Cape Sharp Tidal Venture

Environmental Effects Monitoring Program – Q2 Report

July 1, 2017

Executive Summary

Since November 8, 2016, and throughout the second quarter of the Project, the Cape Sharp Tidal demonstration turbine has been producing electricity for export to the Nova Scotia Power grid and gathering important environmental data at the FORCE site. The Environmental Effects Monitoring Program (EEMP) developed for the Project aims to monitor and better understand potential environmental effects and interactions of specific environmental components (fish, marine mammals, operational noise) in the near-field area (*i.e.*, 0-100-metres) of the OpenHydro Open-Center instream tidal turbine.

The overall research objective of the monitoring program is to verify the accuracy of environmental effect predictions made in the 2009 Environmental Assessment (EA) report. The purpose of this Q2 interim report is to provide a status update for the second quarter of the Project (February 2017 – April 2017). The annual environmental monitoring report (due January 1, 2018) will reflect data collection and learnings from 2017. We are working with industry-leading local and international experts in marine technology in tidal environments to collect and interpret this data.

Second-quarter insights include:

- The turbine continued to perform well during the Q2 commissioning period.
- In the beginning of April operations were initiated to retrieve the turbine to make minor repairs and upgrades to some Turbine Control Centre[1] (TCC) components. This will also provide us opportunity to examine and adjust, where needed, the monitoring instrumentation.
- Testing and data collection from monitoring sensors continued throughout Q2.
- As in Q1 there was no communication from the video camera and one hydrophone. A second hydrophone was intermittent. Two hydrophones and the Gemini sonar continued to operate until the sub-sea cable was disconnected in preparation for turbine retrieval.
- This second quarter has been focussed on identifying areas where the data collection process can be refined and to develop protocols to efficiently manage, store and share that data. This has included software improvements and successful adjustments to monitoring instrument frequencies for improved data collection. Additional work has also been completed on preliminary analysis and data interpretation.
- A contingency monitoring program was developed to be implemented during times of disconnection but when the turbine remains deployed.

These are early days in this important research initiative that will build on and complement the existing 93+ baseline studies completed at the FORCE site and the international body of research on in-stream tidal energy. We remain committed to drawing scientific conclusions about the monitoring program from the detailed data analysis and providing empirical evidence to support and demonstrate those findings.

[1] *The TCC is an electrical component sub-system attached to the subsea base and connected to the turbine which allows for the transformation of raw electrical power from the generator into grid-compatible AC power, as well as transmission of operational and monitoring data in real time. By treating information coming from the multiple sensors located within the turbine system, the TCC is used to optimize the power output in any operating conditions. This is the first time OpenHydro's pioneering TCC technology has been used anywhere in the world. Its design has been a critical step forward in being able to generate electricity from multiple turbines at sea and export to shore via a single export power cable.*

1.0 Introduction

Cape Sharp Tidal Venture (CSTV), a joint venture between Emera Inc. and OpenHydro, deployed one, 2 megawatt (MW) instream tidal energy turbine at the Fundy Ocean Research Center for Energy (FORCE) site near Parrsboro, Nova Scotia on November 7, 2016 (the Project). The Project is the beginning of a 4MW, two-turbine demonstration phase (Phase 1) of an ongoing tidal energy initiative in Nova Scotia.

The Project was reviewed by Fisheries and Oceans Canada (DFO) through an application made under the *Fisheries Act*. This Act focusses on conservation and protection of fish habitat essential to sustaining freshwater and marine fish species and prohibits serious harm to fish [subsection 35(1)]. The Project application was also reviewed under the *Species at Rick Act* (*SARA*) to determine whether it would adversely impact listed aquatic species at risk and contravene sections 32, 33 and 58 of *SARA*. It was determined that this demonstration-scale tidal Project would not result in serious harm, as defined under the *Fisheries Act*, to fish and fish habitat or negative effects to marine mammals and that the Project would not contravene sections 32, 33 or 58 of *SARA*. DFO therefore issued CSTV a Letter of Advice as opposed to an Approval.

In the Letter of Advice, DFO recommended the adoption of an adaptive management approach to monitoring to allow for adjustments and constant improvements to be made to the monitoring program as results become known, and that the results be shared and reviewed on an annual basis with the Fisheries Protection Program (FPP) to ensure that monitoring and management strategies could be modified as appropriate. This Q2 Report is part of that regular update to the FPP by providing a status update on the Project and a follow-up to the Q1 Report. The Q1 Report is available on the Cape Sharp Tidal website: http://capesharptidal.com/eemp/.

