FORCE Marine Mammal EEMP – Year 4 Interim Report

Prepared for FORCE

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FORCE Marine Mammal EEMP – Year 4 Interim Report (C-POD Deployment 1)

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Executive Summary

The main objectives of FORCE's marine mammal EEMP are to assess long-term effects of direct and indirect stressors on harbor porpoise (*Phocoena phocoena*) by monitoring their activity and site use, with the primary objectives to assess firstly, permanent avoidance of the mid field study area during turbine installation and operation and secondly, large magnitude (~50%) change in the distribution (echolocation activity levels) of a portion of the population in the study mid-field area (see SLR Consulting Ltd. 2015).

This interim report provides summary data for the eleventh deployment of C-PODs FORCE's ongoing multi-year EEMP representing the 1st deployment of the fourth year of the EEMP. Data covers the period between August 2019 through January 2020. Results include data collected from five C-PODs representing a total of 636 days of monitoring of the FORCE site. Porpoise were detected on at least one C-POD every monitored day with a median of 11 minutes of porpoise presence per day. The Location S2 had the highest probability of detecting a porpoise in a 10-minute period (9.02% of 10-min periods contained porpoise) while the other locations varied from 3.3 to 4.74 %. The mean percent of lost time due to sediment noise (19.5%) was comparable to previous deployments.

Table of Contents

List of Figures

List of Tables

1. Introduction and EEMP Objectives

Tidal energy is an excellent potential renewable energy source. Worldwide, only a small number of in-stream tidal turbines have been deployed to date. The Fundy Ocean Research Center for Energy (FORCE) is a Canadian non-profit institute that owns and operates a facility in the Bay of Fundy, Nova Scotia (Figure 1), where grid-connected tidal energy turbines can be tested and demonstrated. It enables developers, regulators and scientists to study the performance and interaction of tidal energy turbines with the environment. The offshore test site is in the Minas Passage area of the Bay of Fundy (Figure 2).

Figure 1 Regional location of FORCE test site. Figure 2 Detailed location in Minas Passage.

Harbor porpoise (*Phocoena phocoena*), the key marine mammal species in Minas Passage (Tollit et al. 2011, Wood et al. 2013 and Porskamp et al. 2015), use high frequency echolocation clicks to hunt and communicate and are known to be very susceptible to pulsed noise disturbance (Tougaard et al. 2009), but few studies have focused on exposure to continuous low frequency noise sources, such as those emitted by tidal turbines.

This Year 4 Interim Report describes the results of the 11th deployment of the overall Marine Mammal C-POD Monitoring Program, put in place as part of FORCE's multi-year Environmental Effects Monitoring Program (EEMP) at its marine demonstration and testing facility in Minas Passage. Baseline C-POD monitoring has been ongoing since 2011 (see references above, Appendix A) and year 1, 2 and 3 EEMP results are documented in Joy et al. (2017, 2018) and Tollit et al. (2020).

The main objectives of the marine mammal EEMP are to assess long-term effects of direct and indirect stressors on harbor porpoise by monitoring porpoise activity and site use, with the primary objectives to assess: 1) Permanent avoidance of the mid field study area during turbine installation and operation. 2) Large magnitude (~50%) change in the distribution (echolocation activity levels) of a portion of the population in the study mid-field area (see SLR Consulting Ltd. (2015).

The location of the five C-POD monitoring sites relative to the turbine are found in Figure 3. Appendix A illustrates the long-term C-POD coverage at the FORCE study area.

