FORCE

Fundy Ocean Research Center for Energy

Environmental Effects Monitoring Report 2011-2013

CONTENTS

CONTENTS 2
EXECUTIVE SUMMARY 4
1 INTRODUCTION 8
2 PROJECT UPDATE 9
3 ENVIRONMENTAL EFFECTS MONITORING PROGRAM (EEMP) 11
4 SUMMARY OF MONITORING STUDIES AND PROJECTS FOR 2011-2013 14
4.1 SEABIRD MONITORING PROGRAM 14
4.1.1 Objectives and Study Design 14
4.1.1.1 Shore-based surveys 15
4.1.1.2 Vessel-based surveys 15
4.1.2 Findings 16
4.1.2.1 Baseline Data Collection Results: 2011 & 2012 16
4.1.2.2 Analysis of 2009-2012 Shore- and Vessel-based Survey Data 18
4.2 MARINE MAMMALS MONITORING 20
4.2.1 Study Objectives and Design 20
4.2.1.1 Shore- and Vessel-based Visual Surveys 20
4.2.1.2 Passive Acoustic Monitoring 21
4.2.2 Findings 22
4.2.2.1 Shore- and Vessel-based Visual Surveys 2011 and 2012 22
4.2.2.2 Analysis of 2009-2012 Shore- and Vessel-based Visual Survey Monitoring Data 23
4.2.3 Passive Acoustic Monitoring: 2011 & 2012 25
4.2.3.1 Technology Comparison Results 25
4.3 FISH CHARACTERIZATION 26
4.3.1 Objectives and Study Design 26
4.3.1.1 Acoustic Tracking 26
4.3.1.2 Weir Fisheries Surveys 28
4.3.2 Findings 28
4.3.2.1 Acoustic Tracking 28
4.3.2.1 Weir Fisheries Surveys 31
4.3.3 Over-Wintering Fish Populations 33
4.4 LOBSTER TRACKING 34
4.4.1 Objectives and Study Design 34
4.4.2 Findings 35
4.5 ACOUSTIC ENVIRONMENT 36
4.5.1 Study Objectives and Design 36
4.5.2 Findings 37
4.6 BENTHIC HABITAT MONITORING 38
4.6.1 Objectives and Study Design 38
4.6.2 Findings 38
4.6.2.1 Species Distribution 39

4.7 ELECTROMAGNETIC FIELDS ____ 39
4.7.1 Study Objectives and Design ____ 39
4.7.2 Findings of Review and Risk Assessment ____ 40
4.7.2.1 Potential EMF emission levels from FORCE cables ____ 40
4.7.2.2 Sensitivity and Exposure to marine organisms in Minas Passage ____ 40
4.7.2.3 Potential Impacts to Minas Passage Species ____ 41
5 CONCLUDING REMARKS ____ 43
6 APPENDICES ____ 44

List of Appendices

Appendix A Seabird and Marine Mammal Surveys 2011
Appendix B Seabird and Marine Mammal Surveys 2012
Appendix C Passive Acoustic Monitoring of Cetacean Activity and Movement in Minas Passage: Pre-Turbine Baseline Conditions (2011-2012)
Appendix D Acoustic Tracking of Fish Movements in the Minas Passage and FORCE Demonstration Area: Pre-turbine Baseline Studies (2011-2013)
Appendix E 2013 Investigation of Temporal Patterns in Fish Presence and Abundance at Intertidal Weirs in Minas Basin, Bay of Fundy
Appendix F Minas Passage Lobster Tracking Study 2011-2012
Appendix G Acoustic (Noise) Monitoring in the Bay of Fundy
Appendix H Bottom Substrate and Associated Epibenthic Biota of the FORCE Tidal Energy Test Site in Minas Passage
Appendix I Assessment of Potential Ecosystem Effects from Electromagnetic Fields

ACKNOWLEDGEMENTS

FORCE would like to thank and acknowledge the important contributions of Joseph Kozak (contractor to FORCE) and Lisa Isaacman of the Fundy Energy Research Network (FERN) in preparing this Report; and to the members of FORCE's Environmental Monitoring Advisory Committee (EMAC) for their review and input. We would also like to acknowledge the scientific and engineering consultants and others who conducted important work on behalf of FORCE in 2011, 2012 and 2013, including: Acadia University, Atlantic Marine Geological Consulting Limited, CEF Consultants Ltd., Envirosphere Ltd, JASCO Applied Sciences, Seaforth Geosurveys Inc., Darren Porter (weir operator) and the Sea Mammal Research Unit Limited (SMRU).

EXECUTIVE SUMMARY

FORCE is Canada's leading research centre for the demonstration and evaluation of tidal in-stream energy conversion (TISEC) technology. A key component of FORCE's mandate is to act as a watchdog regarding the environment. If TISEC technology is to grow to a larger, commercial scale project, development must happen safely. As turbines are deployed in the Minas Passage, FORCE is committed to understanding what effects they have on the environment, and reporting those effects to the public.

This is the second Environmental Effects Monitoring (EEM) report for the FORCE demonstration project and provides an overview of the EEM studies and projects completed in 2011 to 2013.

The first EEM report, which was released in November 2011, covered the period from September 2009 until January 2011. During a major portion of this period, the Nova Scotia Power Inc./OpenHydro (NS Power/OpenHydro) turbine was deployed at the FORCE site. The NS Power/OpenHydro turbine was retrieved in December 2010, and until the deployment of a data cable in December 2013, there were no turbines or cables in the water at FORCE.

The Environmental Effects Monitoring Program (EEMP) continued through 2011-2013 in spite of an absence of turbines, with studies focused on collecting background data and investigating monitoring approaches and technologies for use in high-flow environments that could be employed for future EEM programs at the FORCE site. Essentially, this report contains baseline information that will be used with current and future studies to address environmental effects of turbines installed at FORCE.

This report provides a detailed summary of the studies, including goals/objectives, description and the key findings. The findings are those of the study authors/investigators, as is any interpretation or analysis. The studies included monitoring and research activities on seabirds, marine mammals, lobster and fish tracking and movements, marine acoustic environment, benthic habitat and electromagnetic fields (EMF). As in previous years the difficulties of monitoring in a high flow environment challenged the consultants undertaking the studies. The full study reports are attached as Appendices.

Although the EEMP is a work in progress, the studies and reviews over the past few years have added to the body of knowledge regarding the Minas Passage environment and potential monitoring protocols. FORCE recognizes that additional studies are required as part of the "adaptive management" approach - a strategy recommended in FORCE's Environmental Management Plan (EMP) and adopted by DFO. The following highlights the key findings and general observations for the studies completed during this reporting period:

Seabirds: Building on the previous studies in 2009 and 2010, the visual surveys recorded the presence of 47 water-associated bird species in and around the FORCE site using standard seabird observation protocols. Seabird abundance near the FORCE site is considered to be low to moderate relative to rest of the Bay of Fundy. Peak times for abundance and diversity of water-associated birds in the Minas Passage study area appear to be during the spring and fall migration. Diving birds, some species of which are capable of diving to depths of 100 m, were found to be present at the FORCE site year round in very low numbers; however the majority seen in the Minas Passage dive to depths of 10-40 metres.

Marine Mammals: As with previous surveys, the visual observation surveys in 2011 and 2012 confirmed that the harbour porpoise is the dominant marine mammal species observed at the FORCE site. Harbour porpoise were observed most frequently in the area during spring, which is likely associated with herring migration. The presence of a limited number of grey and harbour seals, one white-sided dolphin, and one unidentified whale (west of the FORCE site) were also recorded.

In addition to visual observations for marine mammals, passive acoustic monitoring (C-POD hydrophone) technology was used from 2010 (pilot study during the turbine deployment) to 2012 to assess activity patterns and temporal behaviour in and outside the FORCE site for dolphins and porpoises. C-POD data collected from 2010 to 2012 show a daily but typically low level presence of harbour porpoise in the Minas Passage, and that harbour porpoises are the dominant species. Porpoise presence was highest during the month of May and lowest during the months of July and August coinciding with the seasonal movement of the summer harbour porpoise population into the Bay of Fundy. A one-month pilot study was operated in 2012 to compare the performance of two hydrophones technologies (C-POD and icListenHF). The study showed that flow-induced noise, which varies with tidal height and current speed, limits harbour porpoise detection by both the icListenHF and C-POD hydrophones, especially during spring tide cycles.

Fish Characterization: This study used acoustic transmitters and bottom-moored receivers to track the movement of four species of fish - Atlantic Sturgeon, inner Bay of Fundy Atlantic Salmon, Striped Bass and American Eel. As with previous studies and literature reviews, the results show that the Minas Passage and FORCE site represent an important migratory corridor for all fish species examined. Atlantic salmon post-smolts traversed the passage in late May to mid-June en route to the Bay of Fundy and beyond. American eels exited the Minas Basin via the Minas Passage during mid-September to mid-November, mostly at night during ebb tide and in the top 30 m of the water column. Atlantic sturgeon entered Minas Basin (summer feeding grounds) via Minas Passage in the spring, and exited in the fall, with sporadic use of Minas Passage throughout the summer. Movements in and near the FORCE site showed a preference for depths ranging from 15 to 35 m. Striped bass spent more time in the Minas Passage and near the FORCE test area than any of the other fish species examined. Residency spanned summer, fall and winter and were mostly in the top 40 m of the water column, and located closer to the surface during the night.

An intertidal weir fishery study was undertaken from April to August 2013 to examine the application of weir catches in assessing temporal patterns in fish presence and abundance in the region. Twenty eight species of fish were identified from the weir catches, which consistently featured large numbers of clupeids and flatfishes. The most abundant species were herring and flounders, with fish abundance varying over the season and significantly greater during low tides falling at night. The approach may be useful for monitoring fish assemblages and distribution patterns in the broader Minas Passage and Minas Basin areas, but limited in addressing potential fish interaction with turbines.

Lobster Tracking: This study assessed the use of acoustic transmitters and bottom-moored receivers for recording the movement of tagged lobsters in the FORCE site and Minas Passage. The majority of the fall/early winter tagged lobster detections indicated a westward migration out of the Minas Basin hugging the northern shore of the Minas Passage. Preliminary results suggest that some lobster may remain in the Minas Basin over the winter. The study demonstrated that tagged lobsters can be detected by bottom-moored receivers within turbulent, tidal environments such as the Minas Passage, but that ambient environment noise affects the level of detection efficiency.

Acoustic Environment (Marine Noise): Previous studies using drifting and suspended hydrophones were unsuccessful in measuring marine noise due to the interference from tidal flow, vessels and equipment. In this study, a modified high flow mooring and a streamlined float-based mooring with hydrophones were placed in various positions to test different system designs. The high flow mooring system was successful at collecting quality acoustic data over the full testing period and in recording noise background levels at the FORCE site and Reference site. A further analysis of the data was performed and determined that the high flow monitoring system was capable of measuring ambient and turbine sound, at levels that may disturb marine organisms.

Benthic Habitat: This study analyzed in more detail, the benthic fauna and associated seafloor habitat photos previously collected at the FORCE site, as a baseline to examine any effects as cables and turbines are deployed in the future. It confirmed the low biodiversity of macrofauna at the FORCE site with yellow breadcrumb sponge as the most dominant species. Other commonly observed macrofauna include two species of seastar and northern red anemone. The cable routes and shallow regions of the FORCE test area (<15 m) support seaweeds, macroalgae and greater amounts of fine grained, sandy sediment. In deeper areas (>25 m), few species of macrofauna are present, limited to sessile epifauna, or epifauna with limited mobility. No “at risk” species were observed. It was suggested that, due to the low biodiversity and abundance of sessile macrofauna, the installation of TISEC infrastructure is unlikely to negatively impact benthic communities.

Electromagnetic Fields (EMF): A detailed literature review of current scientific knowledge was conducted to evaluate the potential risk of EMFs from turbines and power cables on marine organisms in the Minas Passage. While rigorous studies to date have been limited, the current literature suggests that EMFs generated by FORCE’s subsea cables or tidal turbines pose a minimal risk of causing direct injury or adverse physiological effects to even sensitive marine organisms. Current knowledge suggests that EMFs from subsea cables may interact with sensitive species if their migration or movement routes take them over the cables, particularly in shallow waters (<20 m). However, the strength of detectable EMFs is known to dissipate rapidly the farther the distance from the source. Significant effects from EMFs, such as disruption to migration or population-scale effects, have not been documented in any species in response to existing subsea transmission cables anywhere in the world (many of which with higher power levels and located in more moderate ocean current conditions than the FORCE project). Thus, in the high currents of the Minas Passage, any effects are expected to be localized to near the cable and of short duration. Although considered a low risk, it is recommended that FORCE track the US studies that are currently underway on the sensitivity of American Lobster to EMF.

Using the results from these studies, and those reported in the first EEM Report, FORCE and the Environmental Monitoring Advisory Committee (EMAC) will further analyze the results, with the assistance of third party expertise, to design an EEM program for implementation before the deployment of the next turbine. This approach is consistent with the principle of adaptive management agreed to in discussion with the responsible federal and provincial agencies.

