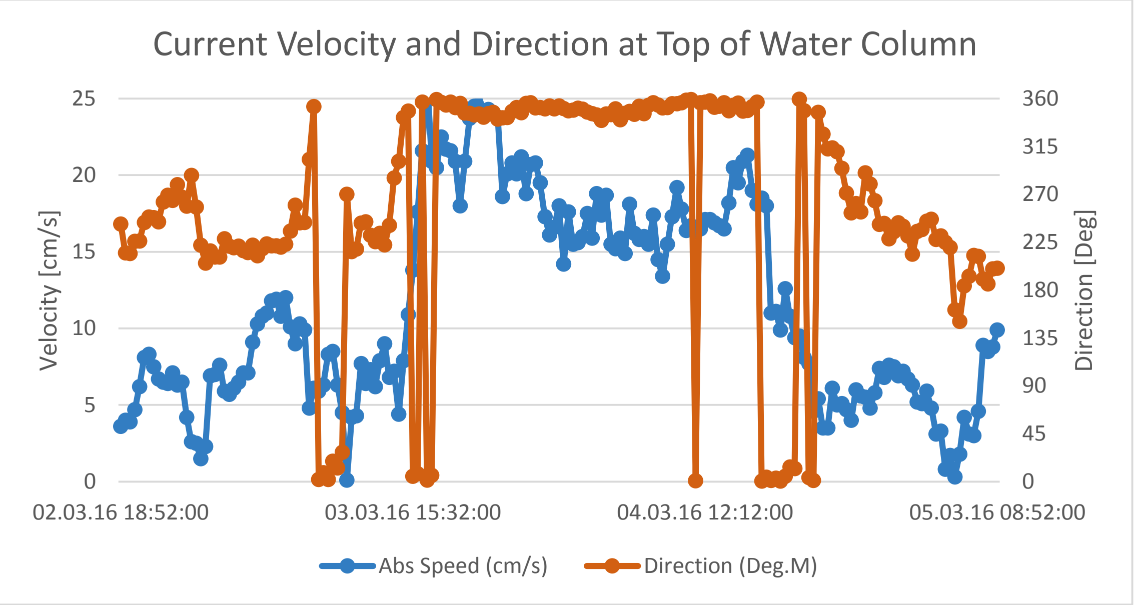
2.4.1 Brine Islands

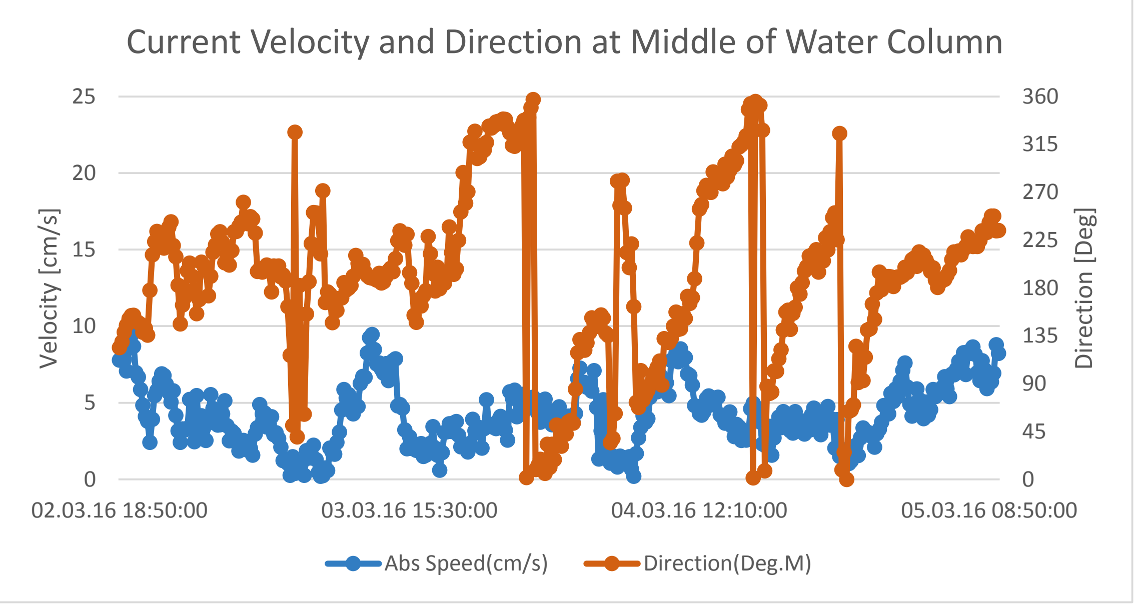
The system was placed at the following coordinates:

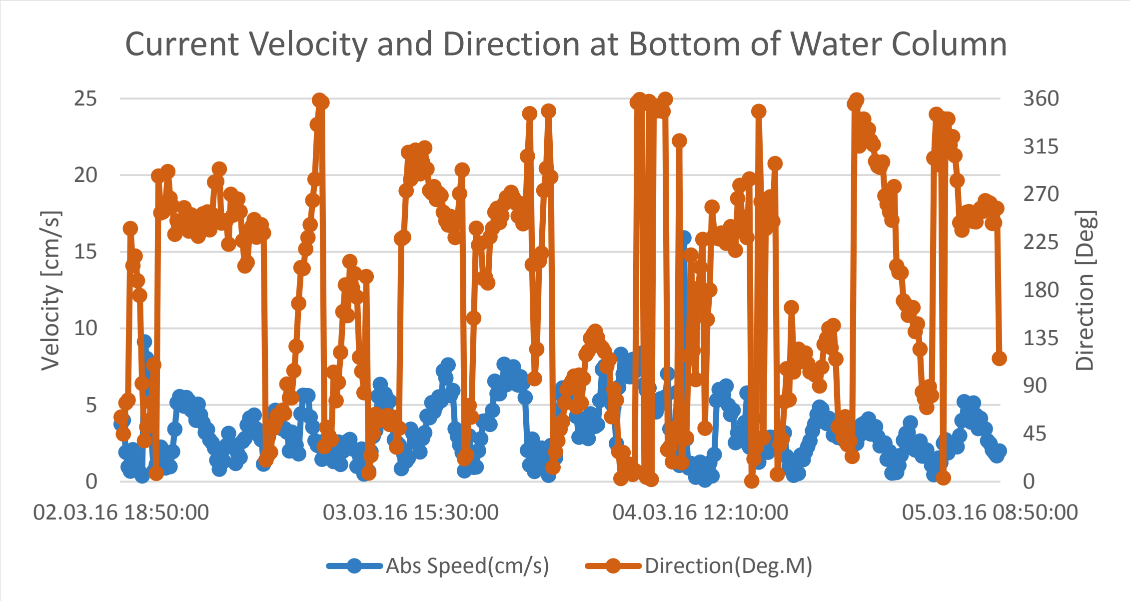
Latitude: 47º 26.736’ N
Longitude: 53º 58.079 W

The system was deployed on the 2nd of March 2016 at 15:00 UTC and recovered on the 5th of March 2016 at 09:45 UTC.

Displayed current measurements were taken at the following depths:
Top: 30 m
Middle: 76 m
Bottom: 115 m


Current Velocity and Direction at Top of Water Column
Velocity [cm/s]
Direction [Deg]
25
20
15
10
5
0
360
315
270
225
180
135
90
45
0
02.03.16 18:52:00
03.03.16 15:32:00
04.03.16 12:12:00
05.03.16 08:52:00
Abs Speed (cm/s)
Direction (Deg.M)


Current Velocity and Direction at Middle of Water Column
Velocity [cm/s]
Direction [Deg]
25
20
15
10
5
0
360
315
270
225
180
135
90
45
0
02.03.16 18:50:00
03.03.16 15:30:00
04.03.16 12:10:00
05.03.16 08:50:00
Abs Speed(cm/s)
Direction(Deg.M)



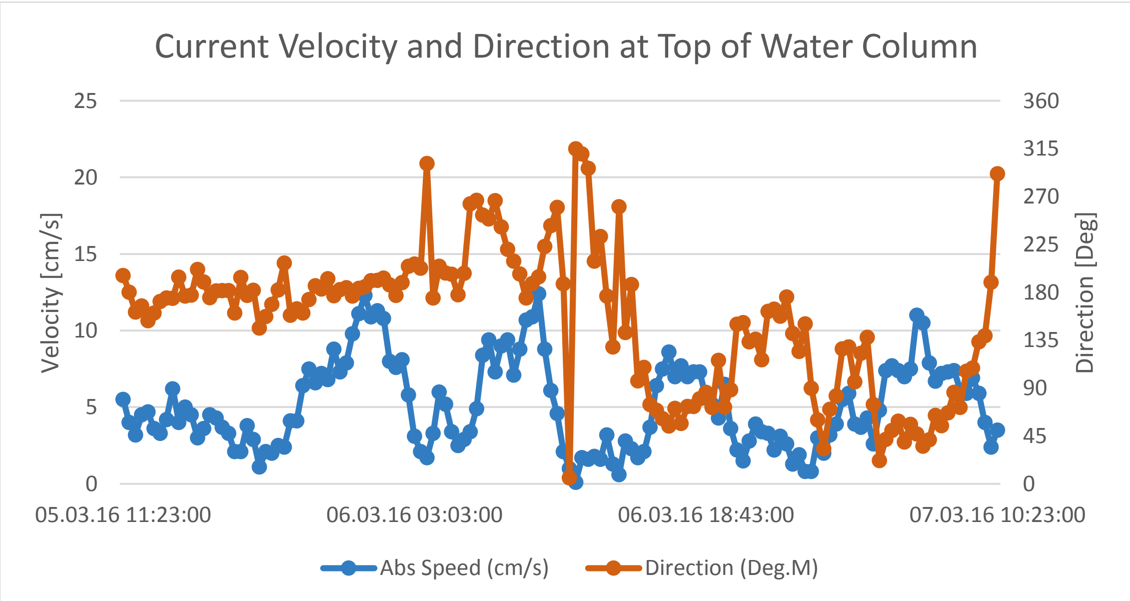
2.4.2 Iona Islands

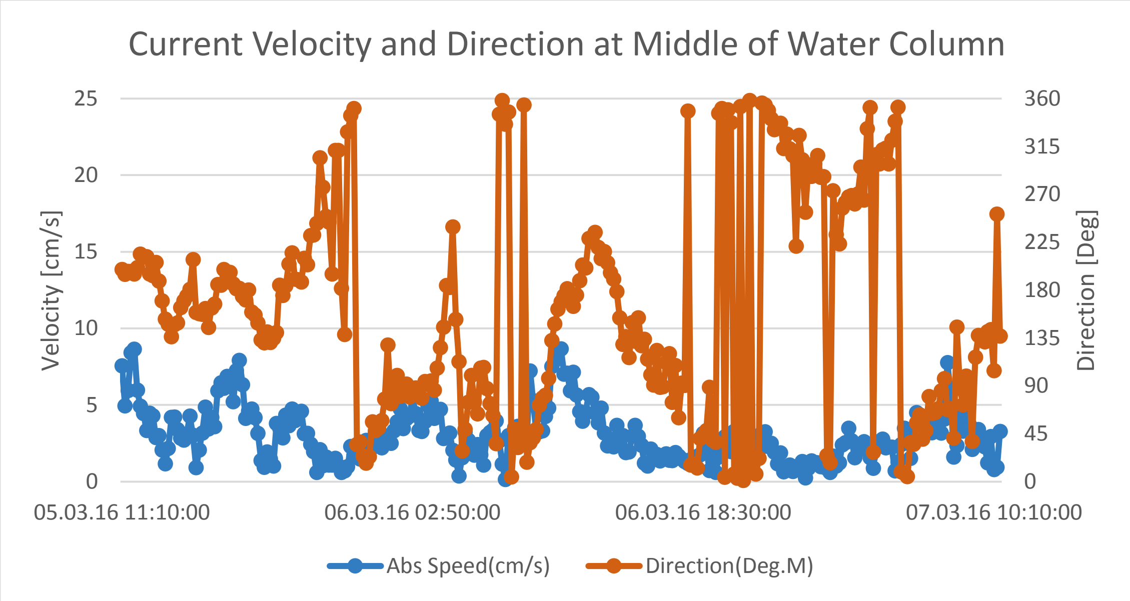
The system was placed at the following coordinates:

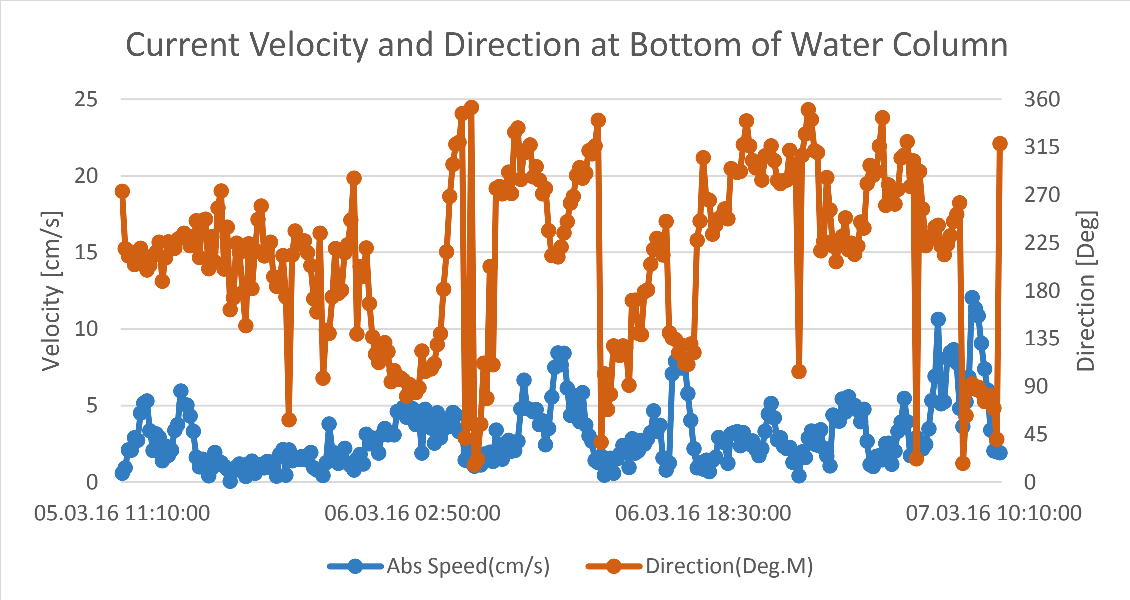
Latitude: 47º 24.607' N
Longitude: 53º 58.600 W

The system was deployed on the 5th of March 2016 at 11:00 UTC and recovered on the 7th of March 2016 at 10:45 UTC.

Displayed current measurements were taken at the following depths:
Top: 30 m
Middle: 65 m
Bottom: 95 m




Current Velocity and Direction at Middle of Water Column
Velocity [cm/s]
Direction [Deg]
25
20
15
10
5
0
360
315
270
225
180
135
90
45
0
05.03.16 11:10:00
06.03.16 02:50:00
06.03.16 18:30:00
07.03.16 10:10:00
Abs Speed(cm/s)
Direction(Deg.M)


Current Velocity and Direction at Bottom of Water Column
Velocity [cm/s]
Direction [Deg]
25
20
15
10
5
0
360
315
270
225
180
135
90
45
0
05.03.16 11:10:00
06.03.16 02:50:00
06.03.16 18:30:00
07.03.16 10:10:00
Abs Speed(cm/s)
Direction(Deg.M)

3 Conclusion

Current parameters were measured in Placentia Bay in the period January to March 2016. The current measurement platform was installed on 11 sites during the period. The total monitoring period varied from site to site between 20 hours up to 7 days.

The general impression is that the current speed is low at all sites. Only on Ship Island, Long Island and Brine Islands were speeds in excess of 20 cm/sec measured which is still considered low. It is, however, noted that the monitoring periods were very short.

Appendix C

Sea Cage Site Physical and Biological Benthic Data

Appendix C-Sea Cage Site: Brine Island (May 2017)

Station	Cage	Latitude	Longitude	Depth (m)	Video Quality	Substrate								
						Primary/ Secondary (>50 % Hard/Soft)	Descriptors							
							Rockwall vertical	Continueous Bedrock	Boulders/Rubble	Cobble	Gravel/Pebble	Mud/Sand	Organic	Floc (% cover)
BI	BI-1	47.45222	-53.96459	82.5	3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% Red algae (Irish moss)	Not present
BI	BI-2	47.45196	-53.96586	82.5	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-3	47.45170	-53.96713	84.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-4	47.45143	-53.96839	89.2	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-5	47.45117	-53.96966	93.7	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-6	47.45091	-53.97093	89.2	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-7	47.45059	-53.97207	88.5	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-8	47.45014	-53.97299	87.7	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-9	47.44923	-53.97432	65.2	3	Primary Hard	Not present	Not present	Not present	40% Cobble		Not present	60% Coralline algae	Not present
BI	BI-10	47.44952	-53.97306	81.0	3	Primary Hard	Not present	Not present	Not present	100% Cobble		Not present		Not present
BI	BI-11	47.44979	-53.97180	90.0	3	Primary Hard	Not present	Not present	Not present	5% Cobble	80% Gravel	Not present	10% Red algae (Irish moss), 5% Coralline algae	Not present
BI	BI-12	47.45005	-53.97053	96.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-13	47.45031	-53.96926	87.0	3	Primary Hard	Not present	Not present	Not present		80% Gravel	Not present	20% Red algae (Irish moss)	Not present
BI	BI-14	47.45058	-53.96800	93.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-15	47.45084	-53.96673	101.0	3	Primary Hard	Not present	Not present	Not present			Not present		Not present
BI	BI-16	47.45110	-53.96546	90.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-17	47.45137	-53.96419	81.0	3	Primary Hard	Not present	Not present	Not present		85% Gravel	Not present	15% Red algae (Irish moss)	Not present
BI	BI-18	47.45051	-53.96379	86.2	3	Primary Hard	Not present	Not present	Not present	90% Cobble		Not present	10% Red algae (Irish moss)	Not present
BI	BI-19	47.45024	-53.96506	92.2	3	Primary Hard	Not present	Not present	Not present	95% Cobble		Not present	5% Red algae (Irish moss)	Not present
BI	BI-20	47.44998	-53.96633	105.0	3	Primary Hard	Not present	Not present	Not present	100% Cobble		Not present		Not present
BI	BI-21	47.44972	-53.96760	108.0	3	Primary Hard	Not present	Not present	Not present	95% Cobble		Not present	5% Red algae (Irish moss)	Not present
BI	BI-22	47.44946	-53.96886	104.0	3	Primary Hard	Not present	Not present	Not present			Not present		Not present
BI	BI-23	47.44919	-53.97013	103.0	3	Primary Hard	Not present	Not present	Not present	100% Cobble		Not present		Not present
BI	BI-24	47.44893	-53.97140	107.0	3	Primary Hard	Not present	Not present	Not present			Not present		Not present
BI	BI-25	47.44867	-53.97267	76.5	3	Primary Hard	Not present	Not present	Not present		80% Gravel	Not present	20% Red algae (Irish moss)	Not present
BI	BI-26	47.44840	-53.97394	66.0	3	Primary Hard	Not present	Not present	Not present	30% Cobble	40% Gravel	Not present	30% Coralline algae	Not present
BI	BI-27	47.44755	-53.97354	96.7	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-28	47.44781	-53.97227	115.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-29	47.44807	-53.97100	115.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-30	47.44834	-53.96973	114.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-31	47.44860	-53.96847	114.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-32	47.44886	-53.96720	113.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	20% Red algae (Irish moss)	Not present
BI	BI-33	47.44912	-53.96593	110.0	3	Primary Hard	Not present	Not present	Not present			Not present		Not present
BI	BI-34	47.44939	-53.96466	101.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-35	47.44965	-53.96340	96.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-36	47.44879	-53.96300	96.7	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-37	47.44853	-53.96426	112.0	3	Primary Hard	Not present	Not present	Not present			Not present		Not present
BI	BI-38	47.44827	-53.96553	115.0	3	Primary Hard	Not present	Not present	Not present			Not present		Not present
BI	BI-39	47.44800	-53.96680	116.0	3	Primary Hard	Not present	Not present	Not present			Not present		Not present
BI	BI-40	47.44774	-53.96807	117.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-41	47.44748	-53.96933	117.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-42	47.44722	-53.97060	117.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-43	47.44695	-53.97187	119.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-44	47.44669	-53.97314	121.0	3	Primary Hard	Not present	Not present	Not present			Not present		Not present
BI	BI-45	47.44583	-53.97274	123.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-46	47.44609	-53.97147	120.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-47	47.44636	-53.97020	117.0	3	Primary Hard	Not present	Not present	Not present			Not present		Not present
BI	BI-48	47.44662	-53.96894	117.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-49	47.44688	-53.96767	117.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-50	47.44715	-53.96640	120.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-51	47.44741	-53.96513	115.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-52	47.44767	-53.96386	109.0	3	Primary Hard	Not present	Not present	Not present		85% Gravel	Not present	15% Red algae (Irish moss)	Not present
BI	BI-53	47.44793	-53.96260	90.7	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-54	47.44708	-53.96220	75.0	3	Primary Hard	Not present	Not present	Not present	15% Cobble	60% Gravel	Not present	20% Red algae (Irish moss), 5% Coralline algae	Not present
BI	BI-55	47.44681	-53.96347	89.2	3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% Red algae (Irish moss)	Not present
BI	BI-56	47.44655	-53.96473	107.0	3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% Red algae (Irish moss)	Not present

Appendix C-Sea Cage Site: Brine Island (May 2017)

Station	Cage	Benthic Indicators				Other Bentic Descriptiors or Observations						
		Beggiatoa (% Cover)	OPC		Barren	Off Gas	Feed	Shell Debris	>Sed. Colour	Flora (% cover)		Fauna (abundance by group)**
			Type	%						Cor. Algae	Other*	eg. Anemones (2), Starfish (1), Porifera (1)
BI	BI-1	Not Present	Not Present	N/A		Not Present	N/A	3%	Grayish Brown		10% Red algae (Irish moss)	Anemone (6), Whelk (1), Clam (1)
BI	BI-2	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (32), Whelk (2)
BI	BI-3	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (2), Whelk (2)
BI	BI-4	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (29), Whelk (2)
BI	BI-5	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (13), Scyphozoa (1), Crab (1), Whelk (2)
BI	BI-6	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (6), Whelk (1)
BI	BI-7	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Aemone (21), Sea star (1), Whelk (1)
BI	BI-8	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (4), Crab (1), Sea urchin (3)
BI	BI-9	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	60% Coralline algae		Anemone (1)
BI	BI-10	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (9), Brittle star (4), Sea star (1), Whelk (1)
BI	BI-11	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	5% Coralline algae	10% Red algae (Irish moss)	Anemone (2)
BI	BI-12	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (24), Whelk (1)
BI	BI-13	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		20% Red algae (Irish moss)	Anemone (2), Brittle star (2), Whelk (1), Crab (1)
BI	BI-14	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (4), Whelk (1)
BI	BI-15	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			
BI	BI-16	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (18), Whelk (1)
BI	BI-17	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		15% Red algae (Irish moss)	Anemone (11), Crab (1)
BI	BI-18	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Red algae (Irish moss)	Anemone (13)
BI	BI-19	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (9)
BI	BI-20	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Flat fish (1)
BI	BI-21	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	
BI	BI-22	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			
BI	BI-23	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (6), Crab (1)
BI	BI-24	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			
BI	BI-25	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		20% Red algae (Irish moss)	Anemone (1), Scyphozoa (1)
BI	BI-26	Not Present	Not Present	N/A		Not Present	N/A	2%	Grayish Brown	30% Coralline algae		Anemone (2)
BI	BI-27	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (1)
BI	BI-28	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (1)
BI	BI-29	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Crab (3)
BI	BI-30	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (2), Small fish (1)
BI	BI-31	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Crab (1), Shrimp (2)
BI	BI-32	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		20% Red algae (Irish moss)	Crab (1), Flat fish (1)
BI	BI-33	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			
BI	BI-34	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (11)
BI	BI-35	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (2), Whelk (1), Clam (2)
BI	BI-36	Not Present	Not Present	N/A		Not Present	N/A	3%	Grayish Brown		5% Red algae (Irish moss)	Anemone (8), Sea urchin (1),
BI	BI-37	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			
BI	BI-38	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			
BI	BI-39	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			
BI	BI-40	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Small fish (1), Crab (1)
BI	BI-41	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (1)
BI	BI-42	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (1)
BI	BI-43	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (3)
BI	BI-44	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			
BI	BI-45	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (2)
BI	BI-46	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (3)
BI	BI-47	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			
BI	BI-48	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (1), Small fish (3)
BI	BI-49	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (1), small fish (2)
BI	BI-50	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Fish (2)
BI	BI-51	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (3),
BI	BI-52	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		15% Red algae (Irish moss)	Anemone (4), Brittle star (1)
BI	BI-53	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (12)
BI	BI-54	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	5% Coralline algae	20% Red algae (Irish moss)	Anemone (3)
BI	BI-55	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Red algae (Irish moss)	Anemone (3), Whelk (1), Sea star (1)
BI	BI-56	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Red algae (Irish moss)	Anemone (8)

Appendix C-Sea Cage Site: Brine Island (May 2017)

Station	Cage	Latitude	Longitude	Depth (m)	Video Quality	Substrate							
							Descriptors						
						Primary/ Secondary (>50 % Hard/Soft)	Rockwall vertical	Continueous Bedrock	Boulders/Rubble	Cobble	Gravel/Pebble	Mud/Sand	Organic	Floc (% cover)
BI	BI-57	47.44629	-53.96600	117.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-58	47.44603	-53.96727	119.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-59	47.44576	-53.96854	120.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-60	47.44550	-53.96980	122.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-61	47.44524	-53.97107	126.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-62	47.44497	-53.97234	120.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-63	47.44412	-53.97194	116.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-64	47.44438	-53.97067	125.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-65	47.44464	-53.96941	123.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-66	47.44491	-53.96814	122.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-67	47.44517	-53.96687	118.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-68	47.44543	-53.96560	113.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-69	47.44569	-53.96434	97.5	3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% Red algae (Irish moss)	Not present
BI	BI-70	47.44596	-53.96307	80.2	3	Primary Hard	Not present	Not present	Not present		97% Gravel	Not present	3% Red algae (Irish moss)	Not present
BI	BI-71	47.44622	-53.96181	72.7	3	Primary Hard	Not present	Not present	Not present	25% Cobble	60% Gravel	Not present	10% Red algae (Irish moss), 5% Coralline algae	Not present
BI	BI-72	47.44536	-53.96141	64.5	3	Primary Hard	Not present	Not present	Not present	20% Cobble	70% Gravel	Not present	10% Coralline algae	Not present
BI	BI-73	47.44510	-53.96267	75.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-74	47.44484	-53.96394	93.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-75	47.44457	-53.96520	108.0	3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% Red algae (Irish moss)	Not present
BI	BI-76	47.44431	-53.96647	114.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-77	47.44405	-53.96774	120.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-78	47.44378	-53.96901	120.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-79	47.44352	-53.97028	118.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-80	47.44326	-53.97154	105.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-81	47.44240	-53.97114	105.0	3	Primary Hard	Not present	Not present	Not present		97% Gravel	Not present	3% Red algae (Irish moss)	Not present
BI	BI-82	47.44266	-53.96988	114.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-83	47.44293	-53.96861	116.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-84	47.44319	-53.96734	112.0	3	Primary Hard	Not present	Not present	Not present			Not present		Not present
BI	BI-85	47.44345	-53.96607	106.0	3	Primary Hard	Not present	Not present	Not present		85% Gravel	Not present	15% Red algae (Irish moss)	Not present
BI	BI-86	47.44372	-53.96481	99.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-87	47.44398	-53.96354	87.7	3	Primary Hard	Not present	Not present	Not present		60% Gravel	Not present	40% Red algae (Irish moss)	Not present
BI	BI-88	47.44424	-53.96227	66.7	3	Primary Hard	Not present	Not present	Not present	25% Cobble	30% Gravel	Not present	25% Red algae (Irish moss), 20% Coralline algae	Not present
BI	BI-89	47.44450	-53.96101	30.7	3	Primary Hard	Not present	Not present	Not present		25% Gravel	Not present	75% Red algae (Irish moss)	Not present
BI	BI-90	47.44364	-53.96061	45.0	3	Primary Hard	Not present	Not present	Not present		50% Gravel	Not present	50% Red algae (Irish moss)	Not present
BI	BI-91	47.44338	-53.96187	76.5	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-92	47.44312	-53.96314	90.0	3	Primary Hard	Not present	Not present	Not present		80% Gravel	Not present	20% Red algae (Irish moss)	Not present
BI	BI-93	47.44286	-53.96441	102.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-94	47.44259	-53.96567	107.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-95	47.44233	-53.96694	97.5	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-96	47.44207	-53.96821	98.2	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
BI	BI-97	47.44181	-53.96948	90.0	3	Primary Hard	Not present	Not present	Not present		85% Gravel	Not present	15% Red algae (Irish moss)	Not present
BI	BI-98	47.44154	-53.97075	84.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-99	47.44069	-53.97035	70.5	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-100	47.44095	-53.96908	78.7	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-101	47.44121	-53.96781	81.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
BI	BI-102	47.44147	-53.96654	78.7	3	Primary Hard	Not present	Not present	Not present	60% Cobble	35% Gravel	Not present	5% Coralline algae	Not present
BI	BI-103	47.44174	-53.96528	89.2	3	Primary Hard	Not present	Not present	Not present		65% Gravel	Not present	35% Red algae (Irish moss)	Not present
BI	BI-104	47.44200	-53.96401	96.7	3	Primary Hard	Not present	Not present	Not present	40% Cobble	60% Gravel	Not present		Not present
BI	BI-105	47.44226	-53.96274	91.5	3	Primary Hard	Not present	Not present	Not present	50% Cobble	40% Gravel	Not present	10% Red algae (Irish moss)	Not present
BI	BI-106	47.44253	-53.96147	75.7	3	Primary Hard	Not present	Not present	Not present	60% Cobble	30% Gravel	Not present	10% Red algae (Irish moss)	Not present
BI	BI-107	47.44279	-53.96021	57.0	3	Primary Hard	Not present	Not present	Not present	65% Cobble	15% Gravel	Not present	20% Coralline algae	Not present
BI	BI-108	47.44191	-53.95981	55.5	3	Primary Hard	Not present	Not present	Not present	30% Cobble	70% Gravel	Not present		Not present
BI	BI-109	47.44165	-53.96106	72.0	3	Primary Hard	Not present	Not present	Not present	40% Cobble	35% Gravel	Not present	15% Red algae (Irish moss) 10% Coralline algae	Not present
BI	BI-110	47.44140	-53.96234	87.0	3	Primary Hard	Not present	Not present	Not present	45% Cobble	55% Gravel	Not present		Not present
BI	BI-111	47.44112	-53.96359	85.5	3	Primary Hard	Not present	Not present	Not present	25% Cobble	75% Gravel	Not present		Not present
BI	BI-112	47.44085	-53.96489	71.2	3	Primary Hard	Not present	Not present	Not present	30% Cobble	30% Gravel	Not present	30% Red algae (Irish moss), 10% Coralline algae	Not present
BI	BI-113	47.44059	-53.96613	78.7	3	Primary Hard	Not present	Not present	Not present	15% Cobble	45% Gravel	Not present	40% Red algae (Irish moss)	Not present
BI	BI-114	47.44033	-53.96740	78.7	3	Primary Hard	Not present	Not present	Not present	20% Cobble	70% Gravel	Not present	10% Red algae (Irish moss)	Not present
BI	BI-115	47.44006	-53.96867	66.0	3	Primary Hard	Not present	Not present	Not present	25% Cobble	55% Gravel	Not present	15% Red algae (Irish moss), 5% Coralline algae	Not present
BI	BI-116	47.43980	-53.96993	58.5	3	Primary Hard	Not present	Not present	Not present	30% Cobble	45% Gravel	Not present	25% Coralline alage	Not present

Appendix C-Sea Cage Site: Brine Island (May 2017)

