ORPC
OCEAN RENEWABLE POWER COMPANY

COBSCOOK BAY TIDAL ENERGY PROJECT

2013 ENVIRONMENTAL MONITORING REPORT FINAL DRAFT

FERC PROJECT NO. P-12711-005

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ORPC Maine, LLC
120 Exchange Street, Suite 508
Portland, ME 04101
Phone (207) 772-7707
www.orpc.co

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EXECUTIVE SUMMARY

Introduction

ORPC Maine, LLC, a wholly-owned subsidiary of Ocean Renewable Power Company, LLC (collectively ORPC), submits this 2013 Environmental Monitoring Report for Phase I of the Cobscook Bay Tidal Energy Project (Project), in compliance with the Federal Energy Regulatory Commission (FERC) pilot project license P-12711-005. This report represents a significant achievement for the Project and its Adaptive Management Plan and demonstrates improved knowledge of our TidGen® Power System's operation and interaction with the marine environment.

The purpose of FERC's pilot project license process is to advance new marine hydrokinetic technology while minimizing the potential for environmental impacts. The process allows developers to test and evaluate new hydrokinetic technologies and determine environmental effects of the technologies, while maintaining FERC oversight and agency input. Pilot projects must be temporary, limited in size, removable, and able to shut down on short notice. License terms ensure environmental monitoring and safeguards during the short project term.

ORPC is using this licensed pilot project to advance, demonstrate, and accelerate deployment of its tidal-current based marine hydrokinetic energy conversion technology, associated power electronics, interconnection equipment, and environmental monitoring program within a replicable full-scale, interconnected array of devices capable of reliably delivering electricity to the domestic power grid. The Project consists of designing, building, installing and monitoring a commercial-scale array of multiple, grid-connected TidGen® devices on the sea floor in Cobscook Bay off Eastport and Lubec, Maine.

The Role of Adaptive Management

The Project has successfully demonstrated the ability to modify license requirements based on the results of science-based data collection, the engagement and concurrence of the Adaptive Management Team (AMT), and clear communication with FERC. This process has garnered international attention as a model for adaptive management.

ORPC provided the 2012 Environmental Monitoring Report to the AMT in February 2013 with a subsequent meeting held on March 12, 2013. This meeting was an opportunity for ORPC to summarize the early results of the monitoring program and solicit feedback from the AMT, including any recommendations for program modifications. ORPC subsequently met with the AMT on September 10, 2013 to provide updated environmental monitoring and project status information.

Through the adaptive management process, ORPC has requested modifications to environmental monitoring to clarify elements of the plan and reduce frequency of monitoring surveys based on increased knowledge of species presence and environmental effects. With concurrence from the AMT, ORPC's license modifications have been accepted by FERC. This process demonstrates a clear reduction in effort and cost on the part of ORPC based on the risk reduction demonstrated by environmental monitoring results.

Environmental Monitoring Results

The 2013 environmental monitoring results continued to build an increased knowledge of marine life interaction with the TidGen® Power System and indicated negligible environmental effects for many elements of the monitoring plans.

Article 405. Acoustic Monitoring Plan
Measurements of the in-water noise level related to the TidGen® Power System demonstrated that sound levels in the vicinity did not exceed 120 dB re 1 $\mu Pa^2/Hz$ at any frequency while the turbine was rotating, both while generating and when freewheeling. Further, the integrated rms levels from 20 Hz to 20 kHz did not exceed 120 dB re 1 μPa^2, the level some regulators have used to establish level B harassment of marine mammals.

Article 406. Benthic and Biofouling Plan
Observations of the exposed cable(s) indicated there continues to be little, if any, evidence of scouring or disturbance to the bottom or the associated faunal community. Results of the post-deployment benthic sampling survey indicated a healthy and highly productive benthic community with no discernible continuing effects from either the installation or operation of the cable. Assessments conducted in July 2013 indicated minor biofouling on the TidGen® turbine generator unit (TGU) with more significant growth on the bottom support frame; however, the functionality of the system did not appear to be compromised.

Article 407. Fisheries and Marine Life Interaction Plan
Hydroacoustic assessments conducted by the University of Maine (UMaine) demonstrate that while fish density was indeed variable, patterns were repeatable and will be useful in understanding the effects of devices. Data collected from the side-looking sonar during operation was minimal and only limited to when the TidGen® was not generating. However, available data allowed UMaine to identify some key issues that should be addressed in the future with the goal of collecting data while the turbine is generating power.

Article 409. Hydraulic Monitoring Plan
Hydrodynamic modeling conducted by Sandia National Laboratories continued to contribute to an understanding of hydraulic effects of the TidGen® Power System. Their work investigated velocity deficits created by the turbines and wake recovery as well as optimization of turbine arrays. Results of the scour monitoring continued to indicate minimal change in seabed elevation around the foundation piles.

Article 410. Marine Mammal Monitoring Plan
Marine mammal observations made by trained ORPC personnel in 2013, including during periods of operation, maintenance and retrieval, did not indicate changes in marine mammal presence or behavior. There was no evidence of marine mammal strike with system components during deployment and retrieval or with TGU foils during operation. In addition,

the continued presence of marine mammals in the vicinity of the Project indicated that the TidGen® Power System was not acting as a deterrent or a barrier to passage into the inner portions of the Bay.

Article 412. Bird Monitoring Plan

The Center for Ecological Research (CER) observed a decline in several species of seabirds in the Cobscook Bay study area in 2012-2013; however, they determined that it was unlikely that the operation of the TidGen® affected seabird numbers because it was not deployed in November 2012, a period when no eiders or Red-breasted Mergansers were observed.

Temporary Variance Period

ORPC requested to place environmental monitoring on a hiatus during the technology optimization period at the AMT meeting in September 2013. ORPC presented the following rationale for the appropriateness of the request:

- Comprehensive pre-deployment environmental studies have contributed to an understanding of inter-annual variability.
- Results-to-date indicated negligible effects to marine life from ongoing operations.
- TGU operational status made adherence to license conditions impractical and did not advance the conditions purpose.
- No undue impacts or impedance of other license requirements were anticipated. ORPC plans to return to adherence of conditions once TGU operation recommences.

Following the meeting, ORPC submitted the temporary variance request to FERC with the concurrence of the AMT. FERC issued a license order approving the temporary variance request on October 29, 2013.

Despite the temporary variance from environmental monitoring for the Project, ORPC will work with UMaine to conduct fisheries monitoring associated with a test of its floating OCGen® turbine technology in 2014. The OCGen® Module Mooring Project represents a significant advancement in marine hydrokinetic technology and deployment procedures while reducing potential environmental effects (elimination of the bottom support frame). Even though the mooring project will not be grid connected (and thus not under FERC jurisdiction), ORPC provided the AMT with detailed project information and requested concurrence on the relocation of the testing from off Shackford Head to within the FERC-licensed Project site.

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

ORPC Maine, LLC, a wholly-owned subsidiary of Ocean Renewable Power Company, LLC, (collectively, ORPC), is a Maine-based developer of hydrokinetic power systems and projects that harness the power of oceans and rivers to generate clean, predictable renewable energy. In partnership with coastal and river communities, ORPC works to create and sustain local jobs while promoting energy independence and protecting the environment.

ORPC received a pilot project license for the Cobscook Bay Tidal Energy Project (Project) from the Federal Energy Regulatory Commission (FERC) on February 27, 2012 (FERC Project No. P-12711-005). The purpose of the Project is to evaluate the potential for a new source of clean, renewable energy generation using tidal energy resources in Cobscook Bay, Maine. ORPC obtained a preliminary permit for the Project area in Cobscook Bay from FERC on July 23, 2007; FERC issued a successive preliminary permit on January 13, 2011. Feasibility studies, including environmental surveys, and pre-filing consultation were conducted, resulting in ORPC's filing of a draft pilot project license application with FERC on July 24, 2009 and subsequently the final pilot project license application in September 2011. The FERC pilot project license boundary for the Project encompasses the proposed development area (Figure 1).

In March 2012, ORPC began construction of the Project off the coast of Eastport and Lubec, Maine (Figure 1). Following installation of the initial phase of the Project during the spring and summer of 2012, the Project began delivering electricity to the Bangor Hydro Electric Company grid in September 2012. This is the first grid-connected installation of ORPC's TidGen® Power System.

<u>TidGen® Power System</u>
ORPC designed the TidGen® Power System to operate in water depths of 60 to 150 ft. The core component of the TidGen® Power System is ORPC's proprietary turbine generator unit (TGU). The TGU utilized four advanced design cross flow (ADCF) turbines to drive a permanent magnet generator mounted between the turbines on a common driveshaft. The ADCF turbines rotated in the same direction regardless of tidal flow direction; rotational speed of the turbines was directly related to water flow speed. The TGU was 98 ft in length, 17 ft high and 17 ft wide. It was attached to a bottom support frame, which held the TGU in place approximately 15 ft above the sea floor. The bottom support frame was 98 ft long by 50 ft wide by 15 ft high. The bottom support frame was constructed of steel, and the TGU was constructed of steel and composite material. The coupled TGU and bottom support frame comprised the TidGen® device (Figure 2). The TidGen® device was connected to an underwater power consolidation module, which was then connected to an on-shore station through a single underwater power and data cable. The on-shore station was interconnected to the local power grid. The TidGen® device and the related cabling and on-shore station comprised a complete TidGen® Power System.

Figure 1. Cobscook Bay Tidal Energy Project location map.

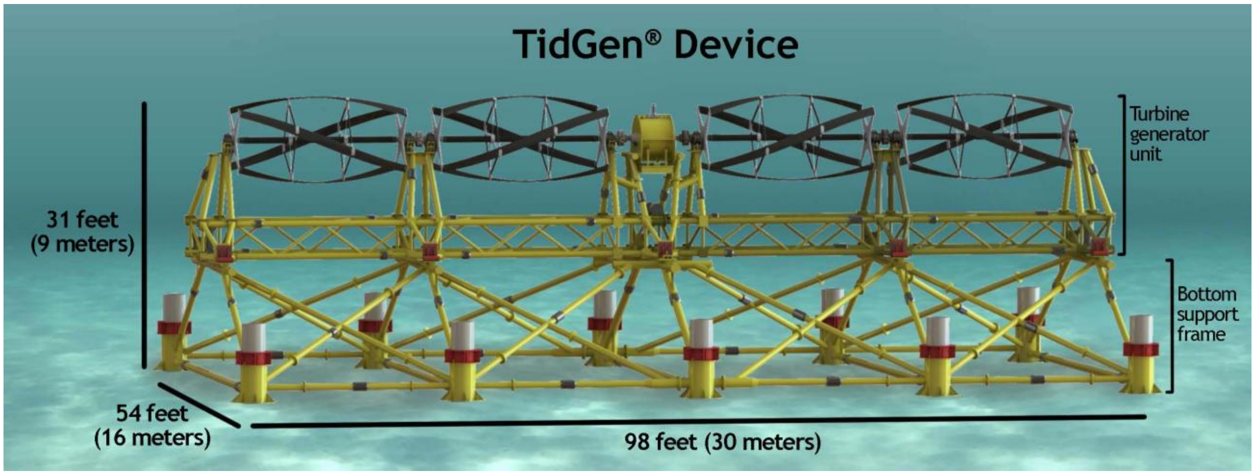


Figure 2. TidGen® device illustrating turbine generator unit and bottom support frame.

1.2 TGU Operation

Electricity generated by the Project was delivered by an underwater power cable to an On-shore Station in Lubec, Maine, where it was power-conditioned and connected to the Bangor Hydro Electric Company (renamed Emera Maine, January 1, 2014) power grid on September 13, 2012. Bangor Hydro issued a Permission to Operate: Certificate of Completion on September 25, 2012.

The TidGen® Power System was monitored from the On-shore Station, which had the capability to start, stop, and monitor the TidGen® Power System. Data, video, and instrumentation readings were transmitted by data cable bundled with the power transmission line. All major system components were instrumented and monitored for operational characteristics and environmental/ecological study, with data collected to document and validate Project performance. The environmental monitoring tower, equipped with Simrad instrumentation to monitor marine life interaction with the TGU, was deployed on August 20, 2012. The Simrad system was subsequently tested and calibrated the following week and has been operational since.

The TidGen® TGU was retrieved and redeployed several times during the winter of 2012/2013 for maintenance. After successfully redeploying the TidGen® TGU on February 22, 2013, ORPC successfully ran the system until a water leak occurred on the generator bullhead connectors, necessitating shut down of the generator on April 21, 2013. The TidGen® Power System operated at approximately 98% availability during this period, enabling significant data related to system operation (performance and environmental interaction) to be gathered.

1.3 TGU Retrieval and Technology Optimization Phase

The TGU was retrieved for inspection when the electrical cabinet and generator leak detectors activated. The crane and barge system utilized previously for retrieval purposes had been demobilized for multiple reasons, including concerns related to reliability of the lifting equipment and costs associated with maintaining the system on site. Alternative means of retrieval of the TGU had already been under development by ORPC and by ORPC's General Contractor. This process led to the development of a catamaran barge with dual winches to retrieve the TGU. This new system was selected, and final design was completed, constructed and delivered to Eastport. ORPC entered into an agreement with the General Contractor to build the new system and perform the full retrieval on a fixed cost basis that was approximately one-third of the average cost of the previous retrievals.

The TGU retrieval was successfully conducted on July 15, 2013 (Figure 3). The TGU was transported to shore, placed on blocking and lifted onto a trailer for transfer to the concrete blocking pads on July 16, 2013.

Figure 3. TidGen® TGU retrieval, July 15, 2013.

Prior to retrieval ORPC had logged considerable operational time, achieved multiple milestones and gathered important lessons learned regarding deployment and retrieval procedures, and turbine operation, performance and environmental interactions. To take immediate advantage of the lessons learned, ORPC decided to proceed with significant engineering improvements to the TidGen® Power System while the TGU was out of the water. This approach allowed ORPC to properly address issues with the generator and identify and implement longer-term design and component part improvements for future versions of the TidGen® Power System. This effort will result in a greater technology gain over time and help sustain successful operations locally.

In addition, ORPC was awarded two U.S. Department of Energy awards for technology performance improvements in January 2014. One of the awards will focus on the development and testing of innovative second-generation power take-off (PTO) components for marine renewable devices. Innovative PTO components will include new and improved designs for bearings and a subsea electrical generator. These technology improvements will be implemented in the TidGen® TGU prior to reinstallation.

2.0 ADAPTIVE MANAGEMENT (License Article 404)

2.1 ADAPTIVE MANAGEMENT PLAN AND TEAM

ORPC developed an Adaptive Management Plan (AMP) as required by the FERC pilot project license (P-12711-005, Article 404) for the Project. The AMP was an integral part of ORPC's implementation of the Project and provided a strategy for evaluating monitoring data and making informed, science-based decisions to modify monitoring as necessary. As required by Article 404, the AMP was drafted in consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Coast Guard, Maine Department of Environmental Protection, and Maine Department of Marine Resources. ORPC also consulted with technical advisors, who were involved with the development of each of the elements of this Project. The AMP reflects the collaborative approach that has been an integral part of the Project since its beginning. Table 1 lists the members of the Adaptive Management Team (AMT) and their respective roles.

Table 1. *Cobscook Bay Tidal Energy Project Adaptive Management Team*

NAME	ORGANIZATION	ROLE	RESPONSIBILITY
Nathan Johnson	ORPC	Project Developer	Communication
Steve Shepard	U.S. Fish & Wildlife Service	Government Regulator	Compliance with established regulations
Sean McDermott	NOAA NMFS, Habitat Conservation Division	Government Regulator	Compliance with established regulations (Essential Fish Habitat)
David Bean	NOAA NMFS, Protected Resources Division	Government Regulator	Compliance with established regulations (Endangered Species)
Linda Mercer	Maine Department of Marine Resources	Government Regulator	Compliance with established regulations
Lt. Megan Drewniak	U.S. Coast Guard	Government Regulator	Compliance with established regulations
Jim Beyer	Maine Department of Environmental Protection	Government Regulator	Compliance with established regulations
Michelle Magliocca	NOAA NMFS, Office of Protected Resources	Government Regulator	Compliance with established regulations (Marine Mammals)
ADVISORY			
Gayle Zydlewski	University of Maine	Technical Advisor	Fisheries Monitoring
Moira Brown	New England Aquarium	Technical Advisor	Marine Mammal Monitoring
Jay Clement	U.S. Army Corps of Engineers	Government Regulator	Advisory

The collaborative approach that was adopted for the AMP was first utilized for the 2009 memorandum of understanding (MOU) between the State of Maine and FERC, that included a working structure to develop and permit Maine's first hydrokinetic power project. An important component of the MOU was to develop appropriate and cost effective environmental studies and monitoring plans. It was clear from the onset that knowledge of the eco-system and its many facets potentially affected by this new hydrokinetic power project would require new methods of inquiry to collect, monitor and evaluate environmental data. Many of the new scientific methods that were developed for the Project have become a new basis for learning, and the scientific community has begun modifying approaches to environmental studies using these new methodologies in other programs. This learning has helped to bring the agencies and industry to a point where they have more tools to confidently address the needs of permitting of a commercial development. ORPC's AMP was designed to utilize not only the environmental studies at the Project site, but also environmental studies from other hydrokinetic projects and related studies from around the world.

ORPC's AMP recognized that many scientific uncertainties exist and that environmental conditions constantly change. The AMP, therefore, was designed to be modified within the Project time line and acknowledged that elements such as key environmental uncertainties, applied studies and institutional structure may evolve over time. The plan has worked well for the agencies, stakeholders, and ORPC as the Project evolved from a concept to the first pilot installation and operation.

The AMP summarized the minor and major license modification process required to make changes to environmental monitoring. ORPC strongly supported the involvement and concurrence of the AMT in applicable license modification requests, and the AMP process establishes a path to proceed in this manner.

2.2 2013 Adaptive Management Team Meetings

ORPC's FERC pilot project license required regulatory review of annual monitoring reports prior to FERC submittal. Therefore, ORPC prepared this 2013 Environmental Monitoring Report with the intent of providing it for comment to the AMT, which included the regulators recommended by FERC. This Report presents results of the Project's environmental monitoring program in 2013.

Similarly, ORPC provided the 2012 Environmental Monitoring Report to the AMT in February 2013, followed by an AMT meeting on March 12, 2013. ORPC summarized the early results of the monitoring program and solicit feedback from the AMT, including any recommendations for program modifications. ORPC subsequently met with the AMT on September 10, 2013 to provide updated environmental monitoring and project status information.

2.2.1 March 12, 2013

ORPC held an AMT meeting on March 12, 2013 at the Maine Department of Environmental Protection's Eastern Maine Regional Office in Bangor. As previously discussed in the 2012 Environmental Monitoring Report, this meeting was an opportunity for ORPC to present 2012 environmental monitoring results and recommendations for modifications in a collaborative setting with the Team. Specific agenda items included:

- Review of adaptive management's role in the Project
- Summary of 2012 activities and lessons learned
- Explanation of environmental monitoring results
- Discussion of recommended modifications and finalization of necessary changes
- Briefing on the overall Maine Tidal Energy Project (Cobscook Bay Phase II and Western Passage Tidal Energy Project (FERC Project No. P-12680)

Subsequent to the March meeting, ORPC received concurrence from the AMT on recommended license modifications. Concurrence and additional comments from the AMT were incorporated into the final draft of the 2012 Environmental Monitoring Report submitted to FERC on March 26, 2013.

2.2.2 September 10, 2013

ORPC held an Adaptive Management Team meeting on September 10, 2013 at the Maine Department of Environmental Protection's Eastern Maine Regional Office in Bangor. Updated environmental monitoring and project status information was provided. Specific agenda items included:

- Project status update, including technology optimization phase
- 2013 environmental monitoring results, challenges, and accomplishments
- ORPC's temporary variance request related to environmental monitoring
- Details on ORPC's OCGen® Module Mooring Project
- Other ORPC activities (RivGen® Power System, ORPC Solutions)

Environmental monitoring results presented to the AMT continued to indicate negligible observed effects.

ORPC provided further details regarding a request to place environmental monitoring on a hiatus during the technology optimization period. Prior to the meeting ORPC had submitted a memo to the AMT summarizing the request. Temporary variance requests have been granted by FERC for traditional hydropower projects in the past. FERC requested concurrence from the AMT related to ORPC's temporary variance request. ORPC presented the following rationale for the appropriateness of the request:

- Comprehensive pre-deployment environmental studies contributed to an understanding of inter-annual variability.
- Results-to-date indicated negligible effects to marine life for ongoing operations.
- TGU operational status made adherence to license conditions impractical and did not advance the conditions purpose.
- No undue impacts or impedance of other license requirements were anticipated.
- ORPC plans to return to adherence of conditions once TGU operation recommences.

Following the meeting ORPC submitted the temporary variance request to FERC with the concurrence of the AMT. FERC issued a license order approving the temporary variance request on October 29, 2013.

At the September meeting ORPC also briefed the AMT on our proposed relocation of the DOE-funded OCGen® Module Mooring Project from off Shackford Head to the FERC-licensed Cobscook Bay Tidal Energy Project site. The relocation was preferred because it would occupy less area within Cobscook Bay and eliminate seasonal restrictions related to commercial fishing activities required at Shackford Head.

The OCGen® Module Mooring Project represents a significant advancement in marine hydrokinetic technology and deployment procedures while reducing potential environmental effects. Despite the fact that the mooring project will not be grid connected (and thus not under FERC jurisdiction), ORPC provided the AMT with detailed project information and requested concurrence on the relocation. The Mooring Project is anticipated to occur in the summer of 2014. A U.S. Army Corps of Engineers permit application was submitted for the Mooring Project on December 20, 2013 with concurrence received from multiple members of the AMT.

Minutes from the March 12, 2013 and September 10, 2013 Adaptive Management Team meetings are included in Appendix A.

2.3 COBSCOOK BAY TIDAL ENERGY PROJECT LICENSE MODIFICATIONS

The Cobscook Bay Tidal Energy Project has successfully demonstrated the ability to modify license requirements based on knowledge gained, the engagement and concurrence of the AMT, and clear communication with FERC.

Table 2 summarizes license modifications completed in 2013. It should be noted that modifications related to rated capacity and inspection and maintenance did not involved the Project's AMT.

Table 2. *Summary of 2013 Cobscook Bay Tidal Energy Project license modifications*

Submittal/License Article(s)	Requested Modifications	FERC Order Date
Exhibit A, Project Description and Operation	Rated capacity of the TidGen® Power System revised from 60 kW to 150 kW.	February 21, 2013
FERC Division of Dam Safety and Inspection - Article 306. Inspection and Maintenance	Clarification of inspection and maintenance activities and frequencies	April 8, 3013
2012 Environmental Monitoring Report - Article 405. Acoustic - Article 406. Benthic & Biofouling - Article 407. Fisheries and Marine Life Interaction - Article 409. Hydraulic - Article 410. Marine Mammal - Article 412. Bird	Modifications vary by license article but generally clarify monitoring plans or reduce frequency of monitoring surveys based on increased knowledge of species presence and environmental effects.	May 8, 2013
Temporary Variance Request - Article 405. Acoustic - Article 406. Benthic & Biofouling - Article 407. Fisheries and Marine Life Interaction - Article 409. Hydraulic - Article 410. Marine Mammal - Article 412. Bird	Hiatus in environmental monitoring during technology optimization phase	October 29, 2013

3.0 ACOUSTIC MONITORING (License Article 405)

The primary goals of the Acoustic Monitoring Plan were to identify and characterize the noise radiated by the TidGen® Power System in the high-velocity environment of the Project site by gathering acoustic data under various environmental and mechanical conditions prior to and during Project deployment. This was accomplished by the following:

1. Ambient noise measurements at the deployment area were conducted in 2011 prior to the deployment of a single-device TidGen® Power System.

2. Noise measurements were conducted in 2011 during ORPC's Beta TidGen® Project to gather preliminary data and gain experience with the equipment and methodologies.

3. Noise measurements were conducted on the single-device TidGen® Power System in April 2013.

4. Noise measurements will be conducted on the multi-device TidGen® Power System after the Phase II deployment.

The equipment and methodologies used for gathering noise data that have helped determine the origins of noise. The Acoustic Monitoring Plan includes this data to characterize the TidGen® Power System's acoustic footprint, in accordance with the FERC pilot project license requirements.

Additional information on potential marine life interaction with the TGU will be monitored as outlined in the Fisheries and Marine Life Monitoring Plan. The presence of marine mammal species in the vicinity of the Project is addressed in the Marine Mammal Plan. Separate from these study plans, ORPC, in conjunction with Scientific Solution Incorporated (SSI), developed and tested an active acoustic monitoring technology and methods. The ultimate goal of this system under development was to monitor marine life automatically and in real time.

3.1 Methodologies

The drifting noise measurement system (DNMS) and measurement methodologies are detailed in the Project's Acoustic Monitoring Plan. The DNMS was developed to overcome the significant challenges of making accurate ambient and radiated noise measurements in high currents. The data acquisition system (Figure 4) was comprised of a pair of hydrophones, a custom two-channel variable gain low noise amplifier and LGR-5327 Data Logger. The hydrophones were attached to the spar buoy to acquire the waterborne acoustic sound pressures and gather noise data while isolated from vertical motion and decoupled from the high velocity currents. The lengths of the hydrophone cables were adjustable; therefore the appropriate length was determined during testing. An anchor hung approximately two meters below the lowest sensor to prevent the hydrophones from getting hooked on the ocean floor if the spar buoy drifted into shallow water. The anchor also provided drag along the ocean floor in shallow areas until the system could be recovered if this became necessary. A list of general specifications for DNMS was presented in the Project's Acoustic Monitoring Plan. A recent upgrade to the system switched to Reson hydrophones Model TC4013 and a 394A40 pistonphone calibrator for more accurate and traceable measurements.

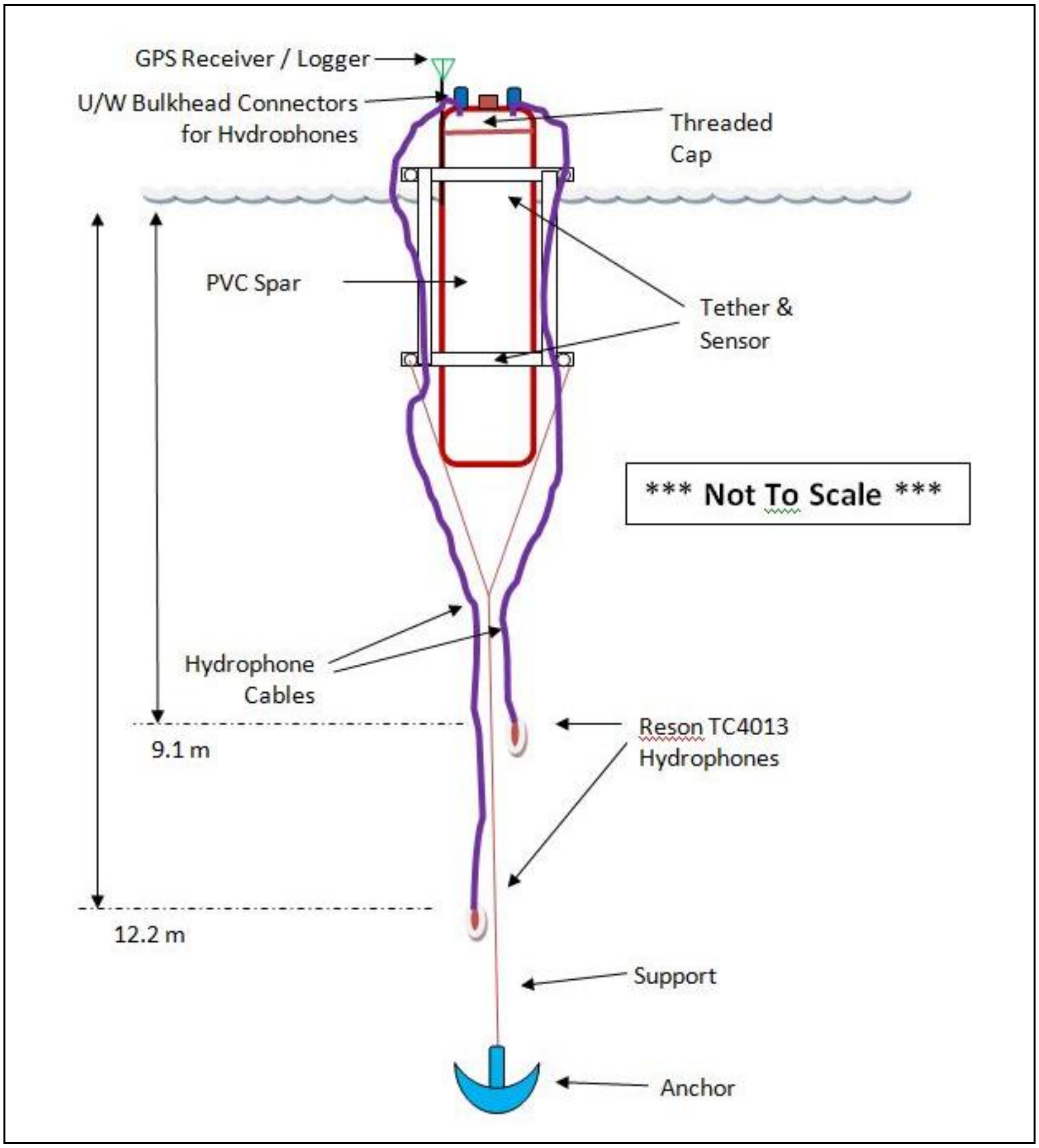


Figure 4. Drifting noise measurement system.

