Roosevelt Island Tidal Energy Environmental Assessment Project

Final Report | Report Number 21-03 | December 2020

NEW YORK STATE OF OPPORTUNITY. NYSERDA

NYSERDA's Promise to New Yorkers:

NYSERDA provides resources, expertise, and objective information so New Yorkers can make confident, informed energy decisions.

Our Vision:

New York is a global climate leader building a healthier future with thriving communities; homes and businesses powered by clean energy; and economic opportunities accessible to all New Yorkers.

Our Mission:

Advance clean energy innovation and investments to combat climate change, improving the health, resiliency, and prosperity of New Yorkers and delivering benefits equitably to all.

Roosevelt Island Tidal Energy Environmental Assessment Project

Final Report

Prepared for:

New York State Energy Research and Development Authority

Albany, NY

Gregory Lampman
Project Manager

Prepared by:

Verdant Power

New York, NY

Mary Ann Adonizio, PE
Project Manager

Jonathan Colby
Director of Technology Performance

NYSERDA Report 20-03 NYSERDA Contract 20802 December 2020

Notice

This report was prepared by Verdant Power in the course of performing work contracted for and sponsored by the New York State Energy Research and Development Authority and the United States Department of Energy Office of Energy Efficiency and Renewable Energy (hereafter the "Sponsors"). The opinions expressed in this report do not necessarily reflect those of the Sponsors or the State of New York, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it. Further, the Sponsors, the State of New York, and the contractor make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods, or other information contained, described, disclosed, or referred to in this report. The Sponsors, the State of New York, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

NYSERDA makes every effort to provide accurate information about copyright owners and related matters in the reports we publish. Contractors are responsible for determining and satisfying copyright or other use restrictions regarding the content of the reports that they write, in compliance with NYSERDA's policies and federal law. If you are the copyright owner and believe a NYSERDA report has not properly attributed your work to you or has used it without permission, please email print@nyserda.ny.gov.

Information contained in this document, such as web page addresses, are current at the time of publication.

Abstract

The Roosevelt Island Tidal Energy (RITE) Environmental Assessment Project (NYSERDA Agreement No. 20802) was the environmental assessment of a pilot demonstration of Verdant Power's generation (Gen5) Kinetic Hydropower System (KHPS) in New York City's East River under the RITE Project. The project included ongoing implementation of regulatory compliance and environmental monitoring in accordance with issued permits and licenses, including a Hydrokinetic Pilot Project License issued in 2012 by the Federal Energy Regulatory Commission (FERC) (License No. P-12611).

In this project, Verdant Power conducted environmental monitoring focused on applying methods and results to the FERC-licensed RITE Project, with data collected under a set of FERC-approved monitoring plans, known as the RITE Monitoring of Environmental Effects (RMEE) Plans. The information and protocols developed under this project and the ensuing adaptive management successes are available to support the development of hydrokinetic generation at other sites in New York State and beyond.

Keywords

Tidal energy, marine energy, hydrokinetic energy, environmental monitoring, adaptive management, RITE Project, kinetic hydropower system, Verdant Power

Acknowledgments

Verdant Power wishes to thank NYSERDA, the United States Department of Energy, as well as its technical partners, particularly Kleinschmidt, in the execution of this project.

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
DIDSON	Dual-Frequency Identification Sonar
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FMPP	Fish Monitoring and Mitigation Plan
Gen	Generation (Gen4, Gen5)
Hz	hertz
ICD	Initial Consultation Document
IEC	International Electrotechnical Commission
ILP	Integrated Licensing Process [FERC]
IO&M	Installation, Operations and Maintenance
KHPS	Kinetic Hydropower Turbine System [Verdant Power]
m	meter
m/s	meters per second
kW	kilowatt
MHK	Marine and Hydrokinetic
MW	megawatt
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NYSDEC	New York State Department of Environmental Conservation
NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and Maintenance
OREC	Ocean Renewable Energy Coalition
ORNL	Oak Ridge National Laboratory
PATON	Private Aid to Navigation
RAD	Remotely Aimable DIDSON
RITE	Roosevelt Island Tidal Energy Project [Verdant Power]
RMEE	RITE Monitoring of Environmental Effects
RTE	Rare, Threatened, and Endangered
SBT	Split-Beam Transducer
SDR	Support Design Report [FERC]
TLP	Traditional Licensing Process [FERC]
USFWS	United States Fish and Wildlife Service
USACE	United States Army Corps of Engineers
WQC	New York State Water Quality Certification

Executive Summary

The Roosevelt Island Tidal Energy (RITE) Environmental Assessment Project (NYSERDA Agreement No. 20802) is the continuing environmental assessment of a pilot demonstration of Verdant Power's new generation (Gen5) Kinetic Hydropower System (KHPS) in New York City's East River under the RITE Project. The project included ongoing implementation of regulatory compliance and environmental monitoring in accordance with issued permits and licenses, including a Hydrokinetic Pilot Project License issued in 2012 by the Federal Energy Regulatory Commission (FERC) (License No. P-12611).

In this project, Verdant Power conducted environmental monitoring focused on applying methods and results to the FERC-licensed RITE Project, with data collected under a set of FERC-approved monitoring plans, known as the RITE Monitoring of Environmental Effects (RMEE) Plans. The information and protocols developed under this project are available to support the development of hydrokinetic generation at other sites in New York State and beyond.

The project is concurrent with the execution of the RITE Demonstration Project (NYSERDA Agreement No. 18785) and a United States Department of Energy Award (DE-EE0007349, Integrated Development and Comprehensive IO&M Testing at RITE of a KHPS TriFrame Mount).

This final report contains all data, information, analysis, and findings generated through the project, including details of test results, data analysis, and ultimate limitations of the executed RMEE Plans. For completeness, the report also provides information on RMEE Plans executed outside the project. Research needs, data gaps, conclusions, and policy implications are also addressed for the application of hydrokinetic activities in New York State and beyond.

1 Overview and Scope

1.1 Objective

The Roosevelt Island Tidal Energy (RITE) Environmental Assessment Project (NYSERDA Agreement No. 20802) is the continuing environmental assessment of a pilot demonstration of Verdant Power's new generation (Gen5) Kinetic Hydropower System (KHPS) in New York City's East River under the RITE Project. The project includes ongoing implementation of regulatory compliance and environmental monitoring in accordance with issued permits and licenses, including a Hydrokinetic Pilot Project License issued in 2012 by the Federal Energy Regulatory Commission (FERC) (License No. P-12611).[1]

In this project, Verdant Power conducted environmental monitoring focused on applying methods and results to an actual case study site at the RITE Project, with data collected under a set of FERC-approved monitoring plans, known as the RITE Monitoring of Environmental Effects (RMEE) Plans.[2]

1.2 The RITE Project

In January 2012, the Federal Energy Regulatory Commission (FERC) issued a 10-year Hydrokinetic Pilot Project License to Verdant Power for the RITE Project (No. P-12611), allowing for the staged installation in the East Channel of the East River (New York, NY) of up to 30 Gen5 KHPS turbines. The initial installation of the RITE Project is the installation of three Gen5 KHPS turbines installed on a single multiturbine mount (Verdant Power TriFrame™), referred to as RITE Install B-1. This preliminary installation will include associated grid connection as well as navigational safety and data acquisition systems for operation[3] as well as environmental monitoring, the subject of this project.

The RITE Project site is located in the East Channel of the East River off the eastern shore of Roosevelt Island, just north of the Roosevelt Island Bridge. An annotated image of the RITE Project site is provided as Figure 1.

Figure 1. RITE Project Site

The licensed project components at RITE include the following (based on Install B-1):

In-Water Components:

- Three Gen5 KHPS Turbines on a TriFrame™ mount (105 kW) in the FERC project boundary.
- Underwater power and data cables to shore.
- Water velocity measurement devices: two ADCPs at North and South points.
- Navigation and safety features: PATON buoys and lighted danger signs.
- Environmental monitoring equipment: Vemco tagged species detection hydrophones (RMEE-4) and Snap underwater acoustic recorders (RMEE-6).

Onshore Components:

- Project control room and storage facility.
- ConEd grid interconnection equipment (distributed generation).

1.3 Scope and Execution

The subject project was contracted in April 2011 and provided for the environmental assessment of two Gen5 KHPS turbines installed on monopiles at the RITE Project under a United States Army Corps of Engineers permit (RITE Install A). However, based on the ongoing technology development schedule and the evolving requirements of the FERC license, a contract modification was executed in December 2015 allowing for assessment to be conducted during the operation of Install B-1 (three turbines on a TriFrame™). A second modification was executed in January 2019 updating the Install B-1 schedule and defining the following tasks:

- Task 1: RMEE-2 Seasonal Dual-Frequency Identification Sonar (DIDSON) Observation Monitoring.
- Task 2: RMEE-3 Seasonal Species Characterization Netting.
- Task 3: RMEE-4 Tagged Species Detection.
- Task 4: Data Analysis and Reporting.

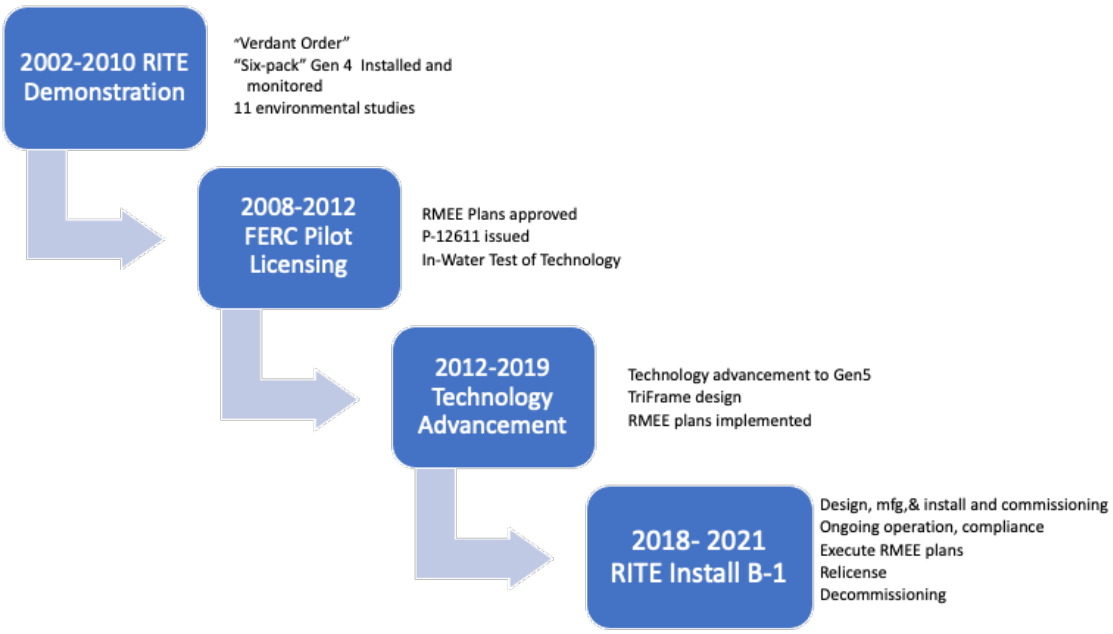
As a result of pre-installation testing and execution of the protocols for monitoring, and under adaptive management consultation with the RITE Project resource agencies[4] in 2019, Verdant Power petitioned to modify Article 401 of the RITE FERC license to remove RMEE-2 and RMEE-3 and modify RMEE-4 and RMEE-6. In October 2019, having received concurrence for this modification from the RITE resource agencies, FERC ordered such modification to the license[5]. Accordingly, and by mutual agreement between NYSERDA and Verdant Power (May 2020), such modifications were also carried over to tasks executed under the subject project.