1 INTRODUCTION

This second EEM Report for FORCE is based on the EEM program covering the period from January 2011 to December 2013. This report includes results from all the EEM studies completed in 2011, 2012 and 2013, with the exception of the side-scan sonar survey which was reported in the first EEMP Report (FORCE, 2011). Many of these studies are a continuation of projects initiated in 2010 or 2011 projects, which were multi-year research activities.

Since there were no TISECs or cables deployed in the FORCE demonstration area during this period, the studies undertaken were still, in most cases multi-year in nature. Therefore, with no technology operating at the site, the EEMP focused on:

(i) continuing to gather background information for in the marine environment;
(ii) the completion of multi-year projects initiated in 2010 or 2011;
(iii) ongoing evaluation monitoring employed during that period; and,
(iv) public record of the ongoing environmental effects monitoring program at the FORCE site.

EMAC recognizes the limited options available for EEM monitoring in the Minas Passage, an extremely high-flow environment (up to 6 m/sec), and therefore, recommended that FORCE take the time to undertake a thorough examination of the monitoring and research studies completed to 2013. As result, no EEM program was recommended for 2014. EMAC did recommend focused evaluation of the existing information, with the intent of defining measurement technologies and protocols to be used in future FORCE EEM programs.

2 PROJECT UPDATE

Presently, the FORCE project consists of four undersea berths for TISEC subsea turbine generators (to be installed), four subsea power cables connecting the turbines to land-based infrastructure, an onshore transformer substation, and power lines connecting to the local power distribution system. The marine portion of the project is located in a Crown Lease Area, 1.6-km by 1-km in area, in the Minas Passage near Black Rock, and the onshore facilities are on leased lands on the West Bay Road approximately 10 km West of Parrsboro.

Presently, all four FORCE berth sites are associated with tidal developers: Atlantis Corp, Minas Energy Inc., Open Hydro, and Black Rock Tidal Power.

Figure 1 shows 2014 plans for the FORCE facility in the Minas Passage, including the marine demonstration area and berth sites, cables routes, data cable, EEM Reference Monitoring Site and onshore facilities.

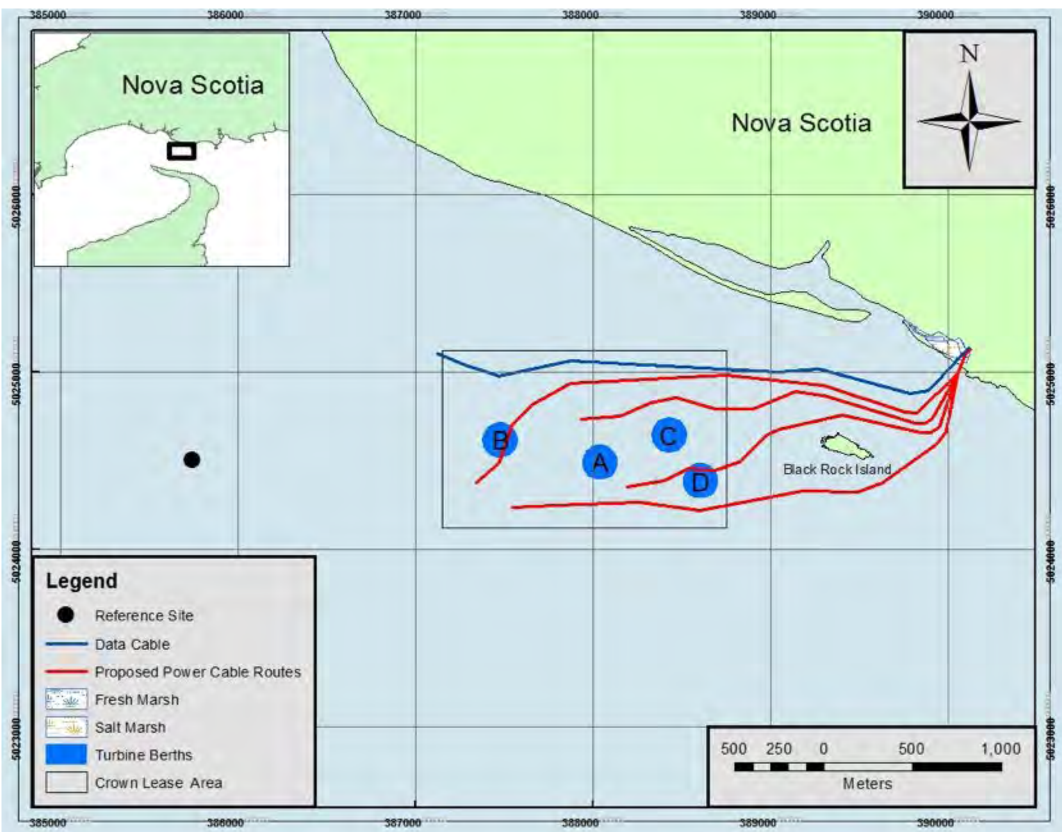

Figure 1: FORCE Site and Monitoring Reference / Control Site

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

The construction of land-based facilities, beginning with the FORCE Visitor Centre was started in February 2010. Subsequently, construction was initiated on a FORCE substation; and, a transmission line from this substation to the Parrsboro substation. All the land-based facilities were completed in 2012.

After the experience gained from the NSPI/OH turbine deployment, it was recognized by FORCE and the berth holders that additional information on the current profiles and other physical data were required. As a result, the schedule for the next turbine deployment was moved forward to incorporate further design considerations. This allowed FORCE additional time to plan and rehearse the submarine power cables.

FORCE successfully installed a data cable in mid-December 2013. The data cable is designed to eventually connect to a recoverable underwater research platform, called the Fundy Advanced Sensor Technology platform (FAST) project being developed by FORCE. The objective of the FAST project is to test multiple under water instruments to measure environmental and physical parameters for application in high-flow environments. The FAST project will take a number of years to implement, but over time should help to enable improvements in technology to measure environmental effects on or near subsea turbines.

As well, to further support operational, research and monitoring activities, the following instrumentation was installed at the FORCE site:

- a weather station was installed in cooperation with the Nova Scotia Community College (September 2013);
- a digital tide gauge was deployed (August 2013); and,
- an X-band radar system was installed in a joint project with Acadia University, to generate maps of surface currents and wave fields (August 2013).

More detailed descriptions of FORCE and its activities, including previous reports, EMAC EEM recommendations and the FAST project, are available at the FORCE website: www.fundyforce.ca.

3 ENVIRONMENTAL EFFECTS MONITORING PROGRAM (EEMP)

An Environmental Effects Monitoring (EEM) program is essentially the repeated measurement of specific parameters to test assumptions or predictions of a Project on the environment. At its most basic, an EEM program seeks to establish or disprove a cause-effect relationship between a specific project activity and specific environmental effect.

In the case of the FORCE project, the parameters or issues to be measured were identified in the Environmental Assessment Registration Document, reviewed and approved under the joint federal and Nova Scotia environmental assessment process.

In consideration of Minas Passage's dynamic environment and the limited monitoring methodologies available for high flow environments, it was recognized by the regulators and Environmental Monitoring Advisory Committee (EMAC) that the EEMP for the Demonstration Project should use an adaptive management approach. Adaptive management is a decision process that promotes flexible decision making that can be adjusted as outcomes from management actions and other events become better understood. The adaptive management approach recognizes the unique and severe physical environment of the Minas Passage and the need to coordinate research data collection and reporting between researchers. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Simply stated, adaptive management is an iterative process of planning and implementing an action, monitoring, evaluation, and making adjustments as needed.

The final EEMP implemented during this period was modified based on advice from the Environmental Monitoring Advisory Committee (EMAC). EMAC was established as one of the conditions of the EA Approval. The Committee consists of independent science experts and stakeholders, including fishers and First Nations representatives. The final EEM plan is provided in Table 1, which summarizes the field components of the Plan for the period from January 2011 to December 2013.

The EEMP was implemented by a number consultants working on behalf of FORCE. To maximize funding and optimize delivery, several of the EEMP studies were expansions by FORCE on monitoring research projects already underway and supported by the Offshore Energy Research Association and/or Acadia University.

Table 1: Summary of 2011 to 2013 EEM Program

EEM PARAMETER	LOCATION	METHOD	2011-2013 SURVEY TIMING
Seabirds	Minas Passage & Crown Lease Area	From shore & vessel observations – CWS Standard protocol Analysis of 4-year program (2009-2012)	Spring, Summer & Winter 2011 Summer 2012
Marine Mammals	Minas Passage & Crown Lease Area	From shore and vessel observations – Standard protocol Analysis of 4-year program (2009-2012)	Spring, Summer & Winter 2011 Summer 2012
	Crown Lease Area	Passive acoustic monitoring – C-POD & IcListen hydrophones	May– Nov 2011- 2012
Lobster Fishery	Minas Passage & Crown Lease Area	Acoustic tagging/tracking –using VEMCO transmitters and receiver lines installed for fish tracking	Nov.-Dec. 2011; Apr. 2012 – Oct. 2013
Fish Movements	Minas Passage & Crown Lease Area	Acoustic tagging / tracking – Acoustic telemetry receiver lines & VEMCO transmitter	May-Nov 2011 May 2012-June 2013
	Minas Passage/Basin	Weir Fisheries – 2 weirs located on Noel and Parrsboro shores	Apr.- Sept. 2013
	Minas Basin	Gill netting	Dec. 2012
Acoustic Environment (Noise)	Reference Site & Crown Lease Area	Hydrophone – Mounted on Bottom Platform	Sept/Nov 2011 & Feb 2012
Benthic Environment	Crown Lease Area & Cable Routes	Analysis of 2008 & 2009 bottom video/still photos	NA
Electromagnetic Fields (EMF)	International/Canada	Literature Review /Analysis	NA

Fisheries and Oceans Canada provided comments on FORCE's 1st EEM report, and FORCE provided a response to their comments and both are available on FORCE's website. Although the key DFO comments related to fish surveys were not addressed under the 2011/2012 program mainly due to timing issues, these are underway in 2013. A weir fisheries study, in cooperation with Acadia University was initiated in April 2013, with the analysis completed in 2014.

The objective of an EEMP is to determine if the original EA predictions are correct. However, there have been a number of challenges facing the program at the FORCE, in particular the lack of measurement technologies that can be used in high flow environments, limited background data for various species, and the lack of an operational turbine at the site.

The goal of this, and the first EEMP report, was not only to collect background data and identify/measure environmental effects, but also to assist FORCE in designing a future monitoring EEM program as turbines are installed at the site.

As studies were completed, the reports were provided to EMAC for their review and feedback. Within the context of this report, EMAC was asked for their advice regarding data and information gaps, and appropriate monitoring approaches for the future based on the studies completed to date.

4 SUMMARY OF MONITORING STUDIES AND PROJECTS FOR 2011-2013

The following Sections provide an overview and outcomes from EEM studies and relevant research projects undertaken during the period from January 2011 to December 2012. These interim and final reports were provided to EMAC, as well as NS Environment and Fisheries and Oceans Canada (DFO) as these became available for their ongoing review and advice, and to assist them in making recommendations for a future EEMP program as turbines are deployed in the demonstration area.

The complete reports for all the field studies and background information are included in the Appendices, and are available to the public as full reports on the FORCE website.

In addition to the aforementioned challenge of environmental monitoring in the dynamic tidal environment of the Minas Passage, many of the studies were hampered by the limited availability of vessels to deploy and retrieve instrumentation or run survey routes.

4.1 SEABIRD MONITORING PROGRAM

4.1.1 Objectives and Study Design

Goal: *Collect pre-deployment (baseline) data on seabird presence and activity using visual survey techniques*

From 2009 to 2012, Envirosphere Consultants carried out a comprehensive observer-based monitoring program to gather information on seabirds in the vicinity of the FORCE tidal energy demonstration site. The goal of the monitoring program was to provide baseline information on seasonal occurrences and abundance of seabird and waterfowl species, particularly diving birds, at the FORCE test site in the Minas Passage (and adjacent Minas Basin and Minas Channel areas) to aid in determining potential impacts of turbine installation. Marine mammal observations were also recorded during these surveys.

The results of the 2009-2010 surveys are reported in the 1st EEMP report[1]. The surveys conducted in 2011 and 2012 extended the seasonal coverage of baseline data, which now extends from early March to late December. This report includes results of the 2011 and 2012 surveys, as well as an analysis of the entire four-year data set.

The monitoring program in 2011 consisted of six one-day shore-based observational surveys (March-April & December) of Minas Passage (Minas Passage study area), including the FORCE crown lease / turbine test site, and two vessel-based surveys (late July and late August) in the

[1] FORCE. 2011. *Fundy Tidal Energy Demonstration Project: Environmental Effects Monitoring Report*

Minas Passage study area and outer Minas Basin and Minas Channel. In 2012, there were six, one-day shore-based observational surveys (June-August) and three vessel-based surveys in mid-July, late July and early/mid-August. A feature of the 2012 surveys was the pairing of some shore-based and vessel surveys to give an indication of the performance of these different survey types at the same time of year (see Reports in Appendices A and B)

4.1.1.1 Shore-based surveys

Shore-based surveys ran from approximately high tide through the 6-hour period of the outgoing tide. Observations were made by eye from the FORCE Interpretive Center. The observer scanned a defined area within Minas Passage several times during successive 30-minute periods, noting all birds seen along with location, maturity, and activity (flying, on water, feeding etc.). This provided an estimate of total number of unique bird sightings per period, and a breakdown by distribution in local areas of significance (FORCE test site, area between Black Rock and shore [inside Black Rock], and the Minas Passage beyond Black Rock [outside Black Rock]). For subsequent analysis and interpretation, the average number of birds of each species per period based on all 30-minute periods was used to summarize bird occurrence on each survey.