2.0 Operational Update

In the second quarter of the Project (February 2017 – April 2017), CSTV remained in a commissioning phase. During this time, OpenHydro continued to focus on ramping up the power production of the machine and establishing normal operating parameters through its control system. In March, FORCE began upgrades to the substation at which point power production ceased.

Tests and data collection also continued on the monitoring technologies (*i.e.*, sonar, hydrophones). This was continuous from deployment until disconnection of the subsea power cable on April 21, 2017 in order to prepare for a temporary retrieval of the turbine. This temporary retrieval was scheduled in order to perform minor repairs and upgrades to some of the Turbine Control Center (TCC) components, which will take place in Saint John, New Brunswick. The turbine will then be redeployed at the FORCE site, again in Berth D. The retrieval will also provide an opportunity to take monitoring learnings from the first six months of operations and to examine and make adjustments or modifications to the monitoring devices located on the turbine.

3.0 Environmental Effects Monitoring Program

3.1 Context

The Environmental Effects Monitoring Program (EEMP) developed for the Project aims to monitor potential environmental effects in the near field area (*i.e.*, 0-100-metres of the turbine) to better understand potential effects and interactions of specific environmental components (*i.e.*, fish, marine mammals, operational noise) with the OpenHydro Open-Center in-stream tidal turbine. The overall research objective is to verify the accuracy of environmental effect predictions made in the FORCE 2009 Environmental Assessment (EA) report, but the monitoring program will also assist with increasing knowledge about monitoring methods and analysis, development of mitigative measures, and building technical knowledge within the local tidal industry. The FORCE EA Report and subsequent 2010 FORCE EA Addendum are available here: http://fundyforce.ca/environment/enviromental-assesment/.

As required by the conditions of the FORCE EA Approval (2009), the CSTV EEMP was developed in collaboration with experts in the field of instream tidal energy and with input from government agencies, including DFO and Nova Scotia Environment (NSE), as well as other instream tidal energy interests including the Offshore Energy Research Association of Nova Scotia (OERA), FORCE, and FORCE's independent Environmental Monitoring and Advisory Committee (EMAC). The CSTV EEMP forms a component of FORCE's EEMP commitment under the FORCE Environmental Management Plan. Both EEMPs have been designed to be complimentary in order to achieve the most meaningful examination of potential effects and in consideration of the extensive baseline studies that have taken place at the FORCE Crown Lease Area since 2008[2].

The CSTV EEMP cornerstone is an adaptive management approach to evaluate data and make informed, science-based decisions to adjust technology and monitoring methods, assess mitigation measures and address concerns as necessary. This approach is necessary because of the unknowns and difficulties inherent with gathering data in harsh tidal environments, such as the Minas Passage. It allows for adjustments and constant improvements to be made as knowledge about the system and environmental interactions become better known.

The CSTV EEMP is reviewed continuously with regulators and FORCE and modified on the basis of accumulated experience and observed progress toward achieving the monitoring objectives. This adaptive approach will assist with resolving knowledge gaps of the potential effects of the Project and will also facilitate the design and implementation of new or modified monitoring strategies.

Additional information is available in the CSTV EEMP document available on the CSTV website: http://capesharptidal.com/eemp/. The FORCE EEMP is available on the FORCE website: http://fundyforce.ca/wp-content/uploads/2012/05/FORCE-EEMP-2016.pdf.

[2] The FORCE website provides a list of baseline studies: http://fundyforce.ca/environment/research/

4.0 Q2 Monitoring Update

The monitoring program was initiated following deployment of the turbine on November 7, 2016. There were no changes to the operation of the monitoring devices on the turbine since Q1. A summary update is provided for the second quarter of operation (February 2017 – April 2017) in the following sections.

4.1 Monitoring Technology Operations

The four passive acoustic monitoring (PAM) (Ocean Sonics icListen hydrophones) sensors and the active acoustic monitoring (AAM) (Tritech Gemini imaging sonar) sensor are co-located on the turbine to create an integrated monitoring system that collects data specific to marine mammals and fish. In addition to these devices, four acoustic doppler current profilers (ADCPs) are mounted on the turbine to provide data on flow, and a video camera was positioned on the subsea base to record the turbine rotor.

Data from all the monitoring devices on the turbine is transmitted continuously through a fiber optic data cable contained within the subsea power cable. Data is logged on-shore to hard drives and remotely saved to an OpenHydro server. As noted in Section 2.0, the turbine was disconnected from the subsea power cable in preparation for retrieval so data collection was halted at this time. A contingency program for monitoring was discussed with NSE and DFO and implemented on May 1, 2017. In recognition of the potential need for contingency planning as part of future operations, a new section on contingency monitoring was added to the CSTV EEMP.