For completeness, this final report covers the full environmental assessment of an operating hydrokinetic energy pilot project, including a summary of the regulatory history, execution of monitoring plans, and implications (research needs/data gaps, conclusions, and policy implications) for the application of hydrokinetic energy technologies in New York State and beyond.

2 RITE Environmental and Regulatory Experience

The eighteen-year history of technology advancement and environmental assessment through both federal and State regulatory processes at the RITE Project is summarized in Figure 2. This includes the Gen4 KHPS RITE Demonstration (2002–2010), the FERC licensing process through 2012, and the technology advancement and operational planning process leading up to Install B-1 (2012–2021). NYSERDA has been a standing partner with Verdant Power throughout this progression, including this project, as well as a support for earlier demonstration efforts and related environmental monitoring that formed the basis of the company's application for the RITE FERC license.

Figure 2. RITE Regulatory Timeframe



The following is a brief overview of Verdant Power's efforts to establish an operating hydrokinetic energy project in the U.S. and New York State regulatory environments.

2.1 Regulatory Approvals for RITE Demonstration, 2002–2005

When Verdant Power first embarked on the development of the RITE Project in 2002 with the filing of a FERC Preliminary Permit application in New York City's East River, there was no precedent process in the U.S.—neither regulatory nor environmental—to evaluate this new type of project and technology.

As such, Verdant proceeded under the established FERC hydropower licensing process, which requires the development of an Initial Consultation Document (ICD) under the Traditional Licensing Process (TLP). When Verdant issued its ICD in 2003, the discussion of the potential environmental effects of a hydrokinetic technology was new to both resource agencies and stakeholders.

In general, the opportunity for a new source of clean energy was well received during scoping meetings held in 2004, but it also raised significant concerns regarding the regulatory scheme for the grid-connected generation of such technology, as well as the potential environmental impacts of operation. In 2005, in order to demonstrate its technology and gather data that could begin to address these concerns, Verdant sought permission from FERC to test a six-turbine field of turbines in the RITE Project site in the East Channel of the East River (RITE demonstration). In a precedent-setting declaratory order (known thereafter as the "Verdant Order"), FERC ruled that this activity did not require a license under the Federal Power Act, as it was consistent with the following findings:

1. The technology in question is experimental.
2. The proposed facilities are to be utilized for a short period for the purpose of conducting studies necessary to prepare a license application, and power generated from the test project will not be transmitted into the national electric energy grid.
3. Nor will it displace power from the national electric energy grid.

Based on these findings, Verdant was allowed to demonstrate the Gen4 KHPS at the RITE Project site and begin developing operational and environmental monitoring data, provided that the company obtain all federal, State and local permits for such a temporary demonstration.

2.2 Gen4 KHPS RITE Demonstration, 2005–2010

In order to comply with the requirements of the "Verdant Order," Verdant Power applied for and subsequently acquired the following three permits to operate the system demonstration:

- U.S. Army Corps of Engineers (USACE), Permit No. NAN-2003-00402-EHA.
- New York State Department of Environmental Conservation (NYSDEC), Permit No. 2-6204-01510/00001 (issued jointly with USACE permit).
- New York State Office of General Services, Lease No. LUW-01008-06.

These permits allowed for the installation and demonstration of the six-turbine Gen4 KHPS field at RITE—the world's first operation of an array of tidal power turbines. As a condition of these permits, Verdant defined a specific Fish Monitoring and Mitigation Plan (FMPP) along with the definition of 11 study plans[6] to be executed before and during the demonstration. While most of the study plans

were executed during 2006–2007, some significant modifications took place after a June 2007 review of the efficacy of the fish monitoring protocols. This adaptive management effort resulted in a redefinition of the study protocols for use in the final phase of the RITE Gen4 KHPS demonstration (deployment 3, fall 2008). The most significant was an effort to observe an operating (rotating) KHPS turbine for fish interaction and to ground truth (i.e., use empirical evidence) the data collected by fixed hydroacoustics. The information developed under this effort was made public in a report to NYSERDA published in March 2011.[7]

Concurrent with studies at the RITE Project, in 2008 FERC issued a whitepaper titled "Federal Energy Regulatory Commission Licensing Hydrokinetic Pilot Projects" that outlined an expedited and streamlined process intended to remove barriers preventing the development and experimentation of new hydrokinetic technologies. Based on FERC's existing Integrated Licensing Process (ILP), this guidance allowed for waivers to create a more efficient process on a case-by-case basis for hydrokinetic projects that meet the following pilot license criteria:

1. Small—interpreted as <5 megawatts (MW).
2. Short term—interpreted as < 10 years.
3. Not located in sensitive areas based on the commission's review of the record.
4. Removable and able to be shut down on short notice—as under an adaptive management framework for monitoring and operation.
5. Removed, with the site restored, before the end of the license term (unless a new license is granted).
6. Initiated by a draft application in a form sufficient to support environmental analysis.

With the long history of demonstration and environmental study conducted at the RITE Project site, Verdant was uniquely positioned to file under these new guidelines and in November 2008 submitted a draft application accordingly.

Based on the body of scientific observation, studies, and results gathered during the Gen4 KHPS RITE demonstration, Verdant proposed a staged pilot project incorporating a suite of environmental monitoring plans that would evolve as the number of turbines increased. Termed the RITE Monitoring of Environmental Effects (RMEE) Plans, these activities were submitted by Verdant Power under its Final License Application to FERC in December 2010 (see section 3 of this report for a full discussion of RMEE Plans).

2.3 RITE Project Pilot Licensing, 2010–2012

The FERC regulatory process involves a FERC and stakeholder review, as well as additional permitting processes and reviews at the federal and State levels. This includes NEPA and Biological Opinion reviews, as well as consistency reviews under the New York State Coastal Management Program and acquisition of a New York State Water Quality Certification permit. Based on the RITE Project satisfying these reviews and requirements, on January 23, 2012, FERC issued a Hydrokinetic Pilot Project License to Verdant Power for the RITE Project (FERC No. P-12611)—the first federal license for a tidal power project in the U.S. A summary of key compliance items from the license follow:

- The project is to be developed in a staged approach for up to 30 turbines on 10 TriFrames for up to 1 MW of installed capacity.
- The license has a 10-year term, expiring on December 31, 2021.
- License Article 302 requires submission of a supporting design report (SDR) for review and approval by FERC to allow installation of the project.
- License Article 401 requires execution of the RMEE Plans on a schedule based on the number of deployed turbines and adaptive management review, as well as annual filing of progress reports.
- License Articles 402 and 404 require consultations and maintenance of plans for public safety and navigation at the project site.
- License Article 403 requires a Project Removal and Site Restoration Plan for decommissioning.

2.4 RITE Technology Advancement and License Compliance, 2012–2019

With the issuance of the FERC license, Verdant embarked on a three-step program to execute the following:

1. Advance technology design of both the Gen5 KHPS Turbine and the TriFrame™ mount for installation under the FERC license.
2. Achieve manufacturing, installation, and O&M cost metrics.
3. Maintain compliance with all regulatory requirements for project operations.

For technology advancement, a key focus was the further refinement of the blade and rotor design for the Gen5 KHPS Turbine. This included laboratory tests of updated prototypes and ultimately in-water dynamometry testing of a full-scale prototype rotor in fall 2012 at the RITE Project site.

During this in-water rotor testing, Verdant Power also conducted a beta test of the RMEE-2 DIDSON protocol (see section 3.2 for further details). Additionally, other key components of the Gen5 turbine (seals, generator/brake, gearbox) underwent final design and accelerated lab testing (with support from

NYSERDA Agreement No. 18785). An integrated design process to develop the TriFrame™ mount and associated installation, operations, and maintenance procedures was also undertaken, supported by the United States Department of Energy Office of Energy Efficiency and Renewable Energy (Award No. DE-E0007349).

During this period, Verdant also maintained compliance with project regulatory requirements, including annual reports on RMEE Plan activities to FERC, which included the following:

- RMEE-3: Species Characterization Netting (2013)
- RMEE-4: Tagged Species Detection (2011–present)
- Rare, threatened, and endangered (RTE) species monitoring (2011–present)

Verdant Power also published scientific papers related to the RMEE-2 DIDSON observation conducted during the 2012 in-water Gen5 rotor test. This information was recently provided to the RITE resource agencies and FERC in 2018 as part of the relicensing process for the RITE Project and is incorporated into this report as appendix A.

In July 2019, after adaptive management consultation with the RITE Project resource agencies, Verdant Power submitted clarifications regarding the execution of the Article 401 RMEE Plans to FERC and on October 3, 2019, FERC issued an order modifying the article as follows:

> License Article 401 is modified as follows: 1) monitoring under conditions 11 (RMEE-2) and 12 (RMEE-3) of the New York Department of Environmental Conservation's Water Quality Certificate (WQC) is suspended; the Tagged Species Detection Plan (RMEE-4) under WQC Condition 13 is modified to place an additional receiver in the east channel of the East River and monitoring to occur on a year-round basis; and the Underwater Sound Monitoring and Evaluation Plan (RMEE-6) under WQC Condition 16 is modified to use two far-field monitoring locations.