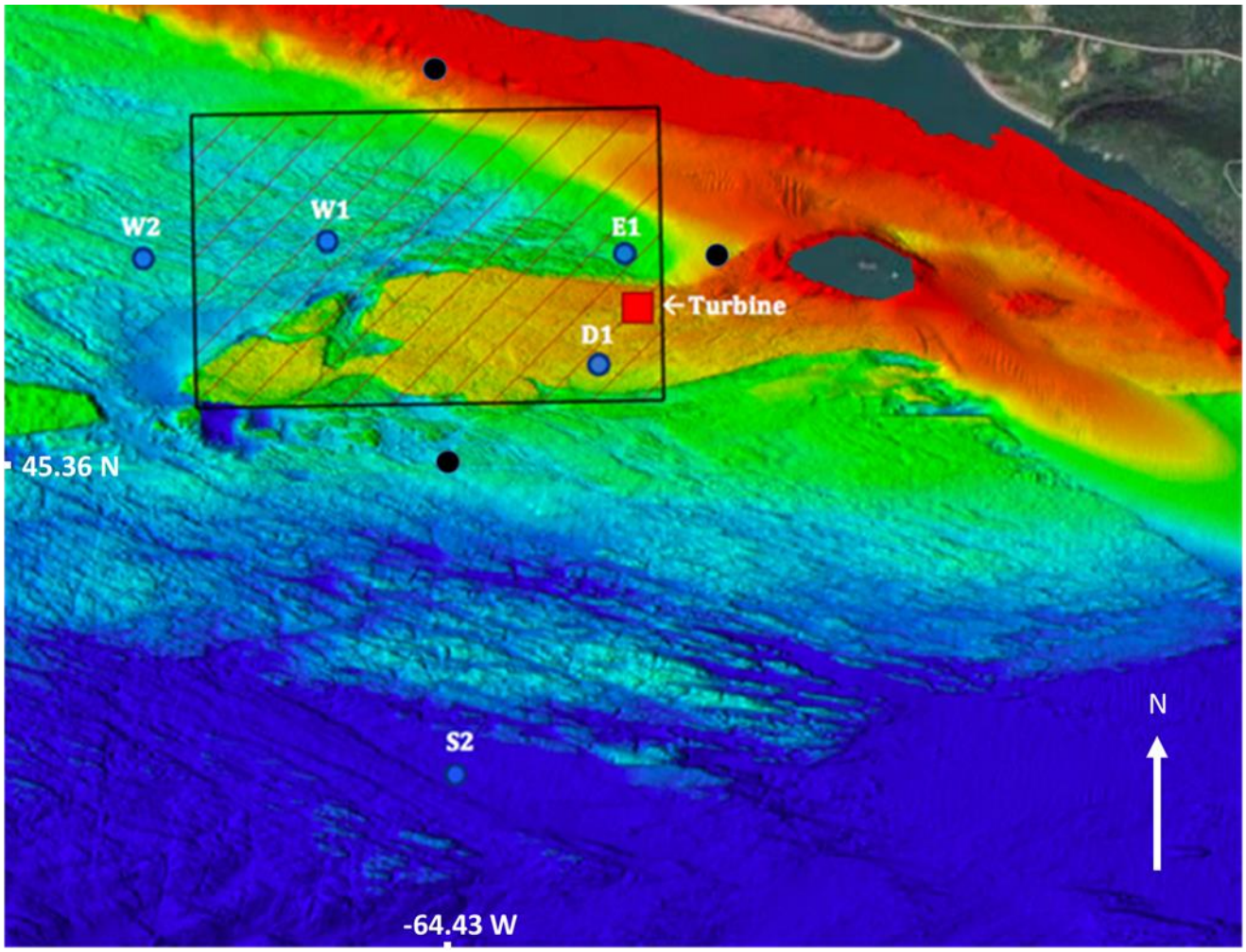

Figure 3 Locations of five monitoring C-PODs and CSTV turbine installed at Berth D. The hatched box denotes the FORCE demonstration area. Shallow water is depicted by warmer colours. C-POD locations are marked and labelled as E1 = East 1, D1 = Berth D, W1 = West1, W2 = West2 and S2 = South2. Locations of three previously used C-POD locations (N1, E2, S1; black circles) are provided.

This interim report provides summary data for the 14 August 2019 to 14 January 2020 deployment of 5 C-PODs as part of FORCE's continued EEMP with further full statistical analysis planned at the end of year 4.

