Appendix II

Passive Acoustic Monitoring Workshop Report

Passive Acoustic Monitoring in association with Tidal Energy Turbines in the Minas Passage: Workshop Report

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Executive Summary

In November 2018, the Fundy Ocean Research Center for Energy (FORCE) convened a workshop of regional experts (i.e., industry partners, academics, stakeholders) in Passive Acoustic Monitoring (PAM) data collection and analyses. FORCE's Environmental Effects Monitoring Program (EEMP) utilizes PAM equipment as its primary means of monitoring marine mammals and for understanding the effects of sound generated by turbines deployed at the FORCE test site, located in the Minas Passage, Bay of Fundy. The FORCE test site is exposed to tidal flows that may restrict the utility of particular types of PAM equipment that are suitable for environmental monitoring elsewhere. Further, regulators have requested clarification regarding the ability of different PAM technologies to detect harbour porpoise (*Phocoena phocoena*) echolocations at the FORCE site, including rates of false-positive detections. Therefore, the purpose of the PAM workshop was to discuss the inherent challenges and operational limitations associated with PAM technologies and methodologies in high-flow environments, and to identify future projects that could facilitate the deployment of PAM technologies best suited for marine mammal and sound monitoring in the Minas Passage. Participants discussed previous and ongoing PAM projects in the Bay of Fundy including challenges, methodologies for overcoming the difficult conditions presented by high-flow environments and initial findings. Importantly, the group discussed opportunities for improvements to PAM technologies, and potential projects and collaborations for the near-future. It is anticipated that members of this group will continue to meet on a semi-regular basis to pursue collaborations and opportunities to improve the utility of PAM technologies in the challenging conditions of the Bay of Fundy.

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Acronyms

AAM	Active Acoustic Monitoring
ADCP	Acoustic Doppler Current Profiler
AMAR	Autonomous Multichannel Acoustic Recorder
CSTV	Cape Sharp Tidal Venture
dB	Decibel
DRDC	Defense Research and Development Canada
FAST	Fundy Advanced Sensor Technology
FORCE	Fundy Ocean Research Center for Energy
HR	High Residence
Hz	Hertz
ISEM	Integrated active and passive acoustic System for Environmental Monitoring of fish and marine mammals in tidal energy sites
kHz	Kilohertz
NS	Nova Scotia
NSERC	Natural Sciences and Engineering Research Council of Canada
OERA	Offshore Energy Research Association of Nova Scotia
PAM	Passive Acoustic Monitoring
PPM	Pulse Position Modulation
SMRU	Sea Mammal Research Unit
STREEM	Sensor Testing Research for Environmental Effects Monitoring
SUBS	Streamlined Underwater Buoyancy System
TL	Transmission Loss

Introduction

On 23 November 2018, the Fundy Ocean Research Center for Energy (FORCE) convened a workshop of regional experts (e.g., industry partners, academia, stakeholders) in passive acoustic monitoring (PAM) data collection and analyses. The purpose of the workshop was to discuss the challenges and operational limitations inherenet with using PAM technologies for marine mammal and sound monitoring in high-flow environments like the FORCE test site in Minas Passage, Bay of Fundy, and to identify potential solutions to improve environmental effects monitoring capabilities for operational in-stream tidal energy turbines in the future. The workshop sought to address questions from provincial (Nova Scotia Department of Environment) and federal (Canada Department of Fisheries and Oceans) regulators with respect to the integration or corroboration of results from multiple PAM technologies to inform predictions made in the FORCE Environmental Assessment (AECOM, 2009). The workshop also explored potential future projects to support further environmental monitoring using PAM technologies with the end goal of lending confidence to environmental effects monitoring technologies and approaches used in support of tidal energy devices.

Background

Passive acoustic monitoring has been ongoing at the FORCE test site for many years. Recent environmental effects monitoring efforts increased in 2016 in anticipation of the installation of a single two-megawatt OpenHydro turbine by Cape Sharp Tidal Venture (CSTV) at the FORCE site.

