Environmental Effects Monitoring Program

Quarterly Report: April 1st – June 30th, 2017

July 1st, 2017

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Executive Summary

The Fundy Ocean Research Center for Energy (FORCE) is Canada's leading research centre for the demonstration and evaluation of tidal in-stream energy conversion (TISEC) technology. This technology (commonly known as "in-stream tidal turbines") is part of an emerging sector designed to generate electricity from the ebb and flow of the tide. It also has application in river systems and has the potential to introduce another non-carbon emitting source of electricity to the Nova Scotia electrical grid.

The first demonstration in-stream tidal energy turbine was operational at the FORCE site for a short time in 2009 and removed in 2010. There were no turbines present at FORCE until Cape Sharp Tidal Venture (CSTV) deployed a two-megawatt demonstration turbine in November 2016 and began a commissioning process. In April 2017, CSTV announced the turbine would be disconnected for temporary retrieval; on June 15th, the turbine was retrieved and moved to Saint John, New Brunswick shortly thereafter.

Environmental effects monitoring programs (EEMPs) began at FORCE 2009; to-date, over 90 tidal research studies have been completed or are underway with funding from FORCE and the Offshore Energy Research Association.

In 2016/2017, EEMP work is being conducted with academic and research partners, including the University of Maine, the Sea Mammal Research Unit Consulting (Canada), Envirosphere Consultants, Acadia University, Luna Ocean Consulting, JASCO Applied Scientists, Ocean Sonics, and Nexus Coastal Resource Management.

The following document is an interim progress report on mid-field monitoring work at the FORCE site from May 2016 up to June 30th, 2017. The 2016-2017 EEM program has completed approximately 175 hours of fish surveys, ten-months of marine mammal monitoring, 16 seabird surveys, bi-weekly beach surveys, and four marine noise surveys. Monitoring activity continued in Q2 2017 (April 1- June 30); monitoring is scheduled to continue through the calendar year. Two new reports on fish and marine mammals are currently under review by FORCE's environmental monitoring advisory committee (EMAC)[1]; an additional seabird report is expected shortly.

The document contains operational summaries from third-party researchers; however, conclusions and analysis will require longer-term data sets.

Fish monitoring: In May 2016, FORCE contracted the University of Maine to initiate a fish-monitoring program using a downward facing hydro-acoustic echosounder (the University of Maine has experience conducting similar monitoring programs for a tidal energy project in Cobscook Bay, Maine). The goal of this program is to describe and quantify fish distributional changes that reflect behavioural responses to the presence of a deployed turbine.

Three 24-hour surveys were complete pre-turbine deployment (May, August, and October 2016) and well as four 24-hour surveys post-deployment (November 2016, January 2017, March 2017, and May 2017). Post-deployment surveys included additional efforts to ensure data collection at the Cape Sharp Tidal turbine. Additional fish surveys are scheduled continue throughout 2017. Data processing and analysis are led by the University of Maine. Interim

[1] EMAC membership is included in Appendix 6; additional information is available online at: www.fundyforce.ca/about/advisory-committees.

reporting indicates “Monitoring of the region should continue in order to assess changes in fish distribution patterns over time”.

Marine mammal monitoring: FORCE contracted the Sea Mammal Research Unit Consulting (Canada) (‘SMRU Consulting’) to complete equipment calibration and data analysis relating to the deployment of passive acoustic monitors (‘C-PODs’) in support of its marine mammal monitoring program. The goal of this program is to detect changes in the distribution of the marine mammals (predominately harbour porpoise at the FORCE site) in relation to operational in-stream turbines.

Three C-PODs and related equipment were deployed in June 2016 and recovered in August 2016. In September 2016, FORCE deployed five C-PODs to ensure data collection during/after installation of Cape Sharp Tidal Venture’s first turbine. These were recovered in early 2017, re-deployed in February, and recovered/redeployed again in June 2017 to ensure an near-continuous period of data collection.

In addition, FORCE has continued its a beach walks and public observation program for marine mammals.

Seabird monitoring: The main objectives of the seabird monitoring program are to obtain site-specific species abundance and behaviour data, which can be used to establish whether the presence of a turbine causes displacement of surface-visible seabirds and marine mammals from habitual waters and to identify changes in behaviour. Nine shore-based surveys were completed by Envirosphere Consultants in 2016, two of which were completed after the Cape Sharp Tidal Venture turbine was installed. This work has continued in 2017 with seven surveys completed thus far.

Marine noise monitoring: FORCE contracted Luna Ocean Consulting in 2016 to complete a study providing recommendations to FORCE regarding how to implement a marine noise monitoring program; Luna Ocean recommended using a passive acoustic program. The goal of this program is to measure both ambient (in the immediate surroundings) noise and noise generated by in-stream turbines for prediction of the potential effects of this noise on marine life.

In summer 2016, FORCE rented drifting hydrophones from JASCO Applied Sciences and Ocean Sonics to collect ambient noise measurements at and near its test site. This work consisted of an August trial and two-days of data collection in October. This work provided valuable acoustic data, as well as experience in different drifter configuration, deployment, and recovery. Drifter data was again collected in March 2017 during turbine operations. Data analysis will be completed by JASCO and Ocean Sonics later this year.

Lobster monitoring: FORCE contracted NEXUS Coastal Resource Management to conduct a lobster catchability study in support of its lobster monitoring program. The goal of this study is to measure whether the presence of a turbine affects the number of lobster entering traps. Commercial lobster traps are used to compare catch volumes in different proximity to the turbine location. The planning for this work is underway; the first survey in this study is expected to occur in summer 2017.

FAST sensor platforms: Independent of EEM programs, FORCE is also conducting marine life effects research through its Fundy Advanced Sensor Technology (FAST) program that utilizes a series of subsea instrument platforms. While EEM addresses immediate, regulated monitoring objectives, FAST supports sensor innovation that may also yield important monitoring-related insights while advancing EEM capabilities for future regulated programs. FAST-1 has been deployed and recovered with an acoustic zooplankton and fish profiler (to assess zooplankton and fish density and depth distribution); FAST-2 will soon be deployed with a dynamic mount with a Tritech Gemini imaging sonar; and FAST-3 was recently deployed with an acoustic zooplankton and fish profiler and an autonomous scientific echo sounder.

Lessons Learned: FORCE's environmental effects program continues to evolve based on operational experience and input. This includes:

- a greater understanding of the impacts of biofouling on equipment, equipment calibration and set-up, efficiency in data collection efforts, data processing techniques and in general marine operations;
- growing skills development;
- understanding of the challenges with planning simultaneous operations during periods of extensive marine operational activity;
- identifying the limitations of planning for scientific operations during limited tidal and weather conditions;
- an adjustment in the timing of the lobster monitoring program in response to advice received from local lobster fishers; and
- identifying methodologies that limit risk regarding instrument recovery.

Moving Forward: FORCE will continue to publish interim reports to summarize ongoing monitoring operations at the site. These interim reports support longer-term analysis by academic and research partners as more data is collected through seasonal and annual cycles. Final reports prepared by EEMP contractors will be published on FORCE's website, www.fundyforce.ca/environment, upon review of FORCE's independent Environmental Monitoring Advisory Committee. The next quarterly report will be prepared for October 1st, 2017.

Contents

Introduction

About FORCE

The Fundy Ocean Research Center for Energy ('FORCE') was created to lead research, demonstration, and testing for high flow, industrial-scale in-stream tidal energy devices. Located near Parrsboro, Nova Scotia, in the Minas Passage of the Bay of Fundy, FORCE is a not-for-profit facility, with funding support from the Government of Canada, the Province of Nova Scotia, Encana Corporation, and participating developers.

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

The FORCE demonstration project was approved on September 15th, 2009 by the Nova Scotia Minister of Environment, and the conditions of its approval[2] provide for comprehensive, ongoing, and adaptive environmental management.

FORCE has had two central roles:

1) Host: providing the technical infrastructure to allow demonstration devices to connect to the transmission grid
2) Steward: research and monitoring to better understand the interaction between devices and the environment

Monitoring and reporting of any environmental effects from tidal turbines at the FORCE site is fundamental to FORCE's mandate—to assess whether in-stream tidal energy turbines can operate in the Minas Passage without causing significant adverse effects on the environment or electricity rates, and other users of the Bay. In this way, FORCE has a role to play in supporting informed, evidence-based decisions by regulators, industry, the scientific community, and the public. As deployments are expected to be phased in over the next several years, FORCE and regulators will have opportunity to adapt environmental monitoring approaches over time as lessons are learned.

In March 2016, the Offshore Energy Research Association (OERA) announced its and the Province of Nova Scotia's, funding support FORCE's fish and marine mammal EEMPs for 2016 and into 2017 at a cost of $250,000.

Background

Since 2009, FORCE has been conducting an environmental effects monitoring program (EEMP) to better understand the natural environment of the Minas Passage and the potential effects of turbines as related to fish, seabirds, marine mammals, lobster, marine noise, benthic habitat,

[2] FORCE's Environmental Assessment Registration Document and conditions of approval are found online at: www.fundyforce.ca/environment/enviromental-assesment.

and other environmental variables. All reports are available online at: www.fundyforce.ca/environment.

An in-stream tidal energy turbine was operational at the FORCE site for a short time in 2009. Since removal of this unit in 2010, no tidal turbines were present at the FORCE site until November 7th, 2016 when Cape Sharp Tidal Venture (CSTV) deployed a single two megawatt OpenHydro turbine. Consequently, the environmental studies conducted up to 2016 have largely focused on the collection of background data.

FORCE's present EEMP was developed in consultation with SLR Consulting (Canada),[3] and strengthened by review and contributions by national and international experts and scientists, provincial and federal regulators, and FORCE's environmental monitoring advisory committee (EMAC), which includes representatives from scientific, First Nations, and fishing communities. The EEMP is designed to:

- monitor the environmental effects of operating turbines;
- focus on five subject areas: lobsters, fish, marine mammals, seabirds, and marine noise; and
- be adaptive, based on monitoring results and input from regulators and EMAC, as well as ongoing turbine operations.

Monitoring Objectives

As part of its mandate, FORCE is tasked with monitoring and evaluating the environmental effects of the activities undertaken at its site and reporting on these effects. The present FORCE EEMP is based the best available scientific advice regarding monitoring approaches and instrumentation and experience in Minas Passage. The EEMP is iterative; regulators will continue to review the program through an adaptive management approach. This means the EEMP will continue to evolve as results and research efforts suggest new approaches or different instruments, and as developments and lessons learned are ascertained, both at the FORCE site and internationally.

FORCE and the berth holders both have roles to play in monitoring environmental effects. FORCE conducts monitoring from the near-field boundary (greater than 100 m from a turbine) to the mid-field (within the FORCE site or less than 1 km from a turbine). Berth holders are responsible for monitoring of environmental parameters at or on the turbine and within the near-field (within 100 m from their turbine[s]).

In general, the present FORCE EEMP was designed to guide environmental monitoring activities at FORCE for the next five years, but it remains responsive to changes in turbine deployment schedules, regulatory guidance, and as data is collected and analyzed. As more devices are scheduled for deployment at the FORCE site, and as monitoring techniques are improved at the site (through FORCE's Fundy Advanced Sensor Technology (FAST) program, see below), the EEMP will be revisited, keeping with the adaptive management approach. This is nature of the adaptive management approach followed at the FORCE site since its establishment in 2009.

The overarching purpose of each EEMP is to verify the accuracy of the environmental effect predictions made in the environmental assessment (see Table 1 below). Specifically, these EEMPs are aimed specifically at post-deployment effects monitoring.

[3] This document is available online at: www.fundyforce.ca/environment/monitoring.

Environmental Effects Monitoring Program	***Objectives***
Lobster	• to determine if the presence of an in-stream tidal energy turbine affects commercial lobster catches
Fish	• to test for indirect effects of in-stream tidal energy turbines on water column fish density and fish vertical distribution • to estimate probability of fish encountering a device based on fish density proportions in the water column relative to turbine depth in the water column
Marine Mammals	• to determine if there is permanent avoidance of the mid-field study area during turbine operations • to determine if there is a change in the distribution of a portion of the population across the mid-field study area
Marine Noise (Acoustics)	• to conduct ambient noise measurements to characterize the soundscape prior to and following deployment of the in-stream turbines
Seabirds	• to understand the occurrence and movement of bird species and observed marine mammals in the vicinity of in-stream tidal energy turbines • to confirm FORCE's Environmental Assessment predictions relating to the avoidance and/or attraction of birds to in-stream tidal energy turbines

Table 1: The objectives of each of FORCE's environmental effects monitoring programs.

Summary of Monitoring Activities

FORCE's latest monitoring program, which focuses on lobster, fish, marine mammals, seabirds, and marine noise, was initiated in 2016 and has continued into 2017. FORCE's EEMP, introduced in 2016, is available online at: www.fundyforce.ca/environment/monitoring.

In November 2016, CSTV deployed a two-megawatt demonstration turbine at the FORCE site. During the first quarter of 2017 (Q1: January 1st – March 31st), FORCE disconnected onshore power cables for safety and technical reasons during a planned upgrade to electrical equipment at the FORCE substation. During the second quarter of 2017 (Q2: April 1st - June 30th), CSTV underwent a period of significant marine operations at the FORCE site in relation to the disconnection of the turbine from the subsea cable (reported April 21st, 2017) and turbine recovery (June 15th, 2017). Updates on the CSTV project, including its quarterly monitoring reports, are available on its website: www.capesharptidal.com.

The following sections provide a summary of the monitoring activities conducted at the FORCE site up to and including the second quarter (Q2) of 2017.

Lobster

2016 Lobster Program

FORCE contracted NEXUS Coastal Resource Management Ltd. (Halifax, NS) to conduct its lobster monitoring program. NEXUS has previous experience in fisheries and marine resource management as well as environmental monitoring of lobster in Atlantic Canada. This program will consist of catchability surveys of commercial lobster traps deployed in locations within two rings around the deployed CSTV turbine (see Figure 1). Lobsters will be caught, carapace length and other physical features will be recorded by technicians, and released.

Due to the design of this program, given its experimental/control 'rings' that compares catch rates closer and farther from a turbine, the survey was required to be delayed until after turbine installation. In 2016, FORCE did conduct initial program planning and gear acquisition.

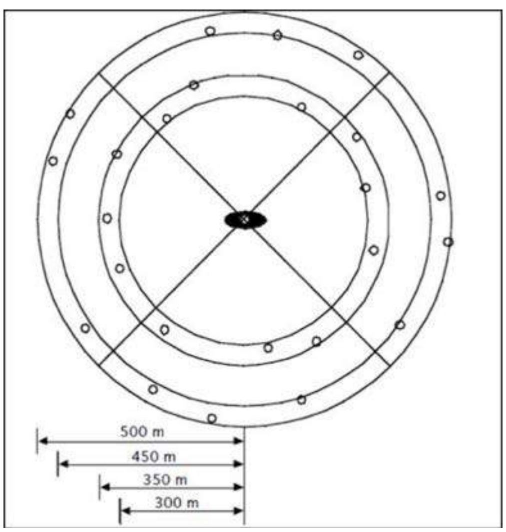

Figure 1: Double-ringed survey design proposed by Bayley (2010), with the dark centre representing the turbine and smaller circles representing lobster traps to be deployed (approximate distances shown) for the lobster monitoring program.

2017 Q1 Lobster Program

In January, FORCE and NEXUS Coastal Resource Management met with local lobster fishers to discuss the lobster catchability study. In this meeting, the fishers provided insight regarding how to catch lobster safely within the Minas Passage. Fishers also suggested an in-season survey would be the best time to conduct the survey given that that is the peak time for lobster movement in the area. This input is being incorporated into the program and FORCE and NEXUS will continue to engage this group and report back on progress throughout the study period.

NEXUS is in the process of defining its operational safety plan for the study and finalizing details such as bait acquisition. Given the feedback received, the first catchability study was expected to occur in spring 2017.

2017 Q2 Lobster Program

The first lobster catchability study under the 2016 FORCE EEMP was expected to be completed in spring 2017; however, the study work has been delayed due to turbine recovery operations (see 'Other Activities & Lessons Learned' below). In order to proceed with safe data collection, this work could not begin until after the recovery of the CSTV turbine.

FORCE anticipates that NEXUS will conduct one study in the absence of a deployed turbine in summer 2017. Future surveys will be conducted when in-stream tidal turbine(s) are deployed at the FORCE demonstration site.

Fish

2016 Fish Program

FORCE contracted the University of Maine (Orono, Maine) to conduct its fish monitoring program. Internationally, the University of Maine is recognized as a leader in the use of hydro-acoustics for fish monitoring purposes. The University is the only non-governmental group in North America with experience conducting similar monitoring programs, its in-stream tidal energy hydro-acoustic fish monitoring project of Ocean Renewable Power Corporation's turbine in Cobscook Bay, Maine.[4]

The goal of this program is to describe and quantify fish distributional changes that reflect behavioural responses to the presence of a deployed in-stream tidal energy turbine. The program uses a downward-facing hydro-acoustic echosounder (sonar) mounted onto a vessel,[5] which traverses transects across the FORCE site while collecting data on fish density and vertical distribution.

Four 24-hour surveys were completed in 2016 (May, August, October, November) and were conducted by FORCE and University of Maine staff. During the November survey (the first post-

[4] This work looked at evasion and avoidance behaviours of fish and marine mammals in relation to the turbine. This work found that the probability of a fish encountering the turbine's blade would be less than 2.9% (Shen et al., 2015; Viehman and Zydlewski 2015) and that there was no difference in marine mammal behaviour in response to a turbine (ORPC 2014).

[5] The echosounder used is a Simrad EK80 (transducer and desktop unit). The EK80 transducer is attached onto the pole mount off the side of the vessel Nova Endeavor. This 'scientific grade' equipment uses sonar technology (split beam echosounder) to detect fish within the water column. GPS is used to verify location of the pole mount during data collection.

deployment survey), additional efforts were made to ensure data was collected above the Cape Sharp Tidal turbine.

The final component to this program has been the transfer of knowledge to Nova Scotians, where University of Maine staff have trained FORCE staff to conduct the data collection.

2017 Q1 Fish Program

A second post-deployment hydro-acoustic survey in support of FORCE's fish EEMP was conducted from January 20th – 22nd, and a third survey was conducted March 21st – 23rd. Both surveys followed the same protocol as surveys conducted in 2016 and consisted of transects conducted throughout the FORCE demonstration site and control areas nearer the Cape Split side of the Minas Passage. In addition, stationary samples were collected above the CSTV turbine. Data collection efforts were led by the University of Maine and FORCE staff.

2017 Q2 Fish Program

Additional data was collected by the FORCE team during the early neap tide in May 2017. Data will continue to be analyzed by the University of Maine. Due to weather conditions, and managing simultaneous operations, a planned fish survey for the second neap tide in June 2017 did not occur. FORCE intends to complete a fish survey during a neap tide in July 2017 to coincide with the deployment of the FAST-3 sensor platform, which contains similar instrumentation to the fish EEMP. Collecting these two data sets will provide valuable information regarding the scientific and operational utility of each method.

Additional surveys for 2017 are planned for the fall migration period to enable year-to-year comparisons.

FORCE has received a draft final report and analysis on the first six hydroacoustic surveys in 2016/2017 from the University of Maine. This final report compares data collected at the FORCE demonstration site as well as a control site on the other side of the Minas Passage to data previously collected through FORCE's monitoring programs (Melvin and Cochrane, 2014)[6] and includes encounter probability estimates. The draft report is currently under review by FORCE's EMAC. EMAC's comments and questions will be shared with the University of Maine prior to the report's public release.

Marine Mammals

2016 Marine Mammals Program

In May 2016, FORCE contracted the Sea Mammal Research Unit Consulting (SMRU Consulting) to conduct the data analysis, interpretation, and reporting for its marine mammals monitoring program. SMRU Consulting, based in Vancouver, British Columbia, is a global leader in marine mammal research and has been involved in Fundy tidal energy research for marine mammals since 2009. SMRU completed initial equipment calibration (while providing training to FORCE ocean technologists) and data analysis on the data retrieved by FORCE relating to the deployed (and recovered) passive acoustic monitoring (PAM) mammal detectors known as 'C-PODs' (as well as supporting equipment such as streamlined underwater buoyancy systems

[6] Available online at: www.oera.ca/wp-content/uploads/2014/12/Final_Report_03Dec2014_Melvin_and_Cochrane.pdf.

known as ‘SUBS’, acoustic releases, and anchors).[7] The goal of this program is to understand if there is a change in marine mammal presence in proximity to deployed in-stream tidal energy turbines.

Figure 2: FORCE ocean technologist and crew of the Nova Endeavor (of Huntley’s Sub-Aqua Construction from Kentville, Nova Scotia) prepare to deploy C-PODs as part of FORCE’s marine mammal monitoring program.

For the second deployment in 2016, in response to regulators, FORCE deployed five C-PODs, which were recovered in early 2017. The timing of that deployment was planned to ensure data collection during/after installation of the CSTV turbine.

FORCE had also added to the scope of work for the visual seabird surveys to also note any observed marine mammals.

In addition, FORCE began a beach walks and associated observation program for marine mammals. No mammals were observed as part of this program in 2016.

2017 Q1 Marine Mammals Program

The five C-PODs deployed in September 2016 were recovered on January 18th, 2017. Following the January recovery, the C-PODs were cleaned and prepared for redeployment by FORCE ocean technologists. The C-PODs were redeployed February 23rd.

[7] The C-PODs, purchased from Chelonia Limited, are designed to passively detect marine mammal ‘clicks’ from toothed whales, dolphins, and porpoises. The species that C-PODS can potentially detect in the FORCE region are Killer Whale (Orca), Northern Bottlenose Whale, Dall’s Porpoise, Harbour Porpoise and Pacific White-Sided Dolphin.

[VIDEO]: February 2017 C-POD deployment: https://vimeo.com/210831115

To enhance its fish monitoring program and to expand its data collection capacity, in partnership with the Ocean Tracking Network[8], FORCE staff attached one VEMCO fish tag receiver to each C-POD mooring for the February deployment. This effort will support increased knowledge of fish movement within the Minas Passage, which has applicability beyond tidal energy demonstration.

In addition, FORCE has continued to conduct its observation program while conducting beach walks along areas of the Cumberland Shore closest to the FORCE site and beyond, and is developing a system for the public to record any observed marine mammals.[9]

During their shore-based observation program, Envirosphere Consultants reported: "Individual harbour porpoises were observed during the November 17th, 2016 and January 16th, 2017 surveys. As well, a harbour seal was observed resting on Black Rock during the January 16th, 2017 survey". These observations are shared with SMRU to support validation efforts of subsea-based C-POD marine mammal monitoring program.

2017 Q2 Marine Mammals Program

In early May 2017, FORCE received a draft final report from the Sea Mammal Research Unit Consulting (Canada) (Vancouver, British Columbia) for the data analysis associated with two C-POD (i.e., marine mammal detector) deployments:

- May 2016 – August 2016: 3 C-PODs
- September 2016 – January 2017: 5 C-PODs

This report is currently under review by FORCE's EMAC and will be shared publicly after the review process is completed. This report represents the first report of what is a multi-year sampling program, as outlined in the FORCE EEMP (2016).

FORCE has contracted SMRU Consulting (Canada) to complete the data analysis for all C-POD deployments in 2017. This includes a recently collected dataset from C-PODs deployed in February 2017 (and recovered in May/June 2017).

One of the C-PODs from the February deployment was discovered by a fisher in Diligent River prior to the planned recovery on May 16th, 2017. The C-POD and SUBS package (which houses the instrument) was returned to FORCE shortly after. Upon inspection, FORCE staff found that the chain links connecting the instrumentation to the anchor had considerable abrasion, which caused the package to surface prematurely.

During recovery on June 1st, 2017, FORCE had difficulty with the recovery of two of the four remaining C-PODs. Though FORCE ocean technologists were able to successfully communicate with the acoustic releases, and were able to confirm the acoustic releases were activated, two of the four remaining C-PODs were not found. Additional search efforts were made prior to the redeployment but were not originally successful. The C-PODs are housed in a

[8] Ocean Tracking Network's website: www.oceantrackingnetwork.org.

[9] See: https://mmo.fundyforce.ca. In the event of an observed stranding or mortality, FORCE staff and volunteers will contact the appropriate authority. The purposes of this tool is to report when an observation has been completed.

large, yellow, and buoyant SUBS package (which have FORCE's contact information on them) that have a high return rate.

Figure 3: C-POD deployment from Nova Endeavor (retrieved Q2 2017).

The three C-PODs that were successfully recovered were redeployed the next day to ensure minimal data gaps. After consultation with SMRU, it was decided that a quicker redeployment of instruments was preferred over a staggered approach—this allows the same C-PODs to be redeployed in the same location, minimizing variability among data sets. However, due to the late recovery of two of the C-PODs, only two of the three originally recovered C-PODs were re-deployed at their original location. The third, which was originally deployed westward of the FORCE test site, was re-deployed nearer the Cape Sharp Tidal Venture turbine to ensure a continued dataset in proximity to the turbine.

Figure 4: A SUBS package, which housed a C-POD and fish tag receiver, recovered in Diligent River lost its rudder.

The fourth C-POD was recovered on June 20th, 2017 after it was found by a fisher in Advocate Harbour. Upon inspection, the SUBS package suffered damage (see image below) and the fish tag receiver supplied by the OTN was lost. FORCE was, however, able to redeploy the C-POD using one of its spare SUBS package on June 22nd, 2017. If the fifth C-POD is not recovered after the next spring tide, FORCE will calibrate its additional (contingency) C-PODs and deploy in the currently vacant C-POD location.

In addition, FORCE staff and volunteers have completed beach walks at Black Rock Beach, West Bay, Fox River, Fraserville, and Diligent River Harbour as part of its marine mammal monitoring program throughout 2017. Beach walks occur on a bi-weekly basis.

In order to promote community participation in program, FORCE has prepared a poster for distribution online and in communities around the Bay of Fundy (see Appendix 6). In addition, FORCE has developed a web-based app to enable beach walkers to report their walks and findings: mmo.fundyforce.ca. During this reporting period, two observations of a seal near Black Rock Beach were reported via the app—one on the evening of May 4th, the other during the day of turbine recovery, June 15th.

Seabirds

2016 Seabirds Program

FORCE contracted Envirosphere Consultants (Windsor, Nova Scotia) to continue with its seabird monitoring program in 2016. Envirosphere has been conducting seabird and marine mammal monitoring at the FORCE site since 2008, contributing to the baseline knowledge at the site. The main objectives of the seabird monitoring program are to obtain site-specific species abundance and behaviour data, which can be used to establish whether the presence of a tidal energy device causes displacement of surface-visible seabirds and marine mammals from habitual waters and to identify changes in behaviour.

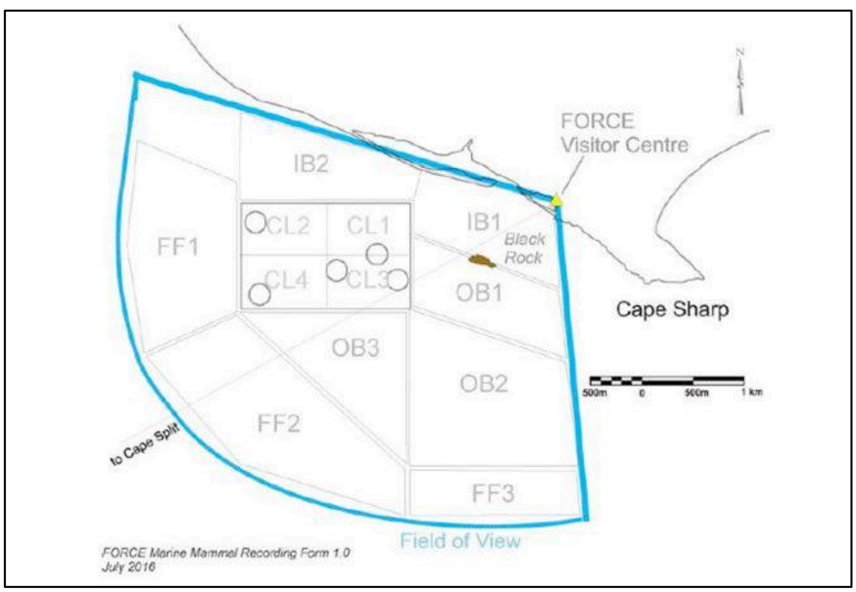

Figure 5: Subdivisions of the FORCE Crown Lease Area for the seabirds monitoring program where ‘CL’ indicates Crown Lease area; ‘IB’ indicates Inside Black Rock; ‘OB’ indicates Outside Black Rock; and ‘FF’ indicates Far-Field area.

Nine shore-based surveys were completed by Envirosphere Consultants[10] in 2016, two of which were completed after the CSTV turbine was installed. For the first three months of observations (May through July), 10 species were observed (lowest in July, highest in June); the following four months (August through November pre-turbine deployment), 22 species were observed (lowest in August and October, highest in September and November) (see Appendices 3-4). The results from the two surveys conducted post-turbine deployment are reported below in the 2017 seabirds section.

Figure 6: Bird observer at the FORCE Visitors Centre conducting a seabird observation study.

2017 Q1 Seabirds Program

Three seabird surveys were completed thus far in 2017: January 17th, February 21st, and March 13th.

2017 Q2 Seabirds Program

Additional seabird surveys were conducted by Envirosphere Consultants Limited (Windsor, Nova Scotia) in April (two surveys), mid-May, and again in mid-June.

FORCE will receive a draft final report and analysis on sixteen surveys completed by Envirosphere from May 2016 – May 2017 during the next reporting period. Upon receipt, the draft report will be shared with FORCE's EMAC for review. EMAC's comments and questions will be shared with Envirosphere prior to consideration prior to the report's public release.

Marine Noise

2016 Marine Noise Program

In early 2016, FORCE contracted Luna Ocean Consulting (Freeport and Shad Bay, Nova Scotia) to provide recommendations to FORCE regarding the best passive acoustic monitoring (PAM) program moving forward as a way to understand underwater soundscapes before/after turbine operations.

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[10] These are completed using 8x and 10x binoculars and a spotting spot (22x magnification Bushnell spotting scope) from a position on the FORCE Visitors Centre deck.

Luna Ocean recommended target areas for data collection (to measure spatial and temporal variation in soundscape around deployment areas), equipment and necessary vessel specifications, and methodology to complete a "drifter" hydroacoustic survey program. Accordingly, in summer 2016, FORCE rented drifting hydrophones[11] from JASCO Applied Sciences (Halifax, Nova Scotia) and Ocean Sonics (Great Village, Nova Scotia) to collect ambient noise measurements at and near its test site with two different drifter configurations. Based on the one day trial in the summer, FORCE then conducted two-days of data collection in October with both drifter configurations. Data analysis will be forthcoming from both JASCO and Ocean Sonics.

[VIDEO]: A drifter is deployed and recovered in the Minas Passage: https://vimeo.com/210829825

Figure 7: Tyler Boucher, FORCE ocean technologist, and crew of the Tidal Runner demobilize after completing data collection using drifting hydrophones in support of the marine noise monitoring program.

2017 Q1 Marine Noise Program

On March 27th, 2017, FORCE completed the first noise data collection post deployment of the CSTV turbine. The purpose of this work is to collect a noise profile using drifting hydrophone systems provided by Ocean Sonics in proximity to the deployed CSTV turbine and to understand the distance that turbine-generated noise can travel. Data analysis is currently underway by Ocean Sonics.

[11] A 'drifting hydrophone' consists of (at a minimum) a buoy and a hydrophone, which is designed to record marine noise. This configuration allows the instrument to travel in the water while limiting flow-related noise (in comparison to a static instrument).

2017 Q2 Marine Noise Program

FORCE is awaiting final data analysis as a result of its drifting hydrophone surveys, which were completed before and after the installation of the CSTV turbine. The results of these surveys will help to inform future noise data collection as well as an integrated analysis of the soundscape of the FORCE demonstration site.

Moving forward, FORCE intends to collect further noise data using a drifting hydrophone system provided by JASCO. FORCE and JASCO are currently working to adapt the JASCO drifter system to reduce risk of its catenary system's interaction with a deployed CSTV turbine.

In addition, FORCE staff is working on defining marine operational methodologies that can reduce risk associated with longer drifts. Longer drifts will provide larger data sets, but pose a risk that drifter system may run ashore or be lost.

Figure 8: Hydrophone deployment where drifters travel 1 – 2 km, collecting sound data in the Minas Passage.

Other Research & Monitoring Activities – Q1

Wetland Monitoring

In addition to EEMP-related activities, FORCE has also undertaken a wetlands monitoring program since 2014 in the wetland where trenching and cable laying took place onshore. This monitoring, completed by Envirosphere Consultants, included periodic walkovers by a biologist and a botany survey in the disturbed area, repeating baseline work done in 2014 and monitoring work completed in 2015. This work consisted of an assessment of plant communities in areas approximately 1m square at locations representing areas in the wetland, and in adjacent areas that were undisturbed by the activity. The survey showed that—as predicted—the wetland is well-vegetated and has largely recovered from the trenching operations associated with the cable installation.

Fundy Advanced Sensor Technology (FAST) Program

FORCE's Fundy Advanced Sensor Technology Program ('FAST') is designed to advance capabilities to monitor and characterize the FORCE site. Specifically, the FAST Program was designed to achieve the following objectives:

1) To advance capabilities of site characterization;
2) To develop and refine environmental monitoring standards and technologies; and
3) To develop marine operating methodologies.

FAST combines both onshore and offshore monitoring assets. Onshore assets include a meteorological (MET) station and radar system; the MET station broadcasts data live on the Ocean Networks Canada (ONC) website[12] while the radar system works to monitor surface currents. Offshore assets include three subsea data collection platforms for both autonomous and cabled data collection; cabled data collection is broadcasted live on the ONC website.

FAST's subsea platforms have a large inventory of site characterization and environmental sensors, marine operations equipment and subsea cables. In addition to marine and terrestrial sensor work, the FAST program also works closely with marine service providers. FORCE regularly works with Dominion Diving Marine Ltd. (Dartmouth, Nova Scotia) and RMI Marine Ltd. (Eastern Passage, Nova Scotia); both marine service providers contribute significantly to the advancement of FORCE's marine capabilities and methodologies.

In 2016, FORCE also initiated several operations under its FAST Program. The FAST-1 platform (an autonomous, battery-powered platform that is designed to support short-term site characterization) underwent a pilot deployment in January and was redeployed from June 17th to July 13th near the CSTV berth to obtain pre-installation site data.

[12] This is available online at: www.oceannetworks.ca/observatories/atlantic/bay-fundy

Figure 9: The FAST-1 platform fixed to the stern of the Dominion Victory.

A second cabled subsea sensor platform, known as ‘FAST-2’, was deployed for eight months (January to September 2016) between the shore and Black Rock in close proximity to the FORCE site, which provided real-time oceanographic and environment monitoring data to the FORCE Visitors Center and ONC via an undersea cable. FAST-2 operated successfully from January 29th to July 12th, 2016 at which time data transmission ceased and a recovery operation was initiated. Delays to avoid lobster fishing season, and due to coordinating other marine operations and weather/tide windows, saw recovery completed on September 9th, 2016.

In 2017, FAST-2 is undergoing enhancements to significantly advance the ability to provide long-term, real-time, targeted imaging of the interaction between marine mammals, fish, and turbines. Specifically, in partnership with Open Seas Instrumentation Inc., the project consists of the development on FAST-2 of:

1. Enhanced ancillary systems to enable the capture of long-term, real-time environmental data; and
2. A dynamic mount to enable the capture of targeted environmental data.

The project builds on extensive shore-side and subsea infrastructure at FORCE, and includes an incremental program for field-testing sensor technologies through three stages: low flow (intertidal zone of the FORCE beach – 2m/s), intermediate flow (between the FORCE beach and Black Rock Island – 4m/s), and high flow (in the turbine deployment region – 6m/s).

The project will be developed in three phases:

Phase 1: Based on the comprehensive evaluation of failure and potential failure points, summarized on the high flow conditions in the turbine deployment area, platform enhancements will be specifically defined and implemented through analysis, design, and fabrication stages.

Phase-2: The second phase will introduce a whole new capability – a dynamic mount – to the FAST-2 platform, and will take its development through three stages: bench testing and testing in low and intermediate flows. No such platform (with a dynamic mount) exists for use in high flows, necessitating innovation in both the design and field-testing stages.

Phase-3: At the field-testing stage, a key innovation is the use of an imaging sonar to evaluate the performance of the dynamic mount. Based on previous studies (e.g., [3]) and on consultation with CSTV, Tritech's Gemini multibeam sonar is well-qualified for monitoring animal interactions with instream turbines.

Imaging sonar already plays a critical role in assessing the interaction of marine life and turbines. To-date, imaging sonars used for turbine monitoring have been mounted on the turbines (e.g., the SeaGen turbine in Strangford Lough[13] and the CSTV turbine in the FORCE region). However, this static mounting imposes a number of limitations (e.g., on the field of view), and further may have no benefit for certain turbine types (e.g., yawing turbines). The project develops technology that is able to image the turbine and surrounding sea life from the seabed, from a potentially unlimited number of perspectives made possible by the dynamic mount.

In February 2017, FORCE deployed 'FAST-3', the third subsea sensor platform built as part of the FAST Program. FAST-3 was deployed between the FORCE beach area and Black Rock near the demonstration site. The platform, which was recovered approximately one month later, was deployed with a suite of sensors to gather data on fish presence and behaviour, including an acoustic zooplankton and fish profiler and a hydro-acoustic echosounder (the same instrument as the instrument being used in the fish environmental effects monitoring program, but mounted on the FAST-3 platform facing upwards). Results from the deployment are being analyzed by Dr. Haley Viehman, a post-doctoral fellow at Acadia University, [14] and will help to identify the best sensor settings and operating schedule for future data collection at the FORCE demonstration site.

Figure 10: The FAST-3 platform prior to deployment on the deck of the Nova Endeavour

[VIDEO]: FAST-3 is recovered from the Minas Passage, data download begins: https://vimeo.com/210830655

[VIDEO]: Dr. Viehman explains how the data is acquired and used: https://vimeo.com/210831742

Data Management

The Offshore Energy Research Association (OERA) released a request for proposals relating to data management in February 2017. The intent of the RFP is to contract a service provider to define and describe a data management system and user interface for use by FORCE. The

[13] The 1.2MW SeaGen unit was the world's first grid-connected commercial scale tidal device. Installed in Strangford Lough, Northern Ireland in 2008, SeaGen underwent marine mammal monitoring, bird and benthic ecology surveys. The monitoring program was managed by environmental consultancy Royal Haskoning DHV with scientific input from Queens University Belfast and the Sea Mammal Research Unit (SMRU) based at St Andrews University in Scotland. The program detected no major environmental impacts.

[14] Dr. Viehman's work is supported by Mitacs through the Mitacs Accelerate Program.

project deliverable will result in an outline of the various options that the FORCE datasets can be hosted and accessed through different user interfaces.

FORCE will work closely with the successful proponent in determining which data management system/approach will work best for FORCE's various data requirements. The RFP closed on March 13th.

Lessons Learned – Q1

Fish Surveys

Numerous lessons learned have been realized in the fish monitoring program:

- A component of the University of Maine's tasks in delivering the fish environmental monitoring program was to provide training to FORCE ocean technologists to take over the data collection portion of the program. This training has enabled Nova Scotia to gain more trained and knowledgeable persons in this highly novel and technical field.
- Due to this work, the University of Maine was able to collaborate with Dr. Haley Viehman of Acadia University to enhance their data processing method and remove turbulence and eddy data.
- Additional learnings for the fish monitoring program include improved instrument calibration and more efficient marine operations.

Marine Noise

Due to the rapidly evolving nature of marine noise monitoring techniques, inherent within the marine noise monitoring program is learning. In order to ensure better data collection, FORCE conducted a trial of two different drifting hydrophone systems, which provided experience for vessel crew and FORCE ocean technologists. The objective of this trial was to familiarize themselves with two types of equipment (Jasco and Ocean Sonics drifting hydrophone systems) and operations of safely deploying and recovering the equipment.

Marine Mammals

In addition to SMRU providing training to FORCE ocean technologists regarding how to calibrate C-PODs correctly (in preparation for deployment), FORCE also was able to lengthen its C-POD deployments due to longer than anticipated battery life.

FAST

Historically, many instruments that were deployed in the harsh undersea environment of the Minas Passage were never seen again. The initial purpose of developing the FAST platforms was to enable secure deployment and retrieval of instrumentation in the Minas Passage. Learnings continue with each deployment of the FAST platforms.

Significant lessons were learned in the recovery of the FAST-2 platform in early September 2016. When recovery was first attempted, the pop-up buoy failed to surface after interrogation and prompting of the acoustic release. As a result, the recovery operation required a diver to attach a lifting line from the platform to the recovery vessel. Upon recovery and inspection, the failure of the pop-up buoy was due to the presence of marine fouling and sediment, which became lodged in the release mechanism preventing the release of the shackle holding the pop-up buoy. Analysis is underway to address biofouling prior to the next deployment.

Other Research & Monitoring Activities – Q2

Hydroacoustic Fish Detection & Modelling Workshop

In late May 2017, FORCE hosted a workshop in partnership with Acadia University's Acadia Tidal Energy Institute on methods of fish detection and population modelling in consideration of in-stream tidal energy projects. This workshop brought together over a dozen researchers from the United States, Scotland, and Canada, including representatives from Fisheries and Oceans Canada, with experience in fish detection at high-flow tidal energy sites. Collectively, these researchers primarily use hydroacoustics to monitor marine animal dynamics at high flow tidal sites, and statistics and models to understand the effects of fish-turbine interactions beyond the scale of individual fish to that of fish populations.

The workshop took place over four days and consisted of presentations and facilitated conversations focused on international experience with tidal and wave energy sites/projects and identification of information gaps and best practices. It is hoped that this workshop will be the catalyst to future collaborative projects amongst the researchers and help identify future methods for data collection and analysis at the FORCE demonstration site.

A workshop report is being prepared and will be shared upon completion.

Data Management

In spring 2017, the OERA awarded SEG Consulting funding to define and describe data management system for use by FORCE. Since that time, SEG, FORCE, and the OERA have examined representative data sets in order to prepare a 'current and future state analysis' and options for a data management system/user interface (DMS). FORCE is currently evaluating these options and will move forward with building the chosen DMS option.

Reports of Fish Injuries

In response to media reports of fish injuries in the south side of the Minas Basin in mid-May 2017, FORCE engaged Envirosphere Consultants to examine the nature of these wounds in further detail. On May 19th, 2017, FORCE staff and Envirosphere joined a representative from Fisheries and Oceans Canada at a weir in the Minas Basin to gain a better understanding of the reported injuries.

Figure 11: A DFO representative examines fish samples at a weir in the Minas Basin.

Envirosphere Consultants personnel continued to monitor incidence of injured fish in fisheries of southern Minas Basin and inflowing rivers for approximately two weeks after the tidal turbine operated by CSTV was removed from the FORCE demonstration site. Envirosphere is in the process of preparing a final report, to be reviewed by FORCE's EMAC, upon the turbine's retrieval.