4.1.1.2 Vessel-based surveys

The survey route was designed to provide coverage of: the Minas Passage study area and areas to the east (Minas Basin) and west (Minas Channel); both nearshore areas and along the axis of Minas Passage-Minas Channel; and daily movements of birds within the general area (e.g. for feeding). Survey times were chosen to catch high tide early in the morning to allow a full tidal cycle during daylight hours and mostly the objective was achieved. A standard watch for seabirds was carried out, modeled after a Canadian Wildlife Service seabird monitoring protocol. A ‘snapshot’ sampling approach was used for flying birds, although all flying birds seen in the observation period were counted. Watches of 5-minute duration were conducted every 10 to 15 minutes in most locations and continuously (every five minutes) at the FORCE test site. The observer monitored the 300 m wide strip of water and air approached by the vessel, alternating sides on successive cruises. Information recorded included counts, species identification, stage (adult, immature, juvenile etc.), distance, and birds observed beyond 300 m. Observation conditions were generally good, with some patchy fog experienced in the August surveys of both years.

4.1.2 Findings

4.1.2.1 Baseline Data Collection Results: 2011 & 2012

During the 2011 and 2012 shore-based surveys, 29 (1516 individuals) and 23 (1078 individuals) species of water-associated birds were observed in the Minas Passage study area, respectively (Table 2). Due to the focus on summer sampling in 2012, seven species of shorebirds were observed in 2012 in the Minas Passage study area, which had not been recorded in previous years. Abundance varied by month and location (Figure 2). Although a moderate number of species occurred in all 2011 surveys, the greatest number of species was observed during spring migration in mid- to late-April. Species which occurred regularly in Minas Passage off the FORCE test site throughout most of the survey period in 2011 included American black duck, common eider, scoters (white-winged, surf and black), red-breasted merganser, great black backed and herring gull, black guillemot and red-throated loon. In 2012, when the focus was on summer sampling, the greatest number of species was observed in early- to late-August. Species which occurred regularly in the Minas Passage in summer 2012 included herring and great black-backed gulls, black guillemot, common eider, common loon and double-crested cormorant.

In the summer vessel surveys in 2011 & 2012, eight (144 individuals) and nine (235 individuals) species of seabirds and waterfowl were sighted, respectively, covering parts of Minas Basin, Minas Passage and Minas Channel. Abundances of seabirds and waterfowl seen on vessel surveys in 2012 were lower than previous years overall, although mid-July abundances were relatively high and comparable to earlier years, while abundances in August were particularly low.

Table 2: Species identified in shore-based (SB) and vessel-based (VB) surveys, 2011 and 2012

SEABIRDS		**WATERFOWL**		**SHOREBIRDS (SB)**
2011	**2012**	**2011**	**2012**	**2012**
▪ Double-Crested Cormorant (SB, VB) ▪ Great Cormorant (SB) ▪ Herring Gull (SB, VB) ▪ Great Black-Backed Gull (SB, VB) ▪ Iceland Gull (SB) ▪ Bonaparte's Gull (VB) ▪ Lesser Blacked-Backed Gull (SB) ▪ Ring-Billed Gull (SB, VB) ▪ Black Guillemot (SB, VB) ▪ Northern Gannet (SB, VB) ▪ Razorbill (SB) ▪ Horned Grebe (SB) ▪ Black-Legged Kittiwake (SB) ▪ Thick-Billed Murre (SB) ▪ Common Murre (SB)	▪ Double-Crested Cormorant (SB, VB) ▪ Great Cormorant (SB, VB) ▪ Herring Gull (SB, VB) ▪ Great Black-Backed Gull (SB, VB) ▪ Ring-Billed Gull (SB, VB) ▪ Black Guillemot (SB, VB) ▪ Northern Gannet (SB) ▪ Black Tern (SB) ▪ Cory's Shearwater (SB) ▪ Greater Shearwater (SB) ▪ Sooty Shearwater (SB) ▪ Razorbill (VB) (one individual)	▪ Common Loon (SB, VB) ▪ Pacific Loon (SB) ▪ Red-Throated Loon (SB) ▪ Red-Breasted Merganser (SB) ▪ Common Merganser (SB) ▪ Common Eider (SB) ▪ King Eider (SB) ▪ American Black Duck (SB) ▪ Long-Tailed Duck (SB) ▪ Canada Goose (SB) ▪ Northern Shoveler (SB) ▪ Common Goldeneye (SB) ▪ Surf Scoter (SB) ▪ Black Scoter (SB) ▪ White-Winged Scoter (SB)	▪ Common Loon (SB, VB) ▪ Pacific Loon (SB) ▪ Red-Throated Loon (SB) ▪ Red-Breasted Merganser (SB) ▪ Common Eider (SB, VB)	▪ Ruddy Turnstone ▪ Red Phalarope ▪ Red-Necked Phalarope ▪ Sanderling ▪ Semipalmated Sandpiper ▪ Spotted Sandpiper (seen on Black Rock only) ▪ Greater Yellowlegs (seen on Black Rock only)

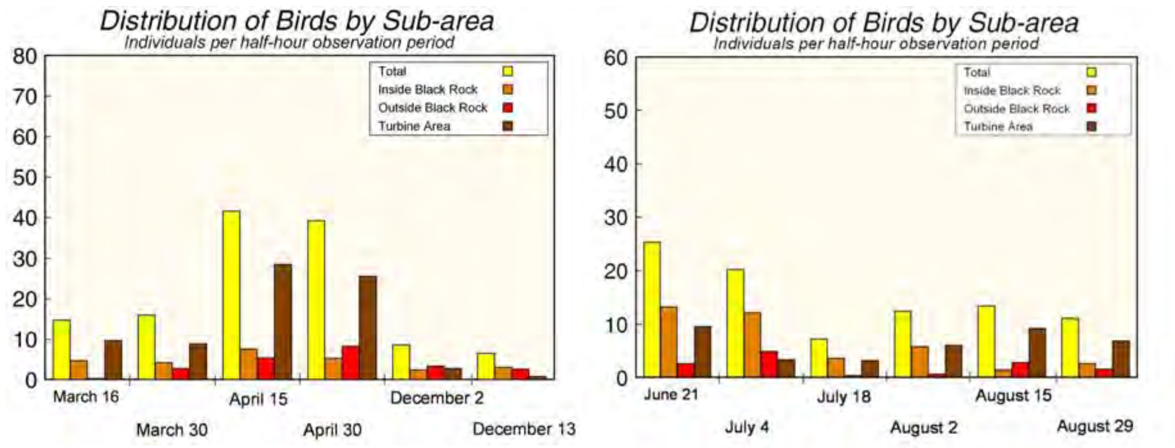

Figure 2: Abundance of water-associated birds per location observed in shore-based surveys in the Minas Passage study area, 2011 (left) and 2012 (right).

4.1.2.2 <u>Analysis of 2009-2012 Shore- and Vessel-based Survey Data</u>

Information from surveys in 2009-2012 gives an annual pattern of abundance of water-associated birds in the study area (Minas Passage, Minas Basin, and Minas Channel).

Some of the key findings of the four-years of FORCE monitoring for seabirds are:

- Forty-seven species of water-associated birds have been observed in the Minas Passage, Minas Basin and Minas Channel study area during shore and vessel-based surveys since 2009.
- Peak times for abundance and diversity of water-associated birds in the Minas Passage study area are during the Spring and Fall migration. Abundance showed a steady increase during the Spring to early Summer (March to early July); low-moderate numbers in July to October; a Fall peak in early November and declining numbers through to December (Figure 3). Abundance was highest in June with predominantly resident birds, and in early November with predominantly migratory birds. Diversity of birds varied seasonally, showing a March-April peak in number of species observed, followed by low and more stable levels in May-June, low with minor peaks in late July and August (due to shorebird migration), a major peak in October, and moderate levels in November-December.

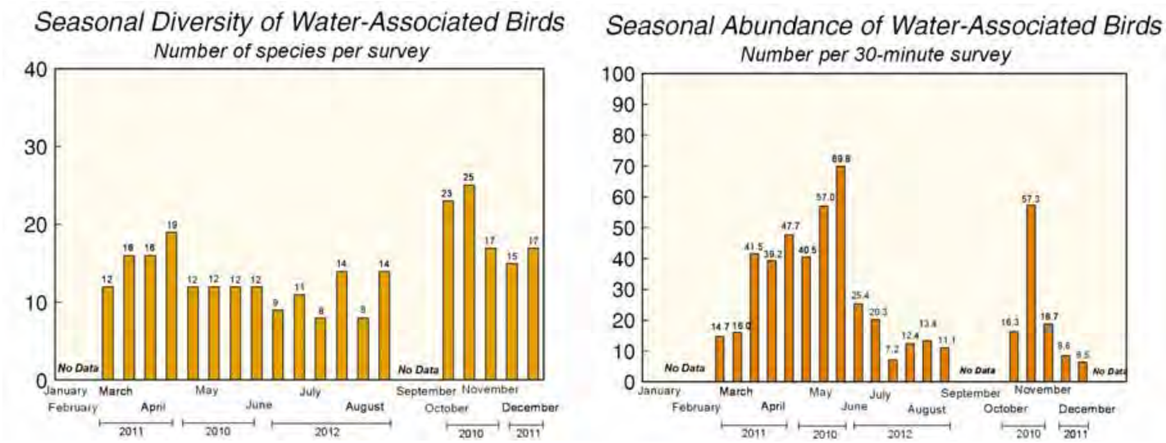

Figure 3: Abundance (left) and diversity (right) of water-associated birds observed in shore-based surveys in the Minas Passage study area, March-December, 2010-2012.

- Overall abundance of seabirds and waterfowl observed in vessel surveys was variable between areas and months, reflecting an overall low number of birds and occurrence of flocks (Figure 4).

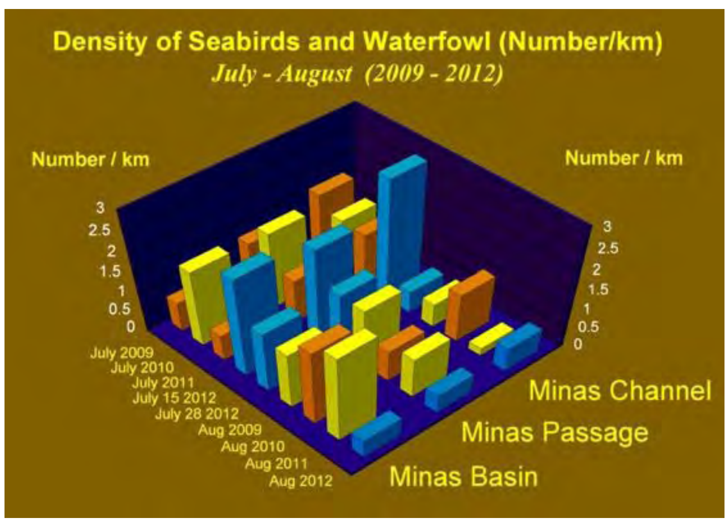

Figure 4: Abundance of seabirds and waterfowl in vessel surveys, July & August 2009 to 2012

- Diving birds, either in migration or resident divers such as common loon and black guillemot, frequently occur in the study area; however overall abundances are low to moderate, and deep divers (e.g. alcids such as common murre and razorbill) are relatively uncommon and low in abundance. In most cases diving birds are usually seen during migration and are occasional visitors in summer.
- For the dominant resident seabird species occurring in Minas Passage, abundances in summer, as shown by vessel surveys, have been comparable to early years of the survey, or trending downward over the course of the monitoring program.

- Within the Minas Passage study area, Black Rock and the tide rips associated with it appears to be a focal point of bird activity for some species such as common eider and black guillemot, although there is a steady movement of birds of many species through the area, particularly during migration (e.g. red-throated loon) either associated directly with the moving water from the falling tide, or daily activity patterns of the birds involved. Some of the species, including herring and black-backed gull and black guillemot, may breed on Black Rock, although it has not been possible from shore observations to confirm breeding activity.

4.2 MARINE MAMMALS MONITORING

4.2.1 Study Objectives and Design

4.2.1.1 Shore- and Vessel-based Visual Surveys

Goals: Collect pre-deployment (baseline) data on marine mammal presence and activity using visual survey techniques

Since 2009, Envirosphere Consultants has carried out a comprehensive observer-based monitoring program for seabirds and marine mammals in the vicinity of the FORCE tidal demonstration site. Although seabirds were initially the primary focus, these surveys also recorded observations of occurrences, group size and behaviour of harbour porpoise and other marine mammals.

