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REVIEW OF THE ENVIRONMENTAL EFFECTS MONITORING PROGRAM FOR THE FUNDY TIDAL ENERGY PROJECT

Context

The Fundy Ocean Research Centre for Energy (FORCE) tidal energy project located in the Minas Passage of the Bay of Fundy is a research and development demonstration site for testing in-stream tidal power technologies in Nova Scotia. The facility consists of four subsea berths for tidal in-stream energy conversion (TISEC) devices, as well as subsea power cables connected to land-based infrastructure for integration into the local power distribution system. Research and monitoring of baseline environmental conditions in the Bay of Fundy in support of the development of in-stream tidal power in Nova Scotia has been on-going over the past decade (see DFO 2008). In 2012, Fisheries and Oceans Canada (DFO) Science undertook a Science Response Process (SRP) to review initial research and monitoring results (2009-2010) reported following deployment of a single TISEC device in 2009 (see DFO 2012). The SRP concluded that insufficient research and monitoring had been undertaken to evaluate the effects of the TISEC device on valued ecosystem components of the Bay of Fundy, and recommended that additional studies be completed, particularly impacts related to marine mammals and fish behavior. In 2015, FORCE submitted a follow-up baseline report summarizing research and monitoring results collected at the demonstration site from 2011-2013. Based on the baseline results, FORCE submitted a proposed five year (2015-2020) Environmental Effects Monitoring Program (EEMP), which has the objective of addressing mid field effects, for DFO review. Last, in 2015-2016, multiple TISEC devices are to be deployed by Cape Sharp Tidal at the FORCE demonstration site, and a near-field, TISEC-specific Environmental Effects Monitoring (EEM) report has been submitted to DFO for review.

The DFO Fisheries Protection Program (FPP), Maritimes Region, has requested DFO Science peer-review the FORCE Baseline Report (2011-2013), the proposed FORCE EEMP (2015-2020), and the Cape Sharp Tidal TISEC-specific EEMP. The questions posed to DFO Science were:

- Are results presented in the FORCE baseline report (2011-2013) adequate for use as baseline information in support of the proposed EEMP for monitoring TISEC devices to be deployed in the Minas Passage of the Bay of Fundy? Are there any other baseline studies that should be completed?
- Is the proposed FORCE EEMP (2015-2020) designed to detect effects on marine valued ecosystem components (VECs) from TISEC devices to be deployed in the Minas Passage of the Bay of Fundy? Are there any EEM components, sampling procedures, techniques or analyses missing from the proposed EEMP that are necessary to appropriately assess the effects on marine VECs from TISEC devices to be deployed in the Minas Passage of the Bay of Fundy?
- Is the proposed Cape Sharp Tidal TISEC-specific EEMP appropriately designed to detect effects on marine VECs from deployment of the TISEC device(s) in the Minas Passage of the Bay of Fundy? Are there any EEM components, sampling procedures, techniques or analyses missing from the proposed TISEC-specific EEMP which are necessary to

appropriately assess the effects on marine VECs from the TISEC device(s) to be deployed in the Minas Passage of the Bay of Fundy?

In support of this SRP, DFO Science drew upon in-house science expertise with knowledge of in-stream tidal power research and monitoring in the Bay of Fundy. In some instances, peer reviewers involved in the SRP were also involved in previous research studies of this nature, some of which have been reported upon in the FORCE baseline report.

Advice provided by DFO Science through this SRP will be used by DFO FPP to meet its regulatory requirements pursuant to the *Fisheries Act* and *Species at Risk Act* and may also be used to support provincial and federal environmental assessment requirements.

This Science Response Report results from the Science Response Process of September 21, 2015, on the Review of the Environmental Effects Monitoring Program for the Fundy Tidal Energy Project.

Analysis and Response

FORCE Baseline Report (2011-2013)

Lobster

General Comments

The VEMCO Technology Range Test reported few or no detections of lobster within 200m of the receivers, when tidal velocities exceeded 1.5 m s^{-1}, during both flood and ebb tides. Lobster tracking results might be considered indicative of lobster movements but are not considered quantitative. Although there were substantial periods where lobsters could not be detected, 33 of 85 lobsters were detected in the first year primarily moving west of the Minas Basin in fall/early-winter in proximity of the FORCE demonstration site. Additional lobsters may have been detected if the extreme tidal currents in the Minas Passage had not inhibited ability of the receivers to detect transmitters during ebb and flood tides. A statement included in the baseline report indicates potential detection problems as a source of uncertainty, although this uncertainty does not appear to be considered further in the report's conclusion that lobsters were detected transiting the demonstration site.

The lobster baseline study demonstrated that a significant proportion of the lobsters in the Minas Basin do transit the area near the demonstration site; however, it does not address what, if any, interactions lobsters would have with TISEC devices and other infrastructure (e.g. cables), including how this might affect lobster behaviour. Future studies may be necessary to detect changes in lobster movement patterns in the Minas Basin resultant of the installation of TISEC devices.

Specific Comments

No specific comments provided.

Fish

General Comments

Results of range testing experiments indicated that acoustic telemetry could be applied to monitor use of the Minas Passage by fish; however, detection efficiency, irrespective of the transmitting power of acoustic tags, will vary inversely with tidal forcing and the distance between transmitters and receivers.