Fundy Advanced Sensor Technology Program

On April 20th, 2017, the Offshore Energy Research Association, the Nova Scotia Department of Energy, and Innovacorp awarded $135,000 to Open Seas Instrumentation Inc. (Musquodoboit Harbour, Nova Scotia) to support innovative approaches to monitoring marine life near an in-stream tidal energy turbine. This project focuses on a redesign of the FAST-2 platform to enable directional sensors to collect data from a specific target, including the face of the turbine. FORCE is a project partner to this project as is the Nova Scotia Community College, Acadia University, Dynamic Systems Analysis, and Ocean Moor Technical Services.

Testing will occur at the FORCE Site with a series of progressive tests that will include low-water near-shore testing, intertidal testing, and testing within the FORCE demonstration site. Significant marine operational challenges, technological upgrades, and the associated electromechanical work is challenging, but the result will be an advancement for environmental effects monitoring.

Figure 12: FORCE personnel work on the FAST-2 sensor platform in mid-June, connecting a multibeam imaging sonar camera to a multiplexer, which collects and transmits data to shore via optical fibres.

FAST-3 was deployed in the FORCE demonstration area on June 23rd, 2017. This will be the first full-length deployment in the FORCE demonstration area with the finalized testing arrangement for Dr. Haley Viehman's (Acadia University) study. The platform will be deployed for approximately 1.5 months, gathering fish and environmental data.

TETHYS STORY: Remote Sensor Platforms for Environmental Monitoring at FORCE, Canada (available online at: https://tethys.pnnl.gov/tethys-stories/remote-sensor-platforms-environmental-monitoring-force-canada)

Lessons Learned – Q2

Simultaneous Operations

During this reporting period, CSTV announced that it would be removing its turbine from the FORCE site.[15] After this announcement in April 2017, CSTV undertook significant marine operations at the FORCE site in relation to the cable disconnection and attempted recovery of the turbine. The turbine was successfully recovered from the site on June 15th, 2017 and transported to Saint John, New Brunswick the following day.

This work has required FORCE to manage simultaneous operations—turbine-related communications, operational support and safety, FAST, and EEMP operations. The management of simultaneous operations presented a two-fold issue—extensive marine operational activity has the potential to compromise EEMP data collection, particularly for fish surveys, and has also restricted the availability of the vessels used in EEMP operations.

EEM Program Lessons Learned

Additional lessons were learned over the course of the second quarter of 2017. In particular, it was identified that the methodology of the fish surveys presents a significant challenge with respect to operational planning. For instance, the data collection for the fish EEMP requires specific weather conditions, which can be challenging when operating during a limited tidal window (neap tide). Successfully planning a survey given the tidal window and weather limitations is challenging. This work highlights the value of bottom-mounted monitoring platforms. The FAST platforms are not subject to the limitations that inhibit vessel-based surveys such as visibility, seasonal constraints, weather, tides, and, most essentially, vessel availability.

The latest C-POD deployment and recovery provided two important lessons learned:

- The failure of one of the C-PODs' moorings highlighted that longer deployments increase the risk of instrument loss (although the C-POD was recovered by a local fisher). FORCE staff are currently review the mooring design.
- Upon recovery, two other C-PODs were not immediately found. FORCE staff are investigating options that can help with instrument recovery.

With increased marine operations at the site, FORCE has required additional support in data collection and FAST-related operations. In May 2017, FORCE hired an ocean technologist intern to support in these efforts as well as interns based at the visitors/operations center to assist in some monitoring activities, including the public observation/beach walks program.

[15] See announcement: www.capesharptidal.com/commissioning.

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Appendix 1: Fish Environmental Effects Monitoring Plan Interim Report

Interim report summarizing analyses from fish surveys completed in May, August, October, and November 2016. Prepared by the University of Maine.

Report to FORCE
4th Fish Survey by UMaine
24-25 November 2016

Prepared by: Aurélie Daroux and Gayle Zydlewski, University of Maine, School of Marine Sciences

This report includes a complete description of the fourth fish monitoring survey in November 2016 (data handling, processing an analysis) as well as new data processing and analyses from the last three surveys (in May, Aug, Oct). This report supersedes the previous three survey reports in regard to **data processing and analyses**.

Overall relative fish densities were significantly different among months. Within each month, we found spatial variability in relative fish density. Spatial variability was related to differences among transect locations and co-varied with tide and day-night conditions. Results to date indicate that mean relative fish densities were significantly higher in the Crown Lease Area (CLA) than in the adjacent control area, *this pattern did not change even after turbine deployment*. However, monitoring of the region should continue in order to assess changes in fish distribution patterns over time.

Introduction

The Bay of Fundy has the largest tides in the world. The Fundy Ocean Research Center for Energy (FORCE) has taken advantage of these tides near Minas Passage and created a facility to allow industry to demonstrate and evaluate tidal in-stream energy conversion (TISEC) technology. FORCE is required to establish an Environmental Effects Monitoring Program (EEMP) covering fish, lobsters, marine birds, marine mammals, and marine noise. This document specifically addresses the EEMP for fish in the area that includes the FORCE Crown Lease Area (CLA). This fourth survey occurred after one TISEC device was deployed at berth D.

The goal of this project is to quantify fish behavior changes, measured as spatial distribution, associated with the presence of deployed TISEC devices in the FORCE CLA. Specific objectives include: (1) testing for indirect effects of TISEC devices on water column relative fish density; (2) testing for indirect effects of TISEC devices on fish vertical distribution; and (3) estimating the probability of fish encountering a device based on relative fish density proportions in the water column relative to deployed TISEC device depth. These objectives are being accomplished using a mobile, down-looking hydroacoustics echosounder (EK80) from a medium-sized boat (the *Nova Endeavor*) using field methods, data processing and analysis techniques, and interpretation that were applied at the successful ORPC Cobscook Bay Tidal Energy Project (CBTEP) site in Maine, USA. These techniques have proven acceptable to local regulators, the US Department of Energy, the US Federal Energy Regulatory Commission, and the scientific community (Viehman et al. 2015). We have revised the approach to suit the needs of the Minas Passage area.

Objectives and survey preparation

This survey was the first one after the first TISEC device installation which occurred on November, 7, 2016. On November 22, all of the hydroacoustic and electrical equipment were installed and connected on the RV *Nova Endeavor* which was docked in Delhaven, Nova Scotia. Calibration was not performed there because the water depth was not suitable (Figure 1).

Figure 1: Delhaven Harbour conditions at low tide.

On November 23rd, the boat was to arrive in Parrsboro to perform a calibration at the pier at slack tide. However, because of the shallow water in Delhaven, the crew needed to wait for high tide to depart and did not arrive to Parrsboro in time for slack water. The arrival time did not provide proper conditions to perform calibrations on November 23rd. So, we left the pier early on November 24th to perform calibrations immediately prior to the survey. We used a fishing line with the calibration sphere at the end, as in the last survey. The echosounder mount was adjusted at an angle to better position the calibration sphere in the echosounder beam. The CW mode calibration had an RMS error of 0.0348 (a calibration is considered good if this value is less than 0.2). The gain (since the last survey) was only modified by 0.1 dB, which is minimal and shows that the transducer settings did not change much between surveys. The FM mode calibration was also very good with an RMS error of 0.2.

The 24th – 25th November survey details

The survey began on 24 November 2016 at 8:30am and finished on 25 November 2016 at 9:15am. Four "grids", each grid composed of 6 impact transects (within the CLA), 3 control transects and 2 "along" transects (running from the CLA to the control site), were conducted. We added a turbine transect (T transect) over the turbine location. Two grids were conducted for each tidal cycle, grid 1 during the day, grid 3 during the night and grid 2 and 4 during both day and night.

Transducer settings were the same as previous surveys: pulse duration of 1.024ms (consistent with Melvin baseline settings), power of 250W (recommended by Simrad) and ping interval of 250ms.

Murray Scotney (FORCE subcontractor, OceanMoor Technical Services) and Aurélie Daroux (UMaine) conducted surveys during one ebb and one flood tide, from 0830 - 2050 on 24 November 2016. Tyler Boucher (FORCE staff) and Aurélie Daroux conducted the rest of the survey from 2100 - 0910 on 24 and 25 November 2016. Details (datasheets with filenames, transect durations, environmental measurements) concerning the proceedings of the survey are included in Appendix I.

The weather was amenable during the entire survey but due to the strong flood tide and the addition of a turbine transect, S2 and S3 control transects as well as the N5 CLA transect (with the tide) from grid 2 was not sampled. All transects in all other grids were completed.

Six Deep Cycle batteries wired in parallel were enough to supply the transceiver during the 24 hour survey. The 24 hour survey resulted in 53.5 Gb of data. Two copies of the data were stored at the end of the survey: (1) University of Maine has the data on a hard drive. At the end of the survey, the data were also copied on (2) Murray Scotney's hard drive and on (3) another hard drive from the University of Maine.

Data processing, preliminary results and conclusions

1) Processing improvements

This report includes analysis from all surveys to date because we improved our processing method and changed how the data were scaled for exporting. All previous surveys were reprocessed using the new methods and results are included here.

1.1) Turbulence detection

The presence of eddies (air entrained in water and in circular motion below the surface of the water) from the surface to 50 m depth impacted the quality of the data on some transects. During the data processing, this surface turbulence must be removed in order to not be integrated as fish.

With the help of Haley Viehman (Acadia University), a new method using reverse bottom detection was developed

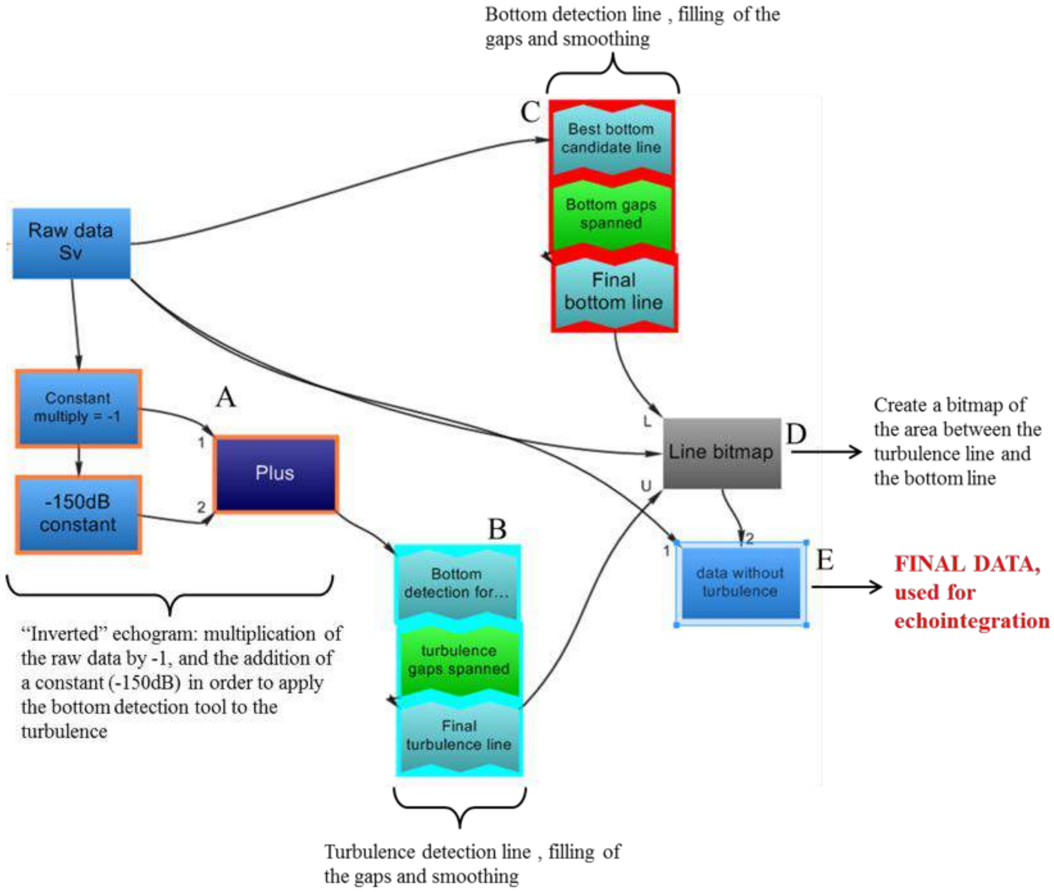


Figure 2: EchoView Dataflow of the processing of the data before echointegration.

The raw data were multiplied by -1.0 and a constant was added so the software interpreted the surface as the bottom of the water column (Figure 2A). Then a bottom detection algorithm was used on the new set of data to smooth the line (Figure 2B). In addition, the usual bottom detection algorithm was applied to detect the actual sea bottom (Figure 2C). A bitmap of the area between the turbulence line and the bottom line was then created (Figure 2D), and the data between those two lines were used for echointegration (Figure 2E and Figure 3). This method is not more time consuming than the previous one and allows us to export turbulence/eddy data. This new method has been applied to all surveys.

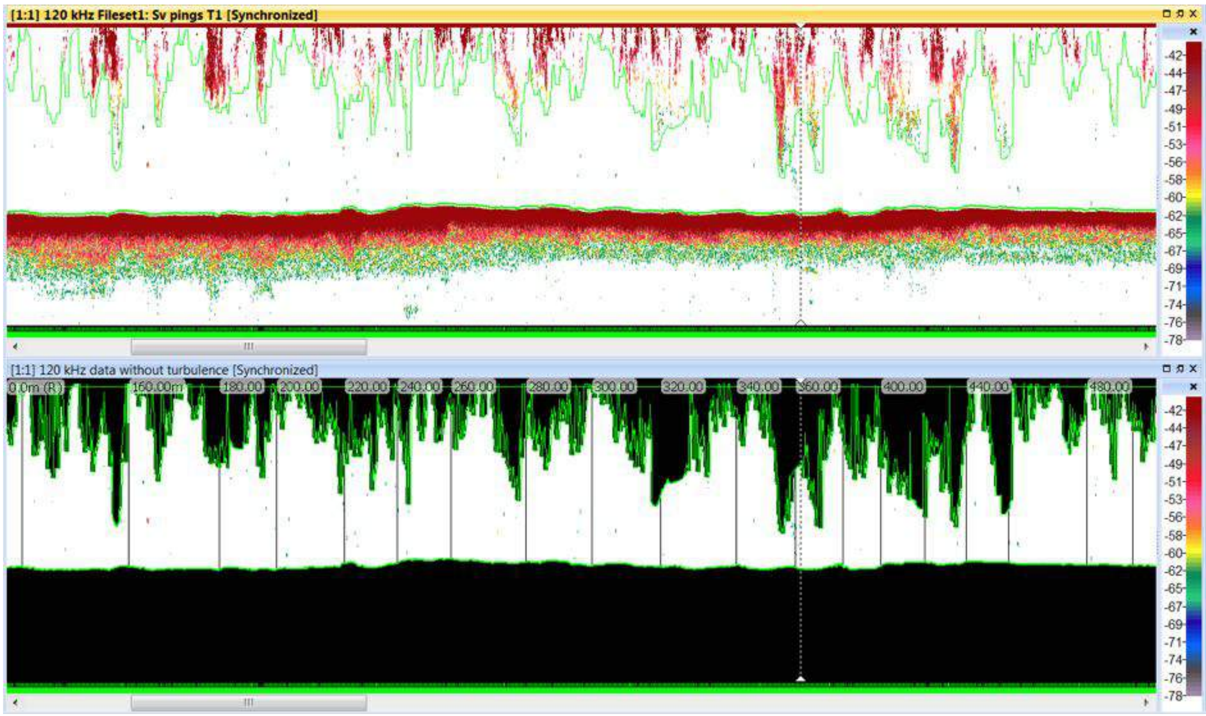


Figure 3: Snapshot of an echogram (Fileset1: Sv ping T1 (top), data without turbulence (bottom) of the Dataflow, see Figure2) where the new reverse bottom detection processing method has been performed. The exported area corresponds to the white part of the echogram between the two black areas in the bottom echogram shown.

1.2) Autocorrelation and data export grid

Previous survey data were exported in 1m vertical layer depth bins (Figure 4, left). This way of organizing the exported data is suitable for analyzing vertical distributions but is not ideal for quantifying total water column relative fish density and its variability within and among transects. Instead, full water column data grouped by distance or time (Figure 4, right) are more appropriate for assessing overall relative density of fish for comparison among transects and locations.

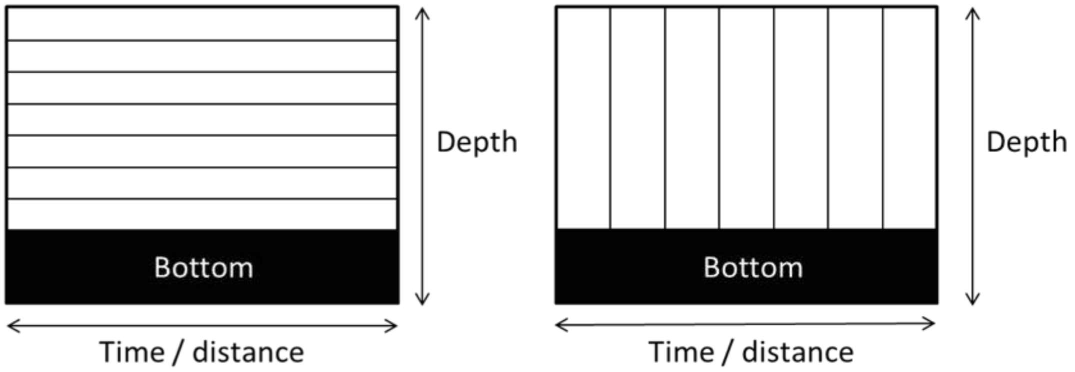


Figure 4: Representation of the data export by 1m depth bins (left) and by 20m vertical distance bins (right).

To assess the best time/distance scale to export data we performed autocorrelation using different intervals. Numerous time intervals (from 1min to 10min) and distance intervals (from 1m to 5m) were tested. We performed autocorrelation tests on 4 transects (GR1_N0A, GR2_N3A, GR3_N5W and GR4_S1W) of each survey. Distance intervals were chosen because time bins had higher within-transect and within-survey variability. Autocorrelation, using 5 m distance bins was then performed on the chosen 4 transects from each survey. As an example, in one sample transect, data were not correlated after 10 m (Figure 5). For the four tested transects of all surveys, 20m distance bins were consistently not correlated. As such, data were echointegrated for the entire water column in 20m distance bins for each transect of all surveys. Exported data were used for the GLM model and graphic display in boxplots. However, for vertical distribution analyses, exports were by 1m depth bins.

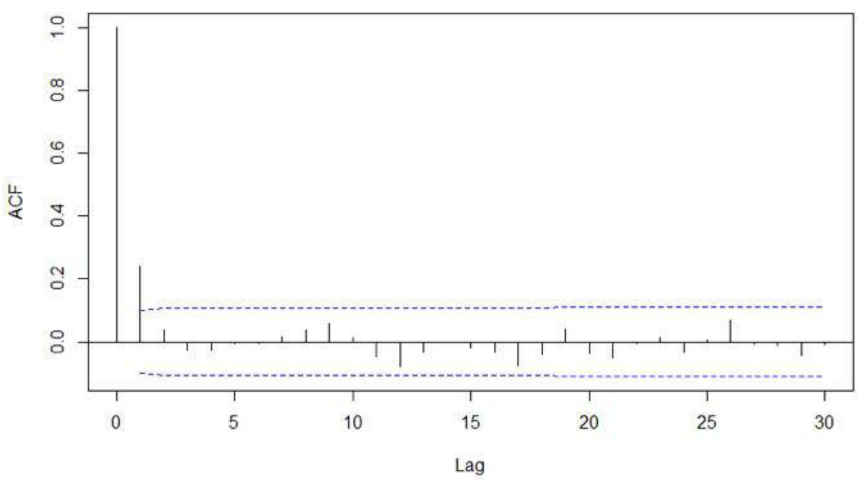


Figure 5: Example of an autocorrelation graph (for GR4_S1W from survey 1), ACF represents the autocorrelation value and the lag interval chosen, here 5 meters. When the ACF is below the blue dotted line the lag indicates the interval where the samples are no longer correlated.

1.3) Environmental parameter characterizations

With the re-processing of all the data, we decided to work on a better definition of the tide and diel variables. Before, datasheet written indications were used to determine the stage of the tide and the period of the day. This personal and subjective determination has been changed. Diel period has been characterized using civil sunrise and sunset hours in order to define dawn and dusk in the same way for each survey. Low tide and high tide have been defined as a 1-hour period around the lowest depth time and the highest depth time using the tide chart from Cape Sharp, http://tides.mobilegeographics.com. This characterization of slack tides will be improved or justified by simulation velocity data (at the time and date of the survey) which will be provided by Richard Karsten from Acadia University.

2) Results

2.1) Statistical Comparisons and variable effects using a generalized linear model

To examine whether there was an influence of environmental factors in the backscatter/relative fish densities, we used a generalized linear model (GLM). This GLM was performed on all surveys using linear relative fish density data (Sv), including all zero data.

The factors included in the GLM were:

- *transect*: the name of the transect
- *diel*: time of the day: day, night, dusk, dawn
- *location*: CLA or control
- *tide*: high, low, ebb and flood
- *turbine*: presence or absence
- *survey*: 1, 2, 3 or 4

with linear Sv, which is the linear acoustic backscatter, also equal to the summation of the contribution from all targets within the 20m distance bins.

$$\mathrm{Sv} \sim transect + diel + location + tide + turbine + survey + transect*diel + transect*tide$$

Akaike information criterion (AIC) is a measure of the relative quality of a given set of data statistical models (the smaller the value of this measure is, the better the model fits the data), we calculated the AIC to determine which model fit the data best (Table 1, 2).

Table 1: AIC results for GLM using linear relative fish density.

	AIC
NULL: Sv ~1	-471914.6
Sv ~ transect	-472502.5
Sv ~ transect + tide	-472664.5
Sv ~ transect + tide + survey	-472712.7
Sv ~ transect + tide + survey + diel	-472871.9
Sv ~ transect + tide + survey + diel + tide	-472871.9
Sv ~ transect + tide + survey + diel + tide + transect*diel	-473274.9
Sv ~ transect + tide + survey + diel + tide + transect*diel + transect*tide	**-473708.8**

Table 2: Results of the ANOVA between the NULL model (Sv ~ 1) and the model with factors (Sv ~ transect + diel + location + survey + tide + turbine + transect*diel + transect*tide)

	Df	Deviance	Resid. Df	Resid. Deviance	F	P-value
NULL	29208	0.00016456				
transect	9	3.38E-06	29199	0.00016118	70.971	<2.20E-16
tide	3	9.60E-07	29196	0.00016022	60.497	<2.20E-16
survey	3	9.78E-07	29193	0.00015924	61.605	<2.20E-16
diel	3	1.90E-07	29190	0.00015905	11.951	8.13E-08
transect*diel	17	2.27E-06	29173	0.00015678	25.214	<2.20E-16
transect*tide	16	2.57E-06	29157	0.00015421	30.379	<2.20E-16

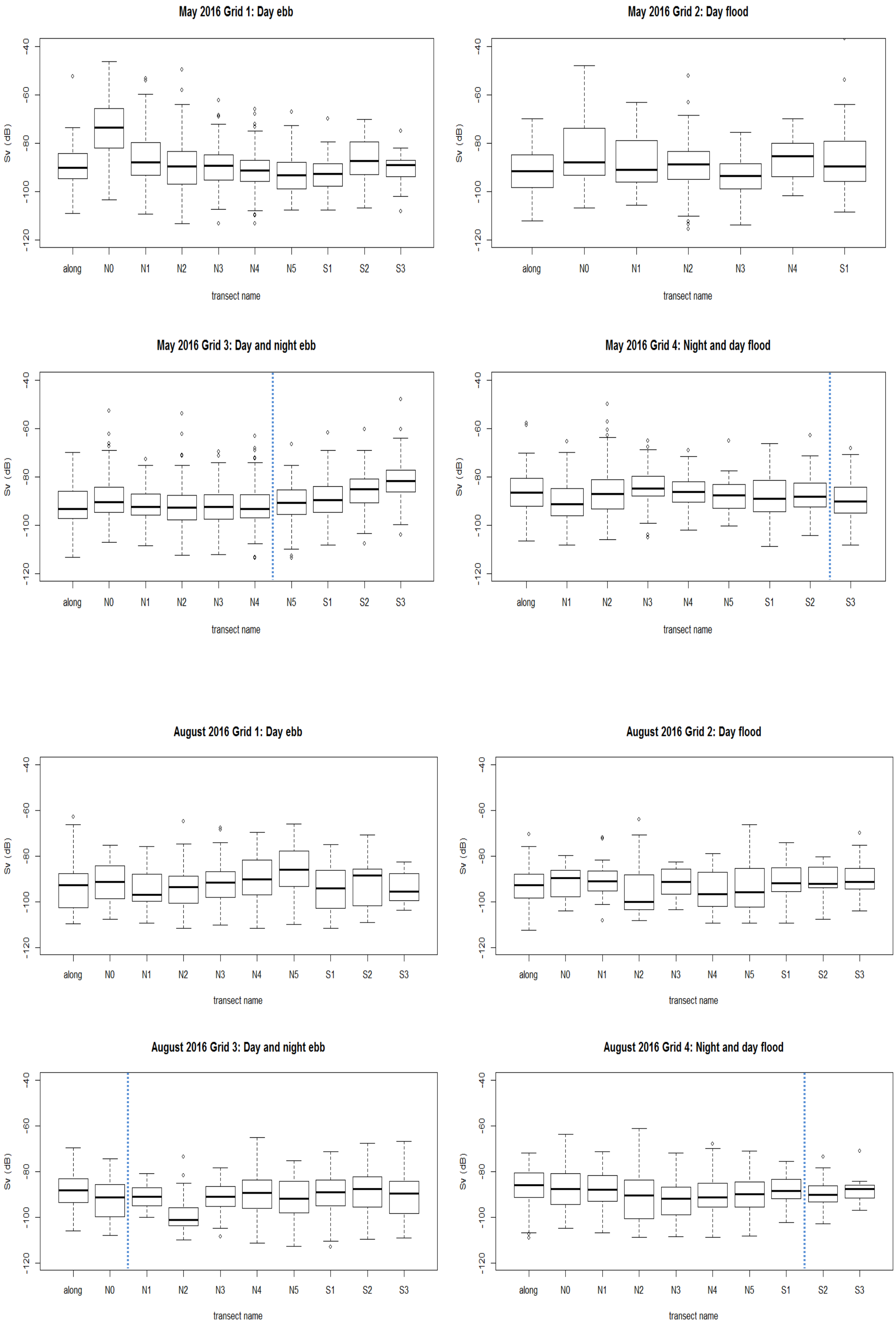
Transect, tide, survey and diel factors all contribute to the variability in relative fish density (Table 2). The interaction between transect and diel condition as well as the interaction between transect and tide support the fact that the difference between relative fish densities during different diel and tidal periods are related to the transect sampled at that time/ tide stage and not diel/tide effects separately.

The turbine presence during the 4th survey did not appear to influence relative fish density in the CLA area. The turbine factor and the location factor did not appear in the results above because they are collinear (vary directly with) with survey (for turbine) and transect (for location) factors.

2.2) Study objectives and data overview

The overall goal of the fish survey study is to quantify fish distributional changes which can reflect behavioral responses to the presence of a deployed TISEC device. The objectives are to: *(1) test for indirect effects of TISEC devices on water column fish density; (2) test for indirect effects of TISEC devices on fish vertical distribution; and (3) estimate probability of fish encountering a device based on fish density proportions in the water column relative to TISEC device depth in the water column. These objectives will be met using a Before-After-Control-Impact (BACI) study design, multivariate analysis (Hotellings T2 tests) of fish vertical distributions, and an encounter probability model.*

<u>To address the first objective</u>, we recorded density estimates by transects (with and against) exploring 4 grids. The data are presented as boxplots in Appendix II (for survey 4) and in Appendix IV (for survey 1 to 3) and are summarized below (Figure 6).


May 2016 Grid 1: Day ebb
May 2016 Grid 2: Day flood
May 2016 Grid 3: Day and night ebb
May 2016 Grid 4: Night and day flood
August 2016 Grid 1: Day ebb
August 2016 Grid 2: Day flood
August 2016 Grid 3: Day and night ebb
August 2016 Grid 4: Night and day flood
Sv (dB)
-40
-60
-80
-100
-120
along
N0
N1
N2
N3
N4
N5
S1
S2
S3
transect name

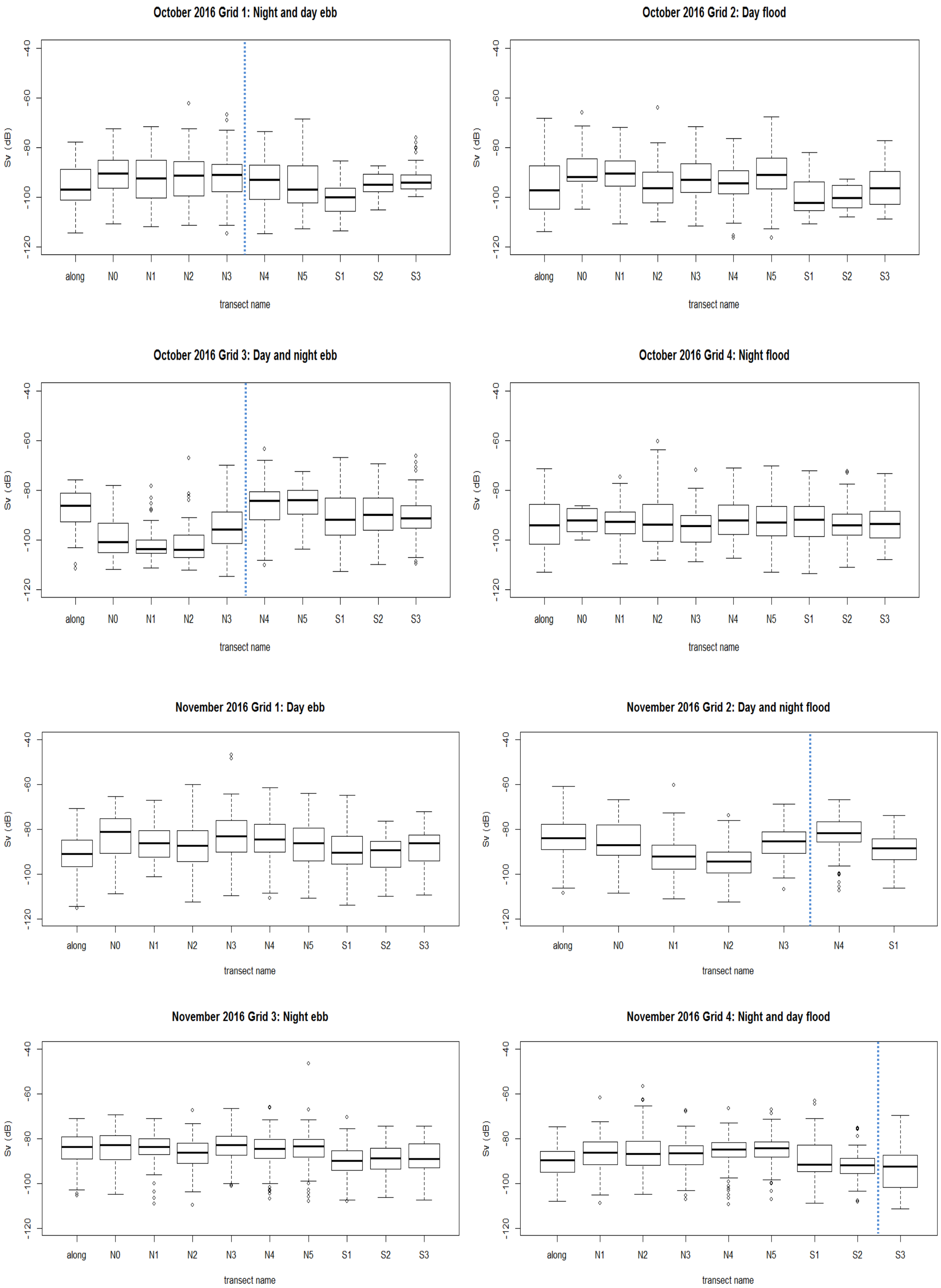


Figure 6: Boxplots of exported Sv (Volume backscattering strength) for the 4 grids conducted in May, August, October and November. The blue vertical dashed line represents the transition between day (to the left of the line) and night (to the right of the line) periods.

During the 4th survey, we observed that the N0 transect had a higher relative fish density, especially for grids 1, 3, and 4 (Figures A2.1, A2.2, A2.4, A2.6, A2.8). The N4 transect also had a higher relative fish density, especially in grid 2, during dusk (Figure A2.4).

Reminder: These boxplots are a visual representation of the relative fish density and not of the number of fish present in each transect. For example, two big fish which reflect a lot of energy can give a transect a higher fish density than a transect with many smaller fishes.

To address the second objective regarding fish vertical distribution, we processed the survey data for density estimates by 1 m vertical layers. To smooth the vertical distributions in each transect, area backscatter strength was averaged by 2 m depth bins (as in the previous reports). Data are presented in Appendix III.

The vertical distributions were variable from transect-to-transect and by grid, and not necessarily consistent between the test area and the channel even for common depths. The only time we observed a higher relative density of fish closer to the surface was in the N1 transect during grid 2 (Figure A3.3).

The "along" transects for each grid were variable with the along transect of grid 4 showing the lowest density and grid 2 one the highest (Figure A3.9).

2.3) Comparison with the previous surveys

The boxplot presentation of these data shows the variability of the relative fish density within surveys. All boxplot representations required zero values to be transformed to NA in order to visualize variation and not center plots on zero values (left panels of Figures 7-12). However, statistical comparisons included zero values As such, mean data plots (right panels of Figures 7-12) are provided to show the mean relative fish density with "zeros" not replaced by NA but using Sv = -999 to represent "zero" data (each point on the plot is the mean) A comparison of relative fish densities between surveys using an ANOVA showed significant differences (p-value <2e-16) among them, for all the statistical tests, 'zero' values have not been replaced by NA. To look at the difference between them more closely, we performed a Wilcoxon test by pair of surveys (Table 3).

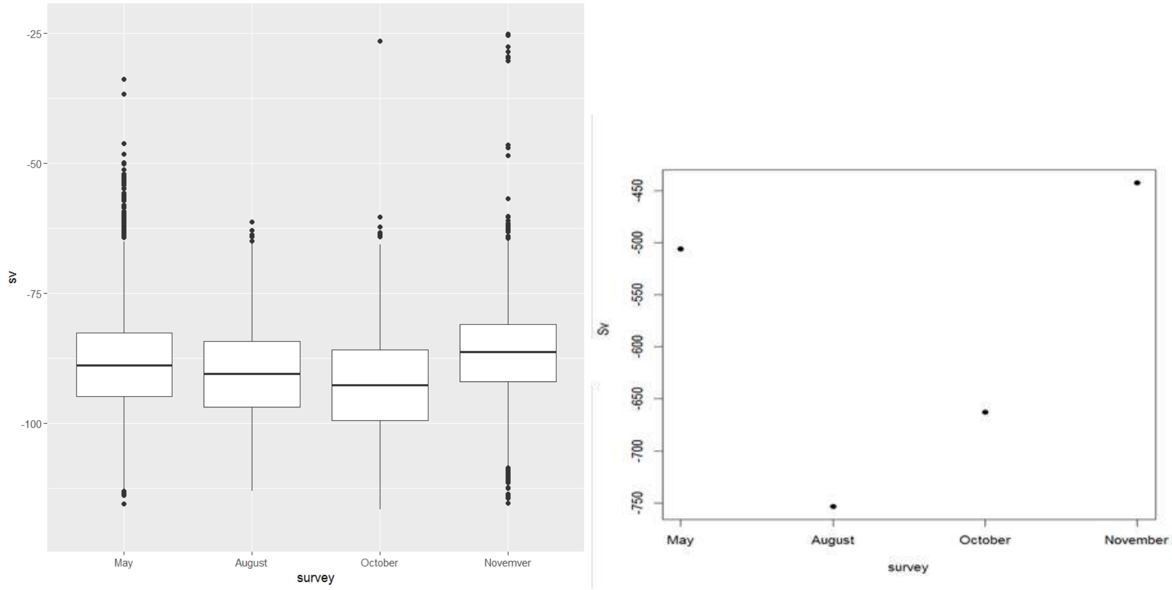


Figure 7: Boxplot of the Sv ("zero" replaced by NA, left) and mean Sv ("zero" not replaced by NA, right) for each survey (1: May, 2: August, 3: October, 4: November).

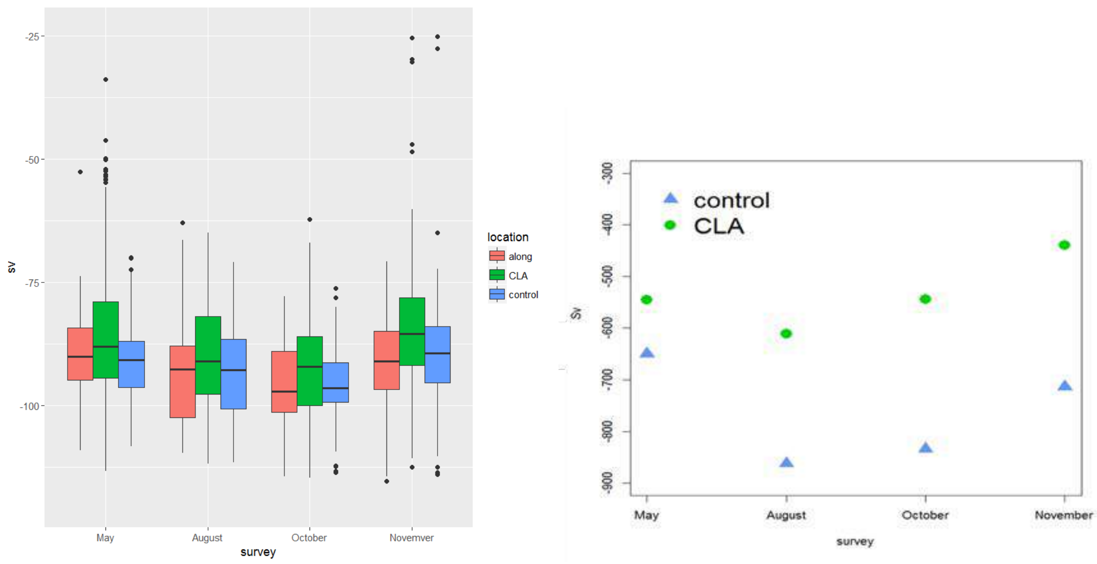


Figure 8: Boxplot of Sv data ("zero" replaced by NA, left) and mean Sv ("zero" not replaced by NA, right) for grid 1 (ebb tide) by location (CLA, control and along transect) and by survey (May, August, October and November).

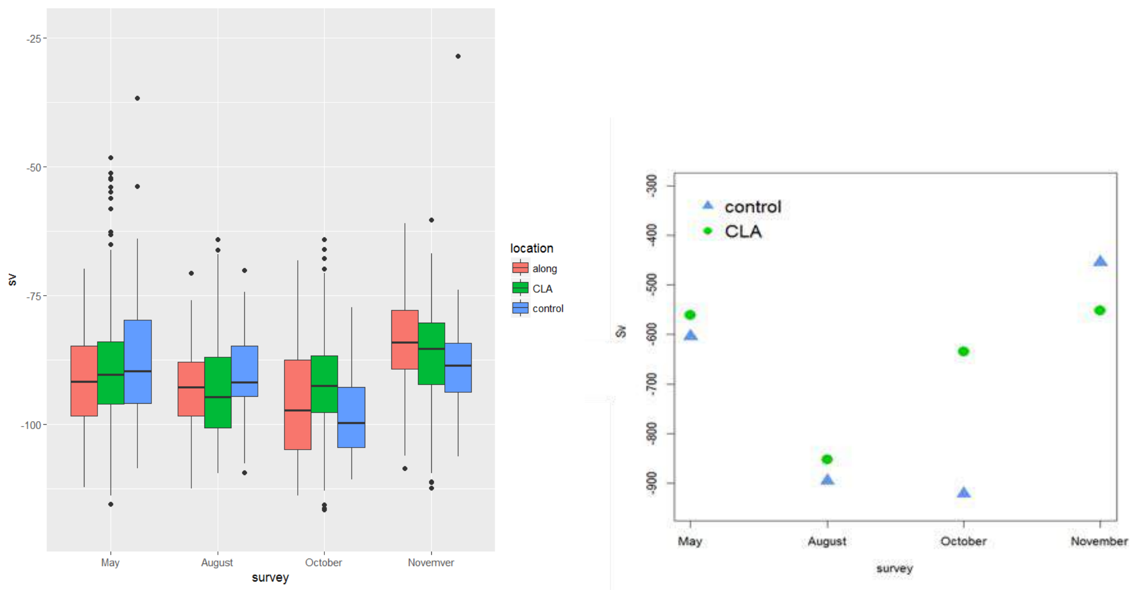


Figure 9: Boxplot of Sv data (“zero” replaced by NA, left) and mean Sv (“zero” not replaced by NA, right) for grid 2 (flood tide) by location (CLA, control and along transect) and by survey (May, August, October and November).

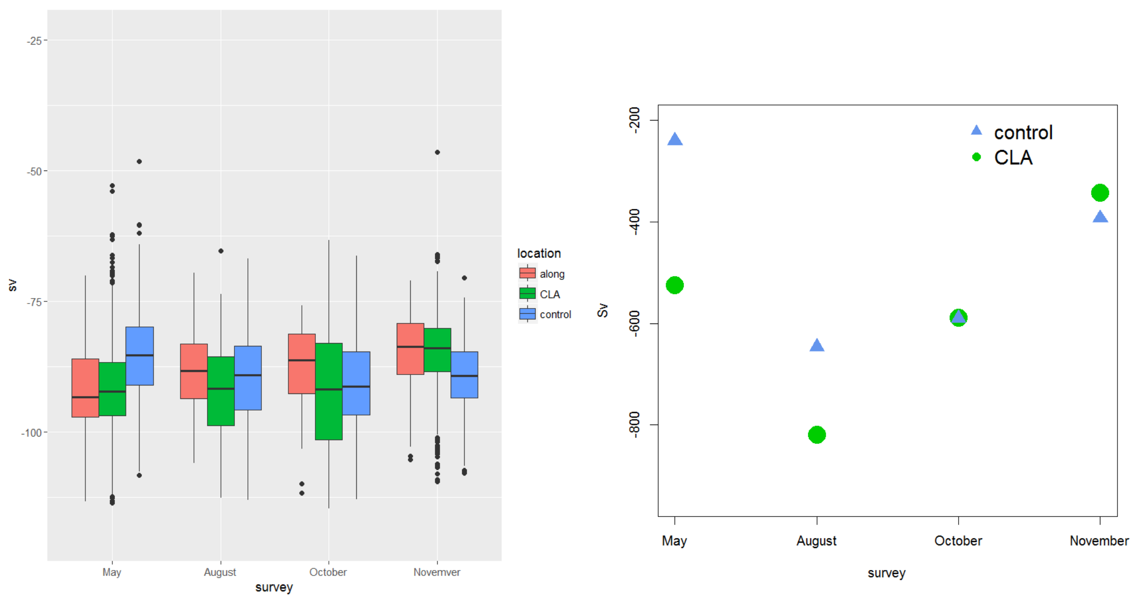


Figure 10: Boxplot of Sv data (“zero” replaced by NA, left) and mean Sv (“zero” not replaced by NA, right) for grid 3 (ebb tide) by location (CLA, control and along transect) and by survey (May, August, October and November).

