CAPE SHARP TIDAL

Cape Sharp Tidal Venture:

Environmental Effects Monitoring Program

February 2016

1.0 Introduction

Cape Sharp Tidal Venture (CSTV), a partnership between Emera Inc. and OpenHydro, is proposing to deploy and operate two, 2 megawatt (MW) instream tidal energy turbines at the Fundy Ocean Research Center for Energy (FORCE) in Parrsboro, Nova Scotia (the Project). This Project will represent a demonstration phase (Phase 1) of an ongoing tidal energy initiative.

An Environmental Effects Monitoring Program (EEMP) (the Program) will be undertaken by CSTV to meet the relevant conditions as described in the FORCE Environmental Approval (September 15, 2009) granted by Nova Scotia Environment (NSE) for effects monitoring, as defined under the Nova Scotia *Environment Act* (NS *EA*). The EEMP is also a component of the CSTV Environmental Management Plan (EMP), developed under the CSTV Environmental Protection Program for the Project, which aims to mitigate, manage and monitor potential environmental effects. The CSTV EEMP is designed to complement the FORCE EEMP which forms part of the FORCE EMP. The CSTV EEMP is an integral part of the overall monitoring of the FORCE CLA. As such, CSTV will ensure continuous collaboration with FORCE to better understand the potential effects of instream tidal devices on the marine environment.

As required by the conditions of the Environmental Assessment (EA) Approval (2009), the EEMP was developed in collaboration with experts in the field of instream tidal energy, monitoring and technology developers and with input from government agencies, including Fisheries and Oceans Canada (DFO) and NSE, as well as other instream tidal energy interests including the Offshore Energy Research Association of Nova Scotia (OERA), FORCE, and the associated FORCE Environmental Monitoring and Advisory Committee (EMAC).

Implementation of this EEMP will lead to a better understanding of the potential near-field (*i.e.*, at the turbine) effects and interactions of instream tidal energy devices, and will assist with increasing knowledge, development of mitigation, and building capacity and relationships within the tidal industry in Nova Scotia.

1.1 Context

Monitoring of the Crown Lease Area (CLA) has been undertaken by FORCE, since September 2008. An updated EEMP for FORCE was finalized in 2016 and will focus on mid-field monitoring of various components. Both EEMPs have been designed to be complimentary in order to address all relevant conditions associated with the FORCE Environmental Approval, to achieve the most meaningful examination of potential effects and to avoid any repetition.

1.2 Purpose

The CSTV EEMP forms an essential part of the successful operation of the Project, a commitment to the protection of the environment, and an integral part of the overall FORCE monitoring program. The purpose of the CSTV EEMP, in conjunction with the FORCE EEMP, will be to better understand potential effects and interactions of specific environmental components (*i.e.*, fish, marine mammals, operational sound) with in-stream tidal devices. This understanding will be useful for verifying the accuracy of the environmental effect predictions made in the EA and will inform future monitoring plans for later tidal development phases at FORCE.

This purpose will be achieved through specific objectives focused on fish and marine mammals, and operational sound and will support CSTV's commitment to: mitigation of potential near-field adverse environmental effects of the Project; collaboration with FORCE on monitoring of the test site; and contribute to a growing body of knowledge about the potential near-field effects of instream tidal energy.

2.0 Strategy and Scope

2.1 Strategy

The Program will be based on an adaptive management approach and will be developed as a complementary program to the FORCE EEMP. The CSTV EEMP will focus on near-field effects and will be employed for the operational period of Phase 1 which includes two turbines (2MW each) and associated infrastructure (*i.e.*, interconnection cable).

Guidance for the Program includes regulatory and policy regimes of Nova Scotia as well as requirements contained in permits, approvals and/or letters of advice from regulatory bodies, including the FORCE EA Approval. Additional guidance includes past experience of CSTV, DFO feedback on previous monitoring programs completed at the site by FORCE, conversations with DFO as well as with technology and subject experts, academia, and research and published documents.

2.1.1 Adaptive Management

An adaptive management approach will be used to evaluate data and make informed, science-based decisions to modify monitoring and assess mitigation measures as necessary. This approach is necessary due to the unknowns and difficulties inherent with gathering data in tidal environments such as the Minas Passage and allows for adjustments and constant improvements to be made as knowledge about the system and environmental interactions become known.