Atlantic Sturgeon, Striped Bass, adult American Eel, and inner Bay of Fundy Atlantic Salmon (smolts) were detected throughout the height of the water column in the Minas Passage, including within the demonstration site. Given the general characterization of Atlantic Sturgeon as a bottom-dwelling species, its use of the water column differed from what was expected. The duration (days) of detections for out-migrating adult American Eel and Atlantic Salmon smolts was relatively brief, indicating these species could transit through the Minas Passage within several tidal cycles. Striped Bass and Atlantic Sturgeon exhibited an extended presence within Minas Passage, suggesting these species may use the Passage to fulfill life-history functions that extend beyond migration (e.g., feeding). Striped Bass exhibited a protracted time series of detections within Minas Passage, which extended into the winter months. Although the number of Striped Bass carrying transmitters with a battery life that allowed for detection into the winter months was small (n=17), the proportion (n=6; or 35%) of Striped Bass detected in the Minas Passage during the months of December-March indicate that the passage may represent important winter habitat for the species, which supports previous determination of this area as important habitat (DFO 2014).

The report contains direct and indirect information on fish use of the Minas Passage, but it provided no information regarding absolute fish abundance within the Passage.

The weir studies provided some baseline information pertaining to the presence of summer fish species in the Minas Basin, as well as their comparative abundances as functions of time and diel cycle. Weir studies were restricted to two far-field sampling locations in the Minas Basin. Analogous information was not collected from within the Minas Passage. Study results indicated that inter-tidal brush weirs have potential as platforms to monitor a broad and diverse fish assemblage and to document seasonal changes in species composition and seasonal growth profiles of age classes by species.

The weirs, however, are not permanent structures and are dismantled during winter months when ice is present. Therefore, weirs do not allow for year-round monitoring, as was recommended by DFO (2012). Further, determination of whether the capture efficiency of the weirs is comparable among-years presently remains unknown. Thus, it will not be possible to determine if fish abundances fall outside the range of inter-annual variability between pre- and post-turbine deployment periods. Overall, the baseline monitoring data accumulated to date is not considered to be sufficient as a baseline indicator of “fish assemblages and their usage of various habitat types, particularly outside of the project area” (DFO 2012). Continued evaluation of the usefulness of low-head intertidal weir catches as monitoring platforms, and evaluation of other existing or on-going monitoring programs as suggested by DFO (2012), is recommended.

Comparable information concerning fish assemblages in the Minas Passage, in proximity to the FORCE demonstration site, was not gathered. Opportunities to gather this information using existing commercial fishery platforms within the passage remain limited.

Specific Comments

No specific comments provided.

Marine Mammals

General Comments

The baseline report indicated that Harbour Porpoise are the marine mammal species that most often occurred in and use the Minas Passage area, and that they occur throughout the year, although there is some seasonal variability in their occurrence. Other species are less common and were only very occasionally observed.

While vessel and shore-based visual surveys and passive acoustic monitoring efforts have provided some baseline data on marine mammal presence in and around the FORCE demonstration site, further research/monitoring is recommended to provide a more complete baseline understanding of marine mammal use of the area -- particularly for Harbour Porpoise.

The vessel-based visual surveys described were primarily designed to assess seabird use of the area, which is not an ideal survey design for detecting marine mammals. For example, observers monitored out to a distance of 300 m, while standard marine mammal survey protocols generally monitor out to a much greater distance (kilometers) to increase the probability of observing marine mammals in the vicinity. The suboptimal protocols used for marine mammals may explain the generally low numbers of Harbour Porpoise detected during the vessel-based surveys.

Most marine mammal observations occurred from shore-based studies that were only conducted during high-tide through ebb tide and, therefore, do not provide a complete picture of marine mammal behavior at the site, as information on marine mammal occurrence during the low through flood tide was not recorded. Additionally, while the shore-based surveys spanned the period of March to December when all four years of data collection (2009-2012) were combined, sampling was relatively limited (e.g., 6 days per year for 2011 and 2012), and no one month was surveyed over multiple years. This limits the ability to assess the degree of natural variability in Harbour Porpoise presence between years. For example, the highest average number of Harbour Porpoise observed per half hour occurred on March 31, 2011. However, it is not clear if this is a consistent trend over years or if late-March 2011 happened to be an anomalous year. Without more extensive data collected, it is difficult to assess consistency in the trends observed over time. A lack of understanding of natural variability in Harbour Porpoise occurrence at the FORCE demonstration site, when no TISEC devices were present, will limit the ability to determine impacts on Harbour Porpoise when devices are deployed and operational.

Survey design, including temporal coverage, should be carefully considered when interpreting the results of these visual surveys.

A significant amount of data was collected during acoustic monitoring studies; however, these studies only included data from the May through January period, so data from the winter (i.e., February to April) is lacking.

Accuracy and effectiveness of the Harbour Porpoise ‘click detection’ technology used for detecting Harbour Porpoise in the vicinity of the recorders is not clearly documented in the baseline report. Information on missed call rate (i.e., proportion of clicks estimated to be missed by the C-POD), and the expected likelihood of acoustically detecting a Harbour Porpoise in the vicinity of the C-POD, should be provided.