2. Methods and Results

2.1. C-POD deployment and recovery information (conducted by FORCE field scientists)

Five C-PODS and associated moorings and buoys were loaded onto the modified lobster fishing boat in Parrsboro, Nova Scotia and deployed on 14 August 2019. The deployments took place in a single tide. Each torpedo-shaped C-POD is approximately 1.21 m (4 ft.) long and approximately 40 cm (16”) in diameter. The C-PODs are assembled into a “subs package” containing the acoustic release mechanism and recovery buoy. This is connected by a 2.5 m long chain to an anchor made of several lengths of chain (Figure 4).

Deployment (lowering overboard) of the C-PODs was completed by assembling each individual mooring on board. The mooring was placed in the water over the stern, the anchor then raised with the capstan via the a-frame mounted on the stern, lifted clear of the deck, and pushed forward away from the vessel and deployed using a quick release when safe to do so, allowing the C-POD and mooring to free fall to the sea bottom.

The following 5 deployment locations were selected (Table 1) and are depicted in Figure 3 above. Depths ranged from 32-70 m. These locations were similar to previous deployments varying from the last reported by ~60m.

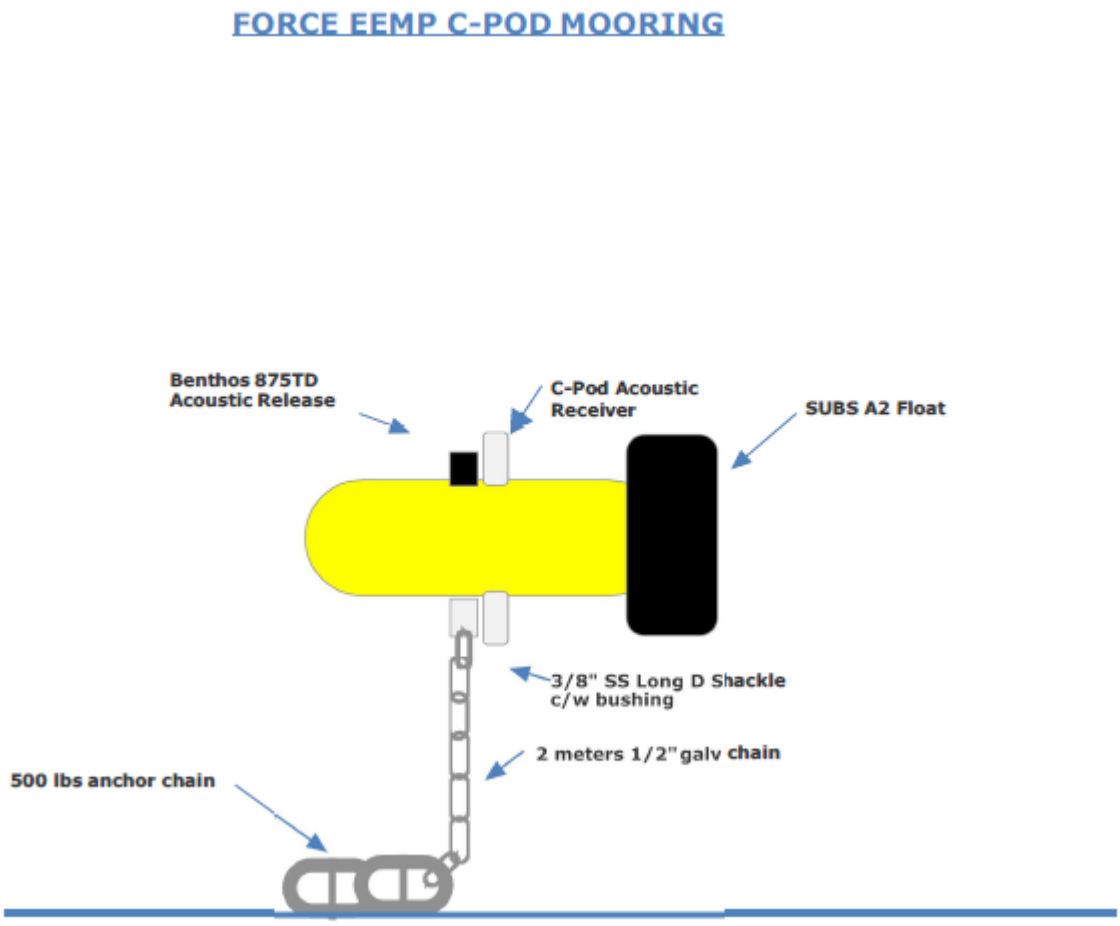

Figure 4 Diagram of FORCE C-POD mooring.

