FORCE

Fundy Ocean Research Center for Energy

Environmental Effects Monitoring Programs
Fundy Ocean Research Center for Energy (FORCE)

March 2016

Executive Summary

The Fundy Ocean Research Center for Energy (**FORCE**) is Canada's leading research centre for the demonstration and evaluation of tidal in-stream energy conversion (TISEC) technology. TISEC technology (commonly referred to as "tidal energy turbines"), is designed to generate renewable energy from tidal resource sites across Canada and the globe. Fundamental to FORCE's mandate is the monitoring and reporting of any environmental effects from tidal turbines at the FORCE site.

FORCE is a demonstration project, with berth sites granted to a number of technology developers (or berth holders) including Atlantis Operations Canada, DP Energy, Black Rock Tidal Power, Cape Sharp Tidal Ventures, and Minas Energy, The government of Nova Scotia has granted 22.5 megawatts (**MW**) of TISEC capacity at FORCE, under the province's developmental feed-in tariff program. This represents the deployment of approximately two to three TISEC turbines by each developer at their berth site. As these deployments are expected to be phased in over the next several years, FORCE and regulators will have opportunity to adapt environmental monitoring approaches over time, both to better understand what effects turbines may have on the environment, and to report on the monitoring results and any identified effects to the public.

Environmental monitoring has been ongoing at FORCE since 2007 when background studies were initiated for the project Environmental Assessment (**EA**). When the initial EA was approved by the federal and provincial governments in 2009, the development and implementation of environmental effects monitoring programs (**EEMPs**) were stipulated in the Terms and Conditions of EA Approval. In response, FORCE completed 20 monitoring studies between 2009 and late 2013, including fish characterization, seabirds, marine mammals, lobster tracking, marine noise, benthic habitat, electromagnetic fields, and more. The results of the studies undertaken to date along with the original EA are available on the FORCE website: http://fundyforce.ca/environment/.

A turbine was operational at the FORCE site for a short time in 2009. Since removal of this unit in 2010, no tidal turbines have been present at the FORCE site. Consequently, the environmental studies conducted between 2009 and 2015 have largely focused on the collection of background data, rather than on monitoring the effects of turbines. This situation will change with the planned deployment of two cable-connected turbines in 2016 followed by additional deployments in subsequent years.

This report describes new EEMPs based on data and lessons learned from the environmental studies conducted to date. The EEMPs are designed to supplement background datasets where needed but are primarily aimed at verifying predictions made in the EA and at monitoring the environmental effects of operating turbines. The EEMPs are intended to monitor potential effects from the initial *demonstration scale* project, rather than from a potential *commercial scale* project that may occur in the future. To this end, the EEMPs are limited to effects within the FORCE Crown Lease Area (**CLA**), and do not attempt to measure effects in the much larger Bay of Fundy.

Monitoring programs have been developed for five subject areas: Lobsters, Fish, Marine Mammals, Marine Seabirds and Acoustics (marine noise). The EEMPs are intended to cover initial turbine deployments over the time period 2016 - 2021. The programs are designed to accommodate unforeseen changes in turbine deployment schedules and are adaptive to initial monitoring results. It is also expected that the design and/or methods of certain programs may be updated in later years once early results are known.

Within the CLA measuring 1.0 x 1.6 km, FORCE leases to each berth holder a dedicated berth some 200 m in diameter. The berth holder in turn will deploy, operate and test their turbine technologies, which will be connected to the electrical grid through dedicated subsea cables. Given these overlapping areas of responsibility, the berth holders are responsible for monitoring within a 100 m radius of their turbines (the so-called "near field" effects), while FORCE will be responsible for monitoring outside of this zone within the CLA (the so-called "mid field" effects). Berth holder-generated EEMPs will be available to provide a comprehensive picture of all monitoring that will be undertaken within the CLA. FORCE will:

- report results from both the FORCE and berth holder EEMPs to regulators; and
- make all EEMP reports available to the public.

The FORCE EEMPs are intended to be practical, achievable using available technologies, and demonstrative of negative or null effects. The monitoring approaches also reflect the difficulty in operating in this high energy environment and certain technological limitations inherent in some of the equipment that will be employed. However, through these EEMPs, FORCE intends to progressively verify the environmental effect predictions made in the original EA over the next five years. A summary of the programs is presented in the table at the end of this report.

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LIST OF ACRONYMS

CLA	Crown Lease Area
CSAS	Canadian Science Advisory Secretariat
DFO	Fisheries and Oceans Canada (formerly the Department of Fisheries and Oceans)
EA	Environmental Assessment
EC	Environment Canada
EEMP	Environmental Effects Monitoring Program
EMF	Electromagnetic Field
EMAC	Environmental Monitoring Advisory Committee
FAST	Fundy Advanced Sensor Technology
FORCE	Fundy Ocean Research Center for Energy
MARS	Marine Animal Response Society
MW	Megawatt
NSE	Nova Scotia Environment
TISEC	Tidal In-Stream Energy Conversion

1.0 INTRODUCTION

1.1 FORCE

The Fundy Ocean Research Centre for Energy (**FORCE**) is Canada's leading research facility for tidal energy technology located in the Minas Passage, Bay of Fundy. FORCE is a private, not-for-profit demonstration facility, with funding support from the Government of Canada, the Province of Nova Scotia, Encana Corporation, and participating developers.

FORCE was designed to explore the potential for tidal in-stream energy conversion (**TISEC**) technology – resembling an underwater windmill – to contribute to Nova Scotia and Canada's renewable energy supply, and leverage the region's existing expertise in the ocean science sector.

FORCE has four key roles, including:

- **Host**: Providing developers with an approved offshore demonstration area, onshore and offshore electrical equipment, an operations facility, and connection to the transmission grid.

- **Monitoring**: As mentioned above, since 2009, FORCE has conducted an independently reviewed environmental effects monitoring program (**EEMP**), and has shared results with the public.

- **Research**: FORCE supports new tools to characterize the resource and advance new monitoring techniques. This includes both onshore radar and weather information as well as offshore underwater monitoring platforms – all part of a program called FAST (Fundy Advanced Sensor Technology).

- **Engagement**: FORCE connects industry, government, academia and the public in an effort to ensure development activity in the Bay of Fundy is transparent and viable.

The FORCE project currently consists of five undersea berths for TISEC subsea turbine generators (to be installed), four subsea power cables that will connect the turbines to land-based infrastructure, an onshore substation, and power lines connected to the North American power transmission system. The marine portion of the project is located in a leased area from the province (FORCE's Crown Lease Area, or **CLA**), 1.6-km by 1-km in area, in the Minas Passage, and the onshore facilities are located approximately 10 km West of Parrsboro, Nova Scotia.

To date, access to FORCE berth sites has been awarded via a provincial tender issued by the Nova Scotia Department of Energy. FORCE developers have received approval through Nova Scotia's developmental feed-in tariff program for a total of 22.5 megawatts (**MW**) of electricity:

- Minas Energy, 4 MW
- Black Rock Tidal Power, 5 MW
- Atlantis Operations Canada, 4.5 MW
- Cape Sharp Tidal Venture, 4 MW

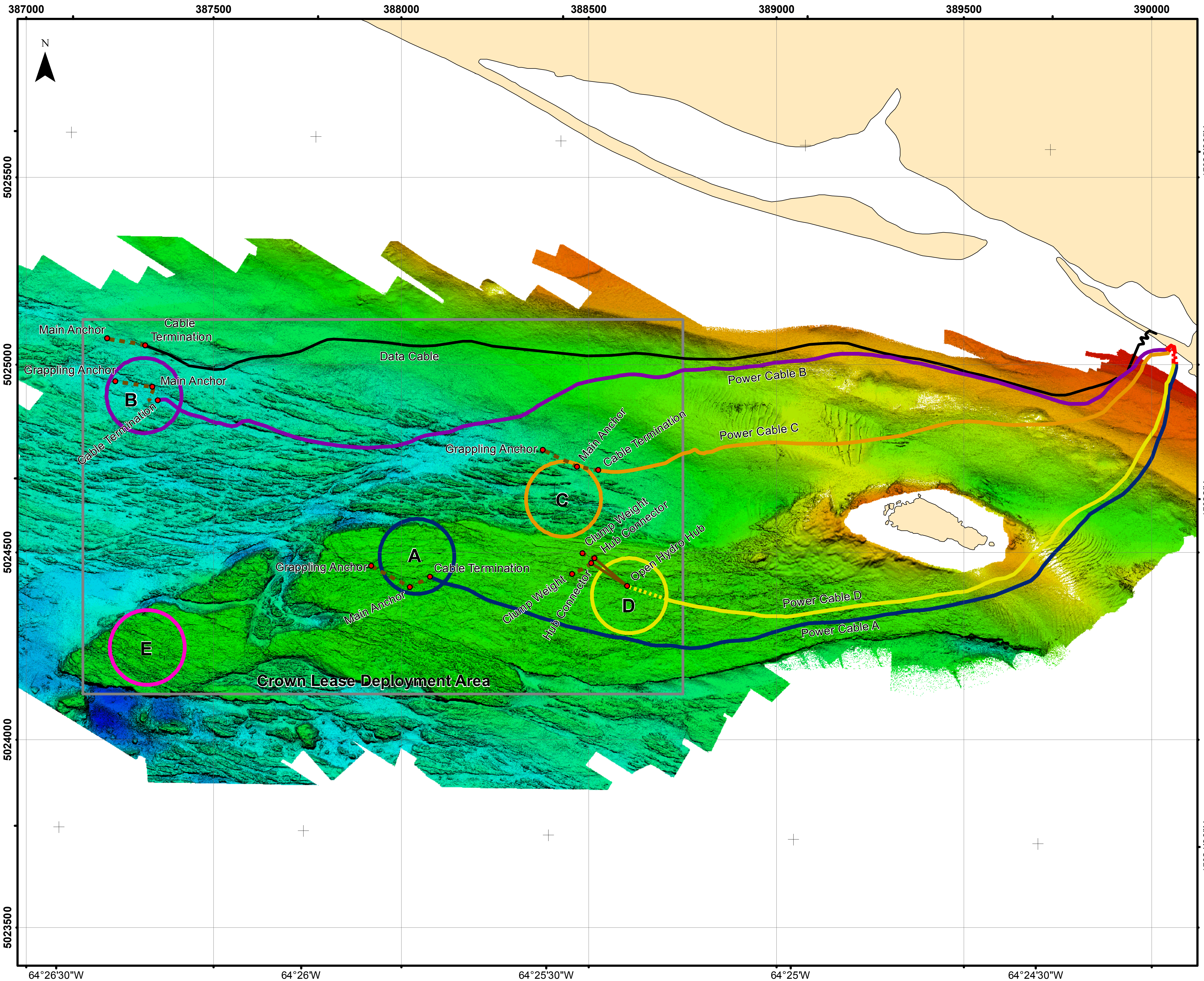
- DP Energy, 4.5 MW

The approval allows the developers to enter into a 15-year power purchase agreement with Nova Scotia Power.

Figure 1 shows the FORCE facility in the Minas Passage, including the marine demonstration area, berth sites and cables routes.