Observed trends from the visual surveys and acoustic data differed; however, the baseline report did not compare the two data types or discuss the reasons behind these observed differences. A comparison of results using these two data types, and a comparison of each data type for monitoring purposes, would be informative.

Specific Comments

Section 4.2.2.2 – Page 24

The report states that density estimates based on the shore-based visual data ranged from 0-1.4 individuals per km^2, and the total number of individuals present during one tidal cycle ranged from 0-42; however, no information is provided on the methods used to obtain these estimates.

Information on density and total number of individuals present by month/season would be useful to better understand seasonal trends in occurrence.

The following statement in the report requires clarification: “Although the activity of the species [Harbour Porpoise] under lower current regimes is unknown, the present observations suggest that Harbour Porpoise would not be particularly likely to encounter turbines during peak currents, when their potential to be harmed is greatest, since they are seen at the surface and are not diving”. It is unclear what data in the baseline report this statement is based upon. References that present data to support this statement should be provided.

Appendices A and B – Methods

It should be clarified why shore-based visual observations were only collected during the high through ebb tide. Observations made during vessel-based surveys indicated Harbour Porpoise were present in the area during flood tides as well.

Information on visibility during shore-based surveys, or Beaufort Sea-state, which can significantly impact Harbour Porpoise visual detectability during the shore or vessel-based surveys, should be documented. Variance in environmental conditions, which might impact detectability, need to be considered when interpreting the survey results.

Appendices A and B – Results and Discussion

Direct comparison between vessel and land-based survey observations could not be made due to differences in methods used between each survey type.

Differing explanations are provided for the presence of Harbour Porpoise in 2012, which should be clarified. It is suggested in Appendix B that the high number of Harbour Porpoise detections in 2012 was an exception, and Harbour Porpoise may not be found regularly at the demonstration site during summer; however, in a subsequent paragraph it is noted that this is just part of the natural variability in Harbour Porpoise occurrence in the area.

Figure 5 in Appendix A and Appendix B presents fluctuating estimates of Harbour Porpoise throughout the year, which is interpreted as seasonal trends (i.e., peak abundance in late-March and August, minimal abundance in late-May, early-June, September, December). Given the relatively high inter-annual and regional variability in Harbour Porpoise occurrence, as noted by the report authors, it is difficult to determine consistency of these trends observed without multi-year repetition. It should be clarified in the baseline report whether these fluctuating numbers are a result of a relatively small sample size (i.e., only two days per month sampled with no repetition in monthly samples over years) or natural variability in species occurrence, rather than simply interpreted to represent seasonal trends.

Appendices A and B – Conclusion and Recommendations

The baseline study concludes that Harbour Porpoise are a fairly common visitor to the Minas Passage from spring to fall and are observed at the FORCE demonstration site, with as many as 38 individuals moving between the shore and outer boundary of the demonstration site on a single ebb tide. However, it is also stated that because Harbour Porpoise are usually seen near the surface when moving through the Minas Passage, the likelihood of interactions with tidal turbines would not be large. The basis for this conclusion is not clear. Information regarding diving depth was not collected during the baseline studies. The statements on the likely depths used by Harbour Porpoise are not being supported by the survey design or survey results.

Appendix C – Conclusions and Recommendations

Section 5.3.1. stated that “very sparse data was collected over the winter and early spring period (December to April inclusive)” and that “baseline data during winter prior to turbine installations at FORCE should be collected as soon as possible to allow for year-round comparisons (before and after turbine installations).” As noted by the report authors and in the general comments above, additional baseline data collection is required to evaluate marine mammal use of the Minas Passage and FORCE demonstration site throughout the year.

Acoustic Monitoring

General Comments

The limited amount of acoustic noise level data collected in late-March to early-April 2012 does appear to delineate true acoustic background but on strong ebb tide flows only and restricted to a single site in the Minas Passage. While progress in measurement methodologies has been achieved, the baseline data collected is insufficient in spatial coverage, temporal coverage, and tidal cycle coverage to characterize ambient noise in the absence of TISEC devices. Considerable baseline monitoring remains to be accomplished, which is acknowledged in the proposed monitoring plan (2015-2020).

Specific Comments

Appendix G – Section 1.3

The report states “sound levels emitted by tidal turbines should increase in frequency and amplitude as the tidal flow increases from slack tide to full flow”. It should be clarified whether turbine rotation rates always increase with tidal flow or if rotation quickly achieves a fixed rate synchronous with 60 Hz generation, and is controlled by the electrical power delivered.

The report states that “Southall et al. (2007) recommended applying a frequency-dependent M-weighting to the sound spectrum before determining the sound pressure level.” This plan reports sound pressure levels (SPLs) over 1/3 octave bands. It should be included in the report as to whether Southall et al. (2007) reported SPLs in the same manner, in addition to applying M-weighting.

The report states “audiograms indicate fish and sea turtles have an auditory range from 70 Hz to 1 kHz.” While the auditory range of sea turtles might be included in this range, as per Figure 6, it is unclear where within this range sea turtles fit. More information regarding sea turtles could be included in the baseline report.

Appendix G – Section 4

The statement “with this noise level the system can easily measure tones from tidal turbines at the level 140 dB re 1µPa at a range of at least 100 m from the turbine” can be misinterpreted to mean a system capable of measuring a sound level of 140 dB at the system itself. For consistency with previous text, the statement should read “with this noise level the system can easily measure tones from tidal turbines with a source level of 140 dB re 1µPa @ 1 m at ranges of at least 100 m from the turbine.” The summary in the main body of the baseline report explains the difference, although a sound level of 140 dB at the source really means at a reference distance of 1 m from the source.

