APPROPRIATENESS OF EXISTING MONITORING STUDIES FOR THE FUNDY TIDAL ENERGY PROJECT AND CONSIDERATIONS FOR MONITORING COMMERCIAL SCALE SCENARIOS

Context

The Fundy Ocean Research Centre for Energy (FORCE) Tidal Energy Project, located near Black Rock in the Minas Passage of the Bay of Fundy, Nova Scotia, is a research and development demonstration site dedicated to testing tidal power technologies, in particular Tidal In-stream Energy Conversion (TISEC) devices. The project consists of four undersea berths for four TISEC subsea turbine generators, subsea cables, and associated land-based infrastructure. The project was assessed under a harmonised provincial and federal Environmental Assessment (EA) process. As a commitment made during the environmental assessment and as a condition of the provincial environmental assessment approval, the proponent, FORCE, was required to develop and implement an Environmental Effects Monitoring (EEM) program for the project. Additional monitoring by a berth holder, Open Hydro / Nova Scotia Power Inc., was required as a condition of authorisations under s.32 and s.35(2) of the *Fisheries Act* issued by Fisheries and Oceans Canada (DFO). The purpose of the EEM program was to verify the effectiveness of any mitigation measures implemented by the proponent, the accuracy of the EA predictions, and compliance with conditions of provincial and federal permits and authorisations. To fulfill the reporting requirements for the EEM program from the commencement of the project in late September 2009 to January 2011, FORCE prepared a monitoring report that provides the results of the EEM program including details of the various monitoring surveys (FORCE 2011). The report covers the period during which the Open Hydro / Nova Scotia Power Inc. TISEC device was present at the site (i.e., November 12, 2009, to December 13, 2010). The device, however, was only verified in normal operation for a few weeks (i.e., November 12, 2009 to December 4, 2009). DFO's Ecosystem Management Branch, Maritimes Region, is now reviewing FORCE's EEM Report and has asked DFO Science to contribute to this review.

DFO's Special Science Response Process was used to review the monitoring studies within the FORCE EEM report and provide input that may improve such monitoring studies in the future, as well as help inform EEM programs for monitoring future commercial-scale tidal energy projects. The specific questions from DFO Ecosystem Management Branch, Maritimes Region, to DFO Science were:

- For each of the monitoring studies, are the sampling procedures, equipment, techniques, frequencies, and analyses appropriate? Can changes be made to any monitoring component that would improve the monitoring plan?
- Are there any missing monitoring studies, sampling procedures, frequencies, or analyses that should be incorporated into the monitoring plan?
- In consideration of a commercial scale scenario (i.e., tidal power device arrays) and the potential environmental effects, are there any other monitoring studies, sampling procedures, frequencies, or analyses that should be incorporated into the monitoring plan?

This Science Response Report results from the Science Special Response Process of March 2012 on the Review of a Fundy Tidal Energy Project Environmental Effects Monitoring Report.

The conclusions of this Science Response Report are that the FORCE EEM program contains a broad range of surveys to collect data and enhance the knowledge of baseline conditions for the ecosystem. However, the EEM report only includes the results of those studies carried out in 2010. Submission of the 2011 monitoring activities and results would enable a more thorough review of the monitoring program to date. One gap in the EEM program is the lack of monitoring studies in the vicinity of the turbine, particularly related to fish behaviour.

For future considerations of commercial scale scenarios, it is recommended that DFO maintain its adaptive management approach to assessing and mitigating the potential impacts of TISEC devices. It is important to note that the monitoring program has not yet effectively monitored for environmental effects of an operational TISEC device as the device was only verified in normal operation for a few weeks (i.e., November 12, 2009 to December 16, 2009). Until such a monitoring program is underway and operational, it is difficult to provide further science advice on improving monitoring surveys to identify and mitigate potential environmental effects.

Background

The FORCE EEM program collected information related to the potential impacts of TISEC devices, background environmental data for the Minas Passage, and provided the proponent an opportunity to test a variety of monitoring approaches and technologies in the challenging Minas Passage environment. An adaptive approach has been used to implement the EEM program, that is, one that reviews activities and outcomes continuously and modifies approaches and methodologies periodically on the basis of accumulated experience and observed progress toward achieving the monitoring objectives. To assist with this approach, FORCE, as a condition of the federal and provincial approvals, has established an Environmental Monitoring Advisory Committee (EMAC), to provide independent expert scientific and traditional ecological knowledge advice on the EEM program. The monitoring report has been reviewed by EMAC and recommendations have been made to FORCE.