Figure 1: FORCE Site including berths and power cable locations

(proceeding page)



Legend

Power Cables And Berth Sites

- Cable & Berth A
- Cable & Berth B
- Cable & Berth C
- Cable & Berth D
- D, Inferred
- Berth Site E
- Unsurveyed Cable Sections
- Data Cable
- Cable Features
- Hub To HC Connectors
- Ground Tackle
- Crown Lease Deployment Area

Notes:

1) Plan view showing FORCE berths, cables and deployed Open Hydro assets.

2) The Data cable was laid in December, 2013; the power cables were laid in October, 2014; the Open Hydro hub and connectors were deployed in December, 2015.

Scale: 0 100 200 300 400 500 m

1:10,000

Datum / Projection: WGS84 UTM 20

Project: Fundy Tidal Energy Demonstration Project

Client: FORCE

Title: FORCE POWER CABLES AND BERTH POSITIONS

Job / Proposal #: 612 | Doc #: SGI-612-105-A

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Rev	Date	Prepared By	Checked By	Comments

Following approval of the Demonstration Project in September 2009, the first TISEC turbine (OpenHydro design) was deployed on November 12, 2009 by NSPI and OpenHydro. The NSPI/OpenHydro turbine was retrieved in December 2010, and since then no further tidal devices have been deployed in the FORCE demonstration area.

1.2 Context

1.2.1 FORCE's EA Approval

An EEMP was made a condition of Environmental Assessment (**EA**) Approval of the FORCE test site in 2009 and a number of biophysical studies have been undertaken since then (FORCE 2011; FORCE 2014; FORCE 2015). These studies were designed to document pre-development conditions, assess instrumentation and data retrieval techniques, and for a limited time when a functioning turbine was present in 2009[1], monitor environmental effects on certain biophysical components.

The original 2009 EA Approval was for three, 1 MW demonstration scale TISEC[2] units. The EA Registration document and Approval both indicate that FORCE's primary environmental monitoring mandate is assessing the potential effects of *demonstration scale* projects at the FORCE site, rather than *commercial scale* effects or broader research priorities. The EEMPs described here therefore address the FORCE demonstration project and predictions made with respect to possible environmental effects, and not larger scale research issues in the greater Bay of Fundy.

At the same time, data generated through these EEMPs may eventually be used by others for modelling and other work intended to predict the potential impacts from 'scaling up' turbine deployments from demonstration to potential future commercial scale developments in the Province.

A 2011 amendment to the EA Approval added a fourth, 1 MW project to be located within the limits of the CLA at the FORCE demonstration site. In March 2015, the Province of Nova Scotia awarded each of the four berth holders the right to test demonstration scale turbine *arrays*, meaning two or more connected turbines totaling up to 5 MW per berth. Subsequently in November 2015, the Province announced that a fifth berth would be permitted within the FORCE CLA. FORCE accordingly requested a second amendment to its EA Approval, which was received in November 2015. The current demonstration project consists of five grid connected, 4-5 MW demonstration scale projects, each project situated within a designated berth within the CLA, with each berth hosting a different turbine type and platform design.

1.2.1 EEMP Development

FORCE in November 2014 issued a public request for proposals for the procurement of services to support the development of enhanced monitoring programs in advance of turbine deployment. The RFP and overall project scope were developed in consultation with FORCE's Environmental Monitoring Advisory Committee (**EMAC**). Following further consultation with FORCE's EMAC, the work was awarded to a project team of experts led by SLR Consulting (Canada) Ltd. and their resulting report

[1] The turbine deployed by Open Hydro and Nova Scotia Power Inc. was present from November 2009 until December 2010 but was only operational for several weeks in November 2009.

[2] In this report, the industry term "TISEC" or Tidal In-stream Energy Conversion unit is used interchangeably with "turbine", which is more common. However it should be recognized that not all TISECs are turbines.

("Consultant's Report" posted here: fundyforce.ca/environment/monitoring/) forms the basis for the FORCE EEMPs described below. Please refer to the Consultant's Report for more detail regarding the project team, past research studies in the Bay of Fundy and additional rationale for each study methodology summarized below.

Following initial discussions with FORCE and EMAC, the study designs in draft form were presented to Fisheries and Oceans Canada (**DFO**), Nova Scotia Department of the Environment (**NSE**), and the joint federal-provincial "One Window" Standing Committee on tidal energy. Concurrently, Cape Sharp Tidal Venture[3] presented their EEMP to the Committee.

At the same time, FORCE updated and sought input from local fishers and First Nation representatives with respect to past monitoring study results and progress on the EEMP mandate. Fishers and First Nation representatives are also members of EMAC and attended EEMP project-related meetings and presentations related to the development of the new EEMP.

The EEMPs are primarily designed to verify the impact predictions made in the EA (AECOM 2009; AECOM 2010). They are based on the monitoring requirements first described in the Terms and Conditions of Environmental Assessment Approval (NSE 2009), which require that the EEMP consider:

- Fish and lobster
- Marine birds
- Marine mammals
- Acoustics (Marine Noise)
- Physical oceanography
- Currents and waves
- Benthic environment

Of these subject areas and based on input by FORCE's EMAC, the present EEMP is limited to monitoring programs for fish, lobster, marine mammals, marine birds (seabirds) and acoustics (marine noise). This is because:

- Given the work already undertaken on the different physical oceanographic components (including currents and waves), both DFO and EMAC have indicated that additional oceanographic measurements are not needed for a demonstration scale project at this time (DFO 2012; EMAC 2011). Nevertheless, ongoing measurements of currents, tides and other oceanographic parameters will be undertaken by both FORCE and the berth holders as part of their operational activities. As an example of these activities, FORCE is deploying a number of autonomous instrument platforms as part of its ongoing commitment to developing innovative research and monitoring techniques in high current environments. More detail on the Fundy Advanced Senor Technology (**FAST**) platforms can be found on the FORCE website at http://fundyforce.ca/fast/

- FORCE is not currently planning to monitor the mid field benthic (sea bottom) environment because it is anticipated that the most pronounced effects, i.e. scouring, may be observed in the near field close to the turbines. FORCE will work with the berth holders to conduct the near field benthic monitoring. Additionally, the benthic biota on the exposed, current-scoured seabed within the CLA

[3] Cape Sharp Tidal Venture is a joint venture between Emera Inc. and OpenHydro, a DCNS Company, formed to deploy OpenHydro-designed turbines at the FORCE site.

was characterised during initial background studies as rather common in the Bay of Fundy. This habitat exhibits little biological diversity or unusual species composition. Given these characteristics, an effort to document minimal (if any) actual changes to the mid field benthic environment was thought to be an unproductive use of the resources available for monitoring.

The Consultant did not develop an EEMP for the subject of electromagnetic fields (**EMFs**). The potential environmental effects of EMFs were described as being essentially negligible in the 2009 EA and subsequently were not listed in the Conditions of EA Approval as requiring a topic-specific EEMP. In addition, a detailed literature review on this subject commissioned by FORCE in 2012 concluded that injury or other adverse effects are unlikely to even the most EMF-sensitive marine organisms (Collins 2012; see also Woodruff *et al.* 2013). As recommended in Collins (2012), FORCE will continue to monitor the emerging international research literature regarding the effects of EMFs on marine biota.

1.3 Objectives

Globally, in-stream tidal energy projects are developing beyond single unit deployments to larger, demonstration (pre-commercial) and commercial scale arrays, and FORCE is following the development trajectory of demonstration (pre-commercial) arrays. As part of its mandate, FORCE is tasked with monitoring and evaluating the environmental effects of the activities undertaken at its site, and reporting on these effects to the public. FORCE is not tasked with determining potential effects from possible future commercial scale projects, since FORCE is a demonstration project and commercialisation falls outside of FORCE's mandate. It is also important to underline that it is unusually difficult (and expensive) to deploy, manage and retrieve monitoring equipment at this high energy site. The FORCE EEMPs are based on past experience in Minas Passage and the best available scientific advice regarding monitoring approaches and instrumentation. The EEMP is iterative and will likely change as early results suggest new approaches or different instruments.

The ultimate objective is to implement EEMPs that will allow the assessment of environmental effects on critical ecosystems within the FORCE project area and nearby waters over the next phase of turbine deployment. In general, these programs have been designed for the next five years, and are responsive to changes in turbine deployment schedules and adaptable to the ultimate turbine positions within the FORCE CLA.

The overarching purpose of each EEMP is to verify the accuracy of the environmental effect predictions made in the EA and maintain compliance with conditions of provincial and federal approvals. In contrast to the research-oriented focus of past work undertaken at FORCE to characterise baseline conditions, these EEMPs are aimed specifically at post-deployment effects monitoring.

As noted above, the EEMPs are designed to be flexible and adaptive to the TISEC deployment schedules. In keeping with the "adaptive management" approach that was recommended by regulators and FORCE since the beginning of the FORCE project, modifications to the EEMPs (if needed) can be implemented once deployment schedules are better known. Adaptive management is an iterative approach that applies lessons learned from past studies to inform the design of future programs. It also attempts to incorporate changing expectations expressed by regulators, the public and the berth holders. As more turbines are deployed, actual effects may differ from effects measured at single devices and the EEMPs can be adjusted to account for this.

1.4 Berth Holder EEMPs

Each berth holder is tasked with monitoring within 100 m of their turbines and thus will develop their own EEMPs. Berth holder EEMPs (once reviewed by the regulators) will be made available in order to provide a comprehensive picture of all monitoring that will be undertaken within the CLA. The new berth holder's EEMPs will be available prior to their turbine deployment. FORCE will:

a) be responsible for reporting the results from both the FORCE and berth holder EEMPs to regulators, and subsequently
b) make the reports available to the public.

1.5 EMAC Recommendations

FORCE's EMAC played a key role in reviewing and critiquing draft monitoring program methods and reviewing the final EEMPs. EMAC is made up of independent scientific experts and representatives from First Nations and the local fishing industry. The Committee is tasked with providing advice on the adequacy of the monitoring programs that FORCE is required to develop and implement under the EA Approval. A list of EMAC members, the Committee's Terms of Reference and their comments regarding the EEMP are available on the FORCE website: fundyforce.ca/about/advisory-committees/

As indicated in EMAC's *Recommendations Regarding the FORCE Environmental Effects Monitoring Program (EEMP) for 2016 and Beyond*, (fundyforce.ca/environment/monitoring/), EMAC supports the monitoring approaches for each subject area as described in this report. EMAC recommendations or suggestions aimed at individual monitoring programs have been incorporated where applicable into the chapters below.

1.6 Regulator Review

Preliminary advice on the Consultant's Report was also received from the Nova Scotia Department of Environment (NSE), DFO and Environment Canada (EC), which have been taken into consideration when designing the monitoring programs described below. Further advice will be provided by the regulators over time, as part of the Adaptive Management approach.

2.0 SECTION 2: LOBSTERS

2.1 Objectives

As described in the EA, a significant adverse effect is defined as one that creates a significant alteration to a population (or a portion of it) to cause an unnatural decline or change in the abundance or distribution of the population to a level from which recovery of the population is uncertain, over one generation or more.

In order to measure a "significant alteration in a population" so that any negative effects can ultimately be determined, knowledge of the abundance and movement of lobsters in the Minas Passage during various times of the year is needed. Past lobster catchability studies combined with acoustic tagging surveys have provided sufficient background information to establish, in general terms, relative abundance and seasonal movement patterns. Please refer to the Consultant Report for a detailed review of past work in Minas Passage on the subject of lobster. Since commercial fishing was the primary concern identified in the EA, the EEMP below is designed to answer the question: does the presence of the turbine affect the number or weight of lobster entering the traps?