Table 1 Deployment location details of 5 C-PODs in Minas Passage.

Location Number	Deployment date	Latitude	Longitude	Depth (m)
W1	2019/08/14	45 21.973	-64 26.074	47
E1	2019/08/14	45 21.984	-64 25.988	42
W2	2019/08/14	45 21.960	-64 26.596	46
D1	2019/08/14	45 21.765	-64 25.424	32
S2	2019/08/14	45 21.008	-64 25.777	70

2.2. C-POD Data QA

C-POD.exe V2.044 was used to process the data and custom Matlab R2019b code used to calculate statistical outputs and create data plots using detection positive minutes (DPM) per day

and DPM per 10-minute period (DPMp10M) as the key metrics for comparison. The QA assessment specifically targets if non-biological interference has occurred, confirms that the porpoise click detector is operational and assess the scale of % time lost due to click maximum buffer exceedance. Buffer exceedance occurs when noise from sediment movement and moorings exceeds internal memory and results in periods of lost recording time in each minute. C-PODs were deployed and retrieved as shown in the Table 2 below, noting that three of the five C-PODs were recovered in December and the remaining two were recovered in January. All dates and times in this report are given in UTC

Table 2 C-POD deployment and retrieval information.

Location number	C-POD number	Deployment date and time	Retrieval date and time	Data Start Date and Time	Data Stop Date and Time	Data Duration (Days)
W1	2790	2019-08-14 T21:47:22	2020-01-14 T18:32:00	2019-08-15 T23:00:00	2020-01-14 T17:32:00	151
E1	2765	2019-08-14 T21:42:00	2019-12-13 T16:43:00	2019-08-15 T23:00:00	2019-12-13 T15:43:00	77
W2	2792	2019-08-14 T21:52:33	2020-01-14 T18:23:00	2019-08-15 T23:00:00	2020-01-14 T17:23:00	152
D1	2793	2019-08-14 T21:37:11	2019-12-13 T16:32:00	2019-08-15 T23:00:00	2019-12-13 T15:32:00	121
S2	2931	2019-08-14 T22:08:17	2019-12-13 T18:25:00	2019-08-15 T23:00:00	2019-12-13 T15:09:00	116

Data were imported from one day after deployment (to give soak time to the hydrophones) [15 August 2019 at 23:00] and one hour before the reported recovery time (Table 2). A data gap was identified at the E1 deployment location between the months of October and December 2019 (Figure 5). The cause of this data gap is not immediately clear but may be related to the buoy being turned on stuck in a non-vertical orientation. The C-PODs have an on/off switch that can be controlled by their internal tilt meter. If the unit were stuck on its side or upside down, it would have stopped recording until the unit was upright again. The remainder of the instruments recorded continuously until recovery. There was no evidence of clock drift on any of the instruments and no other signs of corruption on the remaining data.