The results of the 2009-2010 surveys are reported in the 2011 EEMP report[2]. The surveys conducted in 2011 and 2012 both repeated surveys done at the same time of year in 2009 and 2010 and extended the seasonal coverage of baseline data, which now extends from early March to late December (see Reports in Appendices A and B).

In 2011, Envirosphere completed six one-day shore-based observational surveys (March-April & December) of the Minas Passage (Minas Passage study area), including the FORCE crown lease area / turbine test site; and two vessel-based surveys in late-July and late-August in the Minas Passage study area and outer Minas Basin and Minas Channel. In 2012 Envirosphere completed six, one-day shore-based observational surveys (June-August) and three vessel-based surveys in mid-July, late-July and early/mid-August in the outer Minas Basin, Minas Passage and Minas Channel.

Shore-based surveys ran from approximately high tide through a 6-hour period roughly corresponding with the outgoing tide. Observations were made by eye from the FORCE Interpretive Center. The observer scanned the Minas Passage study area several times during successive 30-minute periods, noting all marine mammals seen, location and activities,

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2 FORCE. 2011. *Fundy Tidal Energy Demonstration Project: Environmental Effects Monitoring Report (September 2009 to January 2011).*

providing an estimate of total number of sightings per period, and a breakdown by distribution in local areas of significance (FORCE test site, area between Black Rock and shore [inside Black Rock], and the Minas Passage beyond Black Rock [outside Black Rock]).
The vessel survey route was designed to provide coverage of the Minas Passage study area and areas to the east (Minas Basin) and west (Minas Channel), including nearshore areas and along the axis of Minas Passage-Minas Channel. Survey times were chosen to catch high tide early in the morning to allow a full tidal cycle during daylight hours. Watches of 5-minute duration were conducted every 10 to 15 minutes in most locations and continuously (every five minutes) at the FORCE test site. The observer monitored the 300 m wide strip of water approached by the vessel, alternating sides on successive cruises. Observation conditions were generally good, with some patchy fog experienced in the August surveys in both years.

4.2.1.2 Passive Acoustic Monitoring

Goals:

- *Collect pre-deployment (baseline) data on marine mammal presence using passive acoustic monitoring technologies*
- *Assess acoustic monitoring technologies and protocols for effectiveness in high flow environments*

In 2010, FORCE funded Acadia University and SMRU Ltd (University of St Andrews) to undertake a three month pilot baseline study (10 August 2010 – 23 November 2010) during which three autonomous Passive Acoustic Monitoring (PAM) devices, specifically C-POD hydrophones (autonomous cetacean echolocation click detectors manufactured by Chelonia Ltd), were deployed and recovered in the FORCE test area using custom-made bottom moorings fitted with acoustic releases (see 1st EEMP report)[3].

In 2011 and 2012, the investigators deployed seven C-PODs to expand the spatial and temporal coverage of the pilot baseline study. During both years of the study, 2 devices were located within the FORCE test area and 5 outside the area (dependent on recovery of C-PODs), ensuring coverage of shallower waters north and deeper waters south, where prey availability may concentrate cetacean foraging. Battery operated C-PODs required multiple (3) deployments per year to cover the time period May to November (see Report in Appendix C).

The main objectives of the project were to determine the baseline patterns in presence of key cetaceans (porpoises and dolphins) in the Minas Passage during spring, summer and fall, and to assess how these vary temporally (with respect to time of day, weeks, months and across years), spatially (within and outside the FORCE test area) and with current patterns (tidal cycles and current velocity). These baseline data will be necessary to assess how activity patterns vary subsequent to the deployment of tidal energy devices.

[3] FORCE. 2011. *Fundy Tidal Energy Demonstration Project: Environmental Effects Monitoring Report (September 2009 to January 2011).*

Concurrently, Acadia University conducted a pilot project to compare the porpoise detection performance of C-PODs with an alternative monitoring technology: a battery powered digital hydrophone and recorder technology, the icListenHF (Ocean Sonics Ltd)[8]. One icListenHF device was deployed in the FORCE test area over a one month period in August 2012 and the performance compared with that of two co-deployed C-PODs over the same time period.

4.2.2 Findings

4.2.2.1 Shore- and Vessel-based Visual Surveys 2011 and 2012

In 2011, two species of marine mammals, harbour porpoise and grey seal, were observed in the surveys. Harbour porpoise was by far the dominant species (77 individuals observed), versus only two grey seals, the latter seen only in the shore-based survey on April 15 (Figure 5). Harbour porpoise (*Phocoena phocoena)* occurred frequently in the Minas Passage study area from early mid-March to late April but were not observed in December. The species occurred typically in groups of 2 but groupings of up to 8 individuals were observed; highest numbers were observed on March 31, when abundance averaged 3.2 animals per 30-minutes during the 6-hour observation period. No other marine mammal species were observed in the 2011 surveys.

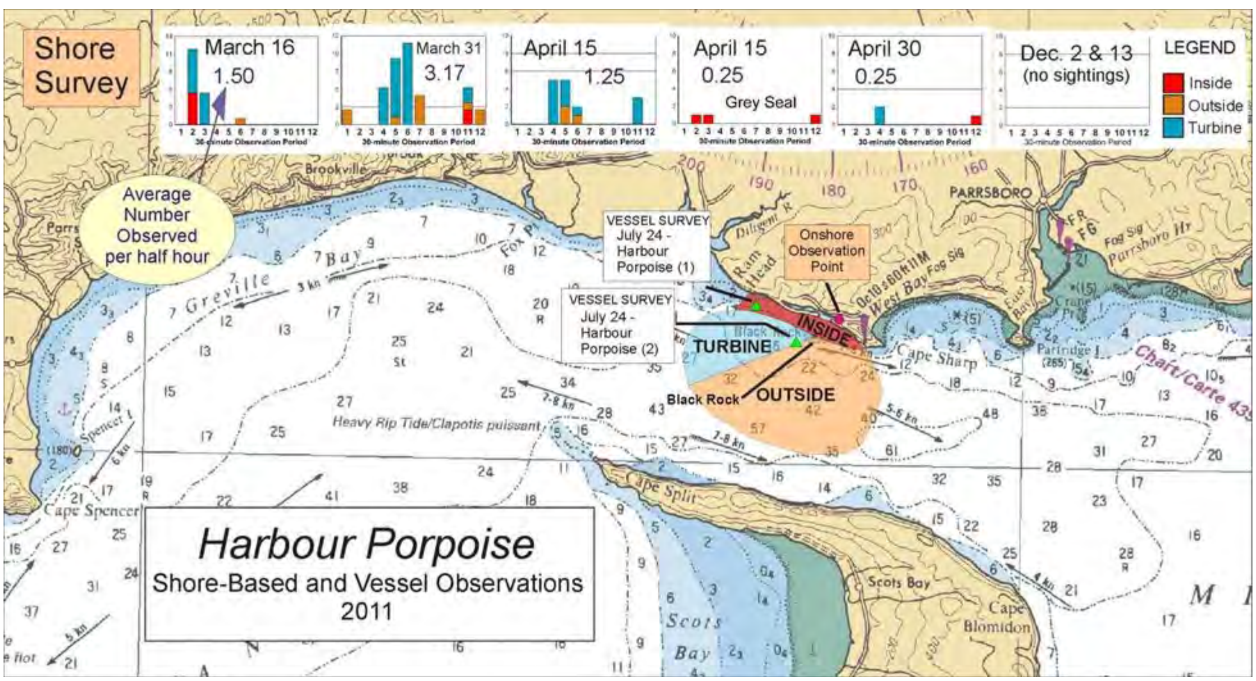

Figure 5: Sightings of marine mammals from shore and vessel-based observations, 2011

Three species of marine mammals, harbour porpoise*,* grey seal and harbour seal, were observed in the vessel- and shore-based surveys in 2012. Harbour porpoise was the dominant species (105 individuals observed); three grey seals (two in Minas Passage between the shore and Black Rock and one just seaward of Black Rock) and two harbour seals (one in Minas Passage and one in Minas Channel near Cape Spencer) were also observed (Figure 6). Harbour porpoise occurred frequently in the Minas Passage study area during the survey period. The species occurred typically singly or in groups of 2-3 but groupings of up to 5-8 individuals also occurred; highest numbers were observed on July 4 and August 15, when abundance averaged 1.9 & 2.6 animals per 30-minutes during the 6-hour observation period, respectively. In both years, individual harbour porpoise were observed more frequently in the area of the FORCE test site (the area seaward of Black Rock towards the Minas Channel and Cape Split), than in the other two areas in the Minas Passage study area (inside Black Rock, outside Black Rock), usually seen swimming seaward with the outgoing tidal stream passing over the FORCE test site. Some of the sightings involved individuals circling as if feeding.

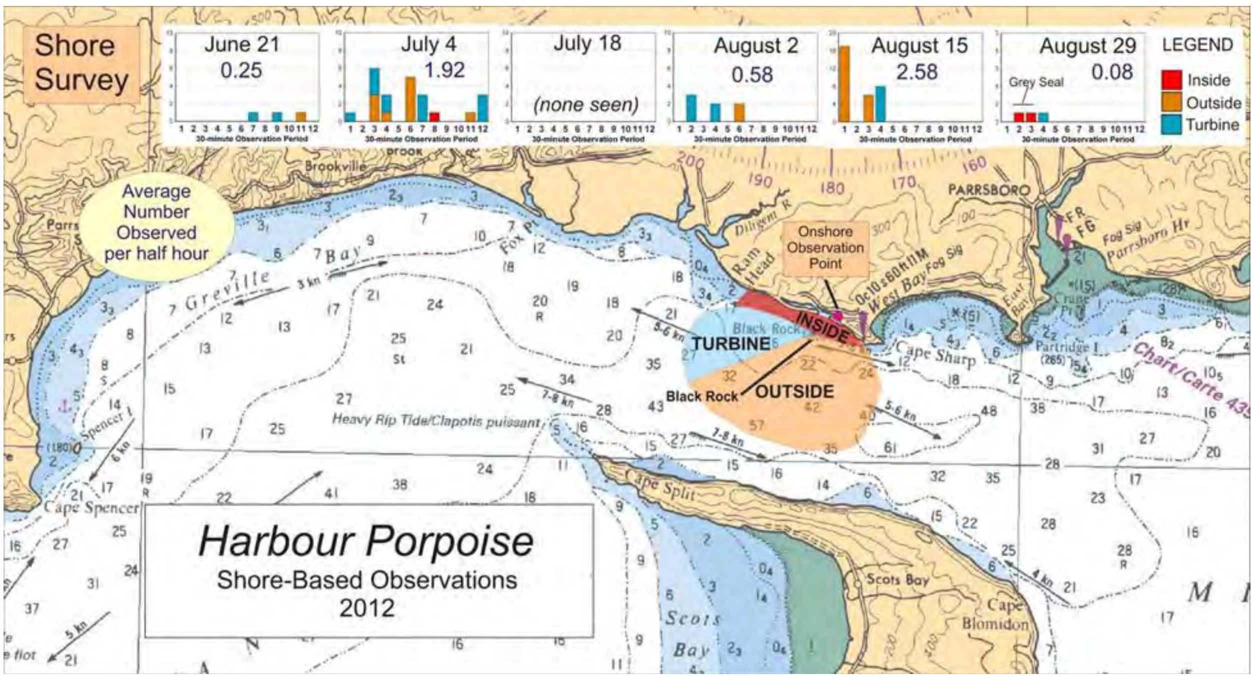

Figure 6: Sightings of marine mammals (harbour porpoise and grey seal) from shore-based observations, 2012

More harbour porpoise were observed on the vessel surveys in 2012 than in all previous years. These observations probably do not indicate a trend, but illustrate the natural high variability of marine mammals in the area and probably a response to variable patterns of prey species movements.

4.2.2.2 Analysis of 2009-2012 Shore- and Vessel-based Visual Survey Monitoring Data

The four years of observations indicate that overall abundance of harbour porpoise in the Minas Passage has varied seasonally with moderate numbers occurring in early March, April and November; peak numbers in late March, early July and mid-August, and low to moderate numbers in late April, May, June-August, October and late November (Figure 7). Abundances are thought to coincide with seasonal movements of fish, particularly spring spawning herring, and other forage species (e.g. squid) which have been reported to show movements in the area. The surveys have also provided information on limited occurrences of seals in Minas Passage and Minas Channel, with harbour seal observed in 2009 and both grey and harbour seal observed in 2010, 2011 and 2012, although in low abundance. No other marine mammals have been seen in the area from 2010 to 2012. In 2009, white-sided dolphin and an unidentified whale were sighted west of the FORCE test site.