Mid-field or ‘site-level’ monitoring using PAM technologies and in relation to the FORCE Environmental Assessment (AECOM 2009) is completed by FORCE and its contractors. Presently, this monitoring has focused on two main initiatives: C-PODs and drifting hydrophones. Mid-field monitoring for marine mammals at FORCE consists of near-continuous autonomous deployment of five C-PODs (designed to record marine mammal echolocations) ranging from 210m – 1,700m from the turbine, building on previous years of C-POD deployments throughout the Minas Passage. FORCE deploys and recovers the instrumentation and analysis has been completed by Sea Mammal Research Unit (SMRU) Canada Ltd.

During the 2016 - 2017 deployment of the CSTV OpenHydro turbine, FORCE conducted a drifting hydrophone survey to coincide with the deployment of autonomous and turbine-mounted hydrophones to monitor turbine-generated sounds at the FORCE test site. An integrated analysis was completed by JASCO Applied Sciences (JASCO) (Martin et al., 2018).

Parallel to the FORCE’s efforts, a research project was initiated by CSTV to study the potential for integrating active acoustic monitoring (AAM) and PAM technologies on an operating in-stream tidal energy turbine. This research project, ‘Integrated Active and Passive Acoustic System for Environmental Monitoring of Fish and Marine Mammals in Tidal Energy Sites (ISEM)’, was developed to explore technologies that could operate as an integrated environmental monitoring system using data analysis software and encompassing active and passive acoustic sensors in order to provide real time detection, classification, localization, and tracking of fish and marine mammals at high energy sites.

Although the success of the ISEM project tasks and objectives have been directly affected by the disruption of the CSTV turbine operation, some successes were realized and will be reported on in the final project report planned for spring 2019. The report will also address lessons learned and recommendations for moving these types of monitoring programs forward to increase understanding of monitoring in tidal energy sites.

Additional PAM activities happening in the Bay of Fundy include:

Integrated Lander Platform

Acadia University and collaborators at SMRU Canada Ltd. have been measuring harbour porpoise (*Phocoena phocoena*) detections in Minas Passage since 2010 (Tollit et al., 2011; Wood et al., 2013; Porskamp, 2013). Acadia University and SMRU Canada Ltd. established PAM (i.e., C-POD) monitoring sites in and around the FORCE test site during December 2013 – June 2014. In order to better assess PAM monitoring methods, Acadia and OceanSonics Ltd. deployed a lander (sub-sea) platform at the FORCE test site in June 2014. Among other instrumentation, the platform carried icListenHF hydrophones, C-PODs, and VR2W receivers that detect acoustic tags. Analysis of the data collected using this sensor suite provided a comparison of C-PODs and broadband hydrophones for monitoring harbour porpoise (Porskamp, 2015; Porskamp et al., 2015). Acadia has also undertaken a great deal of monitoring for acoustically tagged fish (Broome, 2014; Broome et al., 2015; Keyser et al., 2016).

Drifting Platform

Results from the integrated lander platform work generated questions that prompted a long series of experiments using a passive acoustic drifting platform (i.e., 'drifter') to make targeted PAM measurements. Drifter work in 2016 focused on detection range for acoustic tags (Sanderson et al., 2017) and PAM to measure ambient sound and harbour porpoise presence. Drifter work in June 2017 focused on comparison of C-POD data, icListen-coda, and visual harbour porpoise sightings (Adams, 2018; Adams et al., 2018). This work included some preliminary assessments of harbour porpoise localization (Sanderson et al., 2018b), and detections of tagged fish and comparisons of harbour porpoise detections with moored instruments (Sanderson, personal research notes). Drifter work in June 2018 used an array of four synchronized hydrophones and is presently being analysed for porpoise localization. Drifters were also used to demonstrate 'quasi-stable' platform trajectories in the currents of Minas Passage which may prove useful for future monitoring and research (Sanderson et al., 2018b). The 2018 work also undertook further range testing of acoustic tags, particularly to determine the efficacy of Pulse Position Modulation (PPM) transmissions relative to High Residence (HR) transmissions.