The report states “the HF mooring should have two internal hydrophones, one on each side, behind acoustically transparent windows. With this configuration one hydrophone will always be protected from the flow and that the system will record near-ambient noise levels throughout the tidal cycle.” For this arrangement to work effectively, the two internal hydrophone chambers would have to be carefully isolated from one another so that under high pseudo-noise generation, when the flow is directly impinging one window, the noise is not internally communicated to the “quiet” hydrophone that is measuring the ambient background level. The overall dimensions of the device must be kept sufficiently small such that the ported hydrophone does not acquire unwanted directionality at frequencies of interest.

Marine Benthos

General Comments

Although the baseline study provided a detailed report of the FORCE lease area Berths Sites A to C, including the associated cable lay down areas, marine benthos sampling occurred over a one year period with little or no repeat sampling at similar sample locations. As a result, understanding of the natural variability in the system is lacking.

It is recommended that video and still photography studies be undertaken at Berth Site D, including its associated cable lay down routing area, as there is presently no data pertaining to marine benthos for this berth.

The baseline report noted a suspended sediment transport rate of $2.4x10^6$ m^3 y^{-1} entering the Minas Passage area (Wu et al. 2011) while Amos and Joice (1977) reported a transport rate of $3.1x10^6$ m^3 y^{-1}. Given the differing estimates of sediment transport rate entering the Minas Passage area, it is recommended that a more precise value be obtained to determine the net flux of suspended material, including characterization of the grain size moving through the area. Based on the limited number of TISEC devices presumed under the baseline report, it is considered unlikely that sediment transport will affect the units. However, sediment transport may have an effect on both the turbines and overall sediment dynamics of the Minas Basin if a large volume of sediment transport through the Minas Passage is disrupted or altered in some manner.

Specific Comments

Section 4.6.2.1 – Species Distribution

It is unclear what qualitative terms such as “mean low water”, “high flow”, “high percent cover”, and “shallowest birth” are referenced to or what the descriptors are attempting to qualify. For example, it is unclear if “high percent cover” is referring to 40% or 80% cover. Including quantitative values, where possible, in place of such qualitative terms, would be helpful.

Appendix H – Page 3

Bedform dynamics in the Minas Passage are not static, as seen in multi-beam data from 2008-2012 (G. Fader, pers. comm). It is recommended that a reference to the multi-beam study, including a description/analysis, be provided in the baseline report. If bedforms are changing, discussion on the time scale and whether this could be altered by deployment of TISEC devices should be included in the report.

Appendix H – Figure 5

One of the unique features of suspended particulate matter (SPM) in the upper Bay of Fundy is an order of magnitude difference in SPM that is observed throughout the year. While this difference is evident in Figure 5 in Appendix H, there is no reference to it in the text. It should be clarified whether TISEC devices could have an effect by changing local SPM dynamics.

Appendix H – Section 1.6

A reference in support of the following statement found in the report should be included: “the Minas Basin is characterized by a maximum tidal range of 13 m and currents that exceed 2 m/s 50% of the time, peaking at >6 m/s”.

FORCE Environmental Effects Monitoring Program (2015-2020)

Lobster

General Comments

The methodology for proposed monitoring studies on catchability of lobsters in commercial traps in and around the FORCE demonstration site describes a robust, balanced design based on recommendations of Bayley (2010), which should be sufficient for detecting changes in catch rate of lobster in standard traps. The proposed study, however, will likely be unable to discern as to whether any change in catch rate is due to change in lobster abundance or a change in lobster behavior. Non-trap methods for evaluating lobster abundance may be necessary to account for variability in lobster behavior as noted in DFO (2012). The challenging environment of the Minas Basin, however, may limit/prevent use of other lobster sampling methods, such as trawling, underwater cameras, and divers. Continued monitoring of lobster movement using tracking studies is necessary to determine if the installation of turbines has any long term impact on lobster movement/behavior in the area.

Specific Comments

No specific comments provided.

Fish

General Comments

The proposed EEMP acknowledges that hydro-acoustics have limited ability to differentiate between fish species. The proposed monitoring is therefore unlikely to provide information regarding species- specific risks, particularly for fish species of relative low density (when compared to pelagic, schooling clupeoids and Scombrids, for example) either naturally or for conservation reasons (e.g., species designated as at-risk). As proposed, the EEMP will not account for the likelihood of interaction between the four species of interest in the baseline report (i.e., Atlantic Sturgeon, Stripped Bass, adult American Eel, and inner Bay of Fundy Atlantic Salmon [smolts]) and any deployed TISEC devices. All four species exhibited extensive use of the water column in the Minas Passage, including at the FORCE demonstration site. Further, the proposed EEMP acknowledges that hydro-acoustics have limited ability to detect fish near boundaries such as the sea surface, sea floor, or in the immediate near-field (<10 m) environment of a TISEC device. The risk of encounter between fish and TISEC devices, either near the surface or the sea floor areas of the water column, will therefore remain difficult to characterize.