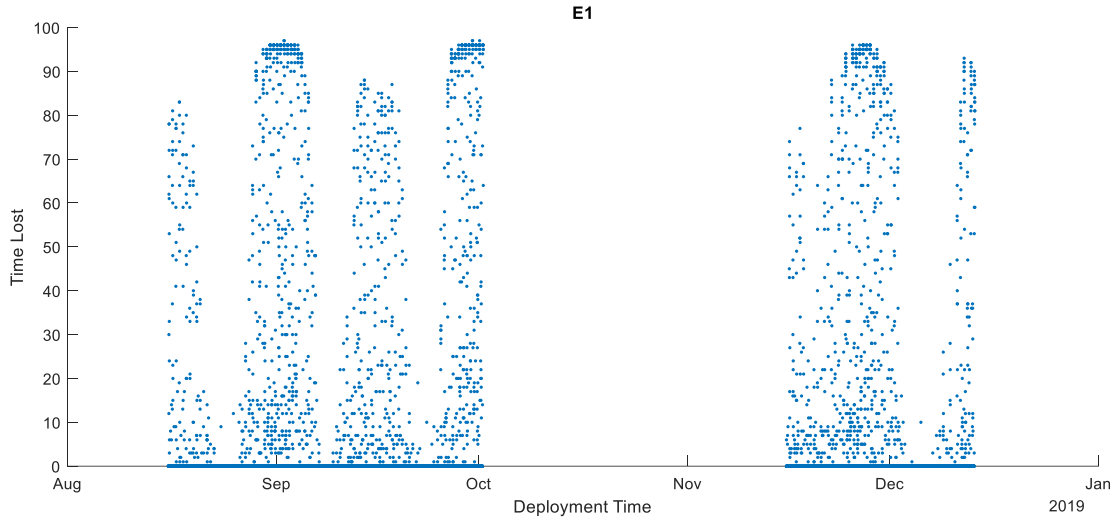

Figure 5 Data exploration at the E1 location. Gap in points indicates data loss between October and December 2019.

2.3. Porpoise click detection rates

2.3.1. Overall summary of detection rates

Across all years of the Minas Passage C-POD monitoring study, there have been a total of 7,155 C-POD days over 1,778 calendar days, with a total of over one million 10-minute periods (Table 3). This interim report covers 152 calendar days, 636 C-POD days with a total of 90,600 10-minute periods (Table 3).

Porpoises were detected on 100% of days across all pods combined, with an overall average median of 11 minutes per day, and with the probability of presence detected in 5.1% of all 10-minute periods across this monitoring period. In other words, overall, for any ten minute period, there is a 1 in 20 chance that porpoise are detected. This later statistic (termed 'PBinDPM=1' within Joy et al. 2018) is considered the optimal comparative metric to assess potential effects, as mean values are skewed by the number of periods without detection. Across individual C-PODs, detection rates averaged 91.4% of days with a C-POD median DPM per day of 11 minutes (IQR = 5-19.5) when presence occurred (Table 4). The DPM value is similar to the previous recording period but the average detection rate across C-PODs was lower.

No dolphin clicks were detected in Minas Passage during this studies' C-POD deployments, as also found during previous deployments (Wood et al. 2013; Joy et al. 2017, 2018).

Table 3 Definitions of deployment scenarios and associated summary of C-POD monitoring effort, turbine status, and EEMP details. The turbine operational period is highlighted in bold.

Deployment Scenario and Turbine Status	**Deployment Dates**	**# of Days Monitored**	**# of Pod-Days**	**# 10-Min Intervals**
2011 Deployment: Absent	2011-05-05 - 2012-01-17	258	958	136,446
2012 Deployment: Absent	2012-05-31 - 2012-12-03	137	391	56,795
2014 Deployment: Absent	2013-12-06 - 2014-07-01	208	689	99,108
2016 Deployment 1: Absent	2016-06-08 - 2016-08-30	84	252	35,775
2016 Deployment 2: Absent	2016-09-23 - 2016-11-06	45	225	32,065
***2016 Deployment 2: Turbine 1 Operational**	**2016-11-07 - 2017-01-18**	**73**	**332**	**47,403**
+*2017 Deployment 3: Turbine 1 Operational	**2017-02-24 - 2017-04-21**	**57**	**262**	**37,229**
+2017 Deployment 3: Turbine 1 Free-spinning	*2017-04-22 - 2017-06-01*	41	146	20,756
+2017 Deployment 4: Turbine 1 Free-spinning	*2017-06-03 - 2017-06-15*	13	39	5,382
+2017 Deployment 4: Turbine 1 Absent	*2017-06-16 - 2017-09-14*	91	357	51,009
+2017 Deployment 5: Turbine 1 Absent	*2017-09-27 - 2018-01-08*	104	520	74,135
+2018 Deployment 6: Turbine 1 Absent	*2018-01-23 - 2018-05-18*	99	480	68,094
#*2018 Deployment 7: **Turbine 2 operational or free-spinning 07-22 to 08-09**, then present (non-operational/non-free-spinning)	2018-05-05 - 2018-08-23	111	542	77,419