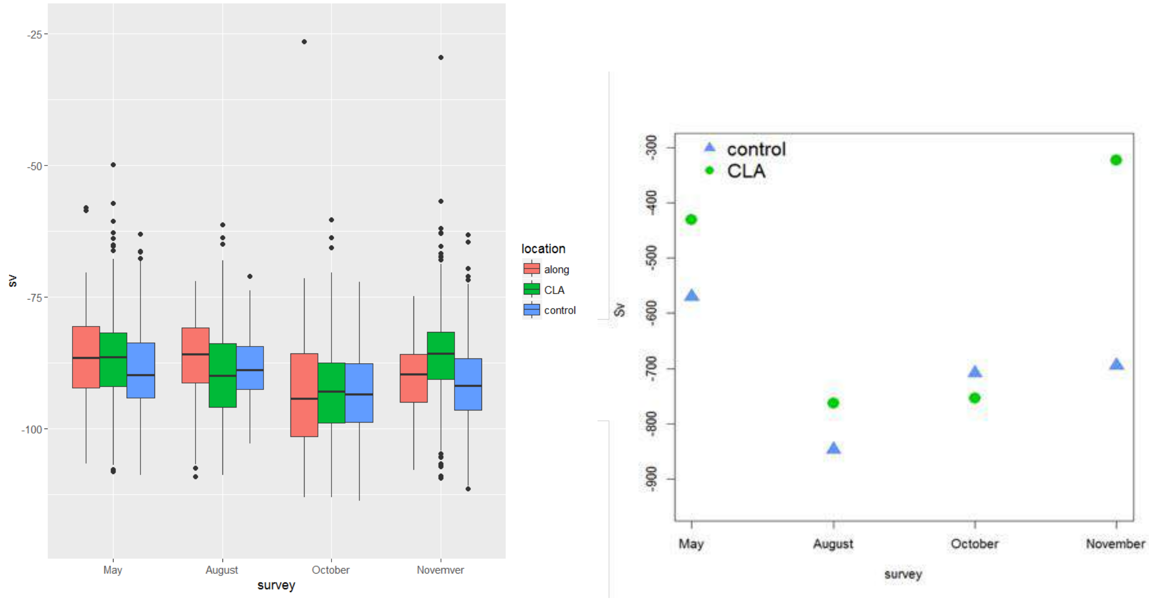


Figure 11: Boxplot of Sv data ("zero" replaced by NA, left) and mean Sv ("zero" not replaced by NA, right) for grid 4 (flood tide) by location (CLA, control and along transect) and by survey (May, August, October and November).

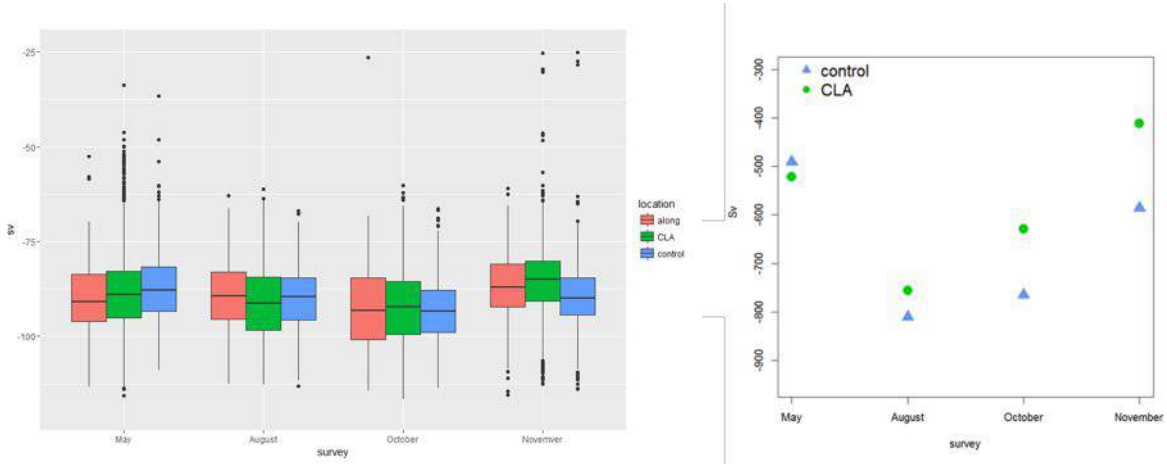


Figure 12: Boxplot of Sv data ("zero" replaced by NA, left) and mean Sv ("zero" not replaced by NA, right) for all surveys (May, August, October and November) by location (CLA, control and along transect)

Table 3: Wilcoxon comparison test results by pair of survey.

	survey 1	survey 2	survey 3	survey 4
survey 1		< 2.2e-16	< 2.2e-16	< 2.2e-16
survey 2			< 2.2e-16	< 2.2e-16
survey 3				< 2.2e-16

May and November had the highest mean relative fish density, and August and October the lowest (Figure 7). Relative fish density is significantly different among all surveys (Table 3). The highest relative fish density in May was predictable and may be associated with alewife spring spawning migrations and the presence of Atlantic herring (Baker et *al*., 2014). The November high density could be related to emigration of juvenile alewife. By late fall, young of the year river herring (alewives) and Atlantic herring are the only abundant clupeid species remaining along the northern coast (Ames and Lichter, 2013). After that period, they move to deeper, warmer depths though the winter (Townsend et *al*., 1989), and return to coastal nurseries in the spring.

For all surveys, during grid 1, CLA transects had a slightly higher (+2 dB on average compared to grid 2 and 3) relative fish density (Figure 8). Looking at the 4 surveys grid by grid, grid 1 and grid 2 (Figure 8 and 9, left) best reflected the global relative fish density by survey (Figure 7, left) with May and November surveys having generally higher relative fish density than August and October. Whereas, in grid 3 and grid 4 (Figure 10 and 11, left) of the 4 surveys, relative fish densities are visually smaller in August and October. Mean linear relative fish densities (Figure 8 to 11, right) had stable values between grids, similar to the global relative fish density.

Difference in relative fish densities between the CLA and control sites varied among grids and surveys, except (p-value= 0.2216) for the November survey during grid 3 (flood tide). For all surveys, expect the May survey, the CLA transects had significantly (p-value < 2.2 e-16) higher mean relative fish densities (Figure 12), which is generally due to the contribution of one transect in the CLA (for example, N5 for August and October surveys). This pattern was consistent for 3 surveys (August, September, and November), potentially indicating that in November, after the turbine installation, fish distribution did not change compared to prior deployment surveys. Nevertheless, continued monitoring is essential to assess the impact of the turbine on fish distributions.

References:

Ames, E.P. and Lichter, J., 2013. Gadids and alewives: structure within complexity in the Gulf of Maine. *Fisheries Research*. 141, pp.70-78.

Baker, M., M. Reed, and A.M. Redden. 2013. Temporal Patterns in Minas Basin Intertidal Weir Fish Catches and Presence of Harbour Porpoise during April – August 2013. *Acadia Centre for Estuarine Research*, Wolfville, NS, Tech. Rep. 120, 2014.

Townsend, D.W., Radtke, R.L., Morrison, M.A., Folsom, S., 1989. Recruitmentimplications of larval herring overwintering distributions in the Gulf of Maine, inferred using a new otolith technique. *Marine Ecolocial Progress Series*. 55, 1–13.

Viehman, H., Zydlewski, G.B., McCleave, J., Staines, G. 2015. Using acoustics to understand fish presence and vertical distribution in a tidally dynamic region targeted for energy extraction. *Estuaries and Coasts*. 38(S1): 215-226.

Appendix I: Scanned survey datasheets attached.

TW and T2 are just half transect.

T° = 9.0° for the calibration

Acoustics Water/Weather Observations

Salinity______ Crew ____________

Date start 11.24.2016 Time start 8:38:03 Vessel __________ Notes:

Date end __________ Time end __________ Location __________

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Grid #	Transect number	Start Date	Start Time	End Time	Tide stage (E,F, H,L)	Temp (C°)	GPS	DATA	Precip. Y/N	Fog Y/N	Day, Night, Dawn, Dusk	Wind Dir Speed	Eddy Y/N + Level 1 to 3	Pass. data Y/N	Boat speed	Wave Height (1/4 m)	Comments
GR1	N0W_E	11.24.16	8:38:03	8:51:25	E	9.0	Y	Y	N	N	Day	<5	Y(1)	Y	4.2	<1/4	High at 8.40.
GR1	N0A_E	//	8:52:04	09:04:01	E	//	Y	Y	//	//	//	//	Y(1)	Y	5.2	//	
GR1	N1W_E	//	9:05:47	09:18:38	//	//	Y	Y	//	//	//	//	Y(3)	Y	5.0	//	
GR1	N1A_E	//	9:18:59	09:32:00	//	//	Y	Y	//	//	//	5.	Y(3)	Y	5.2	1/4 m	
GR1	N2W_E	//	9:34:46	09:46:47	//	//	Y	Y	//	//	//	5	Y(3)	Y	5.3	1/4	weird detection on the bottom have been seen both W and A transects
GR1	N2A_E	//	09:47:48	10:04:40	//	//	Y	Y	//	//	//	5	Y(3)	Y	4.3	1/4	
(W+A) GR1	TW_E	//	10:06:43	10:28:25	//	//	Y	Y	//	//	//	<5	Y(3)	N	9.5 to 6.1	//	go back to see the turbine before the middle of the transect
(W+A) GR1	T2_E	//	10:30:35	10:45:59	//	//	Y	Y	//	//	//	//	Y(3)	N	3.4	//	
GR1	N3W_E	//	10:48:13	10:56:07	//	//	Y	Y	//	//	//	//	Y(3)	Y	6.5	//	
GR1	N3A_E	//	10:56:30	11:22:43	//	//	Y	Y	//	//	//	//	Y(3)	Y	4.0	//	

Grid #	Transect number	Start Date	Start Time	End Time	Tide stage (E,F, H,L)	Temp (C°)	GPS	DATA	Precip. Y/N	Fog Y/N	Day, Night, Dawn, Dusk	Wind Dir Speed	Eddy Y/N + Level 1 to 3	Pass. data Y/N	Boat speed	Wave Height (1/4 m)	Comments
GR1	N4W_E	11.24.16	12:24:46	11:35:00	E	9.0	Y	Y	N	N	Day	<5	Y3	✓	6.5	<1/4	
GR1	N4A_E	"	11:35:30	12:04:50	"	"	"	"	"	"	"	"	"	✓	3.0	<1/4	
GR1	N5W-E	"	12:05:55	12:16:12	"	"	"	"	"	"	"	"	Y2	✓	5.8	<1/4	
"	N5A-E	"	12:17:02	12:41:34	E	9.0	"	"	"	"	"	"	"	✓	3.1	<1/4	
"	South-cut	"	12:43:02	13:01:50	"	"	"	"	"	"	"	<5	Y1	✓	5.0	<1/4	
"	S1W-E		13:02:46	13:12:40	"	"	"	"	"	"	"	<5	Y1	✓	5.5	<1/4	
"	S1A-E		13:13:30	13:29:05	"	"	Y	Y	"	"	"	"	Y(1)	Y	3.4	"	
"	S2W_E		13:30:41	13:43:37	"	9.0	Y	Y	"	"	"	"	Y(1)	Y	5.0	"	wind gust @ 5
"	S2A_E		13:44:38	13:58:03	"	"	Y	Y	"	"	"	"	Y(1)	Y	4.3	"	
"	S3W_E		13:59:41	14:12:26	"	"	Y	Y	"	"	"	"	Y(1)	Y	5.1	"	

Grid #	Transect number	Start Date	Start Time	End Time	Tide stage (E,F, H,L)	Temp (C°)	GPS	DATA	Precip. Y/N	Fog Y/N	Day, Night, Dawn, Dusk	Wind Dir Speed	Eddy Y/N + Level 1 to 3	Pass. data Y/N	Boat speed	Wave Height (1/4 m)	Comments
GR1	S3A_E	11/24/16	14:13:41	14:24:53	E	9.0	Y	Y	N	N	Day	<5	Y(1)	Y	5.1	<1/4	turbine saw 2 times because the boat turned. (slack water) → part of the FM record is at the previous file (GR1_S3A_E) Low Tide at 2:50
GR1	North_FM	//	14:25:00	14:54:00	E	//	Y	Y	N	N	//	//	Y(1)	Y	6.5	//	
GR2	N0A_F	//	14:54:48	15:06:52	F	//	Y	Y	N	N	//	//	Y(1)	Y	5.0	//	
GR2	N0W_F	//	15:07:24	15:18:35	F	//	Y	Y	N	N	//	//	Y(1)	Y	5.4	//	
GR2	N1A_F	//	15:20:05	15:33:13	F	//	Y	Y	N	N	//	//	Y(few)	Y	4.8	//	
GR2	N1W_F	"	15:33:55	15:44:29	F	//	Y	Y	N	N	//	//	Y( )	Y	5.7	//	
GR2	N2A_F	"	15:46:47	16:03:00	F	"	"	"	"	"	"	"	N	Y	4.0	"	
GR2	N2W_F	"	16:03:36	16:14:27	F	"	"	"	"	"	"	"	few	Y	6.0	"	
GR2	TA-F	"	16:16:41	16:40:30	F	"	"	"	"	"	"	"	"	Y	2.5	"	turbine detected.
GR2	TW-F		16:41:18	16:50.17	F	"	"	"	"	"	Dusk	"	Y)		6.0	"	turbine detected.

Sunset = 4.40pm

Grid #	Transect number	Start Date	Start Time	End Time	Tide stage (E,F, H,L)	Temp (C°)	GPS	DATA	Precip. Y/N	Fog Y/N	Day, Night, Dawn, Dusk	Wind Dir Speed	Eddy Y/N + Level 1 to 3	Pass. data Y/N	Boat speed	Wave Height (1/4 m)	Comments
GR2	N3A-F	11.24.16	16:52:30	17:50:10	F	9.0	Y	Y	N	N	Dusk Night	<5	Y(2)	Y	1.6	<1/4	Almost 1h
GR2	N3W-F	"	17:50:38	17:52:22	F	"	Y	Y	N	N	Night	"	Y(2)	Y	8.5	"	
GR2	N4A_F	"	17:59:10	19:12:02	F	"	Y	Y	N	N	Night	"	Y(3)	Y	22	"	
GR2	N4W_F	"	19:12:34	19:19:11	F	"	Y	Y	N	N	Night	"	Y(3)	Y	8.0	"	
GR2	N5A_F	"	19:21:00	19:25:12	F	"	Y	Y	N	N	"	"	Y(3)	N	2.5	"	Running out of time - over to South Side.
GR2	South-Cal	"	19:25:40	19:48:58	F	"	Y	Y	N	N	"	"	Y3	N	6.8	"	
GR2	S1W-F	"	19:49:41	20:02:23	F	"	"	"	"	"	"	"	Y1	Y	5.2	"	Missing bottom -
GR2	S1A-F	"	20:02:57	20:15:12	F	"	"	"	"	"	"	"	Y(1)	Y	6.1	"	
GR2	North-FM	"	20:16:17	20:43:25	F	"	Y	Y	"	"	"	"	Y(2)	Y	8.3	"	background noise in the beginning + missing bottom
			High tide at 9:00PM,				CREW SHIFT AT 20:50										

1.5 3 1.5 1.5 3 1.5

L M H M L

Crew ________

Grid #	Transect number	Start Date	Start Time	End Time	Tide stage (E,F,H,L)	Temp (C°)	GPS	DATA	Precip. Y/N	Fog Y/N	Day, Night, Dawn, Dusk	Wind Dir Speed	Eddy Y/N + Level 1 to 3	Pass. data Y/N	Boat speed	Wave Height (1/4 m)	Comments
GR3	N0W_E	11/24/16	21:00:40	21:13:00	H	9,0	Y	Y	N	N	Night	<5	N	Y	4.8	<1/4 m	Only 75m range, why?
GR3	N0A_E	11/24/16	21:13:32	21:26:00	H	9.0	Y	Y	N	N	Night	<5	N	Y	4.6	<1/4 m	
GR3	N1W-E	11/24/16	21:27:30	21:39:32	E	9.0	Y	Y	N	N	Night	<5	N	Y	5.1	<1/4 m	
GR3	N1A_E	11/24/16	21:40:20	21:53:11	E	9.0	Y	Y	N	N	Night	<5	Y FEW	Y	4.4	<1/4 m	
GR3	N2W_E	11/24/16	21:55:22	22:06:30	E	9.0	Y	Y	N	N	Night	<5	Y FEW	Y	4.9	<1/4 m	
GR3	N2A_E	11/24/16	22:06:20	22:21:48	E	9,0	Y	Y	N	N	Night	<5	Y FEW	Y	4.7	<1/4 m	
GR3	TW_E	11/24/16	22:23:05	22:33:58	E	9.0	Y	Y	N	N	Night	<5	Y	Y	5.3	<1/4 m	- Turbine (Not well detected)
GR3	TA_E	11/24/16	22:35:02	22:57:25	E	9.0	Y	Y	N	N	Night	<5	Y	Y	3.0	<1/4 m	- Turbine well detected
GR3	N3W_E	11/24/16	22:58:42	23:10:05	E	9.0	Y	Y	N	N	Night	<5	Y	Y	5.2	<1/4 m	
GR3	N3A_E	11/24/16	23:10:35	23:36:51	E	9.0	Y	Y	N	N	Night	<5	Y	Y	3.6	<1/4	Tyler hit "Ping off" By accident @ end of transect.

0046052

Grid #	Transect number	Start Date	Start Time	End Time	Tide stage (E,F, H,L)	Temp (C°)	GPS	DATA	Precip. Y/N	Fog Y/N	Day, Night, Dawn, Dusk	Wind Dir Speed	Eddy Y/N + Level 1 to 3	Pass. data Y/N	Boat speed	Wave Height (1/4 m)	Comments
GR3	S3A_E	11/25/16	02:22:22	02:35:17	E	8.0	Y	Y	N	N	Night	<5	Y(1)	Y	3.9	<1/4m	
GR3	NORTH FM	11/25/16	02:35:49	02:56:50	E	8.0	Y	Y	N	N	Night	<5	Y(1)	Y	7.5	<1/4	
GR4	N1W_F	11/25/16	02:57:03	03:08:28	L	8.0	Y	Y	N	N	Night	<5	Y Few	Y	5.3	<1/4	beginning of the transect in FM mode Low TIDE = 03:15 am
GR4	N1A_F	11/25/16	03:09:20	03:21:40	L	8.0	Y	Y	N	N	Night	<5	Y	Y	5.4	<1/4	
GR4	N2W_F	11/25/16	03:23:25	03:35:10	L	8.0	Y	Y	N	N	Night	<5	Y Few	Y	5.3	<1/4	
GR4	N2A_F	11/25/16	03:36:45	03:49:09	L	8.0	Y	Y	N	N	Night	<5	Y FEW	Y	5.2	<1/4	
GR4	TW_F	11/25/16	03:50:10	04:01:16	F	8.0	Y	Y	N	N	Night	<5	Y FEW	Y	5.5	<1/4	- Good turbine detection
GR4	TA_F	11/25/16	04:03:15	04:16:50	F	8.0	Y	Y	N	N	Night	<5	Y Few	Y	4.5	<1/4	- turbine not well detected
GR4	N3W_F	11/25/16	04:18:20	04:28:00	F	8.0	Y	Y	N	N	Night	<5	N	Y	6.1	<1/4	
GR4	N3A_F	11/25/16	04:29:55	04:45:20	F	8.0	Y	Y	N	N	Night	<5	N	Y	4.0	<1/4	

Grid #	Transect number	Start Date	Start Time	End Time	Tide stage (E,F, H,L)	Temp (C°)	GPS	DATA	Precip. Y/N	Fog Y/N	Day, Night, Dawn, Dusk	Wind Dir Speed	Eddy Y/N + Level 1 to 3	Pass. data Y/N	Boat speed	Wave Height (1/4 m)	Comments
GR4	N4W_F	11/25/16	04:48:20	04:57:50	F	8.0	Y	Y	N	N	Night	<5	Y	Y	6.8	< 1/4	
GR4	N4A_F	11/25/16	05:00:15	05:29:31	F	8.0	Y	Y	N	N	Night	<5	Y	Y	3.0	< 1/4	
GR4	N5W_F	11/25/16	05:31:10	05:39:35	F	8.0	Y	Y	N	N	Night	<5	Y	Y	7.1	< 1/4	
GR4	N5A_F	11/25/16	05:42:15	06:47:06	F	8.0	Y	Y	N	N	Night	<5	Y	Y	1.7	< 1/4	-Tide too strong still @ half way after 1 hour - crossing to control to make sure we have time.
GR4	South CW	11/25/16	06:49:00	07:02:50	F	8.0	Y	Y	N	N	DAWN	<5	Y	Y	5.3	< 1/4	
GR4	S1A_F	11/25/16	07:03:30	07:12:31	F	8.0	Y	Y	N	N	DAWN	<5	Y	Y	6.0	< 1/4	
GR4	S1W_F	11/25/16	07:13:01	07:23:42	F	8.0	Y	Y	N	N	DAWN	<5	Y	Y	5.5	< 1/4	
GR4	S2A_F	11/25/16	07:25:00	07:34:12	F	8.0	Y	Y	N	N	DAY	<5	Y	Y	6.5	< 1/4	
GR4	S2W_F	11/25/16	07:34:50	07:46:17	F	8.0	Y	Y	N	N	DAY	<5	Y	Y	5.0	< 1/4	
GR4	S3A_F	11/25/16	07:47:25	07:56:55	F	8.0	Y	Y	N	N	DAY	<5	Y few	Y	6.5	< 1/4	

6:00

6:30 swap 1 & W

Grid #	Transect number	Start Date	Start Time	End Time	Tide stage (E,F, H,L)	Temp (C°)	GPS	DATA	Precip. Y/N	Fog Y/N	Day, Night, Dawn, Dusk	Wind Dir Speed	Eddy Y/N + Level 1 to 3	Pass. data Y/N	Boat speed	Wave Height (1/4 m)	Comments
GR4	S3W_F	11/25/16	08:12:23	08:25:22	H	8.0	Y	Y	N	N	DAY	< 5	N	Y	4.3	< 1/4	
GR4	NORTH FM	11/25/16	08:27:10	9:07:28	H	8.0	Y	Y	N	N	DAY	< 5	Y	Y	6.4	< 1/4	_several turbine Passes at end of transect

Appendix II: Data overview for survey 4

Data summarized in Section 2.2 (Study objectives and data overview) for survey 4 are presented in more detail here, as multiple comparisons among groups. Data are presented using boxplots. Relative fish density (Sv) is plotted for each transect and each grid. Transects against and with the tide have been separated for better visualization of differences. The blue horizontal line in all plots is the mean Sv for the entire survey (all transects). Vertical lines of different colors provide a visual distinction between the CLA area and the control area (red dashed line), day and night periods and tide periods (blue dashed line).

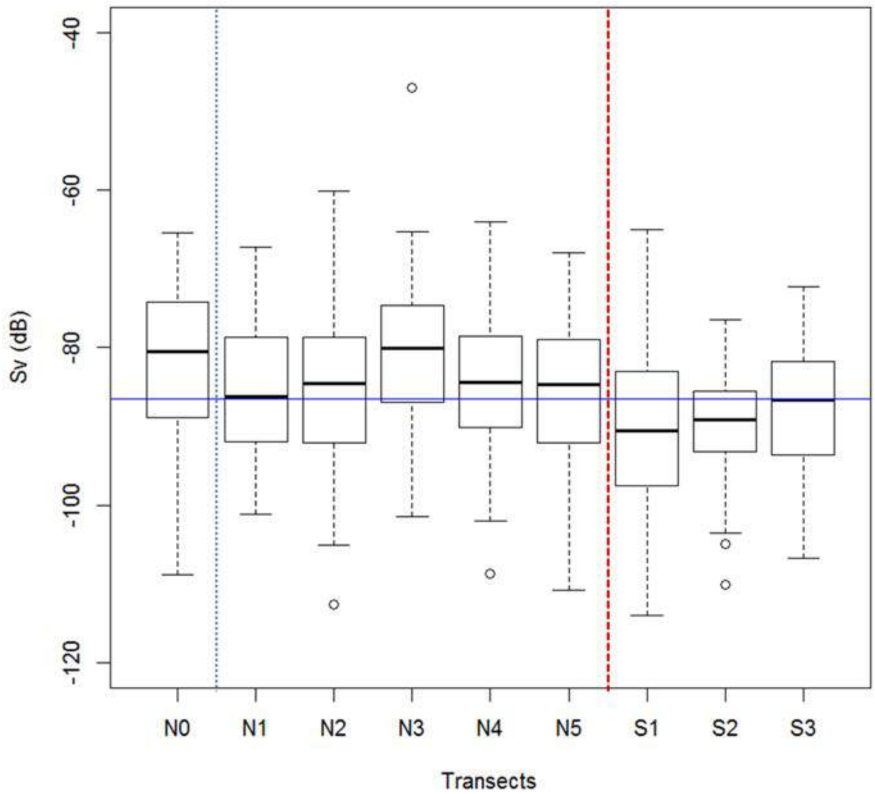

Figure A2.1: Boxplot of exported Sv (Volume backscattering strength) for the grid 1 (ebb) transects ***with*** the tide. The dashed red line separates CLA transects (N0 to N5) from control transects (S1 to S3). The light blue vertical dashed line represents the transition between high tide (N0) and ebb tide (N1 to S3). The lower the negative number (closer to 0) the higher the relative fish density, the blue horizontal line represents the mean Sv for the entire survey (all transects).

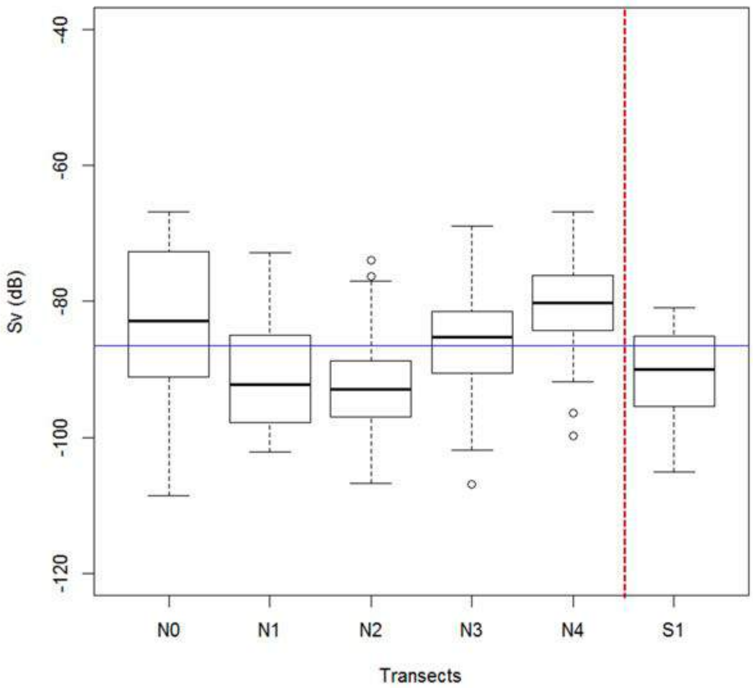

Figure A2.2: Boxplot of exported Sv (Volume backscattering strength) for the grid 1 (day ebb) transects ***against*** the tide. The dashed red line separates CLA transects (N0 to N5) from control transects (S1 to S3). The lower the negative number (closer to 0) the higher the relative fish density, the blue horizontal line represents the mean Sv for the entire survey (all transects).

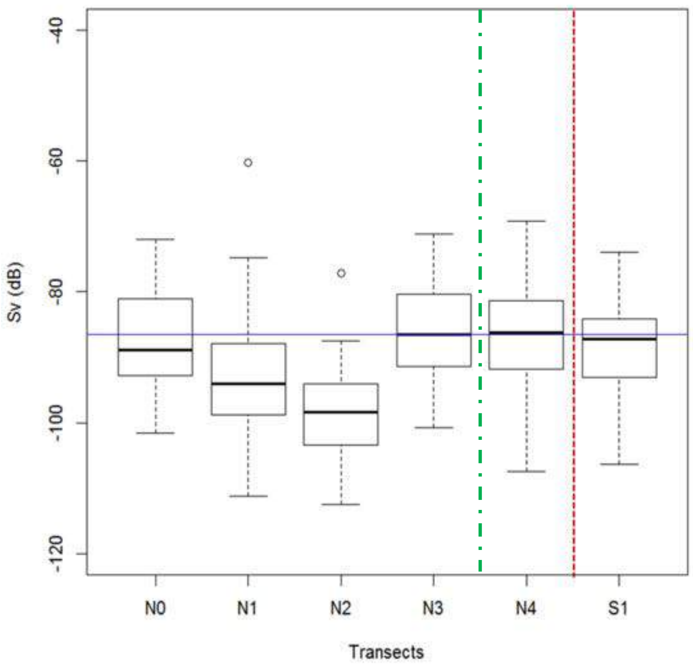

Figure A2.3: Boxplot of exported Sv (Volume backscattering strength) for the grid 2 (Day and night flood) transects ***with*** the tide. The dashed red line separates CLA transects (N0 to N5) from control transect (S1). The lower the negative number (closer to 0) the higher the relative fish density, the blue horizontal line represents the mean Sv for the entire survey (all transects).

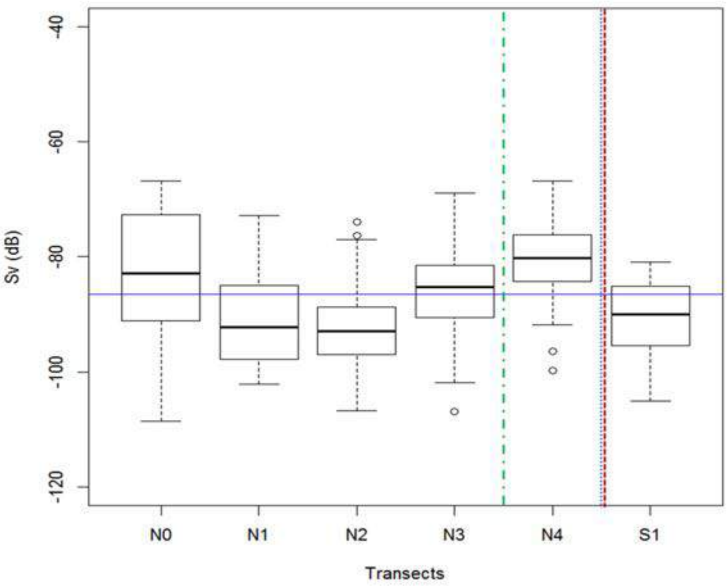

Figure A2.4: Boxplot of exported Sv (Volume backscattering strength) for grid 2 (Day and night flood) transects ***against*** the tide. The dashed red line separates CLA transects (N0 to N5) from control transects (S1 to S3). The green vertical dashed line represents the transition between day (N0 to N3) and night (N4 to S1). The lower the negative number (closer to 0) the higher the relative fish density, the blue horizontal line represents the mean Sv for the entire survey (all transects).

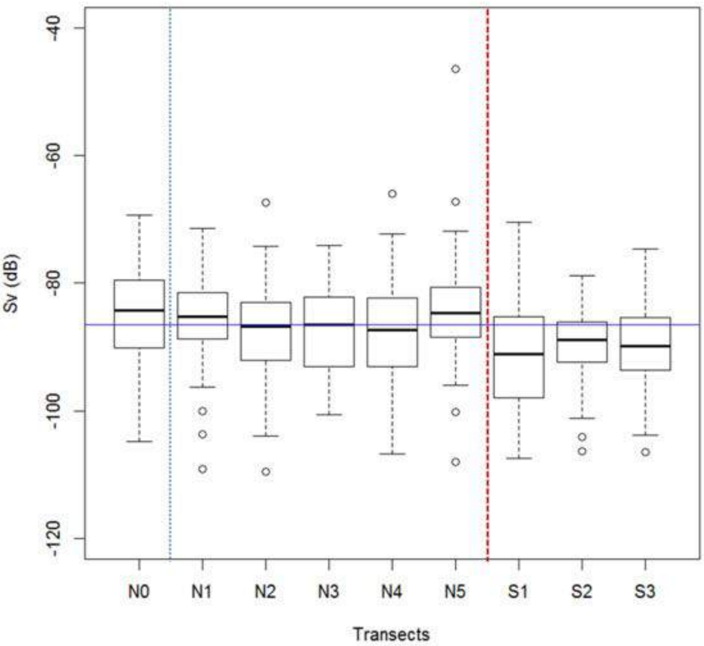

Figure A2.5: Boxplot of exported Sv (Volume backscattering strength) for grid 3 (night ebb) transects ***with*** the tide. The dashed red line separates CLA transects (N0 to N5) from control transects (S1 to S3). The light blue vertical dashed line represents the transition between high (N0) and ebb tide (N1 to S3). The lower the negative number (closer to 0) the higher the relative fish density, the blue horizontal line represents the mean Sv for the entire survey (all transects).

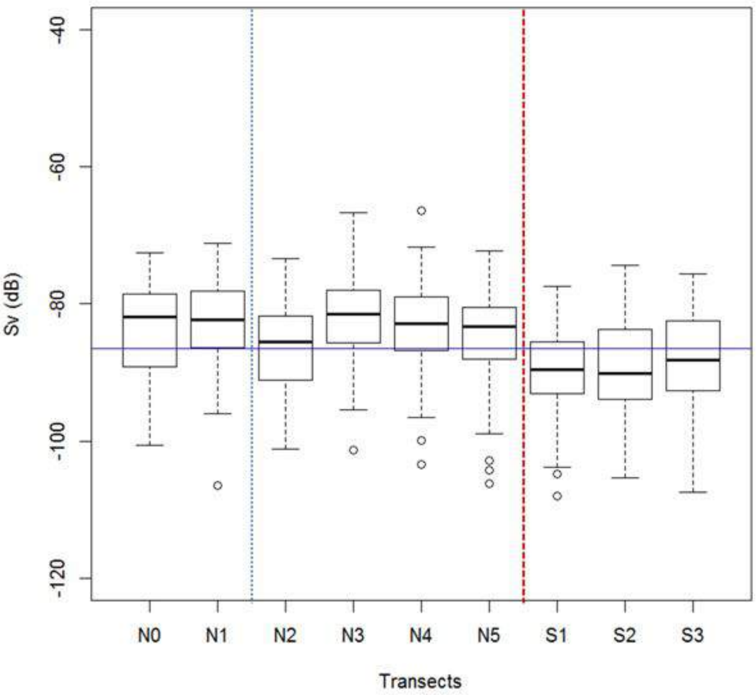

Figure A2.6: Boxplot of exported Sv (Volume backscattering strength) for grid 3 (Night ebb) transects ***against*** the tide. The dashed red line separates CLA transects (N0 to N5) from control transects (S1 to S3).). The light blue vertical dashed line represents the transition between high (N0 to N1) and ebb tide (N2 to S3). The lower the negative number (closer to 0) the higher the relative fish density, the blue horizontal line represents the mean Sv for the entire survey (all transects).

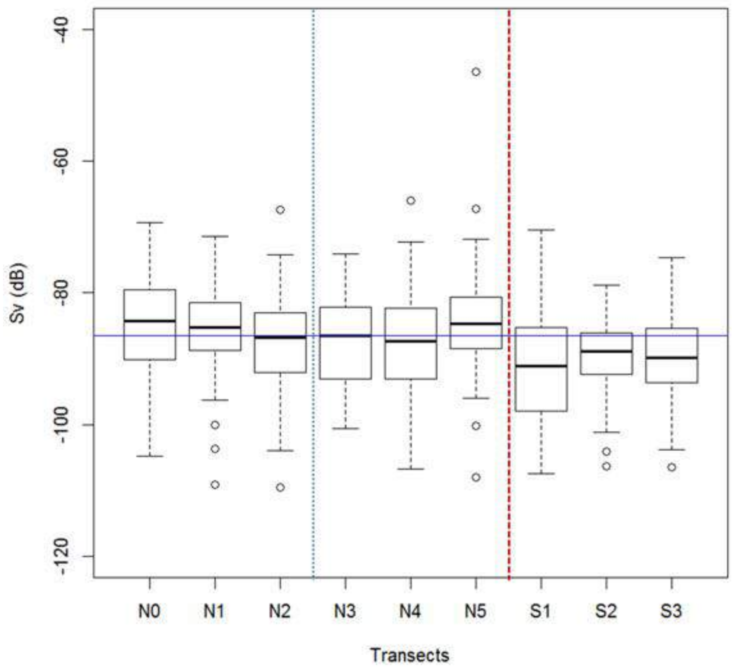

Figure A2.7: Boxplot of exported Sv (Volume backscattering strength) for grid 4 (Night flood) transects ***with*** the tide. The dashed red line separates CLA transects (N0 to N5) from control transects (S1 to S3). The light blue vertical dashed line represents the transition between low (N0 to N2) and flood tide (N3 to S3). The lower the negative number (closer to 0) the higher the relative fish density, the blue horizontal line represents the mean Sv for the entire survey (all transects).

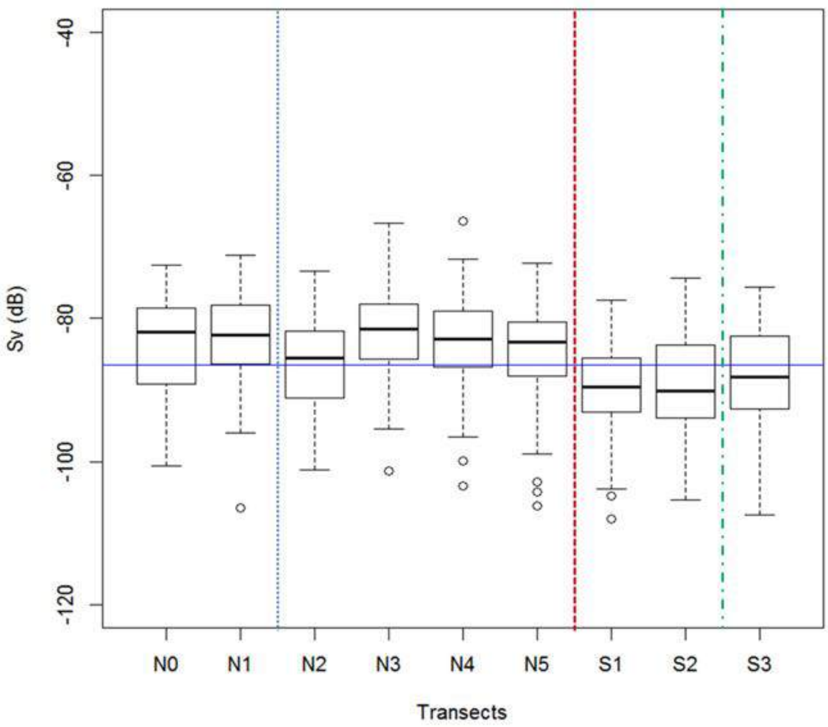

Figure A2.8: Boxplot of exported Sv (Volume backscattering strength) for grid 4 (Night flood) transects ***against*** the tide. The dashed red line separates CLA transects (N0 to N5) from control transects (S1 to S3). The light blue vertical dashed line represents the transition between low (N0 to N1) and flood tide (N2 to S3). The green vertical dashed line represents the transition between night (N0 to S2) and day (S3). The lower the negative number (closer to 0) the higher the relative fish density, the blue horizontal line represents the mean Sv for the entire survey (all transects).

Appendix III: Data overview for vertical distributions.

Section 2.2 (Study objectives and data overview) provides a description of the objectives for this work. Here we summarize details associated with the second objective regarding fish vertical distribution. Data were processed in 1 m vertical layers. To smooth the vertical distributions in each transect, area backscatter strength was averaged by 2 m depth bins. These data have been echointegrated from the bottom to the surface. The data are represented by number of layers (2 meters depth) from the bottom because the depth is not the same for all transects. The maximum depth for each transect was:

Transect	N0	N1	N2	N3	N4	N5	S1	S2	S3	along
Maximum depth (m)	41	50	55	58	54	52	64	52	56	140

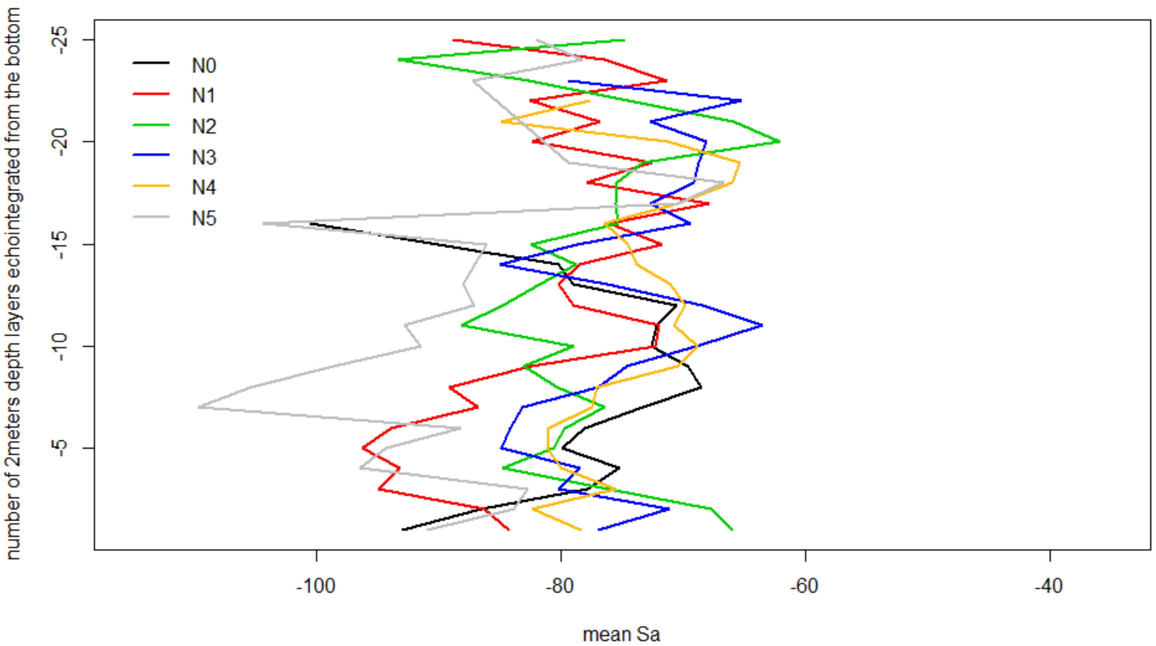

Figure A3.1: Vertical distribution of the mean area backscatter by 2 m depth layers for ***CLA*** transects of ***Grid 1.*** The echo-integration has been made from the bottom which depth varies between transects.