Outcomes will be reviewed continuously with DFO, FORCE's EMAC and others and, where required, approaches and methodologies will be revised on the basis of accumulated experience and observed progress toward achieving the monitoring objectives. This approach will assist with resolving gaps in the knowledge of the potential effects of the Project and usefulness of mitigation measures. The approach will also facilitate the implementation of new or modified monitoring strategies.

2.1.2 FORCE Monitoring

The CSTV EEMP has been designed and will be executed in conjunction with the FORCE EEMP. As such, key comments from the DFO 2012 feedback to the FORCE monitoring program report have been incorporated into the development of the CSTV EEMP including:

- the need for monitoring studies in the vicinity of the turbine(s) particularly related to fish behavior around the devices (*e.g.*, whether fish can avoid the structures);
- concerns around inference to the likelihood of direct encounters of fish with a device since the (2009) test device was not operational for a significant amount of time;

- recognition that monitoring methodologies in the immediate vicinity of the turbine(s) in high flow environments are limited and evolving; and
- the need for more effort needs directed towards gathering monitoring data directly around the turbine (*e.g.*, either a vessel-mounted system or, preferably, an instrumented monitoring platform mounted on the turbine enclosure).

Specifications of the Program will build upon requests and recommendations provided from discussions, and review and feedback from scientific experts, government regulators and other stakeholders. Data will be collected and analyzed for technological and environmental objectives associated with routine operations.

2.2 Scope

The scope of the CSTV EEMP includes the near field monitoring of two main components:

1. Marine Fish and Marine Mammals; and
2. Operational Sound.

CSTV has established a set of general intentions under the scope to be met in the development and application of the EEMP:

- to ensure a complementary program scope to that which will be delivered by the FORCE EEMP;
- to identify information and data uncertainties and provide advice on addressing these uncertainties;
- to include relevant knowledge gained from discussions with Aboriginal groups and stakeholders;
- to assess the effectiveness of Project design features and mitigation measures;
- to assess any identified near-field effects of routine operations;
- to provide regular reporting of results to regulators and FORCE/EMAC; and
- to communicate results to Aboriginal groups and stakeholders.

An overall summary for the CSTV EEMP and FORCE EEMP is provided in Table 1.

Table 1. EEMP Summary for CSTV and FORCE

Responsibility	Objective	Scope	Methodology	Timing
Marine Fish				
FORCE	1. To quantify fish distributional changes that reflect behavioural responses to the presence of a deployed tidal instream energy converter (TISEC) device.	Fish density and vertical distribution.	Down-looking, vessel-towed hydroacoustic echosounder along 9 parallel transects spaced 100 m apart, plus 3 control transects. Each transect is planned to be approximately 1.8 km long. Before-After-Control-Impact (BACI) study design; Multivariate analysis (Hotellings T2 tests) of fish	Six surveys distributed over six months as was done in 2011-12 Each survey to be completed over a full tidal and diel cycle (*i.e.*, 25 hours). Study duration will be five years to capture multiple deployments.

Responsibility	Objective	Scope	Methodology	Timing
	2. To estimate the probability of fish encountering a device.	Estimate probability of fish encountering a device.	vertical distributions. Use of an encounter probability model.	
CSTV	1. Determine the seasonal frequency of occurrence of fish within the near-field environment of the turbines. 2. Integrate data-sets into a strike risk model for fish.	Use of fish detection algorithms for fish frequency Analyze data to describe track trajectories for use in the strike risk model.	Active Acoustic Monitoring (AAM). Data analysis software and use of seasonal data from AAM data-set, as well as a model including track trajectory data.	Start date coincides with operations and will run continuously. Data analysis will be initiated as soon as possible – exact date to be determined. Data analysis will be initiated as soon as possible – exact date to be determined.
Marine Mammals				
FORCE	1. Assess direct effects of operational turbine sound: attraction or avoidance. 2. Assess indirect effects due to changes in prey distribution and abundance: attraction or avoidance.	Determination of possible permanent avoidance of the mid-field study area. Change in distribution of a portion of the population: large scale (~50%) decreases or increases in relative occurrence as measured via echolocation activity levels across the mid-field study area, including in the vicinity of operating turbines.	Deployment of 2 C-PODs at 2 established local study area reference sites in the spring and fall to provide a comparative 'after' data set compared with data collected pre-turbine deployment(s). Deployment of one C-POD 100+m from any occupied berth. Collaboration with Nova Scotia Marine Animal Response Society and local veterinary pathologist if mortality event(s) reported.	Planned for 3 years following first deployment: once in the spring and once in the fall of each year for 3 months duration. Number of C-PODs varies annually depending on number of turbines installed. Planned for 3 years following first deployment: once in the spring and once in the fall of each year for 3 months duration.
CSTV	1. Determine the seasonal frequency of occurrence of harbour porpoise within the near-field environment of the turbines.	Identification of harbour porpoise clicks compared to baseline detection rates [Note: a data quality assessment will be performed to ensure use of acoustic data from the hydrophone with the highest quality (*i.e.*, least flow/sediment noise) by comparison of detection data from all hydrophones over 1	Integrated AAM and Passive Acoustic Monitoring (PAM).	Start date coincides with operations and will run continuously. Data analysis will be initiated as soon as possible – exact date to be determined.