As a result of this determination, Tasks 1 and 2 of the subject project were effectively suspended (prior findings are provided in sections 3.2 and 3.3). Project Task 3, RMEE-4 Tagged Species Detection was expanded as outlined in the FERC order and continued through November 2020 under the project (see section 3.5 for findings). Additionally, while not within the scope of the subject project, three other RMEE plans—RMEE-5 Bird Observation, RMEE-6 Underwater Noise Monitoring, and RMEE-7 Recreational Monitoring—were also continued as required (see appendix B).

2.5 RITE Install B-1 (Gen5 KHPS), 2020–2021

With the completion of the Gen5 KHPS and integrated design process for related installation, operations, and maintenance, Verdant Power pursued the steps necessary to install the system as Install B-1 under the RITE Project (3 turbines on a TriFrame™ mount). Key elements of this process are as follows:

- Submission of a supporting design report (SDR) under License Article 302, comprised of final system design for final FERC review and approval (submitted to FERC as Critical Energy Infrastructure Information).
- Consultations and maintenance of plans for public safety and navigation at the project site under License Articles 402 and 404.
- Submission of a Project Removal and Site Restoration Plan for project decommissioning under License Article 403.

Based on these submissions and final consultations with resource agencies including the United States Army Corps of Engineers and the United States Coast Guard, as well as local stakeholders, on August 19, 2020, FERC provided final authorization for the RITE Install B-1. This deployment was ultimately executed with the installation of three Gen5 KHPS turbines on a TriFrame™ mount into the East Channel of the East River on October 22, 2020 (see Figures 3 and 4).

Figure 3. Install B-1 System Approaching RITE Project Site

East River, New York State, October 22, 2020.

Figure 4. System Installation

East River, New York State, October 22, 2020.

Verdant Power will continue to execute regulatory and environmental monitoring activities at the RITE Project in accordance with the FERC license through to the license expiration (December 31, 2021[8]) as follows:

- Continued execution of RMEE Plans (RMEE-4 Tagged Species Detection, RMEE-5 Bird Observation, and RMEE-6 Underwater Noise Monitoring, RMEE-7 Recreational Monitoring).
- Maintenance of Article 404 Safeguard Plans including six installed PATON buoys.
- Project decommissioning, including removal of all in-water and shoreline assets in accordance with the Article 403 Project Removal Plan.

3 RITE Monitoring of Environmental Effects Plans

As discussed above, a major undertaking and the focus of this RITE Environmental Assessment Project was to develop and execute the RITE Monitoring of Environmental Effects (RMEE) Plans, which are summarized on Table 1. While only RMEE Plans 2, 3, and 4 are within the scope of the subject project, all plans executed in relation to RITE Install B-1 are reviewed to provide the full scope of the environmental assessment effort associated with the RITE Project.

Table 1. RMEE Plans: RITE Install B-1

RMEE Plan[9]	Description	Status (at December 2020)
RMEE-2 Seasonal DIDSON Observation	Seasonal three-week observation in close proximity to turbine system.	Completed February 2014; suspended by FERC October 2019.
RMEE-3 Stationary Netting for Species Characterization	Seasonal netting downstream of turbine system.	Completed May 2013; suspended by FERC October 2019.
RMEE-4 Tagged Species Detection	Continuous detection of tagged species in RITE Project area using Vemco receivers.	Active since 2011; last data download November 2020.
RMEE-5 Bird Observation	Seasonal observation of birds during system operation.	Ongoing October–November 2020.
RMEE-6 Underwater Noise Observation	One month + two weeks underwater sound monitoring of operating turbines.	Ongoing October–November 2020.
RMEE-7 Recreational Use	Seasonal observation of recreational usage in RITE Project area.	Observations planned for recreation season, May–Sept 2021.

As approved in the RITE FERC License, the fundamental questions respective to these plans are as follows:

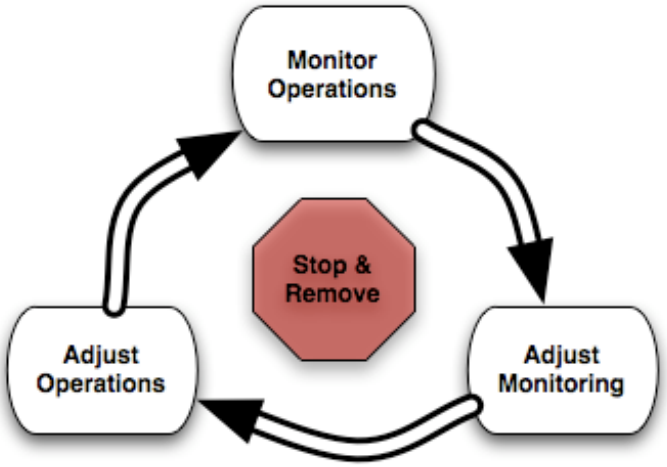
- RMEE-2: How do fish behave around an operating turbine?
- RMEE-3: What is the species characterization at RITE?
- RMEE-4: What is the detected presence, distribution, and frequency of tagged fish?
- RMEE-5: What is the seasonal presence and abundance of birds?
- RMEE-6: What is the operating noise signature of the turbines and will it affect fish?
- RMEE-7: What is the recreational usage at RITE?

Therefore, in consultation with the RITE resource agencies, Verdant has approached the execution of the RMEE Plans seeking to provide the best solutions for system monitoring that will provide the most complete understanding of these key biological questions. Such activities also take into account the body of related information developed since the inception of the RITE Project with the goal of incrementing knowledge within an adaptive management framework, which is further discussed below.

3.1 Role of Adaptive Management

Early on at the RITE Project, Verdant Power embraced the concept of adaptive management in order to develop an approach to understand the interactions of its novel technology with the environment. Adaptive management refers to a flexible decision-making process that can be adjusted in the face of uncertainties as outcomes from operational monitoring and other interactions become better understood. Monitoring (and reporting) of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Figure 5 summarizes this approach, which has been at the center of the development and execution of the RMEE Plans.

Figure 5. Schematic of Adaptive Management Framework



Accordingly, and consistent with the RITE Pilot License requirements:

- Monitoring is conducted.
- Adjustments or modifications (including suspending studies) are to be considered as the project advances.
- Operations can be adjusted if warranted.
- As required, “the project can be shut down at any time” should negative environmental effects be observed.

This fundamental concept underlies the nature of a pilot scale project and has been the consistent framework since the 2006 implementation of the RITE Project.

The practical effect of implementing adaptive management at the RITE Project with the agency stakeholders is summarized below and further detailed in the sections that follow.

- RMEE-2 Seasonal DIDSON Observation: Monitoring conducted in 2012 and related data analysis during 2014–2015 provided sufficient findings to allow for the agencies to conclude this study as of 2019.
- RMEE-3 Stationary Netting: Netting conducted in 2013 and species assemblage data provided sufficient information to allow for the agencies to conclude the study as of 2019.
- RMEE-4 Tagged Species Detection: Monitoring during 2011–2019 allowed for recommendations to modify and adjust the monitoring protocol to better capture tagged species detections around the operating system during 2020–2021.
- RMEE-6 Underwater Noise Monitoring: New IEC standards for noise monitoring were incorporated into an improved monitoring protocol that will be conducted around the operating system during 2020–2021.

3.2 RMEE-2 Seasonal Dual-Frequency Identification Sonar (DIDSON) Observation Monitoring

3.2.1 Background and Objectives

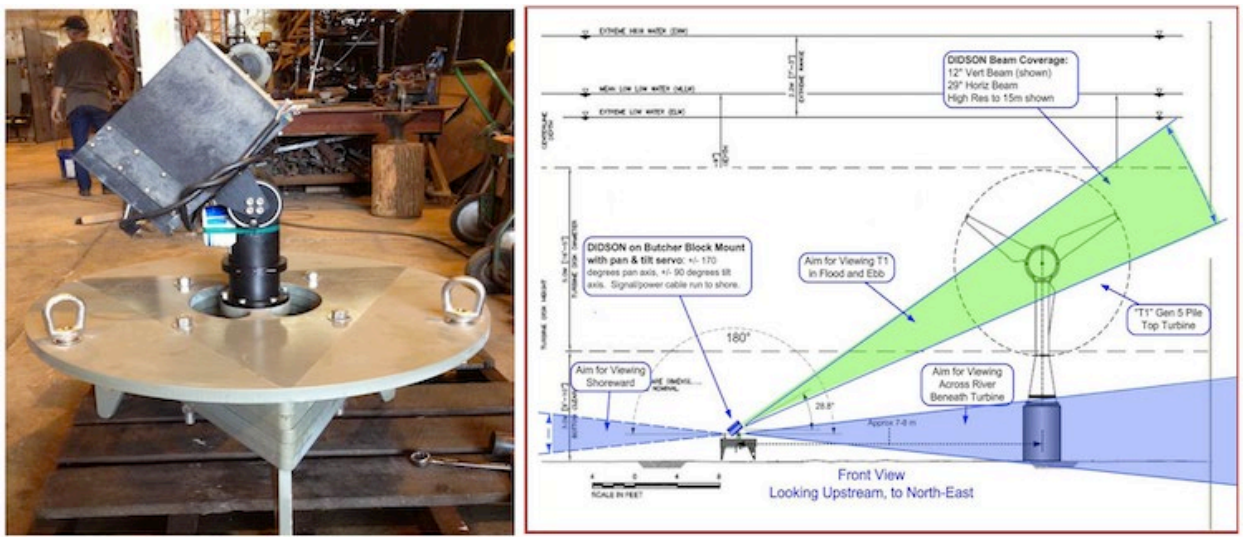
The following outlines the objective of the RMEE-2 Plan under the RITE Pilot License.

The objective of the seasonal DIDSON observation is to:

1. Provide real-time observation of fish behavior near operating KHPS during a seasonal period of known fish abundance. Specifically, the goal is to provide imaging of any fish/KHPS interaction, both spatial and temporal, at the micro scale around a rotating turbine. Parameters that can be observed from the DIDSON will include:
    - fish swimming location and direction relative to the turbine blades. Achieved.
    - fish passage through or around the turbine. Achieved.
    - for fish passing through the turbine, it will be possible in most cases, especially for larger fish to determine if fish avoided the blades or were struck. Achieved.
    - fish size and shape with potentially some species identification, especially for larger individuals (e.g., Atlantic sturgeon, turtles, marine mammals). None observed; species identification not achievable.
2. Add value to the body of collected data on fish presence, abundance, movement pattern, and species in and around the operating KHPS machine by providing micro-scale details of the fish seen at the meso scale by the split beam transducers (SBT).