Measurements were collected at the Project site on April 2 and April 3, 2013 under varying sea states, tidal flows, and turbine generator conditions. Sustained winds of approximately 15 knots generated wave heights of 2 to 3 ft. The DNMS was deployed from ORPC's 40 ft research vessel, *Tide Tracker*, and allowed to drift untethered to collect acoustic measurements (Figure 5). During slack water periods the DNMS was deployed in the direct vicinity of the TGU (within 100 meters). For periods of ebb or flood tidal flows the DNMS was deployed several hundred meters upcurrent, allowed to pass as close as possible to the TGU, and then retrieved several hundred meters downcurrent. During deployments the *Tide Tracker's* engine was shut off. In addition, ORPC staff was in direct communication with operators at the Lubec On–shore Station to record generator output and turbine RPMs. ORPC staff also modified operations to record acoustic measurements while the turbine was "freewheeling," i.e., spinning but not generating power. Turbine RPMs during freewheeling were approximately 50% higher than when generating. An ORPC log sheet used during the measurements has been included as Attachment B. A total of 34 deployments of the DNMS were made at the Project site.

Figure 5. DNMS during deployment at the Project site, April 2, 2013

3.2 Results - Phase I TidGen® Measurements

Measurements of the in-water noise level related to the TidGen® Power System demonstrate that sound levels in the vicinity do not exceed 120 dB re 1 $\mu Pa^2/Hz$ at any frequency while the turbine is rotating, both while generating and when freewheeling. An observable increase in sound level was primarily visible at approximately 105 Hz with a harmonic at 210 Hz, as well as 2.8 kHz and occurred anytime the turbine was rotating. A higher frequency tone near 5 kHz and associated harmonics were only present when the turbine was actively generating, but were at sound spectral levels well below the lower frequency sources, as shown in Figure 6. Further, the integrated rms levels from 20 Hz to 20 kHz do not exceed 120 dB re 1 μPa^2, the level some regulators are using to establish level B harassment of marine mammals. This frequency range was suggested as the appropriate range for this measurement by experts at the workshop on Instrumentation for Monitoring around Marine Renewable Energy Devices in Seattle, Washington, on June 25-26, 2013.

Sound peaks near 105 Hz, 210 Hz, and 2.8 kHz appear to scale with turbine RPM values and are generally louder when the turbine is freewheeling as compared to when it is generating at the same RPM. Sound levels did not vary with range for the same rotation speed at distances ranging from 20 m to 300 m. This fact, coupled with the observation that the sound is present anytime the turbine rotates, independent of electrical generation, indicates the source is likely to be the sound radiating from the structure itself. Given the source, SSI determined that it was not appropriate to scale the measured data by some form of geometric spreading factor. The higher frequencies that only occur when the turbine is generating appear to scale slightly with turbine rotation as well (Figure 6).

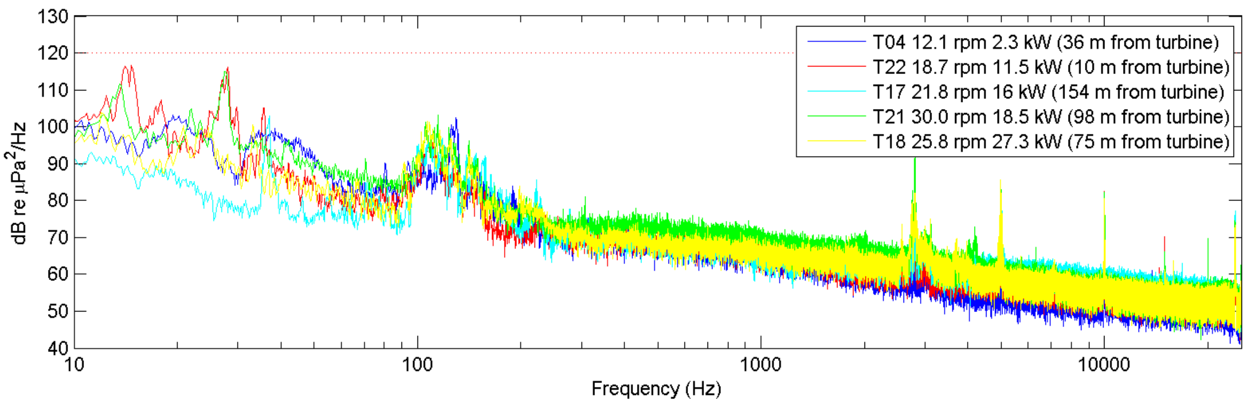


Figure 6. Power spectral density for the generating turbine at various ranges from the turbine. April 2-3, 2013.

3.3 Potential Effects

Resource agencies and stakeholders have indicated concern regarding underwater noise and vibration produced by the TidGen® Power System and the potential effects on marine species as many marine species use sound in communication, navigation, predator/prey interactions, and hazard avoidance. These organisms have biological receptors that are sensitive to sound pressure level, particle velocity, and the frequency of sound. Hastings and Popper (2005) conducted a review of sound effects on fish, primarily related to pile driving. Results of these studies indicated that fish do not experience adverse effects from received sound levels less than about 160 dB re 1µPa; though at higher levels, fish may exhibit avoidance, stress, temporary and permanent hearing loss, auditory and non-auditory tissue damage, egg damage, reduced growth rates, or mortality (Hastings and Popper, 2005). Many of the existing studies did not evaluate different behavioral responses by marine species to variable sound frequencies.

Data compiled by Hastings and Popper (2005) indicated the hearing threshold for Atlantic salmon was between 85 and 130 dB, at frequencies between 30 and 300 Hz. Some additional studies suggested they may also detect sound below 35 Hz (Knudsen et al. 1992, 1994, as cited in Hastings and Popper, 2005). However, detection of a sound does not necessarily equate to an effect. Information on behavioral responses of received sound levels and frequencies were generally limited for these species.

Marine mammals rely on sound for many aspects of their lives, including reproduction, feeding, predator and hazard avoidance, communication, and navigation (Weilgart, 2007). There is considerable variation among marine mammals in both absolute hearing range and sensitivity. Their composite range is from ultrasonic (frequencies greater than 20 kHz) to infrasonic (frequencies less than 20 Hz). Direct hearing measurements, for the most part, are not available for cetacean species, but it is generally believed that a whale's hearing range is related to the range of sound it produces (LGL Ecological Research Associates and JASCO Research, 2005). Pinniped hearing in general has been measured for air and water. In water, hearing ranges from 1 to 180 kHz with peak sensitivity around 32 kHz. In air, hearing capabilities are greatly reduced to 1 to 22 kHz. This range is comparable to human hearing (0.02 to 20 kHz). Harbor porpoise, harbor seals, and gray seals may be affected by Project produced noise (USACE, 2008).

Behavioral responses of marine mammals to sound vary greatly and depend on a number of factors. An individual's hearing sensitivity, tolerance to noise, exposure to the same noise in the past, behavior at the time of exposure, age, sex, and group composition all affect how it may respond. Sometimes it is difficult to know whether observed changes in behavior are due to sound or other causes. Observations suggest that marine mammals tend over time to become less sensitive to those types of noise and disturbance to which they are repeatedly exposed (Richardson et al., 1995).

National Marine Fisheries Service (NMFS) has identified the following noise levels as thresholds for marine mammal harassment:

> Current NMFS practice regarding exposure of marine mammals to high level sounds is that cetaceans and pinnipeds exposed to impulsive sounds of 180 and 190 dB rms or above, respectively, are considered to have been taken by Level A (i.e., injurious) harassment. Behavioral harassment (Level B - has the potential to disturb a marine mammal) is considered to have occurred when marine mammals are exposed to sounds at or above 160dB rms for impulse sounds (e.g., impact pile driving) and 120dB rms for continuous noise (e.g., vibratory pile driving), but below injurious thresholds. These levels are considered precautionary. (NOAA, 2008)

SSI's TidGen® Acoustic Monitoring Report was third party reviewed by Brandon Southall, Ph.D., at the request of ORPC to assure that a marine mammal scientist reached the same conclusion that ORPC minimized the potential risk of adverse environmental affects due to noise from its development project.

Dr. Southall's review determined that the spectrum levels recorded in a variety of conditions indicated that adverse effects to marine mammals were unlikely. The measurements of ambient and different operational conditions clearly indicated that the presence of associated sounds of varying characteristics in the region of hearing for at least some of the marine life known to occur in the vicinity of the Project site (more so for seals and fish than any cetaceans). Protected species in the vicinity of the TidGen® TGU may hear and could potentially be affected by the device. However, the potential for behavioral responses is likely to be extremely limited, and these levels would almost certainly not trip any thresholds for potential level B harassment. In addition, the recorded sound levels would not cause hearing loss or injury by acoustics for any species at any range.

ORPC submitted the Phase I Acoustic Monitoring Report to NOAA's Office of Protected Resources for review and comment on July 12, 2013. NOAA responded with no comments on the Report. The Phase I Acoustic Monitoring Report is included as Appendix B.

3.4 Accelerometer Correlation

Data for the Phase I acoustic survey was collected during varying operating conditions, yet there were no acoustic monitoring instruments mounted on the TidGen® Power System (or other ORPC equipment). However, accelerometers were placed on the TidGen® Power System to measure turbine-induced vibrational accelerations. ORPC hypothesized that as the speed of the turbines increased, the sound and vibrations produced by the generator would also increase. Knowing the DNMS positional change and loading conditions of the TidGen® Power System from the accelerometers, the data could be analyzed to reflect how sounds produced by the TidGen® Power System correlated to increases in the surrounding noise field. This correlation may allow for a potential dynamic real time monitoring system of ambient noise field impact as related to TidGen® Power System operations.

ORPC operators, located at the Lubec On-shore Station, coordinated with the *Tide Tracker* crew to take DNMS measurements to correlate acoustic results to accelerometer recordings on April 2 and April 3, 2013. To get maximum bandwidth from accelerometers, ORPC recorded only one channel at a time. Of greatest interest were the two accelerometers (four channels) attached to the generator and so those channels were prioritized.

The following Correlation Methodology describes the first stage of this correlation and outlines the methodology, feasibility, and limitations to the current procedure.

3.4.1 Correlation Methodology

ORPC utilized data collected by SSI using the DNMS at varying distances from the TidGen® (20 m to 300 m) during the April 2 and April 3, 2013 acoustic survey. SSI's acoustics data was not scaled by a "spreading factor." Thus, SSI's data was assumed to be the approximate sound emitted by the unit, without damping from the water. This assumption was supported by the following observations:

1. Sound levels did not vary with range for the same rotation speed at distances ranging from 20 m to 300 m.
2. Sound was present any time the turbine rotates, whether generating or not, indicating that the source of sound radiation was likely to be from the structure itself.

The fact that these measurements were taking between 20-300 m from the structure and the accelerometers were mounted to various locations on the structure, limited the potential of making this correlation.

Results of the acoustic monitoring indicated specific frequency tones were picked up during freewheeling and generating conditions as previously described in this section. Based on the acoustic results from SSI the following tones were investigated in the accelerometer data:

Freewheeling
- 105 Hz
- 210 Hz (harmonic to 105)
- 2.8 kHz (beyond range of accelerometers)
- Noisiness between 105 and 210 Hz

Generating
- 105 Hz (broader and weaker than freewheeling)
- 210 Hz (weaker than freewheeling)
- 2.8kHz (stronger than freewheeling, beyond range of accelerometer)
- 5 kHz (beyond range of accelerometer
- 10, 15, 20 kHz (harmonics to 5 kHz)

Accelerometers mounted on the TidGen® Power System were the following model:

Wilcoxon Research Model 757 "Biaxial, low profile, underwater accelerometer"
Frequency response: 2-2,000 Hz ±10%
Sensitivity: 100mV/g = 0.1V/g
Raw data output: volts

Figure 7 shows the locations of the eight accelerometers mounted to the TidGen® TGU.

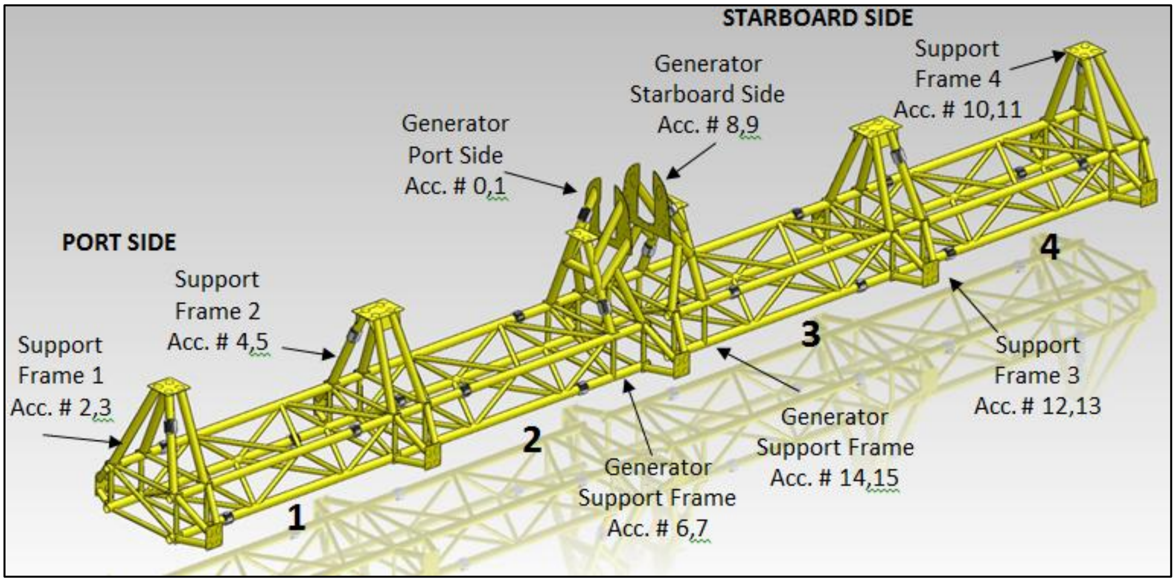


Figure 7. Accelerometer mounting locations

ORPC developed MATLAB scripts and functions to perform data processing and power spectral density (PSD) generation.

Data was collected by ORPC over two days, i.e., the same time periods during which the acoustics data were collected. ORPC found it best to use MATLAB to convert raw data into vectors of acceleration and time.

Power Spectral Density (PSD) creates a plot of power or energy per frequency (Hz) for a given signal. Conceptually, the PSD decomposes a signal into different frequencies present in that signal, to help identify periodicities and common frequencies. The PSD will ultimately give the power carried by the wave. For the accelerometer data, the PSD is displayed in intensity (decibels, dB) per frequency. Because the intensity in the case of the accelerometer data is not sound, rather accelerations, the intensity is referenced to acceleration units (dB re m/s^2). The units of the PSD are intensity per frequency, given as dB re $m/s^2/Hz$.

In signal processing, a window function is used on data that is not periodic. A specific window function must be chosen, both in shape and in length. Using window functions prevents leakage from the signal, and helps avoid errors in performing fast Fourier transforms. The window is essentially the “batch” of signal on which the PSD is performed, repeated with a designated overlap (commonly 50%). The ideal types of windows for a random signal include Hamming, Hanning and Welch.

Welch’s Method

Welch’s method is an approach to spectral density estimation for producing a PSD. The major benefit to Welch’s method is that it uses a Hamming window by default, which is an appropriate windowing option for a random signal. In addition, this method is effective in reducing signal noise better than other methods.

The following four figures are PSDs of accelerometer data collected while the generator was running and when the turbines were freewheeling, all using Welch’s method. The first figure of each pair used the default windowing. The second of each pair used a hamming window of size 1000, with 50% window overlap. The signals looked similar, but the second has reduced noise (Figure 8-11).

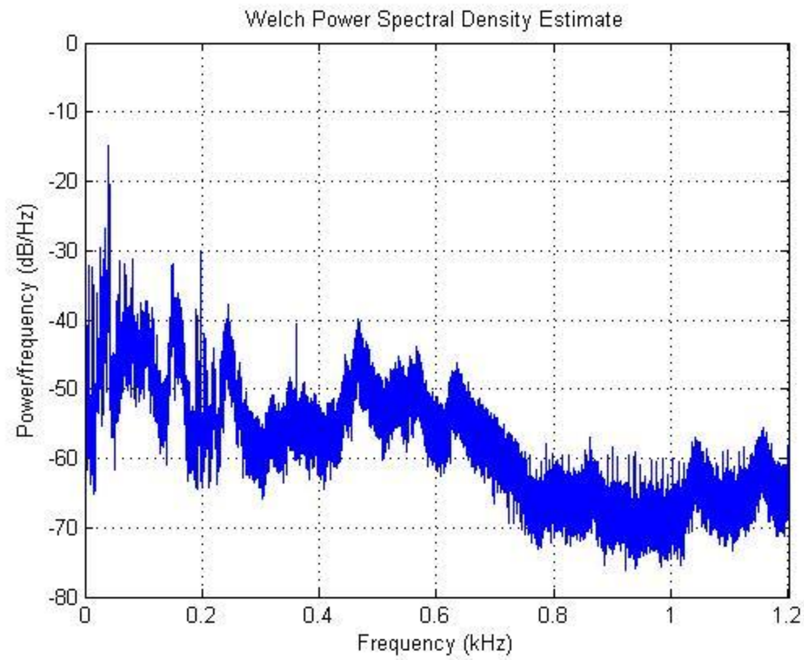


Figure 8. Accelerometer with Generator ON: Welch's Power Spectral Density using Default Window Settings

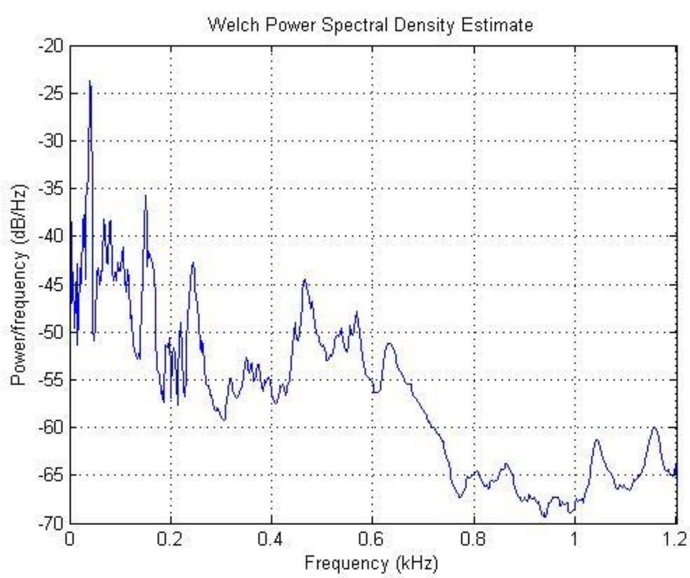


Figure 9. Accelerometer with Generator ON: Welch's Method Power Spectral Density using window size 1000.

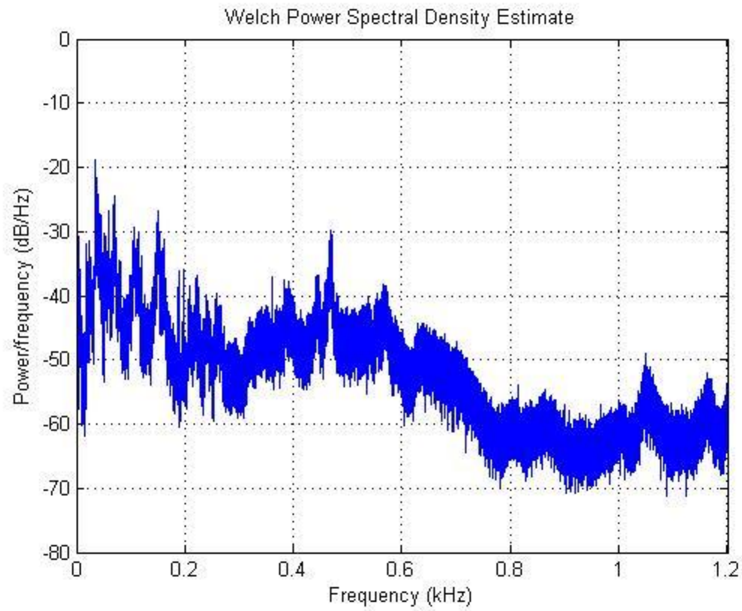


Figure 10. Accelerometer with turbine Freewheeling: Welch's Power Spectral Density using Default Settings

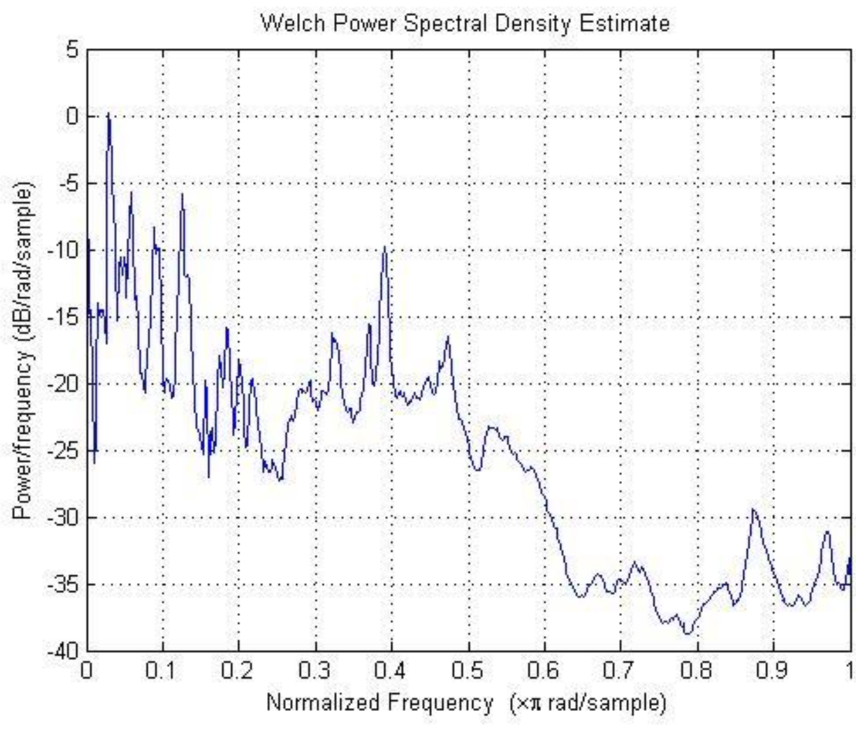


Figure 11. Accelerometer with turbine freewheeling: Welch's Method Power Spectral Density using window size 1000.

The MATLAB function PSD was another method evaluated by ORPC. Using PSD takes more user effort and essentially accesses Welch's method, but offers slightly more transparency. The PSD was run using accelerometer data during power generation. All default settings were used. The PSD looked similar to that of Figure 12, but with reduced noise.

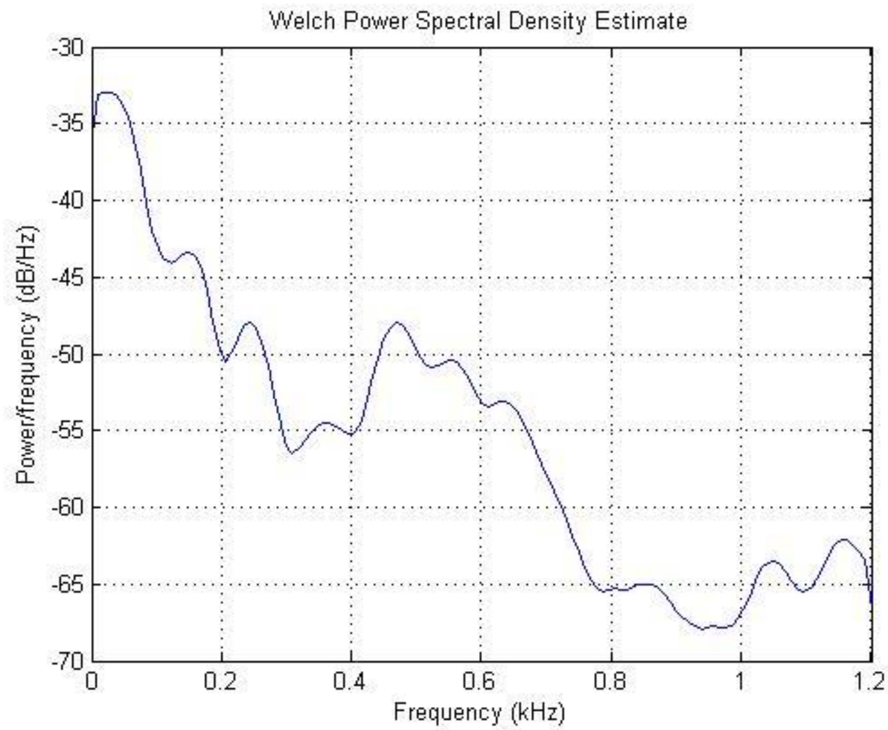


Figure 12. Generator ON, PSD using MATLAB function PSD with default settings

3.4.2 CORRELATIONS

Once an accurate PSD was generated for the accelerometer data, ORPC correlated the acoustics data collected by SSI. Both data sets were in the same format, i.e., energy of the signal at each frequency. Then, "tones" were chosen out of each data set, indicative of "spikes" at the frequencies occurring in both datasets. For example, it was expected that the peaks at 105 Hz and 210 Hz in the acoustics data would appear at the same frequency in the accelerometer data (Figure 13-16).

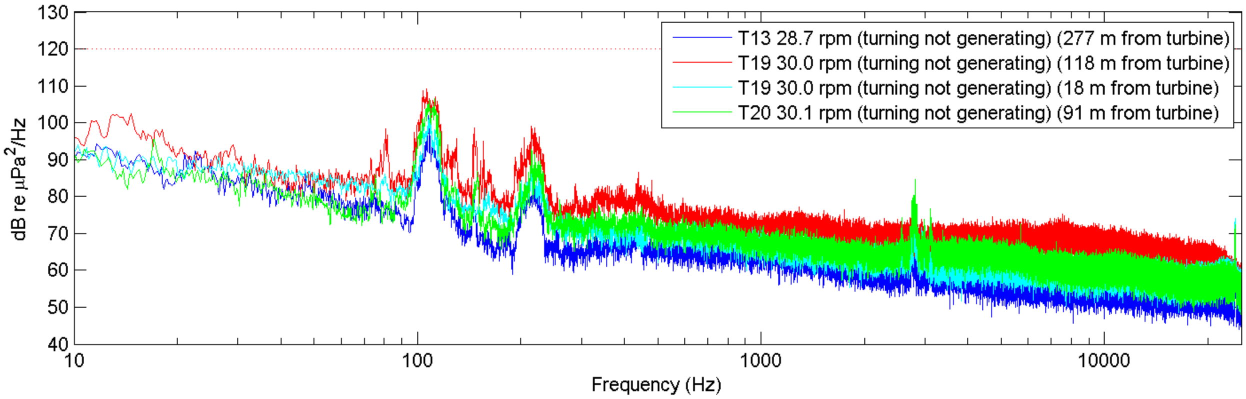


Figure 13. Acoustic results during freewheeling indicating spikes at 105, 210 Hz.