DFO Maritimes Science Branch has participated in numerous regional and national workshops and meetings, led the preparation of CSAS Reports (DFO 2008, DFO 2009), and carried out research activities related to identifying, assessing, and monitoring potential impacts of tidal turbines, as well as improving the understanding of baseline environmental conditions in Minas Passage.

Analysis and Response

Appropriateness of Completed Monitoring Studies

The monitoring report covers a wide range of surveys based on an adaptive management approach to monitor key valued ecosystem components of the Bay of Fundy. The report, however, only includes the results of those studies carried out in 2010, but not those in 2011. For Science to evaluate the effectiveness of monitoring protocols, comment on data analyses, and provide advice on the overall appropriateness of the monitoring program, the complete monitoring datasets should be available, including the 2011 monitoring results. According to the FORCE response to the EMAC's recommendations, monitoring studies were planned for 2011 (e.g., fish

tracking, marine mammal survey, noise baselines), but it is not known whether these studies were completed.

It is recommended that DFO Maritimes Science receive a report of the 2011 monitoring activities and results in order to provide a more thorough review of the monitoring program.

Review of Specific Monitoring Studies

The details of the various monitoring studies that comprised the EEM program were contained in the Appendices of the report. Comments were provided on select studies as described below.

Appendices A to D, F, and G

No Science review was provided for these reports.

Appendix E: Lobster Surveys Final Report

The following points are related to the revised survey design (i.e., BACI design) as noted in the report and are meant to help improve future lobster surveys:

- It was not clear in the report the number of replicate samples to be collected in the vicinity of the turbines. It is recommended that more than one replicate, at the level of the turbine, be collected to improve the robustness of the survey results.
- The design of the monitoring program should allow us to understand the effect while the turbines are in operation. It is not clear whether this design will meet this need.
- Catch rates in term of Kg/trap hauled should also be evaluated in addition to number of lobster caught.
- Monitoring activities should be conducted during the out-of-fishing-season.

It is not clear how the revised monitoring program will be implemented. The monitoring design suggested by Bayley seems adequate, but the report didn't provide sufficient details on how the proposed design changes differ from Bayley's suggestions.

There are additional sampling methodologies that could improve the lobster monitoring program such as: (i) undertake commercial sea sampling monitoring as well in June, July, and November; (ii) implement the standardized FSRS trap program that would better indicate potential impact on sublegal lobsters: (iii) assessing lobster settlement rates via the use of passive collectors; and (iv) tagging survey to determine lobster movement around turbines.

Appendix H: Fish Surveys 2010 – Final Report

An acoustic and trawl survey conducted in 2010 provides relatively good coverage of fish distribution in Minas Passage during the field season. Although the data collection methods are appropriate and the data collected appear valid, the analytical procedures used to estimate biomass (or fish number) are difficult to follow, do not follow standard procedures, and likely are in error. The trawl data also are limited to primarily the upper 20 meters or so with few samples of fish from the lower half of the water column, where most of the turbine structure would be located. Furthermore, there appears to be several analytical errors and unrealistic assumptions that, when applied to the data, could produce reported biomass estimates in excess of 20 times less than expected. A proper re-analysis of the data would resolve the confusion and uncertainty associated with biomass.

A number of more specific comments on this section follow. The section in the report on the conversion of acoustic backscatter is difficult to follow. Usually, all acoustic transect data are used to estimate mean backscatter. In this report, however, a 10% extract (subsample) was used. In general, most target strength equations are based on total length, especially for pelagic species. However, this report used fork length measurements, and there is very little information on the length frequency distribution of fish captured. It was not clear how the backscatter was apportioned into the contribution by each species. Target strength equations are typically for the signal return from a single fish and produce an estimate of number of fish. Mean weight is then used to estimate biomass/density in kilograms. Mean weight or weight/length relationships are not presented in this report. The target strength equations that appear to have been used for herring may be incorrect. Depending upon fish length, the target strength could be off as much as 8-10 dB, and a doubling occurs for every 3 dB. This means that biomass/densities may be underestimated. The report does not provide sufficient detail to repeat any of the analyses.

Appendix I: FORCE Progress Report 2011 – Fish Tracking

The 2010 tracking information generally supports the concept of acoustic tracking platforms as useful tools to help monitor the temporal and spatial distribution of fish both within the vicinity of TISEC devices and the Minas Channel. However, neither detailed comment concerning fish behaviour around the devices (e.g., whether they can avoid the structures) nor inference concerning the likelihood of direct encounters of fish with the devices are possible from the information contained in the report in light of the brief period that the single installed test device was verified to be operational during 2010.