#2018 Deployment 8: Turbine 2 Present, non-operational/non-free-spinning	2018-09-07 - 2018-11-30	85	367	51,722
#2018 Deployment 9: Turbine 2 Present, non-operational/non-free-spinning	2018-12-07 - 2019-04-02	117	453	64,418
#2019 Deployment 10: Turbine 2 Present, non-operational/non-free-spinning	2019-05-04 - 2019-08-14	103	506	72,090
°2019 Deployment 11: Turbine 2 Present, non-operational/non-free-spinning	2019-08-14 - 2019-12-13	152	636	90,600
All Deployment data		**1,778**	**7,155**	**1,020,446**

* turbine operational
+ year 2 EEMP deployment
# year 3 EEMP deployment
° year 4 EEMP deployment

Table 4 FORCE site monitoring summary: Percent of days (across all deployment locations) with high or moderate quality porpoise detections present. Mean percent of days (between deployment locations) with 'NBHF' detections. Number of days without porpoise detection and the median number of detection-positive minutes for days/units with detections.

Deployment Scenario and Turbine Status	Overall % Days Porpoise Present	% Days Across C-PODs Porpoise present	Days Without Porpoise (Days Monitored)	Median (IQR) of Minutes of Detection if Present
2011 Deployment: Absent	99.2	83.2	2 (258)	7 (2, 17)
2012 Deployment: Absent	95.6	82.9	6 (137)	5 (1, 13)
2014 Deployment: Absent	99.0	87.5	2 (208)	9 (3, 16)
2016 Deployment 1: Absent	98.8	92.5	1 (84)	7 (3.75, 14)
2016 Deployment 2: Absent	100.0	76.4	0 (45)	4 (1, 10)
***2016 Deployment 2: Operational**	**97.3**	**73.8**	**2 (73)**	**3 (0, 7)**
+*2017 Deployment 3: Operational	**100.0**	**92.4**	**0 (57)**	**7 (3, 14.75)**
+2017 Deployment 3: Free-spinning	100.0	95.2	0 (41)	7 (4, 12)
+2017 Deployment 4: Free-spinning	100.0	100	0 (13)	12 (7, 18.5)
+2017 Deployment 4: Absent	100.0	96.9	0 (91)	12 (6, 21)
+2017 Deployment 5: Absent	100.0	88.3	0 (104)	8 (2.75, 20)
+2018 Deployment 6: Absent	100.0	88.3	0 (99)	7 (2, 16)
#2018 Deployment 7: Present from 2018-07-22, unknown status	100.0	98.0	0(111)	12 (6, 20)
#2019 Deployment 8: unknown status	100.0	91.04	0(152)	11(5, 19.5)
All Deployment data	**99.1**	**89.03**	**13(473)**	**8 (3, 15)**

* turbine operational
+ year 2 EEMP deployment
# year 3 EEMP deployment
° year 4 EEMP deployment

2.3.2. C-POD location detection rates

Porpoise detections rates varied across locations. Table 5 provides summary of percent probability of detecting a porpoise in a 10-minute interval. The site at W2 again saw high detection rates (9.02% of all 10-minute periods), with E1 also high (4.74% of all 10-minute periods). The sum of daily detection positive minutes averaged below FOUR minutes for W1 and D1. More detailed effects analysis is planned for the end of year 4 EEMP studies that take into account Percent Time Lost across each site.