Responsibility	Objective	Scope	Methodology	Timing
		month].		
	2. Determine the relationship between harbour porpoise occurrence and turbine operations.	Detections obtained by identifying click trains and compared to rates of porpoise detection at 4 representative speed categories using current or RPM data from the turbine (Note: categories to be determined).	Integrated AAM and PAM.	Start date coincides with operations and will run continuously. Data analysis will be initiated as soon as possible – exact date to be determined.
	3. Determine the seasonal frequency of other vocal cetaceans (*e.g.*, white-sided dolphins, right whales etc.). *	Identification of vocalizations.	Integrated AAM and PAM.	Start date coincides with operations and will run continuously. Data analysis will be initiated as soon as possible – exact date to be determined.
	4. Determine the seasonal frequency of occurrence of marine mammals within the near-field environment of the turbines.	Use of marine mammal detection algorithms for marine mammal frequency to discern different species, frequency and evasion behavior.	Data analysis software and use of seasonal data from integrated PAM/AAM data-sets, as well as a model including track trajectory data.	Data analysis will be initiated as soon as possible – exact date to be determined.
	5. Integrate data-sets into a strike risk model for marine mammals.	Analyze data to describe track trajectories for use in the strike risk model.		Data analysis will be initiated as soon as possible – exact date to be determined.
Sound				
FORCE	Establish pre-deployment baseline ambient noise conditions. Use the noise data to verify the EA predictions that suggest turbine sound will not negatively affect marine biota.	Measurement of ambient noise within the CLA.	Within the FORCE CLA: • Deploy a streamlined moored hydrophone system. • Investigate undertaking simultaneous drifting hydrophone measurements for comparison and data validation. Alternatively, the hydrophone can be replaced with a drifting noise source emitting at known frequencies. • Develop an acoustic model.	A deployment period on the order of 1-2 months to capture noise conditions over multiple tidal cycles.
CSTV	Characterize operational turbine sound to assess the effect of turbine operations on the noise profile of the site.	Comparison of sound levels will be completed for a control site and in the near-field environment to identify the frequencies at which the turbine	A high-flow mooring design using 2 fixed autonomous acoustic recorders to collect acoustic measurements will be used. One recorder will be placed at 100 m range from the	Following deployment for two months to provide data collected in a variety of sea conditions and during different turbine operational phases

Responsibility	Objective	Scope	Methodology	Timing
		sound is discernable. Received sound levels will be correlated with tidal state and current speed to assist with characterization of sound levels attributed to flow noise.	turbine and the other at a control location (approximately 2 km away)	
	Determine flow at specific noise levels	Flow data will be collected simultaneously	Flow data to be collected using Acoustic Doppler Current Profilers (ADCPs) located on the turbine structure	

* It is anticipated that detection rates for other vocal cetaceans will be too low for detailed current speed analyses.

Detailed descriptions of the scope and methodologies noted in Table 1 for each CSTV EEMP component are provided in the following sections. A schedule of tasks is provided in Section 4. Appendix A provides a schematic illustrating the locations of sensor equipment on the turbine.