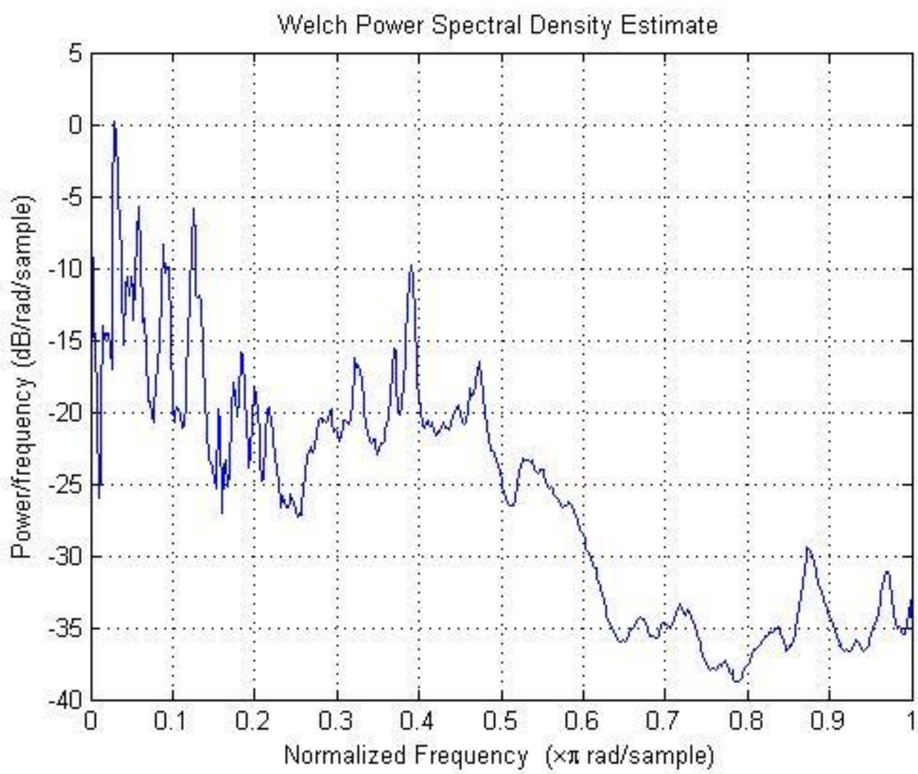


Figure 14. Accelerometer results during freewheeling, indicating numerous spikes between 0-210 Hz.

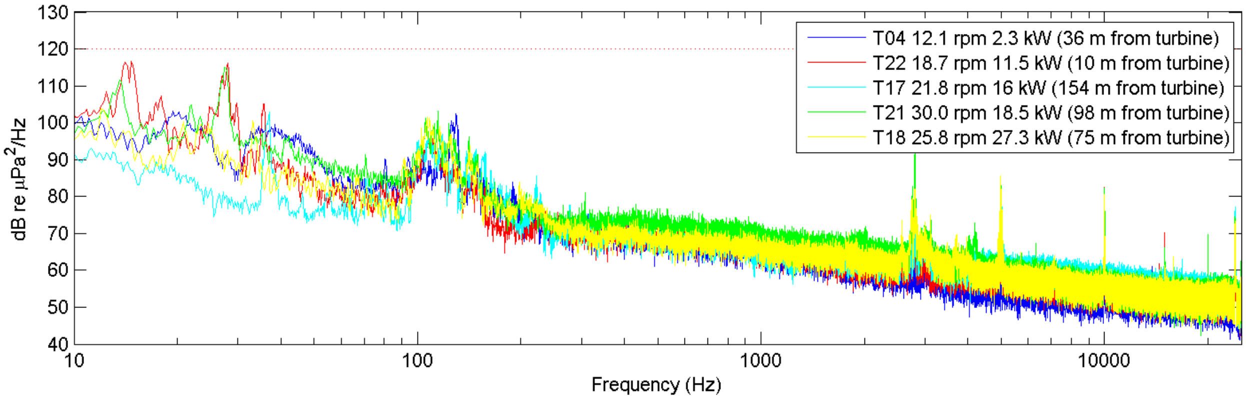


Figure 15. Acoustic results while generating, indicating spikes at 105 and 210 Hz as well as 5 kHz.

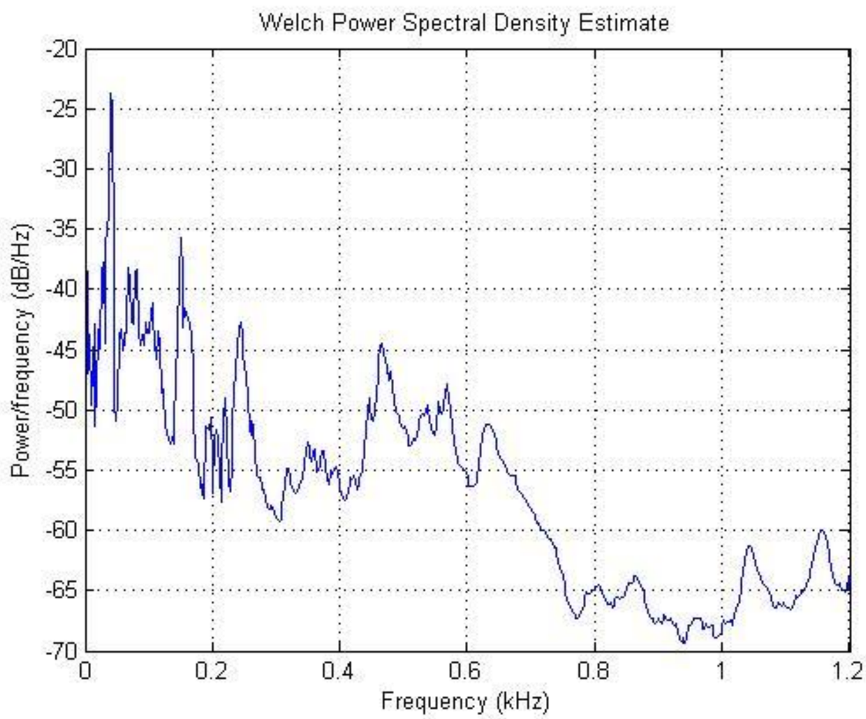


Figure 16. Accelerometer results while generating, indicating potential spikes at 105 and 210 Hz. 5 kHz is above range.

Preliminary results indicated that correlations were feasible; however, the following limitations were identified that need further evaluation.

1. The subsea accelerometer currently used by ORPC had a sampling frequency of 2,400 Hz. The underlying principles of the fast Fourier transform limited the frequencies that can be detected by the accelerometer to 1,200 Hz. The passive acoustics study performed

by SSI detected acoustic signatures higher than 1,200 Hz. Only those sounds with frequencies below 1,200 Hz can be detected by the accelerometers currently installed on the TidGen® TGU.

2. The sampling rate of the accelerometer is too high for the available bandwidth. Data cannot be streamed from the accelerometer at the same time as other data. "Real-time" data streaming is only possible when no other instruments are recording. The accelerometer, at present, is only operated for short periods of time (up to 10 minutes).

3. The DNMS data treated the entire TidGen® Power System as a "point source" sound emitter. The culmination of all sound from the unit (generator, turbines, structural vibration, etc) is picked up in the far field. However, accelerometers were placed on eight locations throughout the turbine, both on the frame and on the generator. It might be possible that the acoustic signature of the device was a combination of all accelerometer readings, which complicated the correlation procedure.

4. Additional effort is required to understand the signal processing tools in MATLAB, and the most appropriate function.

3.5 Conclusions and Recommendations

Measurements of the in-water noise level related to the TidGen® Power System demonstrate that sound levels in the vicinity did not exceed 120 dB re 1 $\mu Pa^2/Hz$ at any frequency while the turbine was rotating, both while generating and when freewheeling. Further, the integrated rms levels from 20 Hz to 20 kHz did not exceed 120 dB re 1 μPa^2, the level some regulators have established for level B harassment of marine mammals.

In collaboration with its technical advisors, ORPC has determined the spectrum levels recorded in a variety of conditions indicated adverse effects to marine mammal to be unlikely. The measurements of ambient and different operational conditions clearly indicated the presence of associated sounds of varying characteristics in the region of hearing for at least some of the marine life known to occur in the vicinity of the Project site (more so for seals and fish than any cetaceans). Protected species in the vicinity of the TidGen® TGU may hear and could potentially be affected by the device. However, the potential for behavioral responses is likely to be extremely limited, and these levels would almost certainly not trip any thresholds for potential level B harassment. In addition, the sound levels recorded would not cause hearing loss or injury in terms of acoustics for any species at any range.

ORPC has developed an initial methodology to correlate acoustic monitoring results collected by the DNMS on April 2 and April 3, 2013 to accelerometer readings collected simultaneously from the Lubec On-shore Station. Preliminary results indicated that correlations were feasible; however, the limitations were identified that need further evaluation.

4.0 BENTHIC AND BIOFOULING MONITORING (License Article 406)

The primary goals of the Benthic and Biofouling Monitoring Plan are to evaluate the benthic community during the Project and to study whether the structures introduced into the marine system contribute to biofouling accumulation that may alter the habitat within the Deployment Area. These goals will be accomplished by (1) characterizing the existing benthic community (pre-deployment); (2) examining the recovery of the benthic resources disturbed during the installation of the subsea cable; (3) examining the benthic community near the deployed TidGen® Power System; and (4) examining the presence and relative extent of coverage of biofouling organisms on the deployed TidGen® Power System. The Benthic and Biofouling Monitoring Plan will use the data gathered to evaluate the potential Project effects on the benthic community in accordance with the requirements of the FERC pilot license process.

The bottom support frame for Phase I of the Cobscook Bay Tidal Energy Project was installed starting in March 2012. Installation of the power and data cables occurred in July 2012 by means of a shear plow. This more passive installation technique resulted in minimal disturbance to the benthos as compared to use of a jet-assisted plow. Additional information regarding the monitoring of the hydraulic flow fields and sediment transport in the Deployment Area is included in the Hydraulic Monitoring Plan.

In addition to a survey conducted in February 2013 (preliminary results included in 2012 Environmental Monitoring Report), ORPC and its subcontractor MER Assessment Corporation (MER), conducted an inspection of the power and data cable route associated with the Cobscook Bay Tidal Energy Project on June 13, 2013. This inspection was conducted using two techniques: (1) a diver-held camera and housing that covered the entire cable route running from the near shore area in Gove Cove on Seward Neck in Lubec to the TidGen® Power System deployment area and (2) a remote drop-camera video of five transects running across the cable route. The inspections included video recordings to document the condition of the cable as well as the benthic habitat along the cable route.

A Phase I (post-deployment) benthic sampling survey was conducted in the subtidal and intertidal areas of the power and data cable route on August 7 and August 8, 2013. MER conducted habitat characterizations of the deployment areas and the subsea and intertidal cable routes.

ORPC performed a biofouling assessment of the TidGen® TGU immediately following its retrieval and relocation to the Deep Cove pier on July 15, 2013. In addition, a biofouling assessment was conducted on the bottom support frame based on diver video collected in July 2013.

The 2013 benthic and biofouling reports are included in Appendix C.

4.1 METHODOLOGIES

4.1.1 BENTHIC SURVEYS OF CABLE ROUTE

ORPC deployed a video transect line along the bottom on June 10, 2013 using the vessel *Tide Tracker* and a Hemisphere VS101 GPS positioning unit. The transect line was made up of four 274 m (900 ft) lines and one 122 m (400 ft) line for a total of 1,219 m (4,000 ft). The transect line was marked at 91-m (300 ft) intervals with orange tape bearing the distance and was held in place by weights dropped at specific distances following a course shown in Figure 17. The original baseline survey transect line was marked in meters rather than feet. Station locations consequently did not correspond exactly; additionally, the baseline survey and diver transect line following the 'As Built' cable route were slightly offset from one another.

Figure 17. June 13, 2013 diver and drop camera video survey transects (Source: ORPC; MER)

Video recordings were made by Brayden's Future, Inc. SCUBA divers using MER's Amphibico VHHCEL57/Sony HDR-HC9 high definition digital video camera, Amphibico VLDIG3AL 35W/50W switchable underwater arc lamp lighting package, and recorded on Sony HD tapes.

The drop camera video recording was conducted simultaneously with the diver video recordings to determine the feasibility of using it as an alternative method of assessing the benthic habitat and associated epifauna. The 36-ft F/V *Lady H* operated by Capt. Butch Harris was used as the surface platform for the video recordings; the vessel is equipped with a hydraulic hauler and davit to facilitate lowering and hauling of the video camera frame.

The tethered drop camera videos were recorded by MER using a SeaViewer Sea-Drop 650 Series real-time color camera system attached to a heavily weighted stainless steel frame equipped with an Amphibico VLDIG3AL 35W/50W switchable underwater arc lamp. The camera video feed was connected to a SeaViewer SeaTrak unit that embeds GPS (WGS84) coordinates and date/time data (GMT) directly on the video recording; the video was recorded on-board the support vessel using a SONY GV-D800 NTSC digital video recorder.

4.1.2 Benthic Sampling

MER conducted the subtidal habitats portion of the Phase I sampling survey in collaboration with Brayden's Future, Inc., divers on August 7, 2013, during a period of two daylight-hour slack tides (one low tide and one high tide) with average amplitude tides of 0.0 m LW and 5.6 m HW (0.0 ft LW to 18.4 ft HW). As previously reported, Upper Cobscook Bay is characterized by large amplitude tides and very strong tidal currents and the selected Deployment Area is subject to some of the strongest tidal currents in the region. These strong currents present constraints on both the timing and duration of survey events (extremely short slack water period). Sampling was consequently conducted immediately before, during and after slack water (high tide or low tide) and the sampling stations sequenced to take advantage of slower current velocities in certain sections of the cable route during specific periods around slack water.

Benthic sampling was conducted in situ by the divers along the transect for the Upper Cobscook Bay Deployment Area and subsea cable route. No video recordings were made during the sampling event since video recording of the entire subtidal cable route had been recently completed on June 13, 2013.

The intertidal habitat characterization was completed during the afternoon of August 7, 2013 and the morning of August 8, 2013.

Subtidal

Benthic infauna samples were collected in triplicate at eleven stations along the transect lines (33 samples). Sediment cores were taken using 4 in. diameter PVC pipe coring devices that were inserted to a depth of 10 cm or full resistance. The contents of the cores were washed through a U.S. Standard No. 35 sieve (500 µm mesh). All material retained on the screen was transferred into plastic sample jars and the jars filled with 10% buffered formalin. Several drops of a 1% Rose Bengal staining solution were added to each sample to assist in the sorting of organisms.

After 5-10 days of fixing, the formalin solution was decanted from the sample jars through a 500 μm mesh sieve and the formalin volume replaced with 70% ethanol to insure preservation of the organisms' integrity, particularly the bivalves and other calcareous forms.

During processing, organisms were sorted from the sediment under lighted magnification lenses and/or binocular dissecting microscopes. Organisms collected from the samples are identified to the lowest practical taxonomic level and enumerated under a stereoscopic dissecting scope to 63x power. Data resulting from the sample processing are entered into an Excel spreadsheet developed by MER that calculates statistics for abundance, taxa richness, and relative diversity (Shannon-Weiner Index, J'). Standard operating procedures for the collection and processing of benthic infauna samples are attached as Appendix I.

Intertidal

Sampling was conducted at three levels within the intertidal zone: (1) upper intertidal (H), (2) mid-intertidal (M), and (3) lower intertidal (L). Three subsets with three replicates each were sampled within each level, thus 9 samples were collected within each level for a total of 27 samples.

Within each subset of each sampling level a 0.25 m^2 (0.5 m/side) 1.27 cm (½-in.) PVC pipe frame was randomly placed to avoid visual bias of the area to be sampled. Prior to sampling, a pre-sampling photo was taken of all sampling stations with frame and station label in place. Where present, all flora (rockweeds) within the frame were removed by cutting down to the base of the holdfast with either scissors or a knife and the collected material placed in a prelabeled plastic bag. On hard substrate, following removal of the rockweed, all organisms within the frame were removed either by picking with forceps or scraping with a narrow paint scrapper or knife (barnacles were counted in situ). In softer sediment where coring was allowed, core samples were collected using 10 cm (4 in.) diameter PVC pipe coring devices and samples processed as described above under Subtidal Benthic Infauna Sampling. All removed material, picked, scraped, or sieved, was placed in one or more pre-labeled 1000 ml Nalgene container and 10% buffered formalin added to cover the organisms. Following collection of all flora and fauna, a post-sampling photo was taken of each station with frame and station label in place. Processing of core samples is the same as described above for the subtidal benthic core samples.

At the completion of on-site sampling, wet-weight of all rockweed samples (including associated fauna, e.g. periwinkles) was measured using a Mettler Toledo BD601scale (600g ± 0.01g / SN 09031AB) tared for an 8 in. aluminum pie pan; some samples required multiple partial weighing. Following weight measurement and recording, the rockweed was placed in an 80 cm by 46 cm by 29 cm fish tote partially filled with freshwater and swirled and agitated to remove all associated organisms. The rockweed was then removed and discarded and the contents of the fish tote poured through a 500 μm mesh screen. Material retained on the screen was then transferred to the Nalgene container corresponding to the station and replicate. All collected material was placed in one or more pre-labeled 1000 ml Nalgene containers and 10% buffered formalin added to cover the organisms.

Once at the lab, each sample was poured onto a 500 µm mesh screen and rinsed. All large organisms, e.g. mussels and snails, were removed, identified, enumerated, and transferred back into the Nalgene container with 70% ethyl alcohol (ethanol, EtOH) for archiving. The remaining small organisms were transferred into smaller Nalgene containers for subsequent microscopic identification and enumeration. Organisms collected from the samples will be identified to the lowest practical taxonomic level and enumerated under an Olympus SZ-60 stereoscopic dissecting scope to 63x power. Data resulting from the sample processing will be entered into an Excel spreadsheet developed by MER that calculates statistics for abundance, taxa richness, and relative diversity (Shannon-Weiner Relative Diversity Index, J'). Standard operating procedures for the collection and processing of intertidal benthic infauna samples was the same as that for the subtidal benthic infauna samples (refer to Appendix I).

4.1.3 Biofouling Assessment

ORPC performed a biofouling assessment during the afternoon of July 15, 2013 while the TidGen® TGU was berthed at the end of the Morrison Landing Pier as well as the same evening following its relocation to the boat ramp. The TidGen® TGU was assessed for percent coverage of biofouling on distinct structural components, and biological samples were taken from representative locations. ORPC performed a visual inspection of corrosion to the host surface in two sections of dense growth; a sacrificial anode and a section of the mounting bracket to the bottom support frame. The following procedures were followed for the inspection:

a. Sections were chosen that were both accessible and have been largely affected by biofouling.
b. Several square inches of plant or animal life were removed by scrapping with a plastic card to expose the surface underneath.
c. The exposed surface was inspected and photographed for corrosion. This surface was compared to a nearby region that had not been affected by biofouling. A detailed description of the appearance was recorded, including notes on discoloration or peeling of paint, exposure of metal underneath, and extent of region affected.

ORPC also evaluated the effectiveness of a test patch of antifouling paint, described further in Section 4.2.3.

On July 10, 2013, two divers recorded footage of the TidGen® bottom support frame for an assessment of scouring around each of the ten piles. The footage from the scouring inspection was used to generate a qualitative report of biofouling on the bottom support frame. Screenshots were taken from the videos of the piles, anodes visible in the footage, and other locations showing significant signs of biofouling. Videos were analyzed in QuickTime Play, and snapshots were taken using Microsoft Snipping Tool. ORPC's assessment included three segments: pile observations, frame observations and anode observations.

4.2 Results

4.2.1 Benthic Survey of Cable Route

Diver Video
Direct comparison between the July 2013 diver video survey and the July 2011 baseline survey was not possible due to the spatial offset between the two. Nevertheless, the July 2013 observations are generally consistent with those of the original baseline video survey of July 2011, i.e., sea urchins, sea peaches, sea cucumbers and scallops were observed as abundant to common in the shallower sections, and sea potatoes, northern red anemones, urchins and sea stars were the predominant organisms in the deeper sections. The northern sea cucumber appeared more abundant in deeper water than previously observed, and northern red anemones also appeared to be abundant where they were previously only common. Sea scallops appeared to be more abundant between Stations 4 and 6; an increase in relative abundance of sea cucumbers and sea scallops was consistent with a reduction in dragging activity for these commercially important species in the immediate vicinity of the cable route.

As in previous monitoring events, the video transect was offset from the *As built* cable route at certain locatons as well as the original baseline survey route. However, the exposed transmission and data cables were seen for several meters in the shallower area and only minimally and partially buried in the deeper section. As before, where the cable is visible on the surface, the cable was observed to be firmly stapled to the bottom and there continued to be little, if any, evidence of scouring or disturbance to the bottom caused by the cable(s). Also, as previously reported, epifauna, including green sea urchins, northern red anemones, sea peaches and sea scallops were seen adjacent to, and in some cases attached to, the cable(s). Based on these observations, it does not appear that the cables are causing any discernible adverse impacts to the substrate habitat or the associated epifauna.

Drop camera
The fauna observed along the drop camera video segments are consistent with the diver recorded video in the same general vicinity. Relative abundance was also generally similar, although some variations exist between the reviews of the diver recording and that of the drop camera.

The combination of the incoming tidal current with an opposing wind out of the northeast made maneuvering of the vessel difficult when crossing the current. Acceleration of the vessel to maintain course caused the camera frame to be raised high off the bottom. Deceleration to allow the camera frame to ride at an appropriate distance off of the bottom resulted in a northwest drift as a combination of the current and wind forces. To complete the transect, the vessel was repositioned several times and allowed to drift with periodic engagement of the engine; this resulted in a zigzag course across the cable route area and periodic “flying” of the camera frame off the bottom.

The high current velocities along the cable route, particularly in the deeper area in the vicinity of the TGU, present substantial challenges for remote video recording. The slack water period during which video recordings can be made unaffected by the current is very short. As mentioned previously, on this occasion recording in the vicinity of the TGU was delayed until the current had shifted to incoming to avoid any possible entanglement with the TGU. Future recordings starting at slack water may provide sufficient time to complete the transect before the current becomes excessively fast.

4.2.2 Benthic Sampling Results

Subtidal
The results of the subtidal benthic infauna analyses for each station, based on the three replicates taken at each station, are summarized in MER's Report (Appendix C) and include total organisms found in the sample, abundance as organisms/0.1 m^2, taxa richness (at species and family levels), and relative diversity (Shannon-Wiener). Detailed information on infauna composition at each station by replicate and photos of the sediment composition at each station are included as Appendices to MER's report.

Intertidal
The upper (high) intertidal area (H) is composed of loose rocks overlying pebbles and coarse sand/fine gravel. The rocks, cobble and pebbles at this upper level of the intertidal area appear subject to shifting, either from currents or waves affecting the area. No flora was observed in any of the three sub-sampling levels (H1, H2, and H3) within this area and the only fauna observed were unidentified amphipods sheltered within the rockweed "wrack" (H1) and cobble and coarse sand (H2, H3).

The mid-intertidal area (M) consists of a shallow layer of rocks, pebbles, and very coarse sand over a sticky marine clay base. The clay appears to provide some sediment stability within this level compared to the upper level, thus allowing it to support flora and fauna, albeit still limited and patchy. The flora is rockweeds, *Fucus* spp. which occurs in small quantities, primarily as geminating plants. Epifauna observed during field sampling include barnacles, *Balanus balanoides*, common periwinkle, *Littorina littorea*, and green crabs, *Carcinus mae*nas.

The lower intertidal area (L) has a sediment composition similar to that of the mid-level area, but with slightly more softer silt, *i.e.* mud layer, as is evident from the post-sampling photographs. Flora is rockweeds, primarily *Fucus* spp. with some *Ascophyllum nodosum* present at all sublevels. Epifauna observed at this lower level include barnacles, *Balanus balanoides*, common periwinkle, *Littorina littorea*, green crabs, *Carcinus mae*nas, common limpet, *Tectura (Acmea) testudinalis*, blue mussels, *Mytilus edulis*, one soft shell clam, *Mya arenaria*, and unidentified amphipods.

Benthic infauna cores were taken using the same methods for collection and preservation described above for the subtidal benthic cores. These will be processed and analyzed using the same methods described above for the subtidal benthic cores and the final results will be reported in the final report along with the subtidal benthic infauna results.

4.2.3 Biofouling Results

TidGen® TGU
The biofouling assessment indicated minor biofouling of the TidGen® TGU. The most significant growth occurred on the generator, sacrificial anodes, and bearing mounts, and on mounting brackets with flat surfaces and complex geometry. Additionally, the evaluation of the applied anti-fouling paint determined that it was not effective in reducing marine growth on the generator (Figure 18-21).

Immediately after retrieval, all regions of biofouling occurrence were photographed for future reference. Additionally, each major component of the TGU was assessed for the percent of surface covered with plant or animal life. The plant and animal species were identified, and the growth was described in terms of plant size, color, strength of adherence, etc. Table 3 describes the location of growth, type of growth and approximate percentage of cover.

Table 3. *Biofouling description for TidGen® components*

Component	Approximate % Cover	Description of Growth
Generator	75	Predominantly tubularian hydroids and lesser barnacles and filamentous algae
Bracelet Anodes	95	Barnacles
Disc Anodes	95	Barnacles and algae, growth on flat surface, rounded edge, and in between stacked discs
Long and Short Flush Mount Anodes	95	Barnacles, >1 cm thick
Chassis	Flat structures – 25 Tubular structures - 5	Flat surfaces – barnacles and algal growth Tubular surfaces – minor algal growth
Foils	10-15	Tubularian hydroids and barnacles
Bearing Mounts and top of Pedestals	50-75	Tubularian hydroids, barnacles and filamentous algae
Mounting brackets to bottom support frame	75	Barnacles, mussels (lower half and behind tubular) and tubularian hydroids

Figure 18. TidGen® TGU following retrieval, July 15, 2013.

Figure 19. TidGen® generator, July 15, 2013.

Figure 20. Bracelet anode.

Figure 21. TGU mounting bracket to bottom support frame

The biofouling inspection identified the presence of the following species:

<u>Plants</u>
Filamentous Algae
Mermaid's Hair

<u>Animals</u>
Barnacles
Blue mussels
Tubularian hydroids

ORPC collected three biologic samples of representative marine growth on the TGU. Samples were removed from the structure with a plastic card to prevent damage and stored in plastic sample jars. Samples were labeled and preserved with Formalin.

ORPC performed a visual inspection of corrosion to the host surface in two sections of dense growth, a sacrificial anode and a section of the mounting bracket to the bottom support frame. A description of the corrosion after removal of the marine growth is summarized in Table 4.

Table 4. *Summary of Corrosion*

Component of TGU	Approximate % Cover	Description of Corrosion after growth removal
Bracelet Anode (Figure 9)	90% barnacle	Small cavities forming underneath growth, as anticipated. Refer to complete Anode Inspection for results of anode-specific inspection.
Mounting bracket to BSF Figure 10)	60% barnacle, 10% filamentous algae, 5% tubularian hydroid	No corrosive effects to surface. Slight residue left underneath barnacles, to be removed during power washing.