2.2 Methodology

2.2.1 Overview

The primary environmental effects variable that will be monitored is the number of lobster caught per trap, combined with (as suggested by DFO 2012) the weight of lobster caught per trap. As in past catchability studies that use standard, baited commercial lobster traps, the primary evaluation of effects will use Analysis of Variance to compare catchability at defined distances from the turbine(s).

Despite the limitations and difficulties imposed by the Bay of Fundy marine environment, the prior lobster catchability studies demonstrated that a simple Before After Control Impact (BACI) study can provide useful environmental effects monitoring data. Bayley (2010) determined the number of samples (traps) needed to detect a change in lobster catchability with sufficient statistical reliability. Based on preliminary results, a reduction in catch of 2 lobsters per trap was considered significant.

2.2.2 Mid Field Study Design

The text below describes a mid-field EEMP with one turbine at the center of the monitoring program. The study design proposes sample collection from random sample stations located within two rings around the turbine: one ring at 300-350 m from the turbine (called the "treatment ring") and one ring at 450-500 m (called the "control ring"). Both rings would be divided into four quadrats (east, west, north and south) and sample sites would be randomly assigned in each ring within each quadrant. Ideally, the quadrats should be aligned with the tidal current direction so that directional effects in front of and behind the turbine in action can be compared with results in quadrats beside the operating turbine.

The double-ring-and-quadrat approach is proposed to account for possible directional effects due to water currents and noise from the turbine, and to allow for current-induced trap movement.

Regarding the total number of sample stations, Bayley (2010) suggests it is important to have a sufficient number of back-up samples to ensure as balanced a design as possible. A total of 24 randomized sample stations, 12 in each ring, is proposed. With two rings (one at 300-350 m and one at 450-500 m), this means six stations in each quadrant.

It is further proposed that **all stations are sampled three times to complete one survey**. Bayley (2010) notes that three replications and six stations per quadrat "would provide good insurance for single losses in locations or site replications, and still retain temporal and spatial replication…"

If all samples could be completed, the total samples per survey would be 72 (24 stations sampled 3 times), meaning 36 samples for the "treatment ring" and 36 samples for the "control ring, which, Bayley notes, provides good power for the main treatment/control effect. A balanced design of 72 samples per survey will provide data to evaluate:

1. Differences in catchability with distance from the turbine ("distance effects");
2. Differences in catchability in front/behind vs beside the turbine ("directional effects");
3. Allowance for loss of samples (traps); and
4. Comparability with existing data.

If the results of this study do not detect a statically significant change in lobster catchability, or the effects of a detected change are so low as to ensure that no significant effects on the commercial harvest will be felt, then the EEMP can be discontinued after a minimum of three surveys**.** A full three surveys are proposed to capture progressive device deployments over time. The actual number of surveys completed will depend on the deployment schedule and initial results.

CEF (2010) reports that approximately 15 stations can be sampled routinely in a typical day. More stations can be sampled at lower amplitude tides because the survey vessel can spend more time in the water and traps remain closer to their set location. At extreme high tides, buoys may remain at the surface for less than 30 minutes at each slack tide, allowing recovery of relatively few traps. This experience implies that all stations can be sampled over the course of two days, and that a single survey consisting of three replicates would require a total of 6 days, not including preparation, trap setting and data analysis.

Given that two turbines will be installed in 2016 within Berth D, the study design proposed above can be easily modified to accommodate two turbines within a single berth, as is proposed for Berth D. The two turbines will be located within 200 m of each other since the berth diameter is 200 m, and so can be treated as a single unit. Once the exact placement of the turbines is known, the ring distance can be adjusted to include and effectively represent both turbines. As with the other EEMPs, study timing will depend on the turbine deployment schedule.

2.2.3 Multiple Turbines

Second in priority is the question of far-field effects. As Bayley (2010) observes: are there larger scale consequences (i.e., outside of 500 m from the turbine) of the turbine presence?

It is unlikely that significant effects in the far field will be detected with only one or two turbines installed. Given this, FORCE proposes to defer any far-field studies until three or more turbines are deployed, as recommended in the Consultant's Report. Once three or more turbines are installed, the study can be expanded as per Design B in the Consultant Report, if deemed appropriate.

At this time, it appears the first two turbines will be deployed in 2016 in Berth D and the next turbines will be deployed in 2017 in Berth B, over 1000 m away. The great distance separating these two turbine berths suggests there will be limited interference or overlap in environmental effects between them. Given this, they are best monitored as separate installations; the mid field study design can be applied to the Berth B turbines. When the next berth is occupied, study designs may be modified to account for the potential cumulative effects from multiple devices.

Once three berths are occupied, the joint effect of multiple turbines can be assessed. Instead of distinguishing distance from turbine on a categorical basis (treatment/control), as implied by the rings in the mid field design, one can take a continuous approach by labelling samples from each site in terms of their distance from one or more turbines (Bayley 2010). To accomplish this, a sufficient number of randomly selected sample stations would be selected at different distances from the turbines and accounting for varying water depths.

Given the uncertainty regarding the timing of future deployments, planning for future studies designed to address multiple turbines will be deferred until short-term study results are known and deployment schedules are further defined.

2.3 Discussion

These study designs include suggestions proposed in DFO (2012):

- The number of replicate samples (traps) is described (three replicates form one survey).
- The monitoring program is designed to assess effects on catchability while the turbines are in operation.
- Catch rates expressed as Kg/trap hauled will also be recorded and evaluated.
- Monitoring activities will be conducted during the out-of-fishing season.

Since the number of lobsters caught per trap-set is not normally distributed[4], Bayley (2010) recommends that future statistical analyses of study results use Generalized Linear Models (GLM) with a negative binomial distribution rather than the standard log(count+1) transformation that is typically applied to data that is normally distributed.

This proposed design requires new stations to be randomly selected. Since depth is known to be a significant variable, CEF (2012) suggests some stratification by depth be introduced into the station selection to ensure that an adequate balance of depths is sampled.

To increase study efficiency and with the intention of reducing current-induced trap movement, certain stations during past surveys were sampled with pairs of traps connected by a 60 m rope. Statistical analysis indicates the results from the paired samples are not comparable to the non-paired samples (Bayley 2010). The reviewer recommended discontinuing the use of paired traps in future surveys. This also reduces the entanglement safety hazard identified in CEF 2010. The 2009-2010 trap pair data can still be used in future analyses: results for one of the two traps from each pair can be randomly chosen, pooled and then used in statistical analyses.

[4] "normal" distribution is a statistical term used to describe data that tends to cluster around a central or mean value.

Difficulties were encountered due to the short time over which the traps could be set and recovered (less than an hour over slack tide) and the time (and expense) required at sea because of low water levels at the wharf. In addition, the strong currents often moved traps from their initial deployment location, typically approximately 100 m from initial deployment location (but up to 1.0 km). During the first fall 2009 survey, 3 of 51 traps were lost. During the second fall 2009 survey, 7 of 48 traps were lost. During the spring 2010 survey 5 of 28 traps were lost. Analysis of results must take into account both trap loss and trap movement. Planning and cost estimates should factor in a 15% trap loss rate.

It should also be noted that lobster populations (i.e., abundance) are noticeably affected by commercial fishing pressures. Noise and vibration effects of four or five turbines may be very difficult to measure in comparison. Given this, the study will be designed to minimize the effects of the commercial harvest on study results i.e. lobster fishing seasons.

3.0 SECTION 3: FISH

3.1 Introduction

The following paragraph describes the predicted demonstration scale impacts on fish (AECOM 2009):

> It is anticipated that marine fish present or migrating through the Project area may experience very limited behavioural changes such as avoidance and aversion, as well as limited mortality and habitat disruption. The extent of these effects is not known given the lack of specific information related to noise generated by the proposed devices, and the background noise in the Project area. By following existing standard construction practices, available guidelines and associated mitigation measures, Project activities and components are not likely to cause significant adverse residual effects on marine fish within the Project area or vicinity (i.e., Minas Passage and Minas Basin). In general, this is due to the relatively small scale of the project, combined with the limited duration and intermittent nature of the Project activities (AECOM 2009).

Possible interactions can occur at different spatial scales relative to the devices, beginning with the near-field. A TISEC device near field interaction could include fish collisions, blade strikes, and/or pressure-induced damage to fish resulting from device cavitation. These events are difficult to capture in real time, especially in the field. There are no field studies where observation of TISEC device blade strike has been recorded but there are laboratory studies that have documented such interactions (Amaral *et al.* 2015). For the purposes of this EEMP, near field interactions such as blade strikes and collisions are assumed to be the subject of monitoring by the device proponents.

Before attempting to answer the question of whether or not there are actual near field physical interactions (e.g. collisions or blade strikes) it is important to address the larger scale question of whether or not TISEC devices affect overall fish use of the water column at ranges from 10-150 m from the device. At these distances and farther (i.e., the mid field), there are possible indirect large scale effects on fish use of the water column due to the presence of TISEC devices. For example, does fish density change and does fish vertical distribution within the water column change due to the presence of a TISEC device? The FORCE project provides a unique situation of deployed devices and the ability to monitor fish responses on the basis of density and depth distribution.

3.2 Objectives

The goal of this EEMP is to describe a means of quantifying fish distributional changes that reflect behavioural responses to the presence of a deployed TISEC device. The objectives of this program are to: (1) test for indirect effects of TISEC devices on water column fish density; (2) test for indirect effects of TISEC devices on fish vertical distribution; and (3) estimate probability of fish encountering a device based on fish density proportions in the water column relative to TISEC device depth in the water column. These objectives will be met using established down-looking hydroacoustic monitoring techniques, Before-After-Control-Impact (BACI) study design, multivariate analysis (Hotellings T^2 tests) of fish vertical distributions, and an encounter probability model.

3.3 Monitored Variables

Fish Density: Down-looking hydroacoustics provides raw data that can be used to calculate fish density by scaling mean volume backscatter (S_v) by the average scattering cross section (σ_{bs}) or averaging fish tracks per sampled volume. This variable is used to represent fish concentration.

Fish Vertical Distribution: This variable is estimated by dividing the water column into equal depth bins (e.g. 1 m) and calculating the proportion of fish density for each bin. This variable is used to represent fish distribution within the water column.

To address the first objective, indirect effects of a TISEC device on monthly fish density estimates (the measured parameter) will be compared using a Before-After-Control-Impact (BACI) design. The "before" component must be estimated from previously collected data from Melvin and Cochrane (2014). The "after" component will be estimated from down-looking hydroacoustics surveys following the methods described in Methodology below. This will provide a statistically defined change in the density of fish at the FORCE CLA after devices are deployed, provided there is such an effect. A control will be used to account for potential annual variability in fish density estimates (Smith 2002). This will inform FORCE of any difference in concentration before and after device installation while accounting for inter-annual variability[5].