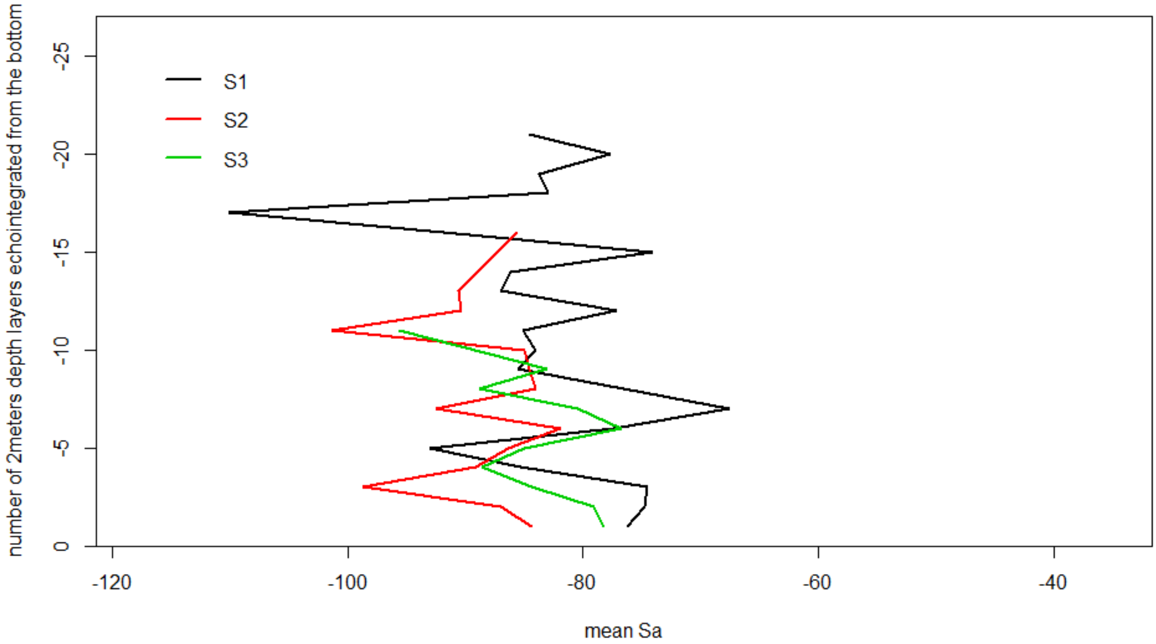

Figure A3.2: Vertical distribution of the mean area backscatter by 2 m depth layers for ***control*** transects of ***Grid 1***. The echo-integration has been made from the bottom which depth varies between transects.

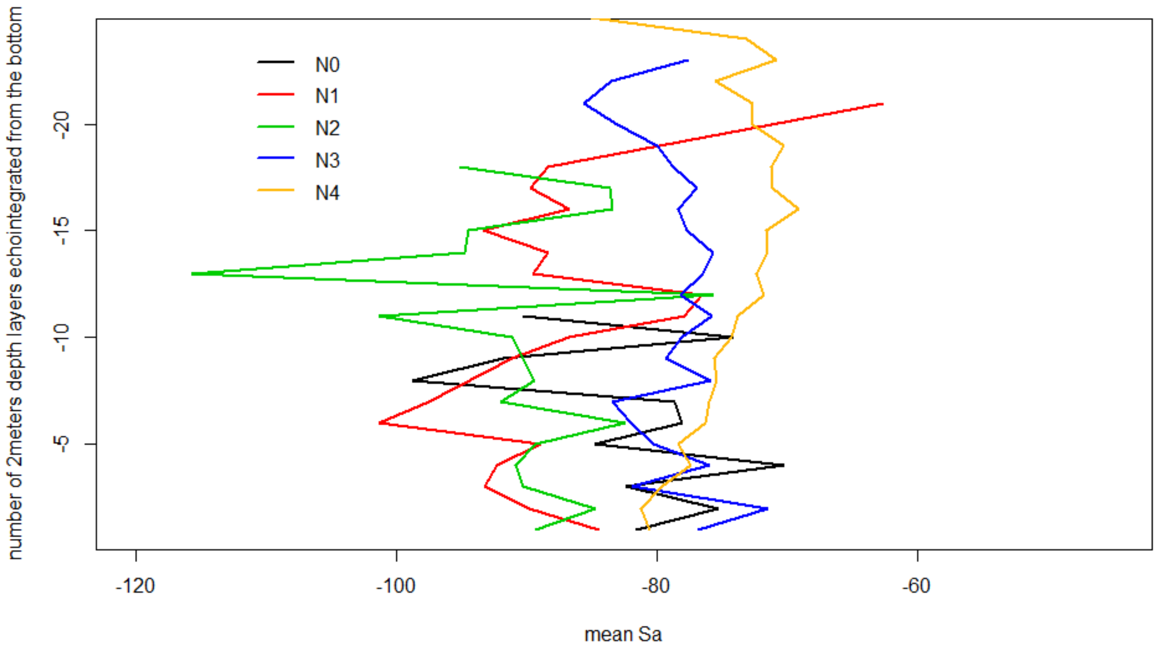

Figure A3.3: Vertical distribution of the mean area backscatter by 2 m depth layers for ***CLA*** transects of ***Grid 2***. The echo-integration has been made from the bottom which depth varies between transects.

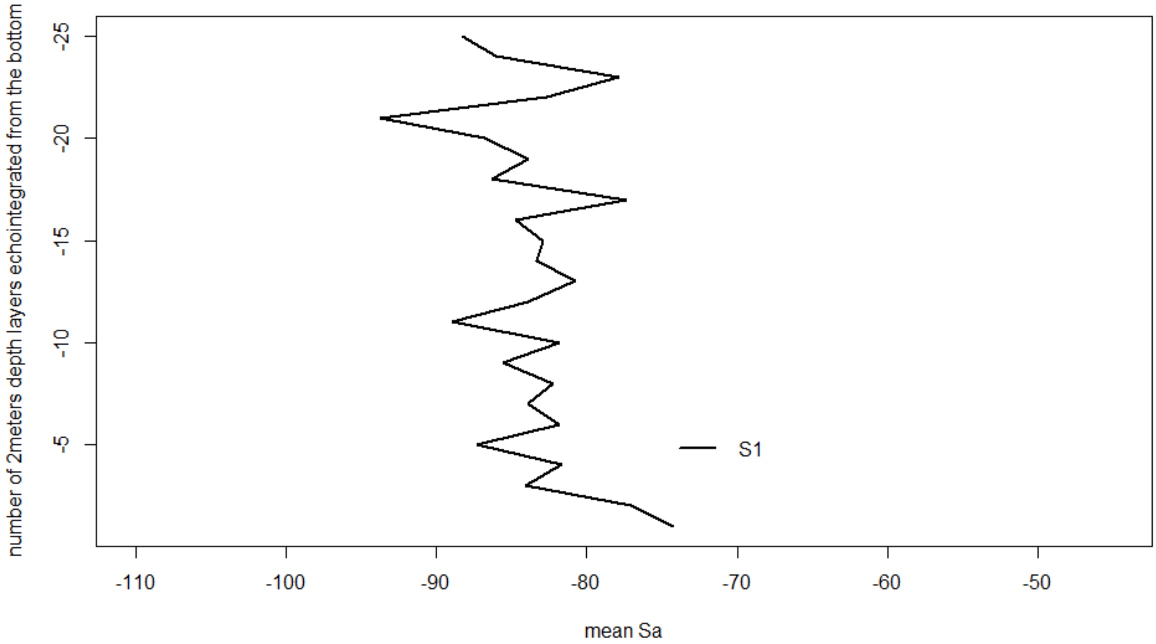

Figure A3.4: Vertical distribution of the mean area backscatter by 2 m depth layers for the c***ontrol*** transect of ***Grid 2***. The echo-integration has been made from the bottom which depth varies between transects.

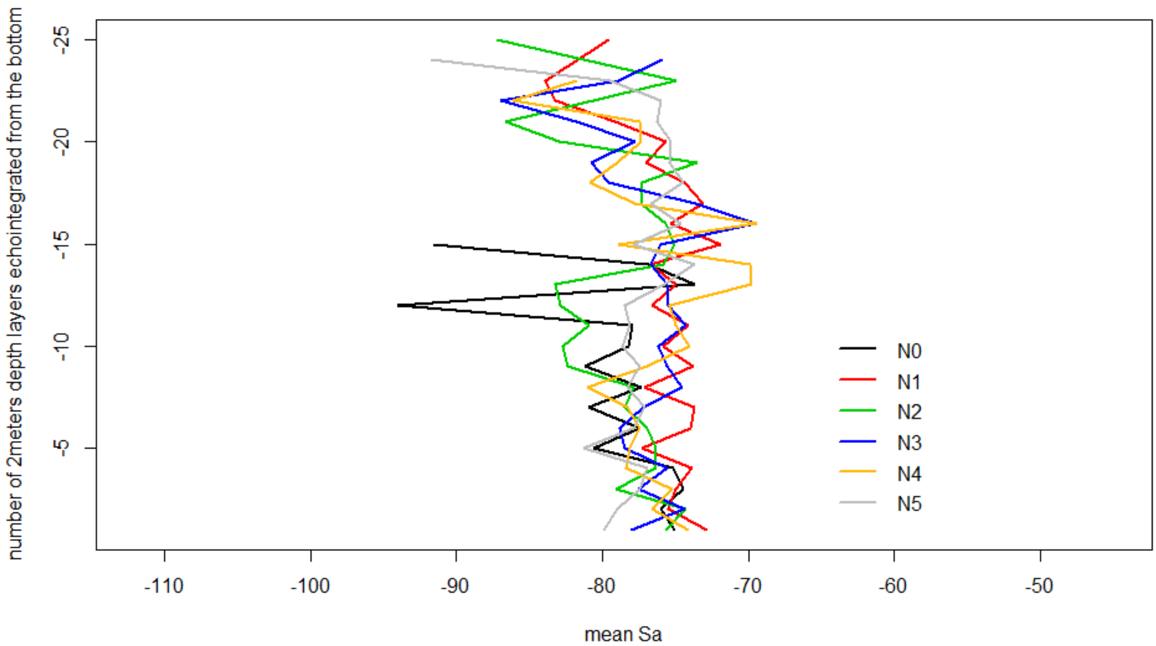

Figure A3.5: Vertical distribution of the mean area backscatter by 2 m depth layers for ***CLA*** transects of ***Grid 3***. The echo-integration has been made from the bottom which depth varies between transects.

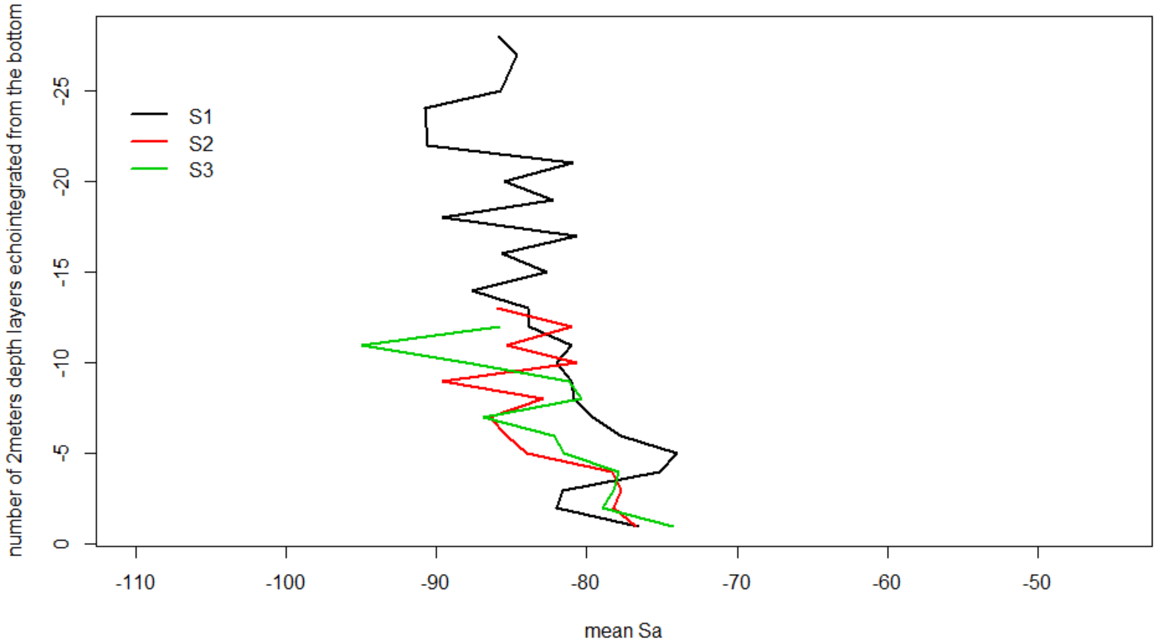

Figure A3.6: Vertical distribution of the mean area backscatter by 2 m depth layers for ***control*** transects of ***Grid 3***. The echo-integration has been made from the bottom which depth varies between transects.

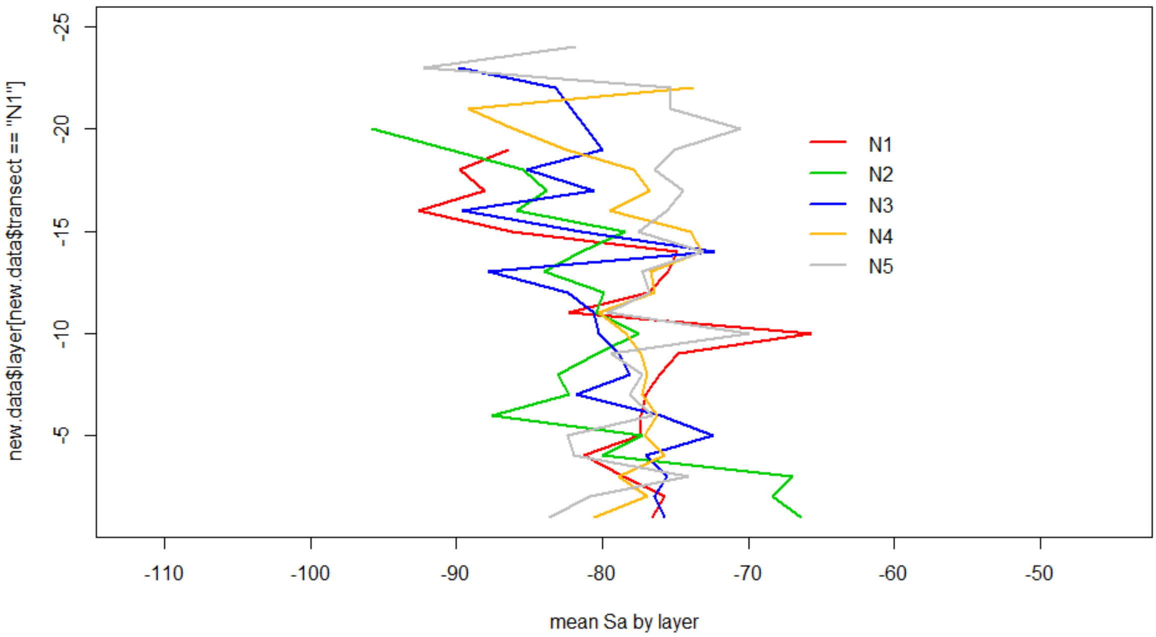

Figure A3.7: Vertical distribution of the mean area backscatter by 2 m depth layers for ***CLA*** transects of ***Grid 4***. The echo-integration has been made from the bottom which depth varies between transects.

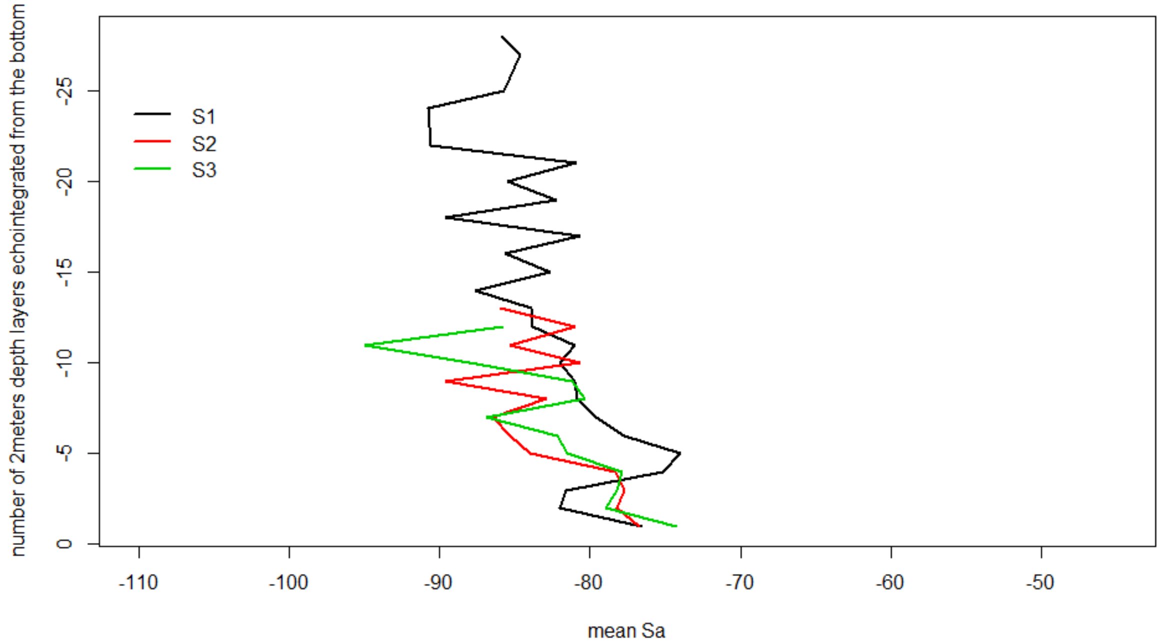

Figure A3.8: Vertical distribution of the mean area backscatter by 2 m depth layers for ***control*** transects of ***Grid 4***. The echo-integration has been made from the bottom which depth varies between transects.

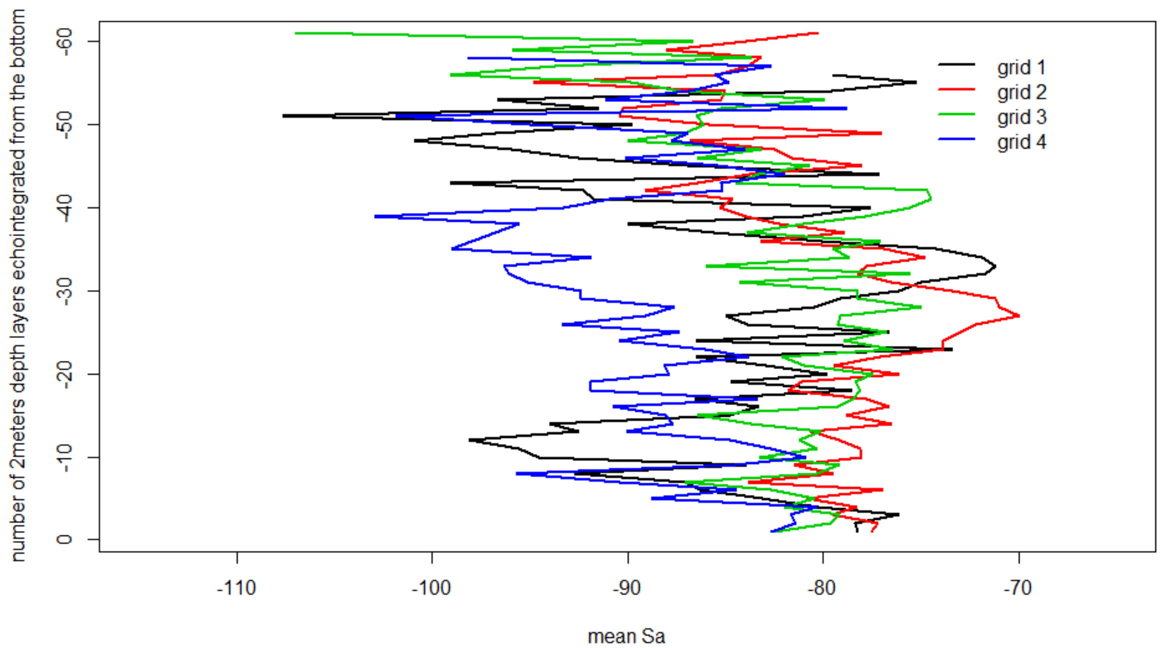

Figure A3.9: Vertical distribution of the mean area backscatter by 2 m depth layers for the ***along*** transects of the 4 grids. The echo-integration has been made from the bottom which depth varies between transects.

Appendix IV: Data overview for survey 1 to 3

Data summarized in Section 2.2 (Study objectives and data overview) for survey 1 to 3 are presented in more detail here, as multiple comparisons among groups. Data are presented using boxplots. Relative fish density (Sv) is plotted for each transect and each grid. Transects against and with the tide have been separated for better visualization of differences. The blue horizontal line in all plots is the mean Sv for the entire survey (all transects). These boxplot are very similar to the ones included in previous reports, any differences would be related to data here being exported in 20m distance bins instead of 1m depth layers.

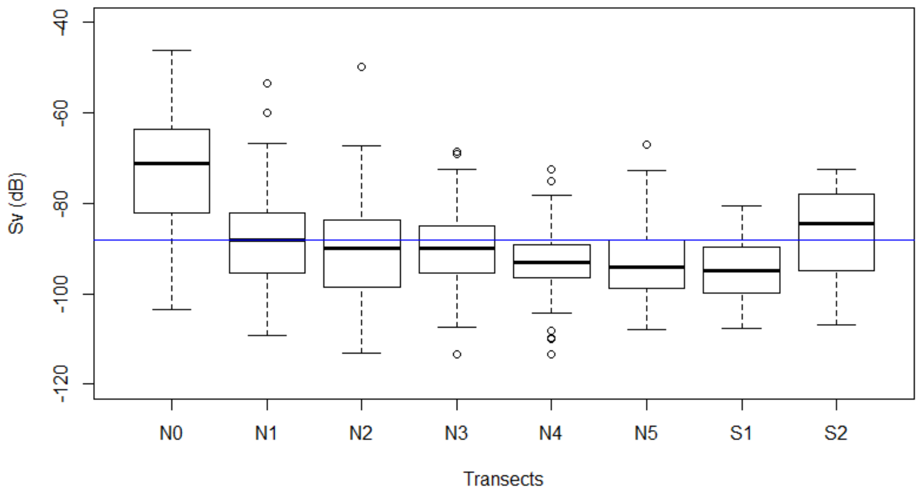

Figure A4.1: Boxplot of exported Sv (Volume backscattering strength) for grid 1 transects ***against*** the tide (ebb) of May survey.

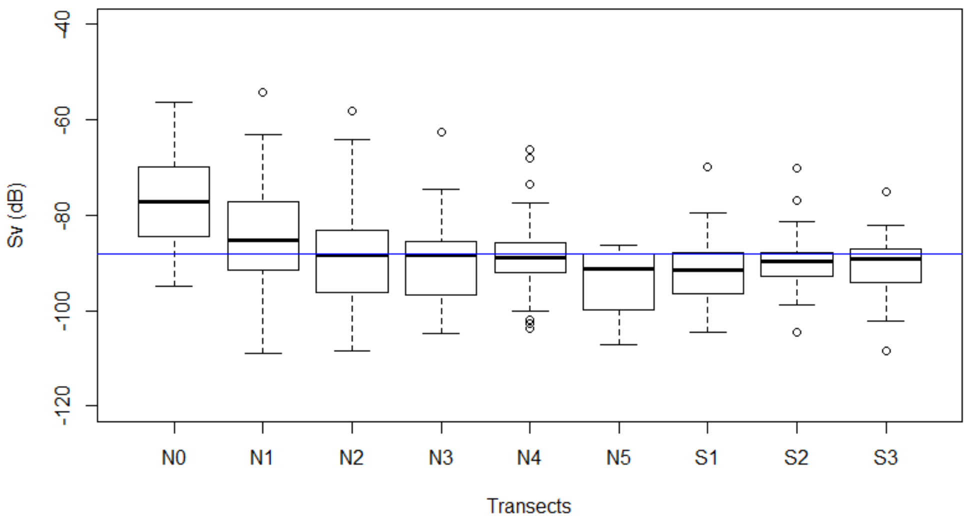

Figure A4.2: Boxplot of exported Sv (Volume backscattering strength) for ***grid 1*** transects ***with*** the tide (ebb) of ***May*** survey.

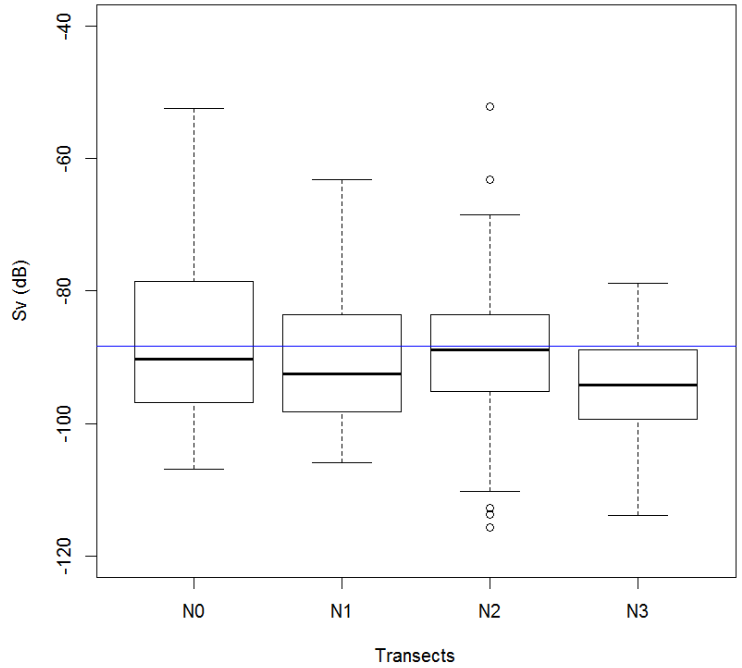

Figure A4.3: Boxplot of exported Sv (Volume backscattering strength) for ***grid 2*** transects ***against*** the tide (flood) of ***May*** survey.

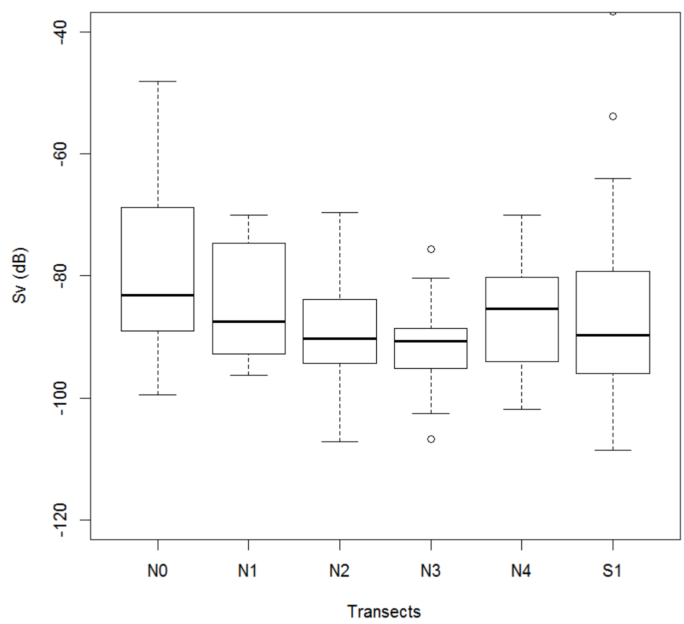

Figure A4.4: Boxplot of exported Sv (Volume backscattering strength) for ***grid 2*** transects ***with*** the tide (flood) of ***May*** survey.

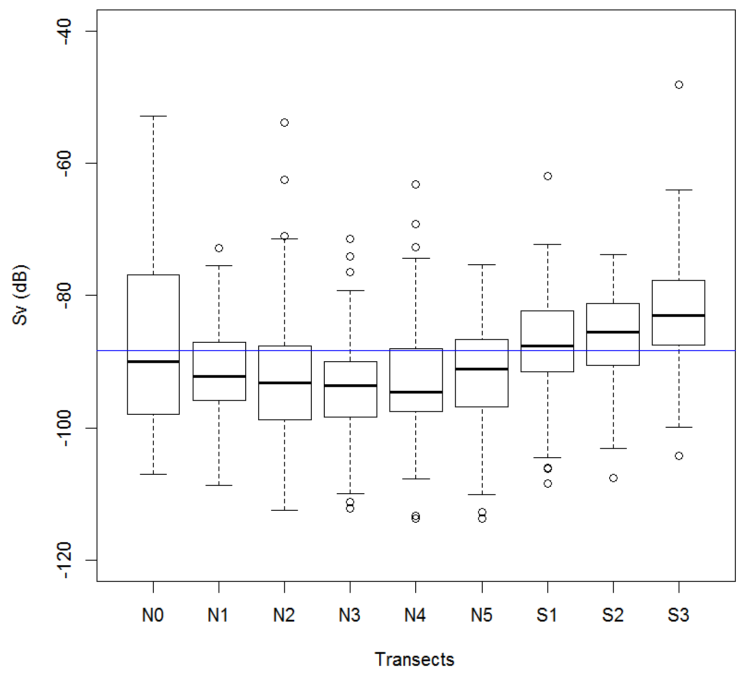

Figure A4.5: Boxplot of exported Sv (Volume backscattering strength) for ***grid 3*** transects ***against*** the tide (ebb) of ***May*** survey.

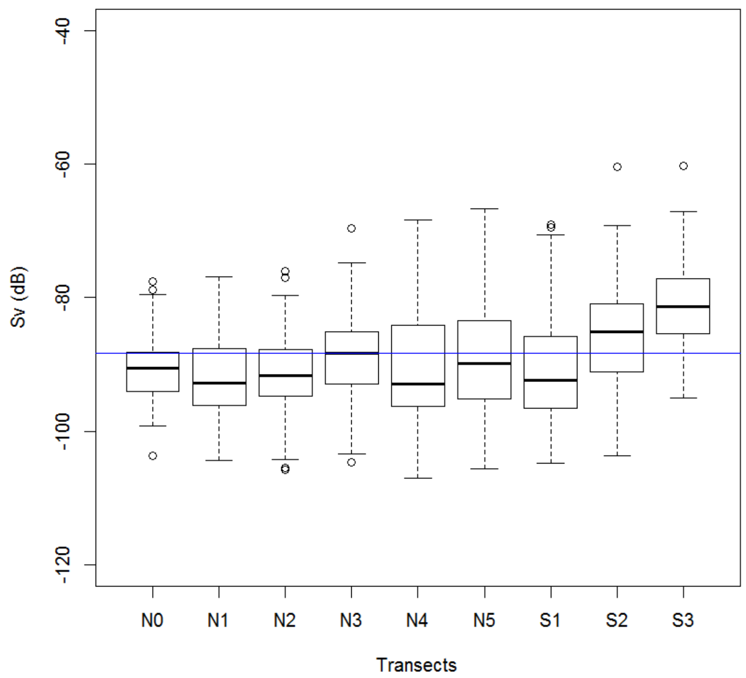

Figure A4.6: Boxplot of exported Sv (Volume backscattering strength) for ***grid 3*** transects ***with*** the tide (ebb) of ***May*** survey.

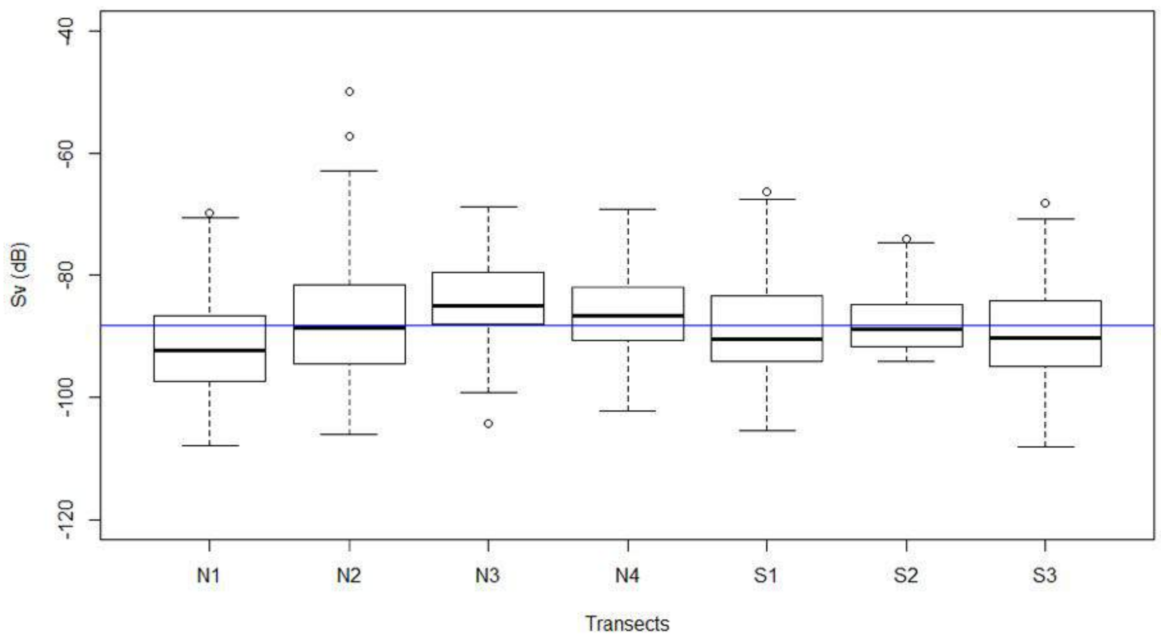

Figure A4.7: Boxplot of exported Sv (Volume backscattering strength) for ***grid 4*** transects ***against*** the tide (flood) of ***May*** survey.

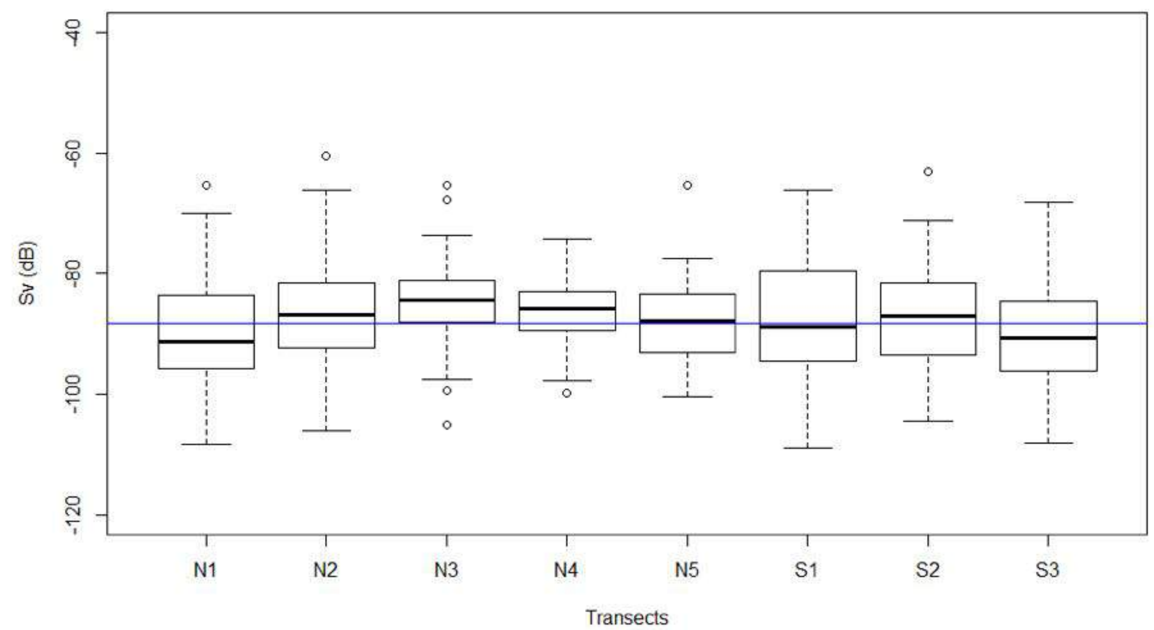

Figure A4.8: Boxplot of exported Sv (Volume backscattering strength) for ***grid 4*** transects ***with*** the tide (flood) of ***May*** survey.

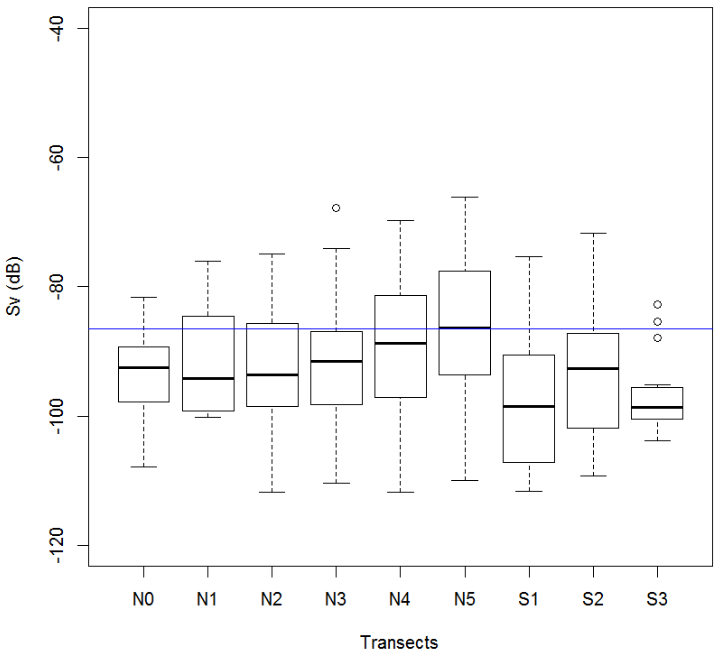

Figure A4.9: Boxplot of exported Sv (Volume backscattering strength) for ***grid 1*** transects ***against*** the tide (ebb) of **August** survey.

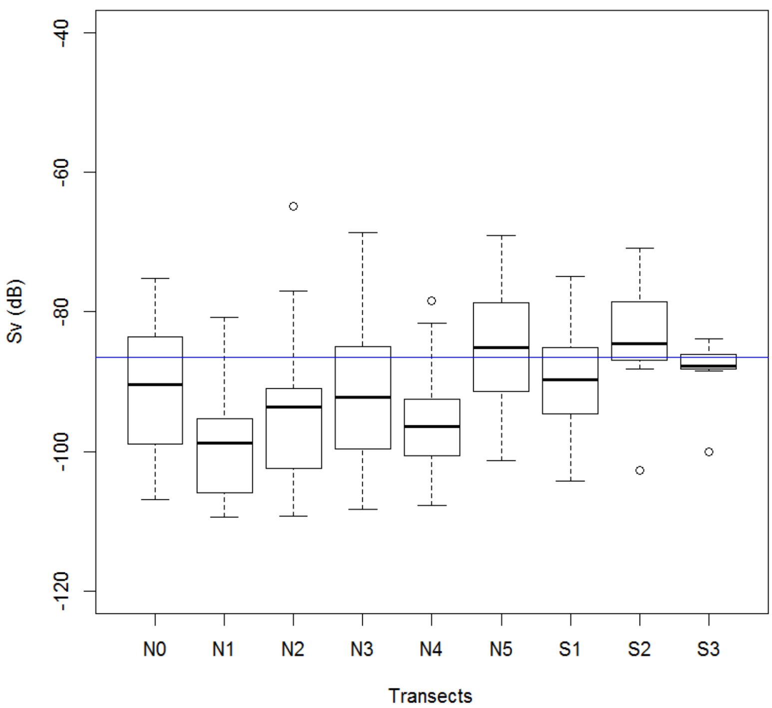

Figure A4.10: Boxplot of exported Sv (Volume backscattering strength) for ***grid 1*** transects ***with*** the tide (ebb) of ***August*** survey.

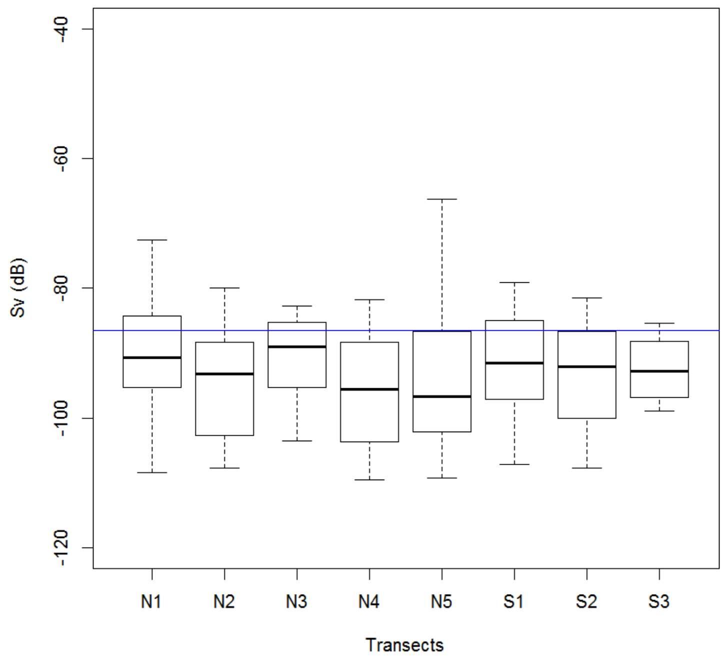

Figure A4.11: Boxplot of exported Sv (Volume backscattering strength) for ***grid 2*** transects ***against*** the tide (flood) of ***August*** survey.

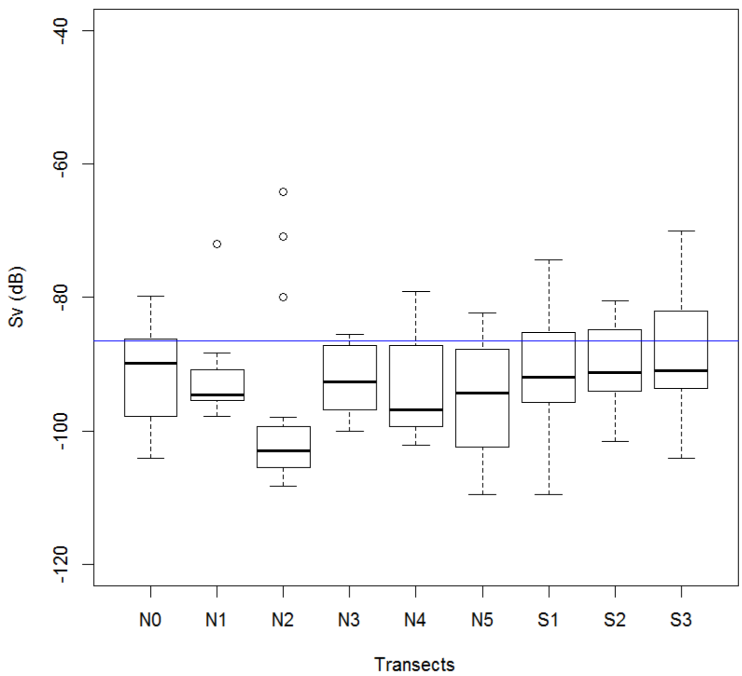

Figure A4.12: Boxplot of exported Sv (Volume backscattering strength) for ***grid 2*** transects ***with*** the tide (flood) of ***August*** survey.