2.2.1 Marine Fish and Marine Mammals

The collection and processing of data relating to marine life at tidal energy sites has so far been limited to individual use of either active or passive acoustic sensor technologies. The data collected is therefore constrained by the limitations of each individual sensor, resulting in the need for further data collection and increased processing time. To date, there are few near-field monitoring programs of instream tidal energy devices and consequently collision risks are not well understood, particularly for marine mammals.

The harbour porpoise (*Phocoena phocoena*) is the only marine mammal species regularly observed in the Minas Passage. Detection of porpoises is typically achieved using Passive Acoustic Monitoring (PAM) techniques, however near-field localization is challenging so Active Acoustic Monitoring (AAM) methods using sonar need to be incorporated in conjunction with PAM to fully understand the likelihood of near-field interactions.

The Minas Passage does not have a diverse marine environment; however both commercial and recreational fisheries are present, with the various species and ecosystems being extensions of those in nearby areas of the Gulf of Maine.[1] The majority of the fish species in the Minas Passage are migratory and therefore present only at specific times of the year, on a seasonal basis, and none are known to spawn in the Passage in the vicinity of the CLA.[1] Important invertebrates include American lobster, crab and sea scallops. The principal and most valuable fishery in the immediate area of the Project site is for lobster which is included in the inner Bay of Fundy lobster fishing area 35 (LFA 35).

Additional fish species that may be present in the Minas Passage and that have been identified by federal or provincial agencies as being endangered, threatened, rare, of special concern, or otherwise of

[1] AECOM. 2009. Environmental Assessment Registration Document – Fundy Tidal Energy Demonstration Project. Volume I: Environmental Assessment. June 10, 2009. 247pp.

conservation concern include: Inner Bay of Fundy salmon (*Salmo salar*), Striped bass (*Morone saxatilis*), Porbeagle shark (*Lamna nasus*), Atlantic wolfish (*Anarhichas lupus*), White shark (*Carcharodon carcharias*), and Shortnose sturgeon (*Acipenser brevirostrum*).

The scope for marine fish and marine mammals is designed around the monitoring of identified valued ecosystem components in the receiving environment that are presently thought to have the most likelihood of direct effects from a demonstration-scale Project. The intent is also to focus on components of importance to the public from an environmental protection standpoint (*i.e.*, species at risk, marine mammals, and fish) and those components that provide direct economic and social benefits to the local stakeholders and Aboriginal communities (*i.e.*, commercial fisheries). The scope of this component will therefore involve an integrated environmental monitoring system that uses data analysis software and encompasses active and passive acoustic sensors, to provide real time detection, classification, localization and near-field tracking of fish and marine mammals, in this case harbour porpoise.

In order to understand the interactions between marine mammals and fish and the instream tidal energy devices, the monitoring results will be utilized to determine seasonal frequency and distribution in the near-field; determine what types of effects may occur in response to turbine operation; and what the outcome may be. If possible, the Program will also explore the possibility of using data results to determine track trajectories of marine mammals (within the field of detection). To achieve this, it is proposed that AAM be used to determine if animals are moving directly at the turbine or moving horizontally and potentially vertically (where target moves out of the field of vision). These data will be considered in describing evasion behaviour and subsequent incorporation into strike risk models.

The scope of this component also includes provisions for testing and evaluation prior to operations.

2.2.2 Operational Sound

Acoustic measurement of tidal turbine operational sound is an important component towards understanding the potential effects of turbine operational sound on marine life. Characterization of operational sound, how it changes with flow speed and how levels compare to those of levels of natural noise created in these high energy environments will inform CSTV on the types of effects (*e.g.*, site avoidance, changes to feeding behaviour, changes in frequency) that may occur to fish and marine mammals and will assist with determining if those effects are having impacts at a population level. The results will provide the basis by which future instream tidal energy projects can evaluate cumulative effects of turbine sound on the environment which will facilitate the development of effective mitigation, if necessary.

The scope for this component involves long-term acoustic measurements and subsequent data analysis to characterize the tidal turbine sound. The analysis will provide increased knowledge and understanding of the characteristics of flow noise in the Minas Passage and the extent to which flow noise obscures the operational sound of the tidal turbines.

2.3 Methodology

2.3.1 Marine Fish and Marine Mammals

An integrated monitoring system will be used to gather passive and acoustic data on marine fish and marine mammals. Data will be collected for a full year.