Station	Cage	Benthic Indicators				Other Bentic Descriptiors or Observations						
		Beggiatoa (% Cover)	OPC		Barren	Off Gas	Feed	Shell Debris	>Sed. Colour	Flora (% cover)		Fauna (abundance by group)**
			Type	%						Cor. Algae	Other*	eg. Anemones (2), Starfish (1), Porifera (1)
BI	BI-57	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	
BI	BI-58	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Small fish (3)
BI	BI-59	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (1)
BI	BI-60	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Fish (1)
BI	BI-61	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (13), Anemone (4), Fish (1)
BI	BI-62	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (3), Whelk (1), Anemone (1)
BI	BI-63	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (3), Anemone (1)
BI	BI-64	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (2), Whelk (1)
BI	BI-65	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (3), Fish (2)
BI	BI-66	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (1)
BI	BI-67	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (3)
BI	BI-68	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (8),
BI	BI-69	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Red algae (Irish moss)	Anemone (2)
BI	BI-70	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		3% Red algae (Irish moss)	Anemone (16)
BI	BI-71	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	5% Coralline algae	10% Red algae (Irish moss)	Anemone (12)
BI	BI-72	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	10% Coralline algae		Anemone (3), Sea star (1), Whelk (1)
BI	BI-73	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Sea star (1), Anemone (9)
BI	BI-74	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (12)
BI	BI-75	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Red algae (Irish moss)	Crab (3), Anemone (8)
BI	BI-76	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (1), Crab (1), Small fish (1)
BI	BI-77	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Aneome (1)
BI	BI-78	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (2)
BI	BI-79	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (2)
BI	BI-80	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (1)
BI	BI-81	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		3% Red algae (Irish moss)	Small fish (1)
BI	BI-82	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Fish (8)
BI	BI-83	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Small fish (1)
BI	BI-84	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			
BI	BI-85	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		15% Red algae (Irish moss)	Anemone (6), Small fish (7)
BI	BI-86	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Whelk (1), Clam (1), Anemone (5), Brittle star (4)
BI	BI-87	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		40% Red algae (Irish moss)	Anemone (4), Whelk (1)
BI	BI-88	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	20% Coralline algae	25% Red algae (Irish moss)	Anemone(1)
BI	BI-89	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		75% Red algae (Irish moss)	
BI	BI-90	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		50% Red algae (Irish moss)	Anemone (3)
BI	BI-91	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (14), Sea star (1)
BI	BI-92	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		20% Red algae (Irish moss)	Anemone (10)
BI	BI-93	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Aneone (7), Small fish (4)
BI	BI-94	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Cleam (1), Scyphozoa (1)
BI	BI-95	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (7), Clam (1)
BI	BI-96	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (5)
BI	BI-97	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		15% Red algae (Irish moss)	Anemone (1)
BI	BI-98	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (13), Small fish (3)
BI	BI-99	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (25)
BI	BI-100	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (15), Whelk (1)
BI	BI-101	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (3)
BI	BI-102	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	5% Coralline algae		Anemone (17)
BI	BI-103	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		35% Red algae (Irish moss)	Crab (1)
BI	BI-104	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (7), Small fishn (3)
BI	BI-105	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Red algae (Irish moss)	Anemone (9), Whelk (2)
BI	BI-106	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Red algae (Irish moss)	Anemone (8), Whelk (1)
BI	BI-107	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	20% Coralline algae		Anemone (1)
BI	BI-108	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	40% Coralline algae		Sea urchin (1), Whelk (1)
BI	BI-109	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	10% Coralline algae	15% Red algae (Irish moss)	Anemone (4), Schyphoza(1)
BI	BI-110	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (31)
BI	BI-111	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (16)
BI	BI-112	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	10% Coralline algae	30% Red algae (Irish moss)	Sea star (1), Anemone (1)
BI	BI-113	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		40% Red algae (Irish moss)	Anemone (8)
BI	BI-114	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Red algae (Irish moss)	Anemone (29)
BI	BI-115	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	5% Coralline algae	15% Red algae (Irish moss)	Anemone (26)
BI	BI-116	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	25% Coralline alage		Anemone (24), Sea star (1)

Appendix C-Sea Cage Site: Gallows Harbour (February and March 2017)

Station	Cage	Latitude	Longitude	Depth (m)	Video Quality	Substrate								
						Primary/ Secondary (>50 % Hard/Soft)	Descriptors							
							Rockwall vertical	Continueous Bedrock	Boulders/Rubble	Cobble	Gravel/Pebble	Mud/Sand	Organic	Floc (% cover)
GH	GH-1	47.36698	-54.69396	76.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% coralline algae	Not present
GH	GH-2	47.36667	-54.69271	88.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-3	47.36636	-54.69147	93.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-4	47.36606	-54.69023	86.0	3	Primary Hard	Not present	Not present	Not present		97% Gravel	Not present	3% Red algae (Irish moss)	Not present
GH	GH-5	47.36575	-54.68899	79.0	3	Primary Hard	Not present	Not present	Not present		97% Gravel	Not present	3% Red algae (Irish moss)	Not present
GH	GH-6	47.36544	-54.68774	83.0	3	Primary Hard	Not present	Not present	Not present		99% Gravel	Not present	1% Red algae (Irish moss)	Not present
GH	GH-7	47.36513	-54.68650	79.0	3	Primary Hard	Not present	Not present	Not present		15% Gravel	Not present	85% Red algae (Irish moss)	Not present
GH	GH-8	47.36426	-54.68696	82.0	3	Primary Hard	Not present	Not present	Not present		98% Gravel	Not present	2% Red algae (Irish moss)	Not present
GH	GH-9	47.36457	-54.68820	86.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-10	47.36488	-54.68944	92.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-11	47.36519	-54.69069	91.0	3	Primary Hard	Not present	Not present	Not present		98% Gravel	Not present	2% coralline algae	Not present
GH	GH-12	47.36550	-54.69193	86.0	3	Primary Hard	Not present	Not present	Not present	12% cobble	58% Gravel	Not present	10% coralline algae/20% Red algae	Not present
GH	GH-13	47.36581	-54.69317	98.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-14	47.36612	-54.69441	63.0	3	Primary Hard	Not present	Not present	Not present	13% cobble	62% Gravel	Not present	25% coralline algae	Not present
GH	GH-15	47.36528	-54.69486	63.0	3	Primary Hard	Not present	Not present	Not present	10% cobble	30% Gravel	Not present	60% coralline algae	Not present
GH	GH-16	47.36497	-54.69362	96.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-17	47.36466	-54.69238	87.0	3	Primary Hard	Not present	Not present	Not present		98% Gravel	Not present	2% coralline algae	Not present
GH	GH-18	47.36435	-54.69113	101.0	3	Primary Hard	Not present	Not present	Not present	10% cobble	85% Gravel	Not present	5% Red alage (Irish moss)	Not present
GH	GH-19	47.36404	-54.68989	94.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-20	47.36373	-54.68865	81.0	3	Primary Hard	Not present	Not present	Not present		99% Gravel	Not present	1% coralline algae	Not present
GH	GH-21	47.36342	-54.68740	74.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-22	47.36257	-54.68785	83.0	3	Primary Hard	Not present	Not present	Not present	25% cobble	75% Gravel	Not present		Not present
GH	GH-23	47.36288	-54.68910	81.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-24	47.36319	-54.69034	89.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-25	47.36350	-54.69158	109.0	3	Primary Hard	Not present	Not present	Not present	3% cobble	92% Gravel	Not present	5% Red alage (Irish moss)	Not present
GH	GH-26	47.36381	-54.69283	106.0	3	Primary Hard	Not present	Not present	Not present	3% cobble	95% Gravel	Not present	2% Red alage (Irish moss)	Not present
GH	GH-27	47.36412	-54.69407	106.0	3	Primary Hard	Not present	Not present	Not present	18% cobble	80% Gravel	Not present	2% Red alage (Irish moss)	Not present
GH	GH-28	47.36443	-54.69531	88.0	3	Primary Hard	Not present	Not present	Not present		99% Gravel	Not present	1% coralline algae	Not present
GH	GH-29	47.36358	-54.69576	103.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-30	47.36327	-54.69452	107.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-31	47.36296	-54.69328	117.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-32	47.36266	-54.69203	119.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-33	47.36235	-54.69079	91.0	3	Primary Hard	Not present	Not present	Not present		99% Gravel	Not present	1% coralline algae	Not present
GH	GH-34	47.36204	-54.68955	96.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-35	47.36173	-54.68830	86.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-36	47.36088	-54.68875	72.0	3	Primary Hard	Not present	Not present	Not present	20% cobble	60% Gravel	Not present	20% coralline algae	Not present
GH	GH-37	47.36119	-54.69000	100.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-38	47.36150	-54.69124	106.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-39	47.36181	-54.69248	138.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red alage (Irish moss)	Not present
GH	GH-40	47.36212	-54.69372	127.0	3	Primary Hard	Not present	Not present	Not present	10% cobble	60% Gravel	Not present	5% Red alage (Irish moss), 25% Corraline algae	Not present
GH	GH-41	47.36243	-54.69497	114.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-42	47.36274	-54.69621	105.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-43	47.36189	-54.69666	110.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-44	47.36158	-54.69542	119.0	3	Primary Hard	Not present	Not present	Not present	10% cobble	77% Gravel	Not present	10% Palmaria, 3% Red alage (Irish moss)	Not present
GH	GH-45	47.36127	-54.69417	127.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-46	47.36096	-54.69293	146.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-47	47.36065	-54.69169	117.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-48	47.36035	-54.69045	99.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-49	47.36004	-54.68920	74.0	3	Primary Hard	Not present	Not present	Not present	8% cobble	89% Gravel	Not present	3% coralline algae	Not present
GH	GH-50	47.35919	-54.68965	83.0	3	Primary Hard	Not present	Not present	Not present	28% cobble	72% Gravel	Not present		Not present
GH	GH-51	47.35950	-54.69089	109.0	3	Primary Hard	Not present	Not present	Not present	5% cobble	85% Gravel	Not present	10% red algae (Irish moss)	Not present
GH	GH-52	47.35981	-54.69214	136.0	3	Primary Hard	Not present	Not present	Not present	10% cobble	20% Gravel	Not present	60% Red algae (Irish moss)	Not present
GH	GH-53	47.36012	-54.69338	113.0	3	Primary Hard	Not present	Not present	Not present	12% cobble	88% Gravel	Not present	25% Red algae (Irish moss)	Not present
GH	GH-54	47.36043	-54.69462	117.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-55	47.36074	-54.69586	112.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-56	47.36105	-54.69710	109.0	3	Primary Hard	Not present	Not present	Not present	5% cobble	85% Gravel	Not present	10% red algae (Irish moss)	Not present
GH	GH-57	47.36021	-54.69755	103.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-58	47.35990	-54.69631	108.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-59	47.35959	-54.69507	111.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-60	47.35928	-54.69383	110.0	3	Primary Hard	Not present	Not present	Not present	10% cobble	65% Gravel	Not present	25% Red algae (Irish moss)	Not present

Appendix C-Sea Cage Site: Gallows Harbour (February and March 2017)

Station	Cage	Benthic Indicators			Barren	Other Bentic Descriptiors or Observations						
		Beggiatoa (% Cover)	OPC			Off Gas	Feed	Shell Debris	>Sed. Colour	Flora (% cover)		Fauna (abundance by group)**
			Type	%						Cor. Algae	Other*	eg. Anemones (2), Starfish (1), Porifera (1)
GH	GH-1	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	5% coralline algae		Brittle stars (7), Feather star (1), Anemone (2)
GH	GH-2	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Brittle stars (9), Seastar (1), Anemone (4)
GH	GH-3	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Brittle stars (1), Anemone (8), Scyphozoa (1)
GH	GH-4	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		3% Red algae (Irish moss)	Sea star (1), Brittle star (7), Anemone (14)
GH	GH-5	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		3% Red algae (Irish moss)	Brittle star (5), Aemone (31), Whelk (1)
GH	GH-6	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		1% Red algae (Irish moss)	Anemone (1)
GH	GH-7	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		85% Red algae (Irish moss)	Brittle star (4), Anemone (1)
GH	GH-8	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		2% Red algae (Irish moss)	Brittle star (2), Anemone (1)
GH	GH-9	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (1), Anemone (2)
GH	GH-10	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (1), Anemone (1), Small fish (5)
GH	GH-11	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	2% coralline algae		Shrimp (1), Anemone (12), Scyphozoa (1), Brittle star (3)
GH	GH-12	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	10% coralline algae	20% Red algae (Irish moss)	Feather star (1), Brittle star (5)
GH	GH-13	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (1), Small fish (5), Anemone (3)
GH	GH-14	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	25% coralline algae		Anemone (5), Brittle stars (4)
GH	GH-15	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	60% coralline algae		Anemone (1), Scallop (1)
GH	GH-16	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Brittle stars (29), Whelk (1), Anemone (2)
GH	GH-17	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	2% coralline algae		Anemone (8), Scyphozoa (1), Brittle stars (3)
GH	GH-18	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red alage (Irish moss)	Anemone (13), Shrimp (5)
GH	GH-19	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (3), Anemone (13)
GH	GH-20	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	1% coralline algae		Anemone (33)
GH	GH-21	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Seastar (1), Anemone (11)
GH	GH-22	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (1), seastar (1), brittle star (4), anemone (8)
GH	GH-23	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (8), Scallop (1)
GH	GH-24	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (5)
GH	GH-25	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red alage (Irish moss)	Shrimp (4), Scyphozoa (3), Anemone (7)
GH	GH-26	Not Present	Not Present	N/A		Not Present	N/A	2%	Grayish Brown		2% Red alage (Irish moss)	Scyphozoa (5), Anemone (2)
GH	GH-27	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		2% Red alage (Irish moss)	Anemone (6), Scyphozoa (4) , Shrimp (2)
GH	GH-28	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	1% coralline algae		Anemone (20), Brittle star (3), Scyphozoa (1)
GH	GH-29	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Holothuroidea (1), Anemone (21), Shrimp (1)
GH	GH-30	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (4), Anemone (7), Scyphozoa (3), Crab (1)
GH	GH-31	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (6), Scyphozoa (3), Anemone (5), Small fish (2)
GH	GH-32	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Amenome (19), Scyphozoa (1)
GH	GH-33	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	1% coralline algae		Anemone (9), Brittle star (1)
GH	GH-34	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (10), Shrimp (4), Scyphozoa (5)
GH	GH-35	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (14)
GH	GH-36	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	20% coralline algae		Sculpin (1), Brittle star (5)
GH	GH-37	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (39), Shrimp (1), Scyphozoa (3)
GH	GH-38	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Sycphozoa (4), Shrimp (3), Anemone (5), Whelk (1)
GH	GH-39	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red alage (Irish moss)	Shrimp (11), Anemone (1)
GH	GH-40	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	25% coralline algae	5% Red alage (Irish moss)	Shrimp (2), Anemone (15), Scyphozoa (1), Sea Cucumber (1), Whelk (1)
GH	GH-41	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (5), Anemone (11), Scyphozoa (6)
GH	GH-42	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (2), Anemone (9), Crab (1)
GH	GH-43	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (7), Anemone (11), Scyphozoa (2), Crab (2)
GH	GH-44	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Palmaria, 3% Red alage (Irish moss)	Ameone (9),
GH	GH-45	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (11), Anemone (6), Scyphozoa (12), Small fish (1)
GH	GH-46	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (7), Shrimp (2), Crab (1), Scyphozoa (12)
GH	GH-47	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (3), Anemone (5), Small fish (1)
GH	GH-48	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (3)
GH	GH-49	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	3% coralline algae		Whelk (2), Brittle star (4)
GH	GH-50	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Brittle star (8), Anemone (7)
GH	GH-51	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% red algae (Irish moss)	Anemone (4)
GH	GH-52	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		60% Red algae (Irish moss)	Brittle star (33), Clam (1)
GH	GH-53	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		25% Red algae (Irish moss)	Shrimp (1), Anemone (2), Brittle star (21), Scyphozoa (1), Clam (1), Sea star (1), Fish (1)
GH	GH-54	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (2), Anemone (8), Scyphozoa (4), Crab (1)
GH	GH-55	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (2),Anmemone (4), Scyphozoa (2), Cottidae (2)
GH	GH-56	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% red algae (Irish moss)	Shrimp (1), Anemone (3), Scyphozoa (4)
GH	GH-57	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (3), Crab (1)
GH	GH-58	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (2), Anemone (2), Scyphozoa (1), Crab (1)
GH	GH-59	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (2), Anemone (6)
GH	GH-60	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		25% Red algae (Irish moss)	Shrimp (1), Anemone (5), Scyphozoa (1), Brittle star (13)

Appendix C-Sea Cage Site: Gallows Harbour (February and March 2017)

Station	Cage	Latitude	Longitude	Depth (m)	Video Quality	Substrate: Primary/ Secondary (>50 % Hard/Soft)	Descriptors: Rockwall vertical	Continueous Bedrock	Boulders/Rubble	Cobble	Gravel/Pebble	Mud/Sand	Organic	Floc (% cover)
GH	GH-61	47.35897	-54.69258	124.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-62	47.35866	-54.69134	109.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-63	47.35835	-54.69010	72.0	3	Primary Hard	Not present	Not present	Not present	46% cobble	54% Gravel	Not present		Not present
GH	GH-64	47.35750	-54.69055	80.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-65	47.35781	-54.69179	113.0	3	Primary Hard	Not present	Not present	Not present		95%Gravel	Not present	5% Red alage (Irish moss)	Not present
GH	GH-66	47.35812	-54.69303	111.0	3	Primary Hard	Not present	Not present	Not present		95%Gravel	Not present	5% Red alage (Irish moss)	Not present
GH	GH-67	47.35843	-54.69428	112.0	3	Primary Hard	Not present	Not present	Not present		97% Gravel	Not present	3% Red algae (Irish moss)	Not present
GH	GH-68	47.35874	-54.69552	110.0	3	Primary Hard	Not present	Not present	Not present		97% Gravel	Not present	3% Red algae (Irish moss)	Not present
GH	GH-69	47.35905	-54.69676	103.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-70	47.35936	-54.69800	93.0	3	Primary Hard	Not present	Not present	Not present		98% Gravel	Not present	2% coralline algae	Not present
GH	GH-71	47.35851	-54.69845	86.0	3	Primary Hard	Not present	Not present	Not present	44% cobble	66% Gravel	Not present		Not present
GH	GH-72	47.35820	-54.69721	93.0	3	Primary Hard	Not present	Not present	Not present		96% Gravel	Not present	4% coralline algae	Not present
GH	GH-73	47.35789	-54.69597	109.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-74	47.35758	-54.69473	103.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-75	47.35727	-54.69348	109.0	3	Primary Hard	Not present	Not present	Not present	20% cobble	68% Gravel	Not present	12% red algae (Irish moss)	Not present
GH	GH-76	47.35696	-54.69224	104.0	3	Primary Hard	Not present	Not present	Not present	5% cobble	90% Gravel	Not present	5% Red alage (Irish moss)	Not present
GH	GH-77	47.35665	-54.69100	86.0	3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% red algae (Irish moss)	Not present
GH	GH-78	47.35581	-54.69145	97.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-79	47.35612	-54.69269	114.0	3	Primary Hard	Not present	Not present	Not present		65% Gravel	Not present	35% Red algale (Irish moss)	Not present
GH	GH-80	47.35643	-54.69393	94.0	3	Primary Hard	Not present	Not present	Not present	32% cobble	48% Gravel	Not present	20% red algae (Irish moss)	Not present
GH	GH-81	47.35674	-54.69517	92.0	3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% red algae (Irish moss)	Not present
GH	GH-82	47.35705	-54.69642	100.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-83	47.35735	-54.69766	122.0	3	Primary Hard	Not present	Not present	Not present	3% cobble	92% Gravel	Not present	5% Red alage (Irish moss)	Not present
GH	GH-84	47.35766	-54.69890	98.0	3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% red algae (Irish moss)	Not present
GH	GH-85	47.35681	-54.69935	80.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-86	47.35650	-54.69811	88.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-87	47.35620	-54.69687	98.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-88	47.35589	-54.69562	107.0	3	Primary Hard	Not present	Not present	Not present	5% cobble	75% Gravel	Not present	20% red algae (Irish moss)	Not present
GH	GH-89	47.35558	-54.69438	102.0	3	Primary Hard	Not present	Not present	Not present	15% cobble	80% Gravel	Not present	5% Red algae (Irish moss)	Not present
GH	GH-90	47.35527	-54.69314	120.0	3	Primary Hard	Not present	Not present	Not present		70% Gravel	Not present	30% Red algae (Irish moss)	Not present
GH	GH-91	47.35496	-54.69190	123.0	3	Primary Hard	Not present	Not present	Not present		75% Gravel	Not present	25% Red algae (Irish moss)	Not present
GH	GH-92	47.35412	-54.69235	122.0	3	Primary Hard	Not present	Not present	Not present		85% Gravel	Not present	15% Red algae (Irish moss)	Not present
GH	GH-93	47.35443	-54.69359	118.0	3	Primary Hard	Not present	Not present	Not present	10% cobble	80% Gravel	Not present	10% red algae (Irish moss)	Not present
GH	GH-94	47.35474	-54.69483	122.0	3	Primary Hard	Not present	Not present	Not present		97% Gravel	Not present	3% Red algae (Irish moss)	Not present
GH	GH-95	47.35504	-54.69607	107.0	3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% red algae (Irish moss)	Not present
GH	GH-96	47.35535	-54.69731	83.0	3	Primary Hard	Not present	Not present	Not present		86% Gravel	Not present	2% coralline algae/12% red algae	Not present
GH	GH-97	47.35566	-54.69856	60.0	3	Primary Hard	Not present	Not present	Not present	90% cobble	10% Gravel	Not present	90% coralline algae	Not present
GH	GH-98	47.35597	-54.69980	58.0	3	Primary Hard	Not present	Not present	Not present	75% cobble	25% Gravel	Not present	75% coralline algae	Not present
GH	GH-99	47.35513	-54.70024	49.0	3	Primary Hard	Not present	Not present	Not present	85% cobble	15% Gravel	Not present	85% coralline algae	Not present
GH	GH-100	47.35482	-54.69900	55.0	3	Primary Hard	Not present	Not present	Not present	30% cobble	70% Gravel	Not present	30% coralline algae	Not present
GH	GH-101	47.35451	-54.69776	71.0	3	Primary Hard	Not present	Not present	Not present	20% cobble	80% Gravel	Not present	15% coralline algae	Not present
GH	GH-102	47.35420	-54.69652	99.0	3	Primary Hard	Not present	Not present	Not present	15% cobble	85% Gravel	Not present		Not present
GH	GH-103	47.35389	-54.69528	112.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-104	47.35358	-54.69404	113.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red alage (Irish moss)	Not present
GH	GH-105	47.35327	-54.69280	119.0	3	Primary Hard	Not present	Not present	Not present		50% Gravel	Not present	50% Red algae (Irish moss)	Not present
GH	GH-106	47.35244	-54.69321	113.0	3	Primary Hard	Not present	Not present	Not present	5% cobble	85% Gravel	Not present	10% red algae (Irish moss)	Not present
GH	GH-107	47.35291	-54.69432	111.0	3	Primary Hard	Not present	Not present	Not present	10% cobble	60% Gravel	Not present	20% red algae (Irish moss)	Not present
GH	GH-108	47.35315	-54.69573	96.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-109	47.35336	-54.69697	95.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-110	47.35367	-54.69822	69.0	3	Primary Hard	Not present	Not present	Not present	25% cobble	75% Gravel	Not present		Not present
GH	GH-111	47.35398	-54.69946	56.0	3	Primary Hard	Not present	Not present	Not present	70% cobble	30% Gravel	Not present	65% coralline algae	Not present
GH	GH-112	47.35429	-54.70069	46.0	3	Primary Hard	Not present	Not present	Not present	85% cobble	15% Gravel	Not present	80% coralline algae/10% red algae	Not present
GH	GH-113	47.35344	-54.70114	61.0	3	Primary Hard	Not present	Not present	Not present	15% cobble	85% Gravel	Not present	10% coralline algae	Not present
GH	GH-114	47.35313	-54.69991	56.0	3	Primary Hard	Not present	Not present	Not present	40% cobble	60% Gravel	Not present	40% coralline algae	Not present
GH	GH-115	47.35296	-54.69876	77.0	3	Primary Hard	Not present	Not present	Not present	8% cobble	92% Gravel	Not present	8% coralline algae	Not present
GH	GH-116	47.35295	-54.69754	67.0	3	Primary Hard	Not present	Not present	Not present	20% cobble	80% Gravel	Not present		Not present
GH	GH-117	47.35178	-54.69318	114.0	3	Primary Hard	Not present	Not present	Not present			Not present	being identified by AMEC	Not present
GH	GH-118	47.35243	-54.69949	74.0	3	Primary Hard	Not present	Not present	Not present	15% cobble	85% Gravel	Not present	10% coralline algae	Not present
GH	GH-119	47.35233	-54.70040	64.0	3	Primary Hard	Not present	Not present	Not present	10% cobble	80% Gravel	Not present	5%coralline algae	Not present
GH	GH-120	47.35259	-54.70159	70.0	3	Primary Hard	Not present	Not present	Not present	10% cobble	80% Gravel	Not present	10% coralline algae	Not present
GH	GH-121	47.35175	-54.70204	69.0	3	Primary Hard	Not present	Not present	Not present	30% cobble	70% Gravel	Not present	30% coralline algae	Not present
GH	GH-122	47.35161	-54.70109	72.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
GH	GH-123	47.35108	-54.70163	76.0	3	Primary Hard	Not present	Not present	Not present	% cobble	92% Gravel	Not present		Not present
GH	GH-124	47.35095	-54.70254	71.0	3	Primary Hard	Not present	Not present	Not present	35% cobble	65% Gravel	Not present	35% coralline algae	Not present

Appendix C-Sea Cage Site: Gallows Harbour (February and March 2017)

Station	Cage	Benthic Indicators				Other Bentic Descriptiors or Observations						
		Beggiatoa (% Cover)	OPC		Barren	Off Gas	Feed	Shell Debris	>Sed. Colour	Flora (% cover)		Fauna (abundance by group)**
			Type	%						Cor. Algae	Other*	eg. Anemones (2), Starfish (1), Porifera (1)
GH	GH-61	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (12), Brittle Star (10), Scyphozoa (1), Whelk (2)
GH	GH-62	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (2), Anemone (5)
GH	GH-63	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (2)
GH	GH-64	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		8% Red algae (Irish moss)	Brittle star (6), Anemone (4)
GH	GH-65	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red alage (Irish moss)	Shrimp (2), Anemone (8), Brittle star (6), Clam (1)
GH	GH-66	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red alage (Irish moss)	Brittle star (22), Anemone (4)
GH	GH-67	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		3% Red algae (Irish moss)	Shrimp (2), Scyphozoa (2)
GH	GH-68	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		3% Red algae (Irish moss)	Shrimp (4), Anemone (13), Scyphozoa (2)
GH	GH-69	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Shrimp (1), Brittle star (2), Scyphozoa (2), Anemone (16)
GH	GH-70	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	2% coralline algae		Brittle star (2), anemone (13)
GH	GH-71	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Brittle star (14), Anemone (3)
GH	GH-72	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	4% coralline algae		Brittle star (16), Anemone (3)
GH	GH-73	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (11), Scyphozoa (4)
GH	GH-74	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (5), Scyphozoa (1), Basket star (1)
GH	GH-75	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		12% red algae (Irish moss)	Anemone (17), Brittle star (7)
GH	GH-76	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red alage (Irish moss)	Shrimp (2), Anemone (3)
GH	GH-77	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% red algae (Irish moss)	Brittle star (4), Anemone (3)
GH	GH-78	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Brittle star (9), Anemone (4)
GH	GH-79	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		35% Red algale (Irish moss)	Anemone (6), Brittle star (16), Sea cucumber (1)
GH	GH-80	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		20% red algae (Irish moss)	Brittle star (19), Sea urchin (1)
GH	GH-81	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% red algae (Irish moss)	Brittle star (20), Feather star (1), Anemone (3)
GH	GH-82	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Crab (1), Shrimp (1), Anemone (29), Brittle star (4)
GH	GH-83	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red alage (Irish moss)	Anemone (8), Scyphozoa (3)
GH	GH-84	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% red algae (Irish moss)	Brittle star (7), Shrimp (2), Fish (1), Scyphozoa (2), Crab (1)
GH	GH-85	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (33)
GH	GH-86	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Brittle star (3), Anemone (39), Shrimp (1), Small fish (1)
GH	GH-87	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Brittle star (1), Anemone (5)
GH	GH-88	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		20% red algae (Irish moss)	Anemone (2), Brittle star (15), Clam (1)
GH	GH-89	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red alage (Irish moss)	Anemone (6), Brittle star (2)
GH	GH-90	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		30% Red algae (Irish moss)	Shrimp (1), Anemone (6), Brittle star (17), Whelk (1)
GH	GH-91	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		25% Red algae (Irish moss)	Anemone (18), Brittle star (8), Sea cucumber (1)
GH	GH-92	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		15% Red algae (Irish moss)	Anemone (5), Brittle star (16)
GH	GH-93	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% red algae (Irish moss)	Anemone (5), Brittle star (6), Shrimp (1)
GH	GH-94	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		3% Red algae (Irish moss)	Anemone (14), Brittle star (2)
GH	GH-95	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% red algae (Irish moss)	Anemone (36), Brittle star (3), Whelk (1)
GH	GH-96	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	2% coralline algae	12% red algae (Irish moss)	Anemone (19), Brittle star (6)
GH	GH-97	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	90% coralline algae		
GH	GH-98	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	75% coralline algae		Anemone (3)
GH	GH-99	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	85% coralline algae		
GH	GH-100	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	30% coralline algae		
GH	GH-101	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	15% coralline algae		Whelk (1), Anemone (2)
GH	GH-102	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Brittle star (4)
GH	GH-103	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (10), Brittle star (1), Sea star (1), Clam (1)
GH	GH-104	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red alage (Irish moss)	Anemone (3), Brittle star (11), Sea cucumber (1)
GH	GH-105	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		50% Red algae (Irish moss)	Anemone (3), Brittle star (16), Sea star (1)
GH	GH-106	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% red algae (Irish moss)	Anemone (1), Brittle star (18), Crab (1), Sea star (1), Feather star (1)
GH	GH-107	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		20% red algae (Irish moss)	Anemone (1), Brittle star (31), Sea urchin (2)
GH	GH-108	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (4)
GH	GH-109	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Brittle star (19), Clam (1)
GH	GH-110	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Feather star (2)
GH	GH-111	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	65% coralline algae		
GH	GH-112	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	80% coralline algae	10% red algae (Irish moss)	
GH	GH-113	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	10% coralline algae		Anemone (5), Seastar (1)
GH	GH-114	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	40% coralline algae		
GH	GH-115	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	8% coralline algae		Anemone (1)
GH	GH-116	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Scallop (1), Brittle star (7)
GH	GH-117											being identified by AMEC
GH	GH-118	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	10% coralline algae		anemone (6), britte star (9), scallop (1)
GH	GH-119	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	5%coralline algae		Anemone (1)
GH	GH-120	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	10% coralline algae		Scallop (1), Brittle star (7), whelk (1), anemone (18)
GH	GH-121	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	30% coralline algae		scallop (1)
GH	GH-122	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (5), feather star (1), brittle star (3)
GH	GH-123	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (2), fish (Cottidae) (1)
GH	GH-124	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	35% coralline algae		Feather star (3), anemone (6)

Appendix C-Sea Cage Site: Long Island (April 2017)