Biofouling of Other TGU Components
As additional inspections were performed, components of the TGU were made accessible that could not be inspected as part of the initial biofouling report, performed July 15, 2013. Minor biofouling was observed on the anodized aluminum Prevco housing, Prevco connector locker rings and inside the "doghouse."

On the Prevco housing, several hydroids and barnacles were affixed to the face of the housing unit. Effects of biofouling were also seen on the doghouse lid, with some growth of filamentous algae. The Prevco locking rings showed growth of predominantly barnacles --hard fouling creatures.

Bottom Support Frame
Analysis of the screenshots taken from the July 10, 2013 videos of the bottom support frame, piles, anodes visible in the footage, and other locations show signs of significant biofouling in certain areas.

The following species were identified during the video review:

- Blue mussels
- Urchins (rock boring)
- Sea stars
- Barnacles
- Algae
- Mermaid's hair
- Hydroids

Overall, fouling did not seem to inhibit functionality of the bottom support frame; however, it could potentially interfere with conduits and fire hoses. The following observations were made:

- Anodes on outermost frame members had dense barnacle growth.
- Anodes that were internal to the structure were relatively clean.
- Piles 9 and 10 have significantly more biofouling than other piles.
- The stretches of frame between piles 1 and 2 and between piles 9 and 10 had very dense barnacle growth, favoring the side closer to piles 2 and 10.

Figure 22, Figure 23, Figure 24 and Figure 25 show varying degrees of biofouling among the bottom support frame components. Figure 26 summarizes areas of biofouling on the bottom support frame.

Figure 22. Inboard anode 3-3-4 showing minimal biofouling

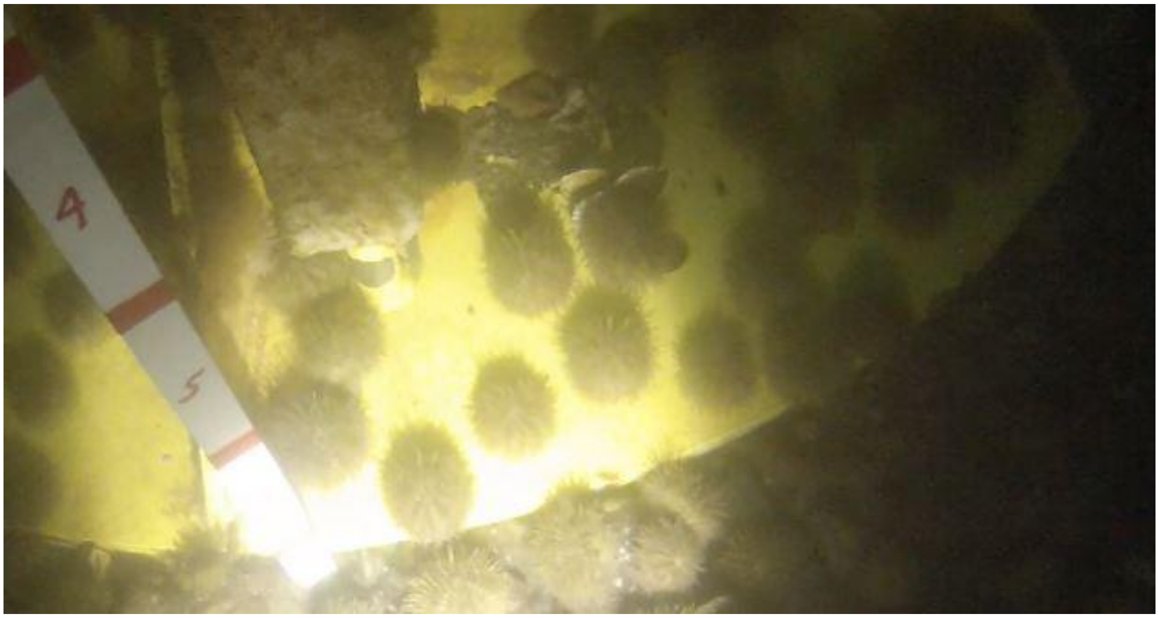


Figure 23. The outboard side of pile 1 with urchins, several mussels and anemones.

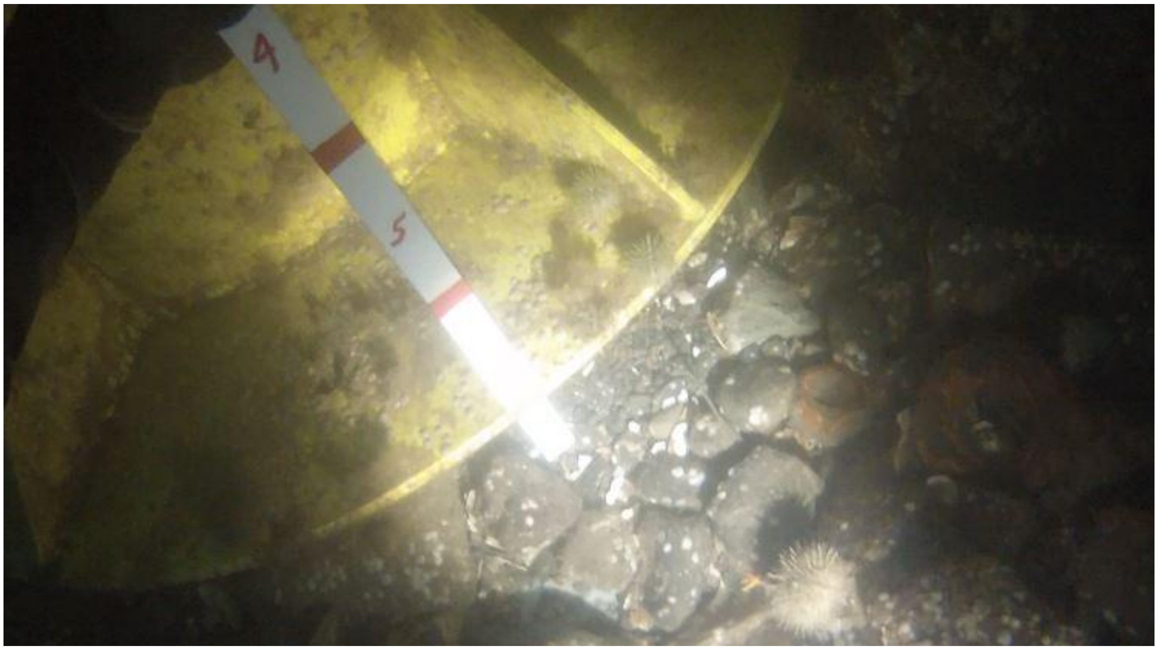


Figure 24. The base plate on pile 5 showed minimal growth.

Figure 25. Significant growth between piles 1 and 2.

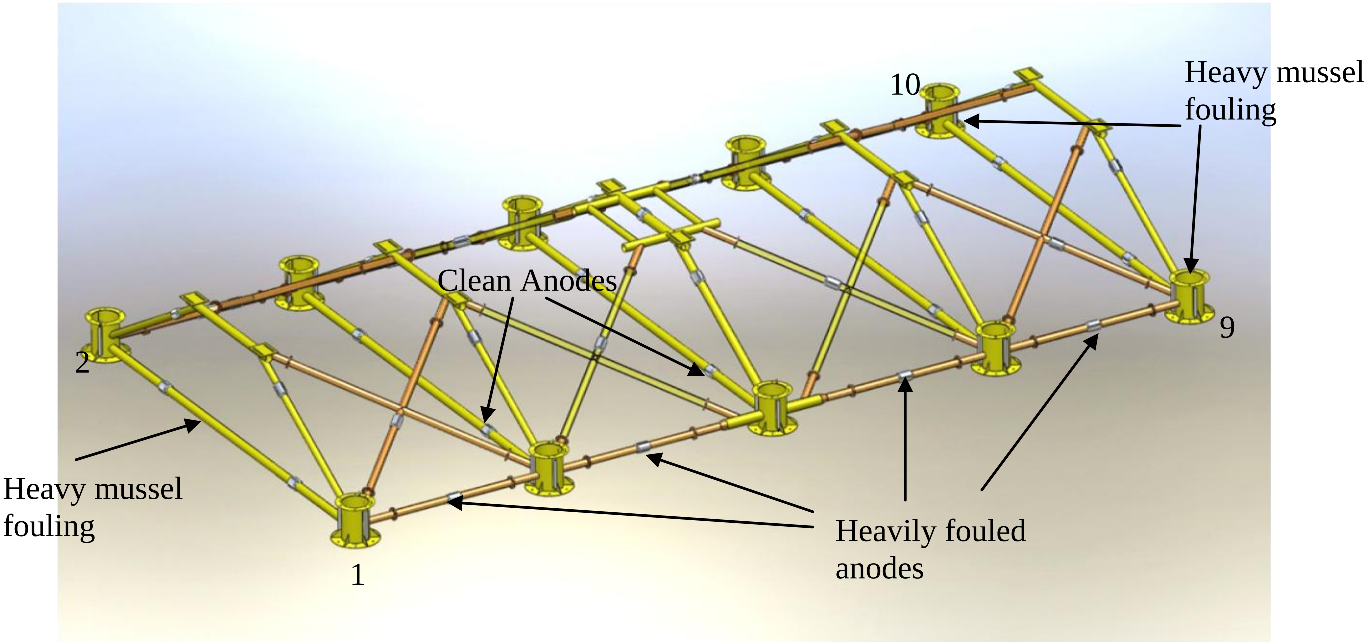


Figure 26. Schematic of bottom support frame biofouling

Effectiveness of Anti-Fouling Paint.

Nanomyte TC-4001M Metal Coat anti-fouling paint was applied to a section of the generator while it was out of the water and following notification of the Project's Adaptive Management Team on February 13, 2013,. The coating test application area is approximately 17.3 in. wide by 21.3 in. high (masking tape included) located on the TidGen® generator back lower quadrant. The top of the test area block was about 5.5 in. down from the generator back structural rib, and the sides of the block are adjacent to the edge of the electronic case struts to the generator (Figure 27). Test Area 1, 2, 3, and 4 are approximately 6.0 in. wide x 8.0 in. high. Area 5 is approximately 3.3 in. x 3.3 in.

The Amerlock Yellow Coating at Areas 1, 2, 3, and 4 were first sanded with 220 grit paper, wiped with a tack clock, and then wiped with a clean lint-free cloth. The Area 5 surface was neither sanded, nor wiped.

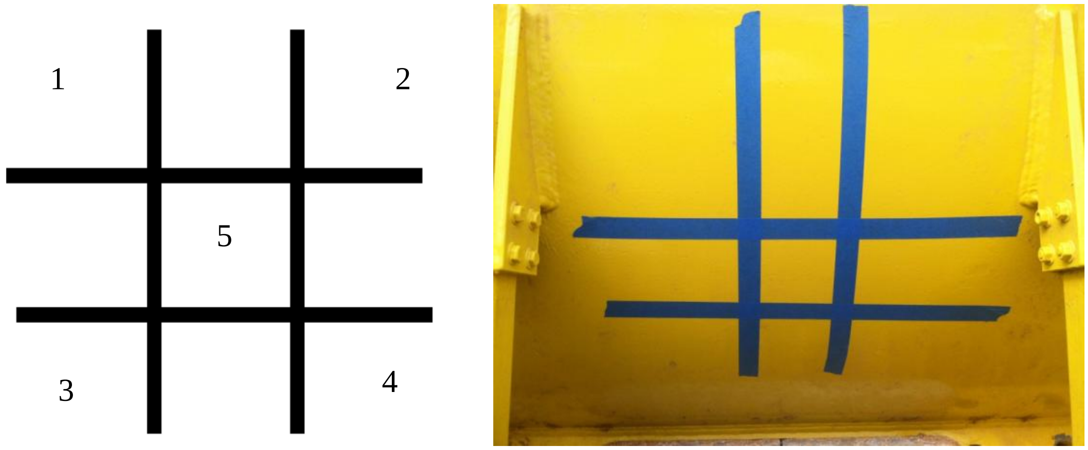


Figure 27. Diagram of anti-fouling paint upon application.

Following retrieval ORPC evaluated the area which was applied with anti-fouling paint (Figure 28). A description of each section is provided in Table 5.

Figure 28. Area treated with anti-fouling tape upon inspection.

Table 5. *Evaluation of anti-fouling paint*

Section 1 *Sanded and wiped* Description of growth: 40% Hydroid, 5% barnacle, 20% algae; Hydroids clustered on outer edge	Not treated	**Section 2** *Sanded and wiped* Description of growth: 25% Hydroid, 5% barnacle, 15% algae; Hydroids clustered on outer edge
Not Treated	**Section 5** *NOT sanded or wiped* Description of growth: 35% Hydroid, 25% barnacles, 35% algae; Barnacles clustered on upper tape line	Not Treated
Section 3 *Sanded and wiped* Description of growth: 5% Hydroid, 30% barnacle, 60% algae; Barnacles clustered on upper tape line	Not Treated	**Section 4** *Sanded and wiped* Description of growth: 15% hydroid, 20% barnacles, 70% algae; barnacles clustered on upper tape line

ORPC's evaluation of the applied anti-fouling paint has determined that it was not effective in reducing marine growth on the generator as applied. Conversations with the material supplier strongly suggest that the coating was not applied in a proper fashion. Any results from this test were therefore inconclusive.

4.3 Conclusions and Recommendations

Cable survey
MER's assessment indicated the diver recorded video quality is very good and offers a clear view of the benthic habitat and associated flora and fauna. The drop camera video quality was generally good, although the current velocity and consequent speed of the camera frame along the bottom made the review process challenging along certain transects. The quality and usefulness of the drop camera videos can likely be improved by making changes to the timing and sequence to the recording of the transects to avoid high current periods.

The faunal community observed along the diver recorded video and drop camera video segments were consistent for the same general vicinity covered by both and were also generally similar to the faunal community distribution observed during the baseline survey of July 2011.

Relative abundance was also generally similar although some variations exist between the diver recording and that of the drop camera due to the different areas covered. Based on observations of the exposed cable(s) there continued to be little, if any, evidence of scouring or disturbance to the bottom or the associated faunal community.

Benthic Sampling
As was previously found, with the exception of the softer, nearshore bottom, the sediment composition over much of the sampling area made collection of accurate benthic cores difficult to near impossible with some samples being “scooped” into the corer by hand by the diver. The benthic infauna data from these cores therefore needed to be treated as semi-quantitative and generally characterizing the benthic infauna community rather than strictly quantitative.

The benthic infauna samples collected along the shallower portion of the subtidal cable route (Station 1-5) at the Upper Cobscook Bay site contained 113 species representing 81 families with polychaetes representing 51.6% of the organisms found. The families most represented, in rank order, were Sepulidae (Spirorbis sp.), Spionidae, Paraonidae, Cirratulidae, Terebellidae, Ampharetidae, Syllidae, Lumbrineridae and Opheliidae, together representing, 47% of all organisms, all families normally found in clean environments with sandy to coarse sediments. Other polychaete families represented included Capitellidae, Phyllodocidae, Polynoidea, Sigalionidae, Nephtyidae, Hesionidae, Nereidae, Scalibregmidae, Maldanidae, Eunicidae, Dorveillidae, Cossuridae, Pectinaridae, Flabelligeridae, Sabellidae and Orbiniidae. Mollusks, representing 18.3% of all organisms, were dominated by Anomia sp., found attached to rocks and shells, representing 13% of the organisms. Crustaceans account for 9.0% of all organisms and were dominated by barnacles and amphipods. Together these represented 87.3% of the 4,442 organisms identified from the 5 stations.

The benthic infauna samples collected along the deeper portion of the subtidal cable route (Station 6-11) at the Upper Cobscook Bay site contained 104 species representing 74 families with mollusks representing 52.9% of the organisms and dominated by *Mytilus edulis* (36.2%) and Anomia sp. (12.4%). Polychaetes represented only 11.6% of the organisms found. The families most represented, in rank order, were Sepulidae (Spirorbis sp.), Polynoidea, Eunicidae, Sigalionidae, Capitellidae, Terebellidae, Syllidae, Ampharetidae, and Cirratulidae. Other polychaete families represented included Phyllodocidae, Spionidae, Paraonidae, Opheliidae, Nereidae, Pectinaridae, Sabellidae and Orbiniidae. Crustaceans accounted for only 3.5% of all organisms; entoprocts represented 25.6% of the population. Together these represented 91.7% of the 8,079 organisms identified from the 6 stations.

Combined, the shallow and deep sampling locations contained 12,521 organisms representing 143 species and 102 families; this was somewhat greater than the 127 species and 90 families found in the 2011 baseline samples as well as the 131 species representing 78 families found in a similar study in Deep Cove in Lower Cobscook Bay in 2009. All of these sampling events were indicative of the biological and functional diversity for which Cobscook Bay and the region is renowned.

The intertidal area remains essentially unchanged other than a reduction in *Fucus* spp. and *Ascophyllum nodosum* in the Middle level and the decrease in number of blue mussels, *Mytilus edulis* in the Lower level where they were found to be abundant during the July 2011 baseline survey. This reduction in mussels, most of which were rather small in 2011, may be related to the increased presence of the green crab, *Carcinus maenas*, which was commonly to occasionally found in the Lower level (L1 and L2; none in L3) in this recent survey but absent in 2011. *C. maenas* has been implicated in a near complete elimination of small soft-shell clams, *Mya arenaria*, in several coastal areas of Maine during the 2013 summer season, especially Casco Bay (pers. obs.); *C. maenas* is known to prey on mussels as its preferred diet (Ropes, 1968).

The intertidal grid sample results again showed the upper, high intertidal area (H) area being essentially barren of organisms except where the seaweed wrack provides shelter to small amphipods (see benthic core results below). The mid-intertidal (M) and lower-intertidal levels (L) offer habitat for isopods, *Idotea* spp., primarily associated with rockweeds, which are the most numerous species at 2,972 individuals representing 56.2% of all organisms found. The common barnacle, *Balanus* sp., ranks second at 1,124 individuals counted representing 21.3% of all organisms found. Other species found, in rank order, are the smooth periwinkle (9.6%), *Littorina obtusata*, common periwinkle (7.1%), *L. littorea*, and rough periwinkle (2.1%), *L. saxatilis*; common amphipods, *Gammarus* sp, represent 147 organisms or 2.8% of the organisms found. Together these species represent 5,239 or 99.1% of the 5,289 organisms found. Other organisms found in very small numbers include Cumaceans, *Diastylis quadrispinosa*, the green crab, *Carcinus maenas*, the limpet, *Tectura (Acmea) testudinalis*, mud snail, *Ilyanassa* sp., blue mussel, *Mytilus edulis*, and oligochaetes.

Compared to the 2011 samples results, the mid-level (M) shows a reduction in both number of species and abundance, but this reduction appears related to the reduced amount of rockweed cover, (which provides both habitat as well as protection from desiccation) in 2013 within the level; the reduced amount of rockweed may or may not be related to the installation of the cable since rockweed cover is naturally patchy in the intertidal as shown in Figures 5 and 6. Results for the lower intertidal level (L) are very similar to those of the 2011 sampling event with number of species higher in 2013, although the dominant species remain the same, and abundance being very similar.

The intertidal benthic cores are dominated by oligochaetes representing 2,298 or 79.1% of the 3,144 organisms found in the samples; these are found primarily in the lower intertidal level with some in the middle intertidal level. The isopod, *Idotea* sp., is found in the lower level (associated with rockweeds) and represents 9.4% of the benthic cores population. Amphipods, *Talochestia* sp., found in the upper (H) area associated with wrack weed, and *Gammarus* spp. found in the lower level, represent 7.1% and 6.0% of the population, respectively. Together, these species represent 3,008 or 95.7% of the organisms found in the benthic cores taken in the intertidal area.

The results of the intertidal benthic infauna core samples show strong similarity between the 2011 and 2013 samples, the number of species being the same and the dominant taxa being oligochaetes and nematodes in the mid-level. In the lower level (L) the number of species is higher in 2013 compared to 2011, but the population is again dominated by oligochaetes and nematodes. The 2011 lower level benthic core samples also contained blue mussels, *Mytilus edulis*, which were absent in 2013. Again, as mentioned above, the lack of small mussels may be related to the increase in green crabs observed at the site. The 2013 samples contained isopods and amphipods not seen in 2011. These latter differences are likely attributable to normal seasonal and inter-annual differences.

Biofouling Assessment
The biofouling assessment performed on the TidGen® TGU immediately following retrieval in July 2013 indicated minor overall biofouling. The most significant growth occurred on the generator, sacrificial anodes, bearing mounts, and on mounting brackets with flat surfaces and complex geometry. Additionally, the evaluation of the applied anti-fouling paint determined that it was not effective in reducing marine growth on the generator.

Analysis of the screenshots taken from the July 10, 2013 videos of bottom support frame piles, anodes visible in the footage, and other locations show signs of significant biofouling in certain areas. However, biofouling did not appear to be compromising the functionality of the bottom support frame.

5.0 FISHERIES AND MARINE LIFE INTERACTION MONITORING (License Article 407)

The goal of the Fisheries and Marine Life Interaction Monitoring Plan was to collect pre-deployment and post-deployment information to provide an initial description of fish distribution and relative abundance within Cobscook Bay to supplement existing information for the general Passamaquoddy Bay area. Specific objectives included:

- Characterize fish presence and vertical distribution in Cobscook Bay with acoustic technologies
- Conduct stratified sampling to evaluate tidal cycle, diel, and seasonal trends
- Characterize fish distribution, species, and relative abundance and summer seasonal occurrence with multiple netting efforts in open-water pelagic and benthic areas, near-shore sub-tidal areas, and intertidal areas of outer, middle, and inner bays within Cobscook Bay
- Use data gathered to develop a preliminary assessment of the potential effects of the Project on fish populations in the Deployment Area and to the extent possible in Cobscook Bay
- Monitor indirect fish interactions with the TidGen® devices(s) to evaluate potential Project effects
- Evaluate potential cumulative effects of the Project based on this comprehensive data set and the direct interaction monitoring data collected

UMaine prepared the Fisheries and Marine Life Interaction Monitoring Plans Annual Report, September 2013 (Appendix D). Phase I of the Project requires monitoring to assess potential effects of the TidGen® Power System on the marine environment. ORPC's monitoring plan regarding marine life has two parts: (1) Fisheries Monitoring Plan and (2) Marine Life Interaction Monitoring Plan.

Fisheries Monitoring Plan
The Fisheries Monitoring Plan was a continuation of research started by UMaine's School of Marine Science researchers in 2009. The study was designed to capture tidal, seasonal and spatial variability in the presence of fish in the area of interest (near the TidGen® deployment site). The design involved down-looking hydroacoustic surveys during several months of the year, and examined the vertical distribution and relative abundance of fish at the project and control site (for relative comparison). Predeployment data were collected in 2010, 2011, and early 2012, and post-deployment data were collected from August 2012 through September 2013 (August 2012 through June 2013 are reported here). Data from the Project site were compared to the control site to quantify changes in fish presence, density, and vertical distribution that may be associated with the installation of the TidGen® Power System.

Marine Life Interaction Monitoring Plan
The Marine Life Interaction Monitoring Plan used side-looking hydroacoustics collected by ORPC at the Project site to assess the interaction of marine life (fish, mammals and diving birds)

with the TidGen® device. This monitoring focused on the behavior of marine life (primarily fish) as they approached or departed from the region of the TGU and attempted to quantify changes in behavior in response to the TidGen® unit. The approximate location of the side-looking hydroacoustic device is shown on Figure 29.

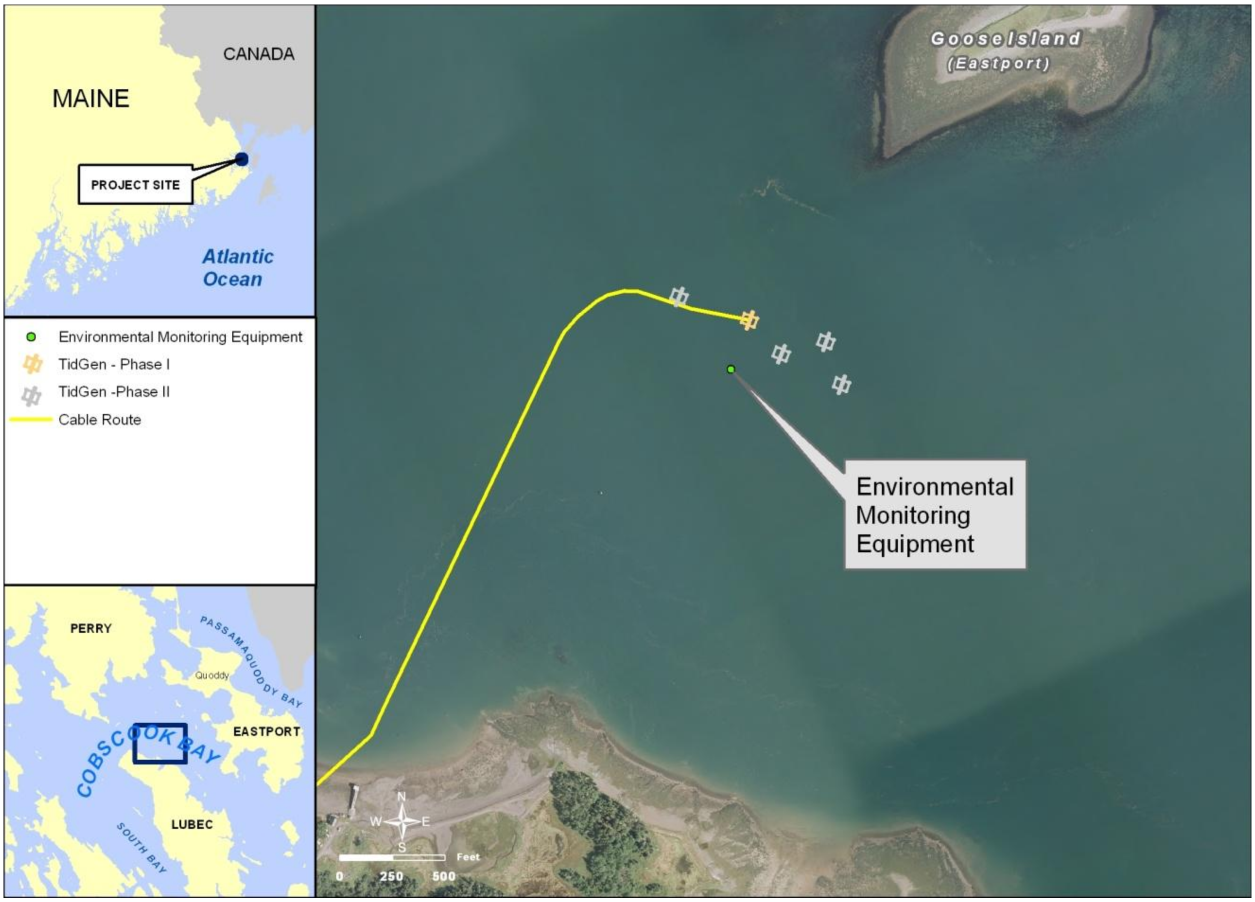


Figure 29. Location of TidGen® 001 and environmental monitoring equipment.

5.1 Methodologies

5.1.1 Fisheries Monitoring Plan (Down-looking Hydroacoustic Surveys)

Fisheries Study Design

Down-looking hydroacoustic surveys were conducted from an anchored research vessel for one 24-hour period several times per year at a project site (CB1) and a control site (CB2) (Table 6, Figure 30). During the time when the complete TidGen® device (bottom support frame and the TGU) was in the water (from here on referenced as "deployment"), three sites were sampled: two at the project location (CB1a, beside the turbine, and CB1b, in line with the turbine) and one at the same control site (CB2) (Figure 30). Sampling locations at the project sites in 2012 varied geographically because of construction activities and related safety concerns around the TidGen®

device. January and March 2012 were pre-deployment surveys, so only CB1 and CB2 were sampled. In January, CB1 was only sampled for 12 hours due to unsafe weather conditions. There was no November 2012 survey because the TidGen® TGU was removed for maintenance at the time.