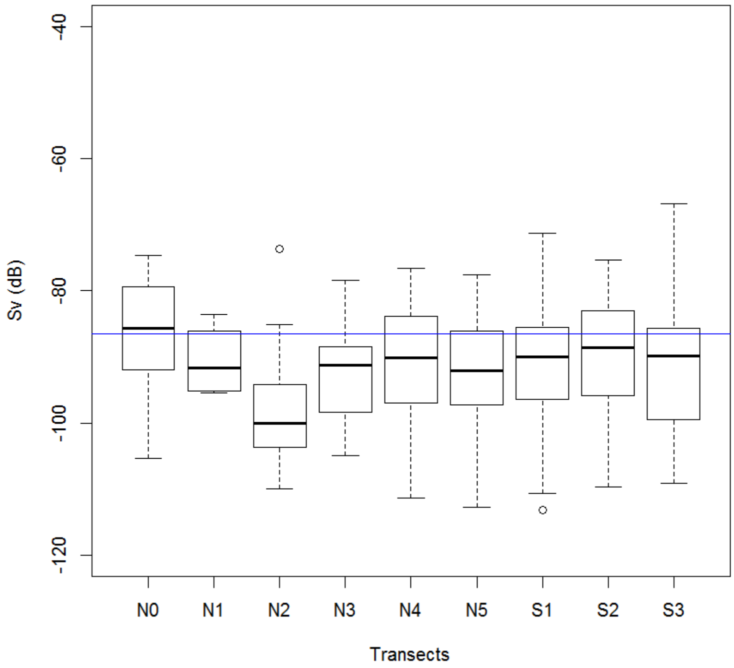

Figure A4.13: Boxplot of exported Sv (Volume backscattering strength) for ***grid 3*** transects ***against*** the tide (ebb) of ***August*** survey.

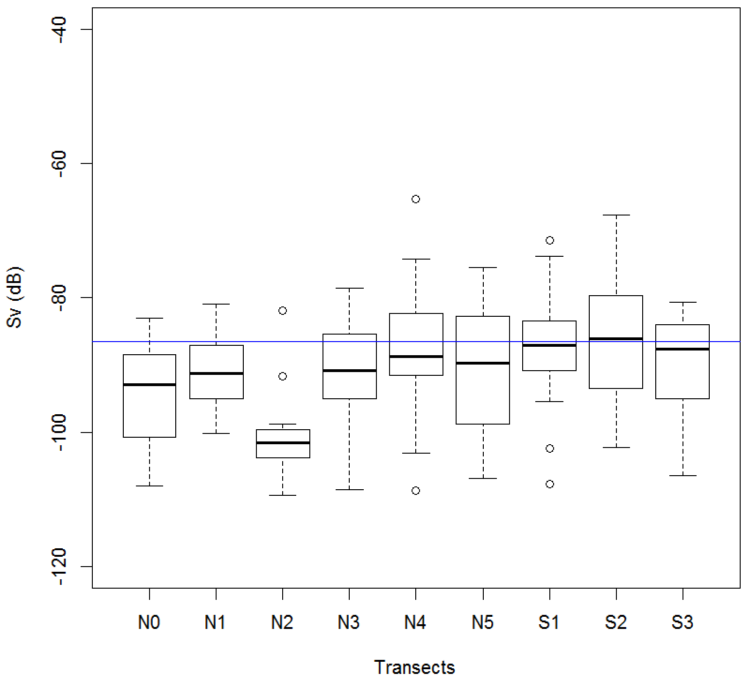

Figure A4.14: Boxplot of exported Sv (Volume backscattering strength) for ***grid 3*** transects ***with*** the tide (ebb) of ***August*** survey.

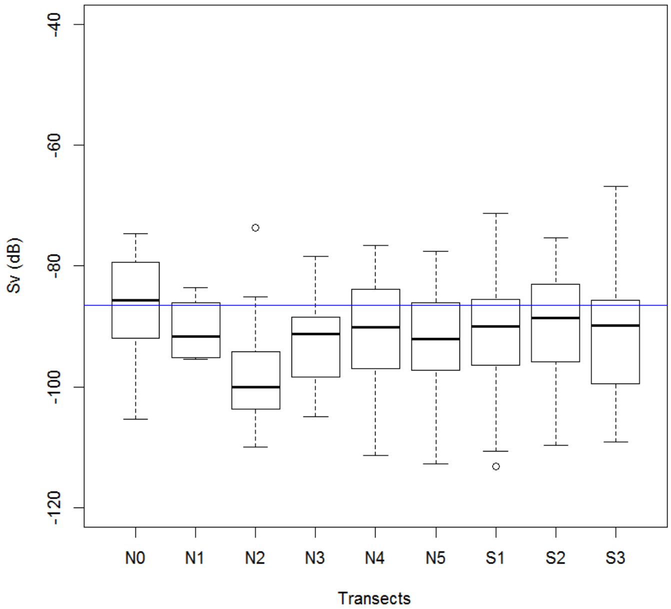

Figure A4.15: Boxplot of exported Sv (Volume backscattering strength) for ***grid 4*** transects ***against*** the tide (flood) of ***August*** survey.

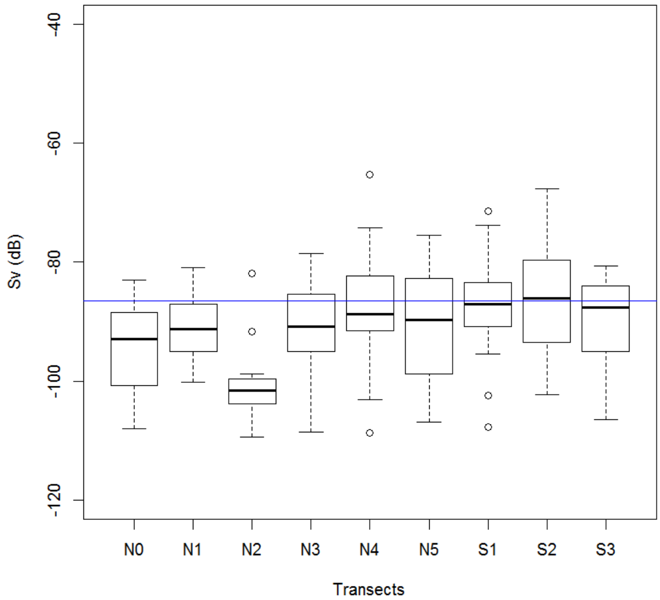

Figure A4.16: Boxplot of exported Sv (Volume backscattering strength) for ***grid 4*** transects ***with*** the tide (flood) of ***August*** survey.

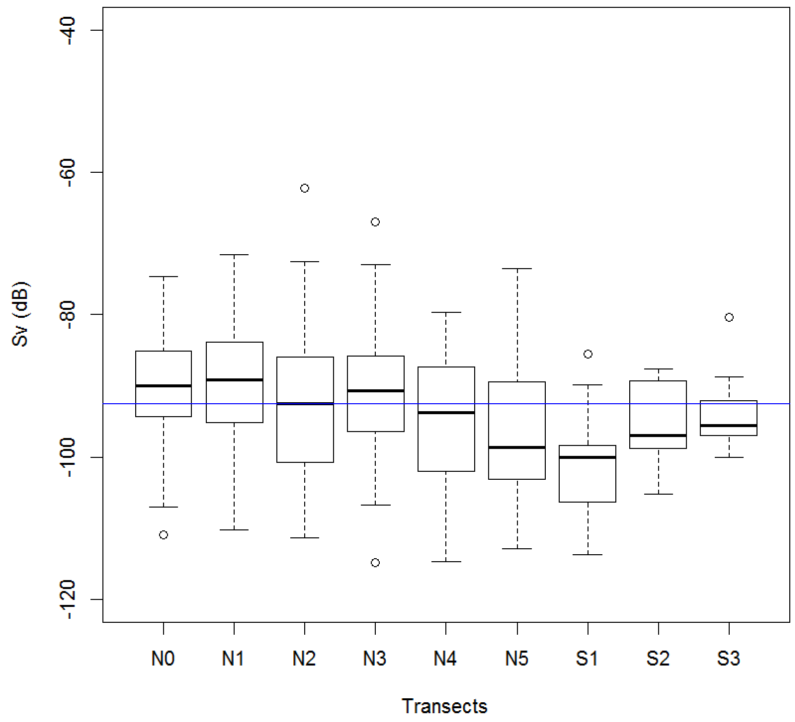

Figure A4.17: Boxplot of exported Sv (Volume backscattering strength) for ***grid 1*** transects ***against*** the tide (ebb) of ***October*** survey.

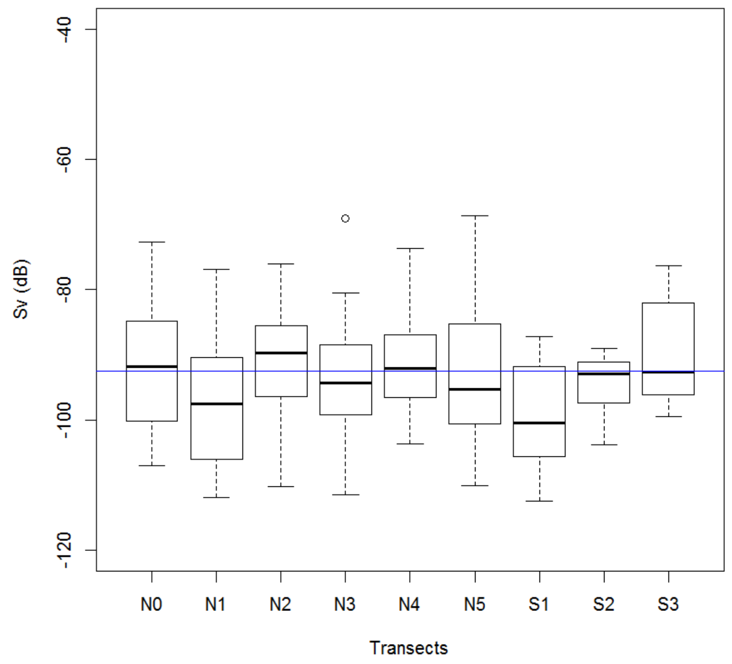

Figure A4.18: Boxplot of exported Sv (Volume backscattering strength) for ***grid 1*** transects ***with*** the tide (ebb) of ***October*** survey.

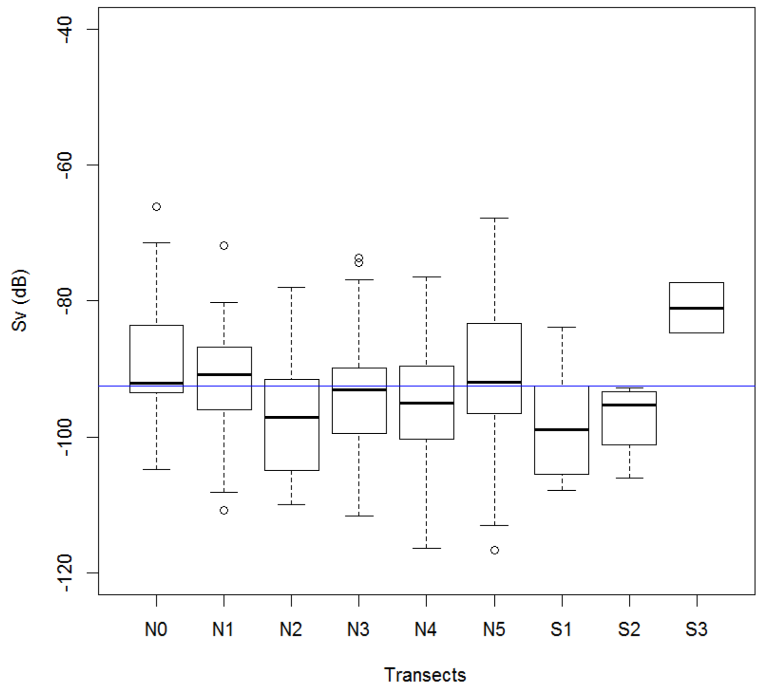

Figure A4.19: Boxplot of exported Sv (Volume backscattering strength) for ***grid 2*** transects ***against*** the tide (flood) of **October** survey.

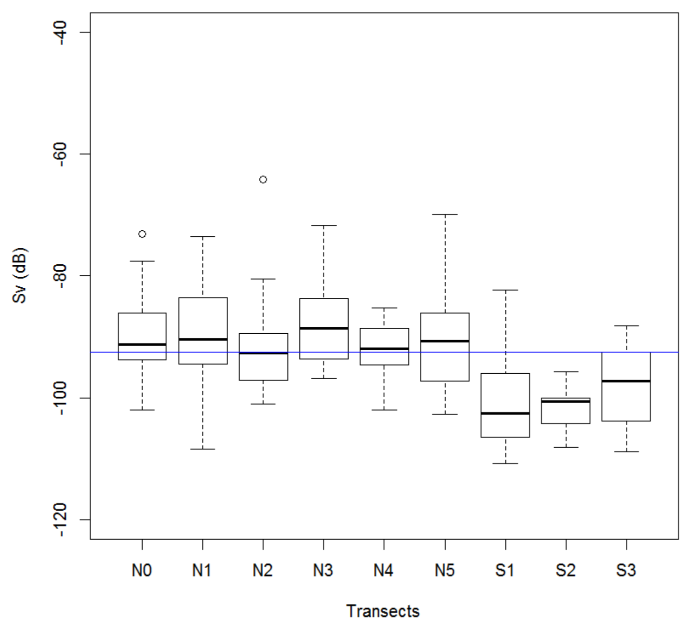

Figure A4.20: Boxplot of exported Sv (Volume backscattering strength) for ***grid 2*** transects ***with*** the tide(flood) of **October** survey.

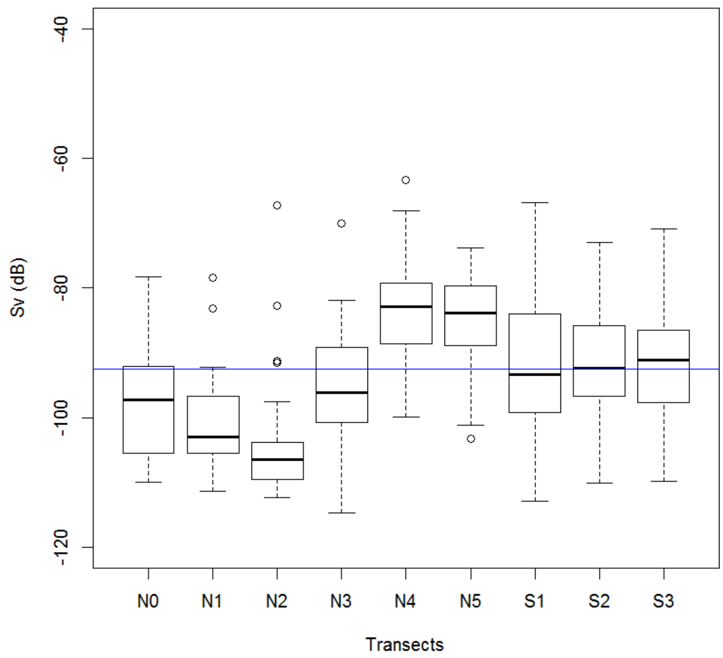

Figure A4.21: Boxplot of exported Sv (Volume backscattering strength) for ***grid 3*** transects ***against*** the tide (ebb) of ***October*** survey.

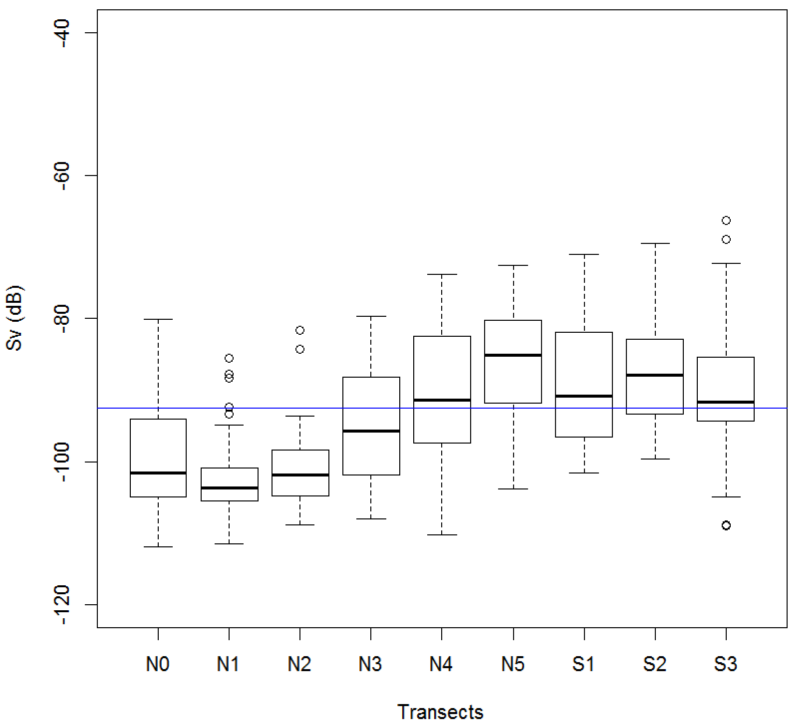

Figure A4.22: Boxplot of exported Sv (Volume backscattering strength) for ***grid 3*** transects ***with*** the tide (ebb) of ***October*** survey.

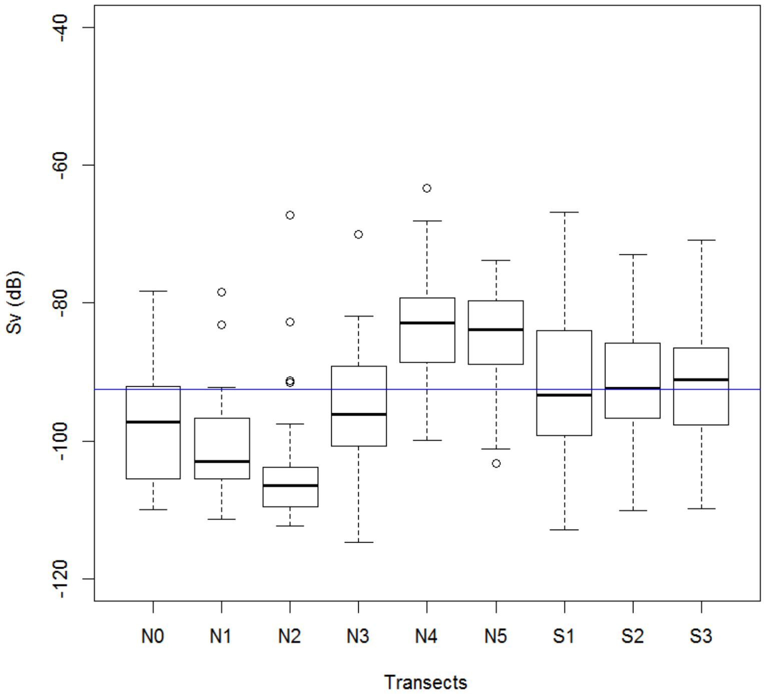

Figure A4.23: Boxplot of exported Sv (Volume backscattering strength) for ***grid 4*** transects ***against*** the tide (flood) of ***October*** survey.

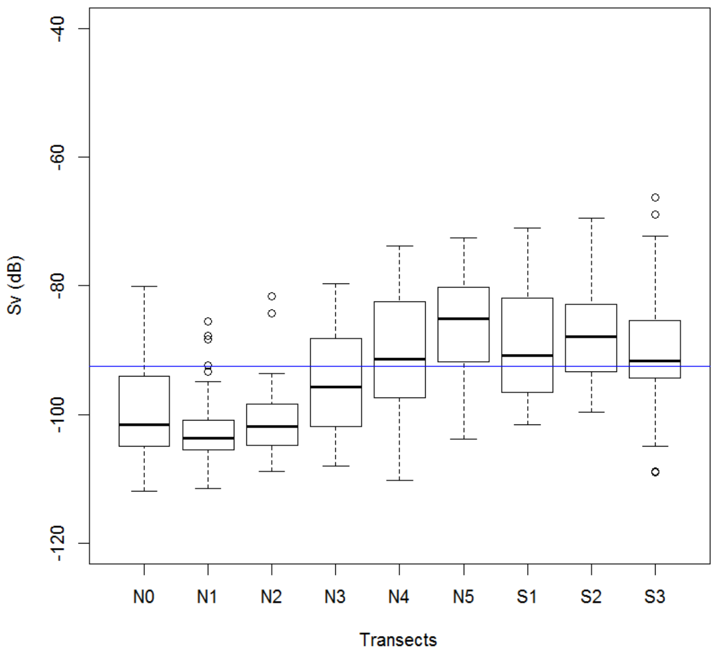

Figure A4.24: Boxplot of exported Sv (Volume backscattering strength) for ***grid 4*** transects ***with*** the tide (flood) of ***October*** survey.

Appendix 2: Marine Mammals Environmental Effects Monitoring Plan Interim Report

Interim report summarizing analyses from C-POD data collection from June – August 2016. Prepared by Sea Mammal Research Unit Consulting (Canada).

FORCE Marine Mammal EEMP - C-PODs in Minas Passage – Summer 2016 Interim Report

SMRU Consulting

[October 5, 2016]

SMRU Consulting, 1529 West 6th Ave., Suite 510, Vancouver BC, V6J 1R1 Canada

Interim Report

Project Name:	**FORCE Marine Mammal EEMP - C-POD 2016**
Client:	FORCE
Project reference number:	SMRUC-2016-4-FEEMP
Lead Scientists:	Jason Wood, Ruth Joy, Dom Tollit
Project Manager:	Dom Tollit
FORCE Field Scientists:	Murray Scotney, Tyler Boucher

Written by:	Dom Tollit
Scientific approval:	Jason Wood
Date:	October 5, 2016

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1. Executive Summary

The main objectives of FORCE's marine mammal EEMP are to assess long-term effects of direct and indirect stressors on Harbour porpoise (*Phocoena phocoena)* by monitoring their activity and site use, with the primary objectives to assess firstly permanent avoidance of the mid field study area during turbine installation and operation and secondly large magnitude (~50%) change in the distribution (echolocation activity levels) of a portion of the population in the study mid-field area (see SLR Consulting Ltd. (2015).

Three C-PODs were successfully calibrated, deployed and recovered to monitor marine mammals (porpoise and dolphins) presence in Minas Passage as part of FORCE's marine mammal EEMP. All 3 C-PODs collected data across the whole 84-day deployment period (June 7th – August 30th 2016). Average percent time lost due to sediment interference was 20-29%, similar to previous studies at these locations. Harbour porpoise were detected across 99% of days, but at low rates with a median of 7 minutes per day with presence detected in 3.64% of all 10 minute periods. Across the previous 2011 and 2012 C-POD baseline study (Wood et al. 2013), porpoises were detected on 98% of days, with higher minutes per day (median = 22 minutes) and present 4.1% of all 10 minute periods (noting this previous study collected data over spring and fall as well as summer). No dolphins were detected as per previous baseline studies. Porpoise detection rates varied across the 84-day study and were at times higher in periods of July and August than observed previously in 2011 and 2012, but lower in June, highlighting inter-annual variability at sites within the demonstration area. While the site near berth D (D1) had higher apparent mean detection rates (0.09 detection positive minutes per 10 minute period) than at sites C1 (0.06) and E1 (0.05), the relative impact of percent time lost across sites (Figure 9a) has not yet been taken into account. This analysis will be undertaken during the GAM modelling planned for the final report, but overlapping standard deviations around these mean detection rates currently suggest insignificant site differences.

Recommend deployment of extra C-PODS at locations W2 and S2 as per past discussions. Maintain current C-POD settings and deployment methodology.

2. Introduction and EEMP Objectives.

Tidal energy is an untapped renewable energy source. Worldwide, only a small number of in-stream tidal turbines have been deployed to date. The Fundy Ocean Research Center for Energy (FORCE) is a Canadian non-profit institute that owns and operates a facility in the Bay of Fundy, Nova Scotia (Figure 1), where grid connected tidal energy turbines can be tested and demonstrated. It enables developers, regulators and scientists to study the performance and interaction of tidal energy turbines with the environment. The offshore test site is in the Minas Passage area of the Bay of Fundy near Cape Sharp, close to and west of Black Rock, roughly 10 km west of the town of Parrsboro (Figure 2).

Figure 1. Regional location of FORCE test site.

Figure 2. Detailed location in Minas Passage.

Harbour porpoise (*Phocoena phocoena*), the key marine mammal species in Minas Passage (Tollit et al. 2011, Wood et al. 2013 and Porskamp et al. 2015), use high frequency echolocation clicks to hunt and communicate and are known to be very susceptible to pulsed noise disturbance (Tougaard *et al.* 2009), but few studies have focused on exposure to continuous low frequency noise sources, such as those emitted by tidal turbines. This interim (Summer 2016) Status Report describes the results of the first 3 months of Marine Mammal C-POD Monitoring Program as part of the FORCE's March 2016 Environmental Effects Monitoring Program (EEMP) at its marine demonstration and testing facility in Minas Passage. The Summer 2016 interim Status Report aims to describe the current Programs objectives, methodology, problems encountered, detection rate results, along with any recommendations for the second deployment. Methodology included optimal site selection, a pre-deployment calibration test, data quality control assessment and preliminary porpoise detection data analysis.

The main objectives of the marine mammal EEMP are to assess long-term effects of direct and indirect stressors on Harbour porpoise by monitoring porpoise activity and site use, with the primary objectives to assess: 1) Permanent avoidance of the mid field study area during turbine installation and operation. 2) Large magnitude (~50%) change in the distribution (echolocation activity levels) of a portion of the population in the study mid-field area (see SLR Consulting Ltd. (2015).

SMRU Consulting Canada undertook the design, analysis and interpretation of marine mammal acoustic monitoring studies to collect previous baseline information in the FORCE tidal demonstration site in Minas Passage, Nova Scotia, Canada. Work was in collaboration with Acadia University and funded by FORCE and OERA. Following a pilot effects assessment study associated with the Open Hydro deployment in 2009-2010 (Tollit et al. 2011), a gradient passive acoustic monitoring design was developed deploying 7 C-POD devices to collect long-term baseline and assess reliability (Wood et al. 2013, Porskamp et al. 2015). A total of 1,342 C-POD site monitoring days were collected across this period. General Additive Models (GAM-GEE) were used to describe Harbour porpoise seasonal activity and key effect variables for a three-year data collection period (e.g., current, location, see Figure 3). This stage of the EEMP project plans to collect further C-POD marine mammal detection data to contrast with previously collected baseline data. Delays in the deployment of the Cape Sharp Tidal Venture turbine have allowed for the collection of additional baseline (rather than turbine effects) information on porpoise detections across 3 locations in summer 2016, with additional detection data to be collected at 5 locations in the fall of 2016, including areas of greater water depth outside of the demonstration area. Additional baseline data will improve future turbine effects analysis, not least in capturing the scale of inter-annual variability in porpoise presence in Minas Passage, but also in further confirming the consistency of key seasonal trends detected in previous 2011-2014 analyses (e.g., spring and fall peaks in presence, higher nighttime activity).

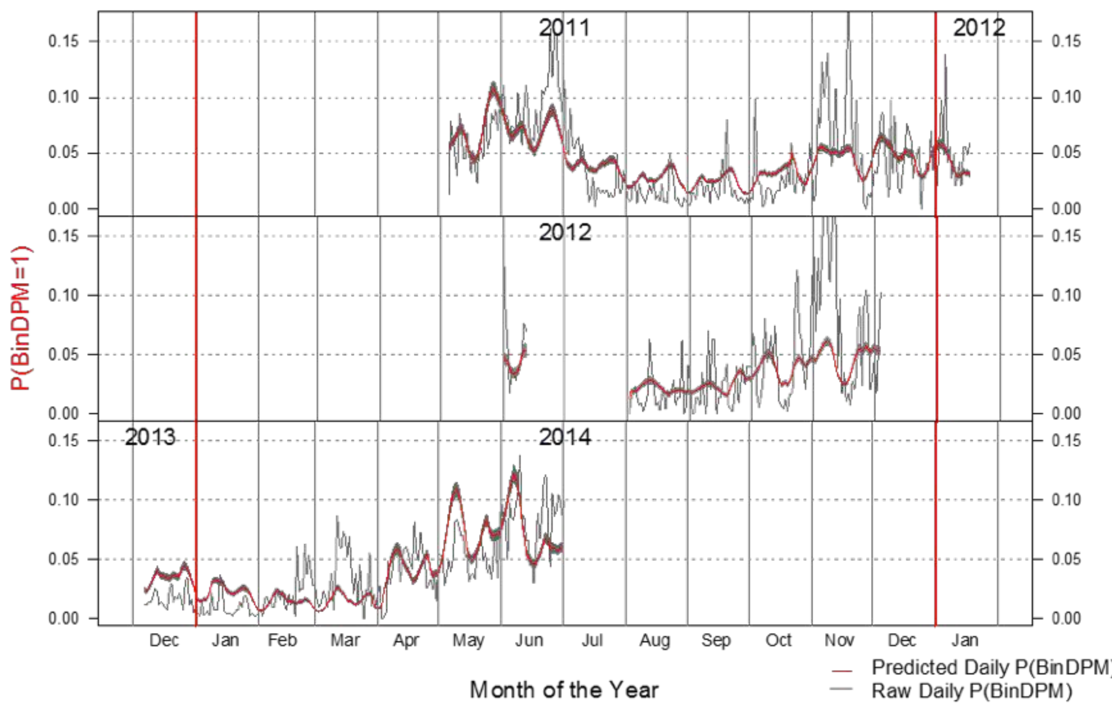

Figure 3. FORCE baseline data 2011-2014. Raw data BinDPM per day (grey lines) versus GAM-GEE model predictions of the overall mean probability of porpoise detection per time bin (PBinDPM) over time (red line), and the associated modeled 95% prediction errors (grey shading on red line).

3. Methods and Results

3.1 C-POD Calibrations

As recommended by FORCE's Marine Mammal EEMP, SMRU Consulting and FORCE staff conducted an echolocation click sensitivity calibration of all 5 available C-POD units to determine reliability and consistency and to make recommendations for the first deployment. The C-PODs were loaded with settings that will be used for the FORCE EEMP as described in Wood et al. (2013) and the hydrophone elements soaked overnight in water.

The calibration trials were conducted at the Ocean Sonics Ltd tank facility in Great Village, Nova Scotia. We played back sequences of 5 successively louder 130 kHz clicks from an icTalk

located at the center of the test tank (Figure 4), and recorded >100 clicks at each amplitude on each unit. C-PODs were mounted around the periphery of the tank (
Figure *4*). This was undertaken twice to test all 5 C-PODs, with one unit tested twice, to ensure between test compatibility.

Figure 4. Experimental setup with the icTalk in the center of the tank, 3 C-PODs around the periphery and an icListen reference hydrophone, also at the periphery.

All 5 C-PODs operated and detected clicks as expected. The time and amplitude of each detected click was exported from the C-POD software for further analysis in R. Figure 5 shows the distribution of click Sound Pressure Levels (SPL) in units of Pascal for each C-POD unit and round (2973 was tested in both round 1 and 3), for each of the 5 amplitude clicks (left to right on the X-axis). Mean SPL were calculated and then converted to dB re 1μPa. Some clicks were not detected by the C-POD unit and this is reported as % clicks missed. The coefficient of variation (CV) is reported for each click amplitude and averaged across all amplitude levels.

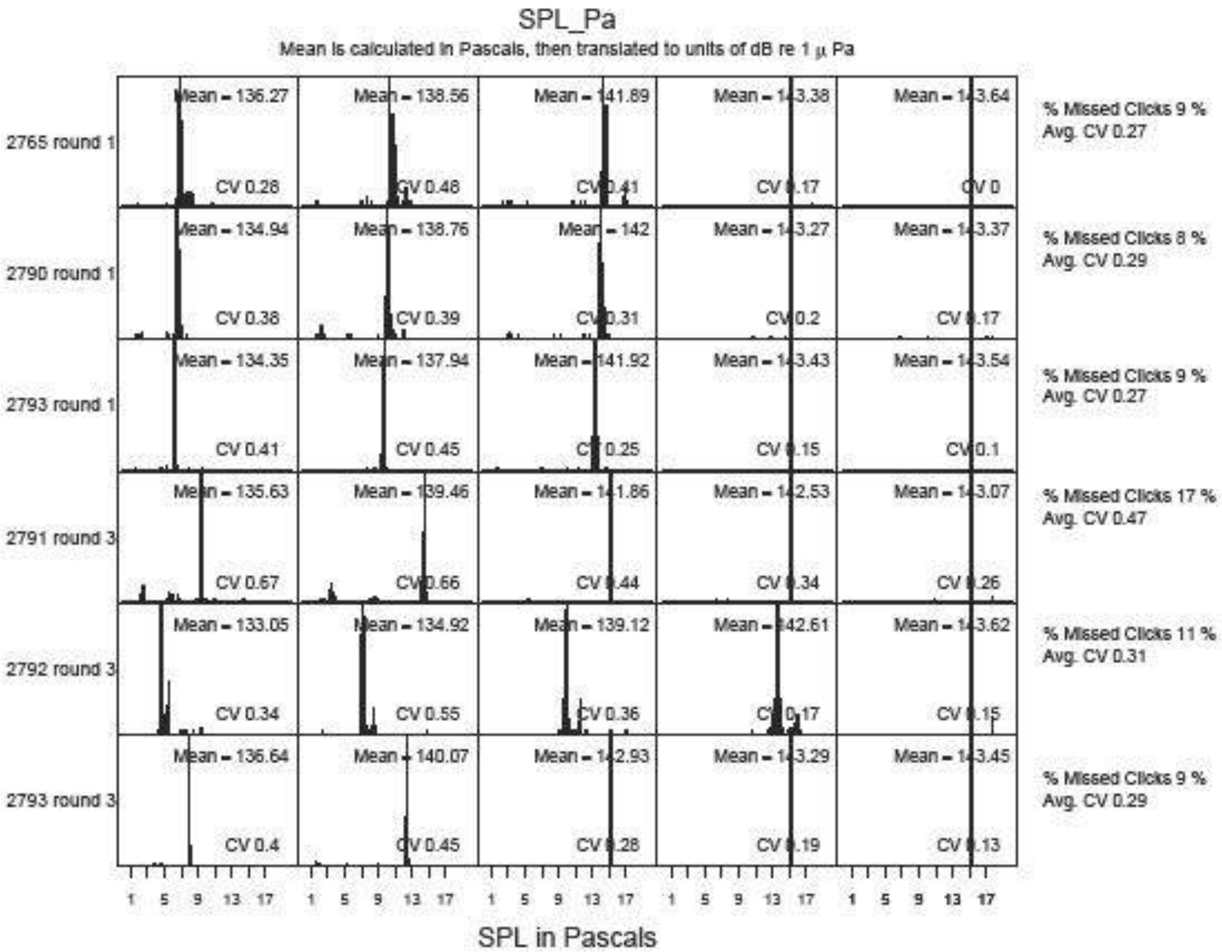

Figure 5. Distribution of click received levels (Sound Pressure Level reported in Pascals). Each column corresponds to each of the 5 amplitude levels of clicks generated by the icTalk. The loudest 2 sets of clicks exceeded the input level of the C-PODs and were thus recorded at the maximum SPL of the system. Each row corresponds to a C-POD number and the round of testing. Round 2 data were ignored as the icListen did not record during that period.

Based on the fact that C-PODs 2765, 2790 and 2793 consistently report similar SPL levels, and have the lowest CV and % missed clicks, we recommended the use of these 3 units in the current EEMP. The sensitivity of C-POD 2791 was clearly lower than all other CPODs with % clicks missed at 17% compared to 8-11% for the remaining CPODs. CPOD 2792 should therefore be the next unit selected for deployment. If C-POD 2791 is used in future deployments, these calibrations could be used to develop click correction factors to more robustly compare detection rates across all 5 units.

3.2 **C-POD Deployment and recovery information (conducted by FORCE Field Scientists)**

Three C-PODS and associated moorings and buoys were loaded onto the modified lobster fishing boat *Nova Endeavor* in Parrsboro, Nova Scotia on June 6, 2016. The deployment took place in a single tide, roughly 3 hours, on 7 June 2016. Each torpedo shaped C-POD is approximately 1.21 m (4 ft.) long and approximately 40 cm (16”) in diameter. The C-PODs are assembled into a “subs package” containing the acoustic release mechanism and recovery buoy. This is connected by a 2.5 m long chain to an anchor made of several lengths of chain (Figure 6).

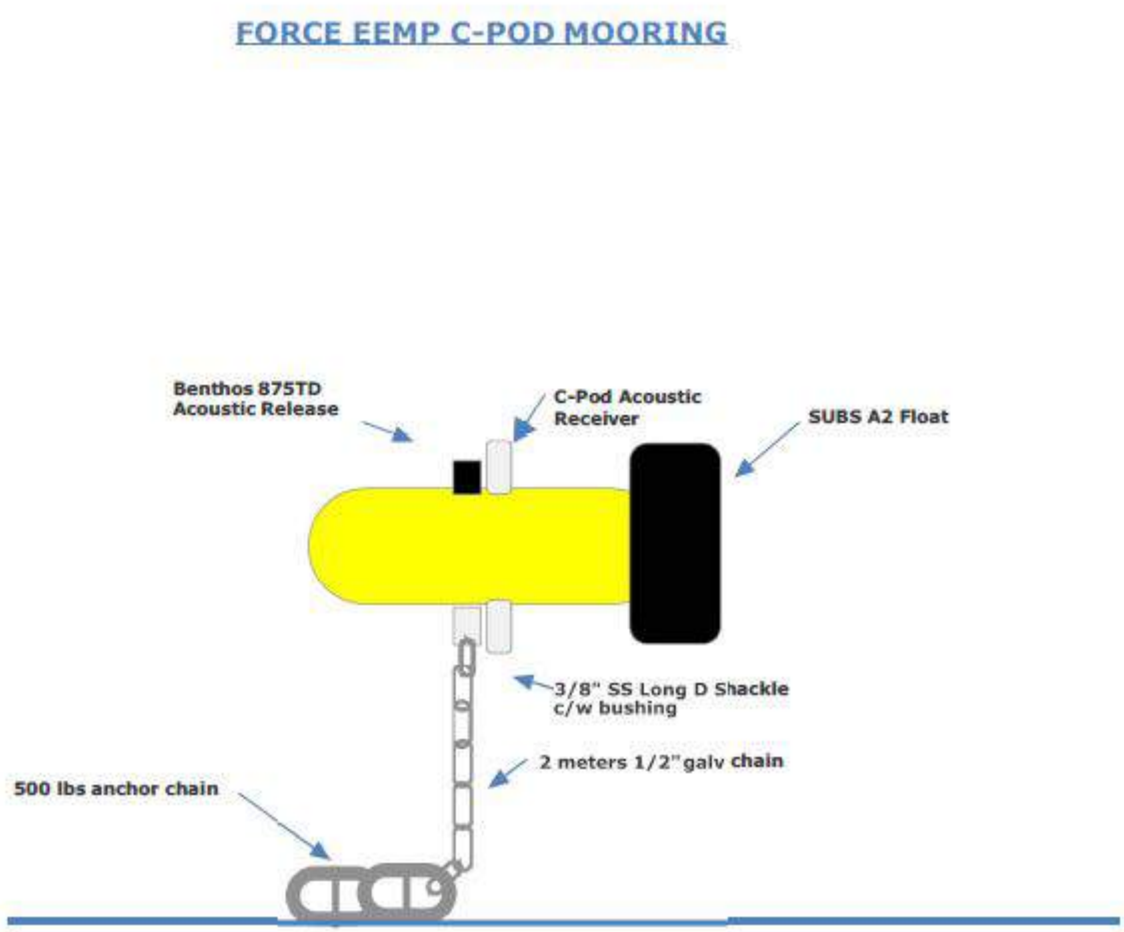

Figure 6. Diagram of FORCE C-POD mooring

Deployment (lowering overboard) of the C-PODs was achieved by assembling each individual mooring on board. The anchor was placed in the water over the stern, the anchor then raised with the capstan via the a-frame mounted on the stern, lifted clear of the deck, and pushed forward away from the vessel and released when safe to do so, allowing the C-POD and mooring to free fall to the sea bottom.

The following 3 deployment locations were selected (Table 1) and are depicted in Figure 7. Depths ranged from 44-66 m.

Table 1 Deployment locations of 3 C-PODs in Minas Passage

C-POD Number	Location goal	Actual location	Deployment depth
W1	-64 26.113 W 45 21.993 N	-64 26.125 W 45 21.944 N	66m
E1	-64 25.334 W 45 21.969 N	-64 25.333 W 45 21.973 N	53m
D1	-64 25.402 W, 45 21.765 N	-64 25.388 W, 45 21.766 N	44m

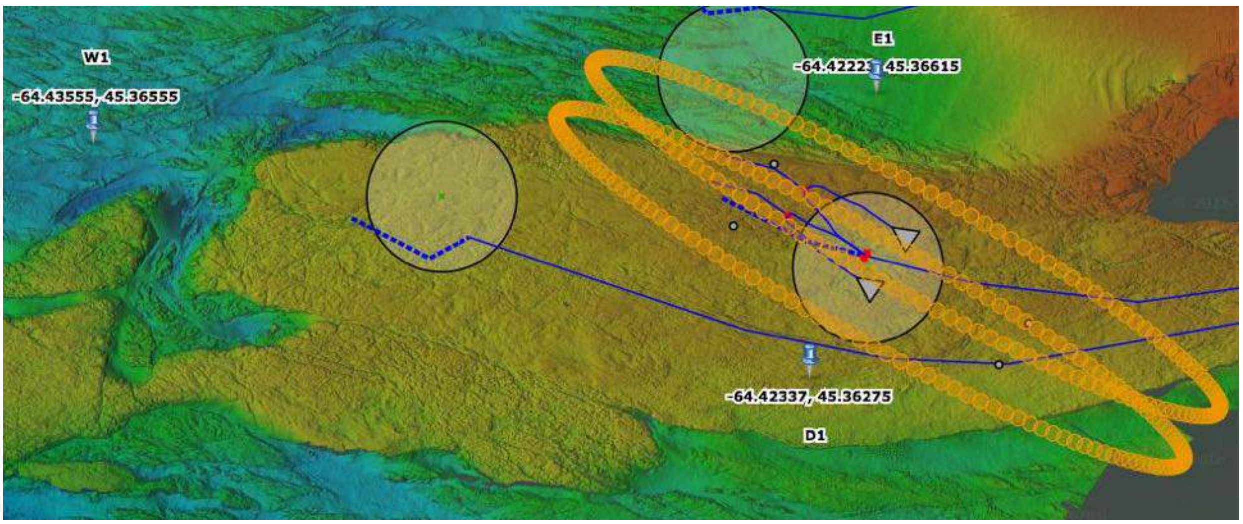

Figure 7. Locations selected for 3 C-POD locations depicted by dropped pins. The locations of the nearby berths are depicted by round black circles and berth D has the location of the two proposed turbines depicted by grey triangles.