To address the second objective, indirect effects of a TISEC device on monthly vertical fish distributions based on 1 m depth bins measured up from the sea floor will be compared using a Before-After-Control-Impact (BACI) design. This provides fish vertical distribution by 1 m increments (the measured parameter). The "before" component of the study will use the dataset from Melvin and Cochrane (2014). The "after" component will be estimated from down-looking hydroacoustics survey data as described in Methodology below. This will provide a statistically defined change in use of the water column (vertical distribution) by fish in the mid-field at the FORCE CLA relative to a control site, if in fact there is such an effect (Staines *et al.* submitted to European Wave and Tidal Energy Conference (EWTEC) 2015). This in turn will inform FORCE of any change in fish vertical distribution before and after device installation and will account for inter-annual variability with control site comparisons.

To address the third objective, indirect effects of fish water column use at the depth of a deployed TISEC device will be assessed using an encounter probability model. The probability that fish will encounter a deployed device is estimated from two components: 1) the proportion of fish being at the device depth when the device absent; and 2) the proportion of fish being at the device depth when the device is present. The product of these two estimates will provide a probability of fish encounter (**Figure 3-1**).

[5] In their review of this program, DFO notes that the proposed use of X and Y transects is “inadequate” since fish abundance mid-channel may not be well correlated with fish abundance in the north end of the grid where the turbines will be deployed. FORCE recognizes this may be the case but will proceed on the assumption that fish distribution is relatively uniform through the CLA. Monitoring data collected by this and other programs over time should help demonstrate fish distribution.

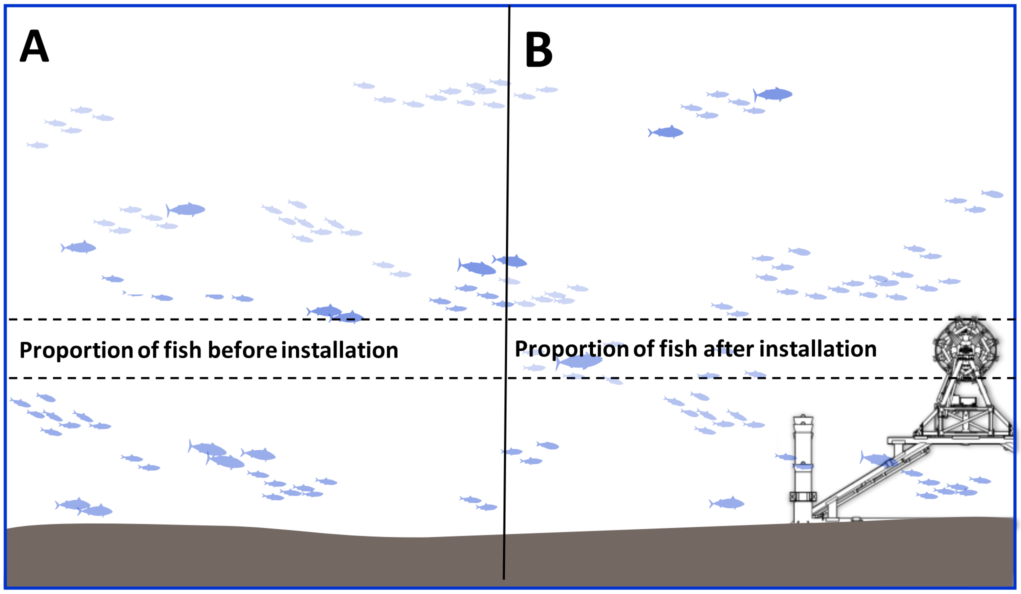

Figure 3-1. Display of part of the water column of a theoretically planned site for TISEC device installation. The dashed lines represent the depth in the water column of interest because it is where the device is located and where potential fish interactions will occur. (A) represents the water column prior to device installation and provides the parameter of fish proportion before installation. (B) represents the water column after device installation and provides the parameter of fish proportion after installation.

3.4 Methodology

3.4.1 Boat Platform and Acoustic Survey System

Previous mobile, down-looking hydroacoustic surveys were performed used an 18.6 m stern trawler (FORCE 2015) and a 15.4 m passenger vessel (Melvin and Cochrane 2014). This EEMP proposes the use of similar sized vessels based on the previous success of these two surveys.

A 120 kHz echosounder system consisting of a transceiver and laptop computer housed inside the boat cabin and transducer that is pole mounted on one side of the boat is proposed. The transducer will be mounted deeper than the boat hull to prevent interference with the keel. The transducer will be mounted using a pole design attached to the gunwale. A GPS unit will be used to provide National Marine Electronics Association (NMEA) serial string data to a laptop computer. For comparability to the Melvin and Cochrane (2014) dataset, a ping rate of 1 s^{-1} is proposed. Proper instrument calibration prior to each survey is recommended according to Foote *et al.* (1987).

3.4.2 Survey Description

The FORCE CLA surveys will consist of 9 parallel transects spaced 100 m apart (**Table 3-1**). Each transect is approximately 1.8 km long. Transects are numbered 0-8 starting nearest to shore. The parallel transects within the FORCE CLA will be followed by three control transects that start at the easterly end of transect 8. Transect Y1 is across the Channel, and the boat will take a southwest bearing across the Channel from the easterly end of transect 8 toward the opposite shore until approximately 30 m depth is reached. From here transect X1 will follow the 30 m contour east to the start of transect Y2 which parallels Y1 back across the channel going north and ending at the westerly end of transect 0 (**Figure 3-2**). This survey design is repeated until slack tide time.

Surveys will be performed, to the extent possible at speeds between five and ten knots, although speeds up to 12 knots are consistent with Melvin and Cochrane (2014).

Table 3-1. Latitude and longitude in decimal degrees for proposed Minas Channel transects for down-looking hydroacoustic surveys. Transects with an asterisk are for control samples. These transect locations are similar to Melvin and Cochrane (2014) but are slightly longer in length to encompass all berth sites within the FORCE CLA.

Along-Channel Transects	**West End**		**East End**	
	Lat	**Lon**	**Lat**	**Lon**
0	45.3725	-64.4409	45.3674	-64.4184
1	45.3717	-64.4414	45.3666	-64.4189
2	45.3709	-64.4419	45.3657	-64.4193
3	45.3701	-64.4424	45.3649	-64.4199
4	45.3692	-64.4430	45.3640	-64.4203
5	45.3684	-64.4435	45.3631	-64.4207
6	45.3676	-64.4439	45.3622	-64.4212
7	45.3667	-64.4444	45.3613	-64.4216
8	45.3658	-64.4449	45.3605	-64.4221
X1*	45.3378	-64.4594	45.3330	-64.4364
Across-Channel Transects	**North End**		**South end**	
	Lat	**Lon**	**Lat**	**Lon**
Y1*	45.3658	-64.4449	45.3378	-64.4594
Y2*	45.3674	-64.4184	45.3330	-64.4364

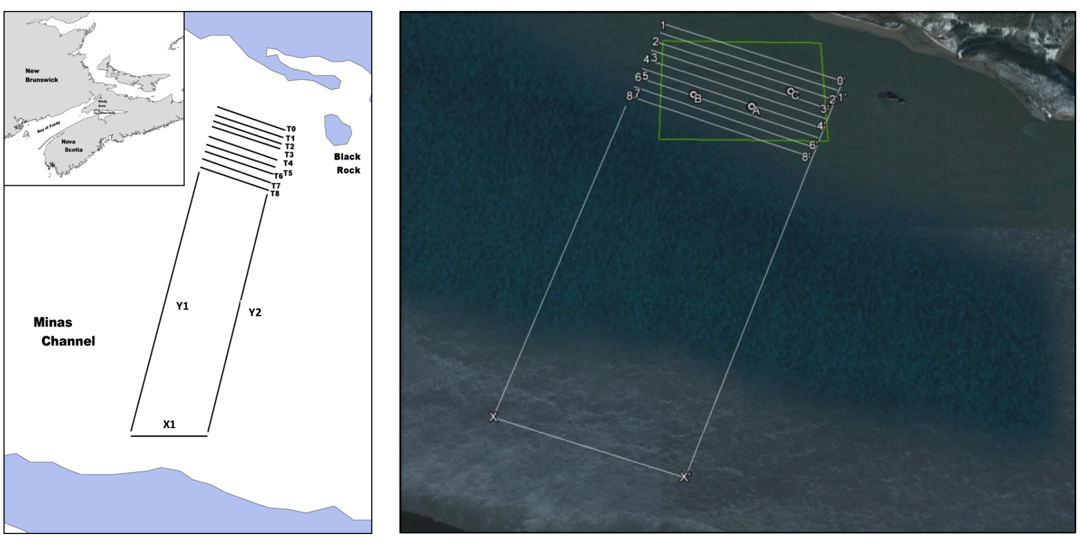

Figure 3-2. Left Map showing approximate locations of all transects for down-looking hydroacoustic survey. Reproduced from Melvin and Cochrane (2014); and Right- Google Earth view of Minas Passage showing proposed survey transect locations, FORCE CLA, and TISEC device berth sites A, B, and C. The green rectangle is the FORCE Crown Lease Area.

3.4.3 Schedule

For the sake of comparability with the Melvin and Cochrane (2014) dataset, this EEMP proposes sampling during the same months on neap tides[6] as was done by Melvin and Cochrane (2014): six survey events distributed over six different months. The months of May, June, August, September, October, and November will match with the 2011-12 dataset.

No surveys are proposed for December through April since these months likely coincide with the lowest water temperatures and lowest fish biomass (Viehman *et al.* 2015; Melvin and Cochrane 2014). July is not surveyed because this month was also skipped in the previous study. **Table 3-2** lists proposed 2016 sampling dates based on dates that coincide with neap tides. These sampling dates may capture the immigration and emigration of migratory fish species that occur in Minas Passage and Minas Basin. Resident fish species and those life stages of migratory species that use the project area will also be captured in these surveys.

Table 3-2. Proposed 2016 Sampling Dates Coinciding with Neap Tides. Start Times = High Tide Times.

Survey	Start date	Start time ADT
1	16 May 2016	9:28 am
2	14 June 2016	8:49 am
3	12 August 2016	8:20 am
4	11 September 2016	8:38 am
5	8 October 2016	6:14 am
6	7 November 2016	5:35 am

Each survey event will consist of a full tidal and diel cycle and therefore last 25 hours. This can be broken up into four separate shifts each around 6 hours. Time between tides when the flow is decreased can be used to change crews and maintain equipment. All surveys should begin on a high tide to ensure that the boat can manage entry and exit from port. Surveying will be limited to calm sea days and if possible, when wind is less than 10 knots for safety and to maximize data quality.

The EEMP proposes extending this study for five years in an attempt to capture multiple deployments that are planned in the FORCE CLA. The first planned installation will be two open centre turbines in 2016.

Extending this monitoring program over five years will improve the ability to determine potential effects on fish use in and around the FORCE CLA in two ways. First, it is imperative to capture future device deployments to address not only potential effects related to individual device types but also to assess cumulative effects from multiple devices operating at the same time. Second, long-term studies have a higher probability of success because they are less likely to mistake single, novel ecological events as

[6] The survey can be performed during both neap and spring tides but if data quality is poor enough to preclude its collection during a certain tidal phase then it would be advisable to avoid this time.

representative. The existence of an effect or lack thereof for several years of surveyed data is stronger evidence when compared to a single year's data. In other words, if there is evidence of a trend for several years as opposed to a single year then that trend is less likely to have occurred by chance alone. Additionally, long-term datasets have the option of time series analysis that can show long term trends and provide evidence for forecasting.