Accordingly, in fall 2012 Verdant Power installed and operated a remotely aimable DIDSON (RAD) unit near an operating dynamometer turbine at the RITE Project site (see Figure 6).

Figure 6. RMEE-2 DIDSON as Deployed at RITE, 2012



This activity ultimately provided over 300 hours of RAD data, both with and without turbine operation.

3.2.2 Test Results and Data Analysis

To analyze this data, Verdant Power partnered with the Oak Ridge National Laboratory (ORNL). ORNL post processed the data and provided a third-party assessment that was used to develop the KHPS-Fish Interaction Model, which forms the basis of Verdant's ongoing environmental compatibility effort. Detailed results of this effort were published in an ORNL final report,[10] as well as conference proceedings[11][12][13] (see appendix A).

In summary, conclusions of the 2012 RMEE-2 study were as follows:

- The objectives of the RMEE-2 plan were achieved in the 2012 observation.
- It is doubtful that further RAD deployments to observe multiple operating turbines is a useful technique at RITE or that it would yield further data.
- Review of 239 hours of DIDSON video in the presence of an operating Gen5 KHPS turbine revealed no drastic changes in swimming behavior as a result of exposure to the turbine.
- Automated data analysis was a challenge because of the rotating turbine.

Specifically, the ORNL analysis included the following conclusion [emphasis added]:

> In conclusion, we found no evidence that fish were regularly struck by turbine blades at the RITE site, and we believe that the likelihood is quite low based on several lines of evidence: the low probability that fish would directly encounter a turbine (Wilson et al. 2007), the apparent long range avoidance seen in this study and another study (Viehman and Zydlewski 2015), the apparent ability of most fish to avoid rotor blades when they are encountered at close range (Amaral et al. 2010, 2015), and the paucity of evidence for direct blade strikes. However, based on the relative number of fish tracks identified under the different turbine conditions, the results of this study do suggest that avoidance might be occurring at a distance beyond the 10–15-m range of the DIDSON system.

3.2.3 Limitations of Study

Verdant Power examined the possibility of RAD deployment during Install B-1 and determined that this configuration would be unable to ensonify all three turbines. Further, and in line with ORNL's findings, the turbulence generated during the operation of the Install B-1 three-turbine system operation would likely limit the effectiveness of the DIDSON observation. Based on this, Verdant Power, in consultation with the RITE resource agencies, proposed suspending activities under the RMEE-2 plan as of 2019 and instead enhancing detection of tagged species under the RMEE-4 plan. FERC acted in October 2019 to approve this recommendation and modified Article 401 of the RITE License accordingly.

3.2.4 Research Needs and Data Gaps

Based on the analysis conducted, it is clear that the DIDSON was a useful tool in imaging the micro-scale impact (or lack thereof) of the KHPS turbine on the local environment, as well as confirming the micro-scale absence (and likely avoidance) of fish around an operating turbine. However, this approach was not deemed effective for larger arrays of turbines. This conclusion is in line with the ORNL findings, which included the following:

- This [RAD] monitoring protocol is focused as discussed on the observation of a single (or few) operating KHPS turbines at the micro scale. It is likely not applicable for multiple turbines in an array condition. Moving toward such studies, it is recommended that research and development funding for alternative techniques or algorithms be undertaken to address the array condition.

3.3 RMEE-3 Seasonal Species Characterization—Netting

3.3.1 Background and Objectives

The following outlines the objective of the RMEE-3 Plan under the RITE Pilot License:

> The objective of netting is to provide a set of net capture data, during May through December with more effort during the seasonal period (mid-September through mid-December) of elevated fish abundance in the project vicinity to provide:
>
> 1. Species characterization information, that combined with the 2006 RITE trawling, and the Ravenswood and other historical impingement data will provide additional understanding of the fish population in the East Channel.
> 2. Species characterization in the immediate vicinity of the turbines that can be used to support the interpretation of the past and future DIDSON monitoring and hydroacoustic evaluations.
> 3. Some observation and/or data for interpretation on potential fish injury due to turbine blade contact in a field of operating KHPS turbines.

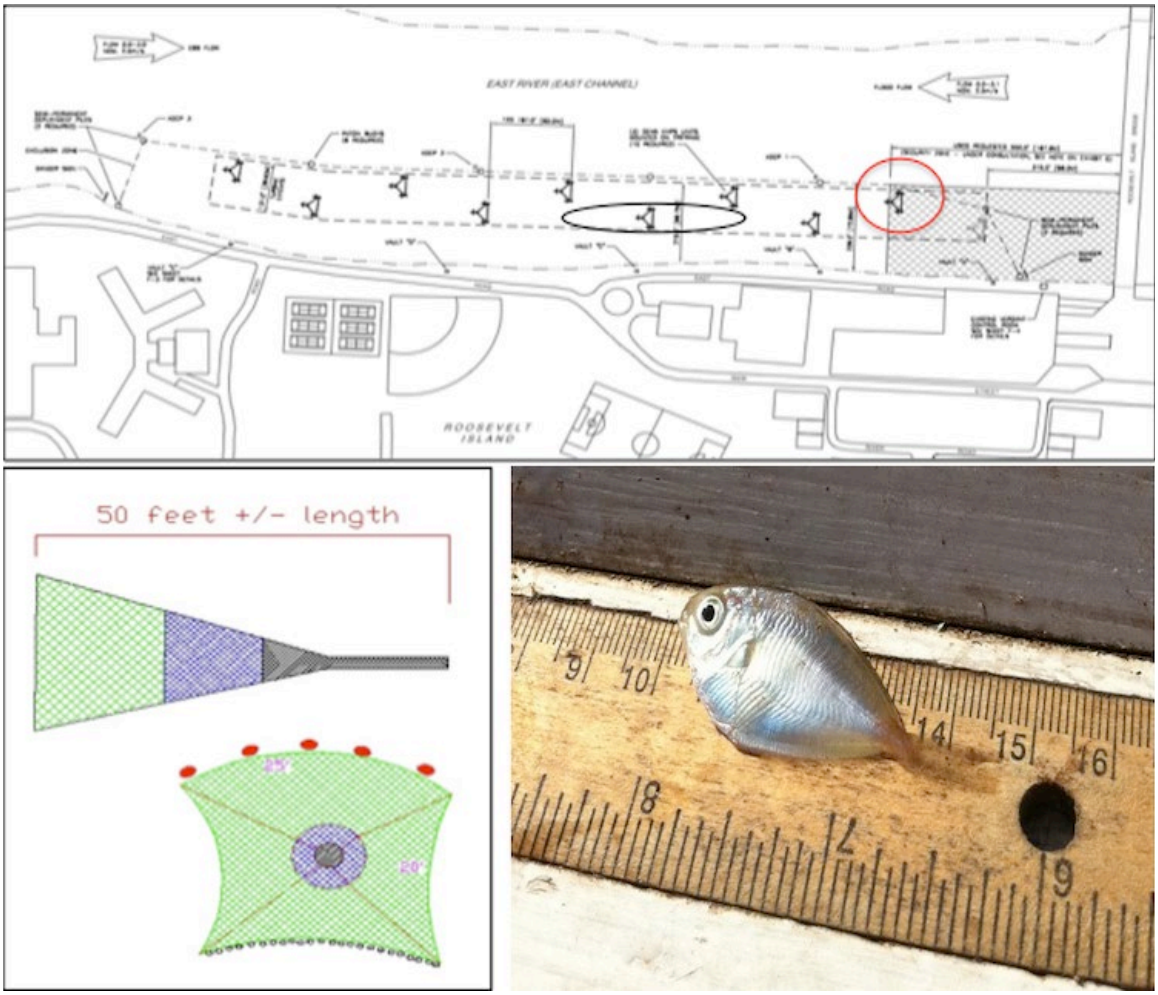
3.3.2 Test Results and Data Analysis

To achieve these objectives, Verdant contracted Kleinschmidt Associates and Normandeau Associates to conduct a netting effort in May 2013 in the vicinity of the RITE Project site in the East Channel of the East River (see appendix A). To characterize the fish assemblages that would have the most likelihood of encountering the RITE Project turbine system, a mid-water (pelagic) research trawl was executed at the site. Sampling was undertaken near slack tide in the near-shore area where hydroacoustics demonstrated most of the fish are located. The full-day effort included three total tows. Upon conclusion of each tow, the contents of the net and all aquatic organisms were sorted, identified, and quantified. Overall, only two aquatic organisms were caught during the tows, as follows:

- Tow 1: Nothing caught
- Tow 2: Callinectes sapidus, blue crab; 44 mm; alive; returned unharmed
- Tow 3: Peprilus triacanthus, butterfish; 37 mm; alive; returned unharmed

Figure 7 depicts the area where the netting was conducted, net specifications, and one of the two organisms (butterfish) caught.

Figure 7. RMEE-3 Stationary Netting at RITE, 2013



3.3.3 Limitations of Study

Based on general observations and confirmed during the actual 2013 netting activities, characterization netting near the RITE Project area is unlikely to yield meaningful results given (1) the difficulty of netting in strong tidal currents and (2) the general absence of fish in the mid-river.

Based on this, Verdant Power, in consultation with the RITE resource agencies, proposed suspending activities under the RMEE-3 plan as of 2019. FERC acted in October 2019 to approve this recommendation and modified Article 401 of the RITE License accordingly.

3.3.4 Research Needs and Data Gaps

While the 2013 netting effort confirmed further netting would be unlikely to yield meaningful results, extensive fish assemblage data available from aquatic organism samples collected at Ravenswood Generating Station, in close proximity to the RITE Project site, were found to be valuable in characterizing the fish assemblage in the RITE Project area. Ravenswood historical impingement data collected between 1991 and 2007 provides characterization of the fish assemblage (72 aquatic species identified) in the East Channel. Table 2 outlines the most common species identified.

Table 2. Top Ten Species in the Ravenswood Impingement Collections

Historically compared to recently collected data (listed in order of descending abundance).