Station	Cage	Latitude	Longitude	Depth (m)	Video Quality	Substrate								
						Primary/ Secondary (>50 % Hard/Soft)	Descriptors							
							Rockwall vertical	Continueous Bedrock	Boulders/Rubble	Cobble	Gravel/Pebble	Mud/Sand	Organic	Floc (% cover)
LI	LI-1	47.33283	-54.68885	66.0	3	Primary Hard	Not present	Not present	Not present	65% cobble		Not present	35% Coralline algae	Not present
LI	LI-2	47.33206	-54.68819	54.0	3	Primary Hard	Not present	Not present	Not present	15% Cobble		Not present	85% Coralline algae	Not present
LI	LI-3	47.33129	-54.68752	58.5	3	Primary Hard	Not present	Not present	Not present	20% Cobble		Not present	80% Coralline algae	Not present
LI	LI-4	47.33051	-54.68685	60.0	3	Primary Hard	Not present	Not present	Not present	15% Cobble		Not present	5% Red algae (Irish moss), 80% Coralline algae	Not present
LI	LI-5	47.32973	-54.68618	55.5	3	Primary Hard	Not present	Not present	Not present	7% Cobble		Not present	8% Red algae (Irish moss), 85% Coralline algae	Not present
LI	LI-6	47.32896	-54.68552	54.0	3	Primary Hard	Not present	Not present	Not present	5% Cobble		Not present	5% Red algae (Irish moss), 90% Coralline algae	Not present
LI	LI-7	47.32852	-54.68664	57.0	3	Primary Hard	Not present	Not present	Not present	12% Cobble		Not present	3% Red algae (Irish moss), 85% Coralline algae	Not present
LI	LI-8	47.32930	-54.68731	61.5	3	Primary Hard	Not present	Not present	Not present	17% Cobble		Not present	3% Red algae (Irish moss). 80% Coralline algae	Not present
LI	LI-9	47.33007	-54.68798	69.0	3	Primary Hard	Not present	Not present	Not present	70% Cobble		Not present	5% Red algae (Irish moss), 25% Coralline algae	Not present
LI	LI-10	47.33085	-54.68865	76.5	3	Primary Hard	Not present	Not present	Not present	85% Cobble		Not present	15% Red algae (Irish moss)	Not present
LI	LI-11	47.33162	-54.68931	75.0	3	Primary Hard	Not present	Not present	Not present	65% Cobble		Not present	5% Red algae (Irish moss), 30% Coralline algae	Not present
LI	LI-12	47.33233	-54.68984	82.5	3	Primary Hard	Not present	Not present	Not present	85% Cobble		Not present	10% Red algae (Irish moss), 5% Coralline algae	Not present
LI	LI-13	47.33175	-54.69072	91.5	3	Primary Hard	Not present	Not present	Not present	90% Cobble		Not present	10% Red algae (Coralline algae)	Not present
LI	LI-14	47.33116	-54.69047	96.0	3	Primary Hard	Not present	Not present	Not present		55% Gravel	Not present	45% Red algae (Coralline algae)	Not present
LI	LI-15	47.33040	-54.68980	82.5	3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% Red algae (Coralline algae)	Not present
LI	LI-16	47.32962	-54.68913	72.0	3	Primary Hard	Not present	Not present	Not present		85% Gravel	Not present	5% Red algae (Irish moss), 10% Coralline algae	Not present
LI	LI-17	47.32885	-54.68846	66.0	3	Primary Hard	Not present	Not present	Not present	75% Cobble		Not present	5% Red algae (Irish moss), 20% Coralline algae	Not present
LI	LI-18	47.32807	-54.68779	55.5	3	Primary Hard	Not present	Not present	Not present	15% Cobble		Not present	5% Red algae (Irish moss), 80% Coralline algae	Not present
LI	LI-19	47.32763	-54.68894	58.5	3	Primary Hard	Not present	Not present	Not present	40% Cobble		Not present	60% Coralline algae	Not present
LI	LI-20	47.32840	-54.68961	76.5	3	Primary Hard	Not present	Not present	Not present	55% Cobble		Not present	45% Coralline algae	Not present
LI	LI-21	47.32918	-54.69028	81.0	3	Primary Hard	Not present	Not present	Not present	65% Cobble		Not present	10% Red algae (Irish moss), 25% Coralline algae	Not present
LI	LI-22	47.32995	-54.69095	90.0	3	Primary Hard	Not present	Not present	Not present		85% Gravel	Not present	15% Red algae (Irish moss)	Not present
LI	LI-23	47.33065	-54.69147	105.0	3	Primary Hard	Not present	Not present	Not present		75% Gravel	Not present	25% Red algae (Irish moss)	Not present
LI	LI-24	47.33011	-54.69225	109.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
LI	LI-25	47.32950	-54.69209	93.0	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
LI	LI-26	47.32873	-54.69143	81.0	3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
LI	LI-27	47.32795	-54.69076	75.0	3	Primary Hard	Not present	Not present	Not present	40% Cobble		Not present	60% Coralline algae	Not present
LI	LI-28	47.32718	-54.69009	67.5	3	Primary Hard	Not present	Not present	Not present	55% Cobble		Not present	45% Coralline algae	Not present
LI	LI-29	47.32673	-54.69124	73.5	3	Primary Hard	Not present	Not present	Not present	70% Cobble		Not present	30% Coralline algae	Not present
LI	LI-30	47.32751	-54.69191	72.0	3	Primary Hard	Not present	Not present	Not present	65% cobble		Not present	35% Coralline algae	Not present
LI	LI-31	47.32828	-54.69258	90.0	3	Primary Hard	Not present	Not present	Not present	95% Cobble		Not present	5% Lamineria	Not present
LI	LI-32	47.32895	-54.69308	100.0	3	Primary Hard	Not present	Not present	Not present	100% Cobble		Not present		Not present
LI	LI-33	47.32838	-54.69411	99.0	3	Primary Hard	Not present	Not present	Not present	95% Cobble		Not present	5% Red algae (Irish moss)	Not present
LI	LI-34	47.32784	-54.69372	88.5	3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
LI	LI-35	47.32706	-54.69305	73.5	3	Primary Hard	Not present	Not present	Not present	10% Cobble	60% Gravel	Not present	5% Red algae (Irish moss), 25% Coralline algae	Not present
LI	LI-36	47.32629	-54.69238	66.0	3	Primary Hard	Not present	Not present	Not present	65% Cobble		Not present	35% Coralline algae	Not present
LI	LI-37	47.32584	-54.69353	61.5	3	Primary Hard	Not present	Not present	Not present	85% Cobble		Not present	15% Coralline algae	Not present

Appendix C-Sea Cage Site: Long Island (April 2017)

Station	Cage	Benthic Indicators				Other Bentic Descriptiors or Observations						
		Beggiatoa (% Cover)	OPC		Barren	Off Gas	Feed	Shell Debris	>Sed. Colour	Flora (% cover)		Fauna (abundance by group)**
			Type	%						Cor. Algae	Other*	eg. Anemones (2), Starfish (1), Porifera (1)
LI	LI-1	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	35% Coralline algae		Brittle star (5), Anemone (1), Scyphozoa (1)
LI	LI-2	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	85% Coralline algae		Brittle star (4)
LI	LI-3	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	80% Coralline algae		Anemone (2), Brittle star (4)
LI	LI-4	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	80% Coralline algae	5% Red algae (Irish moss)	Brittle star (3)
LI	LI-5	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	85% Coralline algae	8% Red algae (Irish moss)	Brittle star (8)
LI	LI-6	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	90% Coralline algae	5% Red algae (Irish moss)	Brittle star (17)
LI	LI-7	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	85% Coralline algae	3% Red algae (Irish moss)	Brittle star (23)
LI	LI-8	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	80% Coralline algae	3% Red algae (Irish moss)	Brittle star (1)
LI	LI-9	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	25% Coralline algae	5% Red algae (Irish moss)	Brittle star (4)
LI	LI-10	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		15% Red algae (Irish moss)	Anemone (5), Brittle star (4), Clam (1), Whelk (2)
LI	LI-11	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	30% Coralline algae	5% Red algae (Irish moss)	Brittle star (12), Anemone (5), Whelk (2)
LI	LI-12	Not Present	Not Present	N/A		Not Present	N/A	5%	Grayish Brown	5% Coralline algae	10% Red algae (Irish moss)	Brittle star (21), Anemone (7)
LI	LI-13	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Red algae (Coralline algae)	Anemone (22)
LI	LI-14	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		45% Red algae (Coralline algae)	Brittle star (11), Anemone (2)
LI	LI-15	Not Present	Not Present	N/A		Not Present	N/A	2%	Grayish Brown		10% Red algae (Coralline algae)	Brittle star (47), Anemone (6), Sea Urchn (1)
LI	LI-16	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	10% Coralline algae	5% Red algae (Irish moss)	Brittle star (11)
LI	LI-17	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	20% Coralline algae	5% Red algae (Irish moss)	Brittle star (24), Anemone (7), Clam (1), Whelk (2)
LI	LI-18	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	80% Coralline algae	5% Red algae (Irish moss)	Brittle star (13)
LI	LI-19	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	60% Coralline algae		Brittle star (13)
LI	LI-20	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	45% Coralline algae		Brittle star (27), Anemone (3)
LI	LI-21	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	25% Coralline algae	10% Red algae (Coralline algae)	Brittle star (13), Whelk (1)
LI	LI-22	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		15% Red algae (Irish moss)	Brittle star (5), Anemone (1), Sea urchin (3)
LI	LI-23	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		25% Red algae (Irish moss)	Scyphozoa (2)
LI	LI-24	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (11), Brittle star (3)
LI	LI-25	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (15), Cottidae (1)
LI	LI-26	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (16)
LI	LI-27	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	60% Coralline algae		Anemone (1), Brittle star (6)
LI	LI-28	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	45% Coralline algae		Brittle star (44), Anemone (2), Clam (1)
LI	LI-29	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	30% Coralline algae		Brittle star (13), Anemone (1)
LI	LI-30	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	35% Coralline algae		Brittle star (9), Whelk (1)
LI	LI-31	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Lamineria	Anemone (5), Whelk (1)
LI	LI-32	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (43)
LI	LI-33	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (18), Small fish (1)
LI	LI-34	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (59), Crab (1)
LI	LI-35	Not Present	Not Present	N/A		Not Present	N/A	1%	Grayish Brown	25% Coralline algae	5% Red algae (Irish moss)	Anemone (2), Brittle star (33), Whelk (1)
LI	LI-36	Not Present	Not Present	N/A		Not Present	N/A	1%	Grayish Brown	35% Coralline algae		Brittle star (6)
LI	LI-37	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	15% Coralline algae		Brittle star (2)

Appendix C-Sea Cage Site: Long Island (April 2017)

Video Quality	Substrate								
	Primary/ Secondary (>50 % Hard/Soft)	Descriptors							
		Rockwall vertical	Continueous Bedrock	Boulders/Rubble	Cobble	Gravel/Pebble	Mud/Sand	Organic	Floc (% cover)
3	Primary Hard	Not present	Not present	Not present	90% Cobble		Not present	10% Coralline algae	Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present	35% Cobble		Not present	65% Coralline algae	Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present	10 cobble	95% Gravel	Not present	5% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present	20% Cobble		Not present	80% Coralline algae	Not present
3	Primary Hard	Not present	Not present	Not present	55% Cobble		Not present	45% Coralline algae	Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		93% Gravel	Not present	8% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		85% Gravel	Not present	15% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		10% Gravel	Not present	90% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		15% Gravel	Not present	85% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		93% Gravel	Not present	8% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		15% Gravel	Not present	85% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		20% Gravel	Not present	80% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		75% Gravel	Not present	25% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		90% Gravel	Not present	10% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		95% Gravel	Not present	5% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		88% Gravel	Not present	12% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present		15% Gravel	Not present	85% Red algae (Irish moss)	Not present
3	Primary Hard	Not present	Not present	Not present	40% Cobble		Not present	25% Red algae (Irish moss), 35% Coralline algae	Not present
3	Primary Hard	Not present	Not present	Not present	40% Cobble		Not present	15% Red algae (Irish moss), 45% Coralline algae	Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present
3	Primary Hard	Not present	Not present	Not present		100% Gravel	Not present		Not present

Appendix C-Sea Cage Site: Long Island (April 2017)

Station	Cage	Benthic Indicators				Other Bentic Descriptiors or Observations						
		Beggiatoa (% Cover)	OPC		Barren	Off Gas	Feed	Shell Debris	>Sed. Colour	Flora (% cover)		Fauna (abundance by group)**
			Type	%						Cor. Algae	Other*	eg. Anemones (2), Starfish (1), Porifera (1)
LI	LI-38	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	10% Coralline algae		Brittle star (38), Aemone (3)
LI	LI-39	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (22), Crab (1)
LI	LI-40	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (46)
LI	LI-41	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (34), Brittle star (7), Whelk (1), Clam (1)
LI	LI-42	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (5), Brittle star (16), Whelk (1), Clam (1), Sea urchin (1)
LI	LI-43	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	65% Coralline algae		Anemone (2), Brittle star (1)
LI	LI-44	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (16), Brittle star (6)
LI	LI-45	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (6), Scyphozoa (1)
LI	LI-46	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (16)
LI	LI-47	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (54), Whelk (1)
LI	LI-48	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	80% Coralline algae		Brittle star (83), Anemone (11)
LI	LI-49	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	45% Coralline algae		Brittle star (18)
LI	LI-50	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (19), Brittle star (2)
LI	LI-51	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (18), Brittle star (16), Cottidae (1)
LI	LI-52	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (2), Brittle star (16)
LI	LI-53	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (5), Brittle star (3)
LI	LI-54	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Aemone (9), Brittle star (22), Crab (1), Sea urchin (1)
LI	LI-55	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (5), Brittle star (8), Whelk (1), Crab (1)
LI	LI-56	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (21)
LI	LI-57	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (28), Brittle star (6)
LI	LI-58	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (18), Brittle star (3)
LI	LI-59	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		8% Red algae (Irish moss)	Anemone (11), Brittle star (1)
LI	LI-60	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		15% Red algae (Irish moss)	Anemone (4), Brittle star (33)
LI	LI-61	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (46)
LI	LI-62	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (12)
LI	LI-63	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		90% Red algae (Irish moss)	
LI	LI-64	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		85% Red algae (Irish moss)	
LI	LI-65	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Red algae (Irish moss)	Anemone (17)
LI	LI-66	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (12)
LI	LI-67	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		8% Red algae (Irish moss)	Anemone (6)
LI	LI-68	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		85% Red algae (Irish moss)	
LI	LI-69	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		80% Red algae (Irish moss)	
LI	LI-70	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		25% Red algae (Irish moss)	Anemone (6), Brittle star (14) Clam (1)
LI	LI-71	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		10% Red algae (Irish moss)	Anemone (8)
LI	LI-72	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		5% Red algae (Irish moss)	Anemone (3)
LI	LI-73	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		12% Red algae (Irish moss)	Brittle star (1), Scyphozoa (1)
LI	LI-74	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown		85% Red algae (Irish moss)	
LI	LI-75	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	35% Coralline algae	25% Red algae (Irish moss)	
LI	LI-76	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown	45% Coralline algae	15% Red algae (Irish moss)	Anemone (3)
LI	LI-77	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (6)
LI	LI-78	Not Present	Not Present	N/A		Not Present	N/A	N/A	Grayish Brown			Anemone (3), Shrimp (1)

Appendix D

Metocean Conditions

for the Placentia Bay Aquaculture Sites

Oceans Ltd.

February 2018

Metocean Conditions
For the Placentia Bay
Aquaculture Sites

Submitted to
LGL Limited
388 Kenmount Road
St. John's, NL
A1B 4A5

by

Oceans LTD.

85 LeMarchant Rd.
St. John's, NL
A1C 2H1

Telephone: (709) 753-5788
Facsimile: (709) 753-3301
Email: oceans@oceansltd.com

February 2018

Table of Contents

Table of Figures

Table of Tables

1.0 Introduction

The metocean conditions for the northern half of Placentia Bay were analyzed. The report is subdivided into two sections. Section 1 outlines the atmospheric environment, and includes wind speed and direction, air temperature, and precipitation while Section 2 outlines the aquatic environment, including ocean currents, waves, tidal and flood conditions, and sea ice and icebergs.

2.0 Atmospheric Environment

2.1 Data Sources

The data sources to describe the climatology of the northern half of Placentia Bay came from four main sources. The MSC50 Wind and Wave Reanalysis data set, the National Hurricane Centre's Tropical Storm data set, two SmartBay buoys and Environment and Climate Change Canada's (ECCC) Weather Stations located around Placentia Bay.

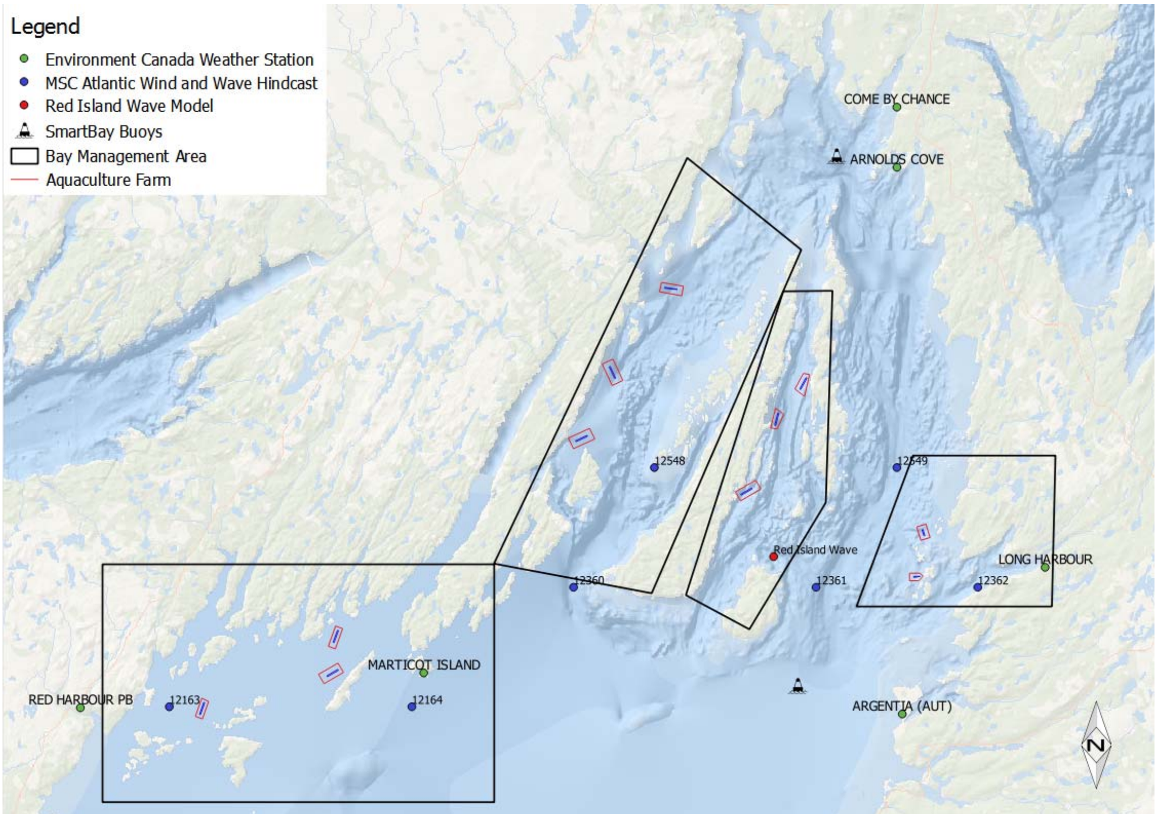


Figure 2.1 Location of Data Sources

2.1.1 MSC50 Wind and Wave Reanalysis

Wind climate statistics for the area were extracted from the MSC50 North Atlantic wind and wave climatology data base compiled by Oceanweather Inc. under contract to ECCC. The MSC50 data base covers the time period from January 1954 to December 2015. Winds from the MSC50 data set are 1-hour averages of the effective neutral wind at a height of 10 m above sea level, asl (Harris, 2007).

Grid Points 12163 and 12164 were chosen to represent conditions within the Rushoon Bay Management Area (BMA), 12360 and 12548 for the Merasheen BMA, and 12549, 12361 and 12362 for the Long Harbour BMA. There were no MSC50 Grid Points located within the Red Island BMA. Due to the proximity of the nearby islands, nearby grid points were of no use to provide a depiction of the climatology within the Red Island BMA. Location information for each grid point is presented in Table 2.1.

Table 2.1 MSC50 Grid Point Locations

Grid Point	Latitude	Longitude
12548	47.5	-54.3
12549	47.5	-54.0
12360	47.4	-54.4
12361	47.4	-54.1
12362	47.4	-53.9
12163	47.3	-54.9
12164	47.3	-54.6

2.1.2 Tropical Storms

Tropical cyclone climatology statistics were calculated from the National Hurricane Centre's best-track dataset (Neumann, Jarvinen, & McAdie, 1993); (Jarvinen, Neumann, & Davis, 1984). This dataset provides positions and intensities at 6-hour intervals for every Atlantic tropical cyclone since 1886. In this report, a subset of the NHC dataset consisting of all storms of tropical origin during the months of April to September from 1960 to 2015 was used. This subset was obtained from the National Oceanic and Atmospheric Administration's Coastal Services Center Historical Hurricane Tracks website. Due to the size of some storms, statistics were derived for all storms which have come within a buffer zone of 150 nm (278 km) of the four BMA's.

2.1.3 SmartBay Buoys

Data from two SmartBay Buoys were used in the analysis: the Red Island Shoal buoy and the Head of Placentia Bay buoy. These buoys measure wind speed and direction, wave height, sea surface temperature, ocean current and barometric pressure. The location of these buoys is provided in Table 2.2.

Table 2.2 SmartBay Buoy Locations

Buoy	Latitude	Longitude
Red Island Shoal	47.315	-54.123
Head of Placentia Bay	47.758	-54.074

2.1.4 Environment Canada Weather Stations

Wind speed, air temperature and visibility statistics were calculated from ECCC Stations near the BMAs. These stations, their location, as well as the available measured parameters are provided in Table 2.3. It should be noted that these measurements were all recorded over different time periods and statistics are not directly comparable to each other. Despite not being directly comparable, these data should give an indication of the conditions expected within the region.

Table 2.3 ECCC Station Locations and Available Data

Station	Latitude	Longitude	Start Date	End Date	Wind	Air Temperature	Precip.
Red Harbour	47.30	-55.01	1989-12-01	2006-02-28		X	X
Marticot Harbour	47.33	-54.58	2005-09-21	2018-02-07	X	X	
Arnold’s Cove	47.75	-54.00	1971-07-01	1994-12-31		X	X
Long Harbour	47.42	-53.82	1969-11-06	1999-12-31		X	X
Argentia	47.29	-53.99	1951-01-01	2017-08-03	X	X	

2.2 General Description of Weather Systems

Placentia Bay, located along the south coast of Newfoundland experiences weather conditions typical of a marine environment with the surrounding waters having a moderating effect on temperature. In general, marine climates experience cooler summers and milder winters than continental climates and have a much smaller annual temperature range. Furthermore, a marine climate tends to be fairly humid, resulting in reduced visibilities, low cloud heights, and receives significant amounts of precipitation.

The climate of the study area is very dynamic, being largely governed by the passage of high and low-pressure circulation systems. These circulation systems are embedded in, and steered by, the prevailing westerly flow that typifies the upper levels of the atmosphere in the mid-latitudes, which arises because of the normal tropical to polar temperature gradient. The mean strength of the westerly flow is a function of the intensity of this gradient, and as a consequence is considerably stronger in the winter months than during the summer months, due to an increase in the south to north temperature gradient.

During the winter months, an upper level trough tends to lie over central Canada and an upper ridge over the North Atlantic resulting in three main storm tracks affecting the region: one from the Great Lakes Basin, one from Cape Hatteras, North Carolina and one from the Gulf of Mexico. These storm tracks, on average, bring eight low pressure systems per month over the area. The intensity of these systems ranges from relatively weak features to major winter storms. Recent studies (Archer & Caldeira, 2008) have shown that there exists a poleward shift of the jet stream, and consequently storm tracks, at a rate of 0.17 to 0.19 degrees/decade in the northern hemisphere. This shift has been related to an increase in the equator-to-pole temperature gradient. McCabe et al. (McCabe, Clark, & Serreze, 2001) obtained similar results, finding that there has been a decrease in mid-latitude cyclone frequency and an increase in high-latitude cyclone frequency. In addition, they found that storm intensity has increased in both the high and mid-latitudes.

In the case where the upper level long wave trough lies well west of the region, the main storm track will lie through the Gulf of St. Lawrence or Newfoundland. Under this regime, an east to southeast flow ahead of a warm front associated with a low will give way to winds from the south in the warm sector of the system. Typically, the periods of southerly winds and mild conditions will be of relatively long duration, and in general, the incidence of extended storm conditions is likely to be relatively infrequent. Strong frictional effects in the stable flow from the south results in a marked shear in the surface boundary layer and relatively lower winds at the sea surface. As a consequence, local wind wave development tends to be inhibited under such conditions. Precipitation types are more likely to be in the form of rain or drizzle, with relatively infrequent periods of continuous snow, although periods of snow showers prevail in the unstable air in the wake of cold fronts associated with the lows. Visibility will be reduced at times in frontal and advection fogs, in snow, and in snow shower activity.

At other times, with the upper long wave trough situated further to the east, the main storm track may lie through or to the east of the study area. With the lows passing closer to the study area and a higher potential for storm development, the incidence of strong gale and storm force conditions is greater. Longer bouts of cold, west to northwest winds behind cold fronts occur more frequently, and because the flow is colder than the surface water temperatures, the surface layer is unstable. The shear in the boundary layer is lower, resulting in relatively higher wind speeds near the surface, and consequently relatively higher sea state conditions. With cold air and sea surface temperatures coupled with high winds, the potential for freezing spray will occur quite frequently. In this synoptic situation, a greater incidence of precipitation in the form of snow is likely to occur. Freezing precipitation, either as rain or drizzle, occurs infrequently south of Newfoundland. Visibility will be reduced in frontal and advection fogs, and frequently by snow.

By summer, the main storm tracks have moved further north than in winter. Low-pressure systems are less frequent and much weaker. With increasing solar radiation during spring, there is a general warming of the atmosphere that is relatively greater at higher latitudes. This decreases the north-south temperature contrast, lowers the kinetic energy of the westerly flow aloft and decreases the potential energy available for storm development. Concurrently, there is a northward shift of the main band of westerly winds at upper levels and a marked development of the Bermuda-Azores sub-tropical high-pressure area to the south. This warm-core high-pressure cell extends from the surface through the entire troposphere. The main track of the weaker low-pressure systems typically lies through the Labrador region and tends to be oriented from the west-southwest to the east-northeast.

With low pressure systems normally passing to the north of the region in combination with the northwest sector of the sub-tropical high to the south, the prevailing flow across the Grand Banks is from the southwest during the summer season. Wind speed is lower during the summer and the incidence of gale or storm force winds are relatively infrequent. There is also a corresponding decrease in significant wave heights.

Frequently, intense low-pressure systems become ‘captured’ and slow down or stall off the coast of Newfoundland and Labrador. This may result in an extended period of little change in conditions that may range, depending on the position, overall intensity and size of the system, from the relatively benign to heavy weather conditions.

Rapidly deepening storms are a problem south of Newfoundland in the vicinity of the warm water of the Gulf Stream. Sometimes these rapidly deepening oceanic cyclones develop into a “weather bomb”; defined as a storm that undergoes central pressure falls greater than 24 mb over 24 hours. Hurricane force winds near the center, the outbreak of convective clouds to the north and east of the center during the explosive stage, and the presence of a clear area near the center in its mature stage (Rogers & Bosart, 1986) are typical of weather bombs. After development, these systems will either move across Newfoundland or near the southeast coast producing gale to storm force winds from the southwest to south over the study area.

In addition to extratropical cyclones, tropical cyclones often retain their tropical characteristics as they enter the study area. Tropical cyclones account for the strongest sustained surface winds observed anywhere on earth. The hurricane season in the North Atlantic basin normally extends from June through November, although tropical storm systems occasionally occur outside this period. Once formed, a tropical storm or hurricane will maintain its energy as long as a sufficient supply of warm, moist air is available. Tropical storms and hurricanes obtain their energy from the latent heat of vapourization that is released during the condensation process. These systems typically move east to west over the warm water of the tropics; however, some of these systems turn northward and make their way towards Newfoundland. Since the capacity of the air to hold water vapour is dependent on temperature, as the hurricanes move northward over the colder ocean waters, they begin to lose their tropical characteristics. By the time these weakening cyclones reach Newfoundland, they are usually embedded into a mid-latitude low and their tropical characteristics are usually lost.

2.3 Wind Speed

Placentia Bay experiences a predominately southwest to west flow throughout the year. There is a strong annual cycle in the wind direction. West to northwest winds which are prevalent during the winter months begin to shift counter-clockwise during March and April, resulting in a predominant southwest wind by the summer months. As autumn approaches, the tropical-to-polar temperature gradient strengthens and the winds shift slightly, becoming predominately westerly again by late fall and into winter.

In addition to mid-latitude low pressure systems crossing the route, tropical cyclones often move northward out of the influence of the warm waters of the Gulf Stream, passing near the Island of

Newfoundland. The tropical cyclone season typically extends from June to November, however may occur outside of this period given the right conditions. Once the cyclones move over colder waters they lose their source of latent heat energy and often begin to transform into a fast-moving and rapidly developing extratropical cyclone producing large waves and sometimes hurricane force winds.

Low pressure systems crossing the area tend to be weaker during the summer months. As a result, mean wind speeds tend to be at their lowest during this season.

2.3.1 Proposed Long Harbour BMA

Mean, minimum and maximum wind speed statistics for the Long Harbour BMA are presented in Table 2.4 and Table 2.6 respectively. An annual wind rose and percent frequency histogram for MSC50 Grid Point 12361 is presented in Figure 2.2.

No wind speed measurements are available within the Long Harbour BMA. Wind speeds from the Argentia weather station and the Red Island Shoal SmartBay buoy provide the closest observations. Mean monthly observed winds from these two stations are lower during than those presented with the MSC50 Grid Points. Maximum wind speeds recorded by the Argentia station are higher during the winter months than the buoys and the MSC50 grid points.

Table 2.4 Mean Wind Speeds (m/s) for the Long Harbour BMA

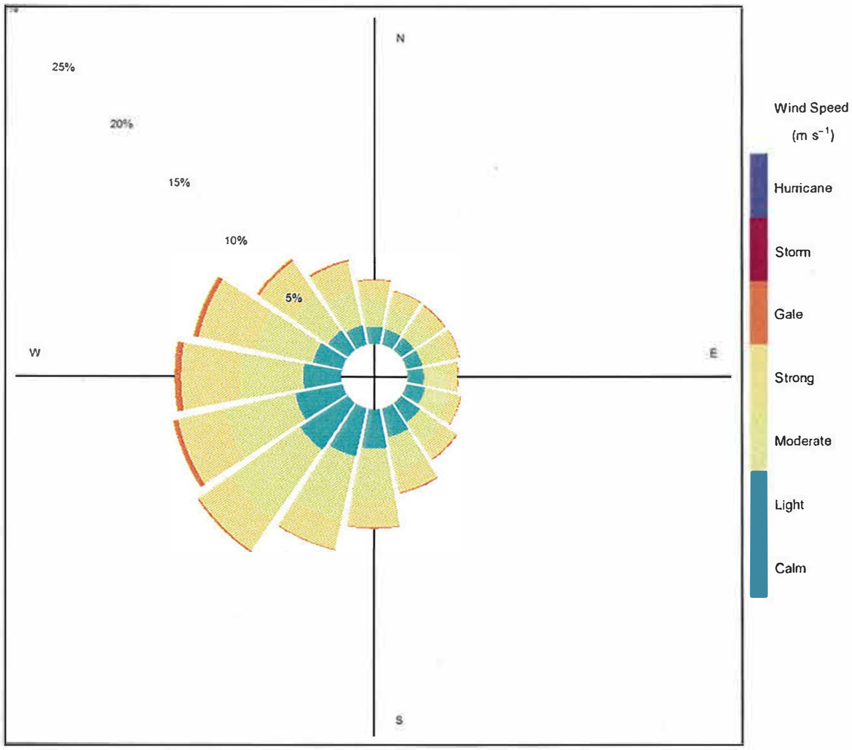
	Argentia	SmartBay Red Island Shoal	GP 12549	GP 12361	GP 12362
January	8.3	8.5	10.7	10.7	10.7
February	8.0	8.7	10.1	10.1	10.1
March	7.5	8.0	9.3	9.3	9.3
April	6.6	7.3	8.0	8.0	8.0
May	5.8	5.6	6.4	6.4	6.4
June	5.6	5.4	5.7	5.7	5.8
July	5.5	5.5	5.5	5.5	5.5
August	5.5	5.7	6.1	6.0	6.1
September	6.0	6.7	7.3	7.3	7.3
October	6.9	7.4	8.6	8.6	8.6
November	7.4	7.9	9.5	9.5	9.5
December	8.1	8.5	10.4	10.4	10.4

Table 2.5 Minimum Wind Speeds (m/s) for the Long Harbour BMA

	Argentia	SmartBay Red Island Shoal	GP 12549	GP 12361	GP 12362
January	0.2	0.2	1.9	1.8	1.9
February	0.1	0.2	0.7	0.7	0.6
March	0.1	0.1	1.0	1.0	1.0
April	0.1	0.1	0.6	0.6	0.6
May	0.1	0.0	0.4	0.4	0.4
June	0.0	0.1	0.2	0.2	0.2
July	0.1	0.2	0.4	0.4	0.4
August	0.1	0.1	0.4	0.4	0.4
September	0.1	0.2	0.5	0.5	0.5
October	0.1	0.1	0.9	0.9	0.8
November	0.1	0.0	0.9	0.9	0.9
December	0.1	0.1	1.4	1.4	1.3

Table 2.6 Maximum Wind Speeds (m/s) for the Long Harbour BMA

	Argentia	SmartBay Red Island Shoal	GP 12549	GP 12361	GP 12362
January	30.3	21.70	25.1	25.2	25.3
February	30.8	22.00	27.0	27.0	27.1
March	24.2	26.60	26.5	26.7	26.4
April	25.8	22.00	20.5	20.6	20.8
May	23.4	19.00	19.3	19.2	19.5
June	20.6	16.00	19.6	19.6	19.8
July	21.7	17.20	22.2	22.2	21.3
August	20.6	20.00	24.7	24.7	25.6
September	26.4	25.20	28.1	28.5	29.9
October	28.6	20.80	26.7	27.0	26.2
November	28.0	21.00	23.7	23.6	23.8
December	30.0	23.90	24.5	24.6	24.6



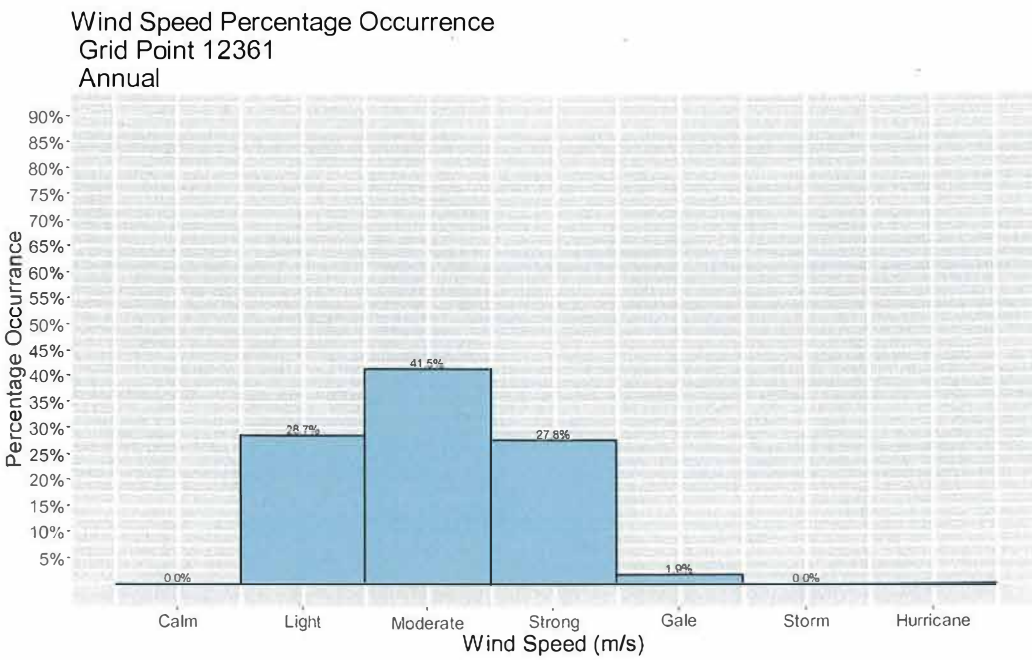


Figure 2.2 Wind Rose and Percentage Frequency Histogram for MSC50 Grid Point 12361 located at 47.4°N; 54.1W near Red Island

2.3.2 Proposed Red Island BMA

Wind speed and direction statistics are unavailable for the Red Island BMA due to lack of both observations and modelled data. Local effects due to the proximity of the islands to the east and west would result in winds being channeled into a north-northeast to south-southwest direction and in some situations the island would act as shelter.