Passive and Active Acoustic Measurements

The 'Sensor Testing Research for Environmental Effects Monitoring' (STREEM) project in Grand Passage, Nova Scotia involves assessment of both passive and active acoustic instruments. Preliminary work (October 2018) involved passively drifting a variety of targets to quantify detection capabilities of an imaging sonar (i.e., Tritech Gemini 720is). Sometimes the targets were acoustically active, in which case their effects on the imaging sonar were identified. Other times, hydrophones were used as targets in order to measure how the imaging sonar interacted with PAM instruments. Interactions between echo-sounders, acoustic tags, the imaging sonar, broad-band hydrophones, and HR2 receivers were also measured. A drifting hydrophone array is also being used to measure sounds from the turbine platform (a PLAT-I from Sustainable Marine Energy Canada) installation. The major thrust for STREEM will be the application of imaging sonars, optical cameras, and hydrophones to study fish-turbine interactions. This work is ongoing, with the major experiment planned for spring/summer 2019.

Long-term Acoustic Monitoring

JASCO Applied Sciences Canada Ltd. and Dalhousie University (Dr. David Barclay; Oceanography Department) are undertaking a long-term acoustic monitoring AMAR (Autonomous Multichannel Acoustic Recorder) study in Grand Passage. The purpose of this work is to understand the effects of this turbulent environment on the ability to detect marine life and the ability of marine life to detect tidal turbines. Data analyses for this project has commenced.

Workshop Objective

In early 2018, regulators (Nova Scotia Department of Environment, 2018) provided feedback to FORCE and CSTV regarding passive acoustic data collection during the 2016-2017 deployment of an OpenHydro turbine at the FORCE site. Specifically, regulators requested clarity regarding harbour porpoise detections between turbine-mounted icListen hydrophones and C-PODs.

> "[Fisheries and Oceans Canada] requests that a direct comparison of data collected by the icListen hydrophone used for near-field monitoring at Berth D to data collected by the C-PODs deployed at East1 and D1 [C-POD locations] during the 2016/2017 deployment period be provided […] Specifically, provide a clear discussion of the results of the Days with Detected Porpoise Clicks with the Lucy Click Detector relative the Number of Calendar Days reported for deployment period" (Nova Scotia Department of Environment, 2018).

In response, FORCE consulted with the workshop attendees to develop a response for its second quarterly report in 2018 (FORCE, 2018) and began planning this workshop for fall 2018.

Problem Statement

Recognizing that C-POD data files are not comparable with icListen data files (Porskamp et al., 2015) and that there were observed discrepancies in 'Days with Detected Porpoise Clicks' between the turbine-mounted icListen hydrophones and the Chelonia C-PODs deployed in proximity to the CSTV turbine, a further examination of PAM devices is warranted at the FORCE site.

The differences in detection rates between these instruments can partly be attributable to their functioning. The icListen hydrophone is considered more sensitive but may be masked by the noise of the turbine during periods of high flow. Research has also demonstrated that C-POD units can sometimes record false positive detections (although this is at fairly low rates), whereas the icListen hydrophones and associated software programs have been developed to separate out the different high frequency sounds to make a positive identification of porpoise clicks. The icListen hydrophones appear to have a greater accuracy in detection rates of high frequency sounds in noisy environments; however, the continued use of C-PODs at the FORCE site is important as it provides a direct comparison to baseline data that was collected at the FORCE site prior to any turbine deployments within the mid-field study area.

A statistical model that accounted for relevant environmental variables and 'Percent Time Lost' was applied to the C-POD data, and was used to test for changes in the distribution and activity of harbour porpoise in relation to the installation and operation of the turbine. The overall effect of turbine operations on porpoise detection rates were found to be significant ($P < 0.01$). East1, a site 210 m north of the turbine at 41 m depth, and D1, a site 230 m south of the turbine at 33 m depth both showed significantly fewer porpoise detections post-installation of the turbine. Both of these sites had overall lower activity levels both with and without the turbine, whereas the sites > 1 km west and south of the turbine had overall higher activity levels and showed no decrease in porpoise detections with the turbine. Given that detection ranges of harbour porpoise are small (< 2-300 m), it is possible that the lower detection rates recorded by the icListen hydrophone mounted on the turbine reflect near-field avoidance by harbour porpoise.

For both types of monitoring devices, additional data collection will be required to cover seasonal and inter-annual variation to understand behaviours of marine mammals in relation to an operational turbine in the mid-field and near-field. The issues experienced during the 2016-2017 turbine deployment have been mitigated through a series of pre-deployment commissioning tests of the icListen hydrophones, new protocol for transfer and management of data, hydrophone synchronization and recognition of the importance of protective measures and specific cabling for all icListen hydrophones.