The proposed plan contains no provision for monitoring, either hydro-acoustically or acoustically, the presence of fish in the FORCE demonstration site during the winter months, despite the baseline results of 2010-2013 indicating that the Minas Passage represents important wintering habitat for adult-sized Striped Bass (a species of interest). The co-wintering of juvenile and adult Striped Bass in other known wintering areas indicated that use of the Minas Passage as a wintering habitat may extend to a broader age distribution than has been documented in the baseline report to date.

The Melvin and Cochrane (2014) dataset is considered inadequate to serve as a pre-deployment baseline for most studies pertaining to the potential effects of TISEC devices at the demonstration site. The surveys were limited to a total sampling period of one year. Individual surveys were conducted at irregular intervals with, at most, two tidal cycles monitored during a survey. The surveys do not establish the characteristic inter-annual variability of either fish abundances or spatial distributions. Thus, comparisons of the baseline data with post-turbine surveys are precluded.

Day-to-day variances in fish distributions and abundances remain unknown. Short term temporal fluctuations in fish abundance were either not sampled or under-sampled due to the short term nature of the baseline surveys. The most conclusive results from the pre-turbine surveys occurred only after application of high degrees of spatial-temporal averaging. Any future attempt to extract information from the same re-deployment data sets at higher temporal-spatial resolutions is unlikely to provide meaningful results due to the short durations of relevant sampling. Since post-TISEC deployment surveys will be of similar duration and spatial coverage as the original Melvin and Cochrane (2014) surveys, it is anticipated that new datasets will have the same limitations as the original baseline data sets.

Specific Comments

Section 3.3 – Studies Completed To Date

Melvin et al. (2009) should be cited in this section of the proposed EEMP. Melvin et al. (2009) presented evidence of the Minas Passage bubble plumes being related to tide rips excited by Black Rock, as well as evidence of little acoustic attenuation for acoustic backscatter sampling traversing such plumes.

Page 3.5: The proposed EEMP indicates that signal attenuation from entrained air can be addressed by eliminating portions of the upper water column from analysis. In contrast, Melvin et al. (2009) indicated that bubble plume anomalous acoustic absorption was minimal in the Minas Passage.

Section 3.4 – Monitored Variables: Fish Density

In regard to the statement “or averaging fish tracks per sampled volume,” the proposed method may work for counting fish passing through the plane of a continuous multi-beam fan, especially if the fan beams are motion stabilized. However, it constitutes a less accurate methodology for single beam systems where the beam boundaries taper gradually in a manner that it is difficult to define whether a fish track lies ‘in’ or ‘out’ of the beam.

Page 3.6: When inter-annual and day-to-day variability are unknown, any “before” and “after” effects in the vicinity of deployed TISEC devices would have to be substantial, and spatially extensive, before they would become evident in a Melvin and Cochrane (2014) type survey. Utilizing the X and Y transects to “control” for the inter-annual variability, as discussed in Section 3.5.5 of the proposed plan, is considered inadequate since fish abundance mid-channel may not be well correlated with fish abundance in the north end intensive parallel grid where the TISEC devices are initially to be deployed.

Mid-water distribution of fish will be difficult to assess given the presence of bubble clouds that are dependent on tidal phase and local wind conditions. Operational TISEC devices will also produce acoustically-visible, spatially-extended downstream wakes. Limited field observations following an initial turbine deployment revealed acoustic wakes arising from turbine enclosure. Wakes arising from operational turbines would presumably be more intense.

The Probability Encounter Model as presented, specifically the formula $p=p_1*p_2$, is unclear and should be clarified in the proposed plan. Probability of a fish encountering a turbine (p) is the probability of a fish being in the depth range when the turbine is operational (p_2). Thus, the p_1 covariate appears irrelevant.

Section 3.5.3

The proposed plan suggests "sampling during the same months on neap tides, as was done by Melvin and Cochrane (2014)." Periods of lowest tidal range were not always selected by Melvin and Cochrane (2014), although the highest tidal ranges were avoided. Weather, boat availability, and the occurrence of high tide in the early morning, to enable convenient departure for single tidal cycle surveys, were more critical factors influencing survey times.

In regard to the statement "surveying should be limited to calm days when wind is less than 10 knots when possible for safety and to maximize data quality," low winds are important to maximize acoustic data quality in the Minas Passage. Melvin and Cochrane (2014) encountered ideal conditions on a number of occasions; however, such conditions are exceptional for the Minas Passage where ideal weather windows can be of short duration and difficult to exploit if the survey vessel is not based locally and readily available.

Section 3.5.5

The Melvin and Cochrane (2014) survey was intended to serve as a pre-TISEC reference dataset, to which post-TISEC deployment survey results would be compared. Attempting to closely match past survey dates along with tidal height and phase, while waiting for acceptable wind conditions, will likely be difficult to achieve. Some of these difficulties are acknowledged in Section 3.6.1 of the proposed plan. It is anticipated that any future results would likely be inconclusive given the challenges involved in this type of study/survey.

Section 3.6

The Fundy Advanced Sensor Technology (FAST) platform could serve as a potential long-term platform for an upward looking split-beam echo-sounder. A bottom-mounted sounder, however, would provide a long, non-temporally aliased, statistically robust time series from which seasonal, tidal, and diel effects on fish abundance could be analyzed. A primary concern would be the need for several simultaneous stations if spatial variability is to be discerned.