The sensors will be co-located on one of the turbine subsea structures and will include the Tritech Gemini Imaging Sonar (active acoustic/AAM); and the Ocean Sonics icListen smart hydrophone (passive acoustic/PAM). Additional information on the technology is provided in Appendix B. Operation of the system is planned to occur with turbine installation and it is intended that data will be gathered over a long duration to ensure that enough detections are made to provide an informed and valuable validation of the data generated. Data analysis will be initiated as soon as possible and exact timing will be determined through discussions with study experts.

A data interface will be created to allow data from each sensor to be combined into an integrated fish and marine mammal data set that will be interpreted to determine the objectives listed in Table 1.

2.3.2 Operational Sound

The methodology for this component will utilize a high-flow mooring design that was developed through several iterations of recorder designs deployed at the CLA in 2012. Successful acoustic measurements were collected using a design in which the hydrophone was contained inside a streamlined housing structure, behind a flow-shielded acoustic window. Lessons learned through the FORCE deployments will be applied to this EEMP, with respect to mooring design and deployment procedures.

Data will be gathered using fixed sound recorders. Acoustic measurements will be collected use two autonomous acoustic recorders, housed in high-flow moorings to reduce turbulent flow around the hydrophones. The recorders will be deployed for two months to provide data collected in a variety of sea conditions and during different turbine operational phases. One recorder will be placed at 100 m range from the turbine and the other at a control location approximately 2 km away. Current data will be collected simultaneous to the acoustic measurements using ADCPs located on the turbine structure. Sound levels will be compared between the two recorders to identify the frequencies at which the turbine sound is discernable. Received sound levels will be correlated with tidal state and current speed to assist with characterization of sound levels attributed to flow noise.

3.0 Reporting

A year-end Project Monitoring Report (the Report) will be submitted, to DFO, for the EEMP as per the DFO Letter of Advice received for the Project. The Report will address all components of the EEMP and will discuss the results and address environmental effect predictions of the EA. Recommendations for any follow-up EEMP as well as any new approach(es) to mitigation will also be provided. Copies of the Report will also be provided to NSE, and to FORCE and EMAC. Exact dates for the reporting schedule will be determined by the turbine installation date/Project commissioning date.

Interim updates will be provided to DFO and FORCE in order to inform future approval processes and will focus on the monitoring activities up to that date.

4.0 Scheduling

The EEMP will be implemented at the start of CSTV operations (*i.e.*, commissioning). A schedule is provided in Table 2. All activities on-site will be coordinated with FORCE to ensure that safety is maintained at all times.