EMAC suggests testing the downward looking hydroacoustic program as soon as possible, i.e. prior to turbine deployment. This 'test run' will identify logistical issues and promote a familiarity with the instrumentation, collection methodology and difficult working conditions.

3.4.4 Data Processing

The surveys in Minas Passage will likely have a major manual processing component to separate the large amounts of entrained air particular to this area. An established method for addressing entrained air at the surface is to eliminate a certain amount of water depth from processing and analysis (e.g. the upper 10 m) (Viehman *et al.* 2015). Some researchers have had success removing entrained air using Schools Detection module algorithms in Echoview software.

Additionally, when utilizing subjective manual processing techniques, it is important to include a quality assurance (QA) and quality control (QC) protocol. Ideally, the quality assurance component is an additional person with hydroacoustics data processing experience to take a subsample of processed data and reprocess it to compare to the results of the first person's outcome. A good method for quality control is to find outliers in the final fish density estimates and reference them to the processed data files. Often times a noise spike or other source of signal contamination is missed during manual processing and is therefore included in the fish density estimate. There are numerous other avenues for QA/QC and any that the researchers have confidence in should be used.

Hydroacoustics data can be processed to provide density as a metric. Fish density can be calculated by scaling the mean volume backscatter (S_v) by the average backscatter cross section (σ_{bs}) for a sampled volume of water or by determining the number of individual fish tracks for a sampled volume of water. Additionally, using just (S_v) as a metric is also effective (Viehman *et al.* 2015). Using S_v alone provides biomass or relative density as a metric instead of density. For Objective 1, S_v will suffice as a metric for the proposed analysis. However, for Objectives 2 and 3, researchers will need to use area backscatter coefficient (S_a) as a metric for the proposed analyses (Staines *et al.* 2015). Researchers with hydroacoustics experience will have knowledge of all of these metrics and their applications.

Based on the objectives of this program, fish density will need to be in two separate forms for the proposed analyses. First, overall fish density estimates for 30 or 60 minute time intervals for the water column are required for the first objective of determining seasonal fish density at the FORCE CLA (hereafter referred to as the impact site) and control sites. Second, fish density estimates for 30 or 60 minute time intervals divided into 1 m depth bins for the water column are required for the second objective of determining seasonal fish vertical distribution at the impact site and control sites (Viehman *et al.* 2015). Objective 1 uses overall fish density of the water column and objectives 2 and 3 use fish density in 1 m depth bins.

3.4.5 Data Analysis

Analysis for Objective 1 would involve a 2-way analysis of variance (ANOVA) based on a before-after-control-impact (BACI) experimental design (Smith 2002). The "before" component will be a previous dataset collected by Melvin and Cochrane (2014) that the aforementioned survey methods are based on. The "after" component of the study could potentially be any year of surveys after TISEC devices have been deployed. The "control" component is taken from the x and y transects of the survey design while the "impact" component is taken from the parallel transects numbered 0-8. The results of a 2-way ANOVA analysis will provide an effect for the before/after component, the control/impact component, and the interaction of the two. A significant interaction effect is evidence of there being an effect of a TISEC device on overall fish density at the impact site (Staines *et al.* 2015).

Analysis for Objective 2 should include using Hotellings T^2 permutation tests to compare the difference between the fish vertical distribution densities of complimentary months of the "before" survey to the "after" surveys for both the control and impact sites. For example, in the "before" survey of Melvin and Cochrane (2014), the month of May in 2012 was sampled. Assume there is an "after" survey performed in the month of May in 2016 after TISEC devices are present. Both of these May samples would be complementary and would be tested for differences. The complementary pair for the impact site transects would be tested and the complementary pair for the control transects would be tested. If both the impact site and control site had non-significant test results or both had significant test results then that would indicate no evidence for effects from TISEC device presence. However, if only one or the other of the control or impact site has a significant test result then this would indicate possible evidence for TISEC device effects on fish vertical distribution.

Analysis for Objective 3 will involve re-analysis of fish vertical distribution data used in analysis of Objective 2. Determining the probability of encounter of fish with TISEC devices at the impact site will require several data inputs that will all be available after device installation and down-looking hydroacoustic surveys have been completed. The first input required is the depth of a particular deployed TISEC device. Knowledge of this depth is important because this is where expected interaction will likely occur with fish moving into the impact site. The probability that fish would encounter the deployed device is estimated using two probabilities: 1) the probability of fish being at the device depth when the device is not present at the impact site (p_1); and 2) the probability of fish being at the device depth when the device is present (p_2). Therefore the probability of fish encountering the device can be calculated as:

$$p = p_1 * p_2$$

Note that the probability (p_1) of fish being at the device depth can be determined from the Melvin and Cochrane (2015) dataset since most of these data were collected at the impact site when no device was present. In fact, this would be the best estimate of p_1. Using the control site to determine p_1 assumes that the control site is similar to the impact site. If the control site is to be used to determine the probability of encounter it should be tested for potential differences with the FORCE CLA. These methods would best be undertaken in 2017 or 2018 after site-specific data have been collected and sample sizes are adequate for confident estimates.

4.0 SECTION 4: MARINE MAMMALS

4.1 Introduction

Many of the impacts of TISEC developments are likely to be the same as those associated with more established marine industries, such as oil and gas exploration, construction and extraction. However, there are a number of potential impacts that are specific to these new technologies. These include, for example:

a) deterrent effects of noise associated with operational and installation activities;

b) disruption of communication as a result of increased underwater noise;

c) indirect effects through changes in prey distribution and abundance; and

d) direct collision or physical dynamic interaction with TISEC devices.

Individual TISEC devices have a relatively small physical footprint so it is unlikely that the presence of single devices or small arrays will pose a significant habitat exclusion risk at a level likely to result in measureable impacts.

Environmental effects from continuous noise sources are related to sound intensity, signal to noise ratios, spectral frequency and the exposure period, but also contextual factors like the novelty of the sound source (Southall *et al*. 2007; Ellison *et al.* 2012). Harbour porpoise (*Phocoena phocoena*), the key marine mammal species in Minas Passage, use high frequency echolocation clicks to hunt and communicate (Kastelein *et al.* 2002) and are known to be very susceptible to pulsed noise disturbance (Tougaard *et al.* 2009), but few studies have focused on exposure to continuous (non-pulsed) periods of low frequency noise sources such as those emitted by tidal turbines.

4.2 EEMP Context

Baseline data collected to date coupled with historical information indicates that only one marine mammal species is present in sufficient numbers to test EA-related distribution or avoidance predictions, namely Harbour porpoise**.** Low sighting rates of harbour and grey seals, white-sided dolphins and sporadic sightings of larger whales (mainly long-fin pilot, minke and humpback whale) result in a lack of statistical power to robustly assess change in abundance or distributions or indeed avoidance by these species, even if current baseline monitoring studies were continued or expanded.

Recognizing that only a small portion of the Bay of Fundy Harbour porpoise population utilizes Minas Passage, this EEMP focuses on the more obtainable 'sub-population' level EA predictions. The overall goal is to assess change in mid field area use by Harbour porpoise, including permanent or large scale avoidance/attraction of the FORCE CLA and surrounding mid field study area.

Marine mammal EA predictions were developed for a minimum of one generation. For Harbour porpoise, this is considered to be seven years, thereby requiring an EEMP that extends over this period. Logically, monitoring studies can be staggered to allow time for site development of multiple turbines and long-term operations in order to maximize the value of the EEMP.

Effort will be directed towards gathering monitoring data in the near and mid field around individual turbines. Given safety considerations near operational turbines, immediate near field monitoring (considered to be within 100 m) is best undertaken by device owners, rather than through the deployment of moveable equipment from surface by independent monitoring entities.

The proposed focus of the marine mammal EEMP is to assess long-term effects of two key stressors on Harbour porpoise:

1) Direct effects of operational turbine noise. Specifically, Harbour porpoises m*ay* respond to the acoustic stressors through attraction or avoidance.

2) Indirect effects due to changes in prey distribution and abundance. Due to dynamic interactions, prey aggregations or near-field avoidance by fish due to acoustic effects, Harbour porpoise may respond to local study area scale prey aggregations through attraction or avoidance.

The assessment of both direct and indirect stressors is achievable concurrently, as both are potentially monitored through relative changes in porpoise activity and relative site use.

Turbine deployment at the FORCE CLA is an incremental process that will occur over a number of years. This EEMP proposal has assumed that two turbines will be deployed at Berth D in 2016, with deployment of additional (and different) turbines in the other berths occurring in subsequent years.

4.3 EEMP Objectives

The primary objectives of the marine mammal EEMP are to assess the following effects:

1) Permanent avoidance of the mid field study area during turbine operations.

2) Change in the distribution of a portion of the population, specifically large scale (~50%) decreases or increases in relative occurrence (echolocation activity levels) across the mid field study area.

The secondary objectives of the marine mammal EEMP are to;

1) Monitor the regional frequency of stranded carcasses in conjunction with the Marine Animal Response Society (MARS) program and assess cause of death where possible and maintain an adaptive management approach to new information on collision risk and from C-POD monitoring studies.

2) Provide recommendations on the potential applications for the FORCE FAST Platform and potential research themes that would increase scientific understanding of the scale of turbine-marine mammal interactions.

These objectives are slightly reduced from those described in the Consultant's Report. Upon further discussion with the report authors, it was decided to wait for the results of studies currently underway before deciding if the use of the passive acoustic AMAR is justified in Minas Passage. Similarly, the year 1 program will now be undertaken post-turbine deployment and so it has been reduced from five CPODs (which were proposed to collect additional but non-critical baseline data) to three CPODs (to detect behavioural changes related to turbine presence).

4.4 Methodology

This EEMP proposes the continued use of C-PODs (housed in SUB-buoys) which are considered sufficient to detect avoidance and large scale changes in "mid field relative occurrence" (specifically via monitoring long-term rates of echolocation activity). The EEMP has a high probability of success at detecting avoidance and a moderate-high probability of success in detecting changes in mid field occurrence rates exceeding 50%.

At a minimum, the EEMP proposes mid field area monitoring using C-PODs at 2 standardized reference sites in years 1, 3 and 7 (Figure 4-1), but this monitoring intensity is adaptive beyond year 3 (i.e., after this 'Phase 1' data has been analysed). In addition, one C-POD will be assigned to each berth as the turbines are deployed and will monitor each berth at 100-150 m distance for fixed periods of time. All C-PODs are deployed for three months in the spring, retrieved and deployed again for three months in the fall to capture periods of peak seasonal occurrence identified in 2011-2014 (Porskamp *et al.* 2015).

In addition to these deployments, the EEMP proposes a three-year collation of stranded marine mammal reports through co-ordination with Nova Scotia Marine Animal Response Society (MARS). A detailed rationale and methodology are detailed below and also summarized in **Tables 4-1 & 4-2.** In summary, for each year the proposed EEMP plans to:

Year 1 (2016):

a) Deploy 2 calibrated C-PODs at two of the five available mid field reference sites (Figure 4-1) in spring and fall to provide an improved porpoise occurrence baseline data set at multiple sites in the spring, as well as a comparative 'after' data set following turbine deployment at Berth D.

b) Deploy 1 calibrated C-POD within 100-150 m of Berth D (Figure 4-1) in fall to provide a berth-focused mid field porpoise occurrence data set (assumes summer-fall 2016 turbine deployment in Berth D).

c) Initiate long-term collaboration with Nova Scotia Marine Animal Response Society and local veterinary pathologist. Assess if dynamic interaction adaptive management triggers have been reached (see Table 4-2).

d) Assess mid field area C-POD data to determine if adaptive management triggers (avoidance or large scale reduction in activity) have been reached (See Table 4-2).