All three aquaculture sites should see lighter winds from the south-southwest to north-northwest than presented with the other grid points. Winds from the north to northeast would get channeled into a north-northeast direction. Similarly, winds from the south to southeast will get channeled into a southeasterly direction. Some strengthening of the winds could occur during this process. Easterly winds at Butler Island and Red Island lease sites will be lighter than those from Grid Point 12361 due to sheltering from the island, while Darby Harbour Farms should see similar winds from the east to southeast as presented with Grid Point 12361.

2.3.3 Proposed Merasheen BMA

Mean, minimum and maximum wind speed statistics for the Merasheen BMA are presented in Table 2.7 and Table 2.9 respectively. An annual wind rose and percent frequency histogram for MSC50 Grid Point 12548 is presented in Figure 2.3.

No wind speed measurements are available within or near the Merasheen BMA. Mean monthly winds from two MSC50 grid points are presented.

Table 2.7 Mean Wind Speeds (m/s) for the Merasheen BMA

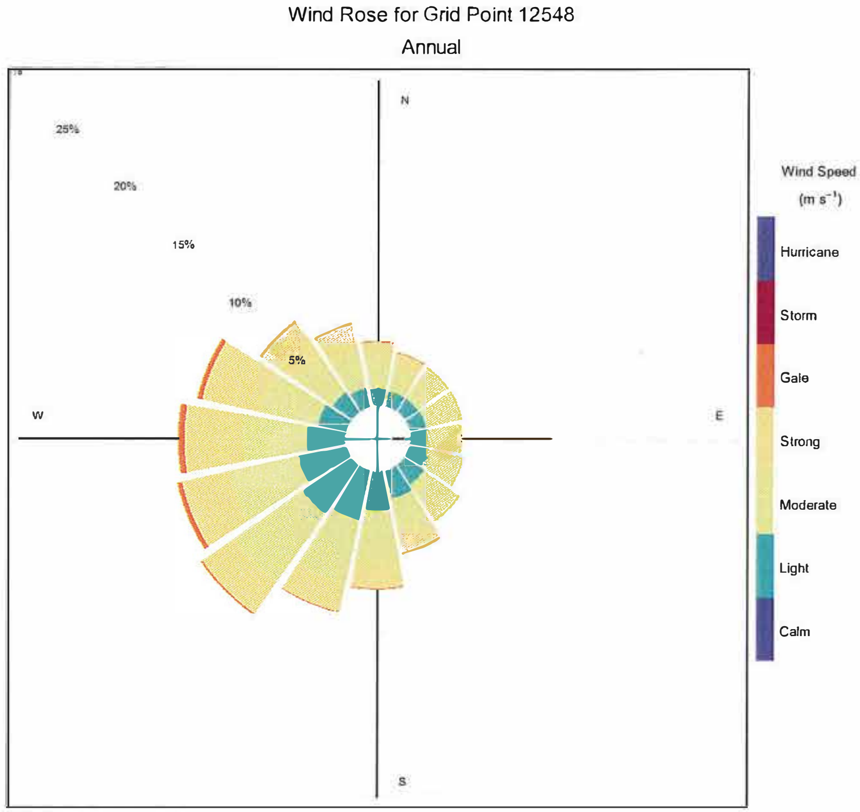
	GP 12548	GP 12360
January	10.6	10.6
February	10.0	10.1
March	9.2	9.3
April	8.0	8.0
May	6.4	6.4
June	5.7	5.7
July	5.4	5.4
August	6.0	6.0
September	7.3	7.3
October	8.6	8.6
November	9.5	9.5
December	10.4	10.4

Table 2.8 Minimum Wind Speeds (m/s) for the Merasheen BMA

	GP 12548	GP 12360
January	1.8	1.7
February	0.7	0.7
March	0.1	1.0
April	0.6	0.6
May	0.4	0.4
June	0.2	0.2
July	0.3	0.3
August	0.4	0.4
September	0.6	0.6
October	0.9	0.9
November	0.9	0.8
December	1.5	1.5

Table 2.9 Maximum Wind Speeds (m/s) for the Merasheen BMA

	GP 12548	GP 12360
January	24.9	25.1
February	26.8	26.9
March	26.8	26.9
April	20.3	20.3
May	18.9	19.1
June	19.3	19.4
July	22.8	22.8
August	22.4	22.8
September	26.9	26.8
October	28.0	28.3
November	23.4	23.3
December	24.4	24.6



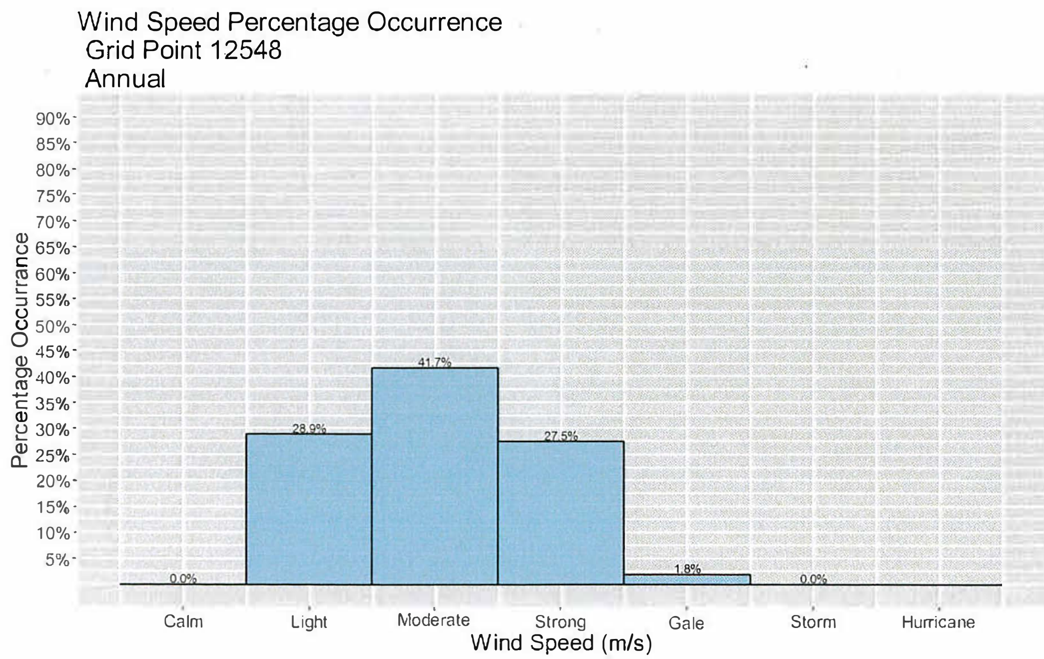


Figure 2.3 Wind Rose and Percentage Frequency Histogram for MSC50 Grid Point 12548 located at 47.5°N; 54.3W within the Merasheen BMA

2.3.4 Proposed Rushoon BMA

Mean and maximum wind speed statistics for the Rushoon BMA are presented in Table 2.10 and Table 2.12 respectively. An annual wind rose and percent frequency histogram for MSC50 Grid Point 12163 is presented in Figure 2.4.

No wind speed measurements are available within or near the Merasheen BMA. Mean monthly winds from two MSC50 grid points are presented.

Table 2.10 Mean Wind Speeds (m/s) for the Rushoon BMA

	GP 12163	GP 12164
January	10.6	10.6
February	10.0	10.1
March	9.3	9.3
April	7.9	8.0
May	6.3	6.3
June	5.6	5.7
July	5.3	5.4
August	6.0	6.0
September	7.2	7.2
October	8.5	8.6
November	9.4	9.4
December	10.3	10.4

Table 2.11 Minimum Wind Speeds (m/s) for the Rushoon BMA

	GP 12163	GP 12164
January	1.0	1.4
February	0.5	0.5
March	0.6	0.9
April	0.4	0.5
May	0.3	0.4
June	0.1	0.2
July	0.2	0.3
August	0.3	0.3
September	0.4	0.5
October	0.9	0.9
November	0.5	0.7
December	1.1	1.3

Table 2.12 Maximum Wind Speeds (m/s) for the Rushoon BMA

	GP 12163	GP 12164
January	25.3	25.3
February	26.2	26.3
March	26.9	26.9
April	20.5	20.3
May	21.3	20.3
June	19.4	19.5
July	21.9	22.2
August	24.4	24.1
September	25.8	26.5
October	30.0	28.9
November	23.8	23.2
December	25.4	25.0

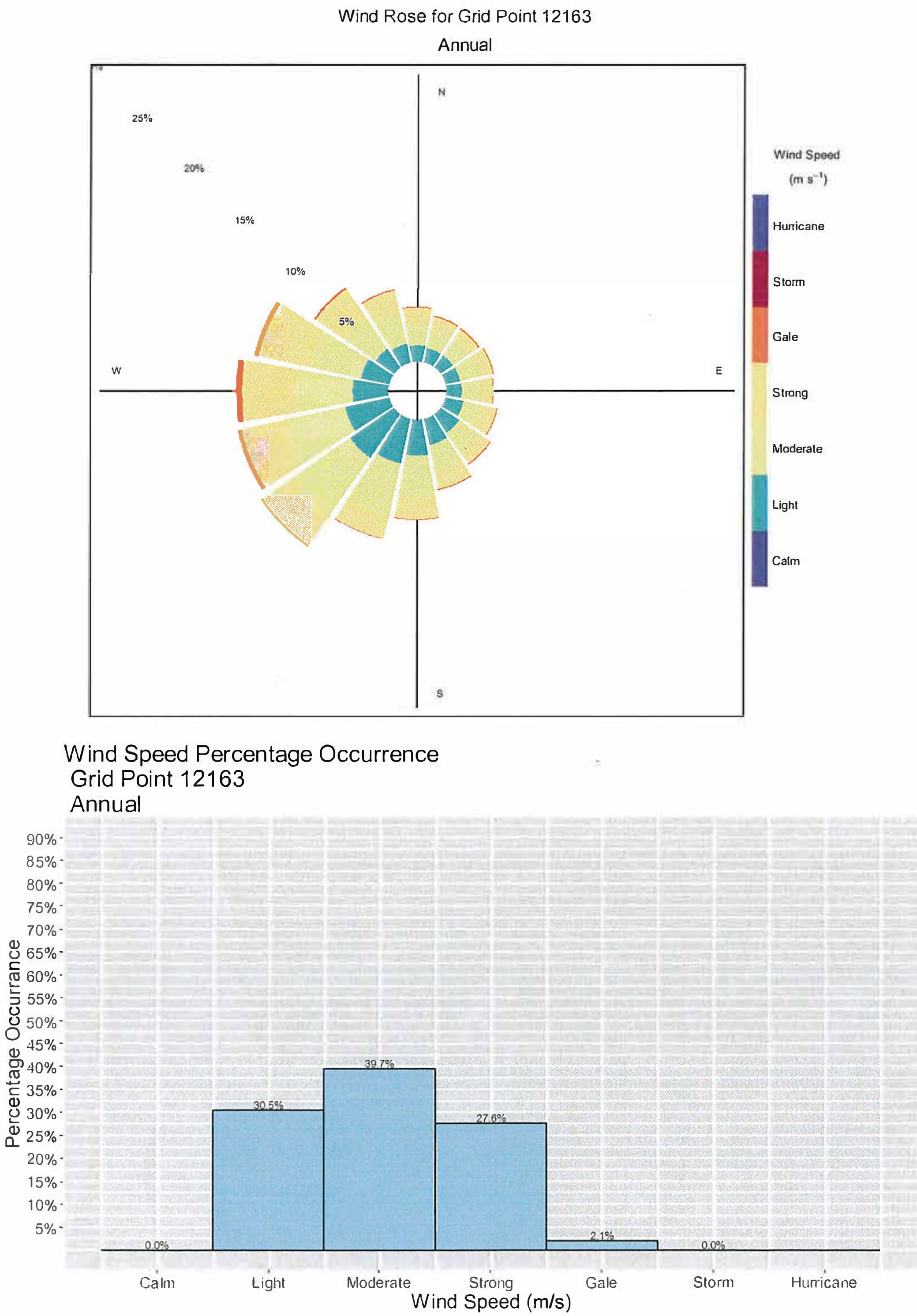


Figure 2.4 Wind Rose and Percentage Frequency Histogram for MSC50 Grid Point 12163 located at 47.3°N; 54.3W within the Rushoon BMA near Oderin Island Farm.

2.3.5 Extreme Wind Speed

Extreme winds were calculated for the northern half of Placentia Bay using the seven MSC50 grid points mentioned above. This data set was determined to be the most representative of the available data sets, as it provides a continuous 60-year period of hourly data for the site. All extremes are specified for return periods of 1-yr, 10-yr, 25-yr, 50-yr and 100-yr. All wind speeds are referenced to the 10 m height asl.

The extreme value analysis for wind speeds was carried out using the peak-over-threshold method. The Gumbel distribution was chosen to be the most representative for the peak-over-threshold method as it provided the best fit to the data. Since extreme values can vary depending on how well the data fits the distribution, a sensitivity analysis was carried out to determine the number storms to use, whereby the number of storms, the 100-year extreme value, the correlation coefficient and storm threshold were all compared on an annual basis.

The extreme value estimates for wind were calculated using Oceanweather's Osmosis software program. The analysis used hourly wind values for the reference height of 10 m asl. These values were converted to 10-minute values using a constant ratio of 1.06 (United States Geological Survey, Conservation Division, 1979).

The annual 1-hour, 10-minutes and 1-minute extreme wind speed estimates are presented in Table 2.13 through Table 2.15 for the Long Harbour, Rushoon and Merasheen BMAs. Since there were no grid points within the Red Island BMA, an extreme wind speed analysis was not possible within this BMA.

There is little variation in the extreme wind speeds for the different locations around Placentia Bay. The annual 1-hour wind speed was found to range from 28.3 m/s at Grid Point 12548 to 28.7m/s at Grid Point 12362 and 12364.

Table 2.13 One-hour Extreme Wind Speed Estimates (m/s) for Return Periods of 1, 10, 25, 50 and 100 Years

BMA	Grid Point	1-yr	10-yr	25-yr	50-yr	100-yr
Long Harbour	**12361**	22.2	25.4	26.7	27.7	28.6
	12362	22.2	25.5	26.8	27.7	28.7
	12549	22.1	25.3	26.5	27.5	28.4
Merasheen	**12548**	22.0	25.2	26.5	27.4	28.3
	12360	22.1	25.4	26.6	27.6	28.5
Rushoon	**12163**	22.6	25.6	26.8	27.7	28.5
	12164	22.3	25.5	26.8	27.8	28.7

Table 2.14 Ten-minute Extreme Wind Speed Estimates (m/s) for Return Periods of 1, 10, 25, 50 and 100 Years

BMA	Grid Point	1-yr	10-yr	25-yr	50-yr	100-yr
Long Harbour	**12361**	23.5	26.9	28.3	29.3	30.3
	12362	23.5	27.0	28.4	29.4	30.4
	12549	23.4	26.8	28.1	29.1	30.1
Merasheen	**12548**	23.3	26.7	28.0	29.0	30.0
	12360	23.5	26.9	28.2	29.2	30.2
Rushoon	**12163**	24.0	27.2	28.4	29.3	30.3
	12164	23.7	27.1	28.4	29.4	30.4

Table 2.15 One-minute Extreme Wind Speed Estimates (m/s) for Return Periods of 1, 10, 25, 50 and 100 Years

BMA	Grid Point	1-yr	10-yr	25-yr	50-yr	100-yr
Long Harbour	**12361**	27.0	31.0	32.6	33.7	34.9
	12362	27.1	31.1	32.6	33.8	35.0
	12549	26.9	30.9	32.4	33.5	34.7
Merasheen	**12548**	26.9	30.8	32.3	33.4	34.6
	12360	27.0	30.9	32.5	33.6	34.8
Rushoon	**12163**	27.6	31.3	32.7	33.7	34.8
	12164	27.2	31.2	32.7	33.9	35.0

2.4 Tropical Storms

There has been an increase in the number of tropical storms that have developed within the Atlantic Basin during the last 19 years. Figure 2.5 shows the 5-year average of tropical storms which have developed within the Atlantic Basin since 1961. This increase in activity has been attributed to naturally occurring cycles in tropical climate patterns near the equator called the tropical multi-decadal signal (Bell & Chelliah, 2006). Despite the increase in Atlantic Basin Storms, there has been no appreciable increase in the number of storms which have entered the Canadian Hurricane Response Zone, or the number of storms passing through the 150nm buffer zone surrounding the BMAs.

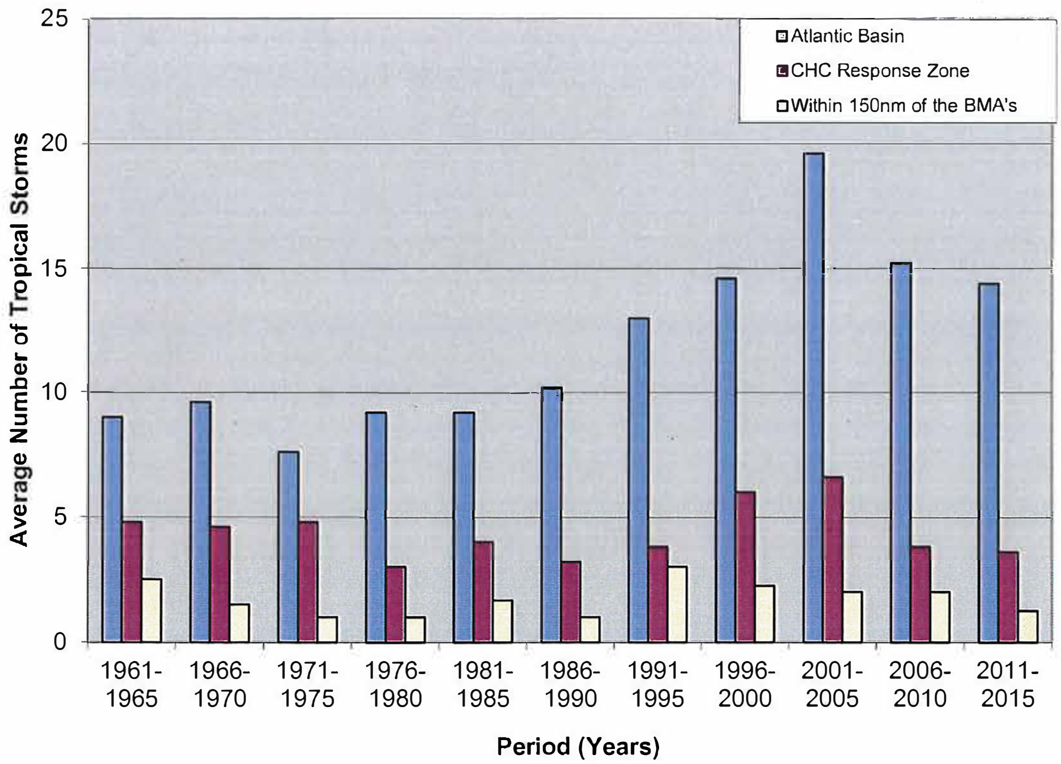


Figure 2.5 5-Year Average of the Number of Tropical Storms which formed in the Atlantic Basin since 1961

A significant number of tropical cyclones which move into the mid-latitudes transform into extratropical cyclones. On average, 46% of tropical cyclones which formed in the Atlantic transform into extratropical cyclones. During this transformation, the system loses tropical characteristics and becomes more extratropical in nature resulting in an increase in size which produces large waves, gale to hurricane force winds and intense rainfall. The likelihood that a tropical cyclone will undergo transition increases toward the second half of the tropical season; with October having the highest probability of transition. In the Atlantic, extratropical transition occurs at lower latitudes in the early and late hurricane season and at higher latitudes during the peak of the season (Hart & Evans, 2001).

Since 1960, 56 tropical systems have passed within 150 nm of the BMAs. The names are given in Table 2.16 and the storm tracks for the months of June - September are shown in Figure 2.6. Of the five months in which tropical storms affected the region, the month of September was the most active with a total of 24 named storms. There were no storms of tropical origin during the months of April and May. It should be noted that the values in Table 2.16 are the maximum 1-minute mean wind speeds occurring within the tropical system at the 10-m asl reference as it entered the area within 150nm of the BMAs.

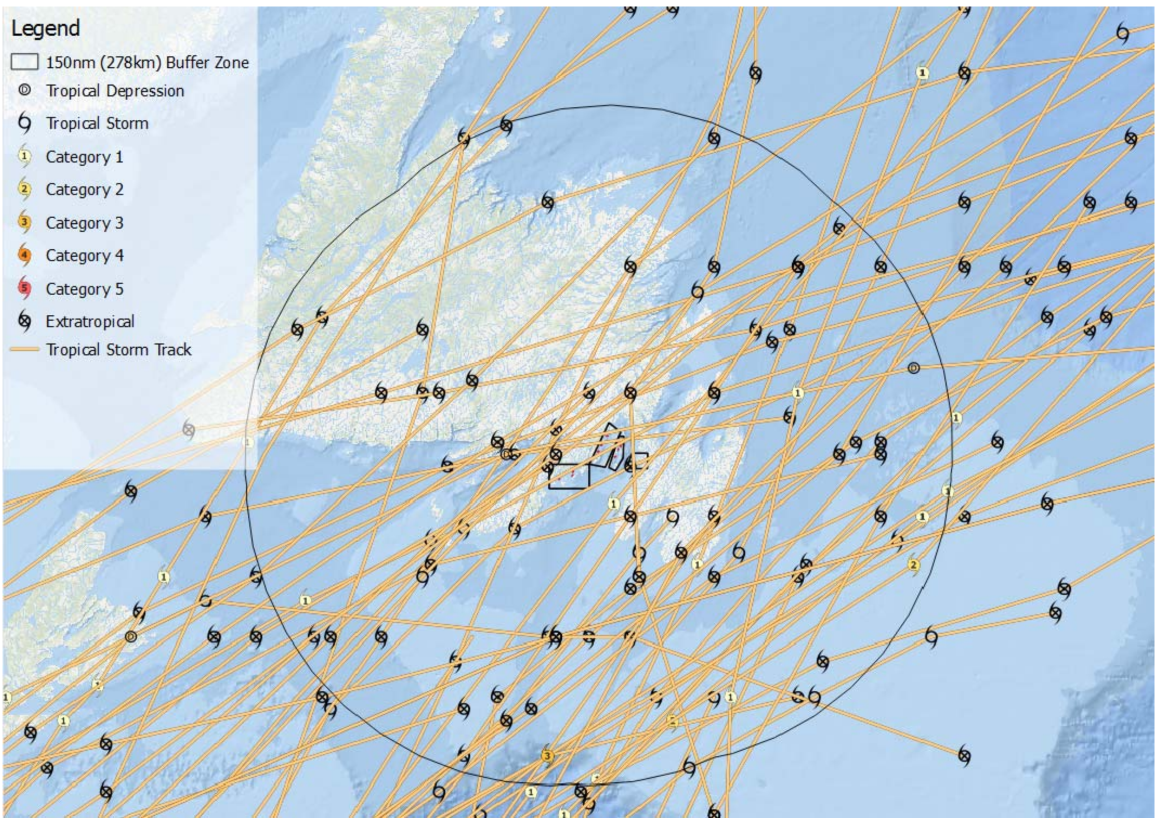


Figure 2.6 Storm Tracks of Tropical Systems Passing within 150 nm (278 km) of the Bay Management Areas (1960 to 2015)

On occasion, these systems still maintain hurricane strength as they enter the area within 150nm of the BMAs. Three Category 1, one Category 2 and one Category 3 hurricanes entered the study area during the period from 1960 to 2015. The most intense of these storms was Hurricane Ella which entered the area on September 5, 1978 with maximum sustained wind speeds of 54.0 m/s and a central pressure of 960 mb.

Table 2.16 Tropical Systems Passing within 150nm of the study area (1961 to 2015)

Year	Month	Day	Hour	Name	Latitude	Longitude	Wind (m/s)	Pressure	Category
1962	September	2	1800	Alma	45.3	-55.5	7.7	N/A	Extra-Tropical
1962	October	9	0600	Daisy	46.0	-54.9	25.7	N/A	Extra-Tropical
1962	October	22	1200	Ella	46.7	-53.4	30.9	N/A	Extra-Tropical
1964	September	15	1800	Dora	47.6	-55.6	28.3	N/A	Extra-Tropical
1964	September	25	0000	Gladys	47.5	-54.9	30.9	N/A	Extra-Tropical
1969	August	12	1800	Blanche	46.0	-54.9	30.9	N/A	Extra-Tropical
1969	August	24	0600	Debbie	45.5	-52.8	41.2	N/A	Category 1
1970	October	18	0000	Unnamed	47.0	-53.0	28.3	N/A	Extra-Tropical
1971	July	7	1800	Arlene	46.5	-53.0	23.1	N/A	Extra-Tropical
1973	October	28	0000	Gilda	45.4	-55.2	28.3	N/A	Extra-Tropical
1974	October	3	1200	Gladys	46.6	-50.6	43.7	960	Category 2
1977	September	30	0000	Dorothy	47.0	-51.0	25.7	995	Extra-Tropical
1978	September	5	0000	Ella	45.0	-55.0	54.0	960	Category 3
1979	August	6	0000	Unnamed	47.5	-55.5	12.9	N/A	Tropical Depression
1982	June	20	1800	Unnamed	45.4	-56.0	30.9	990	Extra-Tropical
1982	September	19	0000	Debby	45.3	-53.5	46.3	970	Category 2
1984	September	2	0600	Cesar	45.5	-51.8	23.1	997	Tropical Storm
1984	September	16	0600	Diana	46.0	-57.8	30.9	995	Extra-Tropical
1985	July	19	1200	Ana	48.0	-54.5	25.7	996	Extra-Tropical
1989	August	8	1200	Dean	46.5	-56.5	28.3	991	Tropical Storm
1990	October	15	0600	Lili	46.6	-56.4	20.6	994	Extra-Tropical
1995	June	9	0600	Allison	48.1	-55.9	20.6	996	Extra-Tropical
1995	August	22	1200	Felix	46.8	-50.8	25.7	985	Tropical Storm
1995	September	11	0600	Luis	47.1	-54.2	41.2	963	Category 1
1996	July	15	0000	Bertha	48.0	-57.0	25.7	995	Extra-Tropical
1996	September	15	1800	Hortense	46.0	-55.0	20.6	996	Extra-Tropical
1996	October	10	0600	Josephine	48.5	-58.0	23.1	985	Extra-Tropical
1998	September	6	0000	Earl	47.0	-54.0	25.7	979	Extra-Tropical
1999	September	19	0000	Floyd	48.0	-56.3	18.0	992	Extra-Tropical
1999	September	23	1200	Gert	46.6	-51.9	30.9	972	Extra-Tropical
2000	September	17	1800	Florence	45.5	-53.0	25.7	1002	Tropical Storm
2000	October	8	1200	Leslie	46.0	-57.0	20.6	1003	Extra-Tropical
2000	October	20	0000	Michael	48.0	-56.5	38.6	966	Extra-Tropical
2001	September	15	0000	Erin	46.7	-52.7	30.9	981	Tropical Storm
2001	September	19	1800	Gabrielle	46.5	-52.0	30.9	986	Extra-Tropical
2002	July	17	0600	Arthur	46.5	-53.9	23.1	999	Extra-Tropical

2002	September	12	0900	Gustav	47.6	-58.6	33.4	963	Category 1
2004	September	1	1800	Gaston	45.0	-55.0	23.1	998	Extra-Tropical
2005	July	30	1200	Franklin	45.8	-51.7	20.6	1005	Extra-Tropical
2005	September	18	1800	Ophelia	47.4	-56.2	23.1	999	Extra-Tropical
2005	October	26	1200	Ilma	45.0	-55.0	25.7	986	Extra-Tropical
2006	June	16	1200	Alberto	47.4	-55.0	23.1	985	Extra-Tropical
2006	July	18	1800	Unnamed	47.1	-55.8	12.9	1009	Tropical Low
2006	July	22	1200	Beryl	48.5	-56.5	15.4	1004	Extra-Tropical
2006	September	13	1200	Florence	45.5	-55.6	36.0	967	Extra-Tropical
2006	October	2	1800	Isaac	45.5	-53.7	28.3	995	Tropical Storm
2007	August	1	1200	Chantal	46.0	-54.5	28.3	990	Extra-Tropical
2008	September	8	0600	Hanna	47.5	-55.4	20.6	996	Extra-Tropical
2009	August	24	0300	Bill	46.9	-56.0	30.9	976	Tropical Storm
2010	September	21	1500	Igor	46.6	-53.2	38.6	950	Category 1
2011	September	16	1800	Maria	46.7	-53.9	30.9	983	Tropical Storm
2011	October	3	1000	Ophelia	46.9	-55.4	30.9	990	Extra-Tropical
2012	September	11	0900	Leslie	45.8	-56.1	33.4	968	Extra-Tropical
2014	October	19	0600	Gonzalo	44.5	-54.8	41.2	968	Category 1
2015	July	15	1200	Claudette	46.0	-55.9	15.4	1004	Tropical Low

2.5 Air Temperature

The moderating influence of the ocean serves to limit both the diurnal and the annual temperature variation along the coast of Placentia Bay as well as over the bay itself. Diurnal temperature variations expected at the aquaculture farms due to the day/night cycles are very small. Short-term, random temperature changes are due mainly to a change of air mass following a warm or cold frontal passage. In general, air mass temperature contrasts across frontal zones are greater during the winter than during the summer season.