The down-looking surveys were carried out using a single-beam Simrad ES60 commercial fisheries echosounder, with a wide-angle (31° half-power beam angle), dual-frequency (38 and 200 kHz) circular transducer. The transducer was mounted over the side of the research vessel 1.8 m below the surface, and ensonified an approximately conical volume of water extending to the sea floor. Current speed was measured every half-hour of each survey using a Marsh-McBirney flow meter (May 2011 to May 2012) or a Workhorse Sentinal Acoustic Doppler Current Profiler (ADCP) (June 2011 onward). A 300 kHz ADCP was used in 2011 and 2012, and a 600 kHz ADCP was used in 2013. Every 30 minutes, the ADCP operated for 1 minute, recording mean current speed in 1 m depth bins from 3 m below the surface to the sea floor.

Table 6. *Months sampled for Fisheries Monitoring Plan (down-looking hydroacoustics). 1 and 2 indicate sampling at CB1 and CB2, respectively; 1a, 1b, and 2 indicate sampling at CB1a, CB1b, and CB2, respectively. Light gray indicates presence of TidGen® bottom support frame only; dark gray indicates presence of complete TidGen® device.*

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2010					1, 2			1, 2	1, 2	1, 2	1, 2	
2011			1, 2		1, 2	1,2		1, 2	1, 2		1, 2	
2012	1, 2		1, 2		1a, 1b, 2	2		1a, 1b, 2	1a, 1b, 2			
2013			1a, 1b, 2		2	2						

Figure 30. Fisheries Monitoring Plan study area and down-looking hydroacoustic survey locations for 2010-2013. CB1 and CB2 are indicated by dashed ovals. CB1a and CB1b are indicated by small round points. CB1 current directions are averages provided by ORPC.

The single-beam transducer was used to obtain an index of fish density, which allowed UMaine to examine changes in fish density over time. This relative measure was also used to assess vertical distribution of fish throughout the water column.

Comparisons of fish density and vertical distribution were made among the control site and project site(s) and among different months at each site. Sampling before and after turbine deployment at the project as well as at a control site improved the ability to distinguish changes that may be related to the presence of the turbine from changes due to annual, seasonal, daily, and tidal variation. These methods were consistent with a before-after-control-impact (BACI) study design.

Fisheries Data Processing

Hydroacoustic data were processed using Echoview® software (5.3, Myriax Pty. Ltd., Hobart, Australia), and statistical analyses were carried out in R (2.15.2, R Core Team, Vienna, Austria). The data collected at the 200 kHz frequency were used in analyses. Processing included scrutinizing the data and manually removing areas of noise (e.g., from electrical interference, a passing boat's depth sounder, high boat motion, or interference from the ADCP). Hydroacoustic interference from entrained air was common in the upper 10 m of the water column, so the top 10 m of the water column were excluded from analyses. Weak hydroacoustic signals, such as plankton, krill, and fish larvae, were excluded by eliminating backscatter with target strength (TS) less than -60 dB. Most fish have TS between -60 dB and -20 dB but TS varies greatly with fish anatomy and orientation (Simmonds and MacLennan 2005). This variability, combined with the TS uncertainty inherent in single beam systems, means that some fish with TS higher than -60 dB were likely excluded from analyses (Simmonds and MacLennan 2005).

In March and June of 2013, some weak background noise from electrical interference could not be eliminated using the -60 dB threshold. Echoview's background subtraction tool (based on the algorithm developed by de Robertis and Higginbottom, 2007) was used to remove this interference.

Because flowing tides were the focus of this study, hydroacoustic data during slack tides were not included in analyses. Slack tides were defined as the hour centered at the time of low or high water. The time of low and high tide was determined using the depth of the bottom line detected in Echoview. Thirty minutes to either side of these time points were then removed from the hydroacoustic dataset.

Fish density was represented on a relative scale using volume backscattering strength, Sv, which is a measure of the sound scattered by a unit volume of water and is assumed proportional to density (Simmonds and MacLennan 2005). Sv is expressed in the logarithmic domain as decibels, dB re 1 m-1. The vertical distribution of fish throughout the water column was examined using the area backscatter coefficient, sa, which is the summation of volume backscatter over a given depth range and is also proportional to fish density (Simmonds and MacLennan 2005). The sa is expressed in the linear domain (m2·m-2) and is additive.

The inspected and cleaned hydroacoustic data were divided into 30-minute time segments, which were large enough to minimize autocorrelation but maintain variation in density that occurred over the course of each survey. Echoview was used to calculate the mean Sv of the entire water column for each 30-min interval. Then, for each interval, sa was calculated for 1-m layers of water. Layers were measured upward from the sea floor, rather than downward from the surface, because the turbine is installed at a fixed distance above the bottom (the top of the turbine is 9.6 m above the sea floor). By calculating the proportion of total water column sa contributed by each 1-m layer of water, the vertical distribution of fish was constructed for each 30-min interval.

Fisheries Statistical Analysis

To examine annual, seasonal, tidal, and spatial variability of fish density in the area of interest, comparisons of water column fish density index (SV) were made using permutation ANOVAs (R package lmPerm; Wheeler 2010), followed by nonparametric Tukey-type multiple comparisons to determine significant differences (R package nparcomp; Konietschke 2012). Five questions were asked:

1) Inter-annual variability: was fish density constant across years? UMaine tested the effect of year on fish density in outer Cobscook Bay, combining data for all sites.

2) Beside vs. in-line with the turbine: were densities similar at the two project sites (CB1a and CB1b)? UMaine tested the effect of site on mean water column SV for surveys in which CB1a and CB1b were sampled (May, August and September 2012, and March 2013). If CB1a and CB1b have similar fish densities, they may be grouped for comparison to CB1 surveys carried out in previous years.
3) Project site vs. control site: is fish density similar at CB1 and CB2, and is CB2 therefore a useful control site? To validate the utility of CB2 as a control site, differences between the project site (CB1) and control site (CB2) were evaluated using month and site as factors.
4) Seasonal variability: is there a consistent seasonal pattern to fish density in outer Cobscook Bay? The effect of month on fish density was tested, combining data for CB1 and CB2.
5) Did deployment of the TidGen® device affect fish density at the project site (CB1)? Results from the tests in (2) were used to compare differences before and after device deployment.

The vertical distribution of fish was compared between sites within each survey, with the goal of detecting differences potentially related to the presence of the turbine. To test the similarity of two distributions, one was fit to the other with linear regression. Similar vertical distributions were indicated by a significant fit (significance level of 0.05) and a positive slope. Negative slope or insignificant fit indicated dissimilar distributions. If distributions at the project and controls sites were similar before the turbine was installed, differences afterward may indicate an effect of the turbine on how fish use the water column (e.g., avoidance of the depths spanned by the turbine). Differences between CB1a and CB1b may also indicate behaviors altered by the turbine's presence.

5.1.2 Marine Life Interaction Monitoring Plan (side-looking hydroacoustics)

Marine Life Interaction Study Design

ORPC mounted a Simrad EK60 split beam echosounder (200 kHz, 7° half-power beam width) to a steel frame located 44.5 m from the southern edge of the TidGen® device (Figure 31). This frame holds the transducer 3.4 m above the sea floor, with the transducer angled 9.6° above the horizontal with a heading of 23.3°. The echosounder sampled an approximately conical volume of water extending for 100 m, directly seaward (southeast) of the TidGen® device (Figure 32). The actual sampled volume used in data analysis did not include the entire beam. The sampled volume extended to the far edge of the turbine (78.1 m), not beyond because after that point, interference from sound reflection off the water's surface became too great to reliably detect fish. The sampled volume was upstream of the device during the flood tide (examining approach behaviors) and downstream of the device during the ebb tide (examining departure behaviors). The echosounder was powered and controlled via undersea cables from the ORPC On-shore Station in Lubec, where data files are stored on a server and collected periodically by UMaine.

Figure 31. Environmental monitoring observation tower.

When operational, the echosounder recorded data continuously. Continuous data collection at a sample rate of 4 to 6 pings per second allowed each fish or other marine animal that passes through the beam to be detected several times, recording information on the echo strength and 3D location of targets within the beam (Figure 33). These data were used to track fish movement during their approach to the turbine (flood tide) as well as during their departure (ebb tide) on a fine spatio-temporal scale. The sampled volume was divided into three zones: the turbine zone (red hatched area, Figure 32a), where fish would be likely to encounter the moving turbine; above the turbine zone (A, Figure 32); and beside the turbine zone (B, Figure 32). Fish numbers and movement in each zone provided indicators of turbine avoidance. The total sampling volume to 78.1 m range (for a 7° hydroacoustic cone) ws 1,866 m3, and of this, 607m3 (33%) were within the turbine zone, 345 m3 (18%) were beside the turbine zone, and 914 m3 (49%) were above the turbine zone.

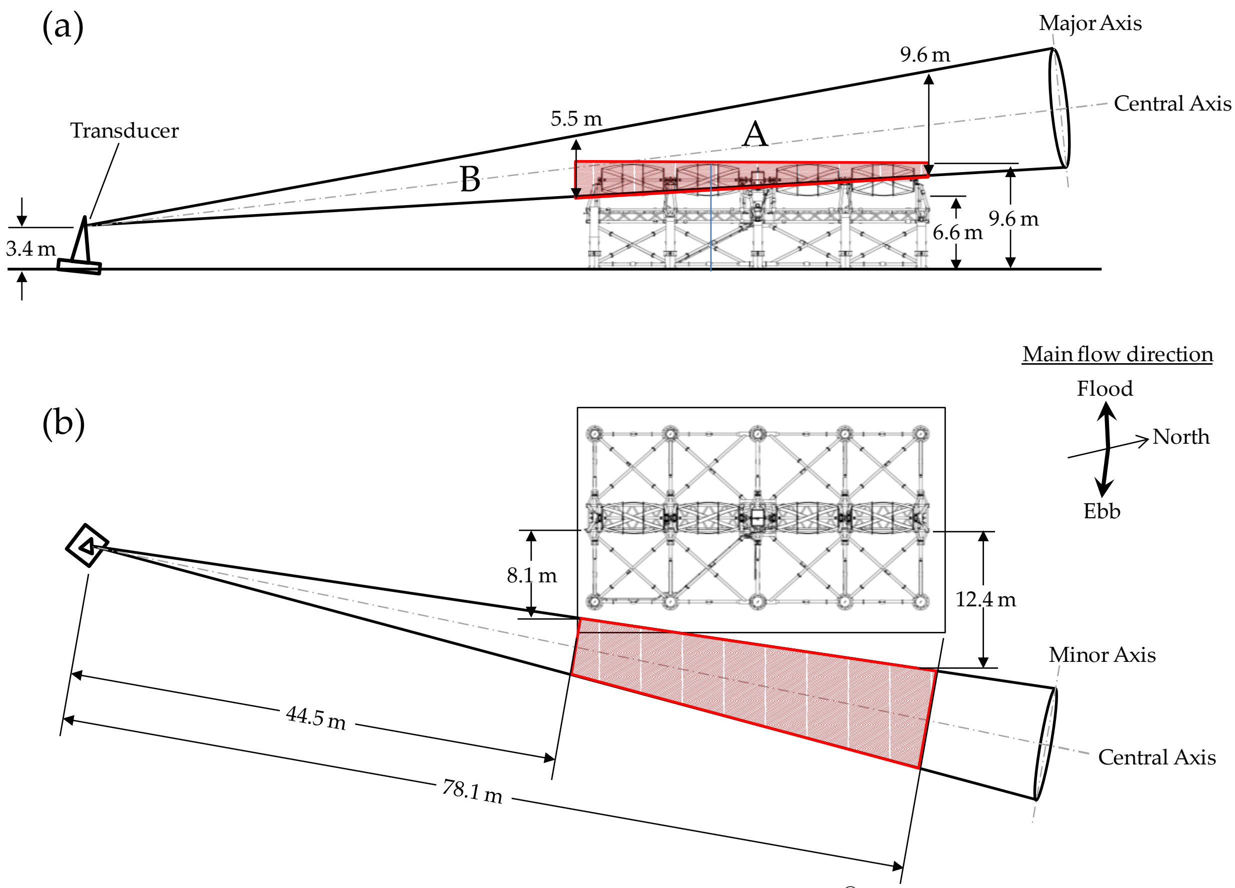
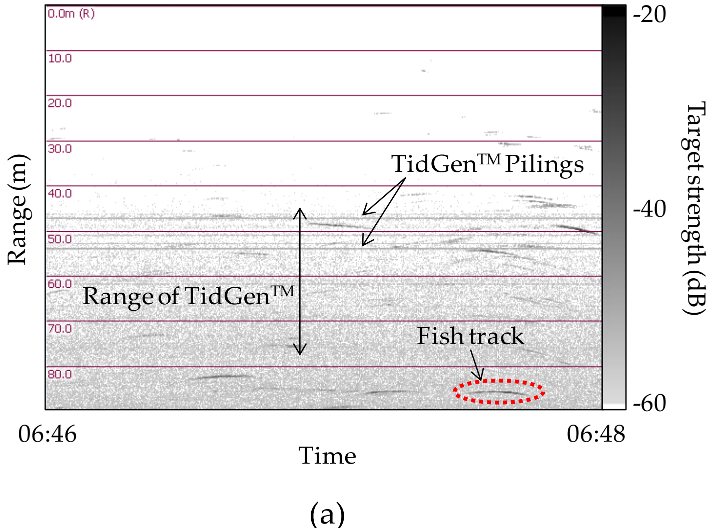


Figure 32. Marine Life Interaction Monitoring Plan setup. TidGen® device and Simrad EK60 support structure shown from (a) the seaward side and (b) above. Hydroacoustic beam represented as 7° cone (half-power beam width) in solid black lines. Red hatched area indicates sampled volume within the turbine zone, A indicates the volume sampled above the turbine, and B indicates the volume sampled beside the turbine. Current directions shown are Project site averages provided by ORPC.



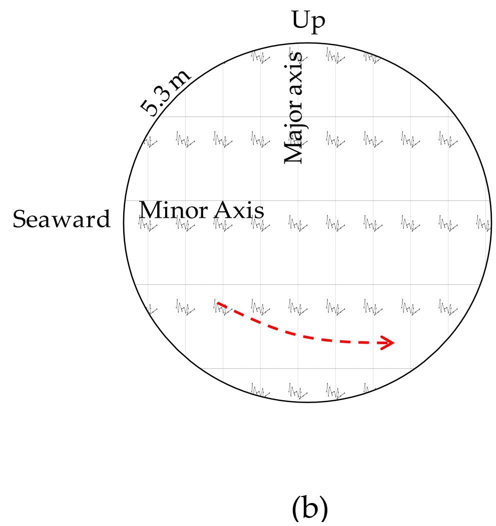


Figure 33. (a) Sample of side-looking hydroacoustic data from September 30, 2012 during the flood tide. (b) Fish in red dashed oval in (a) tracked through beam cross section. Outer circle represents 3.5° off-axis, or 5.3 m at this range. Each dot is a single detection of the fish. Red dashed arrow indicates direction of movement.

ORPC also collected current speed, direction (intermittently; see Section 3.1 and 3.2), turbine movement in rotations per minute (RPM), and turbine operation state (generating or not).

Data Availability
Data collection began on August 29, 2012. Data could not be collected while the turbine was generating power due to electrical interference between the data and power transmission cables running together along the seabed to the shore station. Therefore, hydroacoustic data were collected only for periods of time when the turbine was not rotating (either during slack tides when the current was too weak, or when the brake was applied), or when it was free-spinning (rotating but not generating power). Gaps also existed in the dataset whenever the turbine or hydroacoustic system was being repaired or adjusted, during periods of turbine deployment or removal, and whenever divers were present near the echosounder.

Collection of current speed and direction data by sensors mounted on the TidGen® Power System frame was intermittent. For times when data was available, current direction was not useful for fish behavior analysis due to the placement of ORPC's flow meters, which were oriented to collect information in the plane parallel to the TidGen® device. At times, ORPC collected current speed and direction information with an ADCP placed approximately 4.6 m from the turbine, between the turbine and hydroacoustic transducer. This ADCP operated for various lengths of time (spanning days), obtaining current speed and direction readings every second. When ADCP deployment overlaped with hydroacoustic data collection, the information may be used to analyze fish swimming direction and speed in relation to the current.

Given these constraints to data collection and availability, three subsets of the data collected since August 2012 were analyzed for this report (Table 7). The first two subsets spanned March

19 to 21 and April 18 to April 20, when ORPC ceased normal power generation to allow continuous hydroacoustic data collection with the turbine free-spinning. These dates were chosen because there were nearly two complete tidal cycles during each day and night. While a free-spinning turbine does not have the same hydraulic signature as one generating power, these data should provide a better idea of fish behavior around an operating turbine than data collected while the turbine is held stationary by its brake. Current speed and RPM (range 8.22-16.73) data were available for these time segments. More free-spinning data collection periods had been planned for May, June, July, and August 2013; however, unforeseen circumstances caused turbine operation to cease in April 2013, just after the free-spinning data presented here were collected. The turbine brake was then applied and the turbine held motionless until it was removed in July 2013.

Hydroacoustic data collection continued after the turbine brake was applied, so a third time period was selected from these data for comparison to the free-spinning datasets from March and April. This ‘braked’ dataset spanned April 26 to April 28. These dates were chosen for comparison because they were the closest data available to the April free-spinning period that had similar timing of tides (e.g., nearly two complete cycles during each day and night). Current speed data were not available for this time, however, and were instead estimated using previous current speed data (Section 3.1.3).

Table 7. *Summary of data subset analyzed to date.*

Data subset	Tidal stage	Start Date	Start time	End time	Mean current speed ($m \cdot s^{-1}$)	Duration (hrs)	Mean turbine rotation speed (rpm)*
March Free-spinning	Ebb	3/19/13	17:00	22:20	0.82	5.33	11.80
	Flood	3/19/13	23:15	4:50	0.91	5.58	12.95
	Ebb	3/20/13	5:50	10:40	0.86	4.83	13.52
	Flood	3/20/13	11:40	17:20	0.93	5.67	13.28
	Ebb	3/20/13	18:20	23:20	0.81	5.00	11.95
	Flood	3/21/13	0:20	5:30	0.99	5.17	15.05
	Ebb	3/21/13	6:30	11:40	0.86	5.17	8.22
	Flood	3/21/13	12:40	18:30	0.95	5.83	–
	Ebb	3/21/13	19:30	0:30	0.85	5.00	–
	Flood	3/22/13	1:30	7:00	1.01	5.50	–
	Ebb	3/22/13	8:00	13:00	0.95	5.00	–
April Free-spinning	Ebb	4/18/13	5:00	10:20	0.94	5.33	15.82
	Flood	4/18/13	11:20	16:40	1.02	5.33	16.24
	Ebb	4/18/13	17:40	22:40	0.84	5.00	–
	Flood	4/18/13	23:40	4:50	1.03	5.17	16.24
	Ebb	4/19/13	5:50	11:15	0.91	5.42	15.24
	Flood	4/19/13	12:15	17:30	1.01	5.25	16.22
	Ebb	4/19/13	18:30	23:40	0.86	5.17	14.51
	Flood	4/20/13	0:40	6:00	1.01	5.33	16.73
April Braked	Flood	4/26/13	7:00	12:00	1.22*	5.00	0.00
	Ebb	4/26/13	13:00	18:20	1.24*	5.33	0.00
	Flood	4/26/13	19:20	0:15	1.22*	4.92	0.00
	Ebb	4/27/13	1:15	6:45	1.24*	5.50	0.00
	Flood	4/27/13	7:45	12:45	1.22*	5.00	0.00
	Ebb	4/27/13	13:45	19:05	1.24*	5.33	0.00
	Flood	4/27/13	20:05	1:55	1.22*	5.83	0.00
	Ebb	4/28/13	2:55	7:35	1.24*	4.67	0.00
* Turbine rotation speed while free-spinning is faster than rotation speed during normal operation.							

Marine Life Interaction Data Processing and Analysis

Echoview software (5.3, Myriax Pty. Ltd., Hobart, Australia) was used to process side-looking split beam hydroacoustic data. Processing in Echoview began with manually inspecting the data to identify and exclude unwanted noise (e.g., interference from depth sounders, entrained air from the surface, reflection from surface waves, reflection from fish schools), and setting a target strength threshold of -50 dB to exclude background noise, plankton, and other small objects from analyses. Target strength (TS) is a measure of the relative amount of acoustic energy reflected back toward the transducer by an object, compensating for transmission and signal losses and represented in decibels (dB re 1 m^2; Simmonds and MacLennan 2005). Though TS is dependent on several factors, including fish anatomy (e.g., swim bladder or none) and orientation relative to the transducer, it is generally proportional to fish size (Simmonds and MacLennan 2005). A threshold of -50 dB should eliminate most fish less than 8.7 cm in length (Lilja et al. 2004), assuming they have air-filled swim bladders (e.g., Atlantic herring). For fish lacking a gas-filled swimbladder, such as Atlantic mackerel, this threshold may eliminate larger fish to an unknown degree.

Echoes from single targets were then detected, excluding data collected beyond 78.1 m from the transducer (far edge of the turbine) due to frequent interference from the surface. Single target detection parameters (Table 8) were set liberally to allow a large number of single targets to be detected among the noise, though this also allowed more false detections to occur. Echoview's fish tracking module was then used to trace the paths of individual fish through the sampled volume. Fish track parameters (Table 9) were chosen to limit the effect of false single target detections on the number of detected fish. Fish track data (including time of detection, target strength, and direction of movement) were exported from Echoview to be further analyzed using MATLAB.

Table 8. *Single target detection settings in Echoview.*

Parameter	Value	Units
Target strength threshold	-50.00	dB
Pulse length determination level	6.00	dB
Minimum normalized pulse length	0.24	Unitless
Maximum normalized pulse length	10.00	Unitless
Beam compensation model	Simrad LOBE	
Maximum beam compensation	35	dB
Maximum standard deviation of minor-axis angles	1.000	Degrees
Maximum standard deviation of major-axis angles	1.000	Degrees

Table 9. 4*D fish track detection settings in Echoview*

		Major Axis	Minor Axis	Range
Algorithm	Alpha	0.5	0.5	0.7
	Beta	0.1	0.2	0.1
	Exclusion distance (m)	2.25	2.25	0.2
	Missed ping expansion (%)	0	0	100
Weights	Major axis	0		
	Minor axis	0		
	Range	1		
	TS	0		
	Ping gap	0		
Track Acceptance	Min number single targets in track	5		
	Min number of pings in track (pings)	5		
	Max gap between single targets	8		

In MATLAB, fish tracks that had been contaminated by false single targets were removed based on track properties, including minor and major axis angle, tortuosity, and change in depth and range (Table 10). These settings helped eliminate fish tracks affected by noise from the turbine and other environmental factors. However, one effect of the turbine that could not be removed without drastically limiting the dataset was its apparent masking of weaker fish echoes within its range (i.e., between 44.5 and 78.1 m from the transducer; Figure 34). This masking is apparent in the distribution of fish track TS from beside the turbine and within the turbine's range. As weaker fish tracks were not detected in the range of the turbine, the numbers of fish detected on either side of the turbine were likely to be inflated with respect to numbers of fish detected within the turbine zone or above it, and included more of the weaker echoes (e.g., smaller fish).

Table 10. *Fish track acceptance parameters used in MATLAB processing*

Fish track property	Value required for track acceptance
Minor axis angle	< 3.0°
Major axis angle	< 3.0°
Change in range	> 0.05 m
Change in depth	> 0.05 m
2D and 3D tortuosity	< 5.0

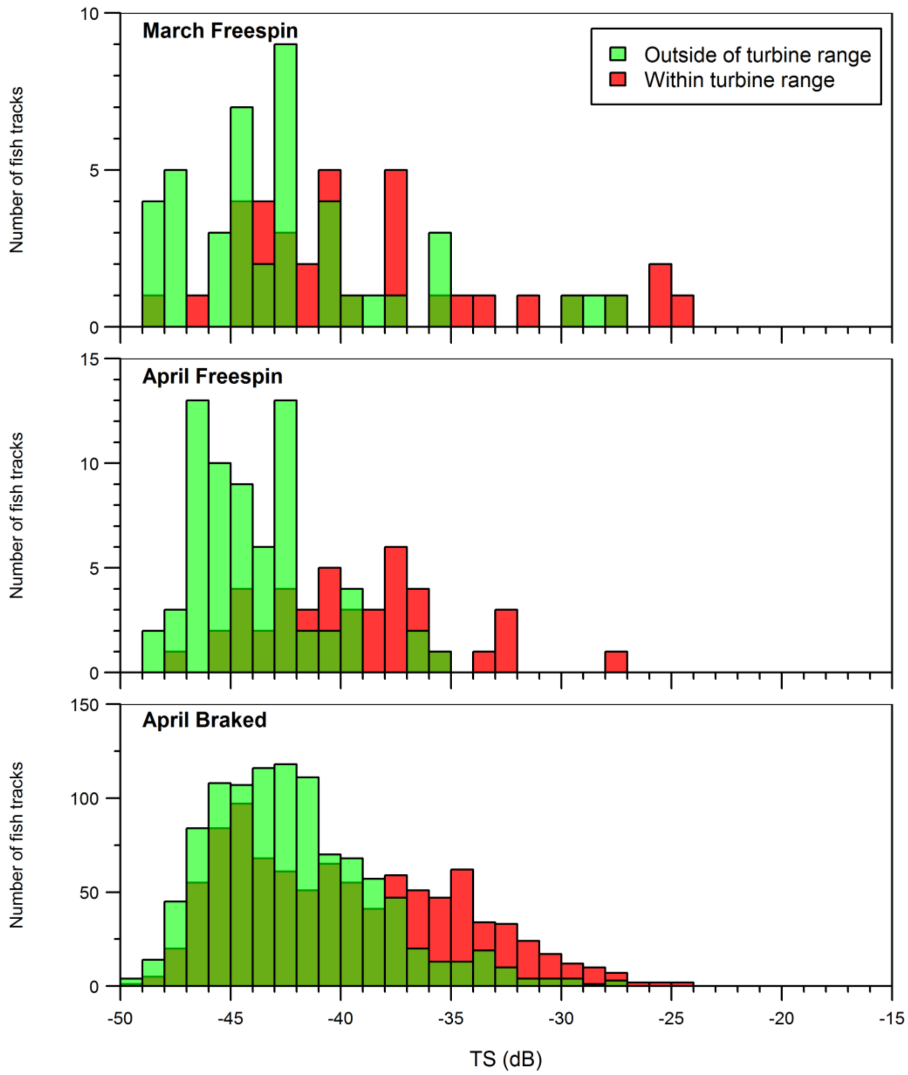


Figure 34. Target strength (TS) distribution from before the turbine range (< 44.5 m from transducer) and within the turbine range (> 44.5 m and ≤ 78.1 m from transducer).

Accepted fish tracks were grouped by tidal stage for analysis of target strength and direction of movement. Flood and ebb tide data were treated separately because a fish's approach to the turbine is sampled during the flood and its departure from the turbine is sampled during the ebb, and behaviors during each are assumed to differ (Viehman 2012; Viehman and Zydlewski accepted).

Fish density and location of tracks

The total number of fish tracks detected in the hydroacoustic data provided an estimate of the density of fish in the sampled volume over time. The location of each fish in the sampled volume was used to place it in one of the three zones near the turbine (Figure 8). Density of fish in a zone (in fish per cubic hectometer, hm^3)was calculated for each time span of interest (e.g., each ebb and flood tide) by dividing the total number of fish detected in the zone by the volume of water to pass through that zone. This volume was calculated by multiplying the area of the zone's vertical cross-section by the approximate linear distance of water to pass through it during the analysis period. The linear distance of water was determined using the mean current speed of each 10-minute time increment. Using 10-minute averages greatly reduced the effect of the noise in the ADCP current speed data. In this way, fish counts were normalized for varying sampling duration and current speed, allowing the direct comparison of densities from different datasets.