Year 2 (2017):

a) Deploy 1 calibrated C-POD within 100-150 m of Berth D (Figure 4-1) in spring to provide a focused near-field turbine porpoise activity data-set.

b) Deploy 1 calibrated C-POD within 100-150 m of Berth B and each of Berths A and C (if occupied) in fall to provide a berth-focused mid field porpoise activity data-set (assumes summer 2017 turbine deployments).

c) Continue collaboration with Nova Scotia Marine Animal Response Society. Assess if dynamic interaction adaptive management triggers have been reached.

d) Assess mid field C-POD data to determine if adaptive management triggers (avoidance or large scale reduction in activity) have been reached.

Year 3 (2018):

a) Deploy 5 calibrated C-PODs at 5 mid field area reference sites (Figure 4-1) in spring and fall to provide 'after' porpoise activity baseline data-set. Identical C-PODs would be located at the same sites as in year 1. Exact sites locations for West 1 and East 1 should consider final turbine and near-field C-POD placement locations and associated cablings, aiming to deploy >400m away in similar water depth.

b) Deploy 1 calibrated C-POD within 100-150 m of Berth B and A/C (Figure 4-1) in spring to provide turbine berth-focused mid field porpoise activity data-set (assumes summer 2017 turbine deployments).

c) Continue long-term collaboration with Nova Scotia Marine Animal Response Society. Assess if dynamic interaction adaptive management triggers have been reached.

d) Assess mid field C-POD data to determine if adaptive management triggers (avoidance or large scale reduction in activity) have been reached.

Years 4-6 (2019-2021):

a) Monitoring intensity and methods dependent on results from years 1-3 and from other TISEC projects worldwide (e.g., adaptive management approach).

Year 7 (2022):

a) Deploy 5 calibrated C-PODs at 5 mid field reference sites (Figure 4-1) in spring and fall to provide 'after' porpoise activity data-set at timescale of one porpoise generation. Identical C-PODs would be located at the same sites as in year 1. Exact sites locations for West 1 and East 1 should consider final turbine and near-field C-POD placement locations and associated cablings, aiming to deploy >400m away in similar water depth.

b) Assess if further environmental effects monitoring required.

As recommended, FORCE will assess the application of shoreline mammal carcass surveys as an additional monitoring tool and indicator potential of mammals strikes by a turbine. Carcass stranding frequencies in the region are believed to be low, but data from pre-installation periods may be useful in comparison with frequencies post-installation. This method provides a cost-effective means to potentially detect lethal collisions by species of conservation and public concern*,* FORCE will contact MARS on a routine basis to obtain updates on any mammals strandings or mortalities reported in the Minas Channel area.

In addition, FORCE will continue to publicize its emergency response number (1-888-850-4625) number so that any mariners, fishers, and general public who observe any unusual occurrences in the area of CLA (i.e., usual seabird activity, fish kills, injured or dead marine mammals) can quickly report this information to FORCE.

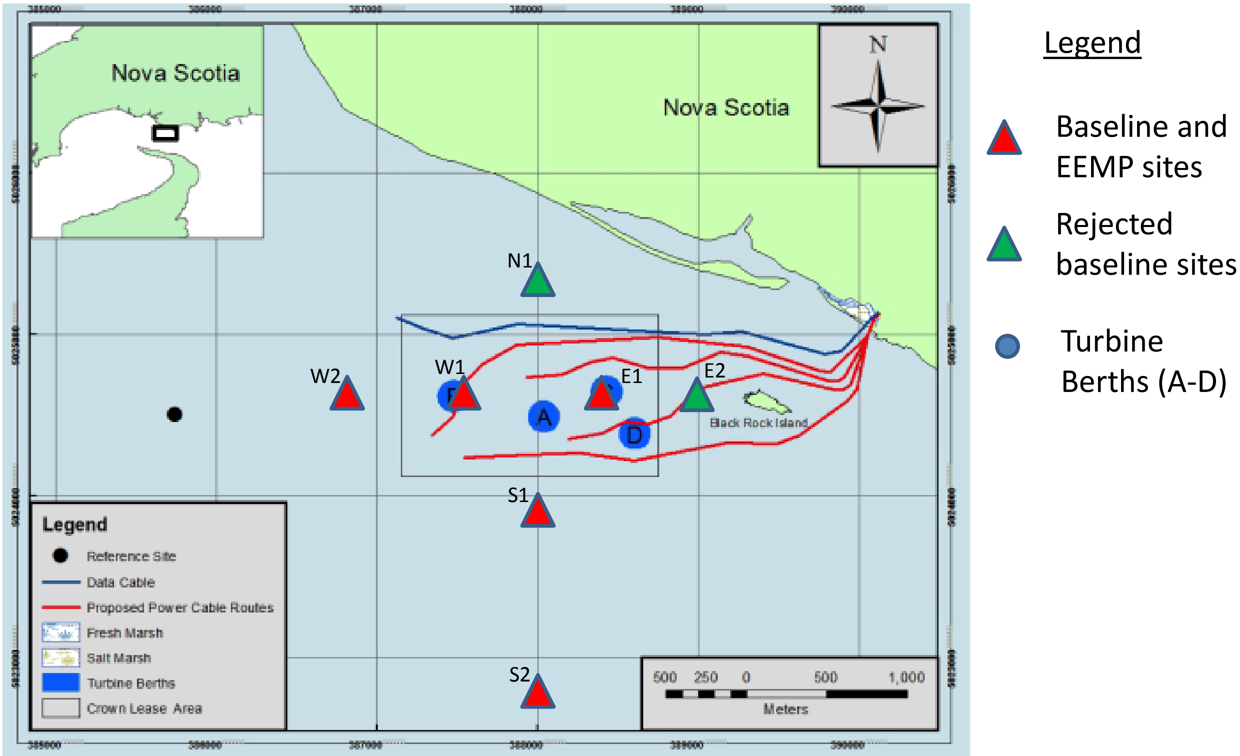

Figure 4-1: Location of past baseline (red and green triangles) and proposed EEMP C-POD monitoring sites in the mid field area (red triangles).

Table 4-1. Summary of Proposed EEMPs Methodology

Phase/Duration	Method Summary	Rationale/Reliability
Phase 1: 3 years (2016-2018) Phase 2: 4 years (2018-2021) Duration and scale dependent on Phase 1 results, noting as a minimum to include year 7 (2022), additional C-POD deployment across local area as per Phase 1	C-POD calibration: Pre-deployments each year. C-POD GLM trend analysis: a) Two C-PODs deployed in the mid field study area (red symbols in Figure 4-1), once in the spring and once in the fall for three months each deployment, 2016, expanded to 5 C-PODs for 2018 and 2022 if warranted by new deployments. b) One C-POD deployed >100 m from Berth D and one >100 m from any other occupied Berth, once in the spring and once in the fall for three months each deployment, 2016, 2017 & 2018 as necessary. Stranding program: Co-ordination with Nova Scotia Marine Animal Response Society, initially 2016, 2017 & 2018.	• Avoidance effects and large scale reductions/increases in relative use by porpoises is detectable, • C-POD deployments (housed in SUB-buoys) provide comparable before-after data, • Intermittent annual coverage but covers key time periods, • Baseline reference sites at East 2 and North 1 excluded as considered sub-optimal. • Adequate area coverage, but low-moderate risk of C-POD failure or loss

Table 4-2. Breakdown of Proposed EEMP Methodology and Adaptive Management Options

Objective	**Summary of Methodology**	**Rationale**	**Probability of Success and Challenges**
1) Detect change in **berth-specific** porpoise probability of occurrence (echolocation activity)	Variables: Change in occurrence (e.g., GLM echolocation activity trends in Julian Day and Day-Night DPM/10 min). Method: 1 C-POD deployed safely (100-150 m) next to a minimum of 3 turbines (site ideally south of each turbine). Duration: 2 deployments April 15-July15 and September 15-December 15. Other considerations: Calibration of new C-PODs required. C-POD ID should be consistent across sites, or aim to maintain consistent sensitivity.	• Long-term C-POD baseline occurrence rates within FORCE CLA should allow detection of large changes in activity (occurrence) in the vicinity of each berth.	• Good success in detecting large scale changes due to operating turbines, related to number of turbines monitored. • Collaboration with developer required. • C-POD failure/loss and near turbine deployment potential risk
2) Detect change in porpoise probability of occurrence (echolocation activity) **in the mid field area**	Variables: Change in occurrence (e.g., GLM echolocation activity trends in Julian Day and Day-Night DPM/10 min). Method: 2-5 C-PODs deployed at key mid field reference sites as in 2011-2014 gradient baseline study area (see red symbols in Figure 4-1). Duration: 2 deployments in years 1 and 3. April 15-July15 and September 15-December 15 Other considerations: Calibration of previously used and new C-PODs required. C-POD ID should be consistent across sites, or aim to maintain consistent sensitivity.	• Increased baseline study area coverage in year 1. • Long-term C-POD baseline rates should allow detection of large scale changes in mid field activity (occurrence). • Year 2 gap in monitoring program to permit increased site development.	• Good success in detecting large scale changes. • Lack of monitoring in year 2 reduces effects reporting and probability of detecting effect. • C-POD failure/loss potential risk. • Assumes robust baseline coverage achieved in year 1. • Consideration of turbine deployment locations and cabling in placement of C-PODS within FORCE CLA in years 3 and 7.

Objective	Summary of Methodology	Rationale	Probability of Success and Challenges
3) Assess if any increase in incidence of mortality events of marine mammals in the region can be attributed to collision	Variables: Frequency of regional carcass strandings and cause of death assessment. Method Opportunistic collection of stranded marine mammals through co-ordination with Nova Scotia Marine Animal Response Society. Pathological interpretation of cause of death of carcass. Duration: 3 years (continuous).	• Low incidence of stranded marine mammals to date. • Ability to detect unusual mortality events if they occur.	• Low chance of success, depending on public involvement and assuming predicted low likelihood of events occurring. • Inability to determine cause of death (C.O.D.) is a risk. • Adaptive triggers should ideally be pre-defined if C.O.D. identified as strike.
4) Possible adaptive management trigger 1: Large scale change in porpoise near-field occurrence	Extend C-POD monitoring duration by one year and consider 2nd C-POD deployment 400m away from turbine.	• Adaptive management trigger based on Phase 1 analysis with increase in monitoring intensity	• Definition of biologically meaningful (large-scale change) trigger point. • Unknown cost of monitoring plan.
5) Possible adaptive management trigger 2: Large scale change at multiple sites in porpoise study area occurrence	Extend C-POD monitoring duration by one year and consider enlarging study area coverage focussed on area of change	• Adaptive management trigger based on Phase 1 analysis with increase in monitoring intensity	• Definition of biologically meaningful (large-scale change) trigger point. • Unknown cost of monitoring plan.
6) Possible adaptive management trigger 3: COD considered	EMAC/Regulator review of information required. Review efficacy and future deployment of currently available monitoring systems (including AAM) to assess near-field dynamic interactions.	• Adaptive management trigger if dynamic interaction stressor risk identified	• Definition of biologically meaningful trigger point and current levels of acceptable risk. • Unknown cost of monitoring plan.