Attendees

Attendees included representatives from:

- Acadia University (Wolfville, NS): Mike Adams, Anna Redden, Brian Sanderson
- Dalhousie University (Halifax, NS): David Barclay
- Emera/Cape Sharp Tidal Venture (Halifax, NS): Carys Burgess
- FORCE: Tyler Boucher, Jessica Douglas, Dan Hasselman, Melissa Oldreive
- GeoSpectrum Technologies Inc. (Dartmouth, NS): Matt Coffin
- JASCO Applied Sciences (Dartmouth, NS): Bruce Martin
- Ocean Sonics (Great Village, NS): Mark Wood
- Offshore Energy Research Association of Nova Scotia (Halifax, NS): Jennifer Pinks

SMRU Canada Ltd. (Vancouver, British Columbia) was unable to attend due to travel restrictions and provided advice beforehand. In addition, Dr. Dom Tollit presented at the Marine Renewables Canada Research Forum on 20 November 2018, highlighting the experience of SMRU Canada Ltd. with marine mammal monitoring at the FORCE test site.

All parties have had experience in data collection methodologies and/or analysis experience with PAM data collected within the Minas Passage, Bay of Fundy.

Proceedings

After a general roundtable introduction amongst participants, the workshop’s objectives and the intent to form broad-scale collaborations for dissemination of research and technical challenges and developing joint research project area were discussed. This is especially important as some valuable lessons learned are not always outlined in publications.

Present Situation at FORCE

Dan Hasselman provided an update regarding the present situation at the FORCE test site in consideration of the OpenHydro turbine (i.e., turbine itself is non-operational, but three of four turbine-mounted icListen hydrophones are operating). It was agreed that it is critical to focus on the near-field at this time: this is key to enable future device developments.

For instance, FORCE has commissioned GeoSpectrum Technologies Inc. and Dalhousie University to examine data from the three turbine-mounted icListen hydrophones (depicted in Figure 1: The locations of the four hydrophones placed on the OpenHydro turbine. Hydrophone 2 (fore port) is presently not communicating.), an autonomous Fundy Advanced Sensor Technology (FAST) platform with two icListen hydrophones, and an AMAR system deployed by JASCO Applied Sciences Canada Ltd. The purpose of this work is to examine the data collected in summer/fall 2018 in the near-field region of the OpenHydro turbine to i) characterize ambient noise levels with a stationary turbine, and ii) evaluate the performance of each hydrophone configuration to provide information about how best to monitor sound at the FORCE test site in the future. Utilization of this near-field data will advance our understanding of the soundscape of the site and will provide valuable information about future mid-field and near-field monitoring at the FORCE site.

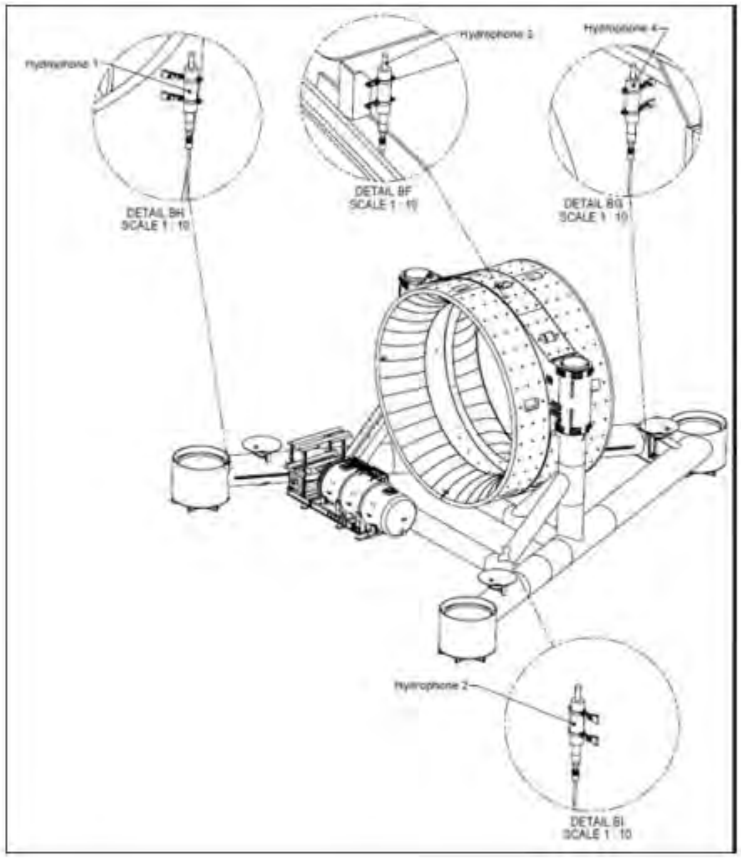

Figure 1: The locations of the four hydrophones placed on the OpenHydro turbine. Hydrophone 2 (fore port) is presently not communicating.