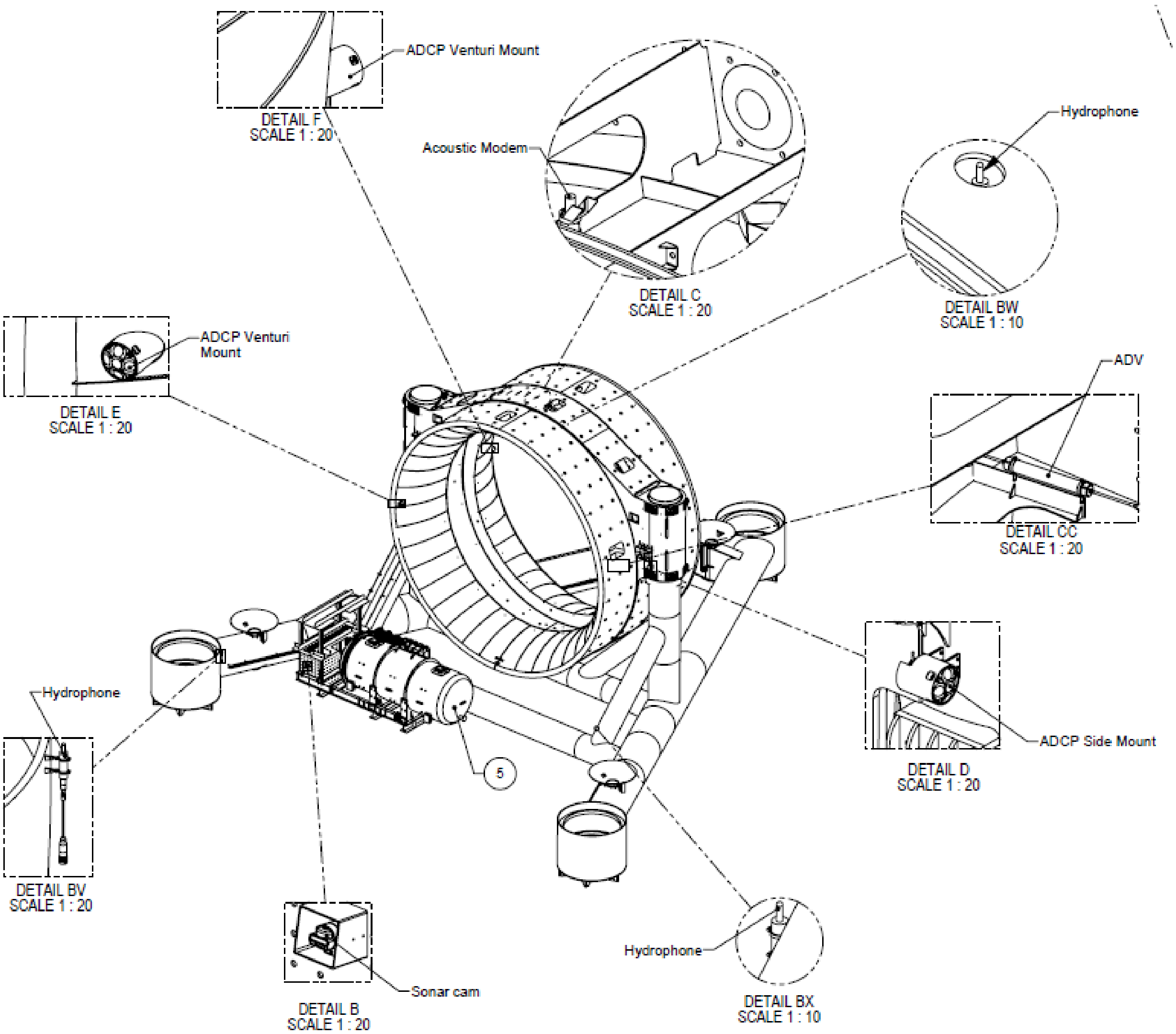
Table 2. Proposed EEMP Schedule

Task		Task Description	Proposed Timeline
Marine Fish/Marine Mammals			
1	Instrument Deployment	Deployment of PAM and AAM sensors will be deployed with turbine installation	Following turbine installation (planned for Spring 2016)
2	Data Gathering	Once the turbine is installed and connected to the subsea cable, the sensor system will become operational and able to collect data (sensors will be tested to ensure correct function and that data is able to be obtained and processed as intended).	Continuously once turbine is in operation. The exact timing of data gathering and data analysis will be dependent on the installation date and, the quality of data captured and number of detections
3	Data Analysis	Use of the click module in PAMGuard software to detect harbour porpoise. Rates of detection will be compared with PAM baseline studies, noting that C-POD detection data may under-estimate porpoise activity rates due to inherent device limitations. Seasonal occurrence rates will be summarized for a 1 year period.	
		Current/RPM data form the turbine, the rates of porpoise detection with be compared at 4 representative speed categories (categories selected after further discussions).	
		Use the whistle and moan module in PAMGuard software to detect vocalizing dolphins and whales. Seasonal occurrence rates will be summarized for a 1 year period.	
		Utilization of marine mammal detection algorithms to determine marine mammal frequency and, <u>if possible</u>, to describe evasion behaviour (i.e., track trajectories) of marine mammals, specifically analyzing data to describe track trajectories (to be used for strike risk models)	
		Utilization of fish detection algorithms to determine fish frequency.	
		Use of the Tritech Gemini to determine if marine mammals are moving directly at the turbine or moving horizontally and potentially vertically (where target moves out of the field of vision). These data are considered valuable in describing evasion behaviour and subsequent incorporation into strike risk models.	
		Development of strike risk models using seasonal data from PAM and AAM data-sets, as well as a model including track trajectory data.	
4	Reporting	Interim Update 1: Presentation of the early monitoring results (*i.e.*, first 3-4 months) focussed on the components of the CSTV EEMP to support future approval processes.	*TBD* - based on date of turbine installation and Project commissioning and data analysis timing, and in consult with DFO
		Interim Update 2: If required, continuation of a presentation of the monitoring results focussed on the components of the CSTV EEMP to support future approval processes.	*TBD* - based on date of turbine installation and Project commissioning and data analysis timing, and in consult with DFO
		Year-end Project Monitoring Report	*TBD* - based on turbine installation and Project commissioning. The final report will be submitted no later than 3 months of the year-end date to allow for final data analysis and review.