Objective	Summary of Methodology	Rationale	Probability of Success and Challenges
probable strike on 1 endangered species or regulator defined number of other species	Consider use of acoustic alarms deployed on turbines (Wilson et al. 2013).		
7) Possible adaptive management trigger 4: External and relevant EEMP studies provide empirical evidence of significant risk to porpoises (or other key marine mammals found in the study area)	EMAC/Regulator review of information required. Acoustic effects: Extend C-POD study area monitoring duration and increase coverage of mid field study area if wide-scale effects documented. Near-field dynamic effects: Review efficacy and future deployment of currently available monitoring systems (including AAM) to assess near-field dynamic interactions. Consider use of acoustic alarms deployed on turbines (Wilson et al. 2013).	• Adaptive management trigger if turbine stressor risk identified and risk considered significant	• Definition of biologically meaningful trigger point and current levels of acceptable risk. • Issues identified in other studies may be site specific or turbine specific.

5.0 SECTION 5: ACOUSTICS (MARINE NOISE)

5.1 Introduction

It has been established that underwater noise may affect certain benthic organisms, fish, cetaceans and other marine mammals, although the type and intensity of noise generated by the different tidal energy devices is not well understood (Cada *et al.* 2007). This is due to the lack of in-water operating hours on most devices and a related lack of concentrated effort to determine their acoustic characteristics. The noise generated by a given device has the potential to induce behavioural changes on marine wildlife in the near- and mid-field marine environment.

Marine mammals and fish, particularly those with swim bladders, may be sensitive to increased noise levels (**Table 5-1**). Fish rely on sounds to communicate, forage, find a mate, and defend themselves. Eggs and larvae may be more susceptible to noise sources since they have no avoidance capabilities (Degraer *et al.* 2013).

Table 5-1: Noise Sensitivities of Select Marine Biota

Organism	Noise Threshold	Source
Fish	• 192 dB (1 µPa) – transient stunning; • 200 dB (1 µPa) – internal injuries; • 220 dB (1 µPa) – egg/ larval damage • 230 – 240 dB (1 µPa) – fish mortality	Turnpenny and Nedwell 1994
Harbour porpoise	Avoidance displayed at noise levels exceeding140 dB re 1 µPa (broadband)	Southall *et al* 2007
Cetaceans and Pinnipeds	120 dB (re 1 µPa) is considered Level B harassment under the US Federal Marine Mammal Protection Act	PUD 2012
Lobsters	None	NERC 2013 PUD 2012
Seabirds	No data	RPS 2011 Leopold and Imares 2009. Turnpenny and Nedwell 1994

The tidal turbines proposed for installation at the FORCE demonstration site have large, moving parts and will naturally generate noise. Additional noise will be generated during installation, maintenance and retrieval. Installation in particular presents the possibility of significant (but temporary) noise levels during the placement of gravity base foundations, moorings and especially monopiles (Degraer *et al.*

2013). While no monopiles are planned at this time, it is possible that such foundations will be used in the future deployment of arrays of certain TISEC devices.

Within the 2009 EA, no specific noise level was identified as excessive or likely to cause significant impact. Instead, "significant impacts" with respect to noise are defined in relation to avoidance by, or injury to, marine birds, marine mammals, benthos and fish (AECOM 2009). Nevertheless, an EEMP to address noise is required as a condition of provincial and federal approval of the 2009 EA. The approval requires that the EEMP "*identify appropriate environmental effects indicators…and…consider project effects on* (among other subjects*) acoustics*."

To compare noise levels between devices and predict effects on marine biota, two critical data sets are needed: (a) the spatial and temporal distribution of ambient noise and (b) turbine device noise levels, often referred to as the device "noise profile" or "source levels". These levels can be assessed by conducting measurements of ambient noise and device broadband and narrowband source levels. The device developers will be providing information on their device noise profiles in order to compare noise levels between devices and predict effects on marine biota.

At the FORCE site it is impractical to measure sound levels at all locations and depths. Moreover, hydrophones deployed on the sea bottom measure noise at a single, near bottom point, which may not provide sufficient information to characterise sound conditions at depths frequented by fish and marine mammals. To overcome these limitations, acoustic modelling can be used over the longer term to predict sound levels at all locations, which in turn are verified by targeted point measurements undertaken to validate the model predictions.

Noise is particularly amenable to numerical modelling given adequate data related to physical oceanography, baseline noise levels, and turbine acoustic characteristics. Acoustic impact models have been successfully developed at other marine energy sites and used to retire risks associated with noise (Ward 2014).

While it is not anticipated that the noise generated by the initial demonstration-type turbine deployments at the FORCE site will have significant impact on marine biota due to their limited scale (AECOM 2009), noise data collected at the demonstration stage will provide information that can be used to predict effects on marine biota, further refine the fish and marine mammal EEMPs, and support an acoustic model over the longer term.

A fixed autonomous recorder with a sheltered internal hydrophone as developed by Martin and Vallarta (2012) appears able to differentiate turbine source noise from ambient sounds. The AMAR equipped Small FAST Platform can also potentially be used to collect pre- and post-deployment noise data, although its deployment schedule and overall research objectives have not yet been established.

The primary data gaps related to noise are the limited ambient noise data collected to date, the lack of operating turbines that can be subjected to noise assessment, and device specific "noise profiles" that must be provided by the device developers.

5.2 Objectives

Given the present lack of turbine "source noise profiles" for use in an acoustic model, and based on the summary presented in the Consultant's Report, additional field research is needed to define the most successful modeling approach and monitoring instrumentation for use in the Minas Passage.

Since the Consultant's Report was completed, the global perspective on collecting noise data suggests that the use of drifting hydrophones is the preferred approach (Norris *et al.,* 2014). In contrast to fixed instruments where water flowing over the microphone combined with the movement cobbles and pebbles along the seafloor combines to cause significant noise that can obscure the noise from turbines, drifting hydrophones move with the current and float above the seafloor. These characteristics prevent interference from both the sound of flow over the hydrophone and the sound of rock movement along the seafloor.

Over the short term, there is a need to:

- Determine the most appropriate acoustic model and related input data requirements;
- Test different instrumentation currently under development by local acoustic engineering firms for both drifting and bottom mounted devices;
- Conduct a drifting hydrophone test survey;
- Test the performance of off-the-shelf acoustic instruments and noise shielding techniques on the FORCE-owned FAST platforms in order to more fully establish baseline conditions.
- Using one or more of the instruments above and/or a drifting hydrophone approach, collect additional noise data with the CLA; and
- Use the noise data to eventually verify the EA predictions that suggest noise from operational turbines will not negatively affect marine biota.

For the purposes of this EEMP, we assume the acoustic characteristics of specific devices, including absolute broadband and narrowband source levels across their operating range, will be measured or determined by the device owners and this information will be shared with FORCE.

5.3 Methodology

In general, a drifting hydrophone that is acoustically isolated from its conveyance will provide better quality data than a hydrophone moored on the seabed or rigidly attached to a structure such as a turbine. Logistically, however, the deployment and collection of drifting hydrophones over a sufficient time period to adequately characterise the acoustic environment is highly labour intensive and this method requires additional effort to process measurements (Schmitt *et al.* 2015). Together, these factors can make drifting programs designed to establish baseline conditions and fully characterise the noise profile of an operating turbine more expensive than moored programs. Given this, moored hydrophones are initially proposed in this EEMP but drifting hydrophones are suggested as a longer term means to verify and validate data collected by a moored system.

In general, locating the hydrophone close to the device will improve the quality of measurements by increasing the measurement signal to noise ratio and simplifying requirements for acoustic channel modelling. Safety is the critical factor in determining how close a hydrophone can be deployed to an operating turbine. Deployment of a fixed hydrophone within 100 m of an operating turbine is optimal. This near-field monitoring within 100 m of the turbine is the responsibility of the berth holder.

In order to achieve the objectives outlined above, the following activities are proposed:

Collect ambient marine noise data

- Deploy a streamlined moored hydrophone system.. A deployment period on the order of one to two months should be considered to capture noise conditions over multiple tidal cycles.

- There is some evidence to suggest that shielded, streamlined hydrophones may in fact under-measure noise due to the actual shielding designed to reduce extraneous flow noise. To determine the accuracy of such a moored system, simultaneous drifting hydrophone measurements may be undertaken by FORCE for comparison and data validation. Alternatively, the hydrophone can be replaced with a drifting noise source emitting at known frequencies. The accuracy and sensitivity of the moored system can then be verified based on this noise source.

- Review data collected from hydrophones mounted on the turbines submitted in the the berth holder EEMP reports and integrate this data with future noise measurement programs and models.

- Identify an appropriate acoustic model to accommodate the data generated by the different instruments.

6.0 SECTION 6: MARINE SEABIRDS

6.1 Introduction

The EEMP for marine birds has been designed with reference to bird surveys previously undertaken at the site (FORCE 2011; 2014; 2015), existing guidance on survey methods and monitoring programs for tidal energy projects that are currently being undertaken both in Canadian and Scottish waters (see RPS 2010; Jackson and Whitfield 2011 and Robbins 2012). Ultimately however an adaptive management approach that allows for "flexible decision making that can be adjusted as outcomes from management actions and other events become better understood" is proposed for this program (FORCE 2015).

6.2 Objectives

To date, marine bird studies at FORCE have not been undertaken in the presence of a functioning tidal turbine; turbines are proposed for deployment beginning in 2016. The potential for direct collision by marine diving birds with tidal energy devices, or harmful effects caused by their presence, including the potential for displacement of marine wildlife from habitual waters, are the primary considerations addressed in this EEMP.

The main objective of this EEMP is to obtain robust site-specific species abundance and behaviour data which can be used to establish whether the installation, presence and operation of tidal energy devices causes displacement of surface-visible wildlife from habitual waters, and to identify any discernible changes to wildlife behaviour.

The EEMP proposed here extends previous monitoring programs and aims to:

- Obtain more data with respect to the occurrence and movement of bird species in the vicinity of the Project site to verify the existing findings of shore and boat based surveys; and
- Within the bounds of the current survey protocols, confirm EA predictions related to the avoidance and/or attraction of birds to vessels and tidal turbines.

6.3 Methodology

6.3.1 Monitoring Approach

Post-deployment monitoring studies at the FORCE site will aim, where necessary, to be more focused than the pre-construction baseline surveys already described. The focus will be on those species identified in the pre-deployment assessment process to be of concern although overall, bird densities in the Project area were found to be rather low in the context of the broader spatial distributions of birds within the Bay of Fundy.

The continuing monitoring program will aim to quantify the magnitude of any changes and provide evidence to demonstrate whether such changes, should they arise, can be attributed to the tidal energy development or whether they have occurred for other reasons.

Jackson and Whitfield (2011) note that post deployment monitoring studies should provide information on:

- Changes to the abundance, distribution or behaviour of species considered to be of high or medium conservation importance;
- The extent to which predicted adverse effects such as disturbance and collision mortality are realised; and
- The extent to which, over time, species affected by disturbance and displacement habituate to the presence of a development.