Matt Coffin (GeoSpectrum Technologies Inc.) elaborated on the data collected from the icListen hydrophones mounted on the FAST platform. Specifically, taking five-minute averages at two-hour intervals, flow noise can be seen in the spectra and is comparable to the flow noise observed in the data from the turbine-mounted icListen hydrophones. Matt pointed out that the sample rate of the raw icListen hydrophone data is 8 kHz, resulting in a 4 kHz cut-off frequency in the spectra. Mark Wood (Ocean Sonics) pointed out that high-frequency spectra are saved in addition to the raw time-series data. After the workshop, Matt located the high-frequency spectra and updated the spectral plots to include these data. Again, the spectra agree well with the turbine-mounted icListen hydrophone data.

Although Bruce Martin (JASCO Applied Sciences Canada Ltd.) has analyzed previous icListen hydrophone data, none of that data was collected when the turbine was non-operational. Therefore, the current data could be used to estimate ambient noise in the Minas Passage with the CSTV turbine present but stationary. This would be valuable information.

While there is accompanying ADCP (Acoustic Doppler Current Profiler) data for the data collection period, GeoSpectrum Technologies Inc. has not analyzed these data. For simplicity, Matt used tidal prediction times to estimate flow speed at the times corresponding to the spectral measurements instead.

Following the meeting, GeoSpectrum Technologies Inc., David Barclay, and Bruce Martin met to discuss the results of the preliminary analysis and developed a statement of work defining more in-depth analysis to follow.

Brian Sanderson (Acadia University) discussed how beam patterns from the various instruments can help with directionality and localization, allowing monitoring to move from presence/absence data to quantitative measurements (i.e., abundance estimates).

The three turbine-mounted icListen hydrophones provide an opportunity to continue PAM research objectives in the Minas Passage regardless of whether the turbine is operational or not. Mark Wood has been surprised by the level of animal activity recorded so far by the icListen hydrophones. Further examination during the winter months will provide additional information about harbour porpoise presence and activity. Mark also noted that this could provide an opportunity to better understand if AAM instruments are interfering with PAM devices. Data from the ADCPs mounted on the turbine are under review; an evaluation of PAM and AAM devices could be worthwhile right now.

Work with fish acoustic telemetry (i.e., fish tagging) (Mike Stokesbury; Acadia University) was discussed. A project that considers the new high-frequency hydroacoustic tags (180 and 170 signal) could provide further clarity about animal movements across instrumentation recorder locations. While tagging efforts are recognized as expensive and extensive, it was agreed that FORCE could coordinate multiple groups to develop a project that uses hydrophones to supplement tag receivers.

Instrumentation Evaluation

Brian Sanderson discussed how AAM devices such as ADCPs interfere with PAM devices. Dr. Haley Viehman (Echoview Software Pty Ltd.; previously Acadia University) has done work on the interference of active acoustic instrumentation on other AAM devices (e.g. Tritech Gemini sonar and ADCPs); additional work focused on AAM-AAM and AAM-PAM instrumentation interference is worthwhile and would facilitate discussions with regulators about the utility of setting duty cycles (i.e., sequentially turning acoustic monitoring devices on/off) to avoid interference and thereby improving the quality of data collected by all acoustic monitoring devices.

It was noted that SMRU Canada Ltd. had engaged the University of St Andrews (Scotland) to look at the interference between the Tritech Gemini imaging sonar with hydrophone data. The ISEM project (in collaboration with SMRU Canada Ltd., Acadia University, and Ocean Sonics) is presently examining the quality of Tritech Gemini data collected during the 2018 CSTV turbine deployment.