It also should be taken into account that the cumulative experience to date from acoustic fish tracking projects in the Minas Basin-Channel area indicate that gear attrition – specifically loss or damage of hydrophones – will be an ongoing issue and therefore should be factored into the financing and operations of future projects.

Appendix J: Side Scan Sonar Survey Final Monitoring Report

The report provides a detailed description of the seabed, which uses appropriate methods and analyses. The study would be more comprehensive with additional video or still imagery of the seabed. There is a reference to the need for quality images at the end of the document and possibly a move to remotely operated vehicles (ROVs). However, these additions to the survey methodology ultimately would increase cost and would require operation within a narrow time window due to strong tidal currents in the project area.

Appendix K: Final Report – Suspended Sediment Monitoring, July 2010

FORCE has done a relatively good job of monitoring near field suspended particulate matter (SPM) conditions, confirming the seasonal cycle suggested by MERIS satellite estimates of maximum surface concentrations in winter and minimum concentrations in summer. They have used the surface measurements of SPM (bucket samples) to represent those of the entire water column, based on the strong vertical mixing due to tidally-induced turbulence. This is a reasonable approach.

There has been no effort to study the "far-field" SPM profiles in Minas Basin, which show a similar seasonal variation at the surface, but the concentration varies with depth because the currents and turbulence are weaker. More studies should be conducted to quantify the SPM variations in the far field, especially looking at extremes associated with the seasonal cycle and the spring-neap cycle of the tide itself.

Missing Monitoring Studies

The FORCE EEM program does not include any monitoring studies to assess the direct interaction between turbines and marine life. This is largely because the methodologies used to monitor biological components in the immediate vicinity (particularly meters to tens of meters) of turbines in high flow environments are limited and evolving. More effort needs to be directed towards gathering monitoring data directly around the turbine. For example, either a vessel-mounted system or, preferably, an instrumented monitoring platform mounted on the turbine enclosure or near the turbine base could be used.

Another factor that has limited the ability of the EEM program to identify environmental effects associated with TISEC devices is the fact that there has only been a single turbine deployed at the site and it was in operation for approximately three weeks as a result of structural damage. In order to properly assess the environmental effects off such devices, several devices will need to be deployed, remain operational, and monitored over a greater period of time.

The monitoring report suggests that there were no known occurrences of fish mortality due to the turbine operation, but the data in support of this statement are weak at best. As stated above, there has been very limited monitoring of fish in the vicinity of the turbine, the turbine was only in verified operation for a few weeks, and the turbine blades (i.e., the components of the turbine that would inflict damage to fish) were damaged and ejected from the turbine at an unknown time(s) during its deployment. In addition, when the turbine was operational (i.e., Nov – Dec 2010), the annual cycle of fish biomass in the Minas Basin was at a low point, particularly for diadromous species. However, fish were detected in the area during the acoustic surveys over the winter months.

In addition to monitoring in the vicinity of the turbine, it would be useful to have as comprehensive as possible baseline of the ecosystem including fish assemblages and their usage of various habitat types, particularly outside the pilot project area. This would enable a more accurate prediction and assessment of basin-wide impacts on biological features of the ecosystem. Opportunities to augment existing or on-going monitoring programs so that they can become informative in the context of effects monitoring for TISEC related activities should be explored.

One option to gather more biological data in the general area is to monitor the bycatch in the nearby fishing weirs. The types of data that could be collected from bycatch monitoring include species type, relative abundance, as well as length, weight, maturity, etc., of individuals. It also is recommended that the monitoring of fish should occur year round. The EMAC recommended fish monitoring until November, but such monitoring still doesn't cover the full temporal scale of the project.

Future Considerations of a Commercial Scale Scenario

There have been many regional and national meetings and workshops on the potential impacts of tidal power generation using TISEC devices in a coastal setting. A set of common potential impacts has been identified during these fora, including impacts to fish, impacts to sediment dynamics, noise, etc. However, there has been little evidence to date that suggests that these concerns ever have been or actually can be effectively addressed through established monitoring programs and protocols. That is, there have been no monitoring data yet collected that clearly show the impact, or lack thereof, of an operational TISEC device or array of devices. In light of the gap of monitoring data for functional TISEC devices, DFO Science would recommend that the

Department maintain its adaptive management approach to assessing the impacts of tidal power generation in the Minas Passage.