Air temperature statistics were calculated for six ECCC climate stations located around the northern half of Placentia Bay. While only Marticot Harbour and Long Harbour are within the BMAs, temperatures are not expected to vary much throughout the region on any given day. Therefore, statistics from these stations can be considered representative of the Placentia Bay coast.

Monthly mean air temperature statistics are presented in Table 2.17. This table shows that temperatures are coldest in the month of February and warmest during the month of August. The moderating influence of the ocean can be seen within these statistics with mean temperatures only reaching the mid-teens during August. Similarly, mean temperatures only drop to around -5°C during the coldest month of the year.

Table 2.17 Monthly Mean Air Temperature (°C) in Placentia Bay

	Arnolds Cove	Come By Chance	Long Harbour	Red Harbour	Marticot Harbour	Argentia
January	-4.4	-4.7	-3.5	-4.7	-2.3	-2.0
February	-5.1	-5.5	-4.0	-5.1	-3.1	-2.4
March	-2.0	-2.3	-1.1	-2.1	-1.8	-0.8
April	2.3	2.2	2.9	2.3	1.8	2.2
May	5.9	6.1	6.8	6.7	5.2	5.6
June	9.5	9.9	10.7	11.0	9.3	9.3
July	13.8	14.1	15.0	15.0	13.5	13.8
August	15.3	15.4	15.9	16.5	15.9	15.7
September	12.6	12.3	12.8	12.9	13.2	13.2
October	7.8	7.5	8.3	8.1	8.9	8.9
November	3.4	3.0	4.1	3.1	5.1	5.0
December	-1.5	-1.9	-0.4	-1.1	-0.1	0.8

The maximum and minimum air temperature statistics in Table 2.18 and Table 2.19 represent the maximum and minimum temperature recorded with that month over the entire record set. Therefore, as can be seen from these tables, while the ocean does have a moderating effect on temperatures, temperatures as high as 30.6°C and as low as -28.9°C have been recorded within the region.

Table 2.18 Maximum Air Temperature (°C) in Placentia Bay

	Arnolds Cove	Come by Chance	Long Harbour	Red Harbour	Marticot Harbour	Argentia
January	11.0	10.5	15.0	12.0	8.4	15.1
February	11.0	14.5	16.0	9.0	5.8	13.7
March	13.9	15.0	17.2	12.5	10.1	14.4
April	19.5	20.0	21.0	17.0	13.8	20.9
May	20.0	20.0	20.5	25.5	15.6	20.6
June	25.0	24.5	25.0	26.0	21.3	23.9
July	26.0	27.5	26.1	28.5	23.3	26.0
August	28.0	29.0	30.6	29.5	23.8	26.1
September	26.0	26.5	27.0	30.0	24.3	24.2
October	19.5	23.0	22.5	21.5	17.5	21.1
November	15.5	16.1	19.5	17.5	14.3	21.1
December	14.0	14.4	16.1	13.0	11.3	15.7

Table 2.19 Minimum Air Temperature (°C) in Placentia Bay

	Arnolds Cove	Come by Chance	Long Harbour	Red Harbour	Marticot Harbour	Argentia
January	-21.7	-25.6	-24.0	-24.5	-17.5	-16.3
February	-25.6	-28.9	-25.0	-28.5	-15.8	-19.5
March	-21.0	-25.0	-22.5	-22.0	-15.9	-21.4
April	-18.0	-18.0	-14.0	-17.0	-11.3	-9.2
May	-6.7	-8.0	-6.7	-6.0	-2.0	-4.6
June	-1.1	-3.3	-5.0	-2.0	-0.1	0.6
July	1.0	2.0	-1.0	0.0	6.2	4.6
August	2.2	1.0	1.7	0.5	6.9	5.8
September	-1.7	-1.0	-2.5	-1.5	3.2	2.2
October	-8.0	-8.0	-6.0	-7.0	-1.9	-1.9
November	-13.5	-15.0	-12.0	-14.0	-6.8	-10.5
December	-20.0	-24.0	-20.0	-23.0	-14.5	-15.9

2.6 Precipitation

Monthly precipitation was recorded at four of the ECCC climate stations in Placentia Bay: Arnold's Cove, Come by Chance, Long Harbour, and Red Harbour. Mean daily and maximum one day precipitation amounts for each month are provided in Table 2.20 and Table 2.21

respectively. Mean, minimum and maximum monthly precipitation amounts for the four climate stations are provided in Table 2.22 through Table 2.24.

Table 2.20 Mean Daily Precipitation Amounts (mm, on days with precipitation) for each month from the ECCC Climate Stations

	Arnolds Cove	Come by Chance	Long Harbour	Red Harbour
January	10.4	9.6	8.7	8.7
February	10.8	9.8	8.9	8.6
March	9.8	9.2	7.7	11.3
April	9.1	8.1	7.3	10.9
May	8.9	6.8	6.1	10.3
June	12.1	9.4	7.6	9.4
July	9.5	7.4	6.8	9.0
August	10.1	8.0	7.5	8.5
September	9.8	8.7	7.4	12.1
October	12.0	9.2	8.0	12.8
November	11.2	8.5	7.4	10.6
December	9.6	8.6	7.6	9.9

Table 2.21 Maximum One Day Precipitation Amounts (mm) for each month from the ECCC Climate Stations

	Arnolds Cove	Come by Chance	Long Harbour	Red Harbour
January	62.6	56.0	53.8	55.0
February	108.0	101.0	68.0	81.6
March	66.0	42.0	80.2	198.5
April	49.4	43.2	82.0	96.4
May	46.6	38.0	55.0	73.6
June	97.2	50.0	92.4	60.4
July	94.4	71.0	63.0	91.4
August	60.0	48.2	78.5	92.0
September	56.6	51.0	68.0	129.8
October	73.7	64.8	119.0	92.0
November	82.0	50.8	66.4	64.6
December	46.8	57.7	41.0	61.3

Mean daily precipitation amounts are the average daily precipitation amounts recorded on days with precipitation over all years. Maximum one day precipitation amounts refer to the maximum amount of precipitation recorded on one day within the month. Monthly mean precipitation amounts refer to the amount of precipitation recorded during the particular month averaged over the entire period.

Table 2.22 Mean Monthly Precipitation Amounts (mm) from the ECCC Climate Stations

	Arnolds Cove	Come by Chance	Long Harbour	Red Harbour
January	120.7	127.7	127.4	162.9
February	104.2	103.0	111.6	149.1
March	100.6	107.4	110.0	144.3
April	85.9	93.2	101.9	145.5
May	92.7	88.9	92.7	146.6
June	126.2	117.2	112.8	114.9
July	94.6	86.1	92.3	124.4
August	101.7	91.8	110.5	120.2
September	111.2	107.9	124.5	179.3
October	139.9	128.4	148.0	207.2
November	124.3	108.1	125.9	176.2
December	111.5	115.0	117.6	174.3

Table 2.23 Minimum Monthly Precipitation Amounts (mm) from the ECCC Climate Stations

	Arnolds Cove	Come by Chance	Long Harbour	Red Harbour
January	37.8	63.0	42.0	101.0
February	17.2	34.1	24.4	54.2
March	42.9	43.4	42.5	78.0
April	20.8	33.4	21.9	65.4
May	38.2	28.8	28.8	49.6
June	42.2	45.2	17.8	53.8
July	21.1	29.0	13.0	57.3
August	29.0	28.2	53.2	80.6
September	33.8	43.7	52.3	92.6
October	54.4	33.7	52.6	117.6
November	58.4	33.0	62.8	74.6
December	56.2	65.9	60.8	142.0

Table 2.24 Maximum Monthly Precipitation Amounts (mm) from the ECCC Climate Stations

	Arnolds Cove	Come by Chance	Long Harbour	Red Harbour
January	202.6	213.7	202.1	278.0
February	265.2	227.6	207.7	226.0
March	169.1	171.0	218.4	279.3
April	196.9	183.8	240.9	361.0
May	153.8	141.9	157.2	245.6
June	300.5	295.9	249.2	186.3
July	233.4	187.5	223.4	195.2
August	204.0	200.7	343.6	196.2
September	196.2	180.2	222.7	294.6
October	231.0	259.4	311.2	355.5
November	185.8	163.5	208.4	273.0
December	193.1	207.2	168.2	231.6

2.7 Climate Change

Climate is naturally variable and can change over a range of time scales from the very short term, to seasonally, and to longer time periods in response to small and large-scale changes of atmospheric circulation patterns. Short-term meteorological variations are largely a consequence of the passage of synoptic scale weather systems: low pressure systems, high pressure systems, troughs and ridges. The energetics of these features varies seasonally in accordance with the changes in the strength of the mean tropical - polar temperature gradient. Long-term changes occur in response to small and large-scale changes of atmospheric circulation patterns and in the past in the Northern Hemisphere were the mainly result of changes in the North Atlantic Oscillation (NAO). While the NAO still has an effect on climate patterns, there is a general consensus amongst the scientific community that Greenhouse Gas emissions have played a significant role in the climate during the last 60 years.

The dominate features of the mean sea level pressure pattern in the North Atlantic Ocean are the semi-permanent area of relatively low pressure in the vicinity of Iceland and the sub-tropical high-pressure region near the Azores. The relative strengths of these two systems control the strength and direction of westerly winds and storm tracks in the North Atlantic and therefore, play a significant role in the climate of the North Atlantic. The fluctuating pressure difference between these two features is known as the NAO.

A measure of the NAO is the NAO Index, which is the normalized difference in pressure between the Icelandic low and the Azores high. A large difference in pressure results in a positive NAO Index and can be the result of a stronger than normal subtropical high, a deeper than normal sub-polar low, or a combination of both. The positive phase of the NAO index results in more and stronger winter storms crossing the North Atlantic on a more northerly track, and cold dry winters in Northern Canada and Greenland, while the negative phase results in fewer and weaker storms crossing on a more west-east track. A time-series of the Winter (DJF) North Atlantic Oscillation Index during the period of 1950 – 2017 is presented in Figure 2.7.

The negative phase of the NAO dominated from the mid to late 1950's until the early 1970's. There was a 5-year period of positive phase in the 1970's, then another shift back to a negative phase for three years from 1977 – 1979. From 1979/80 until the late 2000's the NAO index remained in a generally positive mode, with only six deviations into the negative mode during this 29-year period. Since 2012, the NAO has been in a positive phase with 2015 being the strongest positive phase since 1950. It is uncertain how long this recent trend will persist.

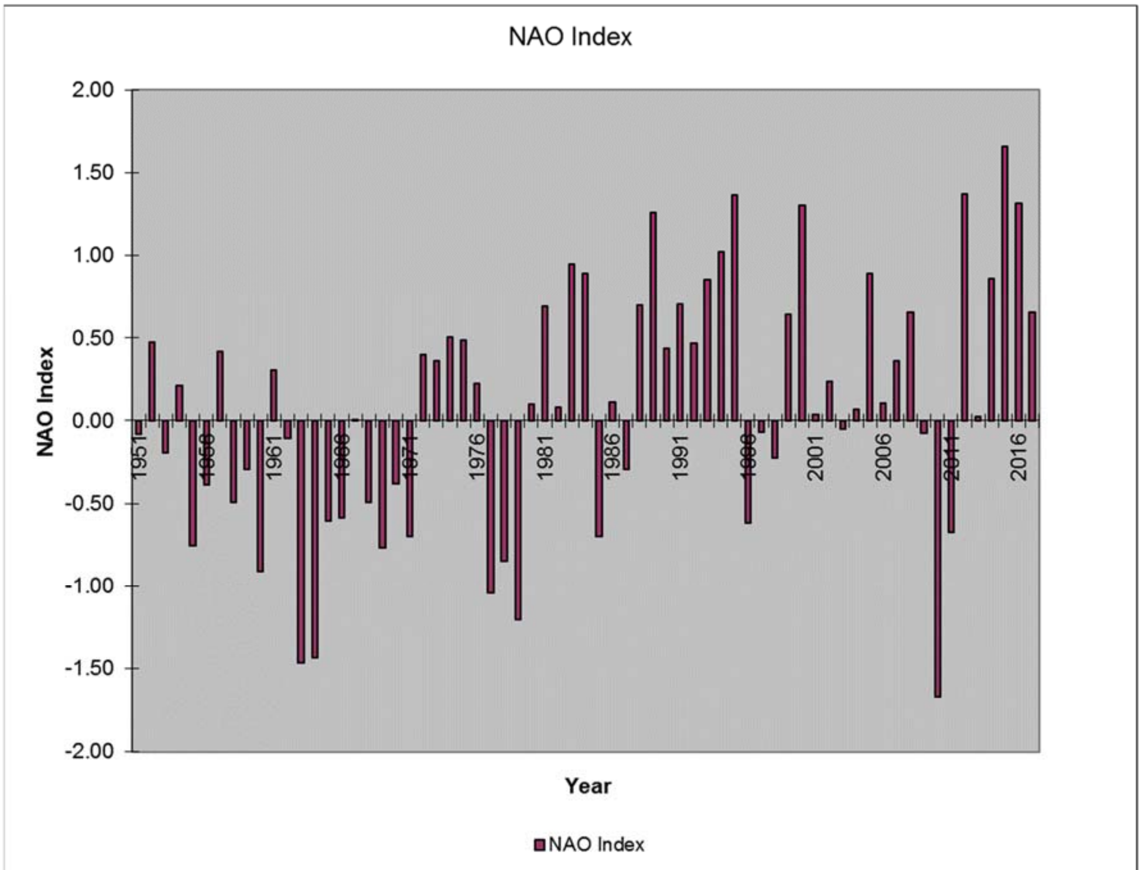


Figure 2.7 The Winter North Atlantic Oscillation Index

2.7.1 Storm Frequency and Intensity

The mean location of extratropical cyclones is referred to as the storm track, the location of which is determined by troughs and ridges in the upper atmosphere. Low pressure systems tend to form in the regions of maximum jet stream located downstream of the upper troughs and follow the jet axes. As a result, areas immediately downstream of an upper trough typically experience more cyclones. A study by Reitan (1974) found that the highest frequency of storms occurs between 40° to 50°N, with one of the most active areas being over the Gulf Stream off the United States Eastern Seaboard. Changes in the location of the jet stream, and intensity of altitude can result in changes in the frequency and intensities of storm systems.

A number of studies have been done recently to assess whether climate change and global warming would have an effect on storm tracks, frequency and intensity. Archer and Caldeira (2008) found that during the period of 1979 to 2001, there was a poleward shift in the jet stream of 0.17 to 0.19 degrees/decade and a significant pressure decrease which would imply an increase in jet stream altitude in the Northern Hemisphere. These results were consistent with an increase in mean temperature from equator to pole. Changes in jet-stream latitude, altitude and strength, have the potential to affect the formation and evolution of storms in the mid-latitudes and of hurricanes in the sub-tropical regions. These results are consistent with a study by McCabe (2001) which showed that from the period of 1959 to 1997, there has been a significant decrease in mid-latitude cyclone frequency and a significant increase in high-latitude cyclone frequency consistent with increases in winter Northern Hemisphere temperatures.

During the summer months, the NAO index has a less direct effect on the climate of Eastern Canada; however, studies have shown that the NAO has an effect on the track of hurricanes in the North Atlantic. During seasons with a negative NAO index, hurricanes tend to follow a track that parallels lines of latitude often ending up in the Gulf of Mexico and the Caribbean (Elsner, 2003), while during seasons with a positive NAO index, hurricanes tend to curve northward (Elsner & Bossak, 2004) along the United States Eastern Seaboard. An analysis of the number of tropical storms entering the Canadian Hurricane Centre Response Zone, however, shows no correlation between tropical cyclone frequency and NAO Index.

2.7.2 Temperature and Precipitation Changes

In the last 60 years, most parts of Canada have experienced warmer temperatures and increased precipitation. It should not be inferred, however, that temperature and precipitation over the whole earth, or even all of Canada is increasing at the same rate. In fact, some areas will experience increasing trends, while other areas may experience a decreasing trend. Over the past century, the earth's temperature has increased by 0.85°C (IPCC, 2013) over the period of 1880-2012. However, between 1895-1995 Canada's temperature increased by 1.1°C (Environment Canada, 1997) with most of this increase occurring during the last decade.

Future climate trends are difficult to predict and the Intergovernmental Panel on Climate Change (IPCC) has developed a number of plausible future climate scenarios. The most commonly used of these scenarios are the Representative Concentration Pathway (RCP) scenarios. RCP scenarios are new scenarios that specify concentrations and corresponding emissions but are not directly based on socio-economic storylines like the SRES scenarios. The RCP scenarios are based on a different approach and include more consistent short-lived gases and land use changes (IPCC, 2013). Four possible scenarios have been chosen by the IPCC to represent future conditions. These four scenarios are the RCP 2.6, RCP 4.5, RCP 6 and RCP 8.5.

According to the IPCC, the projected change in global mean surface air temperature for all four RCP's will likely be in the range of 0.3 to 0.7°C (IPCC, 2013). A regional map showing the 50th and 75th percentile December-February and June-August temperature change in Eastern North America is shown in Figure 2.8.

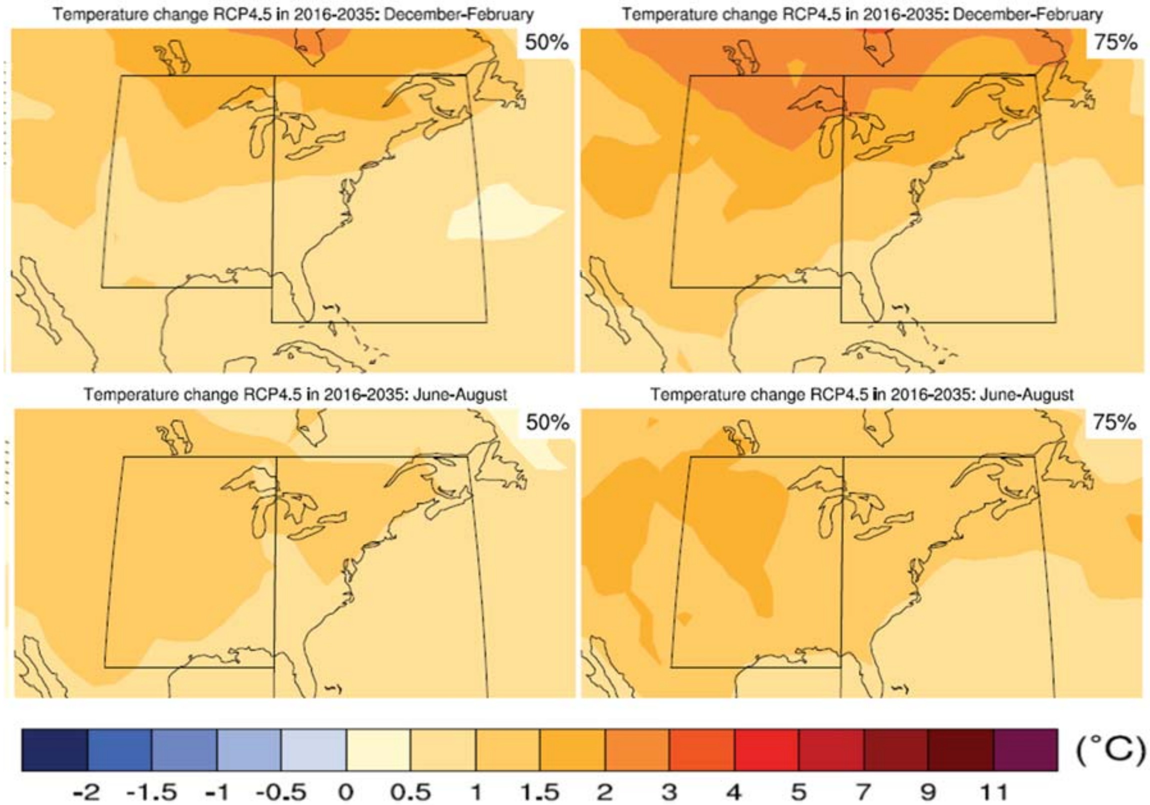


Figure 2.8 Possible future temperature change from the CMIP5 ensemble model running the RCP4.5 scenario for Eastern North America

Changes in precipitation are more difficult to predict than temperature, however ensemble models show some consistency on larger scales, but larger uncertainty on regional scales. The IPCC reports that zonal mean precipitation will very likely increase in high and some of the mid latitudes.

A regional map showing the 50th and 75th percentile December-February and June-August precipitation change in Eastern North America is shown in Figure 2.9. The hatched area denotes areas where the 20-year mean differences of the percentiles are less than the standard deviation of model-estimated present-day natural variability of 20-year mean differences.

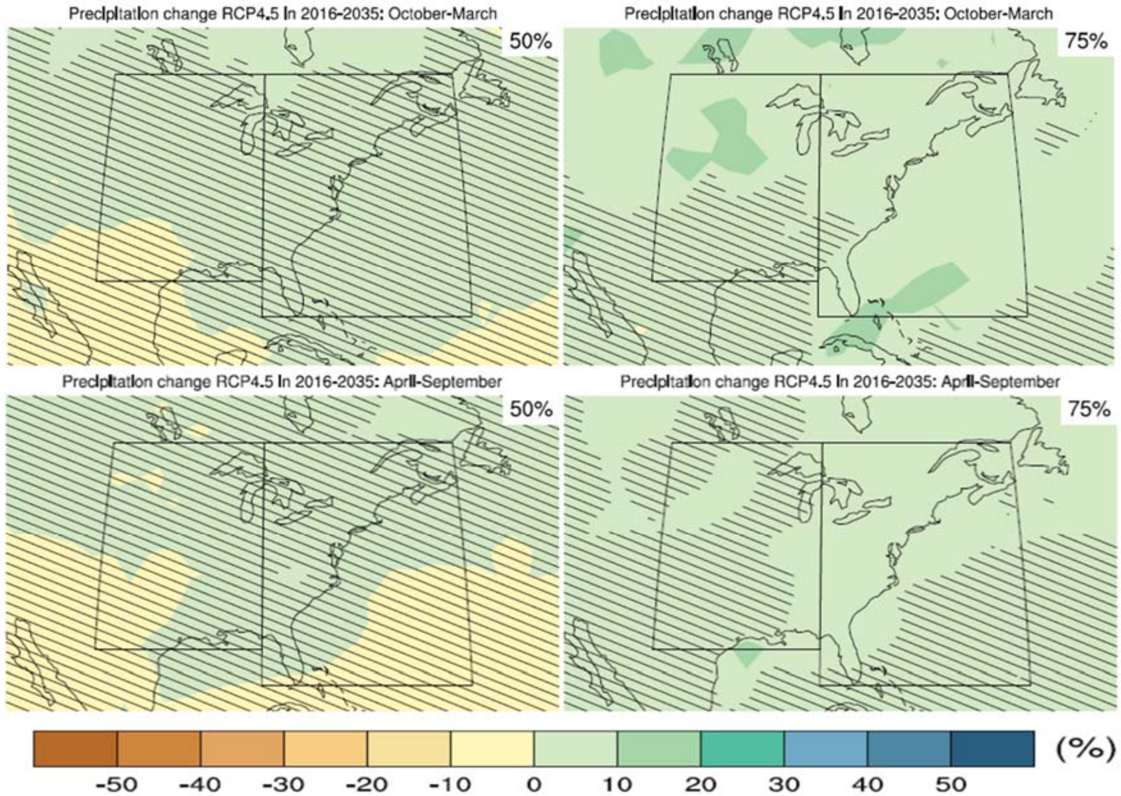


Figure 2.9 Possible future precipitation change from the CMIP5 ensemble model running the RCP4.5 scenario for Eastern North America

2.7.3 Sea Ice and Icebergs

The thickness and extent of ice in the Arctic has long been considered to be a sensitive indicator of climate change. Studies in the past (McLaren, The Under-Ice Thickness Distribution of the Arctic Basin as Recorded in 1958 and 1970, 1989); (McLaren, Walsh, Bourke, Weaver, & Wittmann, 1992); (Wadhams, Evidence for Thinning of the Arctic Ocean Cover North of Greenland, 1990) have shown that sea ice thickness has been decreasing and it was surmised that sea ice thickness would continue to decrease throughout the 1990s. Several recent studies however (Winsor, 2001); (Laxon, Peacock, & Smith, 2003), have shown that this is not the case and that sea ice thickness has remained relatively constant during the 1990s. Winsor (2001) further surmised that the thickness of sea ice cover has remained on a near constant level during the period of 1986 to 1997. This is supported by Wadhams and Davis (2000) who concluded that a substantial part of the thinning in the previous studies took place during the late 1970s and early 1980s.

Inter-annual Arctic winter sea ice variability has been linked to large scale sea level pressure and surface air temperature changes associated with the North Atlantic Oscillation (Deser, Walsh, & Timlin, 2000). The study by Deser et al. examined sea ice concentrations anomalies in the Arctic during 1958 to 1997 and its association with surface air temperature and sea level pressure. The study found that when wintertime sea level pressure (SLP) is lower than normal over the North

Atlantic (positive phase of the NAO), the Labrador Sea ice boundary extends further south in the spring.

A concern that often arises with global warming is whether or not there would be an increase in the number of icebergs off Newfoundland and Labrador due to an increase in calving at tidal glaciers. A study by Marko et al (1994) observed the inter-annual and seasonal variations in the numbers of icebergs passing south of 48°N off eastern North America. This study showed that the number of icebergs off Newfoundland and Labrador is relatively insensitive to iceberg production rates and highly dependent on the Labrador spring ice extent, with higher numbers of icebergs occurring when the sea ice extent is greatest. The spring sea ice ensures iceberg survival by preventing them from grounding and subsequently melting on shallow continental shelves, suppressing sea surface temperatures and suppressing wave heights. A decrease in sea ice extent due to climate variability should result in a decrease in the number of icebergs near the aquaculture sites.

2.7.4 Sea Level Rise

Sea levels are expected have been on the increase and are expected to continue to rise over the next 80 years as a result of climate change. Observations since 1971 indicate that thermal expansion and glacier melting explains 75% of the observed rise. The contribution of the Greenland and Antarctic ice sheets has increased since the early 1990s, partly from the increased outflow induced by warming of the immediately adjacent ocean (IPCC, 2013). There is a high confidence in the future projections of sea level rise due to ocean thermal expansion and a medium confidence in the projections due to glacier melting.

The rate of sea level rise is projected to vary on a regional basis, with some regions experiencing a rise in sea level and others experiencing a decrease in sea level. The global mean is 0.48 m with a total range of -1.76 m to 0.71 m (IPCC, 2013). Decreases in sea levels are expected to occur in regions located near glaciers and ice sheets. Figure 2.11 shows the regional projected sea level rise based on the RCP 4.5 scenario. This indicates a sea level rise of approximately 0.6 m for the waters south of Newfoundland, including Placentia Bay, by the 2081 – 2100 period.

Sea level predictions were also computed for several cities globally. The closest projection to Newfoundland was for the city of New York. A graph of the observed and projected sea level rise for New York is presented in Figure 2.12. This graph indicates a sea level rise of about 0.06 m per year.

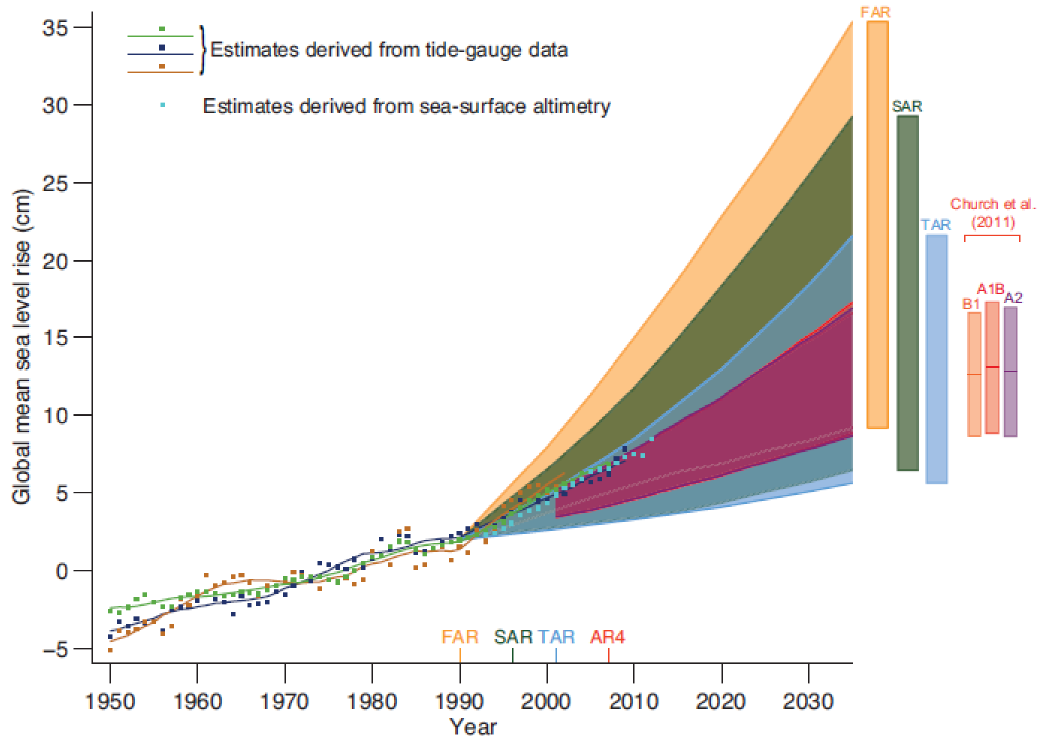


Figure 2.10 Past and future likely ranges of global mean sea-level rise (IPCC, 2013)

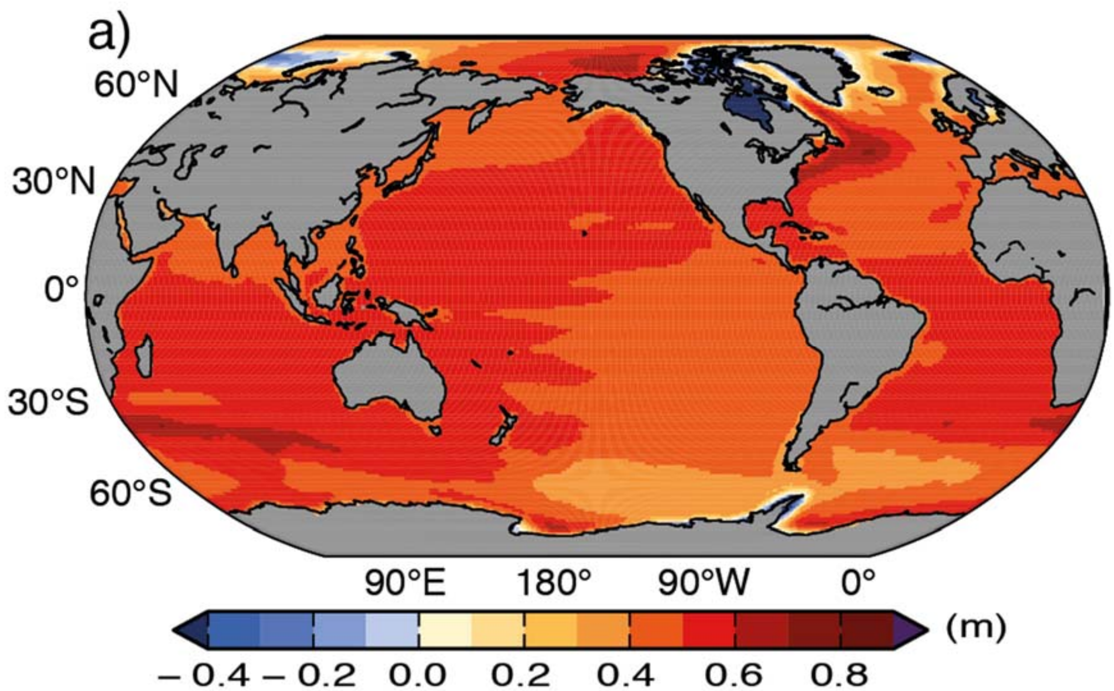


Figure 2.11 Ensemble mean regional relative sea level change (m) evaluated from 21 models of the CMIP5 scenario RCP 4.5 between 1986 - 2005 and 2081 - 2100

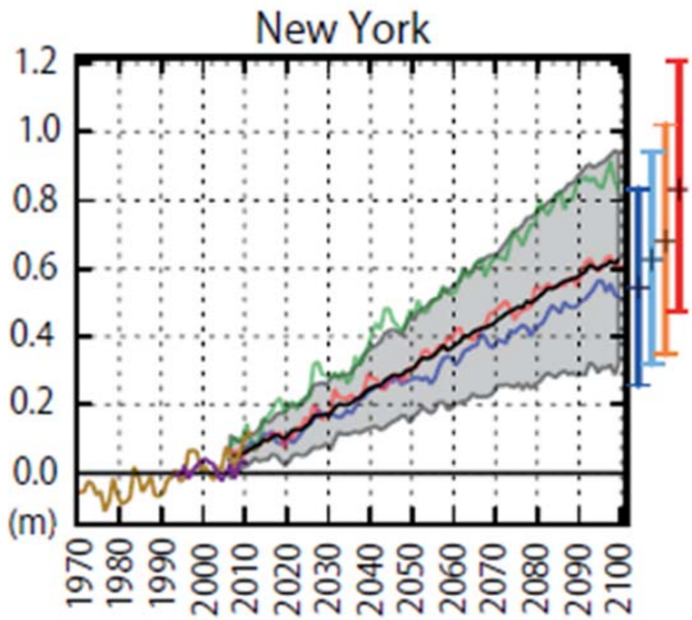


Figure 2.12 Observed and Projected Sea Level Change near New York.