PAM Analysis from November 2016 – June 2017

Bruce Martin highlighted sections in the JASCO Applied Sciences Canada Ltd. report (Martin et al., 2018) that compared various turbine-mounted hydrophones to passively drifting icListen hydrophones deployed by FORCE and the AMAR (Figure 2: Median pressure spectral densities for three different long-term recording positions, the reference recording from the outer Bay of Fundy as well as the drifter measurements from 27 Mar 2017. Frequency-5/3 is the expected slope for turbulent flow noise (Martin et al., 2018).) during the 2016-2017 CSTV turbine operation. At 69 Hz, the data from the AMAR and the turbine-mounted hydrophones correlate well. Further, consistency was observed across instruments and tidal stage – the directional sound source could be due to sediment movement in the water column.

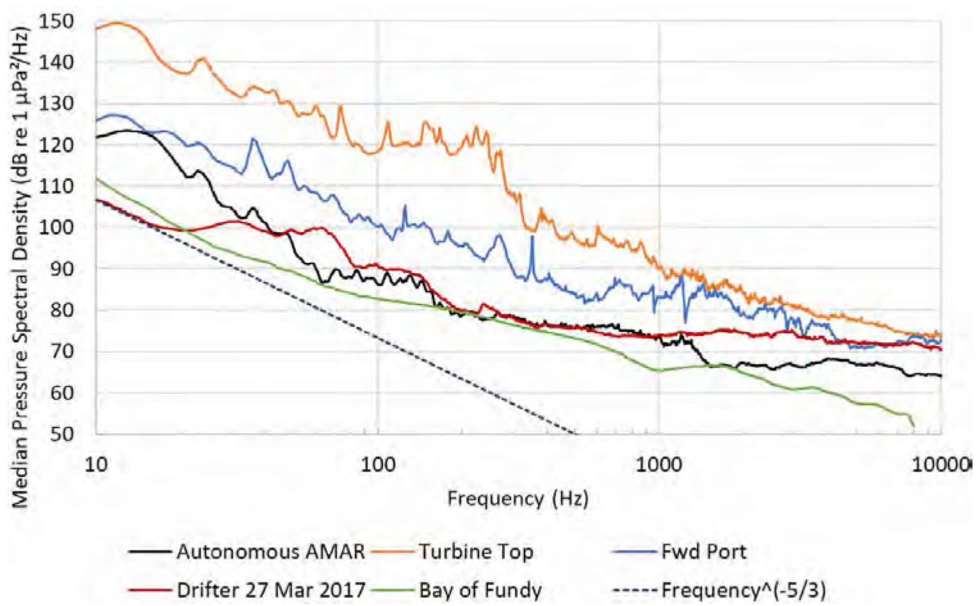

Figure 2: Median pressure spectral densities for three different long-term recording positions, the reference recording from the outer Bay of Fundy as well as the drifter measurements from 27 Mar 2017. Frequency-5/3 is the expected slope for turbulent flow noise (Martin et al., 2018).

It was also observed that the measurements from the AMAR had more vibrational energy, due to its proximity to the sound-source (i.e., CSTV turbine). It was observed that the shape of the lines for the AMAR data when the CSTV turbine was generating power were 'arrowed', indicating a stationary Lloyd's Mirror Effect. At higher frequencies, dramatically different ebb and flood characteristics were detected among the various hydrophone locations on the turbine.

There was discussion regarding the turbine-generated sound (in its various states) relative to vessel traffic elsewhere in the Bay of Fundy, as well as the pre-existing soundscape in the Bay of Fundy.