Marine Mammals

General Comments

Baseline studies that have been conducted indicated that Harbour Porpoise frequent the area throughout the year, with seasonal trends in occurrence being observed (e.g., acoustic data indicates peaks in click presence in the spring and fall). Based on visual survey data, at times of peak sightings up to 42 individuals were estimated to be present in the area during one tidal cycle. Sighting rates were higher at the FORCE demonstration site than at other nearby areas in the Minas Passage. Other species of marine mammals (e.g., Grey Seal, Harbour Seal, White-sided Dolphin, and larger whales) were only occasionally sighted in the area, and thus not enough data exists to monitor potential impacts on these less common species. While the baseline studies have provided some valuable information on marine mammals occurrence in the area, data gaps in the baseline dataset (e.g., gaps in seasonal coverage and knowledge of inter-annual variability), and their impact on the ability to monitor and measure potential changes as a result of TISEC device installation, is not thoroughly addressed in the proposed monitoring plan.

The proposed plan focuses on the assessment of mid-field effects (i.e., detecting changes in Harbour Porpoise use in the mid-field area); however, it is noted in the baseline report that ability to detect these effects will be extremely low. This is one of the major limitations of the marine mammal monitoring being proposed for 2015-2020.

Although the cause of death is often difficult to determine, the proposed carcass monitoring program, which is directed at monitoring near-field effects, is the only proposed activity for monitoring collisions with TISEC devices. Examining marine mammal carcasses, particularly of Threatened and Endangered species, is a priority for the Marine Animal Response Society (MARS), although it is not clear why this program is only highlighted for the first three years of the proposed monitoring plan. As this is the only monitoring element being proposed to detect collision events, carcass monitoring should be conducted throughout the entire monitoring period (i.e,, 2015-2020). In addition to Threatened and Endangered species, monitoring for Harbour Porpoise carcasses could provide information on Harbour Porpoise collisions with TISEC devices, and should also be considered as a priority in the proposed plan, in order to increase understanding of the potential near-field effects of TISEC devices on Harbour Porpoise, which currently remains a knowledge gap.

The proposed passive acoustic monitoring program appears reasonable for detecting mid-field changes in Harbour Porpoise presence/echolocation behaviour in spring and fall. For a more complete monitoring program, deployments during summer and winter, which would provide year-round information on Harbour Porpoise occurrence post-TISEC device installation, should also be considered.

It is unclear how noise generated by the TISEC devices will impact Harbour Porpoise click detection by the C-PODs deployed at the TISEC device berths to study near-field impacts. This requires further consideration/clarification in the proposed monitoring plan.

Table 4-5 provides suggestions of other studies that could be pursued to increase baseline understanding of Harbour Porpoise use of the area, as well as increase ability to study near-field interactions. Further discussion of these studies, including their value for monitoring impacts and priority for monitoring particular impacts, would be informative.

Specific Comments

No specific comments provided.

Physical Oceanography

General Comments

Apart from typographical errors that should be corrected, there are no concerns with the content of this section of the report.

Specific Comments

No specific comments provided.

Acoustic Modelling

General Comments

Despite a lack of detailed specifics and associated time frames, the principal components of the program can be identified. In the form provided, the proposed monitoring plan is considered well designed to detect potential acoustic effects on valued ecosystem components arising from TISEC devices to be deployed in the Bay of Fundy.

According to Section 6.5, the procedural objective is to construct a comprehensive acoustic model from which the acoustic exposure of any species can be computed as a function of geographic location, time, and spatial distribution of (multiple) turbines. However, Section 6.4 qualifies model development as “resources permitting”, which suggests this objective may not be achieved within the contextual or time frame of the monitoring plan as currently proposed. Any modelling component must be evolutionary and open-ended to accommodate a changing physical tidal power infrastructure as it develops. The central focus of the proposed monitoring plan is to provide the basic parameterization for such a model. Thus, a more comprehensive study of baseline ambient noise, building upon the preliminary results and experimental methods treated in the baseline report (2011-2013), is required.

Specific Comments

Section 6.1

The report states “for the purposes of this EEMP, we assume that each device source noise profile will be collected by the developer early in the development and the data will be shared with FORCE.” It is unclear if the collection of the “noise profile” is part of the anticipated studies using the bottom streamlined hydrophones and the small FAST platform outlined in Sections 6.2 and 6.4 of the proposed monitoring plan. The potential collection of turbine-specific noise profiles from similar turbine deployments elsewhere should be given consideration. These profiles would be collected by the turbine developer for use by FORCE in the Minas Passage.

FORCE turbine berths are close together, in some cases less than 500 m apart, with the potential for more than one turbine simultaneously being present in any one berth. It should be clarified whether closely spaced turbines operating simultaneously would present an interference problem when attempting to acoustically-characterize individual turbine profiles.

Marine Benthos

General Comments

An objective of the proposed monitoring plan, with respect to marine benthos, is to identify changes in occurrence, relative abundance, and habitat of benthic species in each of the TISEC device berths relative to reference or baseline conditions; however, a full set of baseline conditions have not yet been obtained. It is recommended a baseline survey be conducted, including a detailed report similar to the baseline report previously completed from 2011-2013. It is further recommended that analysis be completed using similar protocols as documented in the baseline report, to ensure baseline conditions from each berth and cable lay down area remain comparable.