3.0 Aquatic Environment

3.1 Ocean Currents

The bathymetry of Placentia Bay is very irregular with many banks and troughs. There are several islands in the Bay; the largest is Merasheen Island situated in the inner portion of the bay. A deep channel on the eastern side of Placentia Bay has water depths extending to approximately 300 m in some locations. In general, the water is shallower on the western side of the Bay than on the eastern side with the exception of many deep troughs.

In general, the near-surface currents in Placentia Bay have been observed to flow counter clockwise around the Bay. This circulation pattern is not consistent at deeper levels. The flow in Placentia Bay is expected to be the result of tides, winds, and the Labrador Current. Since the variability due to tides account for approximately only 15% of the total variability, other factors are more important. Winds in the area are predominately from the southwest during all seasons and this would contribute to a counter clockwise pattern in the near surface waters. The inshore branch of the Labrador Current follows the bathymetric contours around the Avalon Peninsula. North of Green Bank the direction of the bathymetric contours shift from an east/west direction to a north/south direction. The Labrador Current probably divides at this location with a portion of the Labrador Current contributing to the flow into Placentia Bay and becoming the major contributor to the overall current variability.

3.1.1 Data Sources

Current data in Placentia Bay was collected by the Department of Physics and Physical Oceanography at Memorial University during the spring (April to June) of 1998 and 1999, and by the Bedford Institute of Oceanography (BIO) during winter 1988 (February 16 to March 29) and fall 1998 (September 27 to October 29). The Memorial University data consisted of data from two sites in 1998 and seven sites in 1999. In 1999, there were four moorings deployed in the outer section of the Bay with two instruments on each mooring, and three ADCPs deployed around the islands in the inner section of the Bay in the location shown in Figure 1. Two of the moorings in the outer section of the Bay in 1999 were in the same locations as the moorings in 1998. The BIO moorings consisted of three moorings (Figure 3.1) with two instruments on each mooring; one instrument moored near the surface between 15 m and 25 m and the other moored between 49 m and 63 m.

The Marine Institute School of Ocean Technology has had a Smart Bay Buoy moored in the channel east of Red Island collecting near surface current data at a depth of 0.5 m since 2010. The location corresponds with the current data collected by the Memorial mooring in 1999.

Grieg NL collected current data in each of the 11 proposed aquaculture sites during January to March 2016 (DHI, 2016) to support a dispersion modelling study. The total current monitoring time was limited and varied by site ranging from 20 hours to 7 days in duration.

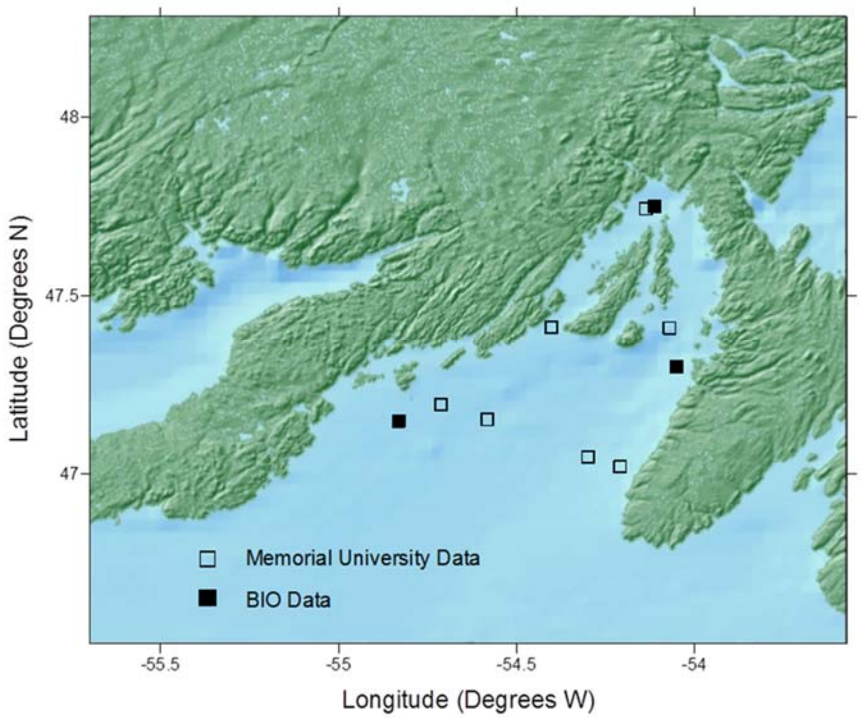


Figure 3.1 Location of Current Meter Moorings in Placentia Bay

3.1.2 Proposed Long Harbour BMA

The proposed aquaculture sites outside Long Harbour are shown in Figure 3.2.

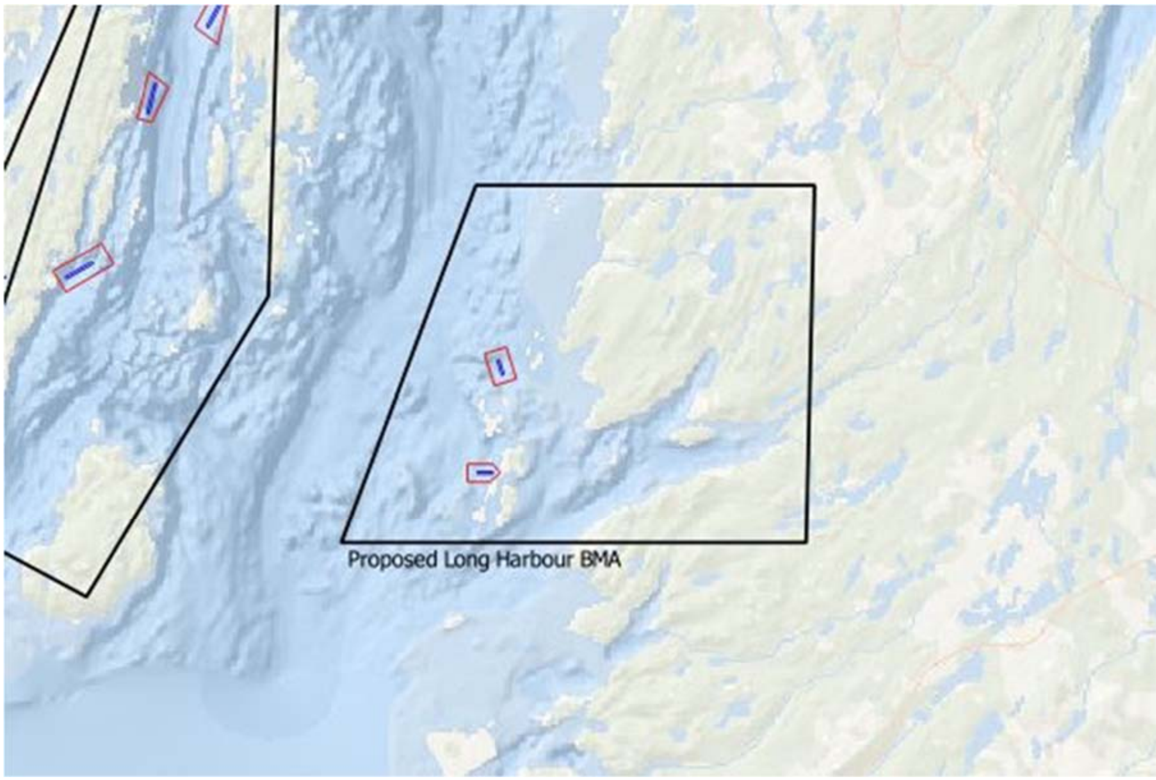


Figure 3.2 Proposed Long Harbour Aquaculture Sites

At the head of Placentia Bay on the eastern side, the Memorial data showed that the current is consistently flowing into the bay with mean speeds between 11 cm/s and 18 cm/s at a depth of 20 m. The maximum current speed reached 75 cm/s during the sampling period in 1999. During the same year the near surface current at 16 m in the middle of the channel between Red Island and the aquaculture site had a mean speed of 16 cm/s and a maximum speed of 79 cm/s. The BIO data collected outside Long Harbour during winter and fall of 1988 showed similar current speeds. The mean current speed at approximately 23 m was between 12 cm/s and 13 cm/s and reached a maximum speed of 75 cm/s. At this location the current is still flowing predominately into the Bay, but at times the current is flowing in the opposite direction, presumably due to tidal influence. The semi-diurnal tidal constituents M_2 and S_2 had values of 6.0 cm/s and 3.7 cm/s, respectively. The tidal current during spring tides is approximately 10 cm/s. A rose plot of the near-surface current is shown in Figure 3.3.

DHI collected current data for GREIG Seafarms between March 2 and March 7, 2016 at two locations in the study area. The currents were measured near the Brine Islands for a duration of

2.8 days and near the IONA Islands for a duration of two days. The current direction was variable at both locations, sometimes showing a tidal influence. At a depth of 30m, the current speed reached a maximum of 25 cm/s near the Brine Islands location and a maximum of 22 cm/s near the IONA Islands

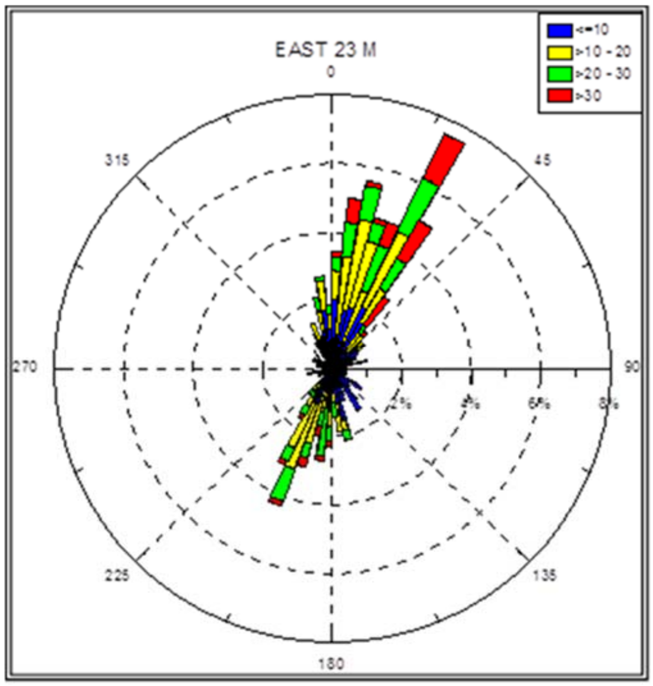


Figure 3.3 Rose Plot of the Near-Surface Current Speeds and Directions Outside Long Harbour in 1988

3.1.3 Proposed Red Island BMA

The location of the proposed aquaculture sites east of Merasheen Island is shown in Figure 3.4. With the exception of current data collected by Grieg NL at each of the aquaculture (lease) sites, there is no current information for the stretch of water between Merasheen Island and Red Island.

Data was collected by DHI for Greig NL between February 20 and March 2, 2016. The sampling periods for the location varied between 0.8 days and six days. The current direction was predominately into the Bay at a depth of 30m and the maximum current speed was 15 cm/s.

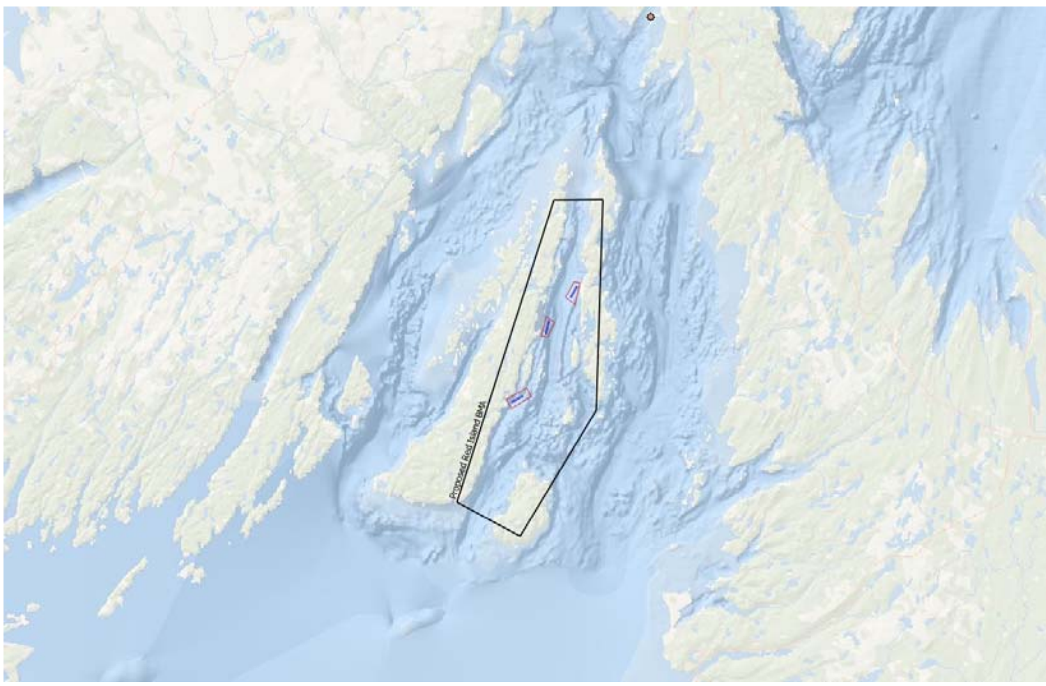


Figure 3.4 Proposed Red Island Aquaculture Sites

3.1.4 Proposed Merasheen BMA

The locations of the proposed aquaculture sites for the proposed Merasheen location are situated west of Merasheen Island. These locations are shown in Figure 3.5.

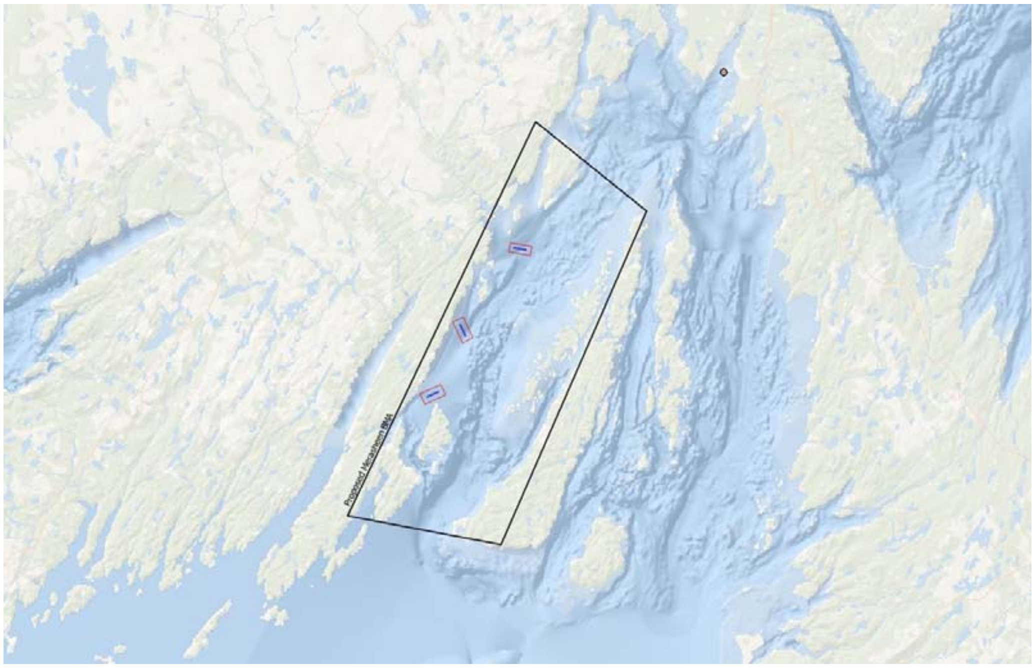


Figure 3.5 Proposed Merasheen Aquaculture Sites

The current speeds on the Western side of Placentia Bay are less than on the eastern side. In 1999, the Memorial data showed that the mean current speed at a depth of 36 m was 7.9 cm/s and reached a maximum speed of 36.5 cm/s during the sampling period. The rose plot in Figure 3.6 shows that the flow was mainly towards the southwest, or out of the Bay. There is also a significant northeast component. The semi-diurnal constituents M_2 and S_2 were 4.0 cm/s and 1.3 cm/s, respectively. During spring tide, the tidal current is expected to be approximately 5-6 cm/s.

DHI measured the currents for Greig NL at three locations in the study area between February 1 to February 20, 2016, for durations of approximately two days, one day and 8 days respectively. The current directions were variable. At a depth of 30m, the maximum current speeds were 10 cm/s for the Valen Island location, 14 cm/s for the Chambers Island location, and 30 cm/s for the Ship Island location.

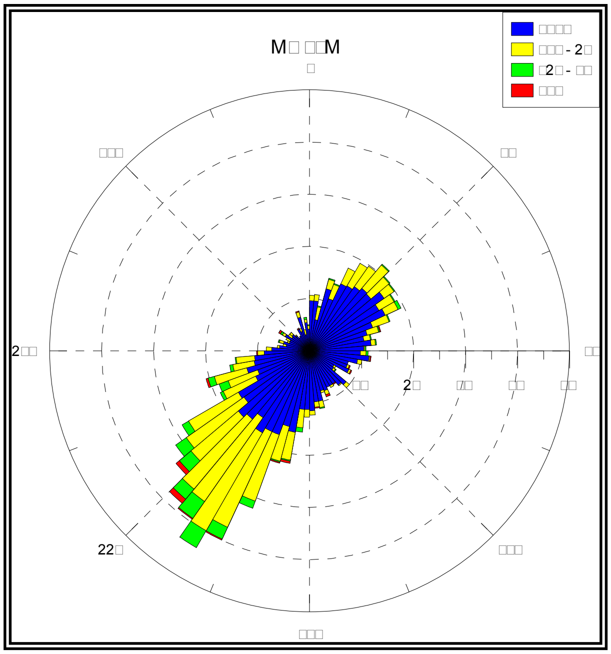


Figure 3.6 Rose Plot of Current Speed and Directions at 36 m west of Merasheen Island

3.1.5 Proposed Rushoon BMA

The location of the proposed aquaculture sites in the Rushoon area is shown in Figure 3.7.

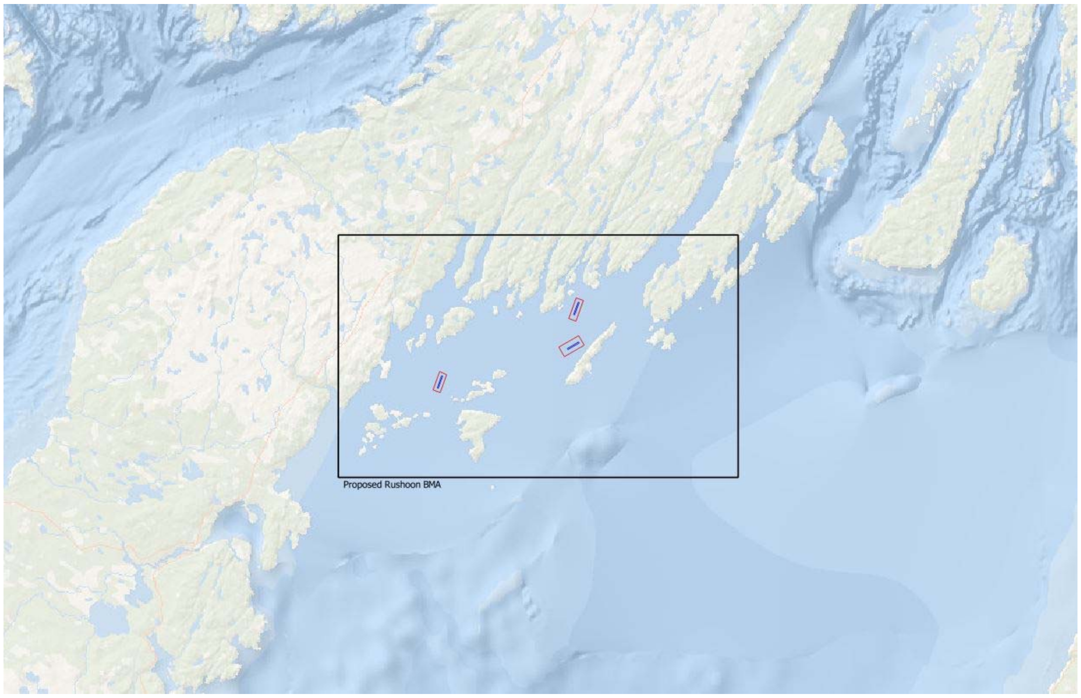


Figure 3.7 Proposed Rushoon Aquaculture Sites

With the exception of current data collected by Grieg NL at each of the aquaculture (lease) sites, there are no current data. The currents are expected to be weak due to the presence of the islands east of the sites. Outside the islands, currents were measured by Memorial University in 1999 and BIO in 1988. The Memorial data showed mean near surface currents (20 m) of 10.3 cm/s and a maximum current of 49.7 cm/s.

The current flowed consistently out of the Bay (Figure 3.8). The semi-diurnal tidal constituents M_2 and S_2 had values of 5.9 cm/s and 1.4 cm/s, respectively. The tidal current at spring tides is expected to be approximately 8 cm/s. BIO data measured during the fall of 1988 showed a similar pattern in the currents. The current flowed consistently out of the Bay with a mean speed of 9.1 cm/s and a maximum speed of 37.3 cm/s. Figure 3.9 presents a rose plot of the current speeds and directions.

The currents were measured at three locations in this study area by DHI for Greig NL between January 28 and February 1, 2016. The sampling period was less than one day at Gallows Harbour and Oderin Island and for approximately two days at Long Island. The current directions are variable. At a depth of 30m, the maximum current speed was 5 cm/s at the Gallows Harbour location, 15 cm/s at the Long Island location and 5 cm/s at the Oderin Island location.

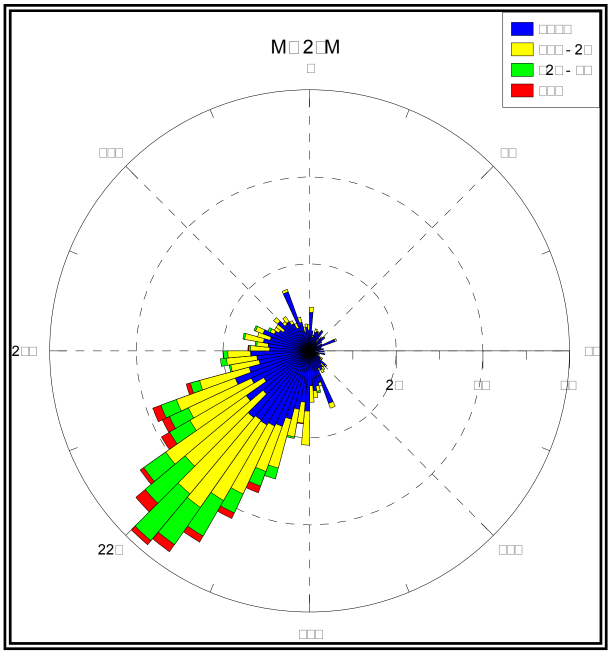


Figure 3.8 Rose Plot of the Near-Surface Current Speeds and Directions from the Memorial University Data Set

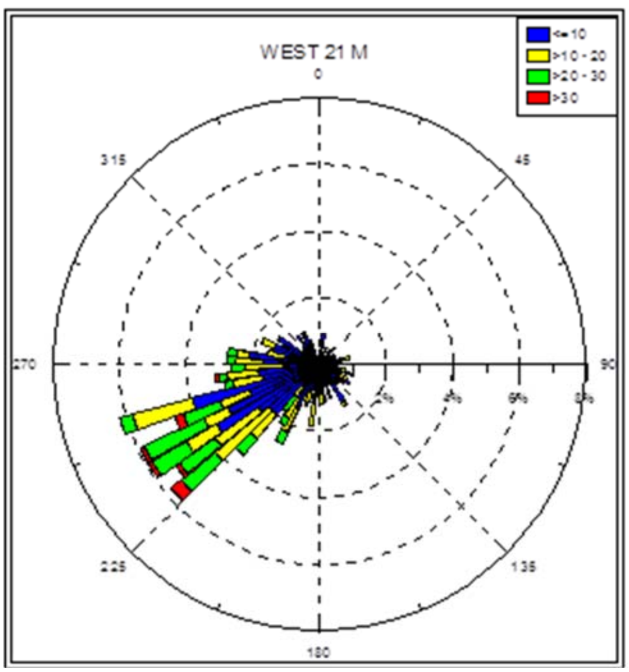


Figure 3.9 Rose Plot of the Near-Surface Current Speeds and Directions Corresponding to the BIO Fall Data Set

3.2 Waves

The main parameters for describing wave conditions are the significant wave height, the maximum wave height, the peak spectral period, and the characteristic period. The significant wave height is defined as the average height of the 1/3 highest waves, and its value roughly approximates the characteristic height observed visually. The maximum height is the greatest vertical distance between a wave crest and adjacent trough. The spectral peak period is the period of the waves with the largest energy levels, and the characteristic period is the period of the 1/3 highest waves. The characteristic period is the wave period reported in ship observations, and the spectral peak period is reported in the MSC50 data set.

A sea state may be composed of the wind wave alone, swell alone, or the wind wave in combination with one or more swell groups. A swell is a wave system not produced by the local wind blowing at the time of observation and may have been generated within the local weather system, or from within distant weather systems. The former situation typically arises when a front, trough, or ridge crosses the point of concern, resulting in a marked shift in wind direction. Swells generated in this manner are usually of low period. Swells generated by distant weather systems may propagate in the direction of the winds that originally produced the waves to the vicinity of the observation area. These swells may travel for thousands of miles before dying away. As the swell advances, its crest becomes rounded and its surface smooth. As a result of the latter process, swell energy may propagate through a point from more than one direction at a particular time.

The wave climate of Placentia Bay is dominated by extra-tropical storms, primarily during October through March. Severe storms may, on occasion, occur outside these months. Storms of tropical origin may occur during the early summer and early winter, but most often from late August through October. Hurricanes are usually reduced to tropical storm strength or evolve into extra-tropical storms by the time they reach the area but they are still capable of producing storm force winds and high waves.

3.2.1 Proposed Long Harbour BMA

The annual wave rose from the MSC50 grid point 12361 is presented in Figure 3.10. The wave rose depicts the direction the waves are travelling to (oceanographic convention) and shows that the majority of wave energy comes from the southwest, travelling to the northeast. This wave direction is mainly due to local topography.

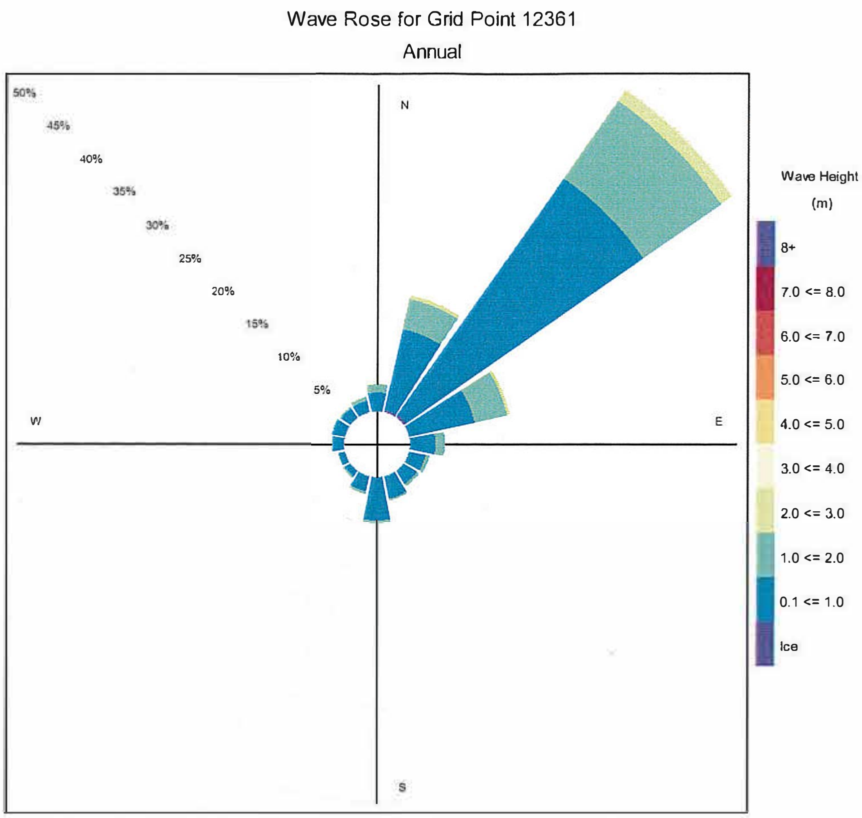
Wave heights were higher at grid point 12361, than the other two grid points. The SmartBay buoy recorded mean wave heights of 1.9 m during the months of January and February and a maximum wave height of 7.9 m in January. Maximum wave heights recorded at the MSC50 sites ranged from 1.3-5.4 m. It seems likely the higher mean heights recorded at the SmartBay buoy are due to a more exposed location than the MSC50 data. The location was covered in ice 4.4% of the time at grid point 12361.

Table 3.1 Mean Wave Height (m) for the Long Harbour BMA

	SmartBay Red Island Shoal	GP 12549	GP 12361	GP 12362
January	1.9	0.7	1.1	0.7
February	1.9	0.6	1.0	0.7
March	1.5	0.6	0.9	0.6
April	1.4	0.5	0.8	0.5
May	0.9	0.3	0.6	0.3
June	0.9	0.3	0.6	0.3
July	0.9	0.2	0.6	0.2
August	0.8	0.3	0.6	0.3
September	1.0	0.4	0.7	0.4
October	1.3	0.5	0.8	0.5
November	1.5	0.6	0.9	0.6
December	1.6	0.7	1.1	0.7

Table 3.2 Maximum Wave Height (m) for the Long Harbour BMA

	SmartBay Red Island Shoal	GP 12549	GP 12361	GP 12362
January	7.9	2.2	4.8	2.3
February	7.5	2.3	5.0	2.1
March	7.0	2.6	5.4	2.2
April	7.0	1.6	3.2	1.9
May	3.9	1.6	3.0	1.9
June	4.0	1.5	2.9	1.8
July	3.3	1.3	3.4	1.3
August	4.0	1.7	4.0	1.7
September	5.0	2.1	3.9	1.9
October	5.8	2.2	4.9	2.1
November	6.9	2.0	4.0	1.9
December	7.8	2.2	4.8	2.3



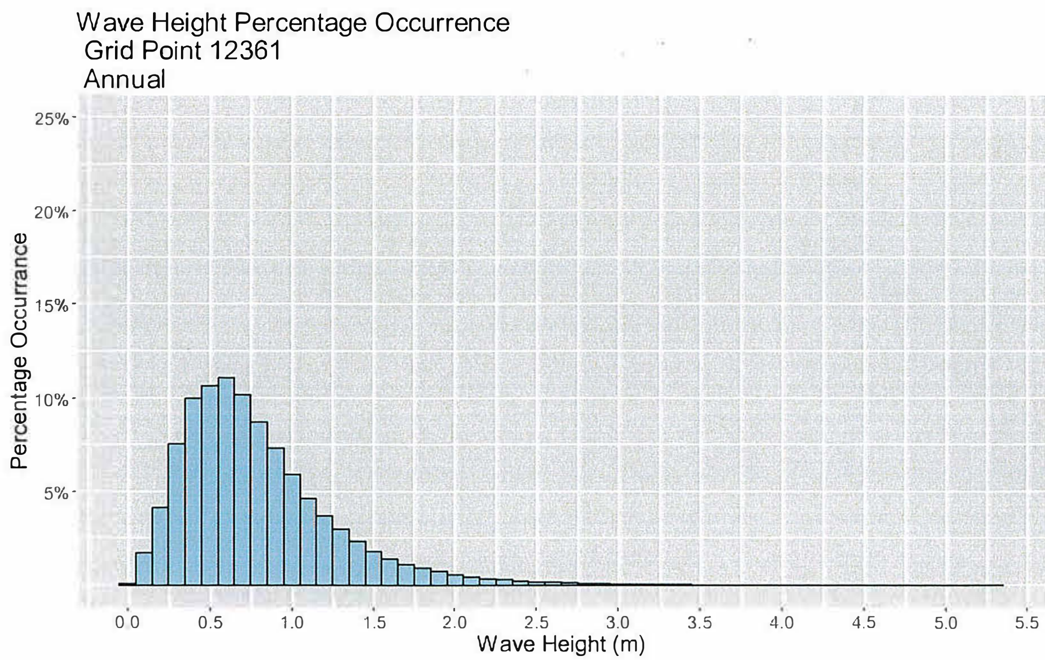


Figure 3.10 Wave Rose and Percentage Frequency Histogram for MSC50 Grid Point 12361 located at 47.4°N; 54.1W near Red Island

3.2.2 Proposed Red Island BMA

Wave heights were previously modelled by Oceans Ltd. for a location north of Red Island. Statistics from this analysis are presented in the absence of any other modelled or measured data near the aquaculture sites. While not completely representative of conditions near the aquaculture sites, these results should give a better idea of conditions than in the open bay.