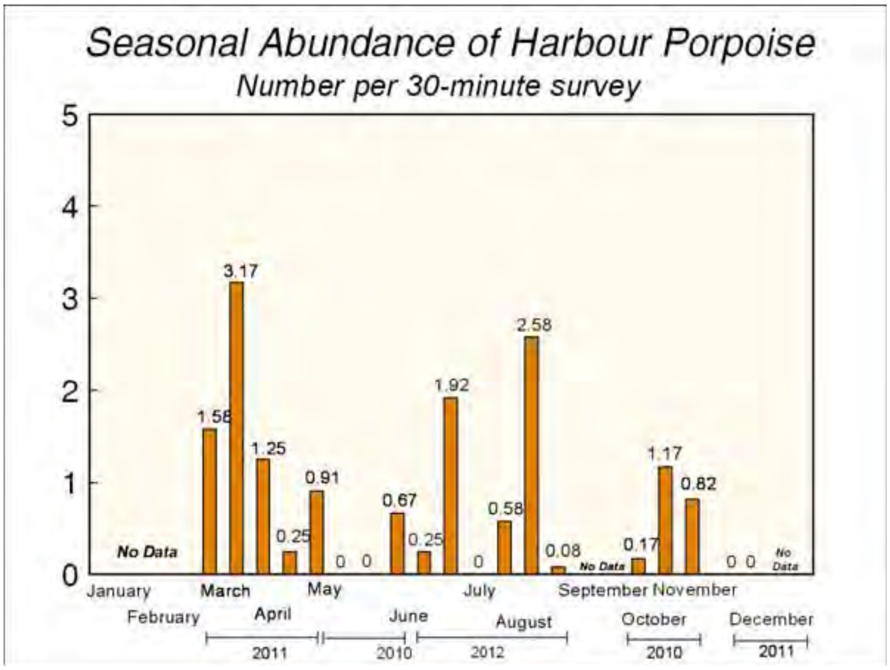

Figure 7: Seasonal occurrence of harbour porpoise during shore-based surveys in Minas Passage, 2010- 2012

Envirosphere analyzed the 2010-2012 dataset on harbour porpoise to estimate total numbers and density in the Minas Passage study site[4]. Based on shore-based data, estimated densities of harbour porpoise on a survey ranged from 0 to 1.4 per km^2 and estimates of the total number present in the outer Minas Basin, Minas Passage and Minas Channel during one tidal cycle ranged from 0 to 42 individuals.

The study investigators suggest: "Although the activity of the species [harbour porpoise] under lower current regimes is unknown, the present observations suggest that harbour porpoise would not be particularly likely to encounter turbines during peak currents, when their potential to be harmed is greatest, since they are seen at the surface and are not diving. Seals are not abundant at the study site, though the typical species (grey and harbour seal) could be attracted to the site if food was available, but because of diving depth under a current regime, they also would not likely encounter turbines."

[4] Results reported in: 'Stewart, P.L. F.L. Lavender, and M.S. MacLean. 2013. *Observations of Harbour Porpoise (Phocoena phocoena) at the Fundy Tidal Energy Demonstration Site, Minas Passage, Nova Scotia, 2009-2012*. Poster presented at the 2013 Nova Scotia Tidal Energy Research Symposium and Forum, May 14-15, 2013, Wolfville, Nova Scotia.'

4.2.3 Passive Acoustic Monitoring: 2011 & 2012

Cetacean baseline data were collected for all three seasons (May – January), but a variety of technical difficulties prevented complete coverage for some units outside of the FORCE test area. In spite of this, a total of 1,342 days of data were collected (1,932,410 minutes). The results suggest the abundance / activity of porpoise in Minas Passage is relatively low in comparison to other active or proposed tidal turbine sites, such as Strangford Lough (Northern Ireland) and Admiralty Inlet (Washington, US). However, hydrophones only record porpoises that are actively echolocating and detection range is likely to vary depending on flow speed, and direction of travel and orientation of the porpoise.

Data collected in 2011 and 2012 indicate a daily (98% of days had detections) but typically low level presence of harbour porpoise in Minas Passage (1.5% of each day). No dolphins were acoustically detected during either year of the study. Porpoise presence was highest during the month of May and lowest during the months of July and August coinciding with the seasonal movement of the summer harbour porpoise population into the Bay of Fundy. A second peak in porpoise presence occurred in late October. The tidal variables of velocity and height had a large impact on porpoise presence in Minas Passage. Porpoise presence, as detected by hydrophones, peaked at low tidal velocities and moderate tidal heights of 1.5 to 3.5 m above mean tidal height. Porpoise detection rates were highest at the deeper locations (those to the south of [84m] and within the FORCE test site [54-56m]) and lowest in the most shallow location north of the FORCE test site [27m]. Diel (day-night) patterns were also evident in the data. Porpoise detections were highest in the early morning hours, just after midnight, and lowest during early afternoon, just after midday.

4.2.3.1 Technology Comparison Results

The Minas Passage has proved a challenging location for deployment of hydrophones. Successfully collecting data at very high tidal velocities was problematic with both hydrophone technologies. Many lessons were learned from this study which can be applied to further refine the technology and deployment methodology to improve porpoise detection in future studies.

The study showed that flow-induced noise, which varies with tidal height and current speed, is associated with reduced harbour porpoise detection by both the icListenHF and C-POD hydrophones, especially during spring tide cycles (i.e., the fastest tidal velocities). As a result, there were few porpoise detections during spring tides for both hydrophone types. Most of the high flow noise was likely due to moving bedforms and the effects of tethered instrument moorings under strain (i.e. strumming, clanking of steel riser chains and shackles).

Sediment noise (i.e. bedload transport) caused by large current velocities within Minas Passage interfered with the ability to detect porpoise by causing memory saturation of the C-POD units.

This impact varied by location with the majority of locations impacted most during spring flood tides. Two C-POD locations outside the FORCE test area were heavily impacted on both ebb and flood tides and were thus avoided in year two of this study.
The icListenHF detected almost all the click trains detected by the two co-located C-PODs in the FORCE test area and, in many cases, recorded detections that one or both of the C-PODs did not. This result most likely reflected the greater detection range and thus listening volume of the icListenHF hydrophone. Although there are advantages with a greater detection range/volume, the downside is that it detects and records more non-target ambient noise than the C-PODs. This resulted in an icListenHF dataset with longer time periods over which harbour porpoise detections could not be identified, if present (i.e. lost recording time). Moreover, the icListenHF has higher start-up and post-processing costs.

In spite of the impact of sediment noise on porpoise detections, the analysis was able to control for sediment noise by including it as a covariate in the statistical modelling, and therefore still make presence predictions for high tidal velocities.

4.3 FISH CHARACTERIZATION

4.3.1 Objectives and Study Design

4.3.1.1 Acoustic Tracking

Goals:

- *Determine temporal (seasonal, diel) movements of tagged fishes within the Minas Passage and FORCE test area;*
- *Identify broad spatial distribution patterns in the Minas Passage (north to south regions, east to west);*
- *Determine depth preferences and movements in relation to tidal stage (ebb/flood) and current speed;*
- *Estimate travel speeds through the passage, based on detections by multiple receiver lines; and*
- *Assess potential risks of fish-turbine interactions at the FORCE site.*

To address the potential risk of environmental effects on fish that utilize the FORCE test area as a migratory route and for other movements (e.g. foraging), a multi-year tracking study was conducted to assess the movements of four species of concern - Atlantic sturgeon, Atlantic salmon, American eel and striped bass (Table 3) (see Report in Appendix D). These species display broad characteristics of movement and depth preferences, and may provide insight on potential impacts on species with similar natural history characteristics.

Table 3: Selected at-risk fish species in the Bay of Fundy, COSEWIC status designations and numbers tagged during 2010-2012

SPECIES	COSEWIC STATUS	# FISH TAGGED
Striped bass	Endangered	165
Atlantic salmon*	Endangered	62
American eel	Threatened	45
Atlantic sturgeon	Threatened	114

* smolts

VEMCO animal tracking technology was used to detect near year-round animal movements (path, velocity and depth) and behaviour of 386 tagged fish in Minas Passage during 2010-2013. VEMCO VR2w hydro-acoustic receivers are passive, single channel, omnidirectional, and function to autonomously detect coded acoustic transmitters which enter the detection radius of the receiver. Receivers were placed in lines ("listening gates") at 300-400 m intervals across both the Minas Passage (5 km wide) and the FORCE test site (1 km wide) (Figure 8). The arrays were designed to detect the presence of transmitters surgically implanted in fish as they moved within the Minas Passage during migrations into and out of the Minas Basin. Custom modified A2 Model SUB streamlined instrument floats were used to house a receiver and an acoustic release. All instrumentation was moored 2-3 m above the seafloor for periods up to 1 year.

Depending on the fish size, fish were implanted with V9, V13 or V16 electronic transmitters; most included pressure sensors. Salmon were tagged in the Stewiacke and Gaspereau Rivers; eels were tagged in the Gaspereau River; striped bass were tagged in the Stewiacke River and Minas Basin nearshore areas; and Atlantic sturgeon were tagged following Minas Basin weir and otter trawl captures.

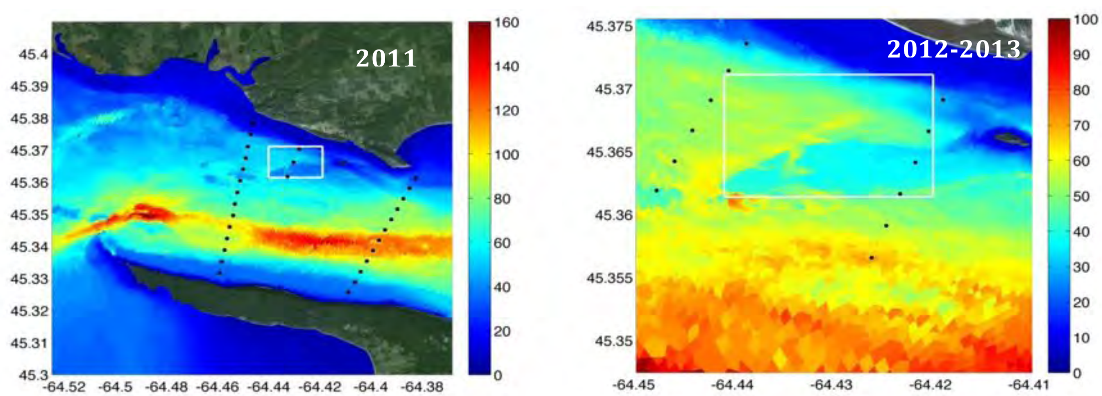

Figure 8: Vemco receiver locations and mean water depths (m) in Minas Passage (left, 2011) and in/near the FORCE site (right, 2012-2013).

4.3.1.2 Weir Fisheries Surveys

Goals:

- *To examine the feasibility of using commercial intertidal weirs along the shores of Minas Basin to address identified information gaps within the EEM program, in particular the seasonal abundance and presence of fishes near the FORCE test site.*
- *To examine the temporal and environmental (e.g. temp, tide height) patterns in the presence and abundance of resident and migratory fishes, as observed in the fish catches at two Minas Basin weirs.*

Sampling took place during April/May – August 2013 and was conducted near weekly during daytime low tides from weirs in Bramber, NS and Five Islands, NS (Figure 9). In addition, diel patterns were examined during two one-week periods during late July and early August at the Bramber site (see Report in Appendix E).

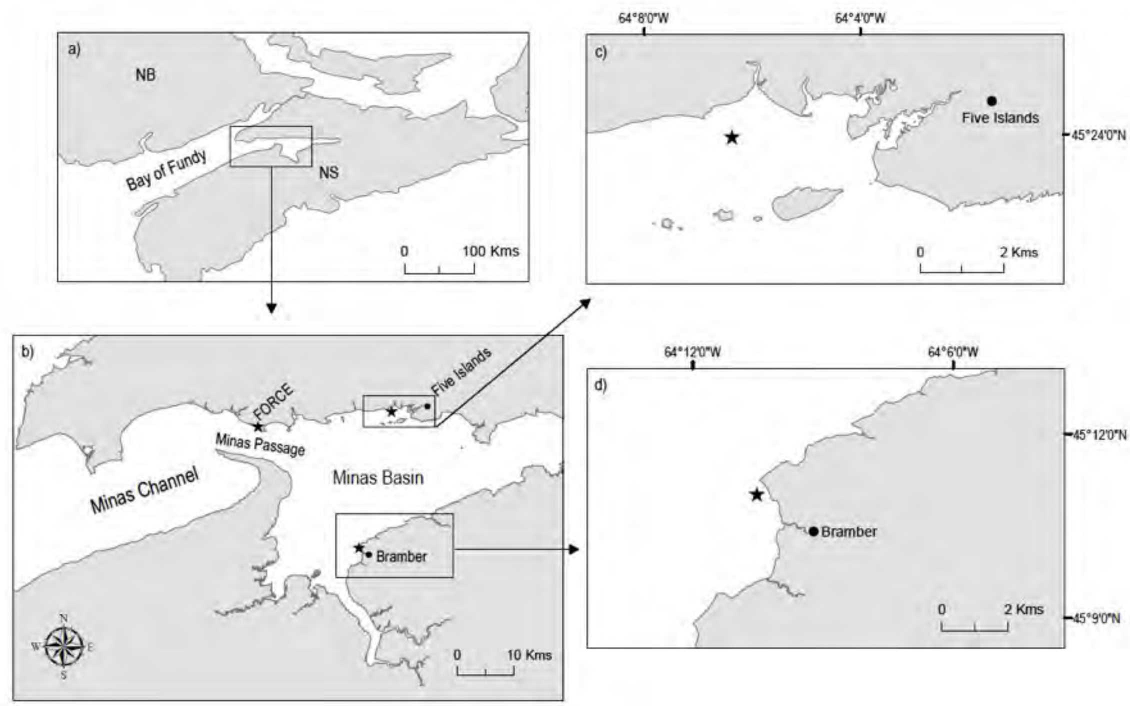

Figure 9: Maps of a) Nova Scotia and Bay of Fundy, b) Minas Basin, Minas Passage and sampling sites, c) Five Islands and weir site (*), and d) Bramber and weir site (*)

4.3.2 Findings

4.3.2.1 Acoustic Tracking

Results show that the corridor for fish migration through the Minas Passage is broad and includes the FORCE test area. Atlantic salmon post-smolts traversed the passage in late May to mid-June en-route to the Bay of Fundy and beyond. Of those smolts detected leaving the river

mouths (N=20), nine were detected in Minas Passage; of these, five were detected by receivers at the FORCE test site.
Tagged American eels exited the Minas Basin via the Minas Passage during mid-September to mid-November, with passage occurring at speeds up to 3m/s and over short time periods (1-6 days), mostly at night during ebb tide. About 90% of the detections at FORCE were during ebb flow periods, with movements largely in the top 30 m of the water column.