Table 5 Descriptive statistics for the 5 C-POD locations for this deployment period. Percent probability (95% CI) of detecting a porpoise in a 10-minute Interval (P(BinDPM=1).

Location number	Means (95%.C.I.)	# 10-minute Intervals
W1	3.87 (2.24 - 14.83)	10760
E1	4.74 (3.47 - 14.58)	21750
W2	9.02 (6.25 - 25.56)	16558
D1	3.3 (2.78 - 8.66)	17241
S2	4.25 (3.47 - 12.64)	21518

Data inspection indicated that the C-PODs deployed at the W1 and W2 mornings continued to collect data through February 4th, suggesting either an error in the metadata provided or that the instrument was not turned off after recovery. All data beyond January 14th were excluded from the analysis. Time lost calculated across all five C-PODs is presented in Figure 6. Mean % time lost was 19.5%, with median of 0% and interquartile range of 0-21% (Figure 6).

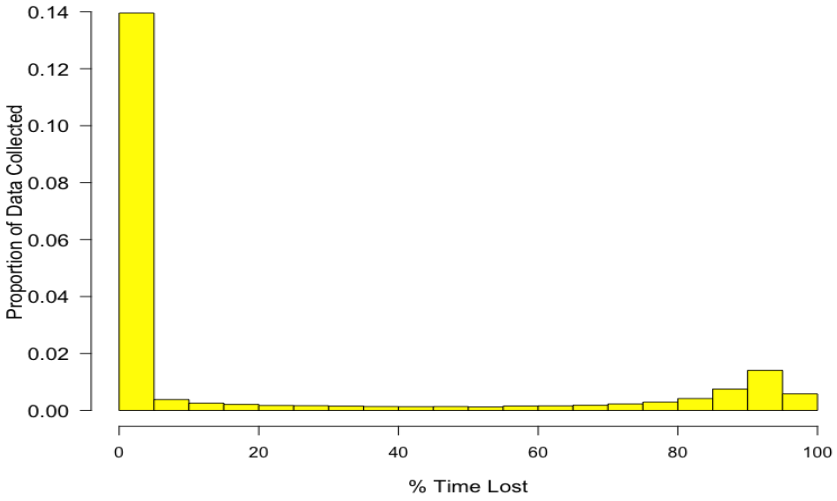

Figure 6 Distribution of time lost across 5 C-POD locations excluding missing data from the E1 unit.

3. Discussion

Five C-PODs were successfully deployed and recovered in Minas Passage as part of FORCE's marine mammal EEMP. A 2 MW OpenHydro tidal turbine was deployed by Cape Sharp Tidal Venture on 22 July 2018 and grid connected on 24 July 2018, however the turbine was not operational during this period covering this analysis.

Four C-PODs returned good quality and continuous data while one (E1) contained a large gap in data that may be related to the unit getting stuck on its side. The instrument deployed at S2 ceased recording five days prior to recovery. Average percent time lost due to sediment noise interference (19.5%) was similar to previous studies at these locations. Across all years of the Minas Passage C-POD monitoring study, there have been a total of 7,155 C-POD days across 1,778 calendar days, with a total of 1,020,446 10-minute periods.

In this current period, across all C-PODs, Harbor porpoise were detected across 100% of monitored days, and at higher rates than are have previously been observed (11min/day) with the exception of deployments in 2017. No dolphins were detected as per previous baseline studies. Differences across deployment locations mirrored previous results. More detailed effects analysis is planned for the end of year 4 EEMP studies that take into account Percent Time Lost.

To date, we consider a sufficiently long timeline of C-POD baseline data has been collected to meet the goals of the FORCE EEMP. Optimally, additional baseline data collection would allow an improved understanding of natural variability and/or detect changing regional trends. However, until active turbines are re-deployed in the FORCE demonstration area, an adaptive management approach might be adopted, whereby baseline studies are curtailed, scaled back to every other year or potentially (to meet DFO expectations) continued at one single long-term monitoring site such as at W1

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Appendix A: Long-term sampling by C-PODs in the FORCE study area.