Surrounded by islands and the mainland, the waters within the Red Island BMA are generally well sheltered from high seas. Red Island lies about 1.5 km to the south around to the southwest; Goat Island is about 2 km to the west; Merasheen Island extends from about 5 km to the west-northwest to 25 km to the north, while Long Island stretches from about 25 km to the north to 7 km to the northeast. Between Long Island and the study site, to the north-northeast, Barren Island lies 9 km distant, while a bit further eastward Little Seal and Great Seal Islands lie 3 and 4 km away, respectively, with Iron Island about 6.5 km to the northeast. From the northeast to the south-southeast, the study site is open to incoming seas from the Eastern Channel off Placentia Bay.

The MSC50 wind and wave reanalysis database (Swail, et al., 2006) provided a historical time series of winds and waves for the study. The closest MSC50 grid point at 47° 24' north latitude and 54° 06' west longitude was only 5 km to southeast of the site in the Eastern Channel.

The following tables and figures present the wave climate at the study site. Table 3.3 lists the mean and maximum significant wave heights for each month, with the maximum wave being the absolute highest value found for each month over the period of the study. Maximum wave heights were not predicted to exceed 3.2 m.

Table 3.3 Monthly Mean and Maximum Waves

Month	Mean Significant Wave Height [m]	Max Significant Wave Height [m]
January	0.7	2.8
February	0.7	2.6
March	0.6	2.7
April	0.6	2.1
May	0.4	2.3
June	0.4	1.8
July	0.4	2.0
August	0.4	2.3
September	0.5	2.4
October	0.5	3.2
November	0.6	2.9
December	0.7	3.2

Figure 3.11 presents the wave height frequency distribution for the entire period. For each wave height category depicted along the bottom of the charts, the height of the bar indicates the expected frequency of occurrence.

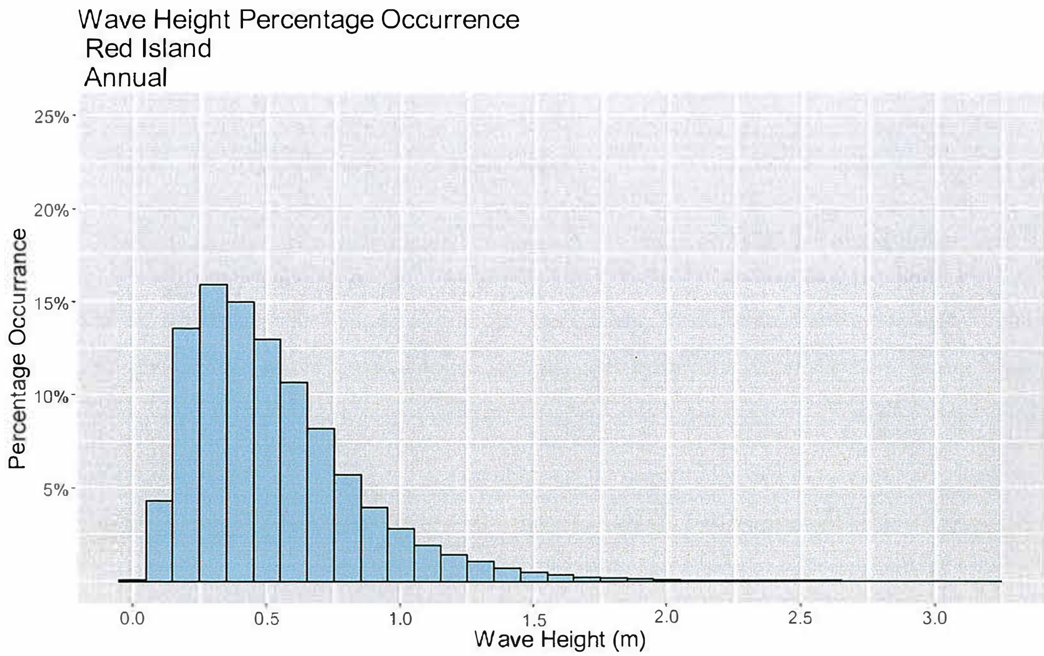


Figure 3.11 Red Island Shoal Percentage Frequency Histogram of Wave Heights.

3.2.3 Proposed Merasheen BMA

The annual wave rose from the MSC50 grid point 12548 is presented in Figure 3.12. The wave rose depicts the direction the waves are travelling to (oceanographic convention) and shows that the majority of wave energy comes from the southwest, travelling to the northeast. Wave heights were higher at grid point 12360, than the other grid point due to its more exposed location (see Figure 2.1). Maximum wave heights at grid point 12360 peaked in October with a wave height of 7.2 m. Maximum wave heights of 6 m or higher were recorded in six months of the year. Maximum wave heights were much lower at grid point 12548, ranging from 1.3 to 2.3 m. It is anticipated that wave heights at the three aquaculture sites in this BMA would be even lower given their proximity to the coast. The location was covered in ice 3.7% of the time at grid point 12548.

Table 3.4 Mean Wave Heights (m) for the Merasheen BMA

	GP 12548	GP 12360
January	0.6	1.4
February	0.6	1.3
March	0.5	1.2
April	0.4	1.0
May	0.3	0.8
June	0.2	0.8
July	0.2	0.8
August	0.3	0.8
September	0.4	0.9
October	0.5	1.0
November	0.5	1.2
December	0.6	1.3

Table 3.5 Maximum Wave Heights (m) for the Merasheen BMA

	GP 12548	GP 12360
January	2.1	6.1
February	2.2	6.4
March	2.3	6.5
April	1.4	4.3
May	1.3	4.2
June	1.3	3.7
July	1.4	4.3
August	1.5	5.2
September	1.8	6.2
October	2.2	7.2
November	1.8	5.5
December	2.1	6.2

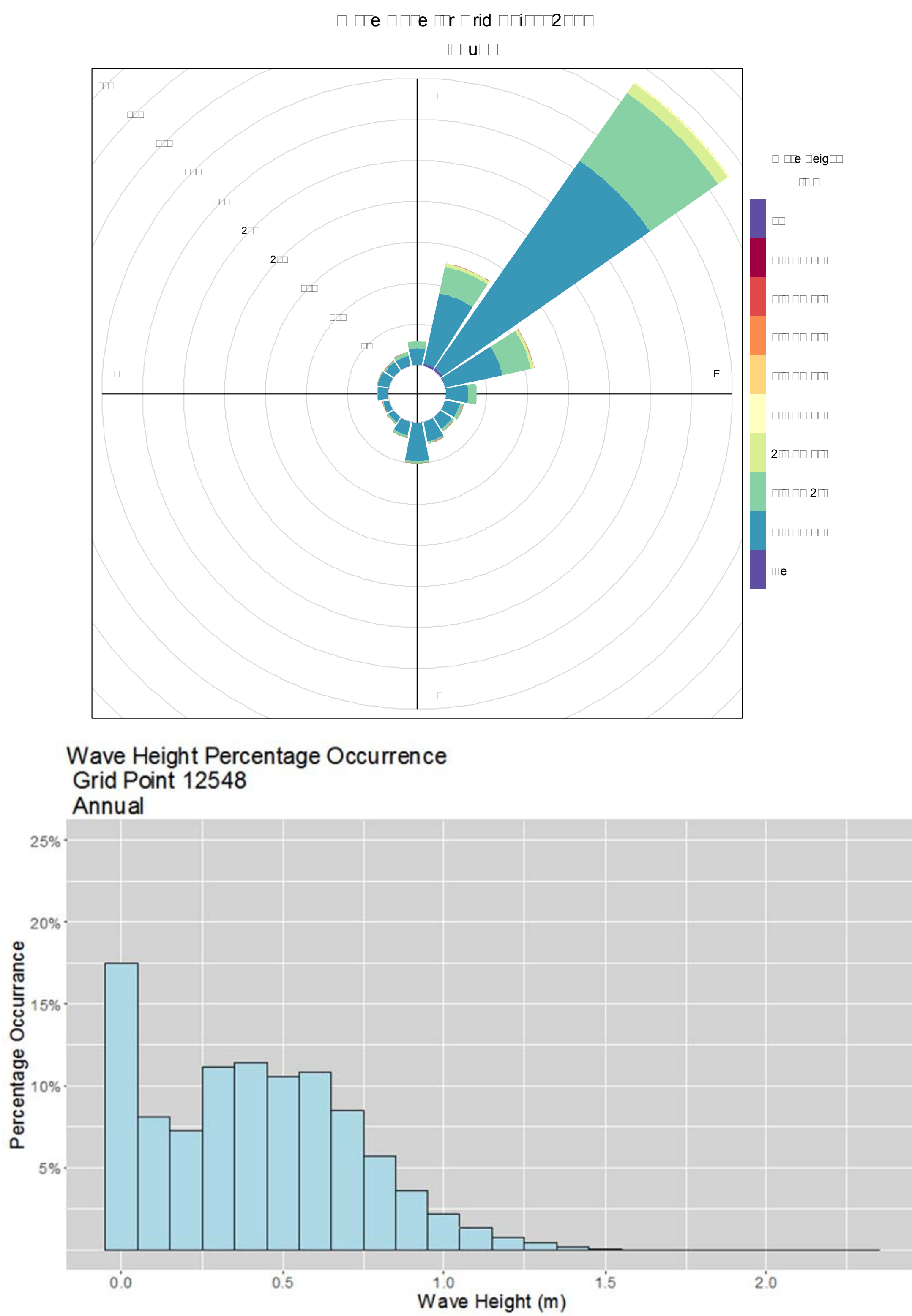


Figure 3.12 Wave Rose and Percentage Frequency Histogram for MSC50 Grid Point 12548 located at 47.5°N; 54.3W within the Merasheen BMA

3.2.4 Proposed Rushoon BMA

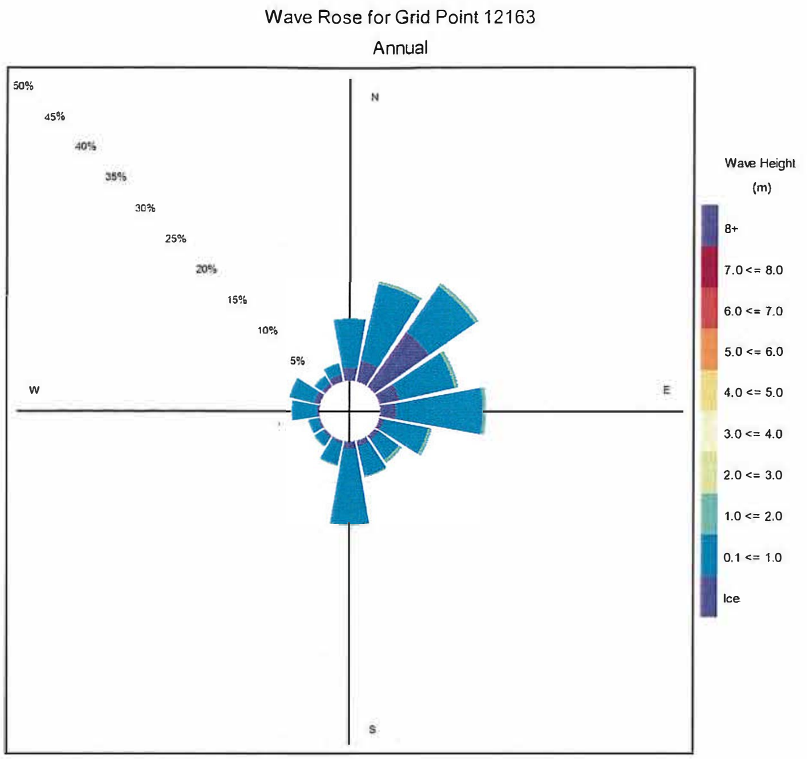
The annual wave rose from the MSC50 grid point 12163 is presented in Figure 3.13. The wave rose depicts the direction the waves are travelling to (oceanographic convention) and shows that the majority of wave energy comes from the west to south-southwest, travelling to the east to east-northeast. Wave heights were higher at grid point 12164, that the other grid point due to its more exposed location. Maximum wave heights at grid point 12164 peaked in October with a wave height of 7.8 m. Maximum wave heights of 6 m or higher were recorded in 8 months of the year at Grid Point 12164, but only in October at Grid Point 12163. Maximum wave heights at grid point 12163 which is relatively close to one of the aquaculture (lease) sites (Figure 2.1), ranged from 3.7 to 6.8 m and on average ranged from 0.8 to 1.3 m. The location was covered with ice 3.7% of the time at grid point 12163.

Table 3.6 Mean Wave Heights for the Rushoon BMA

	GP 12163	GP 12164
January	1.3	1.6
February	1.2	1.5
March	1.1	1.4
April	1.0	1.2
May	0.8	0.9
June	0.7	0.9
July	0.7	0.9
August	0.7	0.9
September	0.9	1.0
October	1.0	1.2
November	1.1	1.3
December	1.2	1.5

Table 3.7 Maximum Wave Heights for the Rushoon BMA

	GP 12163	GP 12164
January	5.2	6.2
February	5.7	6.7
March	5.6	6.7
April	3.7	4.6
May	4.2	5.0
June	3.7	4.1
July	4.0	4.6
August	4.8	6.0
September	5.3	6.9
October	6.8	7.8
November	5.1	6.2
December	5.8	6.9



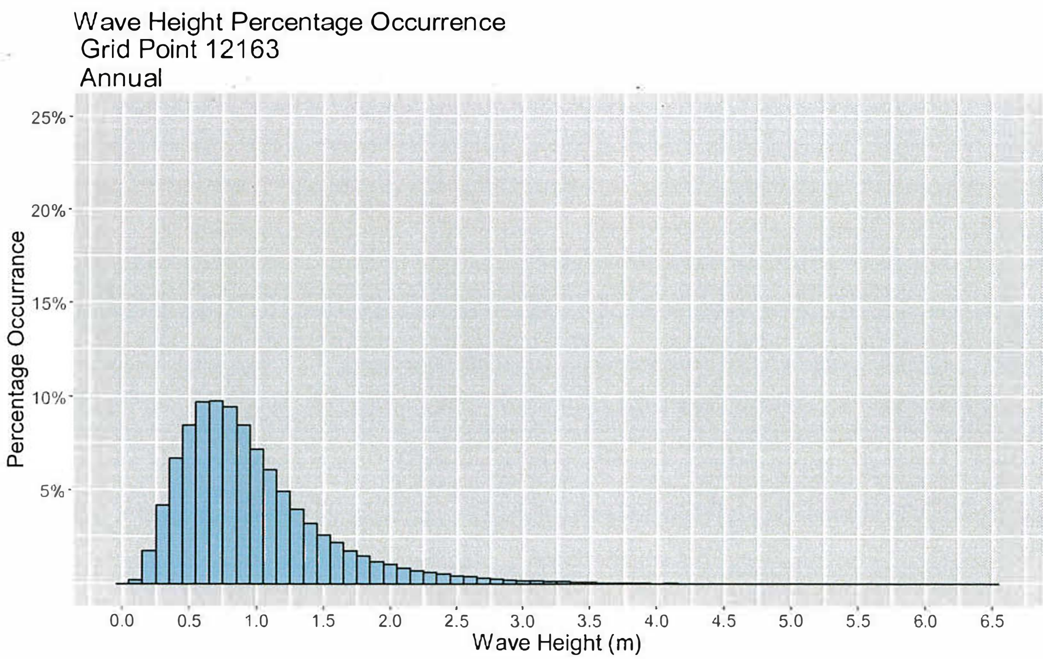


Figure 3.13 Wave Rose and Percentage Frequency Histogram for MSC50 Grid Point 12163 located at 47.3°N; 54.3W within the Rushoon BMA near Oderin Island Farm.

3.2.5 Extreme Wave Heights

Extreme waves were calculated for the northern half of Placentia Bay using three MSC50 grid points: 12163, 12361 and 12548. This data set was determined to be the most representative of the available data sets, as it provides a continuous 60-year period of 1 hourly data for the site. However, only grid point 12163 is adjacent to an aquaculture (lease) site. All extremes are specified for return periods of 1-yr, 10-yr, 25-yr, 50-yr and 100-yr.

The extreme value analysis was carried out using the peak-over-threshold method. The Gumbel distribution was chosen to be the most representative for the peak-over-threshold method as it provided the best fit to the data. Since extreme values can vary depending on how well the data fits the distribution, a sensitivity analysis was carried out to determine the number storms to use, whereby the number of storms, the 100-year extreme value, the correlation coefficient and storm threshold were all compared on an annual basis.

The maximum individual wave heights were calculated within Oceanweather's OSMOSIS software by evaluating the Borgman integral (Borgman, 1973), which was derived from a Raleigh distribution function. The variant of this equation used in the software has the following form (Forristall, 1978):

$$\Pr\{H > h\} = \exp\left[-1.08311\left(\frac{h^2}{8M_0}\right)^{1.063}\right];\ T = \frac{M_0}{M_1}$$

where h is the significant wave height, T is the wave period, and M_0 and M_1 are the first and second spectral moments of the total spectrum.

The annual extreme value estimates for significant wave height for return periods of 1-year, 10-years, 25-years, 50-years and 100-years are given in Table 3.8 for the Long Harbour, Rushoon and Merasheen BMAs. Since there were no grid points within the Red Island BMA, an extreme wave height analysis was not possible.

The annual 100-year extreme significant wave height is estimated to range from 2.2 m at Grid Point 12548 within the Merasheen BMA to 7.7 m at Grid Point 12164 within the Rushoon BMA. Extreme maximum wave heights are estimated to range from 4.2 m at Grid Point 12548 to 13.8 m at Grid Point 12164.

The Iona Islands aquaculture site should expect extreme waves consistent with Grid Point 12361. Sheltered behind an island to the southwest, the Brine Island site should expect waves lower than that of Grid Point 12361.

The three sites within the Merasheen BMA are sheltered from most directions. Extreme significant and maximum wave heights at these three sites would be most represented by Grid Point 12548.

Since wave heights at Grid Point 12164 are predominately to the northeast (from the southwest), both the Gallows Harbour and Long Island aquaculture sites, which are exposed to the southwest, could see these extreme significant wave heights.

It should be noted that the 100-year extreme significant and maximum wave heights are the highest waves expected over a period of 100 years based on probability. The maximum wave height of 6.8 m at Grid Point 12163 in Table 3.7 is higher than the 100-year estimate in Table 3.8. Further analysis shows that the 6.8 m maximum wave height corresponds with the 250-year extreme wave height.

Table 3.8 Extreme Significant Wave Height Estimates (m) for Return Periods of 1, 10, 25, 50 and 100 Years

BMA	Grid Point	1-yr	10-yr	25-yr	50-yr	100-yr
Long Harbour	**12361**	3.4	4.4	4.7	5.0	5.3
	12362	1.8	2.1	2.2	2.3	2.4
	12549	1.7	2.0	2.1	2.2	2.3
Merasheen	**12548**	1.6	1.9	2.0	2.1	2.2
	12360	4.6	5.9	6.4	6.8	7.2
Rushoon	**12163**	4.3	5.4	5.8	6.1	6.4
	12164	5.2	6.5	7.0	7.3	7.7

Table 3.9 Extreme Maximum Wave Height Estimates (m) for Return Periods of 1, 10, 25, 50 and 100 Years

BMA	Grid Point	1-yr	10-yr	25-yr	50-yr	100-yr
Long Harbour	**12361**	6.6	8.2	8.8	9.0	9.4
	12362	3.5	4.1	4.3	4.5	4.6
	12549	3.3	3.8	4.0	4.2	4.4
Merasheen	**12548**	3.1	3.6	3.8	4.0	4.2
	12360	8.6	10.7	11.6	12.2	12.9
Rushoon	**12163**	8.0	9.8	10.5	11.0	11.5
	12164	9.5	11.7	12.5	13.2	13.8

3.3 Sea Ice and Icebergs

3.3.1 Sea Ice

In comparison to other bays surrounding Newfoundland, Placentia Bay is a relatively ice-free bay due to its location along the south coast of Newfoundland. A weekly analysis of the Canadian Ice Service’s 30-year median of ice in Placentia Bay reveals that ice is only present in Placentia Bay from mid-February until mid-April.

Figure 3.14 shows the weekly analysis of 30-year median of ice concentration when ice is present in Placentia Bay. The likelihood of ice present in Placentia Bay is highest during the week beginning March 5th. During this week, the median of ice concentration in Placentia Bay is 9-9+/10.

A detailed map with the weekly analysis of 30-year median of ice concentration in the four Bay Management Areas in Placentia Bay is shown in Figure 3.15. Figure 3.16 indicates that the frequency of sea ice presence in the four aquaculture farm areas is 1-15%.

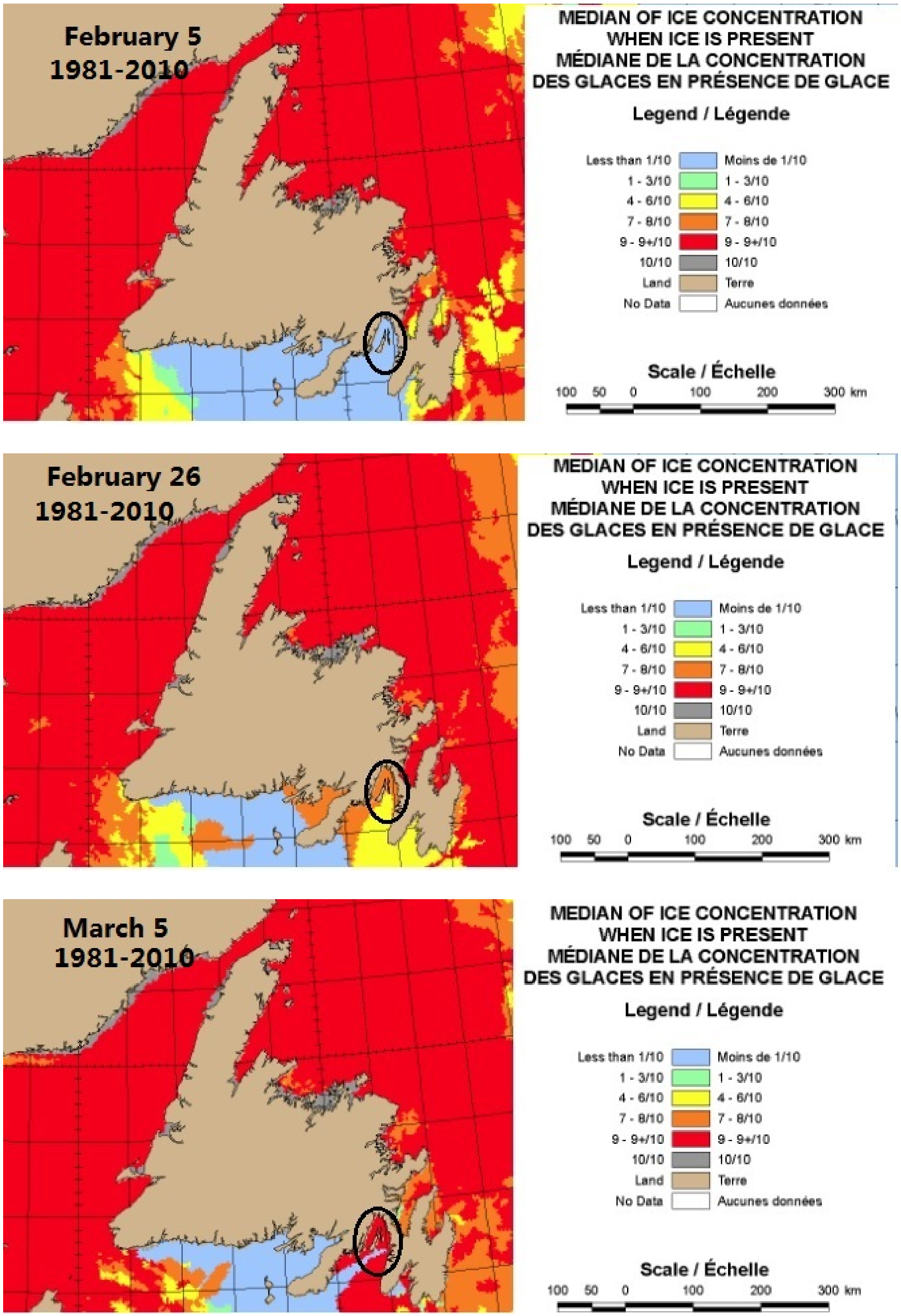


Figure 3.14 Weekly analysis of 30-year median of ice concentration when ice is present in Placentia Bay (black oval) from 1981 to 2010 (Canadian Ice Service).

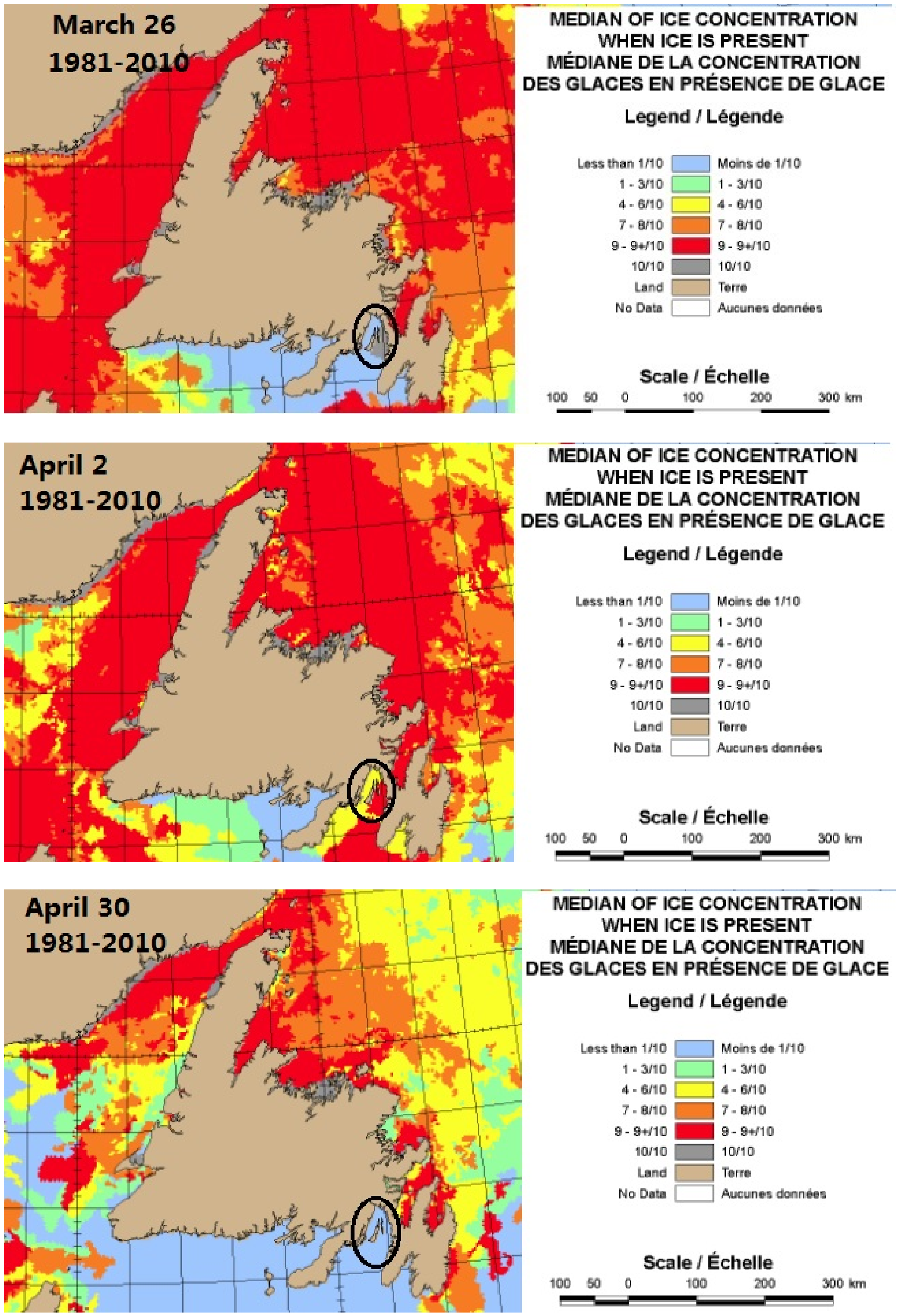


Figure 3.14 Weekly analysis of 30-year median of ice concentration when ice is present in Placentia Bay (black oval) from 1981 to 2010 (Canadian Ice Service) (Cont.).

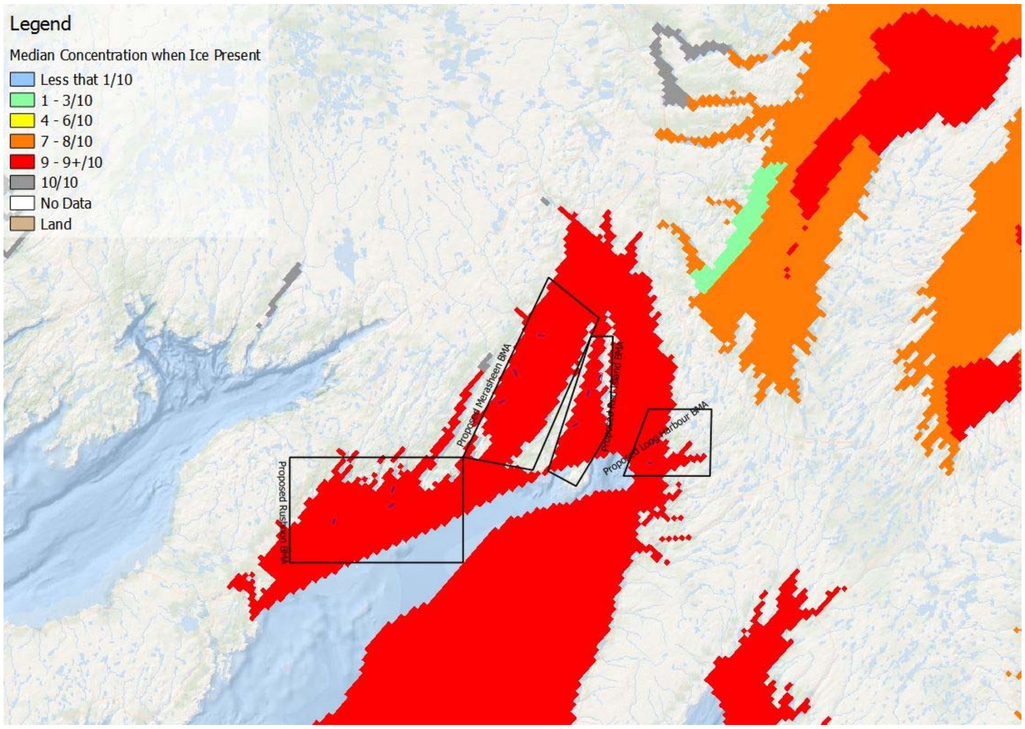


Figure 3.15 Weekly analysis of 30-year median of ice concentration when ice is present for the four BMA's in the week starting March 5, 1981-2010 (Canadian Ice Service).