Atlantic sturgeon entered Minas Basin (summer feeding grounds) via Minas Passage in the spring, and exited in the fall, with sporadic use of Minas Passage throughout the summer. Sturgeon detections in the passage were more concentrated in the southern region. Although sturgeon were detected at all water depths, their movements in and near the FORCE site showed a preference for depths ranging from 15 to 35 m. The highest estimated travel speed (current assisted) between receiver lines was 3.2 m/s.

Striped bass, especially large bass (>60 cm), spent more time in the Minas Passage and near the FORCE test area than any of the other fish species examined. Residency spanned summer, fall and winter. Of the 165 tagged striped bass, 52 swam through the FORCE tidal turbine test site in the Minas Passage, and many at depths of proposed turbine hub height. Striped bass were detected mostly in the top 40 m of the water column, and were located closer to the surface during the night. Maximum travel rate (tide assisted) across the Minas Passage was 3.9 m/s. Near year-round use of the region, including the FORCE test area, makes this species highly vulnerable to interactions with turbines. In addition, many striped bass were shown to utilise the Minas Passage throughout the winter months when water temperatures were in the range of 0-3ºC. At these temperatures, striped bass are expected to have reduced metabolic rates and thus may have limited abilities to detect and avoid turbine infrastructure during winter.

Although general trends in the movements of tagged fish were apparent, the tag transmission datasets for Minas Passage are likely to represent about 40% of the potential detections of tag transmissions, in large part because of high flow effects (i.e. elevated ambient noise levels) on:

1. detection range (distance), which is known to decline as flow speed increases, and
2. detection of complete transmission sequences (8-10 consecutive pings separated by unique spacing intervals). If the receiver does not detect a complete ping sequence, then the transmission is not logged.

Both of these effects may result in tagged fish being able to pass through Minas Passage undetected during high flow periods. In addition, tag detection efficiency declines with current speed and is reflected in striped bass detections shown in Figure 10.

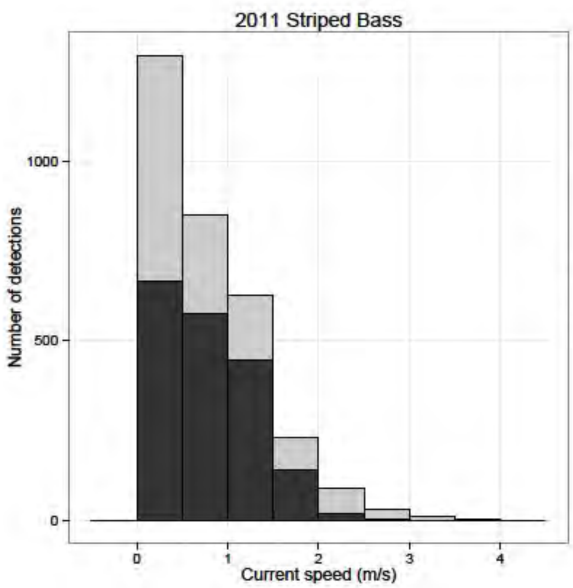

Figure 10: Striped bass detections in relation to depth averaged current speed (m/s) and both flood tide (dark bars) and ebb tide (light bars)

The FORCE test area spans <20% of the width of the Minas Passage, with a single turbine of about 100 m^2 occupying only 0.02% of the cross sectional area of the passage. The probability of fish-turbine encounters is dependent on the size of the fish, swimming depth, duration of occupancy at the site, and water temperature (as it relates to metabolic activity). The results of this study provided evidence of minor use of the passage by out-migrating American eel and Atlantic salmon smolts and more frequent use of the passage by Atlantic sturgeon and striped bass. Of the species examined, striped bass appear to be present year-round and are potentially the most vulnerable to interaction with turbines, especially during the winter months when they are likely to be sluggish.

It is unknown how well migratory fish can control their movements and avoid structures within the passage when travelling at times of peak current speed. The hypothesis that they avoid extreme flow conditions remains untested due to detection efficiency limitations of acoustic receivers operating in a tidal race. Near-field studies using a range of acoustic technologies (e.g. multibeam sonar, acoustic cameras) will be required to address fish behaviour (e.g. avoidance) in close proximity to turbines.

4.3.2.1 Weir Fisheries Surveys

Weir catches included 24 fish species at Bramber and 22 at Five Islands (see Tables 4 and 5). Fish catches were higher in the Bramber weir in large part due to weir construction and size differences. Catches tended to be higher near spring tides and consistently featured large numbers of fish from the Clupeidae family (largely herring) and order Pleuronectiformes (flatfishes). Abundance and species richness varied seasonally, in part due to the spawning patterns of migratory fishes. Weir catches during spring were dominated by mature fish and the summer catches consisted mainly of sub-adults, juveniles, or YOY life stages.

Table 4: The presence and relative abundance of identified fish species (individual fish >7 cm) captured at the Bramber site throughout the study. Fishes that were common are highlighted in bold.

Scientific Name	Common Name	Relative Abundance Date (2013)																					
		Apr 4	Apr 9	Apr 12	Apr 16	Apr 18	Apr 23	May 1	May 8	May 19	May 24	May 29	June 4	June 13	June 18	June 27	July 2	July 12	July 17	July 25	Aug 1	Aug 6	Aug 12
Alosa pseudoharengus	**Alewife**	R	L	M	H	H	M	H	M	M	M	H	M	M	H	H	M	M	M	H	L	M	L
Alosa sapidissima	**American shad**	NP	NP	R	M	M	L	M	R	NP	NP	M	L	M	M	M	L	L	NP	L	L	L	R
Alosa aestivalis	**Blueback herring**	NP	NP	NP	NP	NP	NP	NP	NP	H	M	H	M	H	M	M	NP	L	H	H	NP	NP	R
Clupea harengus	**Atlantic herring**	R	M	L	M	L	L	M	L	L	H	L	M	NP	H	H	H	H	H	NP	H	H	M
Pseudopleuronectes americanus	**Winter flounder**	L	L	L	L	M	M	M	M	M	M	M	M	H	M	M	M	M	L	M	L	L	NP
Scophthalmus aquosus	**Windowpane**	NP	R	R	L	L	R	L	L	L	L	M	M	M	L	M	R	L	M	M	NP	L	L
Liopsetta putnami	**Smooth flounder**	NP	NP	NP	NP	R	L	L	R	L	R	L	M	L	L	NP	NP	L	R	M	R	R	NP
Microgadus tomcod	**Atlantic tomcod**	M	M	M	NP	NP	NP	L	M	M	L	L	R	R	NP	M	NP	L	M	M	NP	M	NP
Osmerus mordax	**Rainbow smelt**	L	L	L	L	L	NP	L	L	L	L	L	M	L	M	M	M	M	M	M	M	H	H
Morone saxatilis	Striped bass	NP	R	L	R	R	R	L	L	L	L	L	L	L	R	L	R	R	L	L	R	L	NP
Scomber scombrus	**Atlantic mackerel**	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	M	M	H	R	L	NP	L	R	NP
Raja ocelleta	Winter skate	NP	R	R	R	R	R	L	L	L	L	L	L	R	L	L	R	L	L	L	R	R	R
Acipenser oxyrinchus	Atlantic sturgeon	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	R	NP	NP	R	R	R	R	NP	R	R	R	NP
Peprilus triacanthus	Butterfish	NP	NP	NP	NP	NP	NP	NP	NP	R	NP	R	NP	R	R	R	NP	R	NP	L	R	NP	M
Squalus acanthias	Spiny dogfish	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP	R	R	NP	NP	NP	NP
Lophius americanus	Monkfish	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP	NP	NP	NP	NP	NP	NP
Tautogolabrus adspersus	Cunner	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP	NP	NP	NP	NP	NP	NP
Pomatomus saltatrix	Bluefish	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP
Morone Americana	White perch	NP	NP	NP	NP	R	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP	NP	NP	NP	NP
Pollachius virens	Pollock	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP	NP	NP	NP
Urophycis chuss	Red hake	NP	NP	NP	NP	R	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP	NP	NP	NP	NP
Merluccius bilinearis	Silver hake	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	L	R	NP	NP	L	NP	R	NP	R	NP	NP	NP
Myoxocephalus octodecemspinosus	Longhorn sculpin	NP	NP	R	R	NP	NP	R	R	R	R	R	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
Hemitripterus americanus	Sea raven	R	R	R	R	NP	NP	R	NP	R	R	NP	R	NP	NP	NP	NP	R	NP	NP	NP	R	NP

NP- Not present in catch; R - Rare (<10); L - Present in low abundance (10-50); M - Present in moderate abundance (50-500); H - Present in high abundance (>500)

Table 5: The presence and relative abundance of identified fish species (individual fish >7 cm) captured at the Five Islands site throughout the study. Fishes that were common are highlighted in bold.

Scientific Name	Common Name	Relative Abundance Date (2013)																			
		May 2	May 7	May 16	May 17	May 22	May 23	May 30	June 5	June 6	June 14	June 20	June 21	June 25	June 26	July 3	July 9	July 17	July 24	July 31	Aug. 9
Alosa pseudoharengus	**Alewife**	M	M	M	M	M	R	M	L	M	M	M	M	H	H	L	M	M	L	L	R
Alosa sapidissima	**American shad**	L	L	M	L	L	NP	M	L	L	M	M	M	H	M	L	M	NP	NP	R	NP
Alosa aestivalis	**Blueback herring**	NP	R	L	NP	L	NP	NP	R	L	H	H	H	H	H	L	L	M	R	L	NP
Clupea harengus	**Atlantic herring**	L	R	L	L	H	M	M	R	NP	NP	H	H	NP	NP	H	NP	H	H	H	H
Pseudopleuronectes americanus	**Winter flounder**	L	L	L	NP	L	L	L	M	L	L	M	M	M	M	L	L	L	L	L	L
Osmerus mordax	**Rainbow smelt**	NP	M	L	L	L	L	M	L	L	L	M	M	M	M	L	L	NP	L	L	M
Scophthalmus aquosus	Windowpane	R	NP	R	R	NP	NP	R	R	NP	R	NP	R	R	R	R	R	R	R	R	NP
Morone saxatilis	Striped bass	NP	R	L	L	M	L	L	R	R	R	R	R	R	NP	NP	NP	NP	NP	NP	NP
Scomber scombrus	**Atlantic mackerel**	NP	NP	NP	NP	R	NP	NP	R	NP	NP	H	R	R	NP	M	R	R	NP	R	NP
Peprilus triacanthus	Butterfish	NP	NP	NP	NP	NP	NP	NP	R	R	NP	L	R	NP	NP	NP	NP	NP	NP	R	R
Hemitripterus americanus	Sea raven	NP	NP	NP	R	NP	R	R	R	NP	R	R	NP	NP	NP	NP	NP	NP	NP	NP	NP
Myoxocephalus octodecemspinosus	Longhorn sculpin	R	NP	R	R	NP	R	R	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
Acipenser oxyrinchus	Atlantic sturgeon	NP	NP	NP	R	NP	R	NP	NP	NP	NP	R	R	NP	NP	NP	NP	NP	NP	NP	NP
Liopsetta putnami	Smooth flounder	NP	R	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R
Raja ocellata	Winter skate	NP	R	R	R	R	R	NP	R	R	R	NP	NP	NP	NP	NP	NP	NP	R	NP	NP
Microgadus tomcod	Atlantic tomcod	NP	R	NP	NP	NP	R	R	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	R	R
Urophycis chuss	Red hake	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP
Merluccius bilinearis	Silver hake	NP	NP	NP	NP	NP	NP	R	NP	NP	NP	NP	R	NP	NP	NP	NP	NP	NP	NP	NP
Squalus acanthias	Spiny dogfish	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP	NP	NP	NP	NP	NP	NP	NP	NP
Syngnathus fuscus	Northern pipefish	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP	NP	NP	NP	R	NP	NP
Salvelinus fontinalis	Brown trout	NP	R	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP	NP	NP	NP	NP
Pollachius virens	Pollock	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	R	NP	NP

NP- Not present in catch; R - Rare (<10); L - Present in low abundance (10-50); M - Present in moderate abundance (50-500); H - Present in high abundance (>500)

Day and night sampling was conducted on 14 consecutive low tides during 12-19 July at Bramber and again in early August. Considerable temporal variation in abundance was observed, with greater numbers of commercial fish captured during dusk/night (Figure 11).