The proposed monitoring plan indicates that any changes to seafloor conditions will remain within natural variability; however, based on data collected to date, including the lack of information for Berth Site D and its cable lay down area, there is no temporal data from replicate stations to determine natural variability of marine benthos. If possible, it is recommended that a second baseline survey be considered prior to emplacement of TISEC devices, at a number of stations, to further quantify natural variability.

The proposed monitoring plan suggests two approaches to monitor marine benthos at the broader FORCE demonstration, as well as specific berth sites. It is suggested the proposed monitoring plan clearly indicate which approach is to be used to collect and analyze data sets that will be used to detect potential changes in the marine benthic environment at these locations.

The marine benthos section of the proposed monitoring plan does not contain information regarding invasive species. Scientists in DFO Science, located at the Bedford Institute of Oceanography, Nova Scotia, are mapping aerial distribution of the invasive species *Didemnum Vexillum* (Carpet Sea Squirt) in the upper Bay of Fundy, including Scott’s Bay, Parrsboro, and the Minas Basin. It is therefore recommended that the proposed EEMP include consideration of the potential spread of invasive species through TISEC deployment, including mitigation, monitoring, and/or planning.

Specific Comments

Section 7.0 – Pages 1-8

Descriptors, such as high energy and highly turbid, should be clearly defined and quantified where possible. For example, in the baseline report turbidity (SPM) concentrations ranged from 2-20 mg L^{-1}. This is unlikely to be considered highly turbid, when compared to Cobequid Bay or the Petitcodiac River, which exhibit concentrations of 1000 mg L^{-1} and 10,000 mg L^{-1}, respectively.

Section 7.6.1 – Adaptive Management

The proposed monitoring plan states "Hydrodynamic modelling, as recommended in the Physical Oceanography EEMP, is proposed as a means to understand the likely effects of progressive energy extraction as more turbines are installed." With only a limited number of TISEC devices being assessed at this stage of development, hydrodynamic modelling could be used to better understand energy extraction; however, as additional turbines are installed a fully coupled sediment-hydrodynamic model that has been validated based on observations is recommended.

Cape Sharp Tidal TISEC-specific Environmental Effects Monitoring Program

Fish

General Comments

The TISEC-specific EEMP focuses on near-field effects and identifies "test(ing) the effectiveness of mitigative measure' as a partial objective; however, no mitigative measures are identified or described in the plan.

While the proposal reasonably adopts an adaptive management approach "to evaluate data and make informed, science-based decisions to modify monitoring and assess mitigation as necessary", with a focus on important ecosystem components, it is not clear the sonar monitoring technology proposed for deployment will be able to identify fish species (particularly those designated as at-risk or otherwise) even in the near-field. The use of a multi-beam sonar mounted on the turbine superstructure, to image discrete fish targets and to track fish trajectories should be regarded as exploratory. The Tritech Gemini 720i is a two-dimensional (2D) multi-beam sonar and, therefore, is inherently incapable of defining general fish trajectories in three-dimensional (3D) space. At most, a fish target's movement within a 2D beam fan might be inferred. Under optimum circumstances, and with attention to fan orientation, fish targets passing through a portion of the turbine aperture might be counted. While small fish targets might be separable from large targets, it is considered unlikely that fish will be imaged with sufficient spatial resolution to permit species identification. Nevertheless, the Tritech sonar does have the near-field focusing capabilities and pulse repetition rates required to make it a candidate for the detection of individual fish targets at high flow rates. Any experimental assessment of its performance for this task would be quite valuable

Melvin and Cochrane (2014) discussed use of multi-beam technologies to observe fish trajectories approaching a turbine. Delineating fish avoidance behaviours by examining fish trajectories alone (unless an estimate of fish volume density can also be derived) would be difficult as fish will travel along curved streamlines around the flow resistant turbine structure, even in the absence of their active turbine avoidance. Using sonar to monitor fish bulk volume backscattering strength in the water column at multiple ranges in front of the turbine might be easier to interpret since active turbine avoidance behaviours would involve some degree of desertion of the water column (i.e., lower fish volume densities) as a parcel of water approaches the turbine. Lower fish densities mean lower volume backscattering strengths, which an appropriate sonar technology could potentially measure. Unfortunately, multi-beam sonars designed primarily for engineering visualization and inspection usually lack the exacting quantitative controls required to obtain high precision estimates of volume backscattering strength. Scientific split-beam sounders do have the required quantitative ability, but usually possess comparatively narrow beam geometries that make their use problematic when mounted proximate to an in-stream tidal turbine. While, sonar measurements of volume backscattering strength may be the best theoretical approach, the hardware to readily achieve this is currently lacking.

Specific Comments

No specific comments provided.

Marine Mammals

General Comments

Little detail on the technologies or their configurations/settings being used is provided within the report. For example, without knowledge of the sampling rates used and the duty cycle/ sampling schedule to be implemented, the appropriateness of using the icListen for detecting Harbour Porpoise clicks and the vocalizations of other marine mammal species of interest, which produce vocalizations in different frequency bands, cannot be evaluated. Information regarding the frequency range the icListen will be recording, the recording or sampling schedule, type of data stored, and spectrum setting being used should be included. Without such information, it is difficult to evaluate the effectiveness or likelihood of success of the proposed EEMP. A more detailed EEMP is required to fully understand what is being proposed, how the data collection and analysis will be conducted, and how results will be compared to the baseline data.