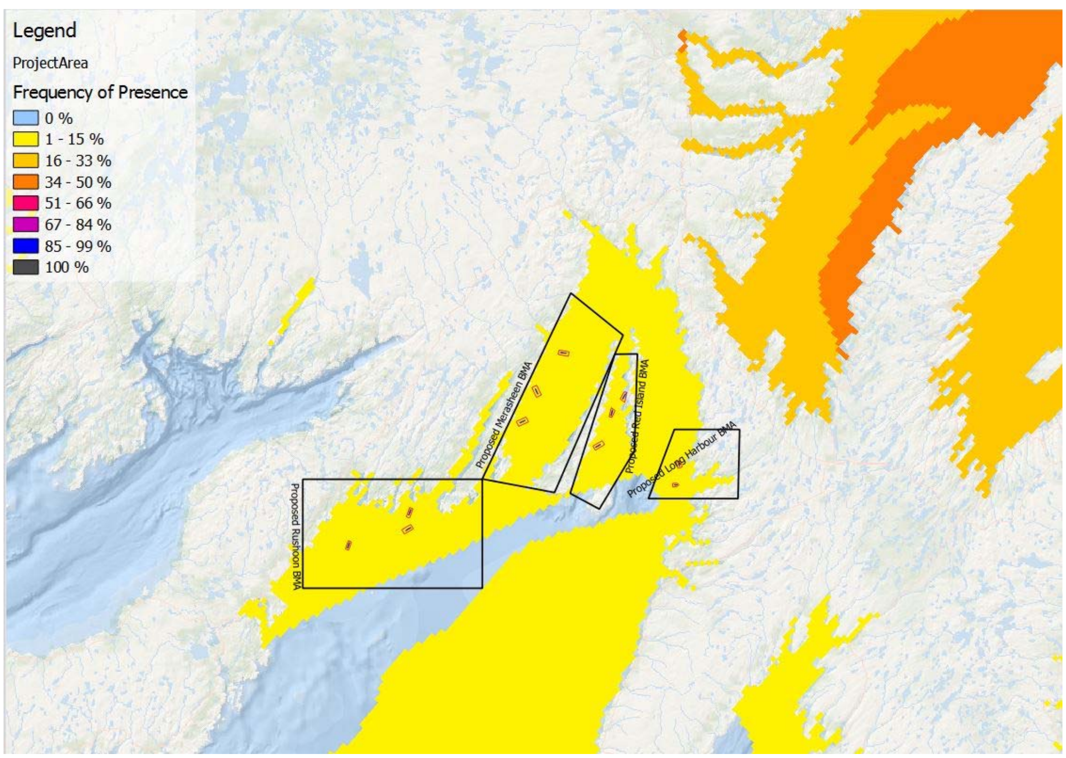


Figure 3.16 Weekly analysis of 30-year frequency of presence for the four BMA's in the week starting March 5, 1981-2010 (Canadian Ice Service).

In an effort to provide more up-to-date sea ice information, weekly sea ice charts for Placentia Bay were analysed over the past 10 years for the presence of sea ice within the northern half of Placentia Bay. A table containing the percent frequency of ice conditions within the region is provided below in Table 3.10. The information provided in this table gives an indication of the worst conditions which occurred within the region. For example, if half of the region was covered in 1/10th ice, and half classified ice free, the information was recorded as 1/10th for the whole area. The concentration of the majority of sea ice present over the last 10 years was less than one tenth. There was one year in which the week beginning February 05 contained 5/10ths coverage of sea ice.

Table 3.10 Percent Frequency of Weekly Sea Ice Concentration for northern Placentia Bay (2008 - 2017)

	Ice Free	Open Water	Bergy Water	Fast Ice	Tenths									
					1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**9+**
Feb-05	70	20	0	0	0	0	0	0	10	0	0	0	0	0
Feb-12	40	50	0	0	0	10	0	0	0	0	0	0	0	0
Feb-19	20	80	0	0	0	0	0	0	0	0	0	0	0	0
Feb-26	30	70	0	0	0	0	0	0	0	0	0	0	0	0
Mar-05	40	60	0	0	0	0	0	0	0	0	0	0	0	0
Mar-12	40	40	10	10	0	0	0	0	0	0	0	0	0	0
Mar-19	50	20	0	20	0	10	0	0	0	0	0	0	0	0
Mar-26	60	20	10	10	0	0	0	0	0	0	0	0	0	0
Apr-02	40	30	20	10	0	0	0	0	0	0	0	0	0	0
Apr-09	40	40	10	10	0	0	0	0	0	0	0	0	0	0
Apr-16	60	10	20	10	0	0	0	0	0	0	0	0	0	0
Apr-23	60	10	10	10	0	10	0	0	0	0	0	0	0	0
Apr-30	70	0	30	0	0	0	0	0	0	0	0	0	0	0

Definitions for the terms “Ice Free”, “Open Water”, “Bergy Water” and “Fast Ice” as defined in the ECCC Ice Glossary (Environment and Climate Change Canada, 2018) are provided below.

Ice Free

No ice present. If ice of any kind is present, this term shall not be used.

Open Water

A large area of freely navigable water in which ice is present in concentrations less than 1/10. No ice of land origin is present.

Bergy Water

An area of freely navigable water in which ice of land origin is present. Other ice types may be present, although the total concentration of all other ice is less than 1/10.

Fast Ice

Ice which forms and remains fast along the coast. It may be attached to the shore, to an ice wall, to an ice front, between shoals or grounded icebergs. Vertical fluctuations may be observed during changes of sea level. It may be formed "in-situ" from water or by freezing of floating ice of any age to shore and can extend a few metres or several hundred kilometres from the coast. It may be more than one year old in which case it may be prefixed with the appropriate age category (old, second-year or multi-year). If higher than 2 m above sea level, it is called an ice shelf.

3.3.2 Icebergs

Figure 3.17 shows the positions of all recorded icebergs within Placentia Bay from 1960 to 2015. Over the 55 years studied, only six icebergs have been sighted inside the four Bay Management Areas. Since the icebergs are moving into the bay from south of the Avalon Peninsula this is not surprising. Environmental factors such as iceberg concentration, ocean currents and wind determine if icebergs will move into the bay.

Table 3.11 summarizes the available information for recorded icebergs in the four Bay Management Areas in Placentia Bay. The Long Harbour, Merasheen and Red Island BMAs had only one iceberg each within the 55 years assessed. In the Rushoon BMA, which is close to the outer bay in comparison to the other three areas, three icebergs were sighted over the 55 years (i.e., 1961, 1995, and 2001). These icebergs range in size from growlers to medium. There was one of unknown size in the Rushoon BMA.

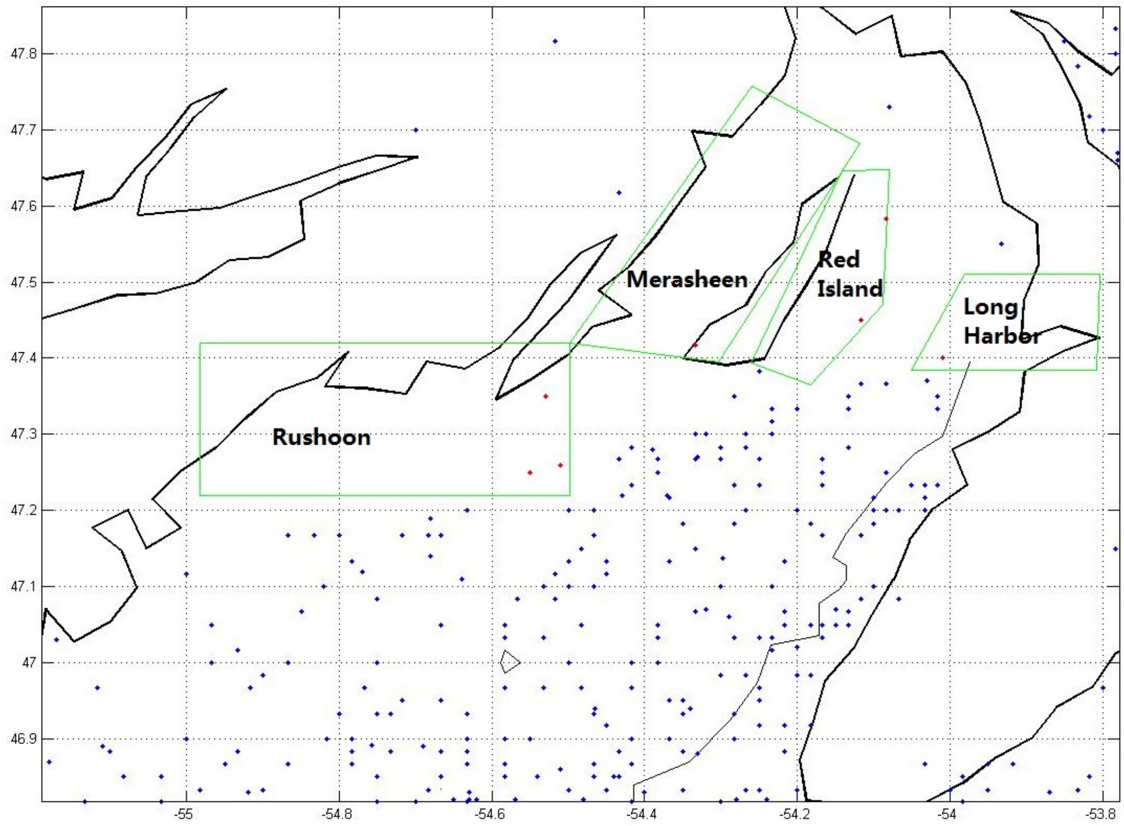


Figure 3.17 Iceberg sightings from 1960 to 2015. The green polygons are the four Bay Management Areas in Placentia Bay. The blue dots are icebergs sighted over 55 years within the farm fields. Some icebergs which were recorded at different coordinates due to drifting are shown.

Table 3.11 Recorded iceberg information in the four Bay Management Areas in Placentia Bay from 1960 to 2015.

BMA	Iceberg Count	Year	Latitude	Longitude	Size
Long Harbor	1	1996	47.40	-54.01	Medium
Merasheen	1	1961	47.42	-54.33	Growler
Red Island	1	1961	47.45	-54.12	Medium
Rushoon	3	1961	47.25	-54.55	Growler
		1995	47.35	-54.53	Small
		2001	47.26	-54.51	Unknown

3.4 Flood and Tidal Conditions

Tidal Heights

The tidal heights for various stations in Placentia Bay are presented in Table 3.12 and have been taken from the Canadian Tide and Current Tables (DFO, 2018). The tidal heights are in reference to chart datum. Recorded extremes from the Great St. Lawrence tidal station were not included in the above report however, were obtained from the Canadian Tides and Water Levels Data Archive (Government of Canada, 2018).

Table 3.12 Placentia Bay Tidal Data

	Mean Water Level	Range (m)		High Water (m)		Low Water (m)		Recorded Extremes(m)	
Port		**Mean Tide**	**Large Tide**	**Mean Tide**	**Large Tide**	**Mean Tide**	**Large Tide**	**Highest High Water**	**Lowest Low Water**
Argentia	1.4	1.6	2.4	2.3	2.6	0.7	0.2	3.4	-0.4
Burin	1.2	1.5	2.2	2.4	2.7	0.6	0.0		
South East Bight	1.2	1.3	2.1	2.5	3.0	0.5	0.2		
Tacks Beach	1.1	1.6	2.4	2.5	2.8	0.8	0.4		
Woody Island	1.2	1.6	2.5	2.4	2.7	0.7	0.3		
North Harbour	1.4	1.7	2.5	2.1	2.5	0.6	0.1		
Come by Chance	1.4	1.6	2.5	2.2	2.5	0.5	0.1		
Arnold's Cove	1.4	1.7	2.5	2.1	2.5	0.6	0.1		
Long Harbour	1.5	1.7	2.7	2.0	2.3	0.5	0.1		
St. Bride's	1.2	1.6	2.5	2.4	2.7	0.8	0.4		
Great St. Lawrence								3.1	-0.2

Water level recorders have been installed at both Argentia and Great St. Lawrence. Measurements from these stations These stations were analyzed for events in which the recorded water levels exceeded 3.0 metres. There were eleven individual events (Table 3.13) recorded at Argentia between the period of February 12, 1971 to March 29, 2018 and five individual events (Table 3.14) at Great St. Lawrence between the period of October 23, 2005 and March 29, 2018. Plots of the highest events at both stations are provided in Figure 3.18 and Figure 3.19.

Table 3.13 Events where the Maximum Water Level recorded at the Argentia Tidal Station exceeded 3.0 metres (Feb 12, 1971 to March 29, 2018)

Date	Tidal Heights
Dec 22, 1983 1100	3.2
Dec 25, 1983 1200	3.2
Jan 10, 1982 1000	3.15
Dec 15, 2016 2200	3.14
Jan 05, 1989 0600	3.13
Dec 04, 2013 0900	3.11
Dec 25, 1991 1200	3.08
Jan 03, 2010 1100	3.05
Dec 13, 2016 0700	3.04
Jan 10, 1974 0900	3.03
Jan 30, 1975 1000	3.01

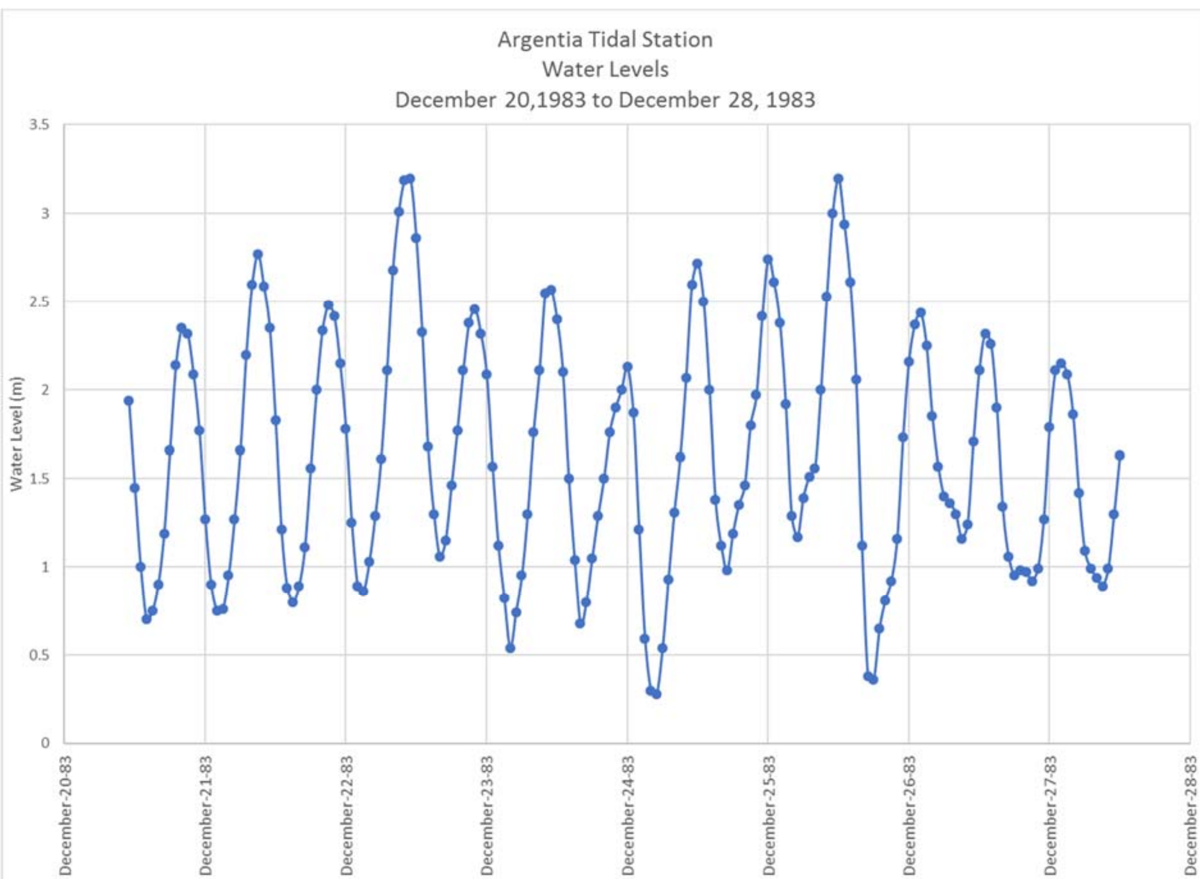


Figure 3.18 Argentia Tidal Station Water Levels (December 20, 1983 to December 28, 1983)

Table 3.14 Events where the Maximum Water Level recorded at the Great St. Lawrence Tidal Station exceeded 3.0 metres (Oct 23, 2005 to March 29, 2018)

Date	Tidal Heights
Feb 01, 2006 1100	3.1
Dec 13, 2016 0800	3.07
Nov 06, 2009 1200	3.05
Oct 26, 2011 0700	3.01
Feb 09, 2016 0900	3.01

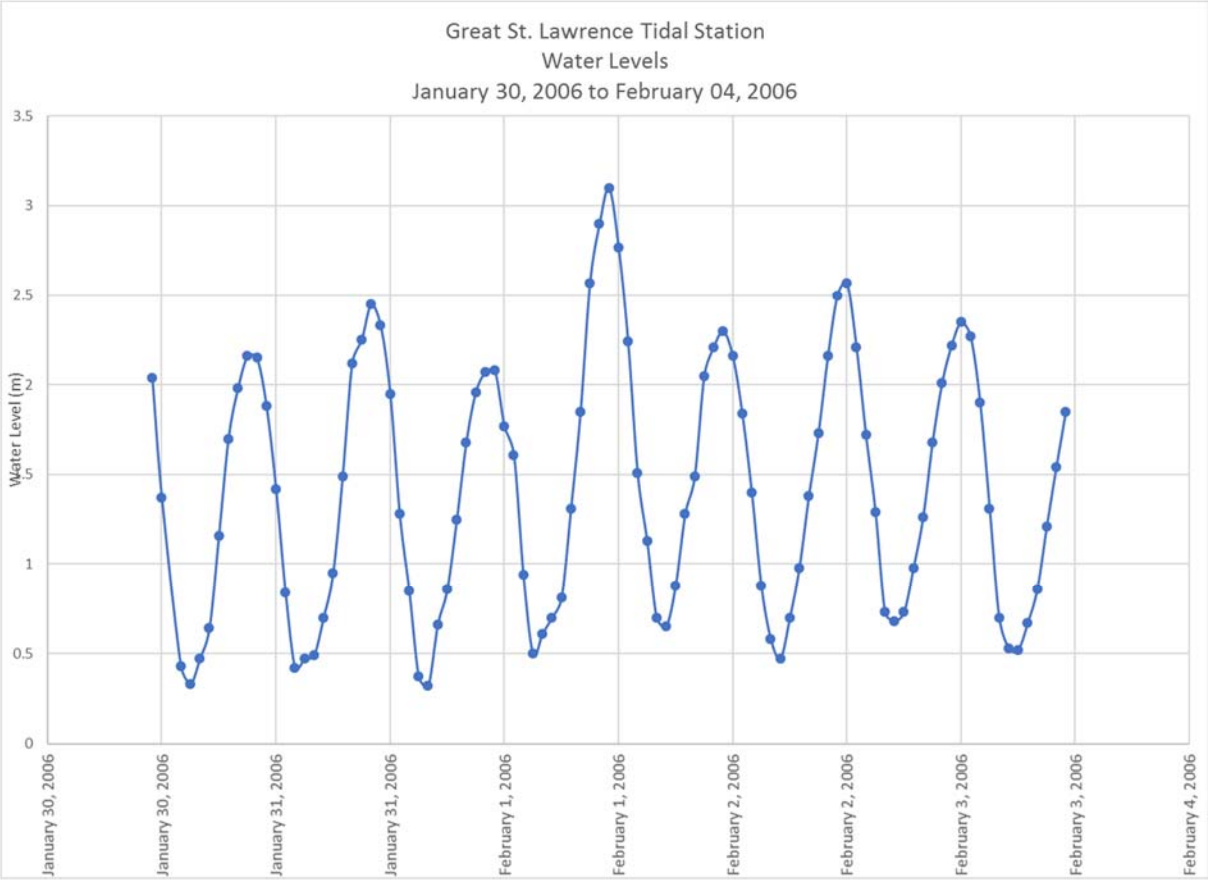


Figure 3.19 Great St. Lawrence Tidal Station Water Levels (January 30, 2006 to February 04, 2006)

Storm Surge

A storm surge is a pronounced increase in sea level associated with the passage of storm systems and defined as the difference between the observed water level and the predicted astronomical tide. This increase in sea level is typically the result of the combined forces of wind stress acting on the ocean and the inverted barometer effect due to the low atmospheric pressure associated with the storm.

Bernier and Thompson (2006) did a study of extreme storm surges in the Northwest Atlantic using a 40-year hindcast of storm surges. In their study, they showed a 40-year return period storm surge between 0.7 metres for the south coast of Newfoundland (Figure 3.20). Near the shoreline of Placentia Bay, the height of a storm surge could exceed 0.7 metres due to the shoaling and funneling effects of a movement of water into more shallow or restricted areas.

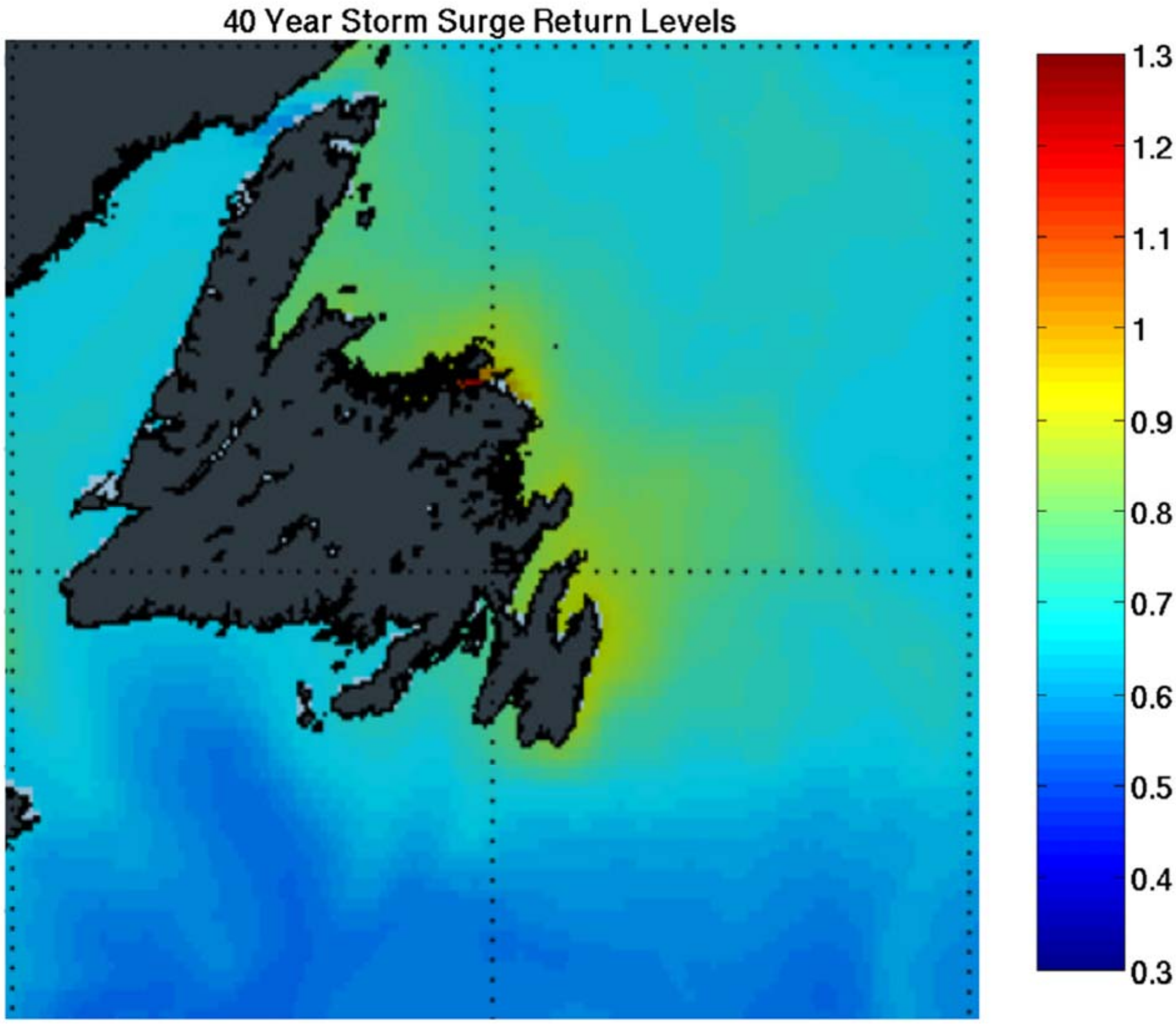


Figure 3.20 40-year return level of extreme storm surges based on the surge hindcast. Colorbar indicates the 40 return levels in metres. (Modified from (Bernier & Thompson, 2006))

During an event on January 16, 2004 a low pressure deepened to 951 mb along the south coast of Newfoundland, then moved inland to lie over central Newfoundland by afternoon. This low pressure became slow moving over Newfoundland resulting in a prolonged period of strong to gale force winds from the south to southwest over Placentia Bay. Using tidal height predictions for Argentia from the Bedford Institute of Oceanography WebTide model (V0.7.1) and calculating the difference between the measured water level records and the WebTide model it was determined that a storm surge near 0.93 m in height was observed at Argentia. This resulted in the sea level at Argentia rising to 2.6 m as a result of the combined tidal and storm surge heights.

Similarly, during the passage of Hurricane Igor on September 21, 2010, a maximum storm surge of near 0.92 metres was observed at Argentia at 1130 the following day. At the same time, the Great St. Lawrence water level recorder measured a maximum surge of near 0.86 m.

Negative storm surges associated with offshore winds can result in a pronounced decrease in water level below the astronomical tide level. These events are usually not as pronounced as onshore storm surges but may be of concern to mariners since they can create unusually shallow water if they occur near the low tide. In December 2006 a negative storm surge of -0.7 metres was recorded at Argentia. This negative surge was the result of an intense low-pressure system passing west of Placentia Bay. As the system passed, strong to gale force northerly winds were generated over Placentia Bay resulting in offshore winds forcing water out of the bay.

In the fall of 1999 and 2000, unusual events were observed in coastal areas of eastern Newfoundland, believed to be associated with the passage of tropical storms Jose in 1999 and Helene in 2000 as they moved across the Grand Banks. The waves had a period of tens of minutes and lasted between one and three hours, depending on location. The waves were large enough to cause local flooding and damage to docks and other structures. At Port Rexton in Trinity Bay the peak-to-trough displacement was 2 to 3 m, destroying the local wharf (Mercer, Sheng, Greatbach, & Bobanovic, 2002). Mercer et al. (2002) attributed the events to be a barotropic wake created by the tropical storms as they moved over the Grand Banks.

References

Archer, C., & Caldeira, K. (2008). Historical trends in the jet streams. *Geophysical. Research Letters, 35*(L08803).

Bell, G., & Chelliah, M. (2006). Leading Tropical Modes Associated with Interannual and Multidecadal Fluctuations in North Atlantic Hurricane Activity. *Journal of Climate, 19*, 590-612.

Bernier, N. B., & Thompson, K. T. (2006). Predicting the frequency of storm surges and extreme sea lvels in the Northwest Atlantic. *Journal of Geophysical Research, 111*(C10009).

Borgman, L. E. (1973). Probabilities for the highest wave in a hurricane. *Journal of Waterways, Harbours and Coastal Engineering Division*, 185-207.

Deser, C., Walsh, J. E., & Timlin, M. S. (2000). Arctic sea ice variability in the context of recent wintertime atmospheric circulation trends. *Journal of Climate, 13*, 617-633.

DFO. (2018). Canadian Tide and Current Tables, Volume 1 Atlantic Coast and Bay of Fundy. Ottawa, Ontario.

DHI. (2016). *Greig Seafarms, Newfoundland: Placentia Bay, current measurements.*

Elsner, J. B. (2003). Tracking Hurricanes. Bulletin of the American Meteorological Society. *Bulletin of the American Meteorological Society, 84*, 353-356.

Elsner, J. B., & Bossak, B. H. (2004). Hurricane Landfall Probability and Climate. In R. Murnane, & K. B. Liu (Eds.), *Hurricanes and Typhoons: Past, Present and Future.* Columbia University Press.

Environment and Climate Change Canada. (2018, 03 02). *Environment and Climate Change Canada - Weather and Meteorology - Ice Glossary*. Retrieved from Environment and Climate Change Canada: https://www.ec.gc.ca/glaces-ice/default.asp?lang=En&n=501D72C1-1&def=hide1B6894C57

Environment Canada. (1997). The Canada Country Study: Climate Impacts and Adaptation, Atlantic Canada Summary.

Forristall, G. (1978). On the statistical distribution of wave heights in a storm. *Journal of Geophysical Research, 83*, 2353-2358.

Government of Canada. (2018, April 04). *Canadian Tides and Water Levels Data Archive*. Retrieved from Fisheries and Oceans Canada: http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/twl-mne/index-eng.htm

Harris, E. (2007). Meteorologist. (C. Lander, Interviewer)

Hart, R., & Evans, J. (2001). A Climatology of extratropical transition of Atlantic tropical cyclones. *Journal of Climate, 14*, 546-564.

IPCC. (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. In T. F. Stocker, D. Qin, G.-K. Plattner, M. M. Tignor, S. K. Allen, J. Boschung, . . . P. M. Midgley (Ed.). (p. 1355). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Jarvinen, B., Neumann, C., & Davis, M. (1984). *A tropical cyclone data tape for the North Atlantic basin, 1886–1983: Contents, limitations, and uses.* NOAA Tech. Memo. NWS NHC 22, NOAA/National Hurricane Center, Miami, FL.

Laxon, S., Peacock, N., & Smith, D. (2003). High interannual variability of sea ice in the Arctic region. *Nature, 425*, 947-950.

Marko, J. R., Fissel, D. B., Wadhams, P., Kelly, P. M., & Brown, R. D. (1994). Iceberg Severity off Eastern north America: It's Relationship to Sea-Ice Variability and Climate Change. *Journal of Climate, 7*, 1335-1351.

McCabe, G., Clark, M., & Serreze, M. (2001). Trends in Northern Hemisphere Surface Cyclone Frequency and Intensity. *Journal of Climate, 14*, 2763 - 2768.

McLaren, A. S. (1989). The Under-Ice Thickness Distribution of the Arctic Basin as Recorded in 1958 and 1970. *Journal of Geophysical Research, 94*(C4), 4971-4983.

McLaren, A. S., Walsh, J. E., Bourke, T. H., Weaver, R. L., & Wittmann, W. (1992). Variability in Sea-Ice Thickness over the North Pole from 1977 to 1990. *Nature, 358*, 224-226.

Mercer, D., Sheng, J., Greatbach, R. J., & Bobanovic, J. (2002). Barotropic waves generated by storms moving rapidly over shallow water. *Journal of Geophysical Research, 107*(C10), 3152.

Neumann, C., Jarvinen, B., & McAdie, C. E. (1993). *Tropical cyclones of the North Atlantic Ocean, 1871–1992.* Coral Gables, FL: National Climatic Data Center in cooperation with the National Hurricane Center.

Reitan, C. H. (1974). Frequency of Cyclones and Cyclogenesis for North America, 1951-1970. *Monthly Weather Review, 102*, 861-868.

Rogers, E., & Bosart, L. (1986). An Investigation of Explosively Deepening Oceanic Cyclones. *Monthly Weather Review, 114*, pp. 702-718.

Swail, V. R., Cardone, V. J., Ferguson, M., Gummer, D. J., Harris, E. L., Orelup, E. A., & Cox, A. T. (2006). The MSC50 Wind and Wave Reanalysis. 9th International Wind and Wave Workshop, September 25-29, 2006. Victoria, B.C.

United States Geological Survey, Conservation Division. (1979). *OCS Platform Verification Program.* Reston, Virginia.

Wadhams, P. (1990). Evidence for Thinning of the Arctic Ocean Cover North of Greenland. *Nature, 345*, 795-797.

Wadhams, P., & Davis, N. R. (2000). Further evidence of thinning ice in the Arctic Ocean. *Geophysical Research Letters, 27*, 3973-3976.

Winsor, P. (2001). Arctic Sea Ice Thickness remained constant during the 1990's. *Geophysical Research Letters, 28*(6), 1039-1041.