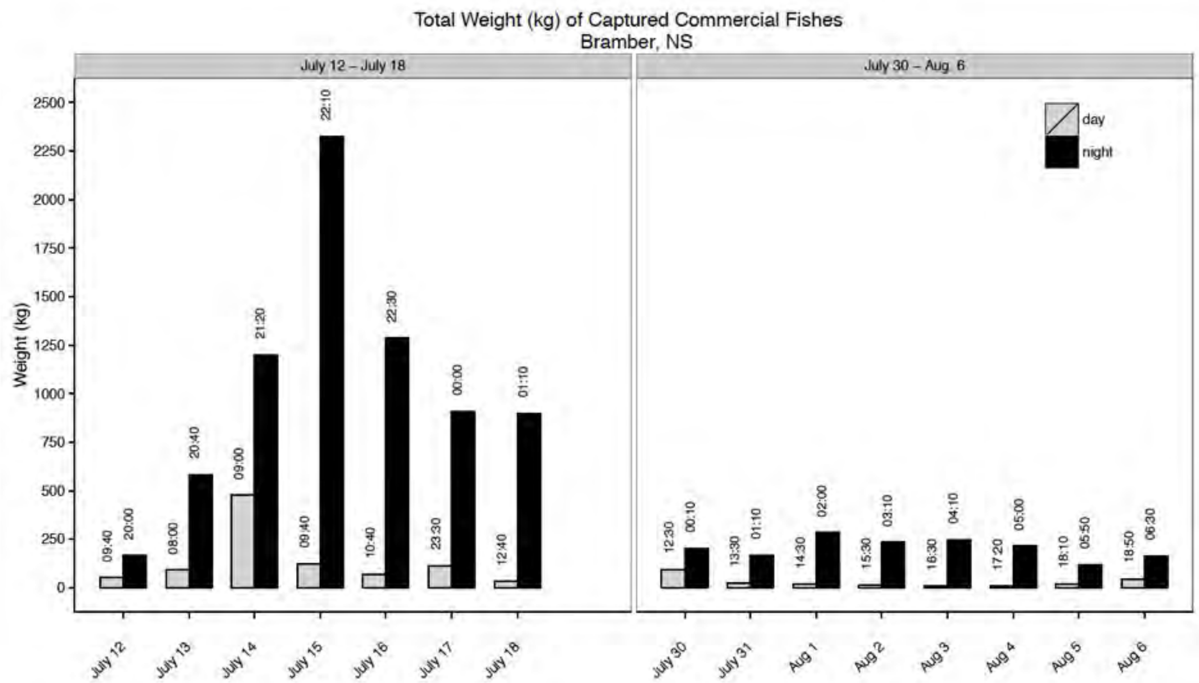

Figure 11: Day-to-day and day/night comparisons of total weight (kg) of captured commercial fishes at the Bramber site. The numbers above each bar indicate the estimated time the weir was fishing, approximately 1-2 hours before low tide.

Overall, the study showed that Intertidal weirs are useful monitoring platforms for assessing Minas Basin fish assemblages. While neither of the weirs included in this study were located directly within Minas Passage, data collected provides pre-turbine baseline data on many migratory fishes that move in and out of the Minas Passage. Intertidal weirs can strengthen on-going environmental monitoring of fishes near tidal energy development sites but are limited in how they can be used to address risk of interaction with tidal turbines.

4.3.3 Over-Wintering Fish Populations

The intent of sampling fish in winter was to determine what species move in and out of the Minas Basin (and by extension via the Minas Passage) and those that are resident year round. It was surmised that most migratory fishes would not be present in the Minas Basin during December.

In late December 2012, sampling of over-wintering fish populations in the Minas Basin using gill netting was conducted by area fishers at the request of EMAC. Three sizes of gill nets were set for one tidal cycle each on December 26th and 27th and the species and estimated weights and lengths for the caught fish were recorded. In total, 52 fish were caught over the two tidal cycles including 1 striped bass, 18 Tomcod, and 33 smelt. While it is not possible to draw conclusions based on this limited survey; it establishes a record of species caught for comparison in future sampling efforts[5].

4.4 LOBSTER TRACKING

4.4.1 Objectives and Study Design

Goals:

- *To evaluate the performance of VEMCO acoustic technology for detecting lobster movements in the Minas Passage.*
- *To examine the seasonal movements of lobsters between the Minas Basin and the Minas Channel, including use of the FORCE test area.*

To determine the year-round use of Minas Passage as a corridor for movement of lobsters, 85 adult American lobsters were captured in November 2011, tagged with VEMCO acoustic transmitters and released back into the Minas Basin by Acadia University Researchers. The lobsters were tracked by 29 bottom-mounted acoustic receiver stations deployed in the Minas Passage (26 spanning the width of the passage, east and west of the FORCE site, and three moored in the FORCE site). Efforts were made to inform local fishers of the study including mailing out information packets to all license holders inviting them to return any tags on trapped lobsters for a $25 reward.

In December 2011, researchers removed 14 receivers from the Minas Passage. Fifteen of the 29 receivers could not be recovered at that time due to malfunctions in the acoustic releases. The receivers were later recovered as mooring hardware deteriorated and buoys washed ashore or were picked up by lobster fishers.

In late April 2012, 24 bottom-mounted receivers were redeployed, 12 spanning the width of the eastern/inner boundary of the Passage and two lines of six along the east and west of the FORCE site. A series of receivers were also moored in the intertidal region of the Minas Basin from spring to fall 2012. Based on tag battery lifespan, detection of tagged lobsters was possible until late summer 2012.

To assess lobster movements during the winter months and to determine the primary mode of locomotion through Minas Passage (walking or potentially swimming/drifting as suggested by lobster fishers), an additional 40 lobsters were tagged in early December 2012 and released in Minas Basin with 20 of these tags housing a pressure (depth) sensor. Data were collected until late October 2013 (see Report in Appendix F).

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[5] Aldous, D., Kozak, J., and Porter, D. 2013. *Experimental Survey Results – Sampling Over-Wintering of Fish Populations in Minas Basin, NS.*

4.4.2 Findings

From fall 2011 to summer 2012 (excluding December – April), 33 of the 85 tagged lobsters were detected in Minas Passage, accounting for 100,287 detections. Detections of tagged lobsters during the 2011 - 2012 season suggest a westward migration out of the Minas Basin in the fall/early winter hugging the northern shore of the Minas Passage. Detected activity was concentrated within the northern portion of Minas Passage including directly within the FORCE test site. Lobsters moved at an average rate of 0.335 ± 0.319 km per day (assuming a straight path between starting positions and receiver detections) with female lobsters exhibiting a greater range of movement speeds than male lobsters. There is also some indication of west to east movement through the Minas Passage in the spring. However, as receivers were not in place December to April, over winter residency or movement through the Minas Passage could not be verified from data obtained during 2011-2012.

A total of 17 tagged lobster recaptures were reported by fishers who returned conventional disc tags for a reward. All reported lobster recaptures by fishers were within the Minas Basin and as such provide no information on extent of migratory movement into the Minas Channel and outer Bay of Fundy.

As of July 2013, a total of 29,470 detections have been logged by the receivers, 99 % by the eastern Minas Passage line and the remaining by the eastern FORCE line. Four female and one male lobster accounted for these detections. One of the detected female lobsters was fitted with a pressure tag; depth data indicated movement on the seabed in eastern Minas Passage.. Results from the 2012/2013 study suggest that a large fraction of tagged lobsters remained in the Minas Basin over the winter, as only one lobster was detected near the FORCE site, the rest appearing to stay within detection range of the inner Minas Passage line or farther up into the basin.

Detection results indicate that lobsters use the Minas Passage as a migration corridor on a seasonal basis (outward in fall and inward in spring) and confirms lobster fisher statements about migration through the northern half of the Minas Passage. However, it appears that not all adult lobsters migrate every year. The concentration of receivers within Minas Passage, and lobster recaptures by fishers during only the fishing season limit the determination of migratory extent of lobsters that exit the Minas Basin.

The data recovered to date confirms that:

- adult lobsters tagged with VEMCO acoustic transmitters can be detected by bottom-moored receivers in Minas Passage;
- lobsters in the Minas Basin move through the Minas Passage towards the Minas Channel in the late fall/early winter; some moved back to Minas Basin in the spring.
- not all adult lobsters in Minas Basin migrate each year; a large proportion overwinter in the Minas Basin.

Level of tag loss is unknown but is likely a significant consideration when interpreting results. Moreover, arrays may not provide complete coverage under all current speeds and over all bottom topography, potentially allowing lobsters to pass through undetected. Significant environmental background noise, especially during periods of high flow speed, is also an issue, as it reduces detection efficiency.

4.5 ACOUSTIC ENVIRONMENT

4.5.1 Study Objectives and Design

Goals:

- *Collect pre-deployment (baseline) data on the ambient acoustic environment in the FORCE test site*
- *Assess and refine mooring designs for acoustic monitoring systems in high flow environments*

Making measurements in high flow conditions, such as the FORCE site in the Minas Passage, is extremely challenging. In addition to surviving the harsh conditions, the acoustic monitoring system must be able to distinguish between ambient and turbine noises at levels that may affect marine life in various flow conditions. Moreover, the acoustic system must be able to constrain pseudo- or flow noise. This noise can be caused by water flowing around the monitoring equipment itself, including the movement and bumping of suspended moorings and strumming noise from cables under tension in the currents.

In 2008 and 2009, FORCE deployed drifting hydrophones (hydrophones suspended from a moving vessel) to collect ambient and turbine noise measurements at the FORCE test site. Because of vessel and surface noise contamination and the short-term nature of drifting measurements, the data were unreliable. Moreover, it was recognized that since drifting measurements would only take a snapshot of the ambient and turbine noise when the hydrophone drifts past, determining noise levels in different tidal and operational conditions would be difficult. Based on this assessment, drifting hydrophones were considered not suitable for high flow environments in the Minas Passage.

In 2011, JASCO Applied Sciences undertook a study to collect ambient noise data at the FORCE site over many tidal cycles using JASCO's Autonomous Multichannel Acoustic Recorder (AMAR) fixed hydrophone and to evaluate and refine JASCO's streamlined, bottom-mounted High Flow (HF) mooring design. This mooring is designed to minimize acoustic pseudo-noise and thus take reliable measurements of ambient and turbine sound in all flow conditions and at levels that may disturb marine life (see Report in Appendix G).

JASCO made three deployments, two in October 2011 and one in March 2012. JASCO deployed two AMARs using HF moorings in October 2011, one in the FORCE test site and one at the FORCE reference site. The moorings were damaged by the harsh conditions and the data could not be retrieved. Over the winter of 2011-2012, JASCO reviewed the mooring design, including computational fluid dynamics (CFD) modelling by the University of New Brunswick and extensive discussions with other teams that deployed oceanographic moorings in the Bay of Fundy. In March 2012, JASCO deployed a modified HF mooring as well as a Streamlined Float-based (SFL) mooring. Hydrophones were set in different locations (inside the mooring sheltered from the flow and on the exterior of the mooring) on both moorings to investigate the effects of hydrophone positions on measured sound levels. The HF mooring was retrieved in early April 2012 and the SFL mooring failed and surfaced early in late March 2012.

Automated processing of the entire dataset was performed with JASCO's Acoustic Analysis software suite to calculate baseline underwater sound conditions in the Bay of Fundy area.

4.5.2 Findings

The extensive review of the mooring design following the failure of the first two deployments in 2011 due to equipment damage and acoustic release failure revealed some insights into improved mooring design for survival, data collection and retrieval.

The modified HF mooring was successful at collecting quality acoustic data over the full testing period in the Minas Passage. The best results came from the hydrophone located on the inside on the HF mooring sheltered from the flow. The SLF functioned properly over only one full tidal cycle (ebb and flood), after which the frame failed and mooring broke free. A comparison of the data collected during the first full tidal cycle (when both the HF and SLF moorings were intact) indicated that the SLF was less successful at reducing pseudo-noise, even with the internal hydrophone.