Historic Impingement Collections	Recent Impingement Collections
Winter Flounder	Winter Flounder
Blueback Herring	Oyster Toadfish
Grubby	Northern Searobin
Northern Pipefish	Smallmouth Flounder
Lined Seahorse	Bay Anchovy
Smallmouth Flounder	Spotted Hake
Atlantic Herring	Blueback Herring
Atlantic Silverside	Atlantic Silverside
Northern Searobin	Alewife
Bay Anchovy	Northern Pipefish

The focus on this historical data review and suspension of netting efforts at RITE following 2013 represent prudent adaptive management decision-making.

3.4 RMEE-4 Tagged Species Detection

3.4.1 Background and Objectives

The following outlines the objective of the RMEE-4 Plan under the RITE Pilot License:

> To provide new and unique detections on the potential presence of the proposed ESA listed Atlantic sturgeon,[14] ESA Listed shortnose sturgeon, along with striped bass, bluefish, winter

flounder and other species that have been acoustically tagged (by others), in the vicinity of the Roosevelt Island Tidal Energy (RITE) project.

Verdant acknowledged the importance of this study early on and since 2011 has operated Vemco tagged species detection hydrophones (VR2W - 69kHz) in both the East and West Channels of the East River to gain information on fish passing near the KHPS at RITE.

Verdant Power has also conducted periodic data downloads, which require on-water vessels and in-water diver support. Tag identification efforts are also coordinated with Vemco and independently by Verdant Power with various East Coast researchers. The process includes the following:

- Screening of the data to ensure test tag detection and isolate possible tags.
- Transmittal of the tags for verification through Vemco, which validates and shares data with researchers.
- Researchers contact to identify tag, species, length, and release date and location.
- Summary and reporting in relationship to RITE site and tidal conditions.

3.4.2 Test Results and Data Analysis

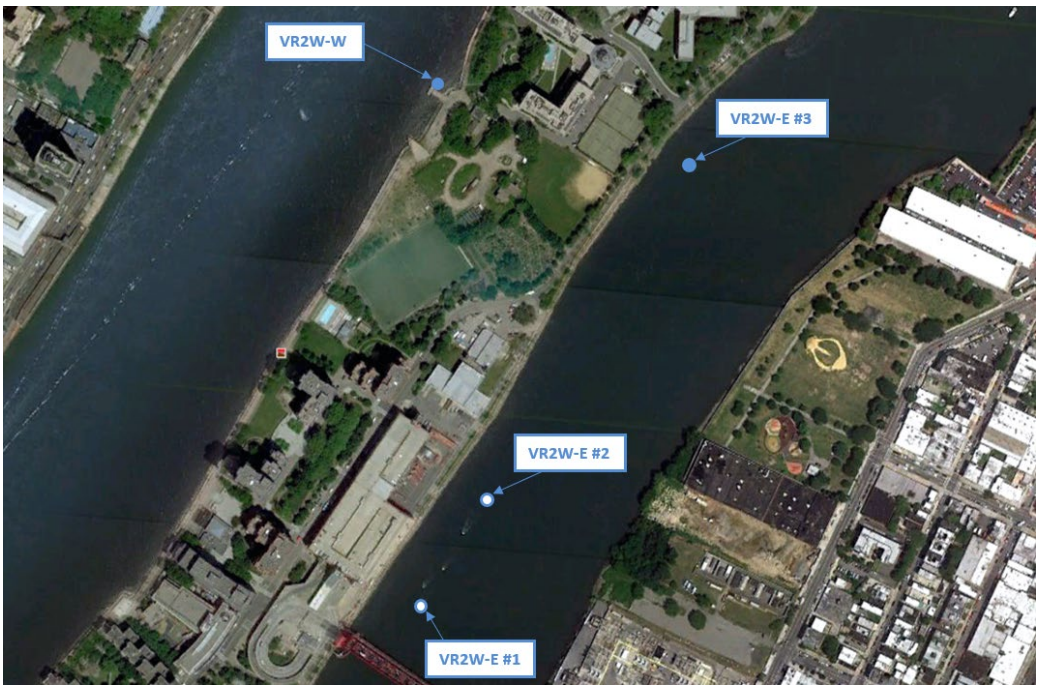
Under the Pilot License, the RMEE-4 plan required detection active during April to November; however, Verdant has extended this to year-round collection where possible, and as limited by battery life. A summary of RMEE-4 operations since 2011 is listed below:

- Two receivers were deployed into the East Channel in May 2011 and operated until 2015, when they were lost due to an extreme ice event in February 2015. A single receiver was deployed as a replacement in August 2015 and operated, with one brief interruption, until it was removed for maintenance in April 2018.
- A single receiver was deployed into the West Channel in August 2011 and remained in continuous operation until it was removed for maintenance in April 2018.
- In October 2019, based on the modification to the RMEE-4 Plan, three receivers were deployed into the East Channel and one receiver into the West Channel (see Figure 8).

The maintenance of these detection receivers requires the retrieval of each receiver (with a diver) for above water data transmission via Bluetooth link. Data download times are relatively short (< 10 min) and receivers are immediately redeployed following successful transmission. Yearly battery, O-ring, and desiccant replacement as maintenance are required for proper operation.

Figure 8. RMEE-4 Vemco Receiver Locations at RITE, 2020

Receiver range is 400m. Approximate East Channel width is 100m.



Results of these activities under the RMEE-4 Plan are summarized below and in Table 3.

- One hundred fifty-five unique tags have been detected, representing a total of 370 fish events, with 29 of unknown/unidentified species.
- Four different tagged species have been detected to date: Atlantic sturgeon, striped bass, American shad, and alewife.
- Totals: 60 Atlantic sturgeon, 278 striped bass, three other species, 29 unknown species.
- East Channel Totals: 12 Atlantic sturgeon, 62 striped bass, one Alewife, three unknown species.
- A predominance of the 370 total detections is in the West Channel (292) as compared to the East Channel (78) where the RITE Project is sited.
- Since 2011, Verdant Power has worked to identify the events reported as "unknown," bringing the total number down to 29 of the 370 total, or 7.8%. Verdant will continue to work with Vemco and the research community to identify the remaining 29 unknown events.

Table 3. Summary of RMEE-4 Species Detections: May 2011—November 2020

	East Channel		West Channel	TOTAL
Total Calendar Days	3466 days		3355 days	**110+ months**
Total Detection Days	2507 days		2811 days	**80+ months**
Total Fish Detected	78		292	**370**
	East Channel		**West Channel**	**TOTAL**
Total Atlantic Sturgeon Detected	12		48	**60**
Total Striped Bass Detected	62		216	**278**
Total Other Species Detected	1		2	**3**
Total Unknown/Unidentified Detections	3		26	**29**

Another significant result of the tagged species detection effort has been the improved parameterizing of the Verdant KHPS-Fish Interaction Model, which is further described in appendix A. This has allowed Verdant to postulate a lower risk to RTE species based on its observations over the nine-year RMEE-4 program.

3.4.3 Limitations of Study

Two acknowledged limitations of this plan are as follows:

- Effective only if researchers tagging fish participate in mutual data exchange.
- The single platform as deployed in the East Channel detects presence (within 400m) but not specific location in relationship to the KHPS which can only be achieved with triangulation.

This effort requires cooperation for continued tagging by researchers and data sharing with many organizations, which does pose a potential hurdle to the success of the protocol for both striped bass recovery efforts and the tagging and identification of the ESA species Atlantic sturgeon. Throughout this study, Verdant has worked with the researchers and believes this ongoing body of information on macro and meso movement of detected species provides important biological information on target species.

Additionally, an acknowledged limitation of the 69Hz tag commonly in use by researchers is that it can only be detected by receivers in proximity (within 400m) of the receiver and not directly pinpoint proximity or movement.

Finally, in examining options for the Install B-1 deployment, Verdant explored improvements to the RMEE-4 protocol. One option would be to deploy additional Vemco receivers and tags and conduct analysis on the triangulation of detected tags to spatially locate, in 3-D, a tagged fish and its track as

it passes multiple KHPS turbines. Verdant was optimistic that such a triangulation concept could be implemented; however, it was later determined that the fish tags used by researchers are not compatible with this change and therefore Verdant did not make this change to the protocol.

3.4.4 Research Needs and Data Gaps

The protocols used to detect tagged species, particularly the presence, abundance, and movement of endangered species, has been significant in understanding the proximity of such species to the RITE Project boundary, as well as for parameterizing the KHPS-Fish Interaction Model. However, it is clear that continued funding and the cooperative efforts of East Coast fish researchers are vital to continuing and expanding the success of such activities, including the study of large fish movement through a field of kinetic hydropower turbines.

3.5 Other RMEE Plans

While outside the scope of the subject project, for completeness, appendix B summarizes the three additional RMEE Plans executed during RITE Install B-1, including the following:

- RMEE-5 Bird Observation
- RMEE-6 Underwater Noise Monitoring
- RMEE-7 Recreational Monitoring

4 Conclusions and Policy Implications

The following provides conclusions and policy implications for environmental assessment of hydrokinetic projects in New York State and the U.S. overall based on the findings of the subject project as well as Verdant Power's extensive experience with regulatory processes during the history of the RITE Project.

4.1 Conclusions

NYSERDA's support for environmental assessment at the RITE Project, both under this project as well as prior related initiatives, has resulted in the achievement of the following groundbreaking milestones:

- Execution of a suite of 11 study plans during the Gen4 KHPS RITE Demonstration (2006–2008). Environmental data gathered through this effort was fully embodied in the final license application to FERC for the RITE Project and resulted in the first commercial license for a tidal power project in the U.S.
- Studies under the Gen4 KHPS informed the proportional RMEE Plans to study effects of the Gen5 KHPS turbines under the FERC license.
- During the period of 2012–2019, execution, in an adaptive management context, of first-of-its-kind RMEE Plans to provide understanding of effects of small-scale array projects on the East River ecosystem.
- During 2020, execution of RMEE-4 during actual grid-connected operation of the Gen5 KHPS system.