Current speed data were not available for the braked turbine dataset, so current speeds from the nearest free-spinning data (April 18-20) were used to obtain an approximation. Since free-spinning data were collected at neap tide (first quarter moon) and braked data were collected at spring tide (full moon), the mean flood tide current speed was multiplied by a factor of 1.2 and the mean ebb tide speed was multiplied by 1.4. These factors were determined using ADCP data collected during spring and neap tides in 2012. While this is a coarse approximation, some estimate was needed in order to make any comparisons between fish numbers obtained from the free-spinning data to those of the braked data.

Direction of movement

The direction of movement (heading, degrees from North; inclination, degrees from horizontal) of each fish was compared to the current direction at the time of fish detection (when data were available). Higher deviation from the water current direction within the turbine zone than in other zones may indicate avoidance behavior during approach (flood tides), or milling during departure (ebb tides).

5.2 Results

5.2.1 Fisheries monitoring plan (down-looking hydroacoustics)

Relative fish density

1) Inter-annual variability: was fish density constant across years? Fish density (mean water column S_v) changed significantly each year. Density was significantly higher in 2010 and 2012 than 2011 and 2013 (Figure 35). Because of these differences, years were analyzed separately in subsequent statistical analyses.

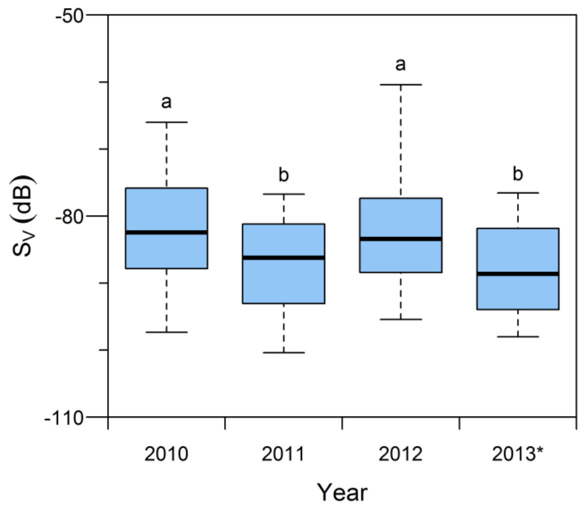


Figure 35. Water column S_v for all years sampled (CB1 and CB2 data pooled together). Bold horizontal line indicates the median, boxes span the interquartile range, and whiskers extend to the 5th and 95th percentiles. Significantly different groups are indicated by letters a and b (*). In 2013, only March, May, and June were analyzed.

2) Beside vs. in-line with the turbine: were densities similar at the two project sites (CB1a and CB1b)? There were no differences in fish density (total water column S_v) between CB1a and CB1b (Figure 36). As such, we grouped these two sites as CB1 in further analyses of water column S_v.

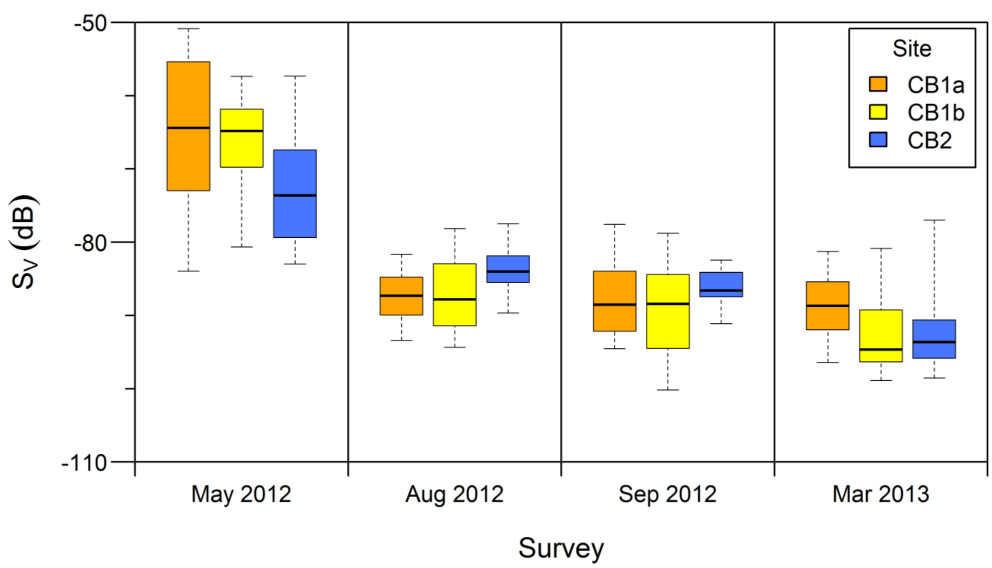


Figure 36. Water column S_v at CB1a, CB1b, and CB2 surveys in 2012 and 2013. Bold horizontal line indicates the median, boxes span the interquartile range, and whiskers extend to the 5th and 95th percentiles.

3) Project site vs. control site: is fish density similar at CB1 and CB2, and is CB2 therefore a useful control site? In each year, fish density varied significantly with month (Figure 37). Site had a significant effect on fish density in 2011, meaning density was greater at CB2 when data from all surveys were grouped together. However, within surveys (months), densities at CB1 and CB2 were not significantly different. The interaction of site and month significantly affected fish density in 2010 and 2012, indicating that site had a different effect on density in the different months. Multiple comparisons showed that fish density was significantly different at CB1 and CB2 in September 2010 and in March and August of 2012, but that there was no effect of site in the other surveys. Interaction effects could not be tested in 2013 since CB1 was only sampled in only one of three months.

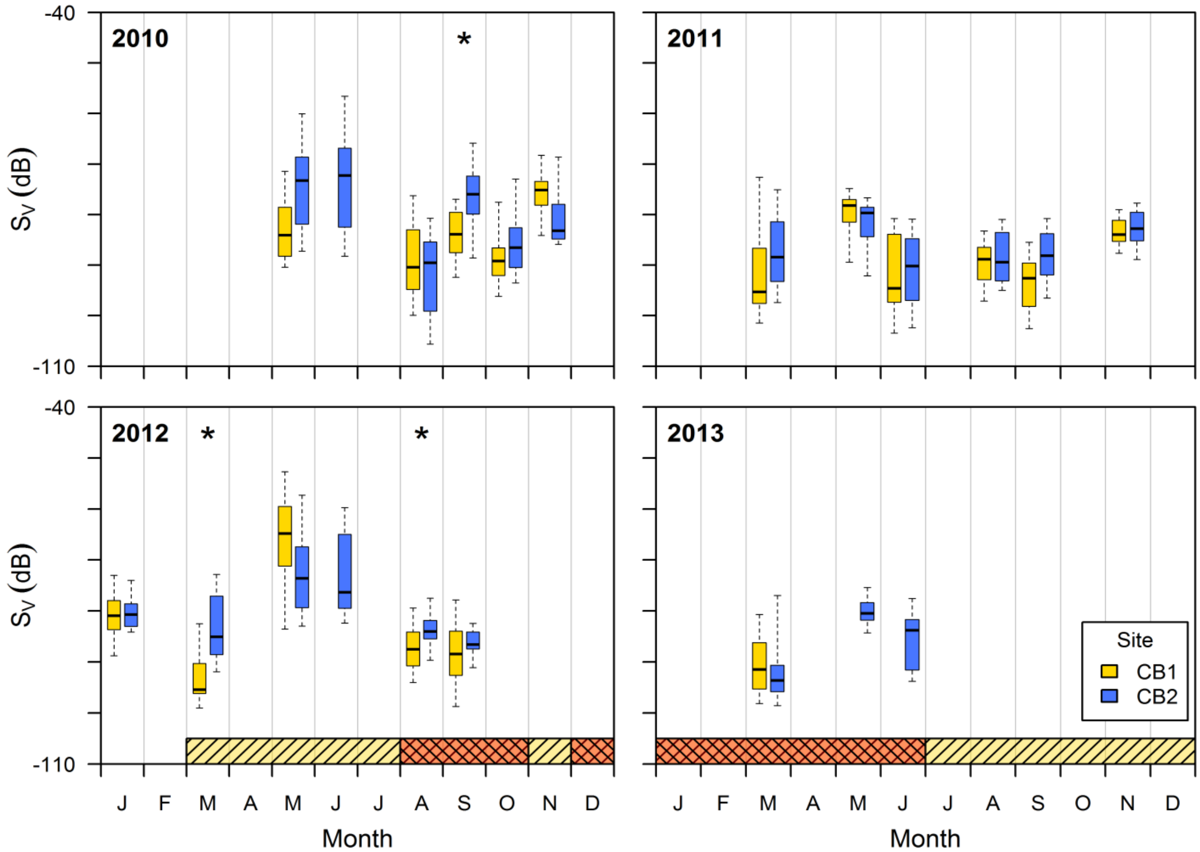


Figure 37. Water column S_v at CB1 (which includes CB1a and CB1b data) and CB2. Bold horizontal line indicates the median, boxes span the interquartile range, and whiskers extend to the 5^{th} and 95^{th} percentiles. Asterisks indicate significant differences between CB1 and CB2. † indicates surveys when only ebb tide data were sampled; ‡ indicates surveys when only daytime was sampled. Yellow hatched box indicates surveys when the TidGen® bottom support frame was present on the seafloor; red hatched boxes indicate when the TidGen® turbine was also present. The turbine was braked (present but not spinning) starting mid-April until it was removed in July.

4) Seasonal variability: is there a consistent seasonal pattern to fish density in outer Cobscook Bay? Results of multiple comparisons indicated highest fish densities in May and June, followed by November (Figure 38).

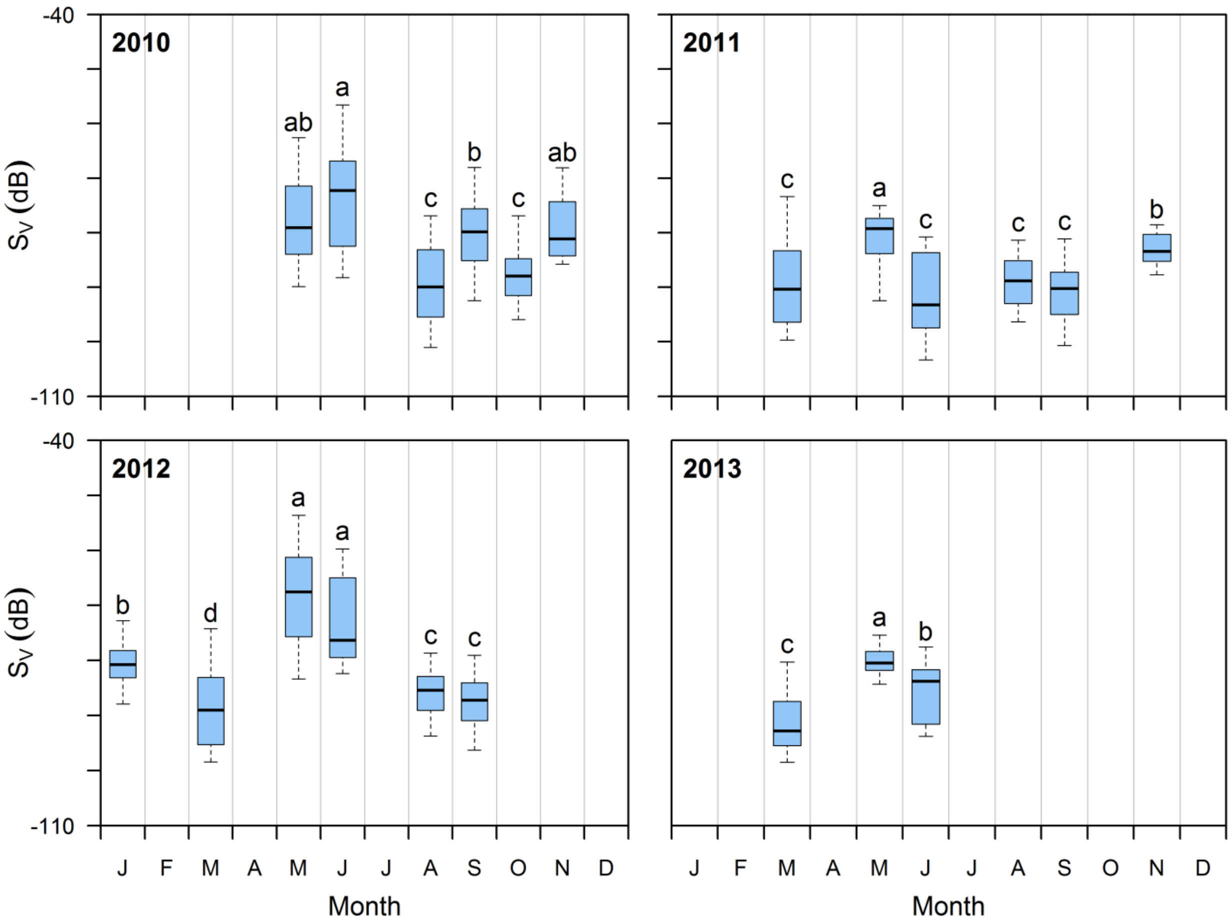


Figure 38. Water column S_v for all surveys (CB1 and CB2 data pooled together). Bold horizontal line indicates the median, boxes span the interquartile range, and whiskers extend to the 5th and 95th percentiles. Significantly different groups within each year are indicated by letters a through d (group a is the highest, d is the lowest).

5) Did deployment of the TidGen® affect fish density at the project site (CB1)? A significant difference between CB1 and CB2 was found only in the August 2012 survey, when CB2 had a higher density index (water column S_v) than CB1 (Figure 39). A similar difference was seen in March 2012, when the turbine's bottom support frame was deployed.

Vertical Distribution

Significant differences were only found between sites CB1 and CB2 in May 2011, CB1 and CB2 in March 2012, CB1a and CB2 in May 2012, CB1b and CB2 in May 2012, and CB1a and CB1b in March 2013 (Figure 7).

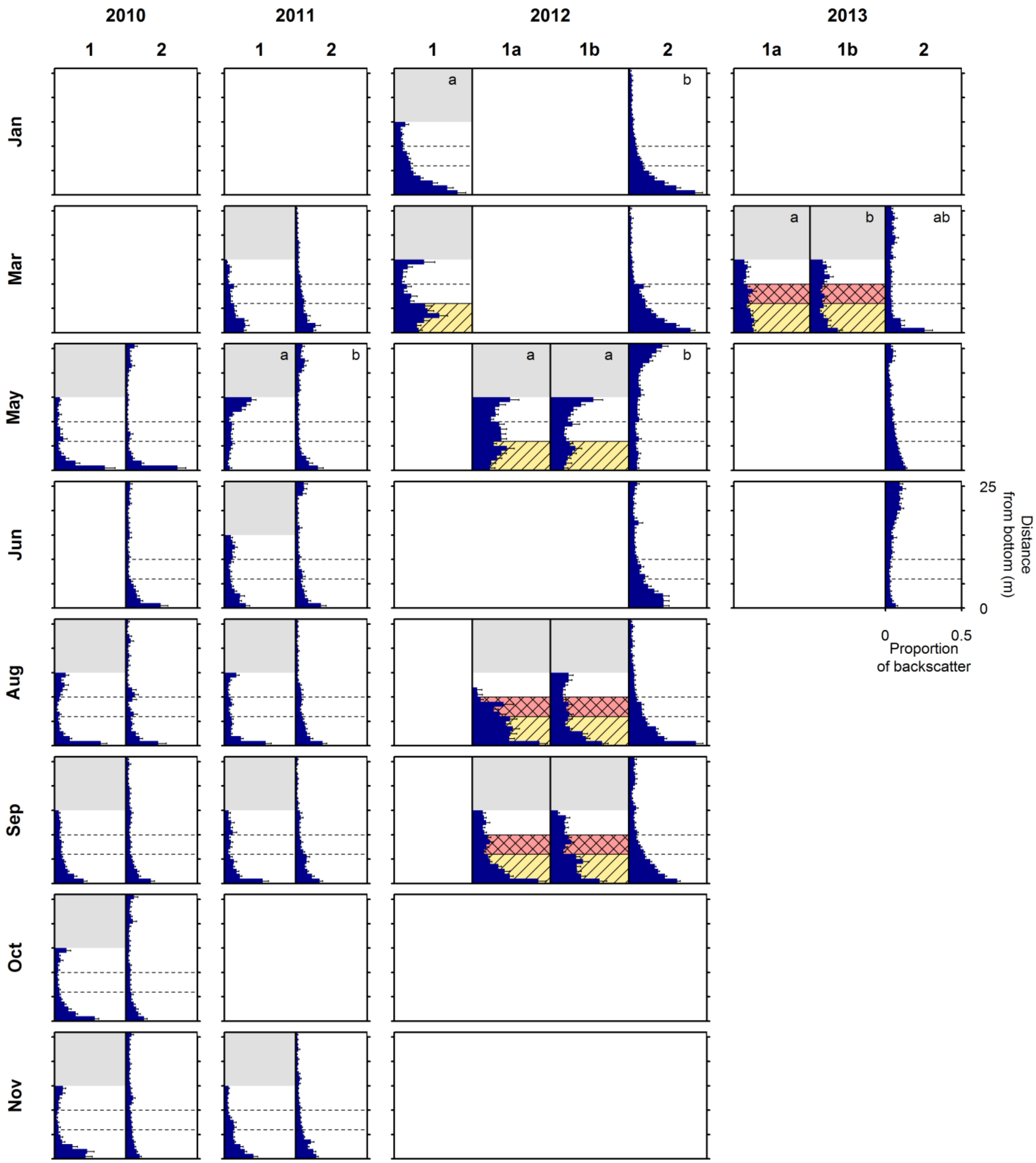


Figure 39. Mean proportion of S_a contributed by each layer of the water column. All layers analyzed are shown for each site (0-15 m above the bottom at CB1, 0-26 m above the bottom at CB2). Whiskers are one standard error. Depth of turbine is indicated by horizontal dashed lines. Yellow hatched areas indicate when the bottom support frame was deployed at the project site; red hatched areas indicate when the turbine was also present. Significantly different distributions between sites are indicated by letters "a" and "b" in the upper right of the graph.

5.2.2 Marine life interaction monitoring plan (side-looking hydroacoustics)

A total of 68 fish tracks were detected during the March free-spinning period, 87 were detected during the April free-spinning period, and 1,827 were detected during the April braked period (Figure 40). The number of flood and ebb tides sampled was too low to carry out statistical analyses of the differences between these sampling periods (5 tidal cycles in March, 4 in each April dataset). The large number of fish in the braked dataset in April compared to the other two datasets is unlikely related to turbine operation. To investigate this, the number of fish detected during the slack tides were also compared across datasets, and showed a similar pattern (Figure 41). As the turbine was not moving (and therefore assumed not to be a contributing factor) during the slack tides in either dataset, this comparison supports a natural increase in fish numbers between the free-spinning periods and the braked period. This would also be in line with results from down-looking hydroacoustic surveys (Section 2.2.1), which have shown a large increase in fish density between March and May.

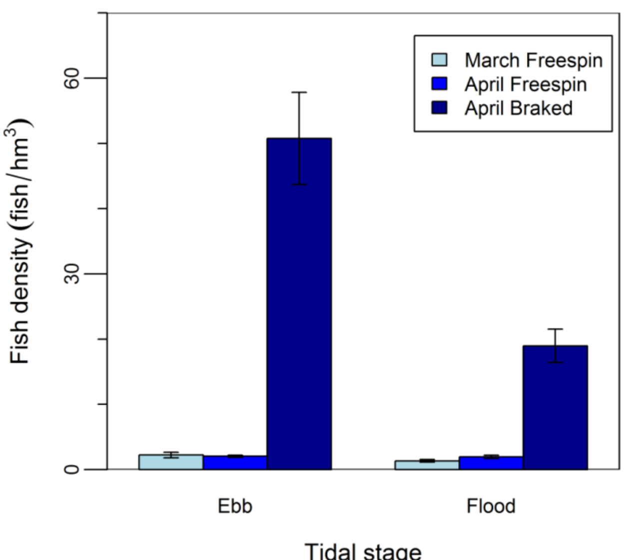


Figure 40. Mean fish density (fish/hm^3) of each tide of each dataset. Whiskers are one standard error.

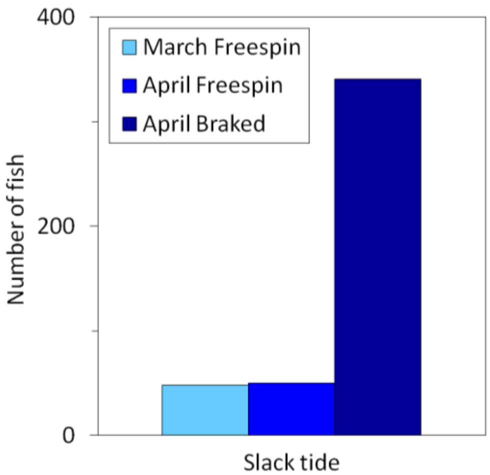
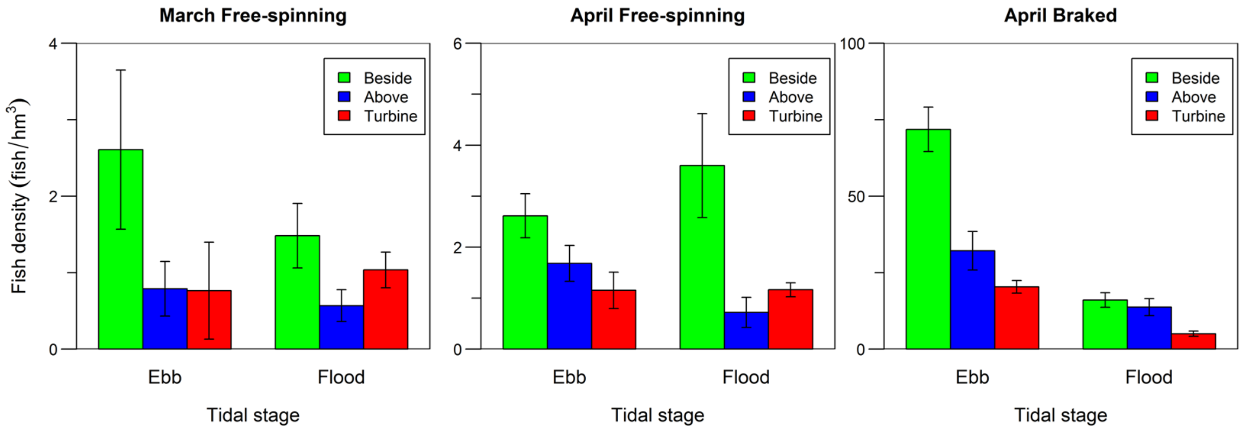


Figure 41. Number of fish detected during the slack tides in each dataset.

Fish density by zone
The mean density of fish in each sampling zone is shown in Figure 42. Density appears greatest beside the turbine and lowest in the turbine zone, though no tests for statistical significance have been carried out due to the low sample sizes (5 tides in March, 4 tides in each April dataset). This is unlikely to be entirely natural or a response to the turbine; rather, it is likely largely due to the masking of weaker fish echoes within the range of the turbine (see section 3.1.3). Though fish track filtering removed much of this effect, the target strength distributions of accepted fish tracks (Figure 42) show that the lower end of the TS spectrum (-50 dB to -41 dB) appear undersampled in the turbine range compared to beside the turbine.

In the braked dataset, more fish were detected during the ebb tide than during the flood tide. This could be explained by the natural movements of fish in the area (e.g., an outward movement of species at the time of the data collection), or may be related to fish sheltering in the lee of the device and its supporting structure. This behavior was previously observed within approximately 3 m of a test turbine (Viehman and Zydlewski, accepted) but more data are necessary before this behavior can be identified in these datasets, especially as the sampling volume of this study is approximately 10 m from the device. The low sample size and the few fish detected to date result in a high degree of variability that makes further comparison of fish counts not useful.



Total = 68 (1.10 fish/hm^3) Total = 87 (1.66 fish/hm^3) Total = 1,827 (27.09 fish/hm^3)

N = 5 N = 4 N = 4

Figure 42. Mean fish density (fish/hm^3) in each zone (+/- 1 standard error).

Direction of movement

The distribution of the headings of fish in each sampling zone peaked at the predominant current direction, indicating fish moved primarily with the prevailing current (Figure 43). Due to the small sample size, statistical significance was not tested. The low number of fish detected in March and April free-spinning periods made interpretation of distributions unconstructive. However, in the braked dataset, enough fish were detected to make slight differences in each zone visible. During the flood tide (approach to the device), more fish were swimming in directions other than that of the main current. During the ebb (departure from the device), more fish swam with the current. The greater variation in fish direction during their approach indicates higher variability in behavior, though sample sizes were too low to draw any conclusions associated with avoidance. Additionally, some of this variation may be due to variable current direction, but this cannot be confirmed without current direction data.

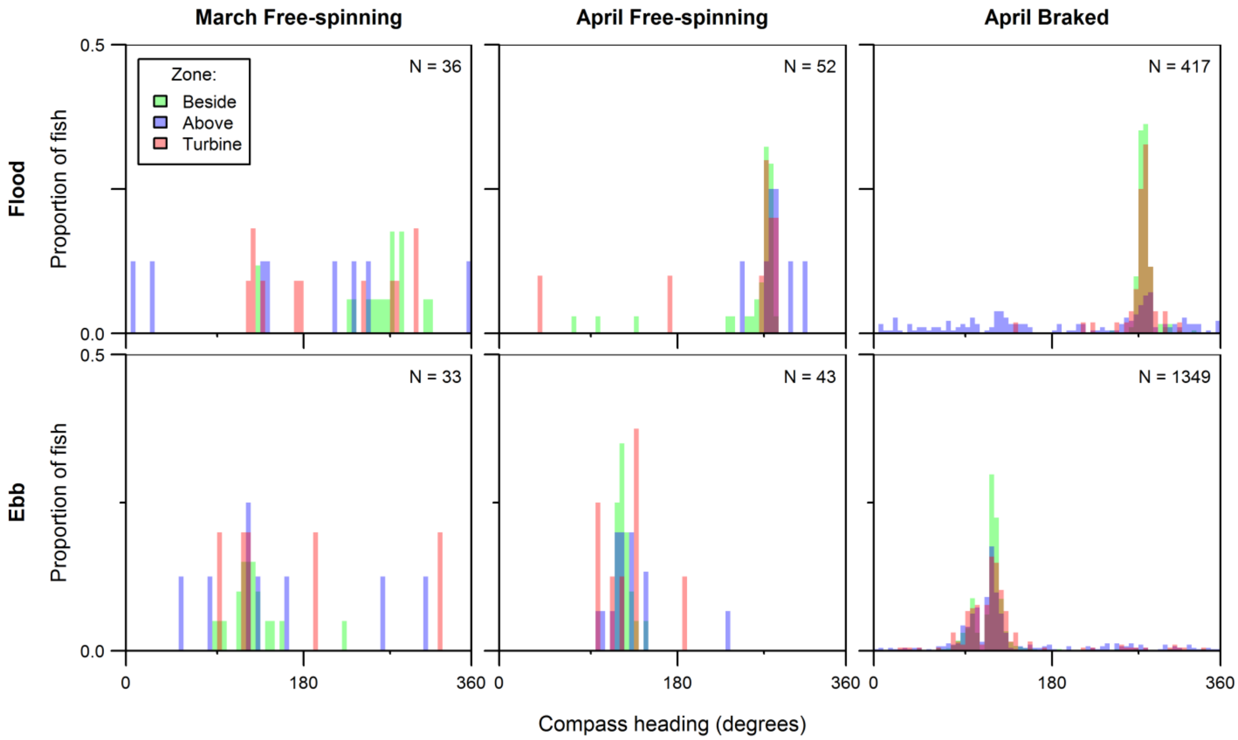


Figure 43. Distribution of fish headings during each dataset (0 = North). Values are scaled to number of fish detected in each zone.

The distribution of inclination angles of fish peaked between -10° and 0°, indicating that most fish were swimming horizontally or slightly downward (Figure 44). Again, the March and April free-spinning datasets did not yield enough fish to draw conclusions. In the braked dataset, variation in inclination angle appeared higher during the flood tide than the ebb tide, as indicated by the wider spread of the distribution. This increased variation could be linked to the fewer numbers of fish detected during the flood tide.