To evaluate the capability of the HF monitoring system to measure turbine sounds at levels that may disturb marine organisms, JASCO reviewed the existing literature on the sensitivity of porpoise to continuous sounds and the audiograms of fish, turtles, porpoise and seals to determine the minimum disturbance threshold of marine organisms at the FORCE site. A root-mean-square (rms) sound pressure level (SPL) of 140 dB re 1 µPa is the lowest accepted threshold level known to disturb species that may be present (from porpoise). 100 Hz is below the frequency of porpoise hearing; however, it represents the approximate start of hearing for most fish, turtles and seals. Thus, the acoustic monitoring system must be capable of measuring the sound level at the turbine (source) of 140 dB re 1 µPa at frequencies above 100 Hz. It is expected that recorders would be placed approximately 100m from a turbine. At that distance, the largest propagation loss from the turbine to the recorder is estimated to be 40 dB. Thus, to determine if the turbine noise at the source (i.e. the maximum) is above the disturbance threshold, a recorder placed 100 m from the turbine must be able to measure 100 dB re 1 µPa for any 1/3-octave band above 100 Hz.

The results demonstrate that it is possible to collect ambient and in-stream turbine noise signatures in high flow conditions using a fixed autonomous recorder. An analysis of the spectrogram of the HF mooring data showed that the shape of the measured noise spectra varied smoothly with frequency. This indicates that the acoustic monitoring system can distinguish tidal turbine noises from the background noise spectra. The data also show that the hydrophone on the inside of the HF mooring (sheltered from the flow) is capable of detecting any pure tones generated by a turbine with a rms SPL of 140 dB re 1 µPa above 40 Hz. Even at full flow, the sheltered internal hydrophone had noise levels in all 1/3-octave bands from 100 – 3000 Hz below 100 dB re 1 µPa. This suggests that the acoustic monitoring system can measure, in any flow state, sound levels from tidal turbines at least 100 m away at levels that may disturb marine life (i.e. 140 dB re 1 µPa).

The trials of the various mooring designs indicates that an acoustic monitoring system in high flow environments, such as the Minas Passage, must be moored on the ocean bottom, have a streamlined shape to encourage laminar flow over the mooring, have an acoustically transparent cover, and have no parts that can move in the current and generate noise. The data indicate that the modified High-Flow (HF) mooring design is capable of measuring ambient and turbine sound levels that can potentially disturb marine life.

4.6 BENTHIC HABITAT MONITORING

4.6.1 Objectives and Study Design

Goal: Characterize pre-deployment (baseline) benthic habitat within the FORCE test site, including benthic substrate type and macrofauna present.

Video and oceanographic surveys, including >2000 still photos of the seafloor, were completed by Envirosphere Consultants Ltd. in 2008 and 2009 in association with the environmental assessment of the FORCE test site (Berths A, B, and C and Cable Routes A, B, and C).

In 2011, FORCE funded Acadia University researchers to analyze in greater detail the benthic fauna and associated seafloor habitats in the FORCE test area prior to turbine installation. The objective was to provide baseline data to aid FORCE berth developers in micro-siting and to examine the effects, if any, of subsea infrastructure (cables, gravity bases for turbines) on the benthic community (see Report in Appendix I).

Acadia investigators analyzed the photos of the three original FORCE berth sites and associated cable routes. Data recorded include: presence/absence and percent cover of macrofaunal species, percent exposed bedrock, percent cover of surficial substrate type (boulder, cobble or gravel [clast] size) and depth below mean low water. Computer image analysis and qualitative and quantitative classification techniques were used to characterize the benthic environment and to map the distribution patterns of the epibenthic macrofauna (for organisms >10 mm).

4.6.2 Findings

The survey detected a low number of species present in the FORCE lease area and along cable routes. *Halichondria panicea* (yellow breadcrumb sponge) is the most abundant species observed in the FORCE lease area. Other commonly observed macrofauna from video stills include two species of seastar, *Asterias vulgaris* and *Henricia sanguinolenta* (bloodstar) and *Urticina felina* (northern red anemone). No "at risk" species were observed in the videographic records. The cable routes and shallow regions of the FORCE test area (<15 m) support seaweeds, macroalgae and greater amounts of fine grained, sandy sediment. In deeper areas (>25 m), few species of sessile macrofauna are observed.

4.6.2.1 Species Distribution

Maps of the distribution patterns of dominant species were produced. The factors appearing to have the most influence over the distribution and percent cover of the dominant sponge species, *H. panicea,* were bedrock type (% exposed volcanic or sedimentary bedrock), followed by depth below mean low water. Percent cover was highest in Berth A, an area of exposed bedrock and high-flow conditions at the substrate-water interface and the shallowest berth. The percent cover of encrusting sponge (both yellow breadcrumb and white sponge) is greatly reduced in the deeper areas with high percent cover of loose sediment (cobble and gravel). Photos showing a high percent cover of yellow sponge did not show significant numbers of other organisms. However, hydroids, serpulid worms and an unidentified biolayer were sometimes observed on yellow sponge mats. A more diverse suite of organisms, including *A. vulgaris*, *H. sanguinolenta*, *U. felina*, tunicates, and gastropods, appear in photos exhibiting little sponge. In areas with loose substrates, it was observed that biota form largely on top of large boulders and rocks; the seafloor is generally scoured and without biota.

No turbine or cable deployments occurred during the study period to permit effects monitoring. However, the investigators offered the following prediction: "given the observed low biodiversity of macrofauna and the prevalence of encrusting yellow breadcrumb sponge, it is unlikely that the installation of TISEC infrastructure will negatively impact the benthic community in the FORCE lease area. It can be expected that the increase in habitat heterogeneity created by the installation of infrastructure will increase both the diversity and overall biomass of macrofauna associated with the seafloor in the turbine test area".

4.7 ELECTROMAGNETIC FIELDS

4.7.1 Study Objectives and Design

Goal: Review Current Literature and Assess Risk from EMFs on organisms in Minas Passage

Electromagnetic fields (EMFs) are produced by various electrical devices and electrical transmission cables. The ability to detect magnetic (B) and electric (E) fields is present in a wide variety of organisms, including invertebrates, fish and marine mammals. Many of these organisms use these fields for navigation, orientation and prey detection. Thus, there has been concern that EMFs produced by subsea transmission cables associated with marine energy developments, and to a lesser extent the marine generators themselves, could affect the health or behaviour of some marine organisms.

FORCE commissioned CEF Consultants to investigate the current knowledge on the potential risks to marine organisms in the Minas Passage due to EMFs generated by the FORCE transmission cables. Available literature on the potential effects of EMFs is summarized as it is related to subsea power cables (and the potential around tidal turbines) installed in the FORCE lease area within Minas Passage, drawing upon a number of recent major reviews in the US and Europe. The report includes a risk assessment and gap analysis on the impacts of EMFs on key marine species in the Minas Passage (see Report in Appendix I).

4.7.2 Findings of Review and Risk Assessment

Evaluation of the impacts of EMFs associated with tidal power development must consider the low frequency of the emissions, the rapid attenuation of the field from the source, and the influence of the high currents and frequent water turbidity at tidal sites such as the Minas Passage. The magnitude of EMF emissions also varies with the tidal and power generation cycle, remaining at peak levels for relatively short periods of time. In addition, the high current environment of the area limits the number of species likely to be exposed to any effects.

4.7.2.1 <u>Potential EMF emission levels from FORCE cables</u>

The magnitude of EMFs from operating subsea cables within the FORCE lease area will depend on the type of power, AC or DC, which will be determined by the individual developers. DC power produces higher induced electric field (iE) levels and directionality of magnetic field. Because details of the tidal turbines to be deployed at FORCE are unknown, the magnitude of EMFs detectable above the seafloor cannot be accurately predicted, particularly when cables run close together near shore. However, based on estimates of similar cables reported in the literature, CEF estimates the FORCE subsea cables are likely to produce a maximum induced electric field of 40 µV/m and a maximum magnetic field of 1.5 µT at the seabed. Moreover, the strength of detectable EMFs is known to dissipate rapidly the farther the distance from the source. Studies of much higher power than those at FORCE have reported that EMFs would fall to background levels (ca. 50 µT) within 20 m of the cable.

While cable burial could reduce the induced electric field (but not the magnetic field) by 10 or 20%, and may provide a barrier between organisms and the strongest fields, burial is not possible at FORCE given the bedrock in the area.

4.7.2.2 <u>Sensitivity and Exposure to marine organisms in Minas Passage</u>

The ability of an organism to detect EMFs from the FORCE cables will depend on numerous conditions including the species' sensitivity to electric or magnetic fields, tidal current conditions, power flow through the cable and orientation of the cable to flows.

Most teleosts (the largest group of bony fishes) do not have a highly advanced electrosensory system. Current research suggests that most teleosts do not react to electric fields of less than 6V/m, orders of magnitude greater than levels produced by the type of power cables being considered at FORCE. However, elasmobranchs (sharks, skates, and rays) are known to be highly sensitive to electric fields and EMF sensitivity has also been documented in agnathans (lampreys), many salmonids (salmon and trout), eels and potentially some herring and cod species. The literature suggests that while some marine invertebrates can detect Earth-strength magnetic fields, the sensitivity threshold is above those likely encountered from subsea cables. Also while sensitive to magnetic fields, the low and brief period of potential exposure suggest that risk to marine mammals is low.

Estimates in the literature suggest the following minimum detection limits:

	Sensitive marine species	Typical bony fishes (Teleosts)
Induced electric fields	0.1 µV/m	> 6V/m
Magnetic fields	2 to 3 nT (postulated)	n/a

Based on review of the literature, CEF postulates that EMF levels from cables of similar power to those deployed at FORCE will be detectable by sensitive organisms within a maximum distance of 30 m. Thus, species which spend time on the seafloor are more likely to be exposed to EMFs for prolonged periods because they are generally less mobile and in closer proximity to the source. Most of the species passing through Minas Passage are pelagic. The potential for impacts to these species is expected to be low because most teleost (bony) fish are not known to be highly sensitive to EMFs and are less likely to be exposed to detectable levels from subsea cables for more than brief periods.

4.7.2.3 Potential Impacts to Minas Passage Species

The available information suggests that the low frequency and power levels of EMFs generated by subsea cables or tidal turbines are unlikely to cause direct injury or adverse physiological effects to even sensitive marine organisms. Behavioural effects could range from a minor temporary change in swimming direction to a major avoidance response or delay in migration. Significant effects, such as disruption to migration or population-scale effects, have not been documented in any species in response to existing subsea transmission cables (even those with higher power levels and located in more moderate ocean current conditions). However, there is documented evidence of attraction and repulsion responses in salmonids, eels, sturgeon and sharks (incl. spiny dogfish) as they pass in close proximity to subsea cables or in experimental EMF studies.

While significant behavioural impacts are not anticipated, the reaction of most sensitive or commercially important species, including European lobster, in Minas Channel to different field levels is still uncertain. Current knowledge suggests that EMFs from subsea cables may interact with these species if their migration or movement routes take them over the cables, particularly in shallow waters (<20 m). However, duration of exposure in the high currents of the Minas Passage is expected to be minimal. Thus, it is expected that any effects will be localized to near the cable and of short duration.

Both laboratory and field studies would be required to answer the questions surrounding the responses of these organisms, the thresholds for response, and the impact of these responses at the species- and/or population-levels. However, current evidence suggests the magnitude of concern due to EMF is low compared to potential stressors from other activities associated with deployment, operation and removal of tidal energy devices, including noise and direct injury. Overall, EMFs associated with tidal energy generating devices and subsea cables at FORCE are unlikely to affect the reproduction and recruitment processes of any species in the Minas Passage, particularly at the demonstration phase, unless multiple devices are very closely packed.

5 CONCLUDING REMARKS

Since 2009, federal and provincial regulators have recognized that the highly dynamic marine environment of the Minas Channel, Passage and Basin would create significant challenges for the measurement of potential environmental effects from the tidal energy devices. As there are few proven technologies for monitoring effects in high current environments, the EEMP at the FORCE site requires the application of "adaptive management" approach.

Since the inception of the project, FORCE has continued to undertake environmental effects monitoring, using standard sampling protocols where possible, such as seabird observations, but in the majority of cases it is been new and ongoing research projects to define the most appropriate sampling approaches.

The lack of an operational TISEC at the site in 2011 thru 2013, has delayed the collection of data relevant to assessing and testing the "environmental predictions" identified in the Environmental Assessment review. But it has provided FORCE with the opportunity to further define the background marine environment in the area and test possible environmental technologies and sampling protocols for this unique environment.

In addition to identifying the appropriate monitoring protocols, the ongoing challenge for future EEM programs still remains--- how to detect and measure any potential effects resulting from only one or a small number of operational turbines and natural variations in the ecosystems related to seasons, weather, etc. or other impacts such as fishing.

Experimentation with various methods and techniques has helped to advance and set standards for work in high flow environments. FORCE and its consultants have been working together to develop new and innovative technology and techniques with which to do research and environmental monitoring. FORCE has made significant advances in characterizing the FORCE test site and providing baseline observations and measurements. The studies covered by this report add to this growing body of knowledge and the further analysis of the data collected will help guide future FORCE environmental effects monitoring.

Using the results from these studies, and those reported in the first EEM Report, FORCE and the Environmental Monitoring Advisory Committee have engaged the assistance of third party expertise to design an EEM program for implementation before the deployment of the next turbine. This approach is consistent with the principle of "adaptive management" agreed to in discussion with the responsible federal and provincial agencies.

6 APPENDICES