Based on these activities, Verdant Power provides the following conclusions:

1. **Proportionality:** Verdant Power notes that perhaps the greatest lesson learned from its experience at the RITE Project is that a "before-and-after" type analysis is truly not appropriate for hydrokinetic energy projects, since the effort to tease out "effects" of the device and/or array is mostly impossible within the dynamic water resource required for such projects. Verdant strongly encourages the concept of "proportionality" for hydrokinetic energy projects. Proportionality refers to an approach that establishes guidelines for baseline data collection and operational monitoring in direct proportion to the scale, stage, duration, and potential of the project to actually cause a measurable effect.
2. **Practicality:** A key issue that arises during consultation with resource agencies and project stakeholders is that there must be a balance between the expected value of baseline and operational monitoring activities and cost effectiveness. In a nascent industry such as hydrokinetic energy, developers are most often in start-up phases and thus lack substantial revenue streams. As such, embarking on extensive baseline studies followed by multiyear operational monitoring—in brutal marine environments—is a hugely risky undertaking, often based on experimental methods that could produce speculative results. This is exacerbated by pressures to get projects online to contribute to forward-looking clean energy mandates at the state and federal levels, all while also driving down the levelized cost of energy. From an early

developer perspective, it is vital at the early stage to work with resource agencies to develop a mutual understanding and development of the cost/value proposition as it relates to proposed data collection methods on the actual indicator receptors that could cause impact. Such issues regarding the costs of studies undertaken here and the resulting impact/effects for future monitoring were discussed during the subject project, thus advancing the initiative, and the hydrokinetic energy industry overall.

3. **Research Funding:** It is clear that if hydrokinetic energy is to be considered part of a long-term offshore renewable energy strategy, the burden of environmental studies cannot rest solely with developers. It is also vital that resource agencies and researchers are funded in parallel to conduct monitoring in accordance with their charters, and in areas of strategic environmental importance and mutual benefit to the industry overall. Equally important, however, is that such research continues to gain the perspective of developers, particularly as it relates to the points #1 (proportionality) and #2 (practicality) above. Esoteric research without these considerations will not be useful to the maturation and commercial viability of the hydrokinetic energy industry. Funding research connected directly to licensed or in-licensing projects is key.
4. **In-Water Experience:** One of the most significant "ah ha" moments in the RITE Project (as documented in the primer case study and related documents[15] was the acceptance—after four years of discussion with resource agencies—that the environmental assessment of a novel technology like hydrokinetics presents a dilemma: You have to let the technology operate in the environment to truly know the effects, but it is difficult to allow the technology to operate in the environment without knowing what the effects might be.

Ultimately, and to their credit, the RITE resource agencies did embrace this concept and allowed the RITE Project to move forward under an adaptive management framework, which—as evidenced through the subject project, and the RITE Project overall—has proven to be an appropriate and responsible approach.

4.2 Policy Implications

As part of this project, Verdant participated in the NYSERDA Environmental Policy Workshop that was conducted in May of 2012, focusing on improving the efficiency and effectiveness of the regulatory process surrounding the siting of hydrokinetic power projects in New York State, with special emphasis on the transition from pilot to early commercial stages.

The effort included the development of two background documents, which served as the basis of discussion to an in-person workshop in May 2012:

Marine and Hydrokinetic Technology—Background and Perspective for New York State: Undertaken by the Ocean Renewable Energy Coalition and Verdant Power, this document represents a hydrokinetic power technology primer that provides context for the Marine and Hydrokinetic (MHK) industry and a state of the technology and environmental analysis, with a specific case study of the Verdant Power RITE Project environmental and regulatory history from 2002–2012 and the FERC Pilot License. This document is useful to understanding the genesis of the current environmental review process for hydrokinetics.

A Review of Regulatory and Policy Requirements for Hydrokinetic Power Projects in New York State[16]: This document was produced by The Pace Energy and Climate Center of the Pace Law School and provides an examination of New York State and federal policies related to the development, siting, and permitting/licensing of hydrokinetic projects (up to the 2012 timeframe). Its content remains a useful guidance in such discussions and decision-making.

The resulting workshop is documented in a third document, **New York State Hydrokinetic Generation Environmental Policy Workshop Post-Workshop Analysis**[17] prepared by the Beacon Institute for Rivers and Estuaries in December 2012.

The following were some policy implications from that workshop and based on the RITE Environmental Assessment experience:

1. Structure adaptive management monitoring plans to optimize proportional learning based on the installed capacity and allow for transferrable knowledge, findings, and review/modification/ retirement of monitoring plans.
2. Utilize conceptual model interaction frameworks with parameterized input that can establish risk and predictability of how a device or array interact with an environment. Support research or monitoring plans that improve the understanding of parameters and allow for re-evaluation through the adaptive management framework. With greater understanding as data is collected, knowledge could be applied to other similar sites and this ability to transfer findings could have significant positive impacts by accelerating project timelines.
3. Build on synergies with other ongoing offshore programs to expand the knowledge, understanding, and effects of both environmental issues and technology challenges.
4. For adaptive management to be effective, more knowledge is needed to understand the macro offshore ecosystems where hydrokinetic (and offshore wind) devices are deployed. With coordinated efforts, both resources can be developed responsibly for New York State.

5 References

FERC Order Issuing Pilot License - FERC P-12611; January 23, 2012. Available for download at www.theriteproject.com

FERC Order Modifying License Article 401 - FERC P-12611-007; October 3, 2019.

New York State Energy Research and Development Authority (NYSERDA). 2011. "Roosevelt Island Tidal Energy (RITE) Environmental Assessment Project." NYSERDA Final Report 11-04 [Based on Gen4 KHPS]. Prepared by Verdant Power New York, LLC (New York, NY). nyserda.ny.gov/publications

New York State Energy Research and Development Authority (NYSERDA). 2012. "New York State Hydrokinetic Generation Environmental Policy Workshop Post-Workshop Analysis." NYSERDA Final Report No. 12-27. Prepared by the Beacon Institute for Rivers and Estuaries, Clarkson University (Beacon, NY). nyserda.ny.gov/publications

New York State Energy Research and Development Authority (NYSERDA). 2012. "Marine and Hydrokinetic Environmental Policy Workshop: Marine and Hydrokinetic Technology Background and Perspective for New York State." NYSERDA Final Report No. 12-27b. Prepared by the Ocean Renewable Energy Coalition (Washington, D.C.). nyserda.ny.gov/publications

New York State Energy Research and Development Authority (NYSERDA). 2012. "A Review of Regulatory and Policy Requirements for Hydrokinetic Power Projects in New York State." NYSERDA Final Report No. 12-27c. Prepared by the Pace Energy and Climate Center (White Plains, NY). nyserda.ny.gov/publications

Oak Ridge National Laboratory (ORNL). 2016. "Informing a Tidal Turbine Strike Probability Model through Characterization of Fish Behavioral Response using Multibeam Sonar Output." ORNL Final Report No. ORNL/TM-2016-219. Prepared by Bevelhimer, M., Colby, J., Adonizio M.A., Tomichek, C., Scheleris, C. www.otsi.gov/scitech/

Tomichek, C., Colby, J., Adonizio, M.A., Frisk, M., Dunton, K., Fox, D., Jordaan, A. "Tagged Species Detection: Approach to Monitoring Marine Species at Marine Hydrokinetic Projects." Paper presented at the 2nd Marine Energy Technology Symposium, Washington, D.C., April 2014.

Tomichek, C., Colby, J., Adonizio, M.A. "Improvements to Probabilistic Tidal Turbine – Fish Interaction Model Parameters." Paper presented at the 3rd Marine Energy Technology Symposium, Washington, D.C., April 2015.

Tomichek, C., Colby, J., Bevelhimer, M., Adonizio, M.A. "Parameter Updates to Probabilistic Tidal Turbine – Fish Interaction Model." Paper presented at the 4th Marine Energy Technology Symposium, Washington, D.C., April 2016.

Verdant Power, LLC Final Pilot License Application - RITE Project, Volume 4: RITE Monitoring of Environmental Effects (RMEE) Plans, Appendices A & B summarizing supporting fishery information, ESA, EFH; 2010. Available for download at www.theriteproject.com

Appendix A: Overview of RITE Environmental Information and Related Publications

Appendix A: Overview of RITE Environmental Information and Related Publications

The compilation of environmental information developed for the RITE Project since 2006 includes three major undertakings:

- The Draft License Application (November 2008)
- The 2010 Final License Application (FLA) (December 2010)
- The 2019 Relicense Application (December 2019)

All of these filings are available on https://elibrary.ferc.gov under docket number P-12611.

To provide context to the environmental assessment conducted under this project, Verdant Power presents the following overview of environmental information current to 2020, as well as the full context of technical reports and papers that support this analysis.

1. Water Resources and Hydrodynamics

Water Quality: Verdant sampled the near surface water from the East Channel, East River in June and December 2011 in conjunction with Sandia National Laboratories (SNL) and measured the salinity values between 19.6 and 20.2 PPT, nearly identical to the results as reported in the FLA. To Verdant's knowledge, all water quality reporting remains accurate as filed in 4.3.2.3 (FLA Vol. 2).

Hydrodynamics: Since the FLA filing, Verdant has continued to advance the state-of-the-art in Computational Fluid Dynamics (CFD) to understand and confirm the micro-, meso-, and macro-scale hydrodynamics of the installed project. The conclusions presented in Exhibit E Volume 2, beginning on p. E-74, are summarized below at the three scales. Work with Oak Ridge National Laboratory (ORNL) and the University of Minnesota Saint Anthony Falls Laboratory (SAFL), and ongoing work with Stony Brook University (SBU), confirms the results as filed in 4.3.2.2 (FLA Vol. 2). Specific advancements at each scale can be summarized as follows; and the papers referenced are included in this addendum.

1) **Micro-Scale:**
    a. **Understanding at 2010 FLA:**
        i. "Non-Rotating units create small wake regions, especially behind the pylon, pile, blades, and tail cone. Very little flow acceleration is visible and what can be seen is generally well above the river bottom. Pressure differences across the stationary and rotating structures do lead to wake regions, however pressures below the vapor pressure are not seen and cavitation is not a concern.

        The turbulent wake, both bluff-body and tip-vortex, led to increased mixing and flow disturbance. However, these regions of increased mixing/scouring/sediment transport are expected to be generally well above the river bottom. The impact of the pile wake, which is near the river bottom, is reduced by the natural presence of a strong turbulent boundary layer.