Task		Task Description	Proposed Timeline
Sound			
1	Instrument Deployment/ Retrieval	Deployment, operation and retrieval of acoustic instruments. Two high flow moored acoustic instruments will be deployed and retrieved using a suitable vessel. ADCPs deployed with turbine installation.	Following turbine installation (planned for Spring 2016)
2	Data Gathering	Processing and initial analysis of sound data collected during deployment of acoustic instruments.	Data collection expected to last for 2 months within operational period
3	Data Collection and Data Processing	Data from ADCPs located on turbines during sound measurement period gathered and prepared for analysis.	Data collection expected to last for 2 months within deployment period
4	Final Analysis	Flow noise and turbine sound characterization will be performed for integration into reporting deliverables.	*TBD* - based on Project schedule and data analysis timing
5	Reporting	Interim Update 1: Presentation of the early monitoring results (*i.e.*, first 3-4 months) focussed on the components of the CSTV EEMP to support future approval processes.	*TBD* - based on date of turbine installation and Project commissioning and data analysis timing, and in consult with DFO
		Interim Update 2: If required, continuation of a presentation of the monitoring results focussed on the components of the CSTV EEMP to support future approval processes.	*TBD* - based on date of turbine installation and Project commissioning and data analysis timing, and in consult with DFO
		Year-end Project Monitoring Report	*TBD* - based on turbine installation and Project commissioning. The final report will be submitted no later than 3 months of the year-end date to allow for final data analysis and review.

APPENDIX A

Schematic showing Turbine Sensor Location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DETAIL F
SCALE 1 : 20
Acoustic Modem
DETAIL C
SCALE 1 : 20
Hydrophone
DETAIL BW
SCALE 1 : 10
ADCP Venturi Mount
DETAIL E
SCALE 1 : 20
ADV
DETAIL CC
SCALE 1 : 20
Hydrophone
DETAIL BV
SCALE 1 : 20
5
ADCP Side Mount
DETAIL D
SCALE 1 : 20
Sonar cam
DETAIL B
SCALE 1 : 20
Hydrophone
DETAIL BX
SCALE 1 : 10

APPENDIX B

Technology Summary

The amalgamation of sonar and hydrophone data will facilitate the development of improved sonar detection and classification software and will therefore greatly enhance target identification of marine fish and marine mammals. A brief summary of the proposed technologies to be used for the marine fish and marine mammal component of the CSTV EEMP: the icListen passive acoustic device; and the Gemini Sea-Tec active acoustic (sonar) device are provided below.

Ocean Sonics icListen Device

The Ocean Sonics icListen device has been developed to perform PAM in the open-ocean and inland waterways and is unique in the tidal industry for two reasons:

1. Acoustic performance is very high, attributable to the integration and tight matching of the sensor and processing electronics.
2. The instrument processes incoming data, providing spectral processed data, and detecting acoustic events configured by the user. New algorithms are in development and will be available as an option.

The Ocean Sonics icListen instrument has been developed to monitor and detect ocean wildlife while collecting anthropogenic sounds and the subsea soundscape. In existing projects that rely on passive acoustics, the combination with active acoustics will enhance tracking and elimination of false positives. The key concept of the Smart Hydrophone is that it performs the routine work that an operator would otherwise need to do. Eliminating the processing at the source makes better use of data channels, and potentially improves response time to events by a huge margin. The design of the icListen also permits multiple units to be combined so that they may operate as a single multi-channel instrument.

Tritech Gemini Sea-Tec Device

Tritech's subsea sonars have been deployed on marine structures since 2008. The Gemini SeaTec system was launched in 2011 and uses Tritech's industry standard Gemini 720id multi-beam sonar and SeaTec target identification and tracking software. This innovative software has been developed from field installations with real-world data and is designed to identify, track and classify targets in real time. The algorithms are based on the expert knowledge of human observers and researchers at SMRU. SeaTec identifies targets of the correct shape and size and examines movements to arrive at a marine mammal probability rating. Previous studies from other tidal sites, aimed at tracking seals and porpoises was also found to detect shoals of fish and was also able to track them successfully. A random sample of fish from the study indicates identification and tracking of fish at a range of up to 20 meters. Identification and simple classification of individual fish at closer ranges is therefore possible with no changes to the algorithms. This is a proof of concept and illustrates that with some attention to specific attributes the algorithms can be extended to improve detection of fish and identify them at longer ranges.