It is suggested that any environmental effects monitoring program should be developed based on the location of the site (i.e., site specific), since the ecosystem characteristics (i.e., biological, physical, chemical, and geologic properties) will vary depending on geographic location. Furthermore, it is also important to know potential placement locations of future TISEC devices since the geographic location will affect the risk of negative impact on ecosystem characteristics such as sensitive habitat, migration routes, nursery areas, etc. For example, there is a significant herring spawning bed near Scots Bay that could be impacted by commercial arrays of TISEC devices in the Minas Basin or Channel area.

An array of TISEC devices likely would generate increased turbulence and high levels of noise that could exceed natural ambient levels sufficiently to impact fish and/or marine mammal movements possibly leading to attraction to the array (increasing risk of turbine strikes), avoidance of the array, and/or at a worst case scenario, deter the migrations of fish into the Minas Basin. In the document detailing FORCE's response to EMAC recommendations, FORCE stated that a request for proposals would be issued in April 2011 to develop a baseline for noise in the area. It is important to make accurate measurements prior to the installation of TISEC devices to determine ambient noise levels; thus, this baseline would support the risk assessment of noise generation from a commercial array.

This potential for increased turbulence and noise in the localized area, and possibly in the far-field, may impact settlement rates for species including lobsters. It is possible to determine and monitor settlement rates for lobsters using passive collectors, which consist of a modified lobster cage filled with suitable substrate for settlement (usually cobble rocks). These collectors have been used by government and academic researchers for the past few years.

In a commercial array scenario, it is proposed that the monitoring of seabed characteristics should take place in the far-field (i.e., distances exceeding five kilometres such as in the upper Bay of Fundy) as well as in the near field. Sediment concentration as well as deposition and erosion of the seabed should be monitored in areas (such as a large, muddy tidal flat / channel complex in the upper Bay of Fundy) where currents could be reduced or accelerated due to changing flow patterns possibly caused by multiple (i.e., greater than five to ten) TISEC devices.

Assessing the various potential risks of a commercial scale array should start with employing the numerical models that have been under development and refinement over the past few years for the area. The hydrodynamic models are well validated for the area, and associated sediment transport models are being developed. To improve prediction of potential impacts, it is critical to continue testing and ground-truthing the model outputs throughout the scale-up approach to a commercial array.

One aspect of ground-truthing is monitoring the change in the tides in the area. However, the far field baseline tidal response (the existing tidal response in the upper Minas Basin) is not particularly well known. The presence of a small number of TISEC devices in the Minus Channel likely will not have any kind of measurable effect on this base physical environmental parameter. However, with commercialisation and installation of large numbers of devices, it is possible there would be a measurable effect. Thus, prior to commercialisation, establishment of quality baseline data for water levels in the area is required. Continued monitoring throughout and following commercialisation would serve to verify model predictions and quantify change beyond natural variation. Presently the only permanent DFO tidal gauge in the Bay of Fundy is located near Saint John, NB.

By the end of 2012, there will have been a number of completed research studies and three years of accumulated monitoring data. It may be advantageous at that point to have a formal peer review of the research and monitoring results in order to identify and define effective monitoring indicators, protocols, and strategies for assessing environmental effects, as well as to identify outstanding knowledge gaps requiring further scientific activities.

Conclusions

The FORCE Tidal Energy Project EEM program contains a broad range of surveys to collect data and enhance the knowledge of baseline conditions for the ecosystem. However, the monitoring report only includes the results of those studies carried out in 2010. It is recommended that DFO Maritimes Science receive a report of the 2011 monitoring activities and results in order to provide a more thorough review of the monitoring program.

DFO Science did not review the survey reports contained in Appendices A–D, F, and G of the Monitoring Report. For those survey reports that were reviewed (i.e., Appendices E and H–K), comments on the methodology and results were provided and recommendations for improvement in specific studies were identified.

One significant gap is that there have not been sufficient monitoring studies in the vicinity of the turbine. Effort needs to be directed to gathering monitoring data around the turbine, particularly related to fish behaviour, using, for example, a vessel-mounted system or an instrumented monitoring platform mounted on or near the turbine enclosure.

For future considerations of commercial scale scenarios it is recommended that DFO maintain its adaptive management approach to assessing and mitigating the potential impacts of TISEC devices. It is important to note that the monitoring program has not yet effectively monitored for environmental effects of an operational TISEC device as the device was only verified in normal operation for a few weeks (i.e., November 12, 2009 to December 16, 2009). Until such a monitoring program is underway and operational, it is difficult to provide further science advice on improving monitoring surveys to identify and mitigate potential environmental effects.

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