A definition of near-field should be included within the report. In addition, the detection range of the sensor system being used for each type of vocalization/species being monitored should be indicated.

The TISEC units will produce underwater noise in the near-field that will impact the detection range of the icListen hydrophones and quality of the spectrum data collected; however, the report does not address how increased underwater noise levels generated by the turbines will impact the ability of the icLIsten to detect vocalizations of the different species of interest, whether the impact of noise on the detection range of the icListen will be tested, or how the differing noise generated during the different flow regimes will be accounted for when analyzing the data.

Additional information regarding the marine mammal detectors being used would be informative. For example, which detector parameters are being used, and how will their accuracy measured/verified for each species.

C-PODS, which are used to collect baseline data, and icListens have different detections ranges. It is unclear how the data collected from icListens will be compared to the baseline data collected by C-PODs.

Determining marine mammal tracks via passive acoustics typically requires comparison of click arrival times across multiple time-synchronized sensors. The report should clarify how marine mammal track trajectories will be determined from the data collected.

Harbor porpoise, which are sensitive to underwater noise, are often deterred from areas by devices producing underwater sounds. As such, the frequency range of the sounds produced by the sonar system, as well as studies that describe harbor porpoise reactions to these sonar systems should be referenced within the report. In addition, studies that demonstrate the effectiveness of the active sonar system being used for the detection of harbor porpoises should also be included.

Specific Comments

No specific comments provided.

Acoustic Modelling

General Comments

The TISEC-specific EEM report is brief. The report indicates that two turbines will be deployed; however, it is unclear whether one or both turbines will be monitored. Two operating turbines in simultaneous operation, and in close physical proximity of each other, would compromise characterization of a single unit.

It should be clarified in the plan whether the more distant station constitutes a component of the FORCE far field monitoring program or would be the responsibility of Cape Sharp Tidal to monitor.

The acoustic noise field of an in-stream tidal turbine cannot be fully characterized through monitoring at 100m and 2000m ranges only. Regardless of whether the turbine aperture constitutes a coherent or largely incoherent acoustic radiating area, it does not constitute a point radiating source when extrapolating noise fields to ranges of less than several turbine diameters from the source. Therefore, extrapolation of acoustic noise levels measured at 100m inwards to the turbine surface would require acoustic modelling best informed by additional closer range experimental measures. Nevertheless, reliable acoustic measurements at the two observation distances, performed over a wide frequency range, would yield valuable calibration or verification points for any acoustic model that may be developed as part of the proposed FORCE monitoring plan (2015-2020) for acoustic noise. While the techniques for measurement and for model spatial extrapolation of acoustic noise levels in high flow environments are still evolving, sparse noise measurements, if performed reliably and properly interpreted, may provide an indication as to whether turbine-generated noise is likely to constitute a significant problem for future development, and perhaps allow an estimate of the scale of development at which such problems would become severe. Properly parameterized acoustic models would be useful in this context.

Acoustic models are not included in the TISEC-specific monitoring plan, only appearing as an option in the proposed FORCE monitoring plan (2015-2020). If models are not developed, careful scrutiny of the initial noise measurements and their implications, is otherwise required.

Specific Comments

No specific comments provided.

Conclusions

Baseline monitoring outlined in the FORCE baseline report (2011-2013) is considered insufficient to provide a thorough baseline understanding of the marine environment of the Minas Passage, as well as the FORCE demonstration site. Collection of additional baseline information will provide a more complete understanding of the natural variability pertaining to fish assemblages and their use of the area, marine mammal use of the area, characterization of ambient background noise in the absence of TISEC devices, and marine benthos. In absence of more extensive data collection, it is difficult to assess the robustness of trends over time, which limits the ability to evaluate potential impacts of operational TISEC devices on marine components.

Data gaps in the FORCE baseline report (2011-2013), and the impact of these gaps on the ability to monitor and measure potential changes resulting from the installation of TISEC devices, are not adequately reconciled in FORCE's proposed EEMP (2015-2020). Further, the EEMP would benefit from consideration of the potential 'scale-up' of TISEC device installation over the next five to ten years. A significant limitation of the proposed EEMP is that it does not sufficiently address the risk of interaction between fish and marine mammals with TISEC devices and is unlikely to result in the detection of both mid- and far-field effects of TISEC devices on fish and marine mammals. Further, evaluation of post-TISEC deployment effects on fish, as compared to pre-turbine deployment data of Melvin and Cochrane (2014), appears unlikely to produce robust conclusions regarding potential impacts, unless the effects of deployed TISEC devices are both extreme and spatially extensive.

The level of detail provided in the proposed Cape Sharp Tidal TISEC-specific EEMP is limited. There is little detail on the technologies and the configurations/settings being used, no mitigative measures are identified or described, and it is not clear whether the sonar monitoring technology proposed for deployment will be able to identify fish species. A more detailed EEMP is required to thoroughly understand the proposed methods, data collection, analysis, and how the results will be compared to the baseline data. Without such information, it is difficult to evaluate the effectiveness or likelihood of success of the proposed EEMP.

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