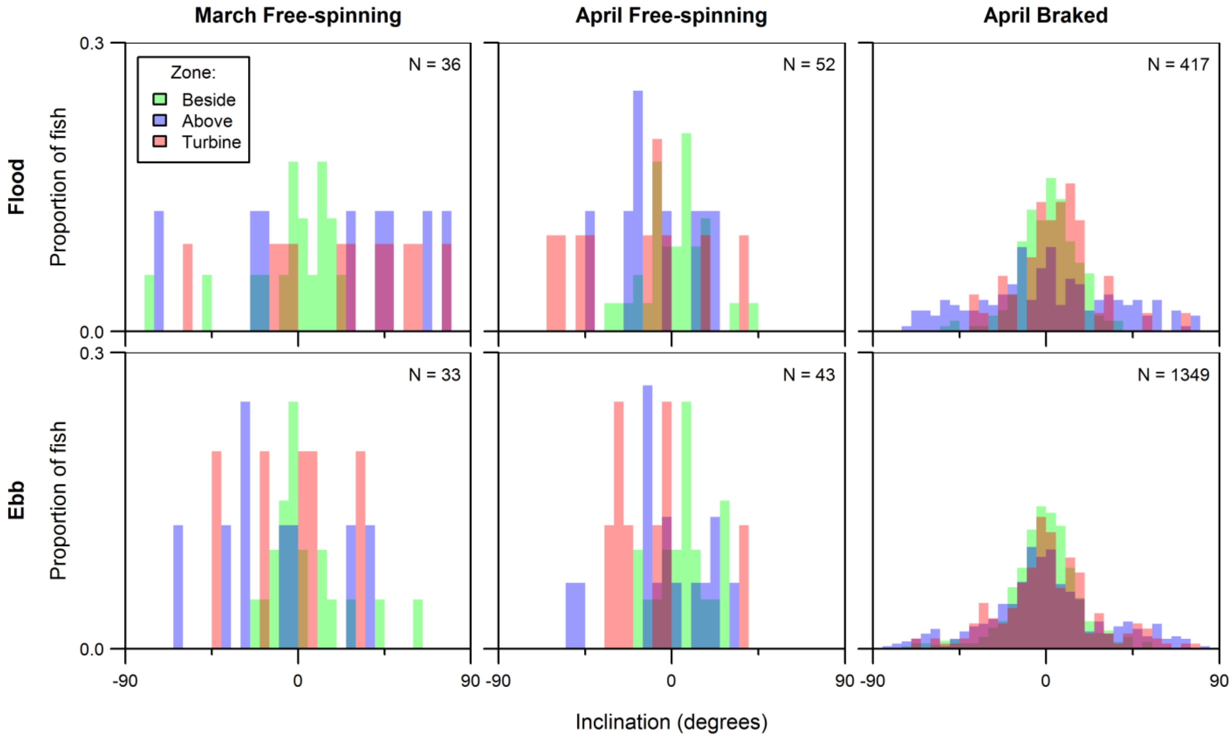


Figure 44. Distribution of fish inclination during each dataset (-90 = down, 0 = horizontal, 90 = up). Values are scaled to number of fish detected in each zone.

5.3 Conclusions and Recommendations

5.3.1 Fisheries Monitoring Plan (down-looking hydroacoustic surveys)

Understanding the interactions between the environment and its biological constituents in tidally dynamic coastal regions is essential for informing tidal power development. Research and monitoring in these areas is limited because of the physical dynamics. Recent interest in tidal power extraction in Cobscook Bay provided the opportunity to develop an approach to assess such areas. The Bay's complicated bathymetry combines with a large tidal range to create high current speeds and flow patterns that vary greatly with location and tide (Brooks 2004, Huijie Xue, unpublished data). Multiple fish species pass through the strong currents of the outer bay to move between deeper ocean habitats and the extensive inshore habitats of the inner bays. Given the extreme variation in currents over time and space and the mixed seasonal and year-round fish community, hydroacoustic measures of relative fish density were expected to vary widely in relation to season and location. UMaine's hydroacoustic assessments demonstrate that while fish density is indeed variable, patterns are repeatable and will be useful in understanding the effects of devices.

Overall Fish Density
1. Inter-annual variability: was fish density constant across years? Differences in overall annual mean S_v with sites combined was discernible. The years 2010 and 2012 had higher fish density than 2011 and 2013. These differences display natural annual variation occurring within the years we have sampled. This highlights the importance of a useful control site in distinguishing changes in density due to turbine deployment from natural variation in fish density over time.

2. Beside vs. in-line with the turbine: were densities similar at the two project sites (CB1a and CB1b)? Both sites were similar and not statistically significantly different. The similarity between data collected at these two sites to date indicates that the inline site, CB1b, is representative of fish passage on a large lateral scale in the area of deployment. In addition, their similarity allowed us to combine them for analyses. It is important to note that the similarity between the inline and beside sites do not represent similarity of fish behavior in these locations. The beside site had little consistency in geographic location month to month and was often hundreds of meters away from the TidGen® device which could have resulted in similar data collected, not truly reflecting fish distribution beside the turbine. Further data closer to the turbine for the "beside" monitoring is necessary.

3. Project site vs. control site: is fish density similar at CB1 and CB2, and is CB2 therefore a useful control site? The utility of the control site becomes apparent when examining the variation between the experimental site CB1 and the control site CB2 within each month sampled. These two sites typically had no significant differences with the exception of CB2 having significantly higher mean S_v in September 2010 and March and August 2012. With only these three exceptions to significant differences, we feel that the utility of the respective sites is valid. The difference in September 2010 could be linked to electrical noise in the hydroacoustic system during that year. The differences in March and August 2012 may be related to construction activities around the TidGen® device: in March, the bottom support frame was being installed, and in August, the turbine was being deployed.

4. Seasonal variability: is there a consistent seasonal pattern to fish density in outer Cobscook Bay? Consistent monthly differences were found for all years, with peaks in density in May and June, followed by November. May of 2012 had much higher mean S_v than other years. This peak may have been related to elevated water temperatures, which affect the movements and growth of fish. For example, midwater trawls carried out near CB2 at this time found fully metamorphosed herring, while in other years the same trawls found larval herring or none at all (Vieser, unpublished data). This early growth of herring would have caused a greater increase in mean S_v than normally seen. It is important to be able to distinguish this type of natural variation from turbine effects.

5. Did deployment of the TidGen® affect fish density at the project site (CB1)? The turbine was deployed during the August and September 2012 and March 2013 surveys. Only August 2013 had a significantly lower fish density at the project site than the control site. This may have been related to increased boat traffic and construction activities at the project site as the device was deployed. These activities included deploying and retrieving ADCPs, divers performing observation or maintenance on the device, or deployment and adjustment of the deployment area

marker buoys. At times, there was also a large construction barge over the TidGen® device. A similar difference between densities at the project and control sites was seen in March 2012, which was just after the bottom support frame was installed. This installation included pile driving, divers, a large barge, and high boat traffic at the project site, all of which may have led to fish avoiding the area. Unfortunately, only three surveys were carried out while the turbine was operating. While there was no difference between project and control sites in the September 2012 and March 2013 surveys (carried out post-deployment and during normal turbine operation), this is not enough information to conclude that the turbine had negligible effect on fish density at the site.

Vertical Distribution
The vertical distribution of fish was rarely different among sites. Distributions showed that fish density generally increased toward the sea floor regardless of time of year. This trend of higher density near the bottom could possibly be related to the decrease in current speed in the boundary layer against the sea floor. Fish may be using this area as a refuge from faster current speeds found higher in the water. There are exceptions to this trend of fish density increasing toward the sea floor in May 2011 at CB1, May 2012 at all sites, and June 2013 at CB2, potentially related to the large numbers of larval and juvenile herring utilizing the upper layers of the water column at those times.

5.3.2 Marine Life Interaction Monitoring Plan (side-looking hydroacoustics)

The original goal of this monitoring was to collect data continuously during turbine operation (while generating power). A power-generating turbine has a different hydraulic and acoustic signature than a turbine that is free-spinning or braked. As such, fish response under these conditions may differ and it is important to collect fish response data while the turbine is generating power.

The dataset analyzed is limited to a few days of free-spinning and braked conditions. It is difficult to draw conclusions about fish behavior with so few fish detected during each tide, particularly during free-spinning periods. Down-looking hydroacoustic survey results indicated that fish densities are low in March compared to other months sampled, which is supported by the low numbers detected during the free-spinning periods in March and mid-April. The braked dataset in late April had many more fish than the earlier two datasets, perhaps linked to the springtime peak in density that was apparent in down-looking data. More data should be collected during times of the year when fish abundance is higher (e.g., May and June), which would provide datasets with higher sample sizes and allow quantitative statistical analyses. Higher sample sizes and statistical testing would lead to more constructive conclusions about effects of the TidGen® on fish behavior. This was originally planned, and will hopefully occur once the turbine has been re-deployed.

Available data allowed UMaine to identify some key issues that should be addressed in the future with the goal of collecting data while the turbine is generating power.

Current speed and direction data are necessary for accurate estimation of fish density and for analyses of fish movement through the beam. Without speed information, the volume of water sampled over time may be miscalculated. In their report, UMaine estimated water speeds based on past data. This is unlikely to be accurate, but in this case even a large miscalculation in current speed would not account for the huge increase in fish density between the free-spinning datasets and the braked dataset. Current direction data is necessary for the identification of fish behaviors related to the turbine, as opposed to those related to current. This can be accomplished by adjusting or adding sensors on the TidGen® or more regularly deploying an ADCP near the TidGen®.

The turbine appeared to be masking echoes from smaller fish within its range. This rendered the TS distributions obtained incomplete, and excluded analyses of the behaviors of smaller size classes of fish. This could be solved by orienting the hydroacoustic beam further away from the device or focusing analyses on larger targets.

When more data are collected, more thorough analyses can be carried out. For now, the numbers of fish detected, their estimated densities, and their direction of movement are qualitative at best.

5.3.3 UMaine Remarks

The fish community of Cobscook Bay was also assessed by UMaine (2013 results are included in Appendix D). In the future, results from that study will be used to identify probable species represented by hydroacoustic targets. However, for now, the masking effect of the turbine on fish must be more carefully examined before target strength distributions will be useful.

6.0 HYDRAULIC MONITORING (License Article 409)

The primary goal of the Hydraulic Monitoring Plan was to characterize the hydrological zone of influence, area for the Project. This will be accomplished by: (1) conducting measurements of the pre- and post-deployment flow fields in the deployment area; (2) providing experimental inputs into a large-scale computational circulation model for the estimation of far field impacts; and (3) monitoring for scouring, or sediment transport processes, within the deployment area. The Hydraulic Monitoring Plan will include the data gathered to characterize the hydrological zone of influence of the Project in Cobscook Bay and the effects (if any) of the TidGen® device on flow and sediment transport, in accordance with the requirements of the FERC pilot project license process.

Additional information regarding the monitoring of the benthic community in the deployment area is included in the Benthic and Biofouling Monitoring Plan.

6.1 METHODOLOGIES

6.1.1 ADCP MEASUREMENTS AND HYDRODYNAMICS

ORPC has been working with Sandia National Laboratories (SNL) and Sea Engineering, Inc. to apply their SNL-EFDC Model to assess hydrodynamics at the Project site. The study focuses on the development of a hydrodynamic model of Cobscook Bay. Potential changes to the physical environment imposed by operation of a multi-device marine hydrokinetic turbine array were evaluated using the modeling platform SNL-EFDC (James et al., 2011; James et al., 2012; James et al., 2006a; James et al., 2010a; James et al., 2010b; James et al., 2006b). Model results with and without a turbine array were compared to facilitate an understanding of how this small turbine array might alter the Cobscook Bay environment. In fiscal year 2013 SNL completed three quarterly reports for the Project, attached as Appendix E to this report.

In the first quarter report, SNL developed and evaluated three different high-resolution grids to study near-field hydrodynamics important to fish swimming patterns, local sediment transport, and array performance. These grids included a telescoping-mesh grid and two high-resolution, rectangular, refined grids. Model results demonstrated that the rectangular refined grids can simulate local-scale hydrodynamics in the study region in Cobscook Bay, with expected trade-offs between domain size/grid resolution and computational expense.

In the second quarter report, a high-resolution refined-grid rectangular grid centered on the proposed turbine array was created and calibrated against ADCP data collected by ORPC from July 5 through August 5, 2011 (654,267-E, 4,974,792-N labeled as "ADCP measurement" on Figure 1). Turbine devices were incorporated into the calibrated domain to investigate resulting flow-field changes. General sediment dynamics trends were identified, where regions with higher potential for erosion or deposition were noted. Differences in velocity fields with and without turbines were also investigated including the velocity deficits created behind the turbines and commensurate wake recovery.

The third quarter report focused on the development of an optimization framework using SNL-EFDC to optimize device placement to maximize array performance and minimize environmental effects (by minimizing 3 flow alteration magnitudes that could affect fish-swimming and sediment-transport behavior). In the process of developing this methodology, the need for a larger domain was recognized. A new (refined grid) domain was constructed and calibrated that encompassed the entire available MHK placement region (array footprint) and the optimization framework was used to identify an optimal array configuration at this site. Finally, power-production results were compared between ORPC's preliminary array layout, and the SNL-EFDC-optimized placement.

6.1.2 Scour Monitoring

TidGen® foundation piles were marked prior to installation for the purpose of measuring changes to seabed elevation from scour. All ten piles were painted with 6-in. squares as well as foot markers as shown in Figure 45. In 2013 ORPC continued dive operations to measure changes in seabed elevation at each of the pile locations. Divers used video, visual inspection, and customized measuring sticks to record the distance between the seabed and the fixed bottom support frame skirt.

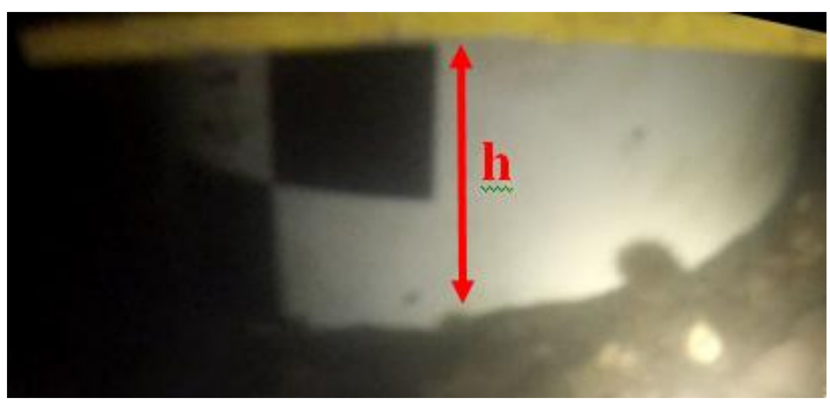


Figure 45. Foundation pile marking scheme for monitoring scour. Foundation pile prior to installation on left. On the right is installed pile #7 indicating the measured reference distance (h) from the bottom support frame skirt to the seabed.

6.2 RESULTS

6.2.1 HYDRODYNAMIC MODELING

SNL developed a framework using SNL-EFDC to optimize the placement of turbine devices to maximize array performance and minimize environmental effects due to flow alterations. The procedure identifies ideal deployment locations to generate the greatest amount of power while also taking into account environmental considerations to avoid potentially adverse effects on sediment dynamics and system ecology. While developing this methodology, the need for a larger domain was recognized. A new domain that contained the entire available turbine placement footprint was constructed and calibrated. Water levels and calibrated flow rates extracted from a previously developed regional-scale model were used to drive flow in the newly created, refined-grid domain. Modeled velocities were in close agreement with ADCP data, suggesting the model accurately predicts system hydrodynamics.

To investigate the potential environmental impacts of the tidal turbines and examine optimum turbine placement, tidal turbines were incorporated into the simulations. General sediment transport trends were identified, where regions with higher potential for erosion or deposition were noted. Differences in velocity fields with and without turbines were also investigated, including a glimpse into velocity deficits created by the turbines and wake recovery. Typically, velocities recovered to 95% of their incident magnitude within 130 m downstream of the devices as shown in Figure 46.

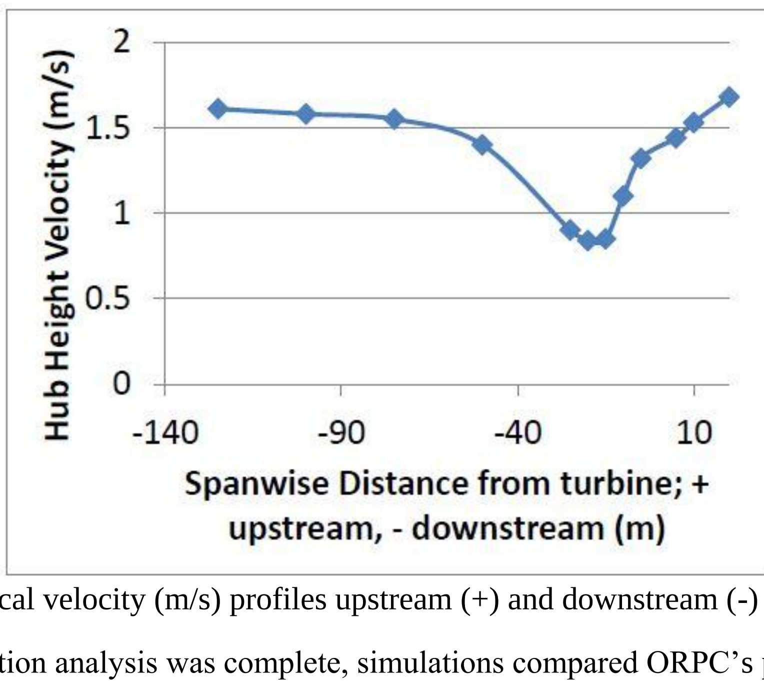


Figure 46. Typical velocity (m/s) profiles upstream (+) and downstream (-) of a tidal turbine

Once the optimization analysis was complete, simulations compared ORPC's preliminary (un-optimized) array configuration to the SNL-EFDC optimized arrangement over the calibration period (July 5 through August 2, 2011). The optimized array configuration produced 125 MW-hr of energy, a 17% increase in power generation over the ORPC-planned array (107 MW-hr).

The optimization analysis examined depth-averaged velocities when assessing hydrodynamic patterns and R%. Depth-averaged velocities were used to facilitate the transfer of data between SNL-EFDC and the post-processing software used to assess velocity fields and R%. However, when conducting the array optimization analyses, power production may be increased and environmental concerns more thoroughly examined by also considering flow in specific model layers; particularly flows at the depth of the turbines. This is because the flow velocity incident to the turbine at hub height is most important to turbine performance. By conducting the analysis based on depth-averaged velocities, the wake behind each turbine is partially obscured. In future optimization studies, the procedure will be modified to specifically consider velocities at the depth where the turbine is deployed.

6.2.2 Scour Measurements

The bottom support frame for the TidGen® Power System was set on the seabed on March 20, 2012. Steel piles were driven into the seabed through the sleeves of the bottom support frame between March 24 and April 4, 2012. Piles are numbered as shown in Figure 47. On March 26, 2012 ORPC's dive contractor conducted a dive inspection of the deployed bottom support frame and recorded distances between the bottom of the frame skirt and the seabed.

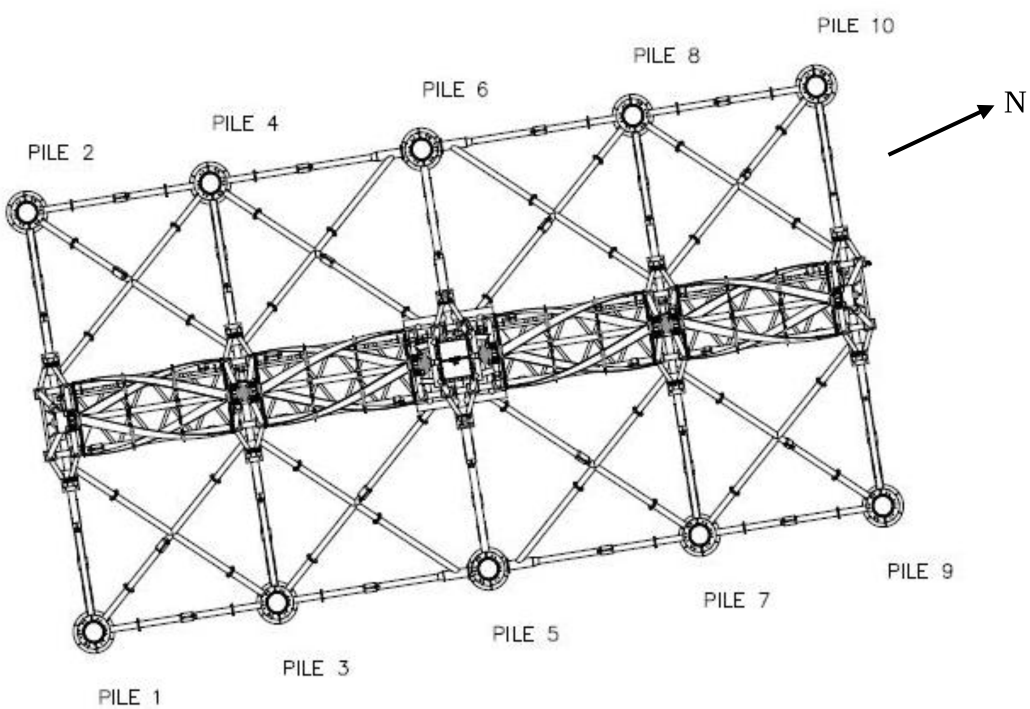


Figure 47. Plan view of TidGen® Power System showing pile numbers

ORPC's dive team continued inspections of the TidGen® Power System between March 2012 and July 2013. Table 6 summarizes change in seabed elevation at the pile locations between March 2012 and July 2013. Due to complexities associated with making measurements underwater, accuracy of measurements is estimated to be no better than 4 in. (Table 11).

Table 11. *Scour Measurements*

Skirt No.	**Distance (inches) of Skirt above Mudline 3/26/2012**	**Distance (inches) of Skirt above Mudline 10/15/2012**	**Distance (inches) of Skirt above Mudline 7/10/2013**	**Approximate Change in Mudline Elevation Since Installation (inches)**
1	2 3/4	0 to 4	7	-4 1/4
2	10	8 to 12	13	-3
3	5 1/2	0 to 4	7	-1 1/2
4	10	6	12	6
5	0	0	4	-4
6	-12	0 to 2	8	-20
7	12 3/4	12	19	-6 1/4
8	9 3/4	0 to 6	13	3
9	20 1/4	15	22	-1 3/4
10	19	-	25	-6

Results of the scour monitoring to date continue to indicate minimal change in seabed elevation around the foundation piles, except at pile 6 where the bottom support frame skirt was embedded upon deployment. There is a slight overall trend of decreased mudline elevation at the pile locations however it is generally within the margin of error (+/- 4 in.).

6.3 Conclusions and Recommendations

Hydrodynamic modeling conducted by Sandia National Laboratories continued to contribute to an understanding of hydraulic effects of the TidGen® Power System. Their work investigated velocity deficits created by the turbines and wake recovery as well as optimization of turbine arrays. Results of the scour monitoring to date continue to indicate minimal change in seabed elevation around the foundation piles.

7.0 MARINE MAMMAL MONITORING (License Article 410)

The primary goal of the Marine Mammal Monitoring Plan is to identify the species, number of animals and their behavior to characterize changes in marine mammal use in and around the deployment area due to the presence of hydrokinetic devices. As a result of knowledge gained during 2012 installation and operation, the concurrence of the Project's AMT, and a license order from FERC, ORPC transitioned from dedicated to incidental marine mammal observations for the Project in 2013.

Incidental observations are performed by trained ORPC personnel for the purpose of conducting multi-season marine mammal observations around the single-device TidGen® Power System after its Phase I deployment. The data gathered will be used to describe marine mammal presence in Cobscook Bay and characterize the effects (if any are detected) of the TidGen® Power System on marine mammals, in accordance with the requirements of the FERC pilot license process.

Additional information on potential direct interactions between marine mammals and the TidGen® Power System will be monitored as outlined in the Fisheries and Marine Life Interaction Monitoring Plans. The effect of noise produced by the installation and operation of the TidGen® Power System on marine mammals is addressed in the Acoustic Monitoring Plan. Separate from these study plans, ORPC worked with SSI under a DOE grant to develop an active acoustic monitoring system—a real-time, automated system capable of tracking the movements of fish and mammals in the vicinity of the TidGen® Power System. The active acoustic monitoring system was successfully tested in Cobscook Bay in June 2013.

7.1 METHODOLOGIES

7.1.1 INCIDENTAL OBSERVATIONS

ORPC conducted visual observations of marine mammals in and around the Project area concurrently with other project-related tasks conducted in 2013. ORPC personnel were trained in accordance with the Marine Mammal Monitoring Plan to identify and record sightings during normal on water activities. In addition, operations staff received detailed training on marine mammal species identification and behavior by Moira Brown, Ph.D., from the New England Aquarium as part of the protected species observer program associated with Phase I pile diving.

Marine mammal species visible from the water's surface were recorded as part of this monitoring effort. Observers scanned by eye and verified species with binoculars, and distance to the sighting with a laser range finder during periods on the water. These skills were developed through training to identify and observe marine mammals while performing other scheduled activities for the Project. If a marine mammal was observed, the observer documented the location where the observation was made, using latitude and longitude or a place name in order to provide perspective of the marine mammal sighting in relation to the TidGen® Power System location, species identification and count, observed behavior (e.g., apparent foraging; floating with tide), weather conditions, and estimated distance from observation point.

7.2 Results – Incidental Observations

Incidental marine mammal sightings in 2013 by ORPC staff do not indicate a change or use of the project area as the project transitioned from pre-deployment to operations. Four marine mammal species were identified in the vicinity of the project; harbor seals, a gray seal, harbor porpoises, and a single minke whale over a total of 89.75 hours. Although ORPC had not recorded minke whale sightings in the project area in the past, local feedback indicates they are known to occur in Cobscook Bay.

It should be noted that the observations recorded in 2013 were opportunistic depending on when ORPC staff were conducting on water activities in the vicinity of the CBTEP. Few observations were made following retrieval of the TidGen® TGU in July 2013.

Table 12 summarizes incidental sightings during 2013 operations and related activities. Completed log sheets are included in Appendix F.

Table 12. *Incidental sightings of marine mammals*

Date	Observation Period (hours)	Number of Observed Harbor Seals	Number of Observed Harbor Porpoises	Number of Observed Gray Seals	Number of Observed Minke Whales
1/22/2013	1.00	0	0	0	0
2/22/2013	1.30	0	0	1	0
2/25/2013	1.00	0	0	0	0
3/4/2013	6.50	0	0	0	0
3/22/2013	2.00	0	0	0	0
3/24/2013	6.00	0	0	0	0
3/25/2013	6.00	0	0	0	0
4/2/2013	6.50	0	0	0	0
4/3/2013	5.50	0	0	0	0
4/3/2013	3.00	0	0	0	0
4/4/2013	3.50	0	0	0	0
4/24/2013	1.50	0	0	0	0
5/21/2013	2.00	1	0	0	0
6/10/2013	2.50	1	0	0	0
6/13/2013	2.25	0	0	0	0
6/18/2013	4.00	3	0	0	0
6/19/2013	4.50	2	0	0	1
6/20/2013	5.75	6	2	0	0
6/20/2013	4.45	6	0	0	0
6/21/2013	5.00	3	0	0	0
7/5/2013	1.50	1	0	0	0
7/11/2013	3.25	1	0	0	0
7/12/2013	2.75	0	0	0	0
8/7/2013	2.75	1	0	0	0
10/4/2013	1.75	0	0	0	0
11/12/2013	2.00	0	0	0	0
12/12/2013	1.50	0	0	0	0
TOTAL	89.75	25	2	1	1

7.3 Conclusions and Recommendations

Marine mammal observations made by trained personnel in 2013, including during periods of operation, maintenance and retrieval did not indicate changes in marine mammal presence or behavior. There is no evidence of marine mammal strike with system components during deployment and retrieval or with TGU foils during operation. In addition, the continued presence of marine mammals in the vicinity of the Project indicates that the TidGen® Power System did not acting as a deterrent or a barrier to passage into the inner portions of the Bay.