        Computational limitations due to blade/rotor resolution requirements prevent the accurate modeling of the far-field (meso-scale) wake behavior."

b. Advancements 2012-2020:

i. Detailed quantification of the hub-height turbulence in May 2011 with two Acoustic Doppler Velocimeters (ADVs) provided by ORNL. Undisturbed values for Turbulence Intensity and Spectral Energy Density, among others, were characterized and utilized in internal load prediction software to predict the loads on the TF+3T with additional accuracy. Journal publications include:

1. "Tidal Energy Site Resource Assessment in the East River tidal strait, near Roosevelt Island, New York, New York," Gunawan, B., Neary, V.S., Colby J., Renewable Energy, no. 71, p 509-517, 2014.

ii. Updated computational fluid dynamics (CFD) work at the University of Minnesota St. Anthony Falls Laboratory (SAFL) on the micro-scale hydrodynamics of an individual KHPS was conducted. Utilizing in-house numerical methods for solving the complex turbine geometry, including the rotor and all stationary components, SBU completed large-eddy simulations (LES) of the Verdant Gen4 KHPS in 2011 and the Gen5 KHPS in 2017 as discussed below. Peer-reviewed journal publications include:

1. "Numerical simulation of 3D flow past a real-life marine hydrokinetic turbine", Kang, S., Borazjani, I., Colby, J. A., Sotiropoulos, F., Advances in Water Resources, vol. 39, p. 33-43, 2012.

c. Observations as of 2020:

i. From the published 2012 paper, "The computed results illustrate the complexity of the flow and show that the power output of the complete turbine is primarily dependent on the rotor geometry and tip speed ratio and is not affected by the stationary components of the turbine and the presence of the channel bed. The complete turbine simulation also reveals that the downstream wake of the turbine consists of three main regions: (1) the outer layer with the spiral blade tip vortices rotating in the same direction as the blades; (2) the counter-rotating inner layer surrounded by the spiral tip vortices; and (3) the core layer co-rotating with respect to the tip vortices. This study is the first to report the three-dimensional wake structure of MHK turbines."

ii. In general, these updated results for the micro-scale hydrodynamics of the Gen4 turbine agree with the conclusions drawn in the FLA. The Gen5 KHPS has a nearly identical rotor geometry and rotates at a lower rpm than the Gen4 KHPS. As such, the understanding of the micro-scale hydrodynamics around an operating KHPS has been advanced, confirming the previous conclusions and re-affirming the complex physics associated with the fluid-structure interaction at the micro-scale.

2) Meso-Scale:

a. Understanding at 2010 FLA:

i. "The in-water data was confirmation of the influence of KHPS units on a mesoscale and is reflected in the quality of energy production during the timeframe and largely informs Verdant Power of the correct lateral and longitudinal spacing of KHPS units.

Velocity magnitudes are greatly reduced directly downstream of a generating unit, while velocity directions are shown up to 90^{o} out of phase with the natural channel direction. These 3-d, rotating, vortex structures convect downstream, centered on the shaft centerline. Their general influence is maintained in a slowly expanding cone downstream from the rotor and is thought unlikely to affect the river bottom.

With regard to localized effects, the presence of the pylon and the areas of lower velocity (reductions up to 50%) behind the stationary KHPS unit pylon during ebb and flood flows do present a potential area of protection and/or habitation. However, as discussed in the Aquatic Resources sections, the fish abundance and population observations generally tend to indicate that fish (both large and small) are not present in the high current zones of the KHPS. Nor are they present in general, during the ebb and flood cycles, and so the decrease in localized velocities would not be likely to effect the predator-prey relationship within the field."

b. Advancements 2012-2020:

i. Updated CFD work at SAFL, the University of Washington (UW) and Stony Brook University (SBU) on the meso-scale hydrodynamics of a TriFrame + 3 Turbines (TF+3T) was completed. Using similar tools, large-eddy simulations (LES) of the wake structure of a TriFrame of three turbines is investigated using both numerical simulations and scale-model experiments. Peer-reviewed journal publications include:

1. "Wake characteristics of a TriFrame of axial-flow hydrokinetic turbines", Chawdhary, S., Hill, C., Yang, X., Guala, M., Corren, D., Colby, J., Sotiropoulos, F., Renewable Energy, Vol. 109, p 332-345, 2017.

c. Observations as of 2020:

i. From the published 2017 paper, "We found that the wake of the upstream TriFrame turbine exhibits unique characteristics indicating presence of the Venturi effect as the wake encounters the two downstream turbines. We finally compare the wakes of the TriFrame turbines with that of an isolated single turbine wake to further illustrate how the TriFrame configuration affects the wake characteristics and power production in an array of TriFrames."

ii. In general, these updated results for the meso-scale hydrodynamics of the Gen4 turbine agree with the conclusions drawn in the FLA. Verdant was able to significantly increase our understanding of the meso-scale hydrodynamics associated with the TF+3T configuration. Further, research suggests that turbine performance on a TriFrame can be improved relative to the performance of 3 individual turbines. Specifically, "The faster momentum deficit recovery and lower turbulent kinetic energy (TKE) in the wake of the upstream turbine of the TriFrame are advantageous when using the TriFrame assembly to build a large turbine array."

3) **Macro-Scale:**
    a. **Understanding at 2010 FLA:**
        i. "A 1-d model for the extraction of kinetic energy, as an additional source of frictional losses, from an open channel can accurately predict the depth and velocity in the East Channel of the East River. The influence of energy extraction is to slightly increase (12 mm) the overall water depth from the inlet of the channel to the extraction planes. As a result, the water velocity is decreased slightly (-0.07 m/s) throughout the channel.

            These modifications to the channel properties are minimal and below the precision available for most measurement devices. As such, the generation of 1 MW from the East Channel of the East River is unlikely to modify the natural channel properties in any way. As part of the operational monitoring, Verdant Power will also continue to install and record water velocity and level data with the use of Acoustic Doppler Current Devices (ADCPs) that will inform the hydrodynamics of the machines and array, as the staged installation progresses. This data, coupled with the RMEE Plans, will continue to build and support the body of science of hydrodynamic effects of operating KHPS units in different configurations."

    b. **Advancements 2012-2020:**
        i. Updated CFD work at SAFL, SBU, the University of Chicago and Argonne National Laboratories during 2015-2017 on the macro-scale hydrodynamics of an array of TF+3Ts has been conducted. Specifically, a new generation unstructured Cartesian flow solver coupled with a sharp interface immersed boundary method for 3D incompressible flows is used to numerically investigate New York City's East River, including the high-resolution bathymetry acquired as mentioned above, and the array of thirty KHPS turbines. Peer-reviewed journal publications include:
            1. "Multi-resolution simulations of an array of hydrokinetic turbines: Site-specific field scale large eddy simulations of the East River in New York City", Chawdhary, S., Angelidis, D., Sotiropoulos, F., Corren, D., Colby, J., Water Resources Research, PENDING

    c. **Observations as of 2020:**
        i. From the pending journal paper, "Simulations indicated that a marginal acceleration in the river flow in the spanwise region where turbines were not placed. Comparison with the baseline flow in terms of mean streamwise velocity as well as vorticity magnitude indicates that there is a very small signature of the turbine wake at the free surface of the channel. This effect could be negligible compared to the free surface disturbances present in the tidal channel otherwise."
        ii. Verdant was able to advance the state-of-the art modelling of the meso-scale hydrodynamics from 1-D to 3-D, a significant improvement in understanding and a fundamental advancement in computational modeling and confirm the previous conclusions regarding de minimus effects of 10 TriFrames in an array.

2. Aquatic Resources

As required by Article 401 of the issued Pilot license, in advance of Install B-1 (3 turbines on a TriFrame), to advance knowledge regarding fish and aquatic resources, Verdant voluntarily conducted RMEE data collection efforts. These include the following:

1) RMEE-2 – Seasonal DIDSON Observation Monitoring

a. Objective (2010 FLA and approved in Pilot license):

From the FERC FLA, "The objective of the seasonal DIDSON observation is to:

i. Provide real-time observation of fish behavior near operating KHPS during a seasonal period of known fish abundance. Specifically, the goal is to provide imaging of any fish/KHPS interaction, both spatial and temporal, at the micro scale around a rotating turbine. Parameters that can be observed from the DIDSON will include:

- fish swimming location and direction relative to the turbine blades.
- fish passage through or around the turbine.
- for fish passing through the turbine, it will be possible in most cases, especially for larger fish, to determine if the fish avoided the blades or was struck.
- fish size and shape with potentially some species identification, especially for larger individuals (e.g., Atlantic sturgeon, turtles, marine mammals).

ii. Add value to the body of collected data on fish presence, abundance, movement pattern and species in and around the operating KHPS machine by providing micro-scale details of the fish seen at the meso scale by the SBTs."

b. Advancements since 2012:

i. Methodology: Verdant, during the 2012 In-water Test (IWT) of the Gen5b rotor, installed and operated a remotely aim-able DIDSON unit in close proximity to the operating dynamometer turbine. A significant data set was collected over 2+ weeks with and without turbine operation.

ii. Analysis: In conjunction with Oak Ridge National Laboratory (ORNL), under US DOE funding, Verdant and ORNL re-evaluated the 2012 DIDSON data using automated data processing techniques to evaluate 5 projects objective:

1. "Quantify near-field (i.e., within 12 m) behavioral response and swimming trajectories of fish encountering an operating HK turbine using 373 hours of video from a deployed DIDSON multibeam hydroacoustic system.
2. Quantify the far-field normal swimming trajectories and distribution of fish in the vicinity of the deployment site using previously collected data from a split beam hydroacoustic system during the same seasonal period.

3. Characterize the relationship between flow dynamics and changes in behavior and distribution (near- and far-field) with correlation of concurrently collected acoustic Doppler current profiler (ADCP) data.

    a. Near-turbine fish trajectories, avoidance behavior, and general distribution relative to near-field hydraulics (i.e., water velocity and tide direction) with and without the influence of a turbine.
    b. Far-field vertical and horizontal distributions and trajectories of fish relative to water velocity and tide stage (ebb, flood and slack tide) with and without the influence of a turbine.