*6.3.2 **Study Design***

Although the study will need to be repeatable year on year, a degree of flexibility is required as the use of a site by marine birds is often highly variable and this can make it difficult to attribute changes to a particular cause (such as a single turbine deployment in the marine environment). If scientifically valid conclusions are to be drawn concerning the effects of development, study design must take into account natural variation and change due to other causes. If this is not done then the monitoring results are likely to be of little value as they are likely to lack the power to either detect change or identify the causes (Jackson and Whitfield 2011).

The post-deployment monitoring study will target the development site and the appropriate nearby areas already identified in the baseline surveys. The inclusion of a buffer around the main survey area will provide information on the birds using the area immediately surrounding a development.

As this project is 'near-shore' (<4 km) and <5 km^2 in total area, a buffer of at least 1 km is proposed.

*6.3.3 **Sampling Frequency***

The timing of shore-based survey visits will be planned so that they are as temporally representative as possible, including the three main temporal cycles: time of day, time of year and state of the tide. Although time of day is not generally regarded as a controlling factor for marine bird surveys, survey work will as far as possible be evenly distributed through the day from dawn to dusk where daylight hours allow.

Bird surveys are generally undertaken at monthly intervals throughout the year. Although there is variation between species, many marine birds follow a broadly similar annual timetable with regard to breeding, moulting, migration and wintering. Therefore, the survey timetable can reflect this, dividing the year up into periods based around the main annual stages, resulting in a survey that is less than monthly in frequency (**Table 6-1**).

Table 6-1: Example Periods for Marine Bird Surveys.

Year Period	Description	Approximate Dates
1	Mid winter	January and February
2	Late winter	February and March
3	Early breeding season	April – mid May
4	Mid breeding season	Mid May – mid June

5	Late breeding season	Mid June – end July
6	Post breeding/moult	August to mid September
7	Autumn	Mid September – October
8	Early winter	November and December

(source: Jackson and Whitfield 2011). Note: survey can *begin* at any time of the year but all sample events should be completed.

For the post deployment seabird EEMP, monitoring will be conducted throughout the year, based on the year periods described in Table 8-2. The annual program is shown on **Table 6-2**. The full methodologies for shore and boat based surveys are given in FORCE (2011) and will be continued where relevant for consistency and repeatability.

The broader survey area has already been characterised in terms of the spatial abundance of marine birds; these data are sufficient to provide the wider contextual picture of the avifauna surrounding the deployment site. As such no further boat surveys are proposed at this stage unless it is required that such surveys provide a continuous picture of bird abundance and distribution in the Minas Channel.

*6.3.4 **EEMP Field Surveys***

As noted above, the current observational monitoring of marine seabirds has provided a comprehensive four-year, pre-deployment data set using standardized field procedures and data interpretation guidelines. However, no turbines have so far been installed for a sufficient time to monitor its effects on marine seabirds. The recommended EEMP builds on this program.

Demonstration-scale tidal turbines will be deployed in phases over the next five years or so. Given the differing designs (and hence the potential for differing effects on marine seabirds) the proposed EEMP is designed to be flexible and adaptive to different turbine forms, deployment schedules and results from early studies.

The proposed EEMP begins once the first two bottom-mounted Cape Sharp Tidal Venture turbines are installed in 2016 and extends through 2017 when additional turbines are slated for installation. The EEMP will seek to repeat and augment the previous surveys undertaken between 2009 and 2012 but will focus on the deployment area more specifically.

*6.3.5 **Shore Based Surveys***

To account for the variability in the temporal span of shore based surveys between 2009 and 2012 it is proposed that future post deployment shore based surveys are repeatable and carried out during the same months on a year by year basis. The surveys will monitor the FORCE Project area including the FORCE test site, the area between Black Rock and shore (inside Black Rock), and the Minas Passage beyond Black Rock (outside Black Rock) as in previous years.

The pre-deployment surveys have identified specific periods of high abundance and diversity (albeit between years) with steady increases in abundance from Spring to early Summer (March to July) with a peak in June. After a period of low to moderate abundance between July and October numbers peaked again in the Fall in early November when local populations were supplemented by migratory movements through the study area. There were however data gaps with little information for the months of January, February, late August, September and October.

The EEMP shore based surveys will be focussed during the periods given in Table 6-1 to cover the whole annual cycle giving a total of 90 hours of observation, or about 16 days annually (**Table 6-2**).

Table 6-2: Marine Seabird Survey Schedule

Year Period	Month	Number of Surveys
1	January	1 (6 hours)
1-2	February	1 (6 hours)
2	March	1 (6 hours)
3	April	2 (12 hours)
3-4	May	2 (12 hours)
4-5	June	2 (12 hours)
5	July	1 (6 hours)
6	August	1 (6 hours)
6-7	September	1 (6 hours)
7	October	1 (6 hours)
8	November	2 (12 hours)
8	December	1 (6 hours)

Note: survey can *begin* at any time of the year but all sample events should be completed.

To ensure consistency with past studies and allow before-and-after deployment data set comparison, shore-based surveys will be undertaken from approximately high tide through the 6-hour period of the outgoing tide. Observation protocols will mirror those described in CWS (2007) and Wilhelm *et al.* (2008) (updated by Gjerdrum *et al.* 2012) for consistency with previous work.

In addition to following the monitoring protocols referenced above, observers will be instructed to record abnormal concentrations of seabirds suggestive of fish kills that may have resulted from turbine operation. It is recommended that the surveyors take a 30 minute break after the first three hour period to help prevent observer fatigue. The vantage point locations will remain the same. To help discern changes in bird activity that may be related to turbine deployment, the observers will record activity and approximate distances from the turbines (i.e., a 'distance to impact' approach).

A post deployment tidal site monitoring programme has been underway at the EMEC tidal test site at Fall of Warness, Eday in the Orkney Islands of Scotland. The survey effort here has been considerable, with some 909 hours of land based observations undertaken over the course of a single year. The method however is tried and tested and it is prudent to collect data is a similar fashion for the sake of maintaining a relatively standard approach to EEMPs at similar projects. With a view to informing any modelling approaches, it is recommended that the bird survey methods adopted by EMEC (2013) are used here.

The following information will be recorded for every seabird sighting made during the scans. Records should be limited to birds that are on the water or that are hovering directly above it (within a few metres), ensuring that the grid square to the location on the water below hovering birds is recorded. In this case the grid adopted is a 500m x 500m grid to ensure that surveys are carried out in a consistent and methodical fashion, ensuring the whole study area is covered.

- DATE Date of the watch.

- TIME Time of the sighting.
- SIGHTING EQUIPMENT The equipment used to sight the bird(s).
- GRID SQUARE The grid square to which the sighting was allocated.
- NUMBER OF SPECIES As birds often form mixed groups, provide the number of species within each group.
- SPECIES The species sighted. As it is often difficult to distinguish birds to species levels, the option is given to enter 'Unidentified '. Further details can be provided in the COMMENTS section.
- NUMBER Estimated total number of birds (regardless of species) in the group.

Details of the following bird behaviors should also be recorded. Any combination of them can be included.

- DIVING FROM FLIGHT One or more birds diving underwater from a hovering or flying position.
- DIVING FROM WATER One or more birds diving underwater from a position on the water surface.
- SWIMMING AT SURFACE The birds are making progress at the surface.
- STATIONARY AT SURFACE The birds are stationary at the surface.
- COMMENTS Any other relevant information about the sighting should be included here. This may include details such as a record of the age or sex classes of the birds (i.e., if there are any relatively small animals in the group or if there are predominantly males or females), and interactions with the turbines (resting, nesting, collisions, etc.).

6.3.6 ***Data Analysis***

In previous survey reports i.e. FORCE (2011) marine bird data has been analysed using two way analyses of variance (ANOVA) that considered the difference in marine bird abundance between sites and between years using density per km^2 as the unit of measurement. A similar method is proposed to assess any potential site specific effects, ensuring that where count data are not normally distributed (as is likely) then these data are either transformed to normality or an equivalent tool used for non-normally distributed data. Such a tool may include for example Mood’s median test or a Kruskal-Wallis test.

7.0 SECTION 7: SUMMARY

EEMPs have been created for five subject areas, based on work conducted to date and the lessons learned during baseline data collection.

1. Fish;

2. Lobster;

3. Marine Birds;

4. Marine Mammals; and

5. Acoustics.

Table 7-1 tentatively shows how each EEMP would be deployed on a year-to-year basis. The actual schedule of each EEMP will depend on a number of factors including weather conditions, device deployment schedule, vessel availability, etc.

As noted in the Introduction, the EEMPs are designed to be flexible and adaptive to the TISEC deployment schedules. In keeping with the "adaptive management" approach used since the beginning of the FORCE project, modifications to the EEMPs (if needed) can be implemented once the deployment schedule is better known. As more turbines are deployed, actual impacts may differ from impacts measured at single devices and the EEMPs can be adjusted to account for this.

FORCE's experience in Minas Passage has demonstrated how challenging it can be to undertake work in this high energy environment. Past work has also highlighted limitations to equipment types and monitoring approaches, and has demonstrated where additional exploration is needed. The EEMPs provide an initial, systematic approach to detecting environmental changes that can be attributed to the turbines. The results of these studies can be used by FORCE, their EMAC, the general public, regulators and the berth holders to first measure and then assess the likely environmental effects of their tidal energy devices.

Table 7-1: Summary of FORCE EEMP Scheduling

Subject	**2016**	**2017**	**2018**	**2019**	**2020**	**Comments**
Lobsters	Winter or Fall: One Survey (2-3 weeks)	Winter or Fall: One Survey (2-3 weeks)	--	Winter or Fall: One Survey (2-3 weeks)	--	• One survey consists of sampling all stations three times. • The number and timing of surveys will depend on fishing season, the deployment schedule and initial results.
Fish	Six months, beginning in April or May	Six months, beginning in April or May depending on initial results and provided new devices are deployed	Six months, beginning in April or May depending on initial results and provided new devices are deployed	Six months, beginning in April or May depending on initial results and provided new devices are deployed	Six months, beginning in April or May provided on initial results and provided new devices are deployed	• Each annual program consists of six surveys distributed over six months. • Each survey completed over a full tidal and diel cycle (25 hours). • Study duration of five years to capture multiple deployments.
Marine Mammals	Spring (3 months) Fall (3 months)	--	Spring (3 months) Fall (3 months)	--	2021: Spring (3 months) 2021: Fall (3 months)	• Two C-PODs at **reference sites** in 2016, 2018 and 2020. • Once in the spring and once in the fall. • Three months each deployment
	Spring (3 months)	TBD – Device	Spring (3 months)	TBD – Device	Spring (3 months)	• One C-POD at 100+m from **each occupied berth** • Once in the spring and once in the fall

Subject	2016	2017	2018	2019	2020	Comments
	Fall (3 months)	Dependent	Fall (3 months)	Dependent	Fall (3 months)	• Three months each deployment.
Acoustics (Marine Noise)	FAST: Spring/Summer (1-2 months)	Will depend on initial results	Will depend on ongoing results	Will depend on ongoing results	Will depend on ongoing results	• To capture ambient noise conditions over multiple tidal cycles.
Marine Seabirds	Monthly		TBD - Monthly	--	TBD - Monthly	• Typically 6 hours per observational event; total of 90 hours of observation; ~16 days annually. • Three years; can be extended if warranted

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