Site selection was based on continuing to monitor the two core long-term baseline sites within the FORCE demonstration area (Sites W1 and E1). These sites represent the best baseline coverage for 2011-2014 with 535 and 470 days of coverage. The third site selected was D1, in the vicinity of Berth D – where CSTV planned to deploy two Open Hydro turbines in summer 2016. A vertical cone of safety (Figure 8) was used to determine how far a C-POD should be deployed in relation to a turbine and the ability to safely recover a C-POD. These precautionary calculations were undertaken by FORCE staff and are fully described in the OSP document.

Recovery of all 3-PODs was successfully achieved by the FORCE Field Scientists on the *Nova Endeavor* on 30 August, 2016.

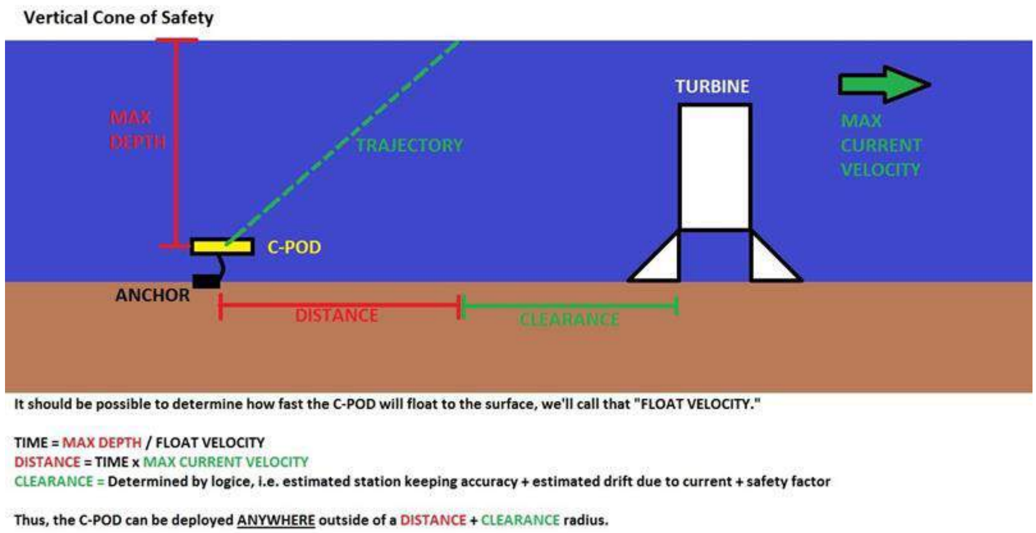

Figure. 8. Illustration of C-POD vertical cone of safety calculations

3.3 C-POD Data QA

C-POD.exe V2.044 was used to process the data and custom Matlab R2016a code used to calculate statistical outputs and create data plots using detection positive minutes (DPM) per day and DPM per 10-minute period (DPMp10M) as the key metric for comparison. The QA assessment specifically targets if non-biological interference has occurred, confirms that the porpoise click detector is operational and assess the scale of % time lost due to click maximum buffer exceedance (due to internal memory restrictions, non-target noise from sediment movement and moorings result in periods of lost recording time in each minute).

C-PODs were started, deployed and retrieved as shown in the Table 2 below. All dates and times in this report are given in UTC.

Table 2. C-POD deployment and retrieval information (date and time)

Location	C-POD number	Start	Deployment	Retrieval
W1	2793	27 May 2016 20:06	7 June 2016 17:52	30 August 2016 14:09
E1	2765	27 May 2016 20:06	7 June 2016 17:59	30 August 2016 13:50
D1	2790	27 May 2016 20:06	7 June 2016 18:08	30 August 2016 13:58

To allow for the hydrophone elements to reach their typical underwater sensitivity, data were analyzed from a day after deployment (8 June 2016 18:00) until just before retrieval (30 August 2016 13:30). This resulted in 82 days, 19 hours and 30 minutes of data at each location spread across 84 calendar days (Julian days 159-243). Data were collected throughout this period on each of the three C-PODs. C-PODs were time synced when started and checked for clock drift after retrieval. Clock drift was estimated at less than 1 minute during this deployment cycle. There was no evidence of data corruption.

Percent time lost was calculated for each C-POD and is presented in Table 3. Mean % time lost ranges from 20-29%. Cumulative probabilities (Figure 9a) are similar to that found for sites W1, N1 and S2 in August 2011 (see 9b taken from Fig. 8 in Wood et al. 2013). Far higher rates were reported by this previous study for S1 and E2 and as a consequence these sites were omitted from consideration to be included in this EEMP.

Table 3. Percent time lost by C-POD location

Location	Mean % Time Lost
W1	26.44%
E1	29.35%
D1	20.03%

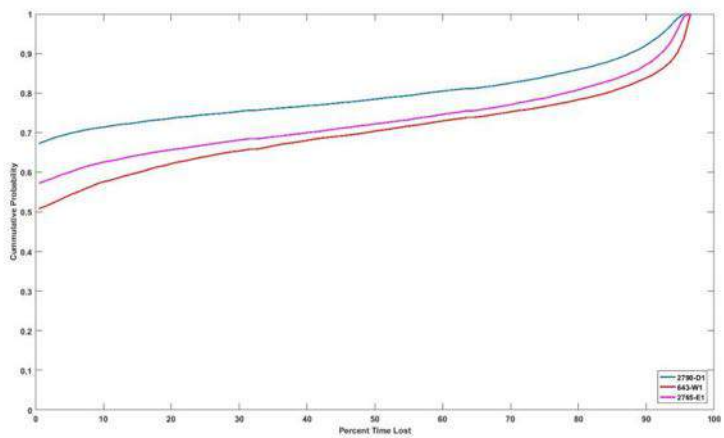

Figure 9a. Cumulative probability plot of percent time lost across 3 locations. D1 has the lowest rates of % time lost.

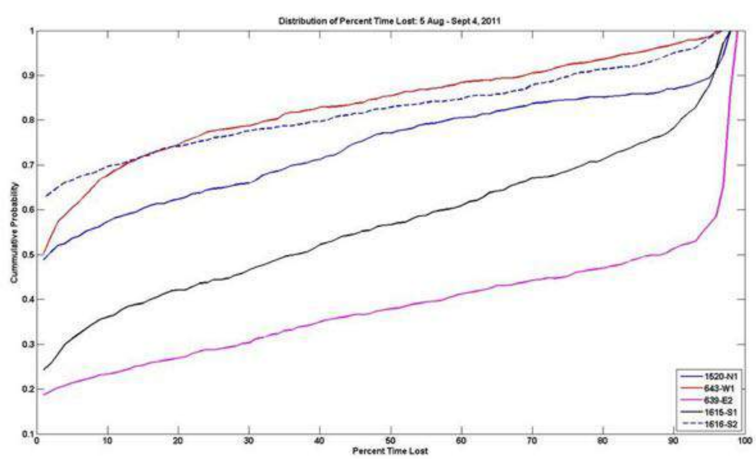

Figure 9b. Cumulative probability plot of percent time lost across 5 locations in August 2011.

3.4 **Porpoise click detection rates**

3.4.1 Overall summary of detection rates

While harbour porpoise were present in Minas Passage on 83 of the 84 calendar days (99%), they were present on average only 0.67% of the minutes in a day (median DPM/day = 7 minutes).

Descriptive statistic are provided in mean DPM per 10 minute period +/- standard deviation (SD). Mean DPMp10M was 0.07 and porpoise were detected in 3.64% of all 10 minute periods (Table4).

Table 4. Descriptive statistics for all the data collected. Percent of 10MP with DPM is the percentage of 10 minute periods with at least one porpoise detection.

Mean DPMp10M	SD	% of 10MP with DPM	No. of 10MP
0.07	0.42	3.64%	35,916

Across the 2011 and 2012 baseline data (Wood et al. 2013), porpoise were detected on 98% of days, present on average 1.5% of minutes per day (median DPM/day = 22 minutes), a mean DPMp10M of 0.08 and a % of 10MP with DPM of 4.1%. These average rates were somewhat higher than found in this June through August study and reflect the inclusion of peaks in presence previously reported during both May-June and late fall (see Figure 3).

Very few possible dolphin clicks were detected in Minas Passage during this studies' three C-POD deployments. These were checked and all confirmed to be false positives. As a consequence, no confirmed dolphin detections were made, as also found during 2011-2012 deployments (Wood et al. 2013).

3.4.2 Study period detection rates

Porpoise detection per day varied through the deployment period. Peaks at all three sites were observed in the second week of June, and mid July and mid August (Figure 10a). Compared to baseline data from 2011 and 2012 (Figure 10b), the June peak was lower than in 2011, but the other peaks noted were not clearly observed in the 2011 (or 2012), highlighting inter-annual variability in porpoise use of these site location in summer. This variability is further highlighted by DPMp10M plots from this study (Figure 11a) compared to those recorded for W1 in summer 2011 (Figure 11b).

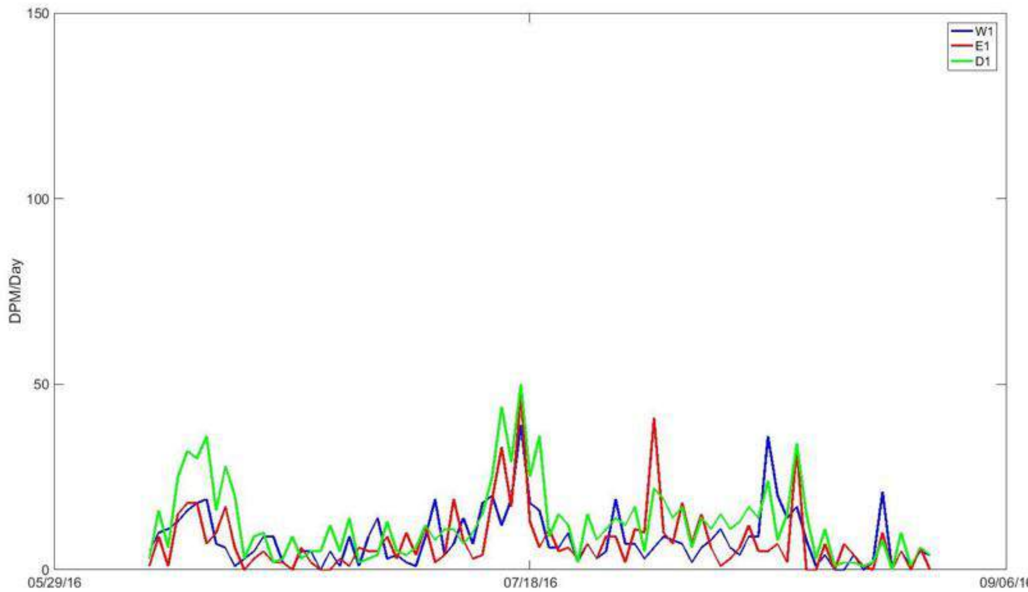

Figure 10a. DPM per day at 3 monitoring locations through the study period (7th June-August 30th 2016).

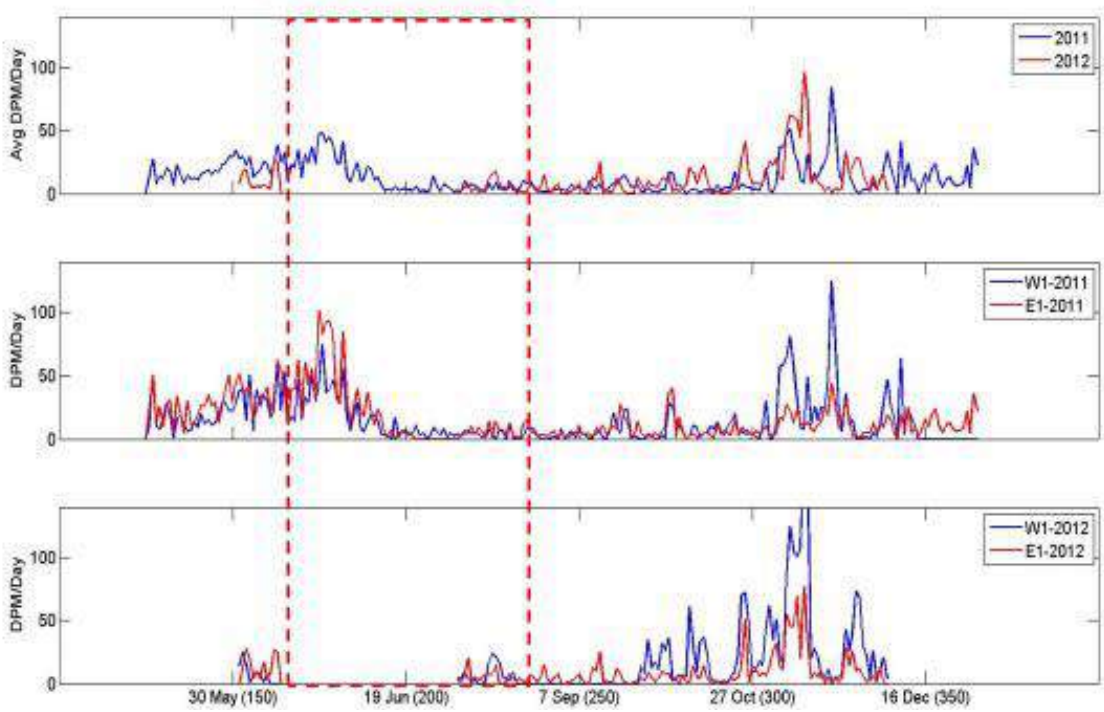

Figure 10b. DPM per day at location W1 and E1 through 2011 and 2012 baseline studies. The dashed red box depict the time period reported in this interim study.

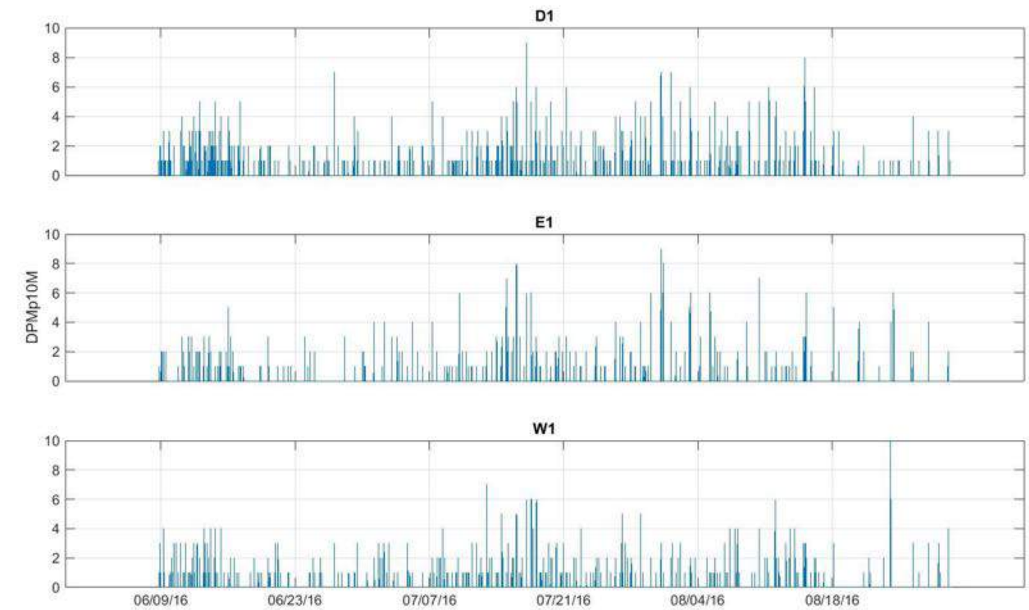

Figure 11a. DPMp10m at 3 monitoring locations through the study period (7th June-August 30th 2016)

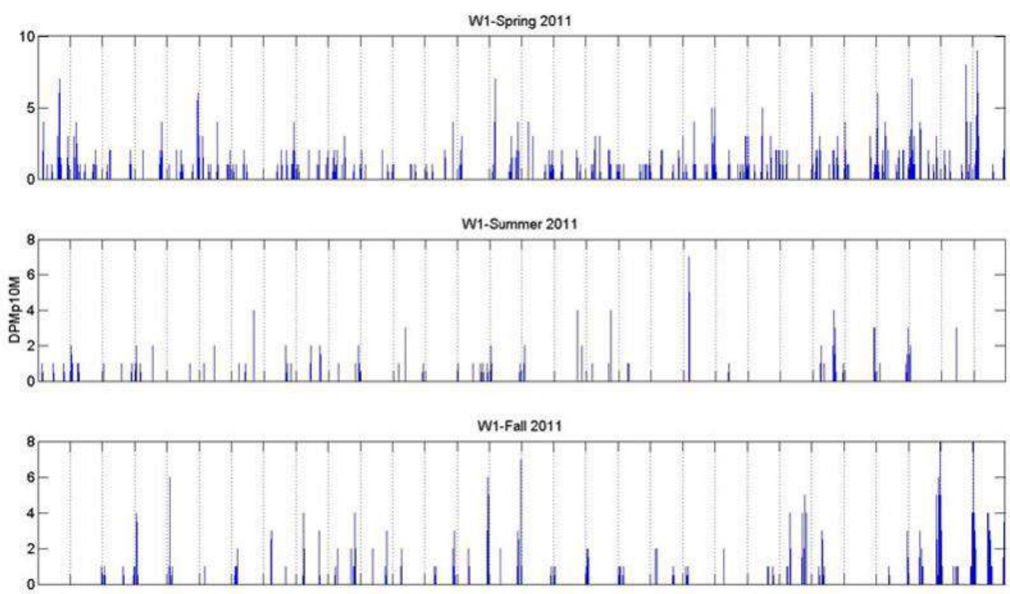

Figure 11b. DPMp10M at location W1 highlighting tends across and within month variability. Top trace is spring 2011, middle trace is summer 2011 (July 29th – August 28th), the bottom trace is fall 2011. Vertical dashed lines indicate the start of a new day (i.e. midnight). The middle trace is directly comparable with the August data presented for W1 in Figure 11a.

3.4.2 C-POD location detection rates

Porpoise detections rates varied across locations, with D1 on average higher than E1 and W1 (Table 5).

Table 5. Descriptive statistics for the three locations used in this study. Percent of 10MP with DPM is the percentage of 10 minute periods with at least one porpoise detection.

Location	Mean DPMp10M	SD	% of 10MP with DPM	No. of 10MP
E1	**0.05**	**0.40**	**2.73%**	**12,067**
W1	**0.06**	**0.38**	**3.35%**	**11,925**
D1	**0.09**	**0.48**	**4.85%**	**11,924**

4. Discussion

Three C-PODs were successfully calibrated, deployed and recovered to monitor marine mammals (porpoise and dolphins) presence in Minas Passage as part of FORCE's marine mammal EEMP. All 3 C-PODs collected data across the whole 84-day deployment period (June 7th – August 30th 2016). Average percent time lost due to sediment interference was 20-29%, similar to previous studies at these locations. Harbour porpoise were detected across 99% of days, but at low rates with a median of 7 minutes per day with presence detected in 3.64% of all 10 minute periods. Across the previous 2011 and 2012 C-POD baseline study (Wood et al. 2013), porpoises were detected on 98% of days, with higher minutes per day (median = 22 minutes) and present 4.1% of all 10 minute periods (noting this previous study collected data over spring and fall, as well as summer). No dolphins were detected as per previous baseline studies. Porpoise detection rates varied across the 84-day study and were at times higher in periods of July and August than observed previously in 2011 and 2012, but lower in June, highlighting inter-annual variability at sites within the demonstration area. While the site near berth D (D1) had higher apparent mean detection rates (0.09 detection positive minutes per 10 minute period) than at sites C1 (0.06) and E1 (0.05), the relative impact of percent time lost across sites (Figure 9a) has not yet been taken into account. This analysis will be undertaken during the GAM modelling planned for the final report, but overlapping standard deviations around these mean detection rates currently suggest insignificant site differences.

Recommend deployment of extra C-PODS at locations W2 and S2 as per past discussions. Maintain current C-POD settings and deployment methodology.

5. References

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Appendix 3: Seabirds Environmental Effects Monitoring Plan Interim Report 1

Interim report summarizing results from seabird surveys from May – July 2016. Prepared by Envirosphere Consultants Limited.

FIRST QUARTERLY SHORE-BASED SEABIRD AND MARINE MAMMAL SURVEY – TIDAL ENERGY DEMONSTRATION SITE, FUNDY OCEAN RESEARCH CENTER FOR ENERGY: MAY 6, JUNE 2 & JULY 2 2016

22 July 2016 – *Revised*

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EXECUTIVE SUMMARY

Three shore-based surveys have been carried out at the FORCE Visitor Center for water-associated birds, with observations of Harbour Porpoises also documented. The surveys took place on May 6, June 2 and July 2, 2016 over a six-hour period in half hour increments on the out-going tide, beginning at high tide and concluding at low tide. The following is an initial quarterly field report for the shore-based surveys at the Black Rock site. Low to moderate densities of seabirds have been observed, lowest in July, followed by May and highest in June with 10 seabird and waterfowl species in total documented. Small numbers of Harbour Porpoise have also been observed on all occasions. A second quarterly field survey report will be submitted in the fall according to the proposed schedule.

Field observations and species identifications were conducted by a professional bird observer, Fulton Lavender of Halifax Nova Scotia, and timed and documented by Valerie Kendall (M.Env.Sc., Project Biologist) and Patrick Stewart (M.Sc., President, Envirosphere Consultants Ltd.). The observations were made in the same general way as earlier surveys (2010-2012)[1], surveying the waters from the interpretive center to mid-Minas Passage within the field of view, which includes the waters across Minas Passage on a line from Cape Sharp, and to the west down the shore into Minas Channel, as well as covering the area towards Cape Split and therefore covering the area proposed for turbine installation. Observations were made with a 22x magnification Bushnell spotting scope as well as 8x and 10x binoculars (Figures 1 and 2).

The seasonal timing of observations has been scheduled so that observations of migrating bird species are adequately represented in the data as much as possible. Abundance of water-associate birds (loons, cormorants, seaducks, gulls, alcids, and waterfowl) at the Minas Passage site shows seasonal peaks corresponding to migratory movements (March-April and October-November) and a late spring to early summer occupation of the area by local resident breeders such as Black Guillemot, Common Eider, Double-Crested Cormorant, and Herring and Great Black-backed Gulls (Envirosphere Consultants 2011-2013). There is a low summer abundance of local species, when migrants are not present and individuals of local breeding species such as gulls and cormorants move out of the area.

The observation team initially records separately all birds sitting or associated with the water in the subdivisions, including on Black Rock (Figure 1). Following this, a flying ‘snapshot’ is carried out to record all birds in flight observed throughout the subdivisions. The remainder of the 30-minute interval is used to record additional birds flying into the area or on the water. Birds observed in the vicinity of Black Rock and also in the crown lease area (“critical area”) are highlighted. A summary of bird and marine mammal observations to date are presented in Tables 1-8. Weather information and environmental data was recorded from the inside weather station operating at the FORCE facility.

[1] Observations from 2011 onward were made from the outdoor observation deck or inside the FORCE Visitor Center. Although this location is about 150 m from shore, the view was satisfactory when the spotting scope and binoculars were used, and the site provided a better overview of the site.

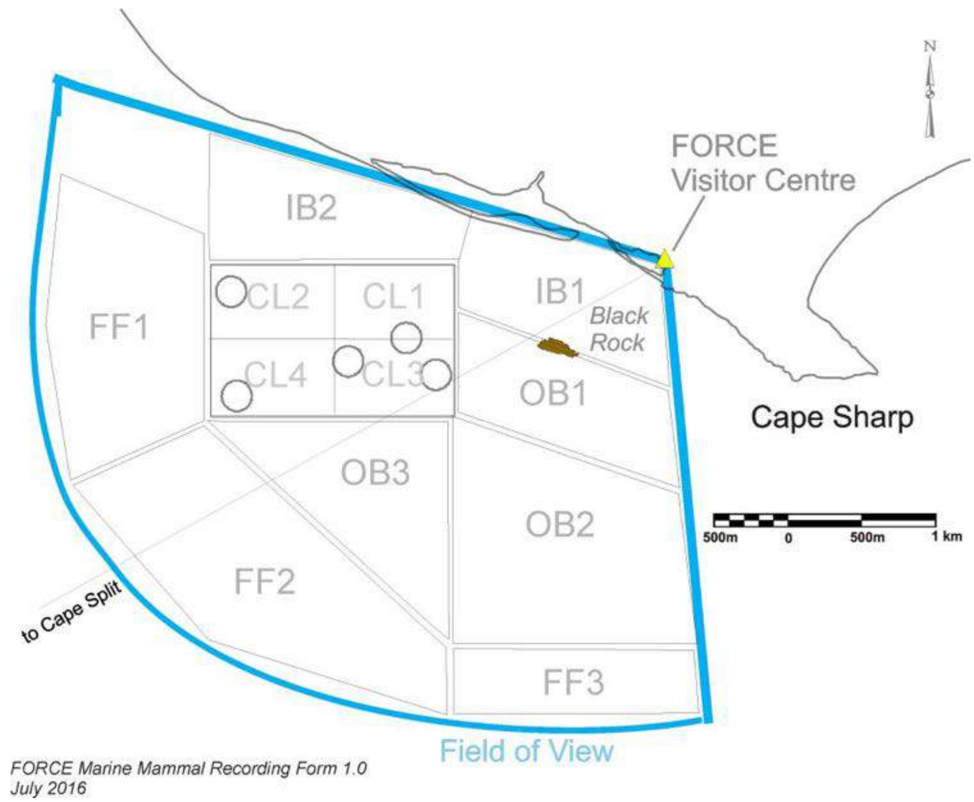

Figure 1. Study area field of view with grid showing open water subdivisions to document marine bird and mammal occurrences. (CL1-4 = turbine field/crown lease area; IB1-2 = Nearshore area/Inside Black Rock; OB1-3 Buffer area/outside Black Rock; FF1-3 Far-field buffer area.

Figure 2. Bird Observer, Fulton Lavender, counting bird occurrences in the nearshore (IB-1 & -2) subdivisions using a 22x magnification Bushnell spotting scope. June 2, 2016.

SUMMARY OF SURVEYS

Friday, May 6, 2016 – The field team arrived onsite at the FORCE Visitor Center, Parrsboro at approximately 0940 Friday morning, consisting of Patrick Stewart (Lead Biologist, Envirosphere Consultants Ltd), Valerie Kendall (Project Biologist, Envirosphere Consultants Ltd), Fulton Lavender (Seabird Observer), Richard Hatch (Assistant Bird Observer), and Joy Baker (Environmental Technician-Envirosphere Consultants Ltd). Objectives for this visit included a safety orientation with Mary McPhee, FORCE Facilities Manager, and an initial bird survey, beginning at 12:38 and ending at 18:12, conducted in 30-minute intervals and coinciding with the outgoing tide cycle.

On this occasion, the observers remained inside the building. Weather was overcast for the duration of the day (100% cloud cover), with light NE winds, ranging from approximately 25 km/h diminishing to less than 10 km/hr by evening. Mr. Lavender was the primary observer and Mr. Hatch and Ms. Baker recorded data.

Observed number of birds overall were low. The most abundant birds noted each half hour were Great Black-backed Gulls (GBBG) on Black Rock for most of the monitoring periods. Ten species of birds were recorded over the six-hour survey period: three species of gulls (Great Black-backed, Herring, and Lesser Black-backed), Double-crested Cormorant, Great Cormorant, Black Scoter, Black Guillemot, Common Eider, and Red-throated Loon.

Two Harbour Porpoises were briefly seen surfacing during the 15:12 – 15:42 observation period within the crown lease area and moving into the farfield region. A single Bald Eagle was observed flying through subdivision IB-1 between 14:12 and 14:42. Many land birds were present around the interpretive center.

June 2, 2016 – Field team, Fulton Lavender and Valerie Kendall, arrived on site in Parrsboro at approximately 10:45. Observations were conducted from the outdoor observation deck at the FORCE Visitor Center. Weather was sunny, with little cloud cover throughout the day. Temperature ranged from 11ºC at noon to a high of approximately 15.7ºC by late afternoon and early evening. Winds were light, approximately 15 km/h ESE diminishing to less than 10 km/h ESE by the end of the six-hour survey. Observations in 30-minute intervals began with high tide at 12:00 and continued until 18:15, in which all bird and mammal occurrences according to the study area subdivisions were recorded.

Overall, numbers of birds were low. The most abundant bird species noted each half hour were Great Black-backed Gulls (GBBG) resting on Black Rock. Ten species of birds were recorded through the day including: four species of gulls (Great Black-backed, Herring, Lesser Black-backed, and Ring-billed), Red-throated Loon and Common Loon, Black Guillemot, Common Eider, Double-crested Cormorant, and Great Cormorant.

Between 17:00 and 17:30, a single Harbour Porpoise was observed moving through IB-1 into IB-2 where it resurfaced momentarily. Prior to the survey start time two Turkey Vultures were noted flying above the shore before flying out of sight east of the visitor center. A number of land bird species, such as robin and hummingbird, were observed throughout the day in the gardens, surrounding forest and the clearing below the visitor center.

July 2, 2016 – Field team, of Fulton Lavender and Patrick Stewart, arrived on site in Parrsboro at approximately 11:00. Observations were conducted from the outdoor observation deck at the FORCE Visitor Center. Weather was slightly overcast with occasional showers and thunderstorms. Temperatures were warm between 16 and 20ºC with light ESE winds ranging from 8 to 18 km/h and shifting to SW at the end of the six-hour survey. Observations were made continuously every 30-minutes beginning at 11:20 and ending at 17:20 according to the survey protocol as described above.

Overall low numbers of birds were recorded. A small number of Great Black-backed Gulls were always present on Black Rock, and Herring Gull and Double-crested Cormorant also occasionally landed on the rock. Common Eiders were often seen on the edge of Black Rock or in the water alongside. Black Guillemots appear to be nesting in two locations in cavities on Black Rock. Adults were seen flying into the cavities and there are possibly two nests. The most abundant birds noted each half hour were Great Black-backed Gulls (GBBG) resting on Black Rock. Eight species of birds were recorded through the day: two gull species (Great Black-backed and Herring); Double-crested and Great Cormorants, as well as Black Guillemot, Common Eider, Red-throated and Common Loons.

An adult & juvenile pair of Harbour Porpoise was seen swimming with the outgoing tide from 12:08 to 12:10. The pair was seen in the OB-1 and OB-2 area just east of Black Rock, and they disappeared behind the rock, reappearing and moving through the CL area and disappearing near the northwest corner of the area. The individuals were close together (very close, almost bumping) and it was presumed the sighting represented a female and offspring, with the adult tending the juvenile. They were swimming in a single direction (with the current) and not feeding. An adult Harbour Porpoise was seen in the next survey period, about 10 minutes after the first sighting, at the western end of the OB-2 zone. This one was seen at the surface and went below the surface and was not seen again. We presumed it was the adult of the pair seen shortly before, but could not be sure. A Bald Eagle was also noted between 14:50 and 15:20 flying NW through subdivision IB-1.

TABLES & FIGURES

Table 1. Seabird and waterfowl abundance, shore-based observations – May 6, 2016 Survey.

Species	Date: May 6, 2016				Time: 12:30 – 6:30			Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.											
	Number of Individuals Sighted per Observation Period											
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	0	0	1	1	1	2	0	0	0	1	0	0	0.5
BLSC	0	0	0	0	0	2	0	0	0	1	0	0	0.25
COEI	0	0	2	2	5	5	1	0	1	0	0	0	1.3
COLO	0	0	1	0	0	0	0	0	0	0	0	0	0.08
DCCO	4	5	5	4	4	2	4	5	4	0	6	0	3.2
GBBG	21	20	21	23	23	20	20	20	20	16	1	0	17.1
GRCO	2	0	2	3	0	3	3	5	4	4	0	0	2.2
HEGU	4	5	3	8	7	8	11	5	4	12	7	0	6.2
LBBG	0	0	0	0	1	0	0	0	0	0	0	0	0.08
RTLO	1	6	1	0	0	0	0	0	0	2	0	0	0.8

Table 2. Seabird and waterfowl abundance, shore-based observations – June 2, 2016 Survey.

Species	Date: June 2, 2016				Time: 12:00 – 18:15				Observer: Fulton Lavender			
	Location: FORCE Visitor Center observation deck facing water, Parrsboro Nova Scotia.											
	Number of Individuals Sighted per Observation Period											
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	2	1	0	1	3	0	0	0	0	1	0	0	0.7
COEI	2	0	1	8	6	3	0	6	3	4	4	4	3.4
COLO	0	0	0	0	0	0	1	0	0	0	1	1	0.3
DCCO	6	2	2	2	3	0	2	7	4	9	9	5	4.3
GBBG	34	21	17	24	18	13	22	18	16	15	17	16	19
GRCO	0	0	0	0	1	1	1	1	2	1	1	1	0.8
HEGU	14	20	23	20	21	14	13	5	1	9	7	9	13
LBBG	0	0	0	0	0	1	0	0	0	0	0	1	0.2
RBGU	0	0	0	0	0	0	0	0	0	0	0	1	0.1
RTLO	0	0	0	0	0	1	0	0	0	0	0	1	0.2

Table 3. Seabird and waterfowl abundance, shore-based observations – July 2, 2016 Survey.

Species	Date: July 2, 2016				Time: 11:20 – 17:20				Observer: Fulton Lavender			
	Location: FORCE Visitor Center observation deck facing water, Parrsboro Nova Scotia.											
	Number of Individuals Sighted per 30-minute Observation Period											
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	5	2	4	2	1	2	0	0	1	1	0	3	1.8
COEI	0	0	1	3	0	3	4	2	2	3	4	6	2.3
COLO	0	0	1	0	0	1	0	0	0	0	0	0	0.2
DCCO	1	3	1	1	0	1	0	2	3	4	3	3	1.8
GBBG	11	13	3	7	6	9	8	7	5	9	8	8	7.8
GRCO	0	0	0	0	0	0	0	0	2	0	0	0	0.2
HEGU	5	4	5	6	5	4	2	10	4	3	2	4	4.5
RTLO	1	0	0	0	0	0	0	0	0	0	0	0	0.1

Table 4. Number of individual sea- and shorebird species observed from the FORCE Visitor Center per 30-minute interval. May 6, June 2, July 2, 2016.

Species	May 6	June 2	July 2
BLGU	0.5	0.7	1.8
BLSC	0.3	0	0
COEI	1.3	3.4	2.3
COLO	0.1	0.3	0.2
DCCO	3.6	4.3	1.8
GBBG	17.1	19.3	7.8
GRCO	2.2	0.8	0.2
HEGU	6.2	13.0	4.5
LBBG	0.1	0.2	0
RBGU	0	0.1	0
RTLO	0.8	0.2	0.1
Total	32.1	42.0	18.7

Table 5. Comparison of species list of marine mammals and seabirds at Fundy Tidal Power Demonstration Site, from shore based observations, 2010, 2011 & 2016.

	2010	2011	2016
ABDU	✓	✓	
Alcid sp		✓	
ATPU	✓		
BLGU	✓	✓	✓
BLKI	✓	✓	
BLSC	✓	✓	✓
CAGO	✓	✓	
COEI	✓	✓	✓
COGO		✓	
COLO	✓	✓	✓
COME	✓		
COME	✓		
COMU	✓	✓	
DCCO	✓	✓	✓
GBBG	✓	✓	✓
GRCO	✓	✓	✓
HADU	✓		
HEGU	✓	✓	✓
HOGR	✓		
ICGU	✓		
KIEI		✓	
LAGU	✓		
LBBG	✓	✓	✓
LTDU	✓	✓	
MALL	✓		
MEGU	✓		
NOGA	✓	✓	
NSHO		✓	
PALO	✓	✓	
RAZO	✓	✓	
RBGU	✓	✓	✓
RBME	✓	✓	
RNGR	✓		
RTLO	✓	✓	✓
SCSP		✓	
SUSC	✓	✓	
TBMU	✓	✓	
WWSC	✓	✓	
TOTAL	33	28	11

Table 6. Seabirds observed at Fundy Tidal Power Demonstration Site, 2016, in shore-based surveys.

Species Code	Common Name	Scientific Name
WATERFOWL		
BLSC	Black Scoter	Melanitta americana
RTLO	Red-throated Loon	Gavia stellata
COLO	Common Loon	*Gavia immer*
COEI	Common Eider	*Somateria mollissima*
SEABIRDS		
DCCO	Double-crested Cormorant	Phalacrocorax auritus
GRCO	Great Cormorant	*Phalacrocorax carbo*
GBBG	Great Black-backed Gull	*Larus marinus*
HEGU	Herring Gull	*Larus argentatus*
LBBG	Lesser Black-backed Gull	*Larus* fuscus
RBGU	Ring-billed Gull	Larus delawarensis
BLGU	Black Guillemot	*Cepphus grylle*

Table 7. Marine mammal observations during shore-based seabird and marine mammal surveys, Fundy Tidal Power Demonstration Site, May 6, June 2, July 2, 2016.

Date	Time (ADT)	Survey Component	Location Sighted	Species	Number
May 6, 2016	15:12-15:42	Shore	Turbine Area (CL) into Farfield Area (FF)	Harbour Porpoise	2
June 2, 2016	17:00-17:30	Shore	Inside Black Rock	Harbour Porpoise	1
July 2, 2016	12:08-12:10	Shore	Outside Black Rock (OB1-2) into Turbine Area (CL)	Harbour Porpoise	2
	12:20-12:50	Shore	Inside Black Rock (IB2)	Harbour Porpoise	1

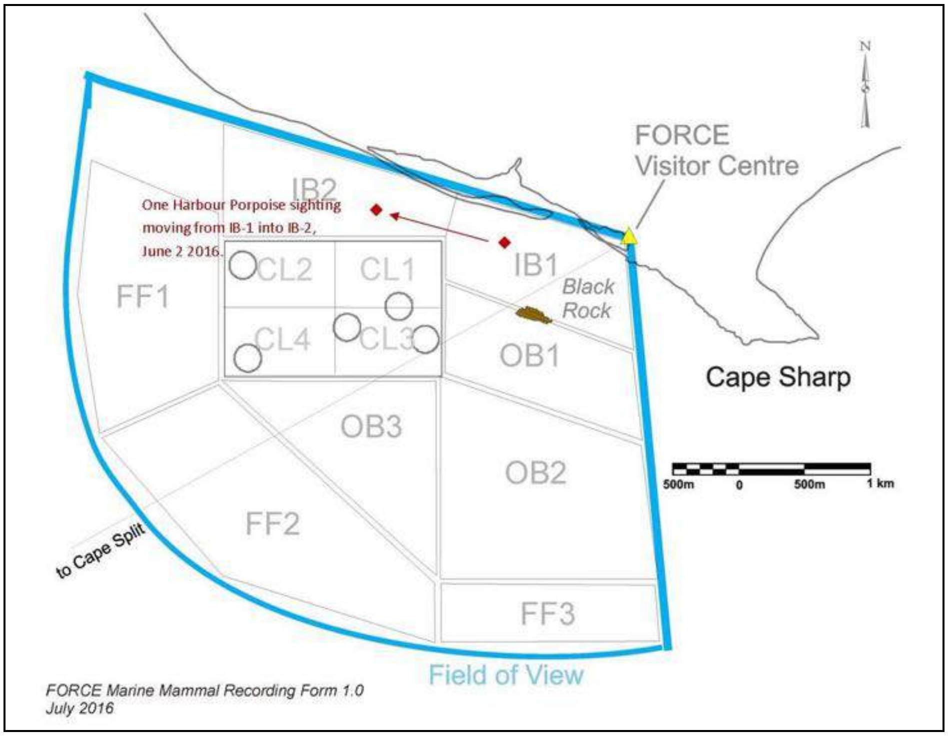

Figure 3. Depiction of a single Harbour Porpoise sighting on June 2 2016 from the FORCE Visitor Center outdoor observation deck.

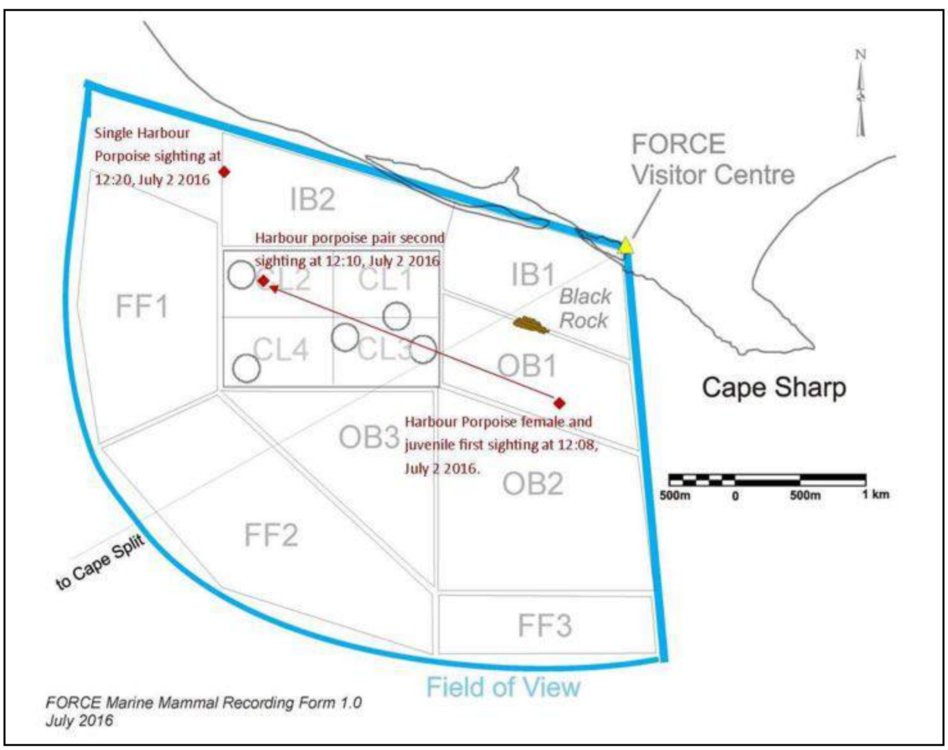

Figure 4. Depiction of Harbour Porpoise sightings on July 2 2016 from the FORCE Visitor Center outdoor observation deck.

Appendix 4: Seabirds Environmental Effects Monitoring Plan Interim Report 2

Interim report summarizing results from seabird surveys from August – November 2016. Prepared by Envirosphere Consultants Limited.

SECOND QUARTERLY SHORE-BASED SEABIRD AND MARINE MAMMAL SURVEY – TIDAL ENERGY DEMONSTRATION SITE, FUNDY OCEAN RESEARCH CENTER FOR ENERGY: AUGUST 2, SEPTEMBER 1, OCTOBER 1 & 17, NOVEMBER 3, 2016

21 November 2016 – *Revised-2*

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EXECUTIVE SUMMARY

Monthly shore-based surveys began at the FORCE Visitor Center for marine birds in the spring of 2016 during early to mid-breeding season. Surveys took place on May 6, June 2 and July 2, 2016 over a six-hour period in half hour increments on the out-going tide, beginning at high tide and concluding at low tide. Observations were summarized in an initial quarterly report dated July 22, 2016. Subsequent surveys, presented in this report, took place on August 2, September 1, October 1 &17, and November 3 during the late and post-breeding/moulting and migration season. To date, eight shore-based surveys have been carried out. In addition to seabirds, Harbour Porpoises have also been documented. Beginning in October, survey frequency was increased to twice monthly in order to capture the migratory period. Low to moderate densities of seabirds have been observed, lowest in October and August, and highest in September and November, with a total of 22 seabird, waterfowl and shorebird species observed. Small numbers of Harbour Porpoise were observed during August, September and October surveys. Overall, the number of birds seen at the site is lower than expected, based on earlier baseline surveys, and reflects the broader pattern of bird abundance not connected with activity at the FORCE site. A third quarterly field survey report will submitted in February according to the proposed schedule.