Turbine operational sound was monitored by a separate deployment of a high flow mooring design of an autonomous multichannel acoustic recorder (AMAR). Data storage is achieved within the instrumentation of this sea bed mounted unit.

4.1.1 icListen Hydrophones

There are four hydrophones located on the turbine. The main objective of these devices is to detect harbour porpoise vocalizations to determine the seasonal frequency of this species, and other vocalizing marine mammals (*i.e.*, whales), and to support data results associated with the Gemini imaging sonar on how marine wildlife interacts with the turbine.

Using four devices creates an opportunity to compare various locations for devices on the turbine; the potential for integration with other monitoring devices; and to examine how much potential exists for localization of porpoise sounds under various tidal and operational conditions. An additional benefit was the redundancy so that in the event that one or more of the hydrophones is damaged, sufficient data can still be collected from one or two units to meet monitoring requirements.

Data collection was consistent in Q2 from two hydrophones. Communications from a third hydrophone has been intermittent and a fourth has not communicated since the turbine was deployed. All hydrophones will be inspected while the turbine is in Saint John for inspection and upgrades (refer to Section 5).

4.1.2 Gemini Imaging Sonar

The Tritech Gemini imaging sonar faces the ebb tide[3] and monitors an area up to 60 m in front of the turbine that is approximately 104 m in width. Species detection ranges from a lower limit of approximately 10 cm in length and upwards. The purpose of this sonar is to investigate the potential for integration with other monitoring devices and to track marine wildlife approaching the turbine in order to better understand potential interactions.

The imaging sonar has operated consistently throughout the second quarter of deployment. An inspection and readjustment to the positioning of the unit is planned after the turbine is retrieved (refer to Section 5).

4.1.3 Video Camera

Communication with the SAIS IP-CAM HD Ethernet underwater video camera has been unsuccessful since deployment; therefore no data has yet been logged from this device. The device will be inspected after the turbine is retrieved (refer to Section 5).

4.1.4 ADCPs

All four ADCPs have been functioning and providing data on flow regimes within the Minas Passage. This information on current velocities will be used to support analysis for all other devices. The results from these instruments are not reported as part of the EEMP, but rather will supplement the data from the other instrumentation to understand flows during specific time periods of interest.

4.1.5 AMARs

The AMAR was deployed approximately 100m from the turbine to perform a Sound Source Characterization (SSC) over a period of 3 months. The SSC measured underwater sound levels from the turbine. The goal of this study was to characterize low frequency (*i.e.,* below 60Hz) sound from the turbine operation and compare it to the ambient (natural) sound created by the environment. A second recorder was deployed as a control unit approximately 2km from the turbine.

The AMAR unit deployed closest to the turbine was successfully retrieved in January 2017. The control unit has not yet been recovered due to weather issues and ongoing competing marine operations at the FORCE site.

[3] The ebb tide was the direction chosen for the sonar as baseline studies showed a greater likelihood of species detection during this time and less turbulence that may affect detection.

4.2 Q2 Preliminary Results

This second quarter has been focussed on identifying areas where the data collection process can be refined and to develop protocols to efficiently manage, store and share that data. Additional work has also been completed on preliminary analysis and data interpretation.

4.2.1 Marine Fish and Marine Mammals

As with Q1, the majority of data analysis for fish and marine mammals in Q2 continued to focus on understanding and improving near-field localization, decreasing areas of interference from the environment and from other instrumentation, and refining algorithms in order to achieve data clarity and, in time, to improve the overall data collection and the monitoring program itself. This is required in order to coordinate and integrate the passive and active acoustic devices to fully understand potential near-field interactions with the turbine.

Gemini Imaging Sonar

Targets identified by the Gemini sonar are classified as one of four possibilities:

i. True positive: a fish or marine mammal;
ii. True negative: an object drifting with the tide (*e.g.* seaweed or driftwood, etc.);
iii. False negative: a fish or marine mammal that is not detected when it ought to be; or
iv. False positive: an object, turbulence or noise is erroneously detected as a marine mammal or fish

Data collection, management and raw data analysis from the Gemini sonar unit continued in Q2. This raw data analysis is required to prepare the data for a later biological analysis. Large amounts of data are being received resulting in a lengthy process for running the software and performing validations. This is in part due to the orientation of the imaging unit which has a larger area of the seabed in the view-plane than expected. This has led to increased identifications of false positives. Data collection and analysis will resume after the turbine has been re-deployed. The data management and analysis is expected to be more efficient with an improved sonar orientation.