8.0 SEA AND SHOREBIRD MONITORING (License Article 412)

The primary goal of the Bird Monitoring Plan was to determine the species, number, and time of peak use of sea and shore birds in the Deployment Area, the onshore landing site where the underwater P&D cables of the TidGen® Power System comes ashore, and the waters immediately off the landing site. Information about the behavior of these birds within these areas was gathered as well. This is accomplished by: (1) conducting multi-season bird observations to characterize the species presence, relative frequency of occurrence, and habitat use in these areas prior to the deployment of a single-device TidGen® Power System (Figure 48); (2) conducting multi-season bird observations in these areas after the Phase I deployment of the single-device TidGen® Power System; and (3) conducting multi-season bird observations in these areas after the Phase II deployment. The Bird Monitoring Plan will use the data gathered to characterize bird presence in Cobscook Bay and the apparent effects (if any) of the TidGen® Power System on sea and shore bird behavior, in accordance with the requirements of the FERC pilot license process.

8.1 METHODOLOGIES

Post-deployment sea and shore bird monitoring was conducted by the Center for Ecological Research (CER) using trained observers familiar with local bird species and behavior. As shown on Figure 48, bird surveys are conducted from Seward Neck within the white lines off North Lubec, Maine. The surveys are separated into the near shore area (A) just offshore from the Landing Site and (B) the Deployment Area for the TidGen® Power System.

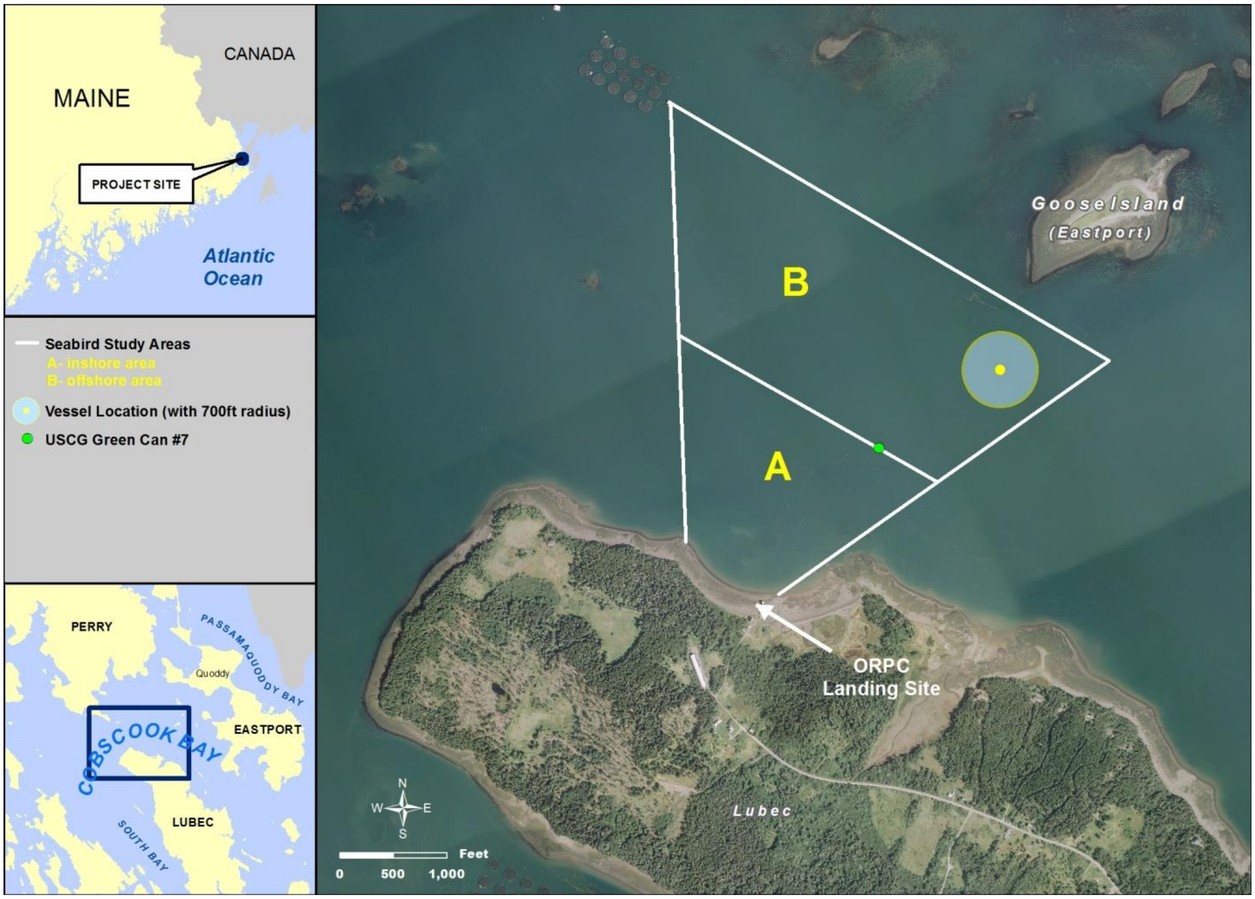


Figure 48. Sea and shore bird study area

Land-based surveys (Holm and Burger 2002) were conducted from the Landing Site in North Lubec. The land-based survey area was delineated by a line extending from the ORPC Landing Site to the east end of Goose Island. The west side of the survey area was defined by a line extending from the Landing Site to a white building located on the salmon farm directly northwest of the Landing Site. The inshore area (A) was marked by a U.S. Coast Guard navigational channel marker (Green Can #7) to the northeast of the Landing Site. The offshore area (B) was delineated by Green Can #7 and a yellow marker west of Goose Island. Observers used 8x or 10x magnification binoculars and 20x to 60x magnification telescopes for bird identification and a continuous scanning technique across the survey area to identify and count all species present. The highest count for each species was recorded for each 15-minute interval (Martin and Bateson 1986).

Special attention was paid to species known to dive to depths of 65 ft or more; these include Long-tailed Duck (*Clangula hyemalis*), King Eider (*Somateria spectabilis*), White-winged Scoter (*Melanitta fusca*), Common Loon (*Gavia immer*), Black Guillemot (*Cepphus grylle*), Razorbill (*Alca torda*), and other alcids. All surveys were conducted during periods of peak bird activity identified in preliminary surveys and last for a period of three hours. Each survey is divided into 15-minute intervals and the maximum number of each species and their behavior is recorded during each interval. All behaviors of birds on the water's surface are registered. Birds are identified as floating (loafing on the surface), diving (active feeding), or swimming. Birds that fly past the survey area but do not land on the water are also counted.

8.2 RESULTS: 2012-2013 WINTER MIGRATING SEASON

CER continued monthly surveys starting in November 2012, for wintering waterfowl and seabirds from the Landing Site at North Lubec. Each survey was conducted for a period of 3 hours. Each survey was divided into 15-minute periods and the maximum number of each species and its behavior (see below) were recorded during each period. For reporting purposes, CER condensed the 15-minute observation periods into hour units by selecting the largest count in each of the four 15-minute periods. They then used the average of these hour counts to determine the number of individuals present for each survey date. Data was presented as the average number of birds seen per month. In the winters of 2010-2011 and 2011-2012, CER sometimes conducted more than one survey per month. If this was the case, they computed and reported the average of these monthly surveys. The February 2013 survey was unable to be conducted due to inclement weather and icy road conditions. A report on the 2012 - 2013 winter migrating period is attached as Appendix G.

<u>Waterfowl and Seabirds</u>

These results are separated into two broad ecological categories based on feeding behaviors. Diving birds, including eiders and other seaducks, loons, grebes, cormorants, and guillemots, differ substantially from surface feeding birds, i.e., dabbling ducks and large gulls.

Diving Birds:

Common Eiders have declined during the three years of this study. There were fewer Common Eiders during the winter of 2012 - 2013 than in the previous two winters. In the first two winters, this species was observed more regularly in the mid-channel area. However, in 2012-2013, Common Eiders were absent in both the mid-channel and the near shore in October and November 2012. During the 2012-2013 field season, the largest count was in the mid-channel in December 2012 (average: 48 individuals) but numbers declined thereafter. The maximum count for 2010-2011 was 33.1 individuals in November and February 2011. In 2011-2012, the maximum eider count in the mid-channel was 77 individuals in March 2012. Common Eiders do not occur in any numbers in the near shore; the only substantial flock was 40 individuals in December 2011.

Long-tailed Ducks remained uncommon in the mid-channel, occurring on two occasions in 2012-2013 (max. 4, Feb 2013); three times in the winter of 2010-2011 (max. of 5.5 individuals, Jan 2011); and four times in 2011-2012 (max. of 10.5 individuals, Feb 2012). This species was seen twice in the near shore of North Lubec in 2012-2013 (4 in Feb 2013; 1 in April 2013); four times in 2010-2011 (max. 5.5 individuals, Jan 2011) and on six occasions in 2011-2012 (max. 3.5 in Feb 2011).

Red-breasted Mergansers continued to occur in small numbers, with a maximum of 3.5 individuals in March 2011, in the near shore and the mid-channel, North Lubec, Maine.

Other ducks were generally uncommon and irregular. CER observed scoters, primarily Surf Scoters, on four occasions in 2010-2011; the only time we noted >3 individuals was January 15, 2011 when we observed an average of 55.5 individuals. Two hundred White-winged Scoters appeared briefly in the mid-channel on January 15, 2011 but remained for less than 15 minutes and never reappeared in large numbers. Scoters were observed on three occasions in 2011-2012; never more than 2 individuals. This species was observed flying west into the upper reaches of Cobscook Bay on several occasions, but the fact that it did not return to the general Deployment Area appears to indicate that this area does not provide optimal feeding habitat for this species. Common Goldeneyes were seen almost exclusively in the near shore at North Lubec. CER did not observe Common Goldeneyes in the winter of 2011-2012. A single Barrow's Goldeneye (*Bucephala islandica*) was seen in near shore on Feb 12, 2011. We observed Hooded Mergansers (*Lophdytes cucullatus*) in the near shore on two occasions and also in mid-channel once.

Common Loons were regular in small numbers in the study area during all three field seasons. Red-throated Loon (*Gavia stellata*) were observed on two occasions in the near shore.

Red-necked Grebes were also regular in small numbers, <5 individuals, in both the near shore area and the mid-channel in Cobscook Bay, Maine. In 2012-2013, this species was only observed in February and March. During the past three winters, single Horned Grebes (*Podiceps auritus*) were seen a total of four occasions in the near shore area and twice in the mid-channel.

Cormorant spp. (Great and Double-crested) were present in small numbers and were slightly more numerous in 2010-2011. Cormorants occurred in very small numbers in the near shore area. Double-crested Cormorants were observed until November, and then departed the area, migrating south. Great Cormorants, the regular wintering cormorant species in Maine, were present from late December to March. A maxima of 3.5 Great Cormorants were counted in January 2011. There were substantially fewer Great Cormorants in the winters of 2011-2012 and 2012-2013.

Black Guillemots were uncommon in winter. CER observed fewer than five individuals per survey in the mid-channel or the near shore during the period between October and April. Razorbills were uncommon and were observed on five occasions; notably, three Razorbills were seen Nov 2010, and 9 individuals were seen January 2012.

Surface Feeding Birds:

Three species of dabbling ducks (Mallard [*Anas platyrhynchos*], American Black Duck, Northern Pintail [*Anas acuta*]) were observed almost exclusively along the shore line in the near shore area of North Lubec, Maine. Dabbling duck numbers increased from January to early March 2011, but diminished thereafter. This increase was likely due to northbound migrants. This trend was not observed in 2012. Three migrant Canada Geese (*Branta canadensis*) were seen once along the near shore, March 2012.

Large gull species were comprised of Great Black-backed Gulls (*Larus marinus*), Herring Gulls (*L. argentatus*), Ring-billed Gulls (*L. delawarensis),* and Glaucous Gull (*L. hyperboreus*). Large gulls were generally present in small numbers except in the mid-channel in December 2011, when we observed an average of 80 individuals, primarily Ring-billed Gulls and Great Black-backed Gulls. Large gulls were largely absent from Cobscook Bay in the winter of 2012-2013.

During the winter of 2012-2013, a single Bonaparte's Gull (*Chroicocephalus philadelphia*) was observed on a single occasion, in November 2013. In the first field season this species appeared in large numbers for a short period in late November and December 2011. Three hundred individuals were observed feeding in the mid-channel in November 2011 and 500 individuals were feeding in the mid-channel in December 2011. This species was not present on January 2012 and was not seen for the remainder of the winter. CER did not observe Bonaparte's Gulls during the winter of 2011-2012.

Eleven species were uncommon and irregular in the Cobscook Bay, Maine study area in winter. Great Blue Herons (*Ardea herodias*) are common in summer and early fall but depart by early November. The other species were unusual between late October and April.

<u>Diving Behavior</u>

Common Eiders, Red-necked Grebes, and Black Guillemots spent substantially less time feeding in 2012-2013, compared to the previous two winters. During the first two winter seasons, most diving seabirds spent >75% of their time actively feeding but this was only true for Common Loons and cormorants in 2012-2013. Common Eiders were observed loafing 98% of the time which was substantially different from the previous two winters.

<u>Bald Eagle and shoreline</u>:

CER observed a single Bald Eagle in 2012-2013. It was seen flying past the study area on February 27, 2013. This was notably different from the 2011-2012 season when they recorded one to four Bald Eagles on all nine surveys. Bald Eagles were formerly listed as federally and state endangered, but this species was down-listed to threatened and is no longer listed at any level. Dabbling ducks were the primary birds to use the shoreline at this time of year. A single Great Blue Heron was observed on October 23, 2011.

8.3 Conclusions and Recommendations

<u>Wintering Waterfowl and Seabirds</u>:
CER observed a decline in several species of seabirds in the Cobscook Bay study area in 2012-2013, compared to the previous two winters. Common Eider, Red-breasted Merganser, and Cormorant numbers were all lower. There were very few large gulls as well. However, Common Loon, Red-necked Grebe, and Black Guillemot numbers were generally similar during this three year period.

It is unclear whether the observed declines in seabird numbers were related to reduced prey abundance. This seems to be a reasonable possibility but it should be noted that these seabirds feed on different prey. Eiders are bottom feeders, consuming benthic invertebrates, whereas mergansers, cormorants, feed primarily on fish and crustacea. One would expect that loons, grebes, and Black Guillemots, which also feed on fish and crustaceans, but did not decline, would have been present in reduced numbers. This was not the case. C. Bartlett (pers. comm.) reported that there were generally fewer large gulls in the Eastport area in the winter of 2012-2013.

It seems unlikely that the operation of the TidGen® Power System affected seabird numbers because it was not deployed in November 2012, a period when we observed no eiders or Red-breasted Mergansers.

Diving Behavior

Common Loons and Cormorants fed at a similar rate as in the previous two winters but Common Eiders, Red-necked Grebes, and Black Guillemots spent less time diving for prey. Common Eiders were observed diving only 2% of the time while they loafed on the surface for 98% of the time. This species dives for invertebrate prey such as Blue Mussels (*Mytilus edulis*) and other invertebrates. Although CER saw this species regularly in the study area, the limited diving activity in the Deployment Area appears to indicate that this site is not a major feeding ground for this species. It seems unlikely that there will be substantial interaction between these diving birds and the TidGen® Power System.

Endangered and Threatened Species:

CER surveys did not find any federally or state endangered or threatened species. A single Bald Eagle was observed on only one occasion. The fact that this species was largely absent suggests that food resources were not as available as in the previous two winters. This species was removed as a threatened species in 2009.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Operational accomplishments made by ORPC in 2013 enabled the collection of significant performance and environmental monitoring interaction data related to the TidGen® Power System.

The TidGen® TGU was retrieved and redeployed several times during the winter of 2012/2013 for maintenance. After successfully redeploying the TidGen® TGU on February 22, 2013, ORPC successfully ran the system until shut down of the generator on April 21, 2013. The TidGen® Power System operated at approximately 98% availability during this period.

This Environmental Report addresses monitoring that occurred during project activities conducted throughout the year, with notable emphasis on operational periods in the spring of 2013.

9.1 The Role of Adaptive Management

The Project successfully demonstrated the ability to modify license requirements based on the results of science based data collection, the engagement and concurrence of the AMT, and clear communication with FERC. This process has garnered international attention as a model for adaptive management.

ORPC provided the 2012 Environmental Monitoring Report to the AMT in February 2013 with a subsequent meeting held on March 12, 2013. This meeting was an opportunity for ORPC to summarize the early results of the monitoring program and solicit feedback from the AMT, including any recommendations for program modifications. ORPC subsequently met with the AMT on September 10, 2013 to provide updated environmental monitoring and project status information.

Through the adaptive management process, ORPC requested modifications to environmental monitoring to clarify elements of the plan or reduce frequency of monitoring surveys based on increased knowledge of species presence and environmental effects. With concurrence from the AMT, ORPC's license modifications were accepted by FERC. This process demonstrated a clear reduction in effort and cost on the part of ORPC based on the risk reduction demonstrated by environmental monitoring results.

9.2 Environmental Monitoring Results

The 2013 environmental monitoring results continued to build an increased knowledge of marine life interaction with the TidGen® Power System and indicated negligible environmental effects for many elements of the monitoring plans.

Acoustics
Measurements of the in-water noise level related to the TidGen® Power System demonstrate that sound levels in the vicinity did not exceed 120 dB re 1 µPa^2/Hz at any frequency while the turbine is rotating, both while generating and when freewheeling. Further, the integrated rms levels from 20 Hz to 20 kHz do not exceed 120 dB re 1 µPa^2, the level some regulators are using to establish level B harassment of marine mammals.

Benthic and Biofouling
Observations of the exposed cable(s) indicate there continued to be little, if any, evidence of scouring or disturbance to the bottom or the associated faunal community. Results of the post-deployment benthic sampling survey indicated a healthy and highly productive benthic community with no discernible continuing effects from either the installation or operation of the cable. Assessments conducted in July 2013 indicated minor biofouling on the TidGen® TGU with more significant growth on the bottom support frame however neither appear to be compromising the functionality of the system.

Fisheries and Marine Life Interaction
Hydroacoustic assessments conducted by UMaine demonstrate that while fish density is indeed variable, patterns are repeatable and will be useful in understanding the effects of devices. Data collected from the side-looking sonar during operation was minimal and only limited to when the TidGen® device was not generating. However, available data allowed UMaine to identify some key issues that should be addressed in the future with the goal of collecting data while the turbine is generating power.

Hydraulics
Hydrodynamic modeling conducted by Sandia National Laboratories continued to contribute to an understanding of hydraulic effects of the TidGen® Power System. Their work investigated velocity deficits created by the turbines and wake recovery as well as optimization of turbine arrays. Results of the scour monitoring to date continued to indicate minimal change in seabed elevation around the foundation piles.

Marine Mammals
Marine mammal observations made by trained ORPC personnel in 2013, including during periods of operation, maintenance and retrieval did not indicate changes in marine mammal presence or behavior. There was no evidence of marine mammal strike with system components during deployment and retrieval or with TGU foils during operation. In addition, the continued presence of marine mammals in the vicinity of the Project indicated that the TidGen® Power System is not acting as a deterrent or a barrier to passage into the inner portions of the Bay.

Sea and Shorebirds
CER observed a decline in several species of seabirds in the Cobscook Bay study area in 2012-2013; however, they determined it unlikely that the operation of the TidGen® device affected seabird numbers because it was not deployed in November 2012, a period when no eiders or Red-breasted Mergansers were observed.

9.3 Temporary Variance Period

ORPC requested to place environmental monitoring on a hiatus during the technology optimization period during the AMT meeting held in September 2013. ORPC presented the following rationale for the appropriateness of the request:

- Comprehensive pre-deployment environmental studies have contributed to an understanding of inter-annual variability.
- Results-to-date indicated negligible effects to marine life for ongoing operations.
- TGU operational status made adherence to license conditions impractical and did not advance the conditions purpose.
- No undue impacts or impedance of other license requirements are anticipated.
- ORPC plans to return to adherence of conditions once TGU operation recommences.

Following the meeting ORPC submitted the temporary variance request to FERC with the concurrence of the AMT. FERC issued a license order approving the temporary variance request on October 29, 2013.

Despite the temporary variance from environmental monitoring for the Project, ORPC will work with UMaine to conduct fisheries monitoring associated with a test of its floating OCGen® turbine technology in 2014. The OCGen® Module Mooring Project represents a significant advancement in marine hydrokinetic technology and deployment procedures while reducing potential environmental effects (elimination of the bottom support frame). Despite the fact that the mooring project will not be grid connected (and thus not under FERC jurisdiction), ORPC provided the AMT with detailed project information and requested concurrence on the relocation of the testing from off Shackford Head to within the FERC-licensed Project site.

10.0 AGENCY REVIEW AND RESPONSE

ORPC held an Adaptive Management Team meeting on September 10, 2013 at the Maine Department of Environmental Protection's Eastern Maine Regional Office in Bangor. The meeting was well attended both in person and those who joined by conference call. As previously discussed in Section 2.2.1, this meeting was an opportunity for ORPC to present 2013 environmental monitoring results in a collaborative setting with the Team. In addition, ORPC described the rationale for a Temporary Variance Request from FERC related to environmental monitoring. Since little additional environmental monitoring data was collected after the September meeting, ORPC did not feel another meeting during the 2014 regulatory review period was pertinent.

Minutes from the September 10, 2013 Adaptive Management Team Meeting are included in Appendix A of this Report.

10.1 Agency Comments and ORPC Response

The 30-day agency review period for the draft report ended on February 24, 2014. ORPC provided a reminder notice to the Adaptive Management Team on February 18, 2014 that also included final benthic sampling results for the intertidal zone.

Table 13 summarizes agency comments received and ORPC's response and/or action. In addition to technical comments, ORPC was pleased to receive positive feedback on the Report and the value and benefit of the adaptive management process. ORPC has revised this report to address comments received where necessary. In addition, this Final Report incorporates data from the final benthic sampling report.

Table 13. *Adaptive Management Team Comments on 2012 Environmental Monitoring Report.*

Page No.	Name/Agency	Comment	ORPC Response/Action
5 of 94	David Bean, NOAA NMFS Protected Resources Division	The NOAA NMFS Protected Resources Division representative on the AMT should be David Bean	Change made in Table 1 on Page 5
	Jim Beyer, Maine Department on Environmental Protection	Letter (February 19, 2014) *The Department concurs with the statements in the report that the creation of Adaptive Management Team (AMT) has been a success for this project. The AMT has allowed the applicant and the regulatory agencies to come to consensus regarding changes to the environmental monitoring plan in an effective and efficient manner.*	Comments noted.

Page No.	Name/Agency	Comment	ORPC Response/Action
		The Department recognizes the difficulty ORPC has had with both the operation of the TidGen and the collection of some of the data for the environmental monitoring, specifically, the fish and marine life interaction studies. We look forward to the time when ORPC can overcome these technical challenges and be able to provide meaningful data for these critical studies and produce power. The Department agreed with the AMT when it decided to forego further environmental monitoring while the TidGen was not in the water. The environmental monitoring will commence, as appropriate, once the TidGen is placed back in the water. The Department concurs with the remainder of the report; however we will differ to the experts in their area of expertise to make the final comments.	
	Lt. Megan Drewniak, Sector Northern New England, Waterways Management Division Chief, U.S. Coast Guard	Email comment (February 20, 2014)The *The Coast Guard does not have any comments or additional input at this time.*	Comment noted.
	Linda P. Mercer, Bureau of Marine Science, Maine Department of Marine Resources	Letter (February 21, 2014) *The Maine Department of Marine Resources (DMR) continues to support the adaptive management approach that ORPC has undertaken for the Cobscook Bay Tidal Energy Project monitoring program.* *As you noted, we discussed the 2013 environmental monitoring results during the September 10, 2013 the Adaptive Management Team meeting. The DMR has no additional comments on the environmental and biological monitoring results (Articles 405, 406, 407, and 410)*	Comments noted.

Page No.	Name/Agency	Comment	ORPC Response/Action
		that are presented in the report, or on the MER Benthic Report. *The DMR concurred with Adaptive Management Team on ORPC's decision to forego monitoring while the TidGen is out of the water. We look forward to continued participation on the adaptive management process when monitoring is resumed.*	
	Sean McDermott, NOAA NMFS, Habitat Conservation Division	Email comment (February 24, 2014) *This report documents the process and findings very well. We understand the monitoring will be in hiatus, as described in the report. To that end we do not have recommendations at this time. Please keep us posted as ORPC gets closer to the next deployment phase.* *One comment on the report. The acoustics monitoring subsection Under Environmental Monitoring Results (Section 9.2) identifies data for the test unit in freewheel and generating mode. The results seem to indicate the level of noise generated does not exceed limits known to cause injury. I also recall statements made suggesting the natural background noise at this site is very high. It might be worth noting the ambient level of noise to put the project into context.* *Lastly, we support the continued cooperative arrangement between OPRC Maine and the University of Maine, Orono. The monitoring completed by the University has been tremendously useful in understanding the level of potential impacts associated with the test units. We also look forward to improvements to the fisheries monitoring techniques to gain*	Comments noted.

Page No.	Name/Agency	Comment	ORPC Response/Action
		better understanding of fish-project interaction.	

10.2 Public Dissemination of 2013 Environmental Monitoring Results

In accordance with ORPC's Adaptive Management Plan, the 2013 Environmental Monitoring Report will be made available to the public. In addition to the Report being available on FERC's website, it will also be posted to ORPC's website. Hard copies of the full report will be provided to the municipal offices of the City of Eastport and the Town of Lubec, and ORPC will coordinate further dissemination with community organizations.

ORPC has also developed a brief summary of 2013 environmental monitoring results that can be easily distributed to the local communities and the industry as a whole. This summary will be posted to ORPC's website simultaneously with the 2013 Environmental Monitoring Report. The summary is included as Appendix I to this report.

11.0 LITERATURE CITED

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Appendix A

Adaptive Management Team Meeting Minutes, March 12, 2013
Adaptive Management Team Meeting Minutes, September 10, 2013

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Appendix B

Phase I Acoustic Monitoring Report, July 22, 2013

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Appendix C

Review of video recordings of June 13, 2013, MER Associates, July 23, 2013

Interim Report, Subtidal and intertidal benthic survey, Upper Cobscook Bay, Maine, August 7-8, 2013, MER Associates, February 17, 2014

ORPC Biofouling Inspection Report (TGU), October 5, 2013

ORPC Biofouling Inspection Report (BSF), August 27, 2013

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Appendix D

Fisheries and Marine Life Interaction Monitoring, Bi-Annual Report, University of Maine, School of Marine Sciences, September 2013

2013 Annual Report: Maine Department of Marine Resources Special License Number ME 2013-02-03, University of Maine, School of Marine Sciences, January 6, 2014

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Appendix E

FY13Q1 Water Power Report, Grid Investigations: SNL-EFDC Model Application to Cobscook Bay, ME, Sandia National Laboratories, December 31, 2012

FY13Q2 Water Power Report, Fine-Grid Model Calibration and MHK Incorporation: SNL: SNL-EFDC Model Application to Cobscook Bay, ME, Sandia National Laboratories, March 29, 2013

FY13Q3 Water Power Report, MHK Array Placement Analysis: SNL: SNL-EFDC Model Application to Cobscook Bay, ME, Sandia National Laboratories, June 30, 2013

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Appendix F

ORPC Marine Mammal Recorder Sheets

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Appendix G

Report to ORPC on Bird Studies in Cobscook Bay, Maine, Third Winter Season Period of Investigation, November 2012 – April 2013, Peter D. Vickery, Ph.D., July 2013

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Appendix H

Agency Review Responses

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Appendix I

Summary of 2013 Environmental Monitoring