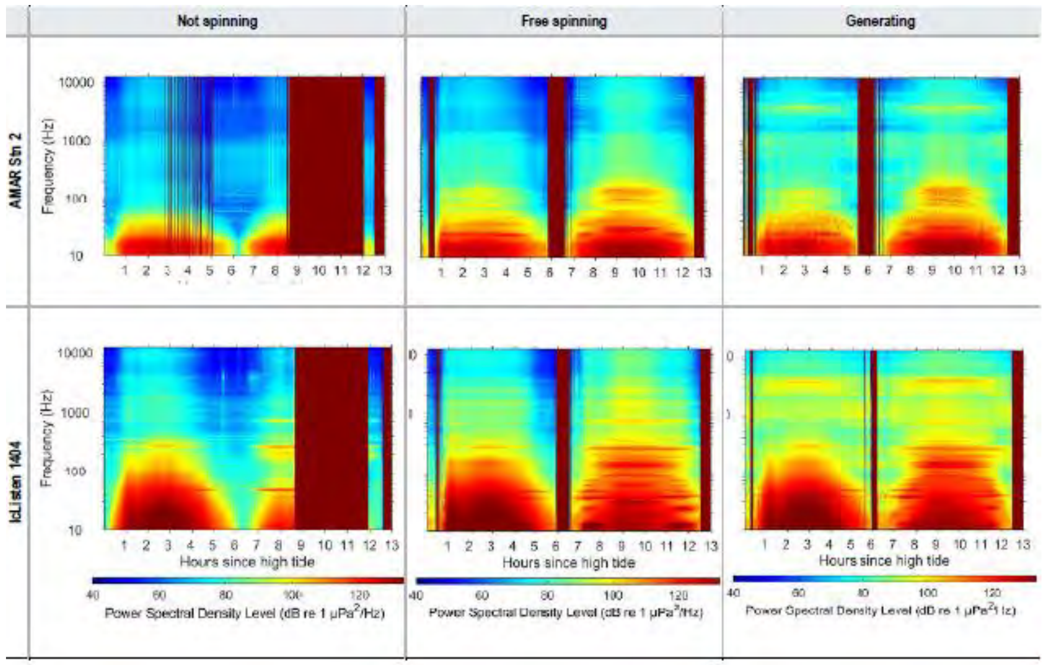

Figure 3: Power spectral density versus tidal increment time, turbine state, and recorder. The horizontal axis is time in hours since high tide. Times with less than 30 samples of data are blocked out in red (JASCO, 2018).

C-POD Utility

Brian Sanderson and Anna Redden (Acadia University) presented the issue of C-POD false detections, and issues with interfering noise and related data loss. C-POD performance is compromised above certain flow thresholds and does not assist with localization or abundance measurements. Some targeted experiments on the moorings used for C-PODs in the Minas Passage (known as SUBS – Streamlined Underwater Buoyancy System) are required.

SMRU Canada Ltd. undertook additional analyses to assess loss of data by C-PODs under high flow conditions. Data loss occurs when the 1-minute long internal memory buffer of the C-POD is filled with clicks before the end of that minute of monitoring (termed 'Percent Time Lost'). Percent Time Lost had little effect on data quality between ebb current speeds < 2.4 m/s (95.0% of 10-minute periods) and flood current speeds < 2 m/s (71% of 10-minute periods). At ebb current speeds up to 2.9 m/s (99.0% of 10-minute periods) and flood current speeds up to 3.5 m/s (95.5% of 10-minute periods), Percent Time Lost does not exceed 65.0%. Despite the use of statistical methods to take Percent Time Lost into account, C-POD monitoring performance above these current speeds appears less reliable, noting that these speeds only occur over a small fraction of the tidal cycle.

Bruce Martin mentioned how geometry and directionality (including beam patterns and signals) are critical elements for proposed experimental trial work and must be considered in instrument mounting configuration (either on platforms, moorings, or turbines).

Dan Hasselman highlighted communications from Dom Tollit regarding a new PAM instrument called 'Sound Trap 300 HF', which can achieve continuous audio recordings at a low sample rate, while simultaneously capturing short audio snippets of each click detection at full 576 kHz sample rate. This is a compact acoustic recorder developed by Ocean Instruments New Zealand in collaboration with SMRU Ltd.

and uses the PAMGuard software to detect porpoise clicks.[1] Bruce highlighted a new instrument, an F-POD, which is under development by Chelonia (provider of the C-PODs) and is available for testing.

Calibration and Instrumentation Life

It was noted that C-PODs operate best in the first year of life. There will be a need for FORCE to recalibrate/refurbish these instruments soon.

Laboratory and In Situ Tests

Mark Wood described a test completed at the Aquatron facility (Dalhousie University), which resulted in less useful data as the walls of the facility 'clip' the hydrophone.

Anna Redden and Brian Sanderson discussed open water testing, which suffered from interference with boats and echosounders (which can be quite large – 200 dBs at times).