Field observations and species identifications were conducted by a professional bird observer, Fulton Lavender of Halifax Nova Scotia, and documented by Valerie Kendall (M.Env.Sc., Project Biologist), Patrick Stewart (M.Sc., President) and Richard Hatch (Bird Observer, Halifax Nova Scotia). The observations were made in the same general way as earlier surveys (2010-2012)[1], but using a grid system adopted for the present surveys. Waters were surveyed from the interpretive center to mid-Minas Passage within the field of view, which includes the waters across Minas Passage from the site and down the shore into Minas Channel, as well as covering the area towards Cape Split and therefore covering the area proposed for turbine installation. Observations were made with a 22x Celestron spotting scope as well as 8x and 10x binoculars (Figures 1 and 2).

Seasonal timing of observations has been scheduled so that critical times for birds, in particular for migrating birds, are adequately represented in the data as much as possible. Abundance of water-associated birds (loons, cormorants, seaducks, gulls, alcids, and waterfowl) at the Minas Passage site in past showed seasonal peaks corresponding to migratory movements (March-April and October-November) and a late spring to early summer occupation of the area by local resident breeders such as Black Guillemot, Common Eider, Double-Crested Cormorant, and Herring and Great Black-backed Gulls (Envirosphere Consultants 2011-2013). There is a low summer abundance of local species, when

[1] Observations from 2011 onward were made from the outdoor observation deck or inside the FORCE Visitor Center. Although this location is about 150 m from shore, the view was satisfactory when the spotting scope and binoculars were used, and the site provided a better overview of the site.

migrants are not present and individuals of local breeding species such as gulls and cormorants move out of the area.

The observation team initially records separately all birds sitting or associated with the water in the survey subdivisions, including on Black Rock (Figure 1). Following this, a flying 'snapshot' is carried out to record all birds in flight observed throughout the subdivisions. The remainder of the 30-minute interval is used to record additional birds flying into the area or on the water. Birds observed in the vicinity of Black Rock and also in the Crown Lease Area ("critical area") are highlighted. A summary of bird and marine mammal observations to date are presented in Tables 1-8. Weather information and environmental data was recorded from the weather station operating at the FORCE facility.

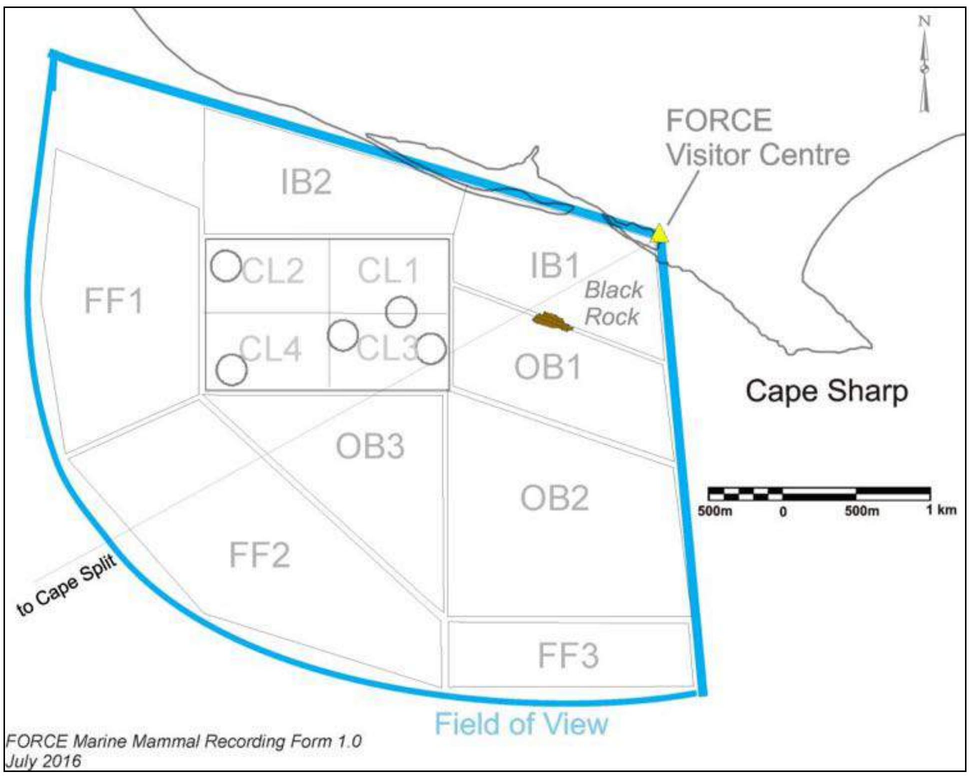

Figure 1. Study area field of view with grid showing open water subdivisions to document marine bird and mammal occurrences. (CL1-4 = turbine field/crown lease area; IB1-2 = Nearshore area/Inside Black Rock; OB1-3 Buffer area/outside Black Rock; FF1-3 Far-field buffer area.

Figure 2. A view of Minas Passage during a marine bird survey on October 17, 2016. Bird Observer: Fulton Lavender, using a 22x Celestron spotting scope.

SUMMARY OF SURVEYS

August 2, 2016 – Valerie Kendall (Project Biologist, Envirosphere Consultants Ltd) and Fulton Lavender (Seabird Observer) arrived at the FORCE Visitor Center, Parrsboro at approximately noon and began the survey at 13:00. Bird observations were made in 30-minute intervals coinciding with the outgoing tide for six hours. Peak high tide for Parrsboro was at 12:56 (www.tides.gc.ca). Mr. Lavender was the primary observer and Ms. Kendall recorded data.

The survey was completed outdoors on the FORCE Visitor Center outdoor observation platform overlooking the Passage. Weather was sunny with partial clouds throughout the day (50% cloud cover); winds were light from the east and east-southeast, and ranged from approximately 4 – 11.3 km/h.

Observed number of birds overall were low. The most abundant birds noted each half hour were Herring Gulls sitting on Black Rock for most of the monitoring periods. Birds were also actively flying through and circling within the observation area, and waterfowl were noted on the water. Twelve species of birds were recorded over the six-hour survey period: four species of gulls (Great Black-backed, Herring, Ringbilled, and Lesser Black-backed), Double-crested Cormorant, Great Cormorant, Black Scoter, Black Guillemot, Common Eider, and Common Loon, and two shorebird species, Spotted Sandpiper and Lesser Yellowlegs.

One Harbour Porpoise was briefly sighted surfacing within the Crown Lease Area at about 14:00. A single Bald Eagle was observed flying through subdivision IB-1 at approximately 13:40, and again at 14:24 closer to shore. Many land birds were also present around the interpretive center.

September 1, 2016 – The field team, Fulton Lavender and Valerie Kendall, arrived onsite at approximately 12:30 and began the survey at 13:15. Observations were conducted from the outdoor observation deck at the FORCE Visitor Center. Weather was overcast (100% cloud cover) but cleared to about 10% cloud cover by mid-afternoon. Temperature ranged from 19.5 ºC at 12:15 to a high of 22.2 ºC by late afternoon and early evening. Winds were light, ranging between 8.3 – 13.7 km/h E and ESE. Observations in 30-minute intervals began with high tide at 13:15 and continued until 19:15, in which all bird and mammal occurrences according to the study area subdivisions were recorded.

Overall, numbers of birds were low. The most abundant bird species noted each half hour were Double Crested Cormorant resting on Black Rock and occasionally flying or on the water feeding. Five species of birds were recorded through the day including Herring and Ring-billed Gulls, Double-crested Cormorant, Great Cormorant and Wilson's Storm Petrel. Birds were predominantly observed flying through the observation area. Breeding season has passed and sexes could not be distinguished.

At approximately 14:50, an estimated four Harbour Porpoise were observed at the surface in the Crown Lease Area and swimming in a northwest direction.

October 1, 2016 – Field team, Fulton Lavender, Patrick Stewart and birding assistant, Richard Hatch, arrived onsite in Parrsboro at approximately 11:00. Observations were conducted from the outdoor observation deck at the FORCE Visitor Center beginning at 11:30. Weather was mostly cloudy with occasional sunny breaks. Temperatures were warm between 14.7 and 17.2 ºC with light ESE winds ranging from 8 to 18 km/h and shifting to SW and W during the second half of the six-hour survey and generally wave conditions were flat/ripples. Observations were made every 30-minutes beginning at 11:30 until 14:30. Porpoise sightings delayed the start of the subsequent survey until 14:35. The complete survey ended at 17:05.

Overall, low numbers of birds, and a total of 12 seabird species, were observed and recorded. A pair of Bald Eagles were present on the western end of Black Rock for the early afternoon, from the beginning of the survey until 15:35 and may have deterred some of the gulls from landing there. Occasionally Great Cormorants and Double Crested Cormorants landed on Black Rock and on the surrounding water, and a Common Loon and Red-throated Loon were also noted in the study area. A small number of Herring and Ring-billed Gulls and a single Great Black-backed Gull were observed. Other species included a Black Duck, Canada Goose and Red-breasted Merganser, which were noted on the water within close proximity to Black Rock (ie. OB1, IB1, CL). A Peregrine Falcon was also observed flying westward along the beach at the site.

An adult-juvenile pair of Harbour Porpoise was seen swimming just east of Black Rock (see Figure 5) at 14:07. They were observed again in the northeast corner of OB1 at 14:10 and continued northwest through the northeast corner of CL1. They were last seen in IB2 at approximately 14:11. It appeared they were moving at a leisurely, feeding pace. Another individual porpoise was noticed in Minas Passage, swimming along the axis of the Passage and located roughly east of a line towards Cape Split. It appeared to be swimming at a faster pace and surfaced 3 to 4 times. It was first seen at 14:10 and last seen about 14:11. Since porpoises tend to travel in groups, it is likely additional animals were present in the outer passage accompanying the one that was sighted. Shortly after this sighting, five adults were seen approximately 300 meters from shore, at 14:28, between the observation point and Black Rock. The group was noted to be moving northwestward, largely parallel to the coast through IB1, near the northeast corner of CL1 and were sighted in IB2 at 14:31, resurfacing three more times as they moved west through IB2, and exhibited a behavior which appeared to be dive feeding.

October 17, 2016 – The field team, Fulton Lavender and Valerie Kendall, arrived onsite at approximately 11:10 and began the survey at 11:45. Observations were conducted from the outdoor observation deck at the FORCE Visitor Center. Weather conditions were relatively warm (15 – 18.4 ºC), with 100% cloud cover in the morning to almost completely clear by the end of the survey (5% cloud cover). Wind was from the west and ranged from about 18 kph in the morning to 30 kph by late afternoon, and dropping to about 23 kph by the final 30-minute survey interval (17:15). Wave conditions consisted of large wavelets and scattered white caps. Unlike the other surveys, which began around high tide, to accommodate for the change in daylight hours and earlier sunset, the survey was started at about mid-tide. This allowed completion of the survey before sunset. Peak tide was at 14:05.

Overall, numbers of birds were minimal, and lowest for all surveys so far, with a total of nine species. Black Rock did not have any birds for the majority of the day, with the exception of a single juvenile Great Cormorant that arrived about 14:15 and remained sitting on the rock until about 16:50, at which time it flew away in an easterly direction. Occasional Herring Gulls, and single Ring-billed and Great Black-backed Gulls were documented throughout the afternoon. During the final two 30-minute intervals, seven Herring Gulls were noted flying primarily eastward through the study area outside Black Rock. Double-crested Cormorant, Common Eider, Common Loon, Black Scoter and a single White-wing Scoter juvenile were also observed. The bird species noted most consistently each half hour was Herring Gull flying through the study area and feeding.

November 3, 2016 – The field team, Fulton Lavender and Valerie Kendall, arrived onsite at approximately 11:40 and began the survey at 12:15. Observations were conducted from the outdoor observation deck at the FORCE Visitor Center. Weather conditions were relatively cool and stable between 8.5 and 9.1ºC, with 100% cloud cover for the duration of the day. Wind speed was very low at less than one kph to about six kph resulting in flat water conditions. The survey began at about mid-tide in order to complete the survey during day light hours. Peak tide was at 15:01.

Overall, numbers of birds were minimal and eleven species were observed. Black Rock was unoccupied for the entire survey with the exception of a single Great Black-backed Gull that landed on the rock just after 18:00 in the final 30-minute interval. Black Scoters were the most abundant bird species, and Surf Scoters were also observed – these are migrants through the site at this time of year. Herring Gulls were present in small numbers for each interval; a single Iceland Gull flew in from the southeast and landed in the Crown Lease Area; and a single Atlantic Puffin was noted flying west through the Crown Lease Area during the second final survey interval. Long-tailed Duck, Razorbill, and Red-throated Loons were also observed.

During the survey, vessels from Cape Sharp Tidal Development Ltd. were onsite and a vessel and barge were present in the study area (OB3) by mid-afternoon (approximately 14:45, onward) testing equipment for a turbine deployment which took place on November 7, 2016. As daylight faded, it is possible the lights from the vessel and barge might attract birds but no association of sightings with these activities were noted.

TABLES & FIGURES

Table 1. Seabird and waterfowl abundance, shore-based observations – August 2, 2016 Survey.

Species	Date: August 2, 2016				Time: 13:00 – 18:30				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	1	2	8	2	0	0	1	0	0	0	0	1	**1.3**
BLSC	0	0	0	0	0	0	0	0	1	0	0	0	**0.1**
COEI	1	1	2	1	1	1	1	2	2	2	3	0	**1.4**
COLO	0	0	0	0	1	0	0	0	0	0	0	0	**0.1**
DCCO	0	1	3	3	3	4	2	1	3	1	2	4	**2.3**
GBBG	3	4	3	3	2	2	2	2	3	1	1	2	**2.3**
GRCO	3	1	3	3	3	3	2	2	2	1	2	3	**2.3**
HEGU	20	13	10	15	5	4	1	1	4	3	2	4	**6.8**
LBBG	0	0	0	0	0	1	0	0	0	0	0	0	**0.1**
LEYE	0	0	0	0	0	0	0	0	0	0	0	3	**0.3**
RBGU	0	0	0	0	4	4	3	3	3	7	6	6	**3.0**
SPSA	2	0	0	0	0	0	0	0	0	0	0	0	**0.2**

Table 2. Seabird and waterfowl abundance, shore-based observations – September 1, 2016 Survey.

Species	Date: September 1, 2016				Time: 13:15 – 18:45				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
DCCO	8	8	14	17	11	12	14	11	8	5	10	8	10.5
GRCO	3	4	4	0	2	1	1	4	5	12	14	21	5.9
HEGU	6	9	3	1	6	2	0	5	3	1	0	1	3.1
RBGU	1	1	0	0	6	12	3	1	2	0	0	0	2.2
WISP	0	0	0	0	4	0	0	0	0	0	0	0	0.3

Table 3. Seabird and waterfowl abundance, shore-based observations – October 1, 2016 Survey.

Species	Date: October 1, 2016				Time: 11:30 – 17:05				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLDU	0	0	0	0	0	0	4	0	0	0	0	0	0.3
BLSC	0	2	9	0	0	0	0	0	0	0	0	0	0.9
CAGO	0	0	1	0	0	0	0	0	0	0	0	0	0.1
COLO	0	2	1	1	1	1	1	1	1	1	1	1	1.0
DCCO	1	2	0	1	0	0	1	2	0	0	2	1	0.8
GBBG	0	0	0	0	0	0	0	0	0	0	0	1	0.1
GRCO	1	1	2	0	1	0	0	1	2	2	1	1	1.0
HEGU	1	3	2	7	0	0	3	0	31	0	1	5	4.4
PEFA	0	0	0	0	0	0	0	0	0	0	0	1	0.1
RBGU	1	2	0	0	0	0	0	0	1	1	3	0	0.7
RBME	0	0	0	0	0	0	0	0	0	1	0	0	0.1
RTLO	1	0	0	0	0	0	0	0	0	0	0	0	0.1

Table 4. Seabird and waterfowl abundance, shore-based observations – October 17, 2016 Survey.

Species	Date: October 17, 2016				Time: 11:45 – 17:15				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLSC	6	0	0	0	0	0	0	0	0	0	0	0	0.5
COEI	0	0	0	0	0	0	1	0	2	2	2	2	0.8
COLO	0	0	0	0	0	0	0	1	0	0	0	0	0.1
DCCO	0	0	0	0	0	0	0	0	0	0	0	1	0.1
GBBG	0	1	0	0	0	0	0	0	0	0	0	1	0.2
GRCO	0	0	1	0	1	2	2	2	2	2	0	0	1.0
HEGU	0	1	2	1	0	0	0	3	0	0	7	7	1.8
RBGU	0	1	0	0	0	0	0	0	0	0	0	0	0.1
WWSC	0	0	0	0	0	0	0	1	0	0	0	0	0.1

Table 5. Seabird and waterfowl abundance, shore-based observations – November 3, 2016 Survey.

Species	Date: November 3, 2016				Time: 12:15 – 17:45				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLSC	20	0	0	7	15	0	15	0	97	17	0	21	16.0
COEI	0	0	0	0	0	0	0	1	0	0	0	0	0.1
COLO	0	0	0	0	0	0	0	1	0	0	0	0	0.1
GBBG	0	0	0	0	0	0	0	0	0	0	0	1	0.1
HEGU	2	0	0	0	2	0	0	0	2	4	41	13	5.3
ICGU	0	0	0	0	0	0	0	0	0	0	1	0	0.1
LTDU	0	0	0	0	0	0	5	0	0	0	0	0	0.4
ATPU	0	0	0	0	0	0	0	0	0	0	1	0	0.1
RAZO	0	0	0	0	0	0	0	1	0	0	0	0	0.1
RTLO	0	3	3	2	0	1	0	0	1	1	1	0	1.0
SUSC	0	0	0	0	0	0	0	0	0	12	0	0	1.0

Table 6. Comparison of average number of individual sea- and shorebird species observed from the FORCE Visitor Center per 30-minute interval. August 2, September 1, October 1 & 17, November 3, 2016.

Species	August 2	September 1	October 1	October 17	November 3
BLDU	0	0	0.3	0	0
BLSC	0.1	0	0.9	0.5	16.0
CAGO	0	0	0.1	0	0
COEI	1.4	0	0	0.8	0.1
COLO	0.1	0	1.0	0.1	0.1
DCCO	2.3	10.5	0.8	0.1	0
GBBG	2.3	0	0.1	0.2	0.1
GRCO	2.3	5.9	1.0	1.0	0
HEGU	6.8	3.1	4.4	1.8	5.3
ICGU	0	0	0	0	0.1
LBBG	0.1	0	0	0	0
LEYE	0.3	0	0	0	0
LTDU	0	0	0	0	0.4
PEFA	0	0	0.1	0	0
ATPU	0	0	0	0	0.1
RAZO	0	0	0	0	0.1
RBGU	3.0	0	0	0	0
RBGU	0	2.2	0.7	0.1	0
RBME	0	0	0.1	0	0
RTLO	0	0	0.1	0	1.0
SPSA	0.2	0	0	0	0
SUSC	0	0	0	0	1.0
WISP	0	0.3	0	0	0
WWSC	0	0	0	0.1	0

Table 7. Comparison of species list of marine mammals and seabirds at Fundy Tidal Power Demonstration Site, from shore based observations, 2010, 2011 & 2016.

	2010 May, June, October, November	**2011** March, April, December	**2016** May – November
ABDU	✓	✓	
Alcid sp		✓	
ATPU	✓		✓
BLGU	✓	✓	✓
BLKI	✓	✓	
BLSC	✓	✓	✓
CAGO	✓	✓	✓
COEI	✓	✓	✓
COGO		✓	
COLO	✓	✓	✓
COME	✓		
COMU	✓	✓	
DCCO	✓	✓	✓
GBBG	✓	✓	✓
GRCO	✓	✓	✓
HADU	✓		
HEGU	✓	✓	✓
HOGR	✓		
ICGU	✓		✓
KIEI		✓	
LAGU	✓		
LBBG	✓	✓	✓
LEYE			✓
LTDU	✓	✓	✓
MALL	✓		
MEGU	✓		
NOGA	✓	✓	
NSHO		✓	
PALO	✓	✓	
RAZO	✓	✓	✓
RBGU	✓	✓	✓
RBME	✓	✓	✓
RNGR	✓		
RTLO	✓	✓	✓
SCSP		✓	
SPSA			✓
SUSC	✓	✓	✓
TBMU	✓	✓	
WISP			✓
WWSC	✓	✓	✓
TOTAL	33	28	22

Table 8. Seabirds observed at Fundy Tidal Power Demonstration Site, 2016, in shore-based surveys.

Species Code	Common Name	Scientific Name
WATERFOWL		
BLSC	Black Scoter	Melanitta americana
SUSC	Surf Scoter	Melanitta perspicillata
WWSC	White-winged Scoter	Melanitta deglandi
CAGO	Canada Goose	Branta canadensis
LTDU	Long-tail Duck	Clangula hyemalis
RBME	Red-breasted Merganser	Mergus serrator
RTLO	Red-throated Loon	Gavia stellata
COLO	Common Loon	*Gavia immer*
COEI	Common Eider	*Somateria mollissima*
SEABIRDS		
DCCO	Double-crested Cormorant	Phalacrocorax auritus
GRCO	Great Cormorant	*Phalacrocorax carbo*
GBBG	Great Black-backed Gull	*Larus marinus*
HEGU	Herring Gull	*Larus argentatus*
LBBG	Lesser Black-backed Gull	Larus fuscus
RBGU	Ring-billed Gull	Larus delawarensis
ICGU	Iceland Gull	*Larus glaucoides*
BLGU	Black Guillemot	*Cepphus grylle*
RAZO	Razorbill	*Alca torda*
ATPU	Atlantic Puffin	*Fratercula*
WISP	Wilson's Storm Petrel	*Oceanites oceanicus*
SHOREBIRDS		
LEYE	Lesser Yellowlegs	*Tringa flavipes*
SPSA	Spotted Sandpiper	*Actitis macularius*

Table 9. Marine mammal observations during shore-based seabird and marine mammal surveys, Fundy Tidal Power Demonstration Site. August 2, September 1, October 1 & 17, November 3, 2016.

Date	Time (ADT)	Survey Component	Location Sighted	Species	Number
August 2, 2016	14:00	Shore	Crown Lease Area (CL)	Harbour Porpoise	1
September 1, 2016	14:50	Shore	Crown Lease Area (CL) towards FF1	Harbour Porpoise	4
October 1, 2016	14:07 – 14:10 – 14:11	Shore	IB1 into OB1 through CL into IB2	Harbour Porpoise	2
	14:10 – 14:11	Shore	OB3	Harbour Porpoise	1
	14:28 – 14:31; 14:32 – 14:39	Shore	IB1 near northeast corner of CL, into IB2; West through IB2	Harbour Porpoise	4 & 5

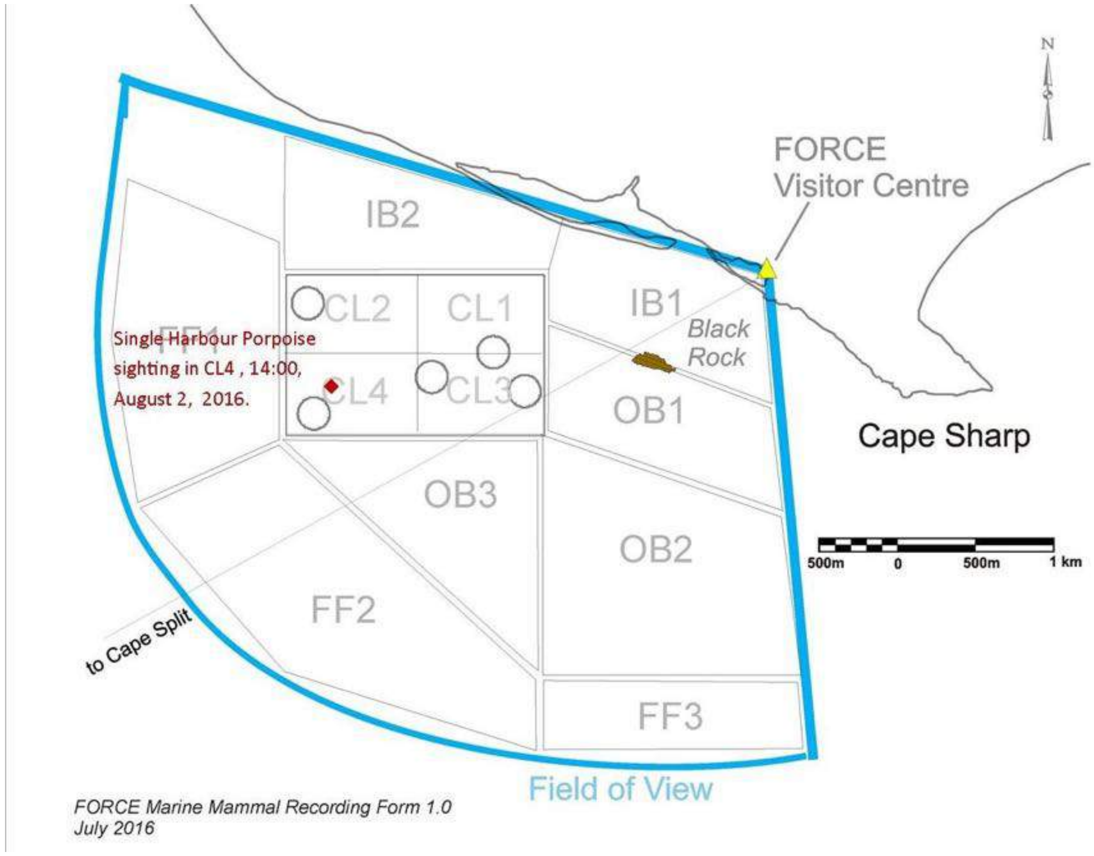

Figure 3. Depiction of a single Harbour Porpoise sighting on August 2, 2016 from the FORCE Visitor Center outdoor observation deck.

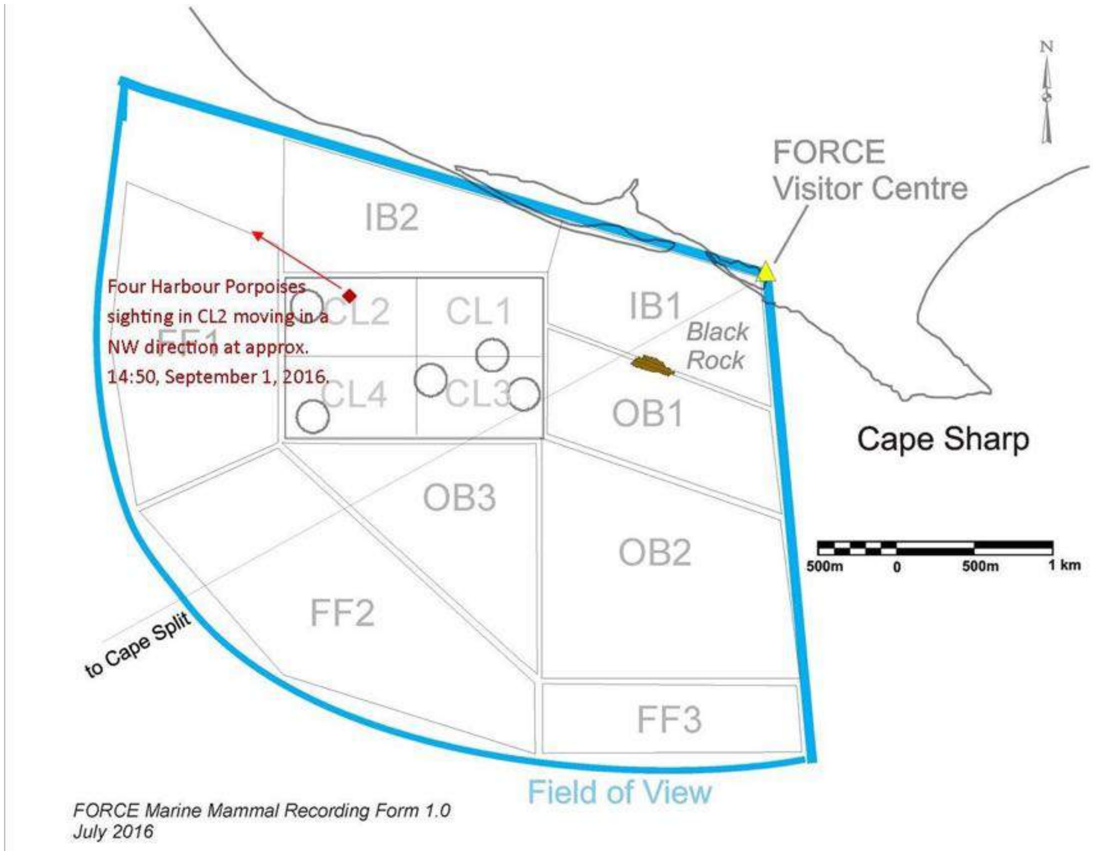

Figure 4. Depiction of Harbour Porpoise sightings on September 1, 2016 from the FORCE Visitor Center outdoor observation deck.

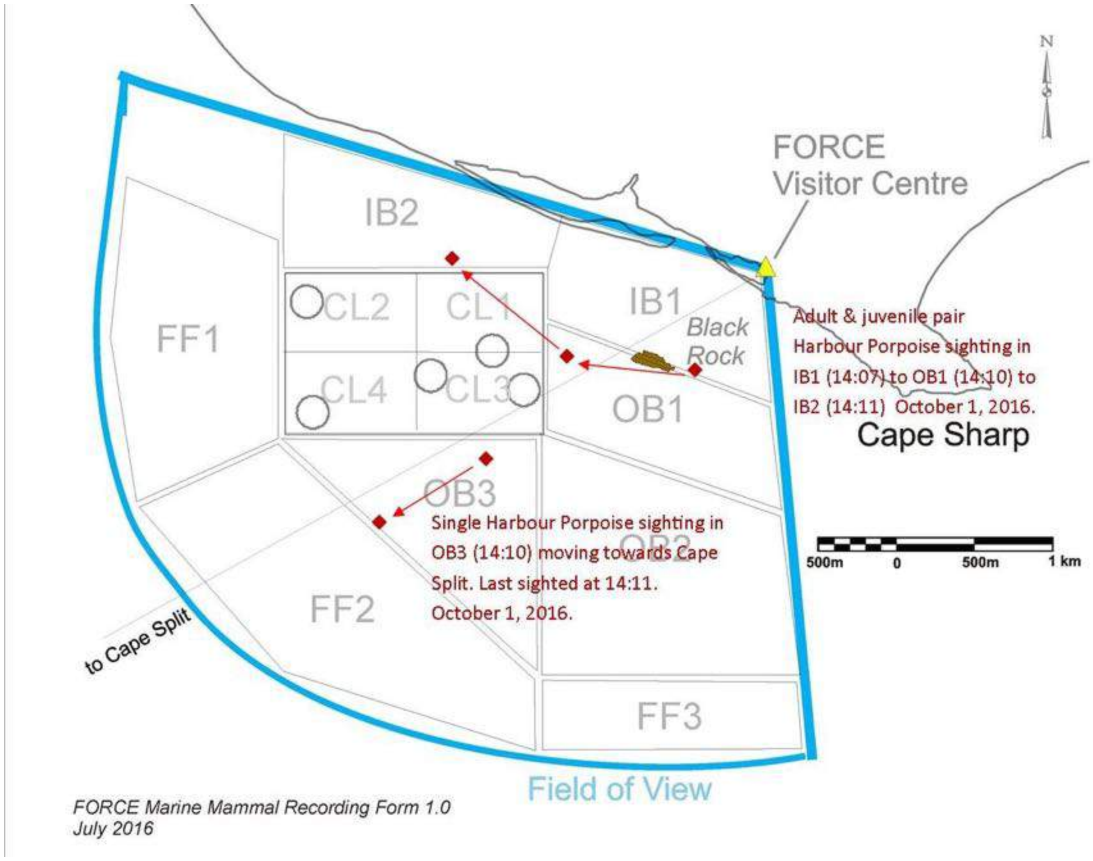

Figure 5. Depiction of first Harbour Porpoise sightings on October 1, 2016 from the FORCE Visitor Center outdoor observation deck.

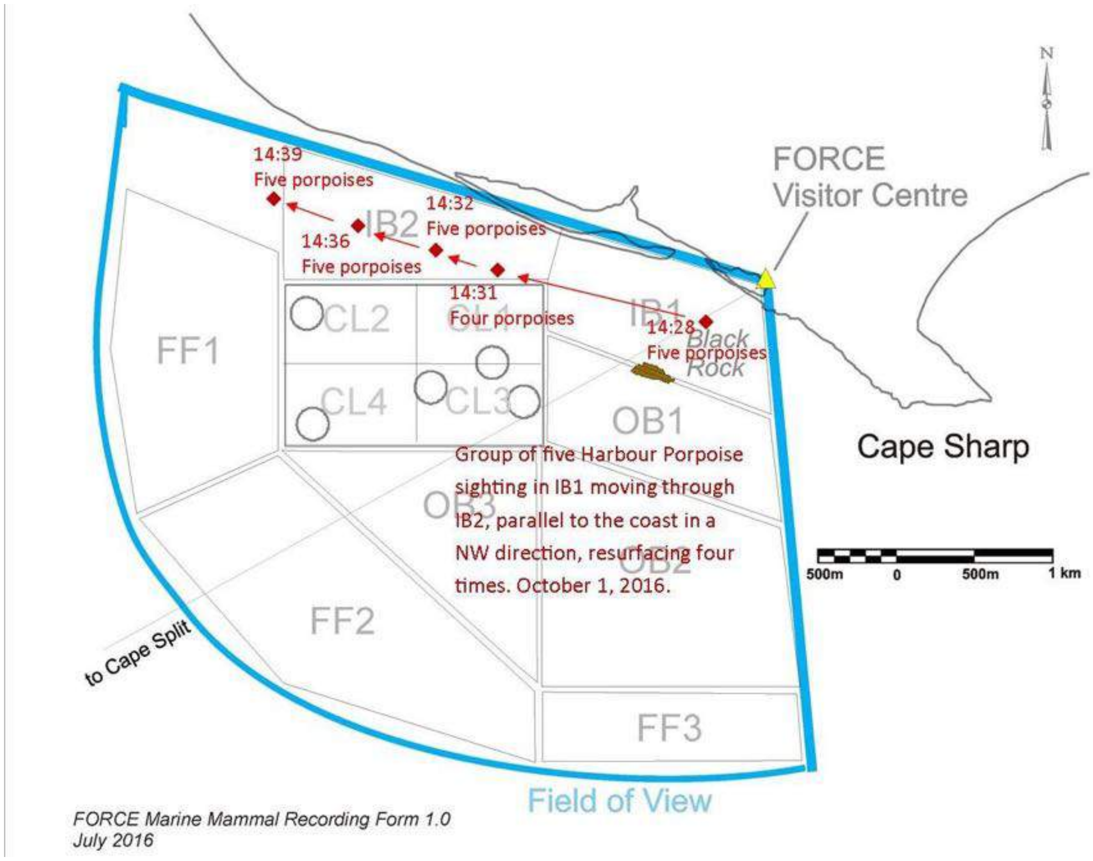

Figure 6. Depiction of second Harbour Porpoise sightings on October 1, 2016 from the FORCE Visitor Center outdoor observation deck.

APPENDIX

OBSERVATIONS FROM MAY 6, JUNE 2, JULY 2, 2016

Table 1. Seabird and waterfowl abundance, shore-based observations – May 6, 2016 Survey.

Species	Date: May 6, 2016			Time: 12:30 – 6:30				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.											
	Number of Individuals Sighted per Observation Period											
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	0	0	1	1	1	2	0	0	0	1	0	0	0.5
BLSC	0	0	0	0	0	2	0	0	0	1	0	0	0.25
COEI	0	0	2	2	5	5	1	0	1	0	0	0	1.3
COLO	0	0	1	0	0	0	0	0	0	0	0	0	0.08
DCCO	4	5	5	4	4	2	4	5	4	0	6	0	3.2
GBBG	21	20	21	23	23	20	20	20	20	16	1	0	17.1
GRCO	2	0	2	3	0	3	3	5	4	4	0	0	2.2
HEGU	4	5	3	8	7	8	11	5	4	12	7	0	6.2
LBBG	0	0	0	0	1	0	0	0	0	0	0	0	0.08
RTLO	1	6	1	0	0	0	0	0	0	2	0	0	0.8

Table 2. Seabird and waterfowl abundance, shore-based observations – June 2, 2016 Survey.

Species	Date: June 2, 2016			Time: 12:00 – 18:15				Observer: Fulton Lavender				
	Location: FORCE Visitor Center observation deck facing water, Parrsboro Nova Scotia.											
	Number of Individuals Sighted per Observation Period											
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	2	1	0	1	3	0	0	0	0	1	0	0	0.7
COEI	2	0	1	8	6	3	0	6	3	4	4	4	3.4
COLO	0	0	0	0	0	0	1	0	0	0	1	1	0.3
DCCO	6	2	2	2	3	0	2	7	4	9	9	5	4.3
GBBG	34	21	17	24	18	13	22	18	16	15	17	16	19
GRCO	0	0	0	0	1	1	1	1	2	1	1	1	0.8
HEGU	14	20	23	20	21	14	13	5	1	9	7	9	13
LBBG	0	0	0	0	0	1	0	0	0	0	0	1	0.2
RBGU	0	0	0	0	0	0	0	0	0	0	0	1	0.1
RTLO	0	0	0	0	0	1	0	0	0	0	0	1	0.2

Table 3. Seabird and waterfowl abundance, shore-based observations – July 2, 2016 Survey.

Species	Date: July 2, 2016				Time: 11:20 – 17:20				Observer: Fulton Lavender				
	Location: FORCE Visitor Center observation deck facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per 30-minute Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	5	2	4	2	1	2	0	0	1	1	0	3	1.8
COEI	0	0	1	3	0	3	4	2	2	3	4	6	2.3
COLO	0	0	1	0	0	1	0	0	0	0	0	0	0.2
DCCO	1	3	1	1	0	1	0	2	3	4	3	3	1.8
GBBG	11	13	3	7	6	9	8	7	5	9	8	8	7.8
GRCO	0	0	0	0	0	0	0	0	2	0	0	0	0.2
HEGU	5	4	5	6	5	4	2	10	4	3	2	4	4.5
RTLO	1	0	0	0	0	0	0	0	0	0	0	0	0.1

Table 7. Marine mammal observations during shore-based seabird and marine mammal surveys, Fundy Tidal Power Demonstration Site, May 6, June 2, July 2, 2016.

Date	Time (ADT)	Survey Component	Location Sighted	Species	Number
May 6, 2016	15:12-15:42	Shore	Turbine Area (CL) into Farfield Area (FF)	Harbour Porpoise	2
June 2, 2016	17:00-17:30	Shore	Inside Black Rock	Harbour Porpoise	1
July 2, 2016	12:08-12:10	Shore	Outside Black Rock (OB1-2) into Turbine Area (CL)	Harbour Porpoise	2
	12:20-12:50	Shore	Inside Black Rock (IB2)	Harbour Porpoise	1

Appendix 5: Seabirds Environmental Effects Monitoring Plan Interim Report 3

Interim report summarizing results from seabird surveys from November 2016 – February 2017. Prepared by Envirosphere Consultants Limited.

THIRD QUARTERLY SHORE-BASED SEABIRD AND MARINE MAMMAL SURVEY – TIDAL ENERGY DEMONSTRATION SITE, FUNDY OCEAN RESEARCH CENTER FOR ENERGY: NOVEMBER 17 2016; DECEMBER 1 2016; JANUARY 16 2017; FEBRUARY 21 2017

24 February 2017 – *Revised*

Prepared for:

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EXECUTIVE SUMMARY

Monthly shore-based surveys for marine birds began at the FORCE Visitor Center in the spring of 2016 during early to mid-breeding season. Beginning in October and ending in December, survey frequency was increased to twice monthly in order to capture the migratory period. Surveys took place on May 6, June 2 and July 2, 2016 over a six-hour period in half hour increments on the out-going tide, beginning at high tide and concluding at low tide. Observations were summarized in an initial quarterly report dated July 22, 2016. Subsequent surveys took place on August 2, September 1, October 1 & 17, and November 3, 2016 during the late and post-breeding/moulting and migration season. These observations were reported in a second quarterly report submitted to FORCE on November 21, 2016.

Surveys presented in the following report were completed on November 17, 2016, December 1, 2016, January 16, 2017, and February 21, 2017, for a total of twelve shore-based surveys completed to date. Low to moderate abundances of seabirds were observed, lowest in November (113 individuals) and highest in January (558 individuals, primarily Herring and Great Black-backed Gulls), with a total of 17 seabird species observed. Individual harbour porpoises were observed during the November 17th 2016 and January 16th 2017 surveys. As well, a harbour seal was observed resting on Black Rock during the January 17th 2017 survey. Overall the number of birds observed at the site is lower than expected, based on earlier baseline surveys, and reflects the broader pattern of bird abundance not connected with activity at the FORCE site. A report will be submitted in the spring of 2017 providing a comprehensive analysis of the year-long seabird monitoring program according to the proposed schedule.

Due to poor weather condition, a second December survey (scheduled for December 15, 2016) was cancelled. In January, survey frequency returned to once monthly. Field observations and species identifications are conducted by a professional bird observer, Fulton Lavender of Halifax Nova Scotia, and documented by Valerie Kendall (M.Env.Sc., Project Biologist). Observations are made in the same general way as earlier surveys (2010-2012)[1], but using a grid system adopted for the present surveys. Waters are surveyed from the interpretive center to mid-Minas Passage within the field of view, which includes the waters across Minas Passage from the site and down the shore into Minas Channel, as well as covering the area towards Cape Split and therefore covering the area designated for turbine installation[2]. Observations are made with a 22x Celestron spotting scope as well as 8x and 10x binoculars (Figures 1 and 2).

Seasonal timing of observations have been scheduled so that critical times for birds, in particular for migrating birds, are adequately represented in the data as much as possible. Abundance of water-associated birds (loons, cormorants, waterfowl, gulls, alcids) at the Minas Passage site in past showed seasonal peaks corresponding to migratory movements (March-April and October-November) and a late

[1] Observations from 2011 onward were made from the outdoor observation deck or inside the FORCE Visitor Center. Although this location is about 150 m from shore, the view was satisfactory when the spotting scope and binoculars were used, and the site provided a better overview of the site.