In Q2, Tritech also focussed on software development, in particular improving individual target identification and target tracking ability, as well as synchronizing the imaging sonar with the hydrophones. The work in Q2 specifically involved:

- Application of a number of different image processing techniques to create a new filter to identify targets in the data. This included smoothing and de-noising techniques and identification techniques to evaluate improvements in identifying single targets.
- Implementation of a new algorithm to test with fish data and to compare to existing marine mammal algorithms.
- Looking at ways to change how small targets (potentially fish) are dealt with along with optimization methods to maintain real time operations.
- Work on development of fish measurement techniques which have proven extremely successful for later biological analyses.

Ongoing work will focus on improvements to target tracking abilities and improvements to group classification as well as cross referencing and human validation of automatically detected targets.

While the turbine is in Saint John, we will take the opportunity to reposition the Gemini sonar with the objective of reducing the amount of seabed in the sonar view. This will decrease interference from the seabed and is expected to facilitate data analysis by decreasing the numbers of false positives.

icListen Hydrophones

During the second quarter, data from two hydrophones was continually collected and preliminary processing began. Processing will continue with using automated click detectors.

On March 27, 2017, the recording settings on one hydrophone (1404) were changed to record the full bandwidth data to improve detection of harbour porpoise clicks without as much interference from other equipment on the turbine. The changes were done remotely at the FORCE site. The second hydrophone (1405) continues to record data but is receiving background noise from other equipment close to the hydrophone that may mask the frequencies at which harbour porpoises click are found. Analysis of this relationship is ongoing.

Early observations of the data found frequent porpoise detections over many days during the Q2 period. Most porpoise clicks were found during slack tide, possibly due to the masking of porpoise clicks during peak tide. The hydrophones have also detected vessel presence.

Hydrophone data will continue to be analyzed for comparison among the units and to the Gemini imaging sonar. During the retrieval the team will consider moving hydrophone 1405 to a quieter area on the turbine where there will be less noise from other equipment. Future tasks will also involve troubleshooting the communication issues related to that of the other two non-functioning hydrophones; providing quantitative data for days of harbour porpoise visits; and understanding turbine operation better to have context for additional data processing.

4.2.2 Operational Sound

A preliminary analysis of the sound data from the recovered recorder (closest to the turbine) was provided in the Q1 Report. Those results suggested that turbine sound is indistinguishable from flow noise below 60 Hz. In the case of the Minas Passage therefore, this could mean that the sound produced by the turbine is lower than the ambient or natural noise for most of the tidal cycle.

CSTV will work with JASCO to continue to try and recover the control unit which is still deployed in the Minas Passage in order to compare data from the two units.

5.0 Mitigation

A number of mitigative measures have been identified to adapt the present monitoring program moving forward:

i. The ability to remotely access some of the instrumentation provides the ability to adjust frequency settings and explore options to avoid interference with other instrumentation. This work was ongoing in Q2.

ii. With the opportunity to access the turbine and subsea structure during the planned temporary retrieval, the following activities are planned:
   - repositioning of the Gemini sonar;
   - examination, issue identification, and repair (if needed) of two of the hydrophones and associated cables and connectors; and
   - examination of the video camera and associated cables and connectors.

iii. In consultation with DFO and NSE, CSTV is developing an additional component to the monitoring program to address times when the turbine may be deployed but no longer connected to the subsea power cable, and therefore unable to collect data from the monitoring devices. This could occur during deployment or retrieval operations. The contingency program will be collaborative with FORCE.

6.0 Additional Items

As noted in the Q1 report, CSTV is looking into additional monitoring components to complement the present monitoring program and to continue to meet the commitments made to stakeholders prior to deployment. This includes:

- Participating in FORCE's beach walk monitoring program;
- Continuing to engage with fishery stakeholders to create improved consultation processes; and
- Staggering a second turbine deployment to allow additional opportunity for data monitoring, collection and analysis.

In addition, and in conjunction with FORCE and Open Seas Instrumentation Inc., OpenHydro is continuing work to integrate, test, qualify and deploy a second Gemini imaging sonar on one of the FORCE Fundy Advanced Sensor Technology (FAST) platforms. Wet tests are planned at the FORCE site while the turbine is in Saint John. The sonar will be deployed with the FAST platform and positioned near a turbine, to provide a view plane of the side of the turbine structure. The purpose of this initiative is to explore the potential for monitoring the close vicinity of one side of the turbine rotor.

CSTV will also investigate the scope of the next stage of operational noise studies that will focus on measuring turbine operational noise above 60Hz and comparing results to ambient (natural) levels.