One of the benefits of the Gemini sonar is that the sound emitted is limited to very high frequencies (*i.e.*, above the hearing ranges of most marine species), which means minimal impact to marine life. Unfortunately, this can also be a drawback as targets have only been detected successfully at up to approximately 60 m. Hydrophones, on the other hand, can detect certain mammal species at distances of 1 km and porpoises, the main marine mammal species of interest in the Minas Passage, at around 200 m. Hydrophones have a longer detection range than sonar, but are capable of detecting animals that produce sounds louder than the surrounding environment. During peak tide changes, when the turbine is working hardest, hydrophones will not detect the full complement of sounds present due to current-induced noise. Complementing the sonar with the passive acoustic detector fills in those gaps during noisy periods, and gives more confidence to marginal detections. Since silent wildlife cannot be detected with hydrophones, sonar must be utilized.

Combining these two data streams provides a solution that has proven in tests to be of minimal disturbance to marine mammals and the ability to detect key cetacean species at both moderate and near-field ranges. Furthermore, the smart hydrophones to be used for the Program will be able to perform some identification and categorization steps. Supplying Gemini SeaTec with approximate locations of confirmed marine mammals will vastly improve the probability ratings that are presently used and the information can also be used to alert SeaTec to a previously unidentified target or to anticipate a new target about to come into the sonar's field of view.

Coinciding with this Project is the release of the next generation Tritech Gemini Sonar with acoustic zoom capability. This will provide an unprecedented level of detail directed at areas where potentially valid targets are detected at long ranges typical in subsea turbine environments. More detail about targets will allow better analysis of the sonar returns and give a better indication of the type of target (*e.g.*, initial work suggests that marine mammals have a distinctive pattern of sonar intensity values).

JASCO High Flow Mooring and Autonomous Multichannel Acoustic Recorders (AMAR)

This project will utilize a bottom-mounted hydrophone unit. This design allows researchers to avoid the difficulties experienced with drifting hydrophones that, although display reliability in high flow environments, will only provide a snapshot of the ambient noise and turbine sound as the instrument passes the turbine. Similarly, issues that may be experienced with a suspended hydrophone (*e.g.*, loss of mooring in high flow environments, measurement of strumming noise, inability to measure ambient sound levels in high flow conditions etc.) are also avoided with the use of a bottom-mounted instrument.

A bottom-mounted hydrophone is also favourable in high flow environments as the instrument can reduce flow noise due to water pressure since flow speeds at the bottom of water columns are generally lower than elsewhere in the column. This flow induced 'noise' can be further minimized by shielding the hydrophone. JASCO incorporates both considerations into their design, resulting in a streamlined design called the High-Flow (HF) Mooring (Figure 1A).

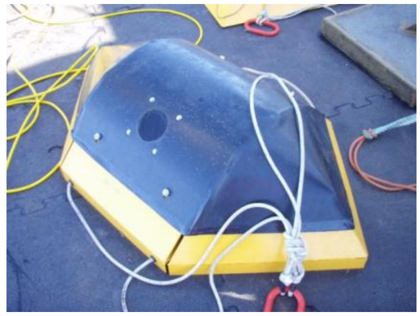

Figure 1A. High flow mooring. The circle near the top of the cover is an acoustically transparent window (Source: JASCO Applied Sciences)

Underwater sound is recorded with AMARS. The AMAR electronic board is the basis of the AMAR family of sound measurement instruments: single channel autonomous recorders, multichannel and directional sensor recorders, vertical arrays, towed arrays, over-the-side real-time analysis systems, and cabled observatories. The AMAR board features eight channels of 24-bit analog-to-digital conversion at simultaneous sample rates up to 128 kHz; it also supports one channel of 16-bit digital sampling at rates up to 800 kHz. The AMAR board can host up to seven solid-state memory modules, each with a 256GB capacity, giving 1792GB of on-board solid-state memory.