[2] The Cape Sharp Tidal Development turbine was installed on November 7, 2016. Observations documented in the current survey include both pre- and post-installation.

spring to early summer occupation of the area by local resident breeders such as Black Guillemot, Common Eider, Double-Crested Cormorant, and Herring and Great Black-backed Gulls (Envirosphere Consultants 2011-2013). There is a low summer abundance of local species, when migrants are not present and individuals of local breeding species such as gulls and cormorants move out of the area.

The observation team initially records separately all birds sitting or associated with the water in the survey subdivisions, including on Black Rock (Figure 1). Following this, a flying 'snapshot' is carried out to record all birds in flight observed throughout the subdivisions. The remainder of the 30-minute interval is used to record additional birds flying into the area or on the water. Birds observed in the vicinity of Black Rock and also in the Crown Lease Area ("critical area") are highlighted. A summary of bird and marine mammal observations to date are presented in Tables 1-8. Weather information and environmental data was also recorded from the weather station operating at the FORCE facility.

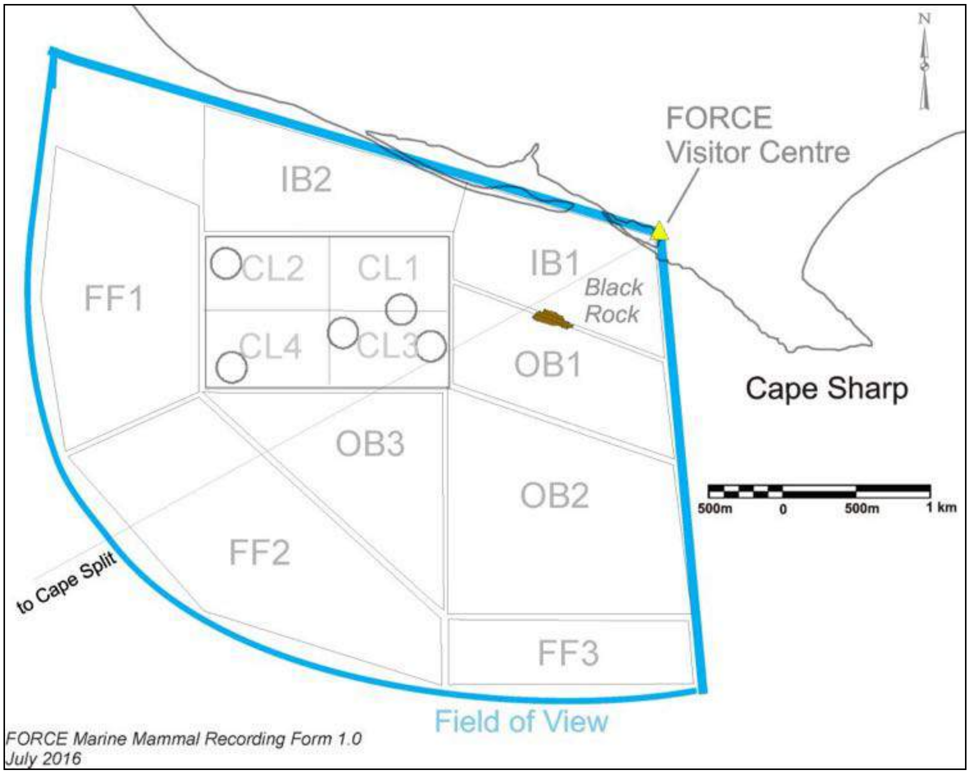

Figure 1. Study area field of view with grid showing open water subdivisions to document marine bird and mammal occurrences. (CL1-4 = turbine field/crown lease area; IB1-2 = Nearshore area/Inside Black Rock; OB1-3 Buffer area/outside Black Rock; FF1-3 Far-field buffer area.

Figure 2. A view of Minas Passage during a marine bird survey on January 16, 2017.

SUMMARY OF SURVEYS

November 17, 2016 – Valerie Kendall and Fulton Lavender arrived at the FORCE Visitor Center at 11:45 am and began the survey at 12:00 pm. The temperature was steady at about 11°C for the duration of the survey with an overcast sky. Winds were low and primarily from the west, shifting to southerly at the time of the final survey. Peak high tide was at 14:25. The survey was completed at 17:10 once daylight had ended.

A total of 12 bird species were observed during the survey including an Arctic Loon and Atlantic Puffin, both flying west through the CL subsection during the 14:30 survey segment; and Common Loon was also observed flying east through the CL subsection. Arctic Loon habitat in North America is along the Pacific coast, primarily Alaska. Over-wintering habitat in North America is not well documented, however observation of birds in Mexico and California indicate a preference for sheltered bays with calm water. The presence of a vagrant Arctic Loon in the Minas Basin is unusual and has not previously been documented (Fulton Lavender, pers comm 2016; Birds of North America, Online 2017).

Red-throated Loon was the most abundant bird, observed flying west through the Minas Passage, outside Black Rock and through the CL subsection. Over 60 loons were counted, attributed to migratory behavior of the species, which overwinters in coastal and estuary areas in Nova Scotia and further south along the Atlantic coastb. Other species in smaller abundances observed flying through the CL subsection included Black Scoter (4), Long-tailed Duck (3), Common Murre (8) and Red-necked Grebe (1). Common Eider were occasionally observed flying through IB1 and a single Razorbill was observed flying west through OB2. Small numbers of Herring Gull and Ring-billed Gull were observed throughout the survey circling or flying, generally west, in the CL and and IB1 subsections. Additionally, a single harbour porpoise was observed during the 13:30 – 14:00 survey segment in the OB1 subsection, west of Black Rock.

December 1 2016 – Valerie Kendall and Fulton Lavender arrived at the FORCE Visitor Center at 11:50 and began the survey at 12:30. Weather conditions were overcast with light rain on arrival that subsided by the survey start time; light fog remained throughout the day. The temperature increased throughout the day beginning at 3.7°C to reach 6.1°C by the final survey interval, which ended at 17:00. Visibility was poor by late afternoon (15:00) due to a fog bank from the south, allowing visibility to just beyond Black Rock (roughly one kilometer from shore). Winds were moderate and gusty, coming from an ESE direction, about 25 kph and causing rough water conditions (wavelets with white caps).

Bird abundance was low with no birds documented for five of the survey intervals. A single American Black Duck was observed during the 13:00 survey segment, and a single Herring Gull and a Great Black-back Gull were observed during two of the survey segments. During the final survey segment (16:30 – 15:00), 148 Herring Gulls, one Great Black-backed Gull and one Ring-billed Gull arrived and landed on Black Rock. Five Common Merganser were also observed flying east through IB1. A total of five bird species were observed. The survey concluded at 17:00 when daylight was ending.

December 15, 2016 – Upon arrival in Parrsboro, increasingly poor weather conditions prevented the survey from being completed as visibility of the survey site as well as travel conditions were unsuitable.

January 16, 2017 – Valerie Kendall and Fulton Lavender arrived at the FORCE Visitor Center at 11:30 and began the survey at 12:15. Cloud cover was sparse for the first hour of the survey, and became completely cloud covered for the remainder of the survey. Winds were light at about 30 kilometers per hour (kph) from the west, and the temperature ranged from about -4°C, at the survey start, to about -2°C at the survey end. Peak high tide was at 15:25.

Bird abundance was low during the first half of the survey. Six, and then eight, Common Goldeneye were present on the water close to shore in IB1. Black Duck (3), Common Eider (4), a Common Murre and a Common Loon were also observed flying through IB1 and the CL subsections. During the last two hours of the survey, a large number of Herring Gulls and Great Black-backed Gulls, and an Iceland Gull, flew in to land on Black Rock. By the completion of the survey, at 17:45, over 300 gulls were present on Black Rock. A total of eight bird species were observed. Additionally, a single harbor porpoise was observed at 13:09 swimming from the Crown Lease (CL) area into the OB1 subsection heading towards West Bay. It resurfaced at about 13:13 east of Black Rock in OB1. A harbour seal was also observed on the east end of Black Rock close to the water line at about 13:00. It remained until about 14:30 when the water level of the incoming tide submerged its resting place and the seal swam away.

February 21, 2017 – Valerie Kendall and Fulton Lavender arrived at the FORCE Visitor Center at 11:15 and began the marine bird survey at 12:00. Weather conditions were sunny with a clear sky, light winds and a temperature of about zero degrees Celsius. Peak high tide was at 8:23 and low tide at 14:42.

Bird abundance was low for the duration of the survey with a total of six species observed including a single Common Loon, a single Red-throated Loon, and three Great Cormorant, which were observed flying east through the CL subsection. Five Common Goldeneye were present on the water from the start of the survey until the end of the 14:00 survey segment, diving and feeding, near the shore in IB1. Single Herring Gulls were occasionally observed through the afternoon circling outside Black Rock and began to increase in number, along with Great Black-backed Gulls during the last three half-hour survey segments as they arrived to land on Black Rock. At the completion of the survey (18:00), 41 Herring Gulls and 58 Great Black-back Gulls were present on Black Rock.

TABLES

Table 1. Seabird and waterfowl abundance, shore-based observations – November 17, 2016 Survey.

Species	Date: November 17, 2016				Time: 12:00 – 17:00				Observer: Fulton Lavender			
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.											
	Number of Individuals Sighted per Observation Period											
	1	2	3	4	5	6	7	8	9	10	11	**Average**
ARLO	0	0	0	0	0	1	0	0	0	0	0	0.1
ATPU	0	0	0	0	0	1	0	0	0	0	0	0.1
BLSC	2	0	0	3	0	0	0	0	0	0	0	0.5
COEI	0	2	0	0	0	0	0	0	0	5	0	0.6
COLO	0	1	0	0	0	0	0	0	0	0	0	0.1
COMU	8	0	0	0	0	0	0	0	0	0	0	0.7
HEGU	2	1	2	0	0	0	1	1	0	1	5	1.2
LTDU	0	0	0	0	0	3	0	0	0	0	0	0.3
RAZO	0	0	0	0	0	1	0	0	0	0	0	0.1
RBGU	0	0	2	0	1	0	0	0	2	0	0	0.5
RNGR	0	0	0	0	0	0	0	1	0	0	0	0.1
RTLO	1	1	1	0	50	8	4	2	0	0	0	6.1

Table 2. Seabird and waterfowl abundance, shore-based observations – December 1, 2016 Survey.

Species	Date: December 1, 2016				Time: 12:30 – 16:30			Observer: Fulton Lavender		
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.									
	Number of Individuals Sighted per Observation Period									
	1	2	3	4	5	6	7	8	9	Average
ABDU	0	2	0	0	0	0	0	0	0	0.2
COME	0	0	0	0	0	0	0	0	5	0.4
GBBG	0	0	1	0	0	0	0	0	1	0.2
HEGU	0	0	1	0	0	0	0	2	148	12.6
RBGU	0	0	0	0	0	0	0	0	1	0.1

Table 3. Seabird and waterfowl abundance, shore-based observations – January 16, 2017 Survey.

Species	Date: January 16, 2017				Time: 12:15 – 16:45			Observer: Fulton Lavender			
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.										
	Number of Individuals Sighted per Observation Period										
	1	2	3	4	5	6	7	8	9	10	**Average**
ABDU	3	0	0	0	0	0	0	0	0	0	0.3
COEI	0	0	4	0	0	0	0	0	0	0	0.4
COGO	6	6	8	0	0	0	0	0	0	0	2
COLO	0	1	0	0	0	1	0	0	0	0	0.2
COMU	0	0	1	0	0	0	0	0	0	0	0.1
GBBG	0	0	0	0	0	0	31	63	71	110	27.5
HEGU	4	0	0	0	0	0	1	2	14	231	25.2
ICGU	0	0	0	0	0	0	0	1	0	0	0.1

Table 4. Seabird and waterfowl abundance, shore-based observations – February 21, 2017 Survey.

Species	Date: February 21, 2017				Time: 12:00 – 17:30				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
COLO	0	0	0	1	0	0	0	0	0	0	0	0	0.1
GBBG	0	0	0	0	0	0	0	0	1	7	8	42	4.8
COGO	5	5	5	5	5	0	0	0	0	1	0	0	2.2
GRCO	0	0	0	0	0	0	0	3	0	0	0	0	0.3
HEGU	1	0	0	0	0	0	1	1	2	22	2	12	3.4
RTLO	0	0	0	0	1	0	0	0	0	1	0	0	0.2

Table 5. Comparison of average number of individual sea- and shorebird species observed from the FORCE Visitor Center per 30-minute interval.
2016 –November 17 & December 1 | 2017 – January 16 & February 21

Species	Nov 17	Dec 1	Jan 16	Feb 21
ARLO	0.1	0	0	0
ATPU	0.1	0	0	0
ABDU	0	0.2	0.3	0
BLSC	0.5	0	0	0
CAGO	0	0	0	0
COEI	0.6	0	0.4	0
COGO	0	0	2	2.2
COLO	0.1	0	0.2	0.1
COMU	0.7	0.4	0.1	0
DCCO	0	0	0	0
GBBG	0	0.2	27.5	4.8
GRCO	0	0	0	0.3
HEGU	1.2	12.6	25.2	3.4
ICGU	0	0	0.1	0
LBBG	0	0	0	0
LEYE	0	0	0	0
LTDU	0.3	0	0	0
PEFA	0	0	0	0
RAZO	0.1	0	0	0
RBGU	0.5	0.1	0	0
RBGU	0	0	0	0
RBME	0	0	0	0
RNGR	0.1	0	0	0
RTLO	6.1	0	0	0.2
SPSA	0	0	0	0
SUSC	0	0	0	0
WISP	0	0	0	0
WWSC	0	0	0	0

Table 6. Comparison of species list of marine mammals and seabirds at Fundy Tidal Power Demonstration Site, from shore based observations, 2010, 2011 & 2016.

SPECIES	2010	2011	2016	2017
	MAY, JUNE, OCTOBER, NOVEMBER	MARCH, APRIL, DECEMBER	MAY – NOVEMBER	JANUARY - FEBRUARY
ARLO			✓	
ABDU	✓	✓		✓
Alcid sp		✓		
ATPU	✓		✓	
BLGU	✓	✓	✓	
BLKI	✓	✓		
BLSC	✓	✓	✓	
CAGO	✓	✓	✓	
COEI	✓	✓	✓	✓
COGO		✓		✓
COLO	✓	✓	✓	✓
COME	✓			
COMU	✓	✓	✓	✓
DCCO	✓	✓	✓	
GBBG	✓	✓	✓	✓
GRCO	✓	✓	✓	✓
HADU	✓			
HEGU	✓	✓	✓	✓
HOGR	✓			
ICGU	✓		✓	✓
KIEI		✓		
LAGU	✓			
LBBG	✓	✓	✓	
LEYE			✓	
LTDU	✓	✓	✓	
MALL	✓			
MEGU	✓			
NOGA	✓	✓		
NSHO		✓		
PALO	✓	✓		
RAZO	✓	✓	✓	
RBGU	✓	✓	✓	✓
RBME	✓	✓	✓	
RNGR	✓		✓	
RTLO	✓	✓	✓	✓
SCSP		✓		
SPSA			✓	
SUSC	✓	✓	✓	
TBMU	✓	✓		
WISP			✓	
WWSC	✓	✓	✓	
TOTAL # OF SPECIES	33	28	25	11

Table 7. Seabirds observed at Fundy Tidal Power Demonstration Site, 2016 - 2017 Shore-based Surveys.

Species Code	Common Name	Scientific Name
WATERFOWL		
BLSC	Black Scoter	*Melanitta americana*
ABDU	American Black Duck	*Anas rubripes*
CAGO	Canada Goose	*Branta canadensis*
COEI	Common Eider	*Somateria mollissima*
GOCO	Common Goldeneye	*Bucephala clangula*
COLO	Common Loon	*Gavia immer*
LTDU	Long-tail Duck	*Clangula hyemalis*
RBME	Red-breasted Merganser	*Mergus serrator*
RTLO	Red-throated Loon	*Gavia stellata*
SUSC	Surf Scoter	*Melanitta perspicillata*
WWSC	White-winged Scoter	*Melanitta deglandi*
SEABIRDS		
ARLO	Arctic Loon	*Gavia arctica*
ATPU	Atlantic Puffin	*Fratercula*
BLGU	Black Guillemot	*Cepphus grylle*
DCCO	Double-crested Cormorant	*Phalacrocorax auritus*
GBBG	Great Black-backed Gull	*Larus marinus*
GRCO	Great Cormorant	*Phalacrocorax carbo*
HEGU	Herring Gull	*Larus argentatus*
ICGU	Iceland Gull	*Larus glaucoides*
LBBG	Lesser Black-backed Gull	*Larus fuscus*
RAZO	Razorbill	*Alca torda*
RBGU	Ring-billed Gull	*Larus delawarensis*
WISP	Wilson's Storm Petrel	*Oceanites oceanicus*
SHOREBIRDS		
LEYE	Lesser Yellowlegs	*Tringa flavipes*
SPSA	Spotted Sandpiper	*Actitis macularius*

Table 8. Marine mammal observations during shore-based seabird and marine mammal surveys, Fundy Tidal Power Demonstration Site. August 2, September 1, October 1 & 17, November 3, 2016.

Date	Time (ADT)	Survey Component	Location Sighted	Species	Number
November 17, 2016	13:30 – 14:00	Shore	OB1	Harbour Porpoise	1
January 16, 2017	13:09 & 13:13	Shore	OB1; East of Black Rock	Harbour Porpoise	1
January 16, 2017	13:00 – 14:30	Shore	Black Rock	Harbour Seal	1

APPENDIX

Observations from May 6, June 2, July 2, 2016

Table 1. Seabird and waterfowl abundance, shore-based observations – May 6, 2016 Survey.

Species	Date: May 6, 2016				Time: 12:30 – 6:30				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	0	0	1	1	1	2	0	0	0	1	0	0	0.5
BLSC	0	0	0	0	0	2	0	0	0	1	0	0	0.25
COEI	0	0	2	2	5	5	1	0	1	0	0	0	1.3
COLO	0	0	1	0	0	0	0	0	0	0	0	0	0.08
DCCO	4	5	5	4	4	2	4	5	4	0	6	0	3.2
GBBG	21	20	21	23	23	20	20	20	20	16	1	0	17.1
GRCO	2	0	2	3	0	3	3	5	4	4	0	0	2.2
HEGU	4	5	3	8	7	8	11	5	4	12	7	0	6.2
LBBG	0	0	0	0	1	0	0	0	0	0	0	0	0.08
RTLO	1	6	1	0	0	0	0	0	0	2	0	0	0.8

Table 2. Seabird and waterfowl abundance, shore-based observations – June 2, 2016 Survey.

Species	Date: June 2, 2016				Time: 12:00 – 18:15				Observer: Fulton Lavender				
	Location: FORCE Visitor Center observation deck facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	2	1	0	1	3	0	0	0	0	1	0	0	0.7
COEI	2	0	1	8	6	3	0	6	3	4	4	4	3.4
COLO	0	0	0	0	0	0	1	0	0	0	1	1	0.3
DCCO	6	2	2	2	3	0	2	7	4	9	9	5	4.3
GBBG	34	21	17	24	18	13	22	18	16	15	17	16	19
GRCO	0	0	0	0	1	1	1	1	2	1	1	1	0.8
HEGU	14	20	23	20	21	14	13	5	1	9	7	9	13
LBBG	0	0	0	0	0	1	0	0	0	0	0	1	0.2
RBGU	0	0	0	0	0	0	0	0	0	0	0	1	0.1
RTLO	0	0	0	0	0	1	0	0	0	0	0	1	0.2

Table 3. Seabird and waterfowl abundance, shore-based observations – July 2, 2016 Survey.

Species	Date: July 2, 2016				Time: 11:20 – 17:20				Observer: Fulton Lavender				
	Location: FORCE Visitor Center observation deck facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per 30-minute Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	5	2	4	2	1	2	0	0	1	1	0	3	1.8
COEI	0	0	1	3	0	3	4	2	2	3	4	6	2.3
COLO	0	0	1	0	0	1	0	0	0	0	0	0	0.2
DCCO	1	3	1	1	0	1	0	2	3	4	3	3	1.8
GBBG	11	13	3	7	6	9	8	7	5	9	8	8	7.8
GRCO	0	0	0	0	0	0	0	0	2	0	0	0	0.2
HEGU	5	4	5	6	5	4	2	10	4	3	2	4	4.5
RTLO	1	0	0	0	0	0	0	0	0	0	0	0	0.1

Table 7. Marine mammal observations during shore-based seabird and marine mammal surveys, Fundy Tidal Power Demonstration Site, May 6, June 2, July 2, 2016.

Date	Time (ADT)	Survey Component	Location Sighted	Species	Number
May 6, 2016	15:12-15:42	Shore	Turbine Area (CL) into Farfield Area (FF)	Harbour Porpoise	2
June 2, 2016	17:00-17:30	Shore	Inside Black Rock	Harbour Porpoise	1
July 2, 2016	12:08-12:10	Shore	Outside Black Rock (OB1-2) into Turbine Area (CL)	Harbour Porpoise	2
	12:20-12:50	Shore	Inside Black Rock (IB2)	Harbour Porpoise	1

Observations from August 2, September 1, October 1 & 17, November 3, 2016

Table 9. Seabird and waterfowl abundance, shore-based observations – August 2, 2016 Survey.

Species	Date: August 2, 2016				Time: 13:00 – 18:30				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	1	2	8	2	0	0	1	0	0	0	0	1	**1.3**
BLSC	0	0	0	0	0	0	0	0	1	0	0	0	**0.1**
COEI	1	1	2	1	1	1	1	2	2	2	3	0	**1.4**
COLO	0	0	0	0	1	0	0	0	0	0	0	0	**0.1**
DCCO	0	1	3	3	3	4	2	1	3	1	2	4	**2.3**
GBBG	3	4	3	3	2	2	2	2	3	1	1	2	**2.3**
GRCO	3	1	3	3	3	3	2	2	2	1	2	3	**2.3**
HEGU	20	13	10	15	5	4	1	1	4	3	2	4	**6.8**
LBBG	0	0	0	0	0	1	0	0	0	0	0	0	**0.1**
LEYE	0	0	0	0	0	0	0	0	0	0	0	3	**0.3**
RBGU	0	0	0	0	4	4	3	3	3	7	6	6	**3.0**
SPSA	2	0	0	0	0	0	0	0	0	0	0	0	**0.2**

Table 10. Seabird and waterfowl abundance, shore-based observations – September 1, 2016 Survey.

Species	Date: September 1, 2016				Time: 13:15 – 18:45				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
DCCO	8	8	14	17	11	12	14	11	8	5	10	8	10.5
GRCO	3	4	4	0	2	1	1	4	5	12	14	21	5.9
HEGU	6	9	3	1	6	2	0	5	3	1	0	1	3.1
RBGU	1	1	0	0	6	12	3	1	2	0	0	0	2.2
WISP	0	0	0	0	4	0	0	0	0	0	0	0	0.3

Table 11. Seabird and waterfowl abundance, shore-based observations – October 1, 2016 Survey.

Species	Date: October 1, 2016				Time: 11:30 – 17:05				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLDU	0	0	0	0	0	0	4	0	0	0	0	0	0.3
BLSC	0	2	9	0	0	0	0	0	0	0	0	0	0.9
CAGO	0	0	1	0	0	0	0	0	0	0	0	0	0.1
COLO	0	2	1	1	1	1	1	1	1	1	1	1	1.0
DCCO	1	2	0	1	0	0	1	2	0	0	2	1	0.8
GBBG	0	0	0	0	0	0	0	0	0	0	0	1	0.1
GRCO	1	1	2	0	1	0	0	1	2	2	1	1	1.0
HEGU	1	3	2	7	0	0	3	0	31	0	1	5	4.4
PEFA	0	0	0	0	0	0	0	0	0	0	0	1	0.1
RBGU	1	2	0	0	0	0	0	0	1	1	3	0	0.7
RBME	0	0	0	0	0	0	0	0	0	1	0	0	0.1
RTLO	1	0	0	0	0	0	0	0	0	0	0	0	0.1

Table 12. Seabird and waterfowl abundance, shore-based observations – October 17, 2016 Survey.

Species	Date: October 17, 2016				Time: 11:45 – 17:15				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLSC	6	0	0	0	0	0	0	0	0	0	0	0	0.5
COEI	0	0	0	0	0	0	1	0	2	2	2	2	0.8
COLO	0	0	0	0	0	0	0	1	0	0	0	0	0.1
DCCO	0	0	0	0	0	0	0	0	0	0	0	1	0.1
GBBG	0	1	0	0	0	0	0	0	0	0	0	1	0.2
GRCO	0	0	1	0	1	2	2	2	2	2	0	0	1.0
HEGU	0	1	2	1	0	0	0	3	0	0	7	7	1.8
RBGU	0	1	0	0	0	0	0	0	0	0	0	0	0.1
WWSC	0	0	0	0	0	0	0	1	0	0	0	0	0.1

Table 13. Seabird and waterfowl abundance, shore-based observations – November 3, 2016 Survey.

Species	Date: November 3, 2016				Time: 12:15 – 17:45				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLSC	20	0	0	7	15	0	15	0	97	17	0	21	16.0
COEI	0	0	0	0	0	0	0	1	0	0	0	0	0.1
COLO	0	0	0	0	0	0	0	1	0	0	0	0	0.1
GBBG	0	0	0	0	0	0	0	0	0	0	0	1	0.1
HEGU	2	0	0	0	2	0	0	0	2	4	41	13	5.3
ICGU	0	0	0	0	0	0	0	0	0	0	1	0	0.1
LTDU	0	0	0	0	0	0	5	0	0	0	0	0	0.4
ATPU	0	0	0	0	0	0	0	0	0	0	1	0	0.1
RAZO	0	0	0	0	0	0	0	1	0	0	0	0	0.1
RTLO	0	3	3	2	0	1	0	0	1	1	1	0	1.0
SUSC	0	0	0	0	0	0	0	0	0	12	0	0	1.0

Table 14. Marine mammal observations during shore-based seabird and marine mammal surveys, Fundy Tidal Power Demonstration Site. August 2, September 1, October 1 & 17, November 3, 2016.

Date	Time (ADT)	Survey Component	Location Sighted	Species	Number
August 2, 2016	14:00	Shore	Crown Lease Area (CL)	Harbour Porpoise	1
September 1, 2016	14:50	Shore	Crown Lease Area (CL) towards FF1	Harbour Porpoise	4
October 1, 2016	14:07 – 14:10 – 14:11	Shore	IB1 into OB1 through CL into IB2	Harbour Porpoise	2
	14:10 – 14:11	Shore	OB3	Harbour Porpoise	1
	14:28 – 14:31; 14:32 – 14:39	Shore	IB1 near northeast corner of CL, into IB2; West through IB2	Harbour Porpoise	4 & 5

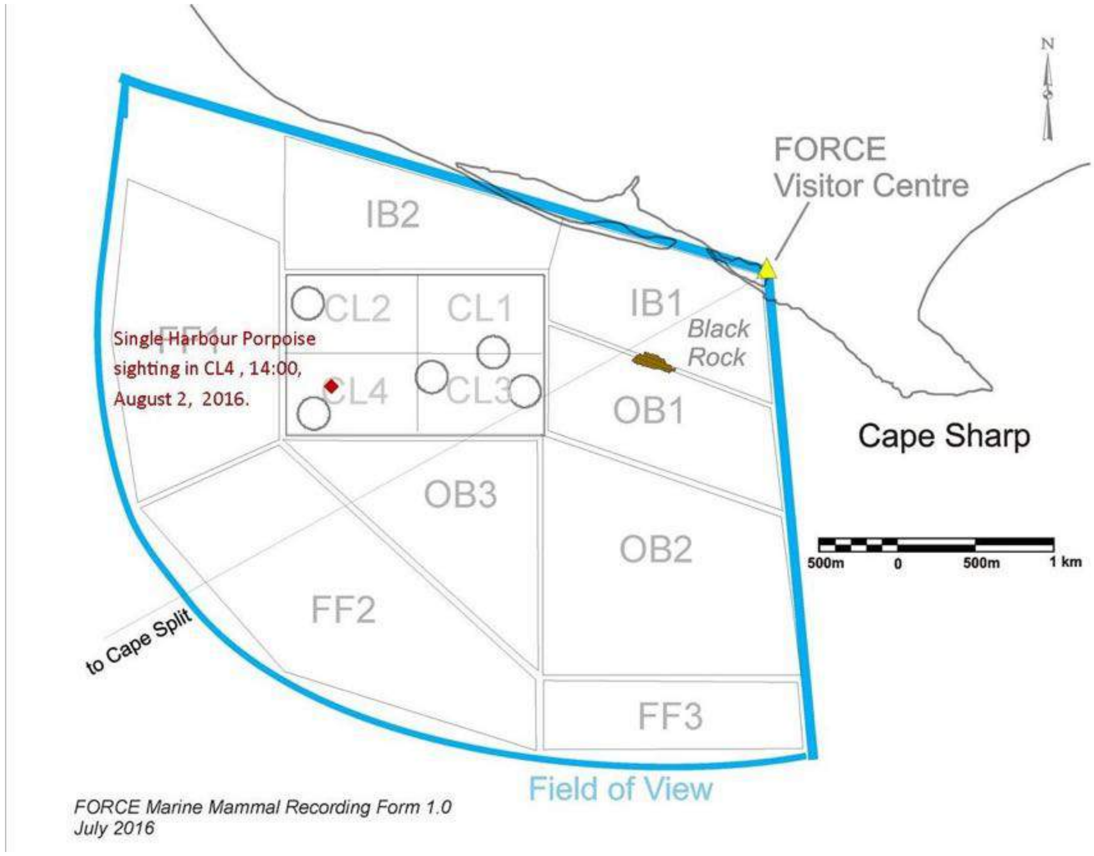

Figure 3. Depiction of a single Harbour Porpoise sighting on August 2, 2016 from the FORCE Visitor Center outdoor observation deck.

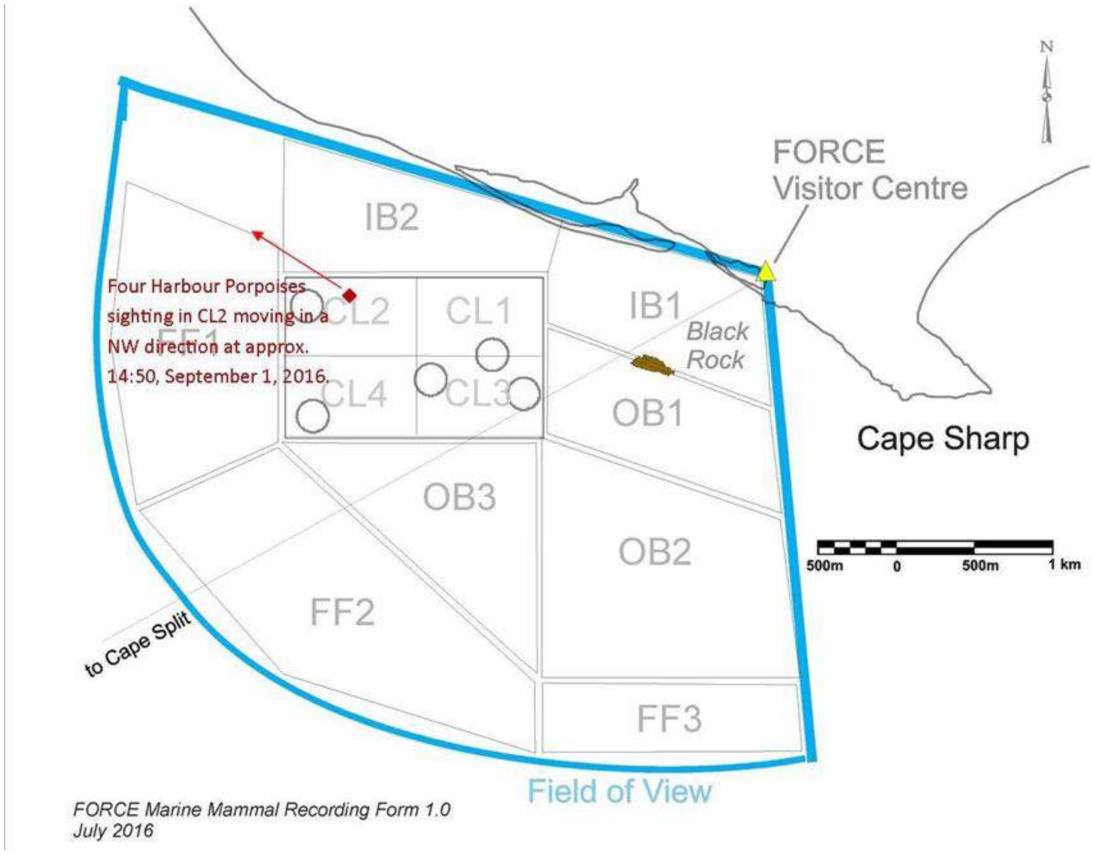

Figure 4. Depiction of Harbour Porpoise sightings on September 1, 2016 from the FORCE Visitor Center outdoor observation deck.

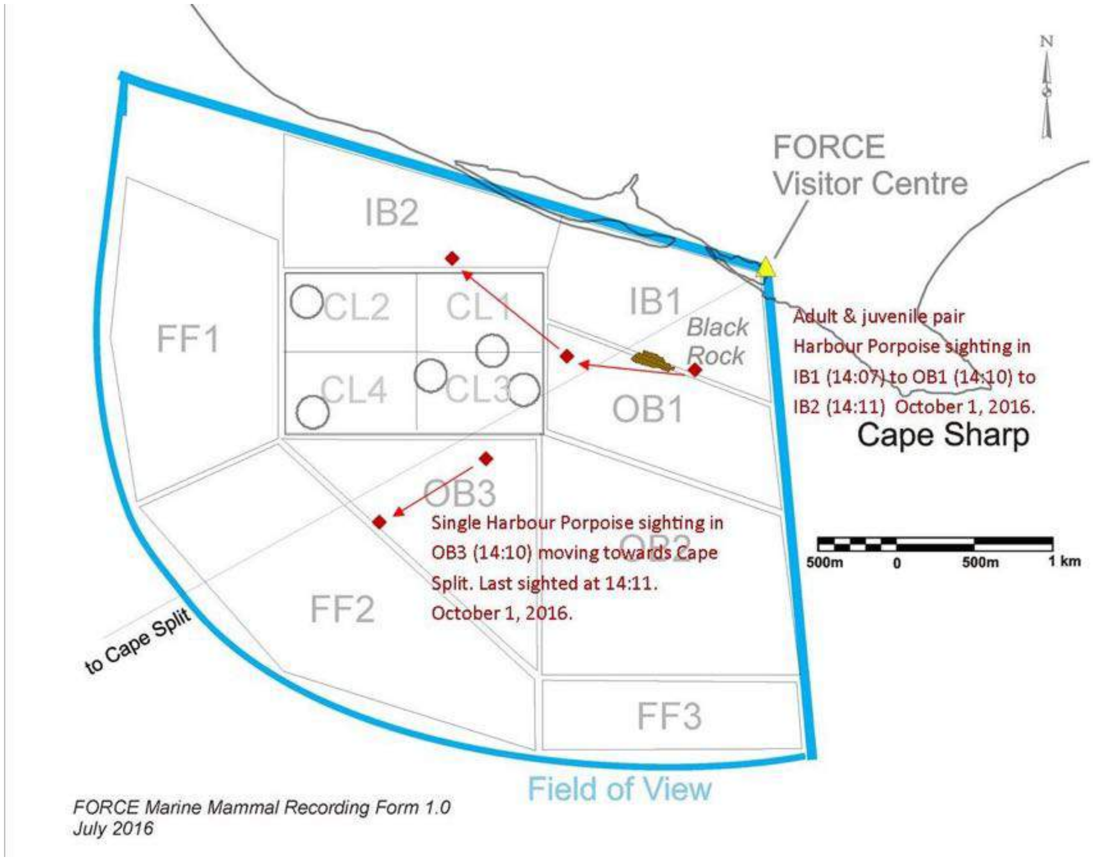

Figure 5. Depiction of first Harbour Porpoise sightings on October 1, 2016 from the FORCE Visitor Center outdoor observation deck.

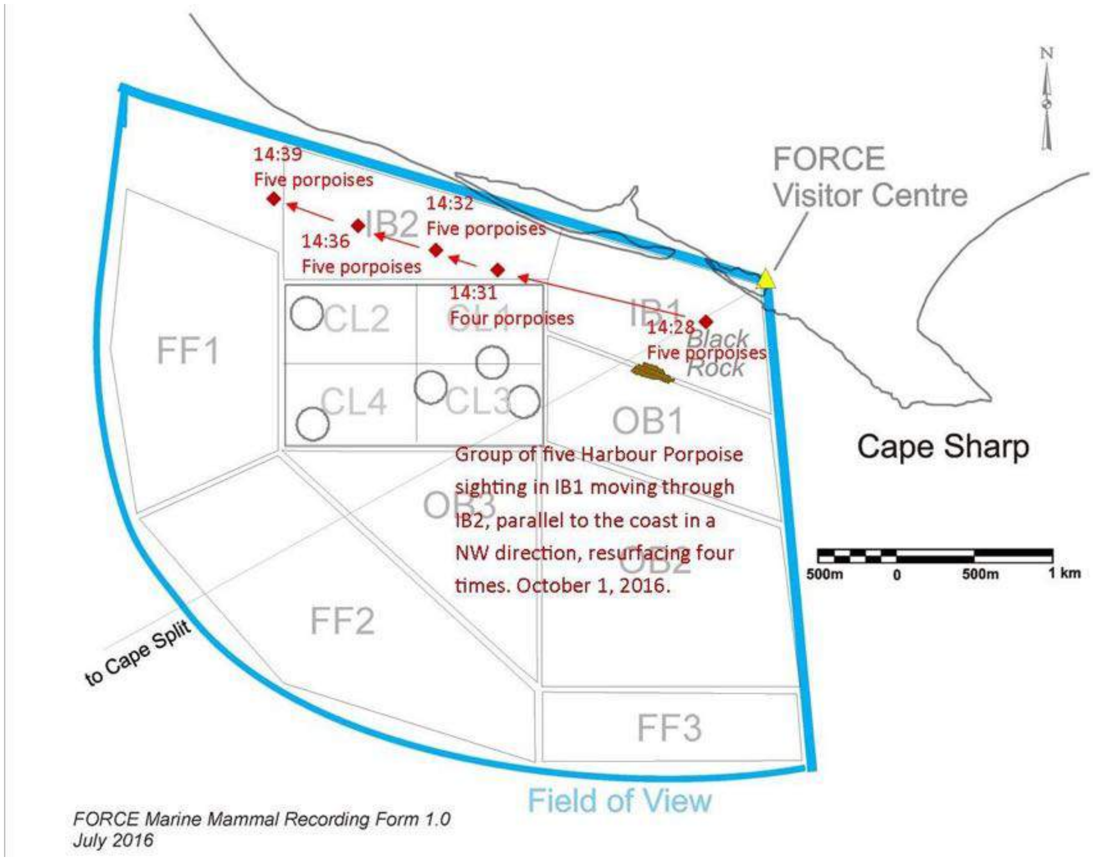

Figure 6. Depiction of second Harbour Porpoise sightings on October 1, 2016 from the FORCE Visitor Center outdoor observation deck.

Appendix 6: Environmental Monitoring Advisory Committee (EMAC)

EMAC membership includes:

- Gordon Beanlands, Ph.D., Retired, EMAC Chair
- Donald Aldous, Retired, Fisheries and Oceans Canada
- Sana Kavanagh, Nova Scotia Mi'kmaq Representative
- Graham Daborn, Ph.D., Emeritus Professor, AcadiaUniversity
- Andrew Hebda, M.Sc., Nova Scotia Museum
- Mike Stokesbury, Ph.D., Acadia University
- Mark Taylor, Fishers' Representative, President of Heavy Current Fishers Association
- Timothy Milligan, M.Sc., Emeritus Scientist, Bedford Institute of Oceanography
- Anna Metaxas, Ph.D, Dalhousie University
- John Tremblay, Ph.D., Scientist Emeritus, Bedford Institute of Oceanography, DFO

Additional information is available at: http://fundyforce.ca/about/advisory-committees/

Appendix 7: FAST-3 platform program: *Acoustic detection of fish presence and depth distribution at the FORCE tidal energy test site in the Bay of Fundy: assessing risk of interaction with tidal turbines*

FORCE has developed marine sensor platforms as part of the Fundy Advanced Sensor Technology (FAST) program to monitor physical and biological characteristics of the test site.

This acoustic detection project uses the FAST-3 platform, which houses two different fisheries sonars (a narrowband single beam and broadband split beam). Specifically, the platform includes an Acoustic Doppler Current Profiler (ADCP) and two echosounders: the ASL Acoustic Zooplankton and Fish Profiler (AZFP) and the Simrad Wideband Autonomous Transceiver (WBAT).

The platform will be deployed for one month at a time, several times per year. The general objectives of this two-year program are to:

- To assess the temporal patterns in fish presence and risk of fish-turbine interactions at the FORCE tidal energy site; and
- To evaluate different acoustic technologies for monitoring fish at the FORCE test site.

Data analysis will be completed by Dr. Haley Viehman, a post-doctoral researcher at Acadia Centre for Estuarine Research at Acadia University. Results from this work will provide a better understanding of the temporal variation in fish presence at the tidal energy site, the potential effects of tidal energy turbines on fish, and the development of best practices for effects monitoring of fish with active acoustics. This research will directly address the regulatory needs of this emerging renewable energy industry.

FAST-3 was deployed for the first time in February 2017 at a test location near the FORCE site. Results from this deployment helped identify the best sensor settings and operating schedule for future data collection at the FORCE demonstration site. The platform was redeployed within the FORCE test site in June 2017.

[VIDEO] Dr. Viehman explains the project: https://vimeo.com/210831742

Appendix 8: Marine Mammal Monitoring Poster

Marine Animal Public Reporting

fundyforce.ca/environment/marine-animal-reporting

As part of FORCE's environmental effects monitoring program, we are asking for your help.

Our monitoring program relies on the public reporting of any unusual marine life behaviour. This includes, but isn't limited to:

- a marine mammal stranding or in distress
- marine animal mortalities
- unusual concentrations or behaviour of seabirds

Animal in Distress/Mortality

If you see a marine animal in distress or wish to report a marine animal mortality, please contact the Marine Animal Response Society (MARS) toll-free hotline (1-866-567-6277).

Public Reporting

FORCE staff and volunteers also conduct an ongoing shoreline survey program. We welcome your participation: please contact facilities manager Mary McPhee at reporting@fundyforce.ca or 902-254-2510.

To report observations at any time, you can:

1. Use the online observation form (https://mmo.fundyforce.ca/)

OR

2. Send a paper copy of the Marine Mammal Report Form (fundyforce.ca/environment/marine-animal-reporting/) to reporting@fundyforce.ca

OR

3. Send the following info to reporting@fundyforce.ca:
   • Photos/videos (if possible)
   • A description of what you see
   • Note your location, weather conditions, time of day, etc.

Harbour porpoise

Information Sharing

All observations will be shared with Fisheries and Oceans Canada (DFO) and the Nova Scotia Department of Environment and the public via the FORCE website (personal information is confidential and for contact purposes only).

Learn more about FORCE's environmental programs at fundyforce.ca/environment/

Online app:
https://mmo.fundyforce.ca/

fundyforce.ca