While it was recognized that laboratory facilities are useful in certain contexts (e.g., isolate signals, turbidity changes, multiple instruments, etc.), it was determined that open water test sites are preferable for PAM. Some tests were done in Saint Mary's Bay, but the data is not yet analyzed. More data will be collected, but that work has been delayed until 2019 (spring/summer) due to weather.

Additional Studies & Resources

Care will be required in designing and interpreting any detection experiments. Ideally, all sensors being compared should be co-located. Where they are not co-located, the experiment should be designed to help reduce the impact of spatial and temporal variations in transmission loss (TL). GeoSpectrum Technologies Inc. has conducted a number of TL studies and similar experiments where many pulses have been transmitted over a period of time to various sensors. Even small changes in location and time (e.g., on the order of a wavelength and seconds to minutes) have resulted in TL variations on the order of 10 dB. Thus, any detection experiments should do their best to overlap sampling in space and time and ensure sufficiently long duration and variation in source location to try to ensure that all sensor locations are presented with similar test data.

Recommendations & Next Steps

All attendees agreed that it was useful for this group to reconvene again to discuss research projects (present and future) and lessons learned in greater detail. The strength in a group that shares best practices that are not necessarily found in publications is valuable and was recognized by all. It was also recognized that there is a good understanding of existing PAM technologies available, which provides a suitable background for beginning newer, innovative research projects.

The following were identified as potential research projects (in no particular order):

- Take advantage of the opportunity to continue acoustic research with the OpenHydro turbine before it is removed (options highlighted below).
- Assessment of beam patterns of commercially available tools and the potential for their interactions in a specific experimental design.

[1] More information: http://www.oceaninstruments.co.nz/soundtrap-click-detector/

- Exploration of mooring systems to optimize C-POD deployments and data collection. A comparison of existing C-POD mooring systems (utilizing SUBS packages), a (cabled) FAST platform, a lift-tilt system, and a deep-water drifter could provide a proper assessment of false positive detections, and most importantly differences in detection rate probabilities in the high-flows of the Minas Passage. This would allow for a comparison between previous baseline detection rates and detection rates using alternative devices and platforms. This approach could increase our understanding of C-POD limitations, possibly quantifying these limits.
- Synthesis of pre-existing data and baseline information collected by PAM receivers within the Minas Passage. This would include:
    - Revisiting C-POD data in consideration of poorer quality data points in order to evaluate the efficiency of these instruments;
    - Analysis of ambient conditions, including an AMAR deployment (June – November 2018); and
    - Quantify noise and transmission loss.
- Co-location of instrumentation near an operating tidal energy turbine. Potential options include:
    - Co-locating a C-POD with a newer Chelonia instrument known as an 'F-POD' (to be acquired from Chelonia);
    - Co-location of a C-POD with an icListen hydrophone on a FAST platform (cabled is preferred given the quantity of data from hydrophone); and
    - Placing a C-POD near the CSTV turbine, which has three operating hydrophones on it, on a FAST platform or with a SUBS package.
- An evaluation of harbour seal (*Phoca vitulina concolor*) and grey seal (*Halichoerus grypus*) within the Minas Passage. This could include an evaluation of habitat use, estimated abundance, and include the use of visual observations.
- Using synthetic clicks to assess instrumentation performance. Using a fixed-point source from Ocean Sonics, the ability of instruments to detect vocalizations across different tidal states, configurations, and in different sections of the water column would be assessed.
- Troubleshooting the fourth non-communicating icListen hydrophone on the OpenHydro turbine. Access to FORCE substation is required to communicate with the devices.
- Cumulative sound profiling at the FORCE site. This model could consider multiple turbines and their relative sound profile within the Minas Passage over different tidal stages but start with a single operating turbine when it is deployed.
- An evaluation of AAM interference with PAM devices in the Minas Passage.
- An examination of fish tag detections using pre-deployed hydrophones in the FORCE test site in cooperation with tag manufacturers.
- Continued PAM research options in Grand Passage as step-wise approach to Minas Passage deployments.

The possibility of working towards a submission to the OERA's Open Call Program was discussed.[2] A discussion was also had regarding the required resources to complete this work.

The group agreed to its continued value and will attempt to reconvene in 2019.

[2] More information: http://www.oera.ca/news/requests-for-proposals-funding/open-call-program/

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