4. Update parameterization of existing fish interaction model developed for the East River and the RITE Project.

5. Use study results to assess which approaches (e.g., field observation, experimentation, models) will be most effective for predicting or monitoring the effects of turbine arrays."

iii. Data and Results: The summary of this analysis is provided in the final ORNL report ("Informing a Tidal Turbine Strike Probability Model through Characterization of Fish Behavioral Response using Multibeam Sonar Output", Bevelhimer, M., Colby, J., Adonizio M.A., Tomichek, C., Scheleris, C., ORNL/TM-2016-219, July 2016).[1] These results have also been published in a number of journal articles and conference proceedings, including:

    1. "Hydroacoustic Assessment of Behavioral Responses by Fish Passing Near an Operating Tidal Turbine in the East River, New York", Bevelhimer, M., Scheleris, C., Colby, J., Adonizio M.A., Transactions of the American Fisheries Society, Vol. 146, Issue 5, 2017
    2. "Parameter Updates to Probabilistic Tidal Turbine – Fish Interaction Model," Tomichek, C., Colby, J., Bevelhimer, M., Adonizio, M.A., Proceedings of the 4th Marine Energy Technology Symposium, April 2016
    3. "Fish Behavioral Response During Hydrokinetic Turbine Encounters: Applying Multi-beam Hydroacoustics Results to a Fish-Turbine Interaction Model," Bevelhimer, M., Scherelis, C., Colby, J., Tomichek, C., Adonizio, M.A., Proceedings of the 3rd Marine Energy Technology Symposium, April 2015.

c. Observations as of 2020:

Based on the analysis of data conducted 2012-16, it is clear that the DIDSON was a useful tool in imaging the micro-scale impact (or lack thereof) and confirmed the micro scale absence (and likely avoidance) of fish around an operating turbine.

[1] As attached; also available on PNNL Tethys database (https://tethys.pnnl.gov/publications/informing-tidal-turbine-strike-probability-model-through-characterization-fish)

In Verdant's opinion, further DIDSON data collection and analysis is unlikely to be useful during B-1 as the micro-scale interaction and fish impact has been shown to be de minimis. This is particularly true in light of the level of micro-scale impacts associated with the incidental take permit of the Ravenswood Generating Station, located in close proximity to the RITE Project Area. This conclusion was presented to the agencies in an adaptive management context in 2019.

Evaluation of the RMEE-2 protocol for the Pilot license was conducted by the agencies, who concurred, and FERC suspended further RMEE-2 DIDSON analysis in an October 2019 order.

2) RMEE-3—Seasonal Species Characterization Netting

a. Objective (2010 FLA and approved in Pilot license):

RMEE-3 "The objective of netting is to provide a set of net capture data, during May through December with more effort during the seasonal period (mid-September through mid-December) of elevated fish abundance in the project vicinity to provide:

i. Species characterization information, that combined with the 2006 RITE trawling, and the Ravenswood and other historical impingement data will provide additional understanding of the fish population in the East Channel.

ii. Provide species characterization in the immediate vicinity of the turbines that can be used to support the interpretation of the past and future DIDSON monitoring and hydroacoustic evaluations.

iii. Potentially provide some observation and/or data for interpretation on potential fish injury due to turbine blade contact in a field of operating KHPS turbines."

b. Advancements since 2012:

i. Methodology: The RMEE-3 netting methodology was reviewed by the agencies and filed in the FERC Docket (2013 filings in 2014 – 1/15/2014). It should be noted that no comments on the methodology were received.
ii. Data and Results: The netting results were reviewed by the agencies and filed in the FERC Docket (2013 filings in 2014 – 1/15/2014) Verdant contracted Kleinschmidt Associates and Normandeau Associates to conduct a netting effort in May 2013 in the East Channel of the East River. During that effort, 3 total tows, only 2 aquatic organisms were caught:
    1. Tow 2: *Callinectes sapidus*, blue crab; 44 mm; alive; returned unharmed
    2. Tow 3: *Peprilus triacanthus,* butterfish; 37 mm; alive; returned unharmed

It should be noted that no comments on the results were received.

c. Observations as of 2020:

In Verdant's opinion, based on the 2013 effort, in general species characterization netting near the RITE Project Area is unlikely to yield meaningful results given the difficulty of netting in strong tidal currents and the general absence of fish in the mid-

river. However, extensive fish assemblage data is available from aquatic organism samples collected at Ravenswood Generating Station, which is in close proximity to the Project site, and was used in the pilot license application and more recent data was reviewed by the agencies in 2018-2019. This conclusion was presented to the agencies in an adaptive management context in 2019. Evaluation of the RMEE-3 protocol for the Pilot license was conducted by the agencies, who concurred, and FERC suspended further RMEE-3 Species Characterization Netting in an October 2019 order.

3) RMEE-4 – Tagged Species Detection

a. Objective (2010 FLA and approved in Pilot license):

From the FERC FLA, "The objective of this plan is to provide new and unique detections on the potential presence of the proposed ESA listed Atlantic sturgeon, ESA listed shortnose sturgeon, along with striped bass, bluefish, winter flounder and other species that have been acoustically tagged. Detection would occur in both the east and west channels of the East River, proximate to the RITE Pilot project boundary. Once that is achieved, based on collected data, revision and updated evaluation of species with respect to Installs B-1, B-2 and C will occur."

b. Advancements since 2012:

i. Methodology: The details of the methodology for tagged species detection using VEMCO VR2W receivers in both the East and West Channel of the East River are provided in the FERC fillings from 2012-2017.

ii. Data and Results: Verdant submitted annual reports on the monitoring of tagged species detections in 2012, 2013, 2014, 2015, 2016 and 2017. In summary, as shown in the 2017 FERC filing (7/31/2018), 334 total fish were detected, 264 in the West Channel and 70 in the East Channel. Normalized over the 70+ months of data collection, 40 fish were detected per year in the West Channel vs. 12 fish detected per year in the East Channel. Of the 334 total detections: 252 were striped bass, 29 were Atlantic sturgeon, 3 were other species (Alewife and American shad) and 50 are unidentified. These results have been published in a number of conference proceedings, including:

1. "Parameter Updates to Probabilistic Tidal Turbine – Fish Interaction Model", Tomichek, C., Colby, J., Bevelhimer, M., Adonizio, M.A., Proceedings of the 4th Marine Energy Technology Symposium, April 2016 [Included in 2017 FERC filing (7/31/18)]
2. "Improvements to Probabilistic Tidal Turbine-Fish Interaction Model Parameters", Tomichek, C., Colby, J., Adonizio, M.A., Proceedings of the 3rd Marine Energy Technology Symposium, April 2015
3. "Tagged Species Detection: Approach to Monitoring Marine Species at Marine Hydrokinetic Projects", Tomichek, C., Colby, J., Adonizio, M.A., Frisk, M., Dunton, K., Fox, D., Jordaan, A., Proceedings of the 2nd Marine Energy Technology Symposium, April 2014

c. Observations as of 2020:

The multi-year tag detection effort has proven an effective method to detect previously tagged species and to provide input to parameters in the assessment of the risk of fish-turbine interaction at the RITE Project. This effort requires cooperation for continued tagging by researchers and data sharing with many organizations, a potential hurdle to the success of the protocol for both striped bass recovery efforts and the tagging and identification of the ESA species Atlantic Sturgeon. A further limitation with the current protocol is that the configuration of the receivers does not allow for any location specific information regarding the fish within the river.

This limitation was explored with the agencies in an adaptive management context in 2019 and it was mutually decided that for the 2020-21 Install B-1 period, Verdant would install an additional receiver (as reported in this report) in an effort to enhance data collection opportunities near the operating turbines. FERC acted to approve and modify the RMEE-4 tagged species detection efforts accordingly in an October 2019 order.

4) KHPS-Fish Interaction Model

a. Objective (2010 FLA and approved in Pilot license):

As described in Vol 4 of the 2010 FLA, a 2-Dimensional (2D) probabilistic KHPS–Fish Interaction Model (KFIM) was developed to determine the overall risk of strike by using a product of independent sub-probabilities.

The model considered a 2D lateral cross-section of the channel at the location of the turbine and comprised seven major parameters: Probability of Blade Rotation (P1), Distribution of Water Velocity over the Tidal Cycle (P2), Fish Distribution (East vs. West Channel) (P3), Turbine Rotor Area (P4), Blade Interaction with Fish (P5), Fish Distribution Fish Distribution (At Different Velocities) (P6) and Avoidance Behavior (P7). These parameters were combined to provide the total probability of strike for fish of various lengths that correlate so species of interest in the RITE Project area. The results of the KFIM were accepted by agencies as included in the 2012 order issuing the FERC license.

b. Advancements since 2012:

Efforts prior to Install B-1 fish study efforts (2012-2018) indicate an update and potential reduction to the risk.

The most recent updates and to the KFIM parameters are provided in recent filings with the FERC (2019) RMEE-4 filing as Attachments C and D. As stated in Attachment D, Table 3 and Table 4, the probability of strike for both Atlantic sturgeon and black sea bass are reduced for all number of deployed turbines. For Install B-1, the updated probability of blade strike was reduced from 0.26% to 0.02% for Atlantic Sturgeon (L = 104 cm). Similarly, for black sea bass (L = 25 cm), the updated probability of blade strike was reduced from 0.10% to 0.005%.

Similar reductions are postulated for the entire field of 30 Turbines.

c. Observations as of 2020:

The above efforts to verify the parameterization of the KFIM at RITE continue to advance the understanding of fish interaction in the presence of operating Verdant Power Gen5 turbines and overall indicate an update and potential reduction of the risk as summarized in 2012. Evaluation of the KFIM parameters are shown in the table below and reflect the most current knowledge of the reduction of predicted risk to aquatic species in the presence of operating Verdant Power KHPS.

In response to a request from the National Marine Fisheries Service (NMFS), Verdant and Kleinschmidt developed an in-stream KHPS-Fish Interaction Model (KFIM) for the East River. The overall intention of this model was to quantify the risk that Verdant's KHPS turbines present to fish at the proposed RITE Project. Table 1 summarizes the parameters of the KFIM model and initial settings that were used by Verdant in assessing KHPS-fish interaction in 2010 and the proposed adjustment as a result of RMEE-4 and ORNL work.

The actual KFIM is a representation in a proprietary spreadsheet that has a probability-based model that determines the overall risk of a turbine blade striking a fish (blade strike). The intent of the model was to initially concentrate on the turbine interaction with the shortnose sturgeon and Atlantic sturgeon, as these are ESA species of interest at the RITE site. However, comparative results were also generated for species identified in the Essential Fish Habitat Assessment performed as part of Verdant's Final Pilot License Application in 2010.

The National Oceanic and Atmospheric Administration/National Marine Fisheries Service, in its September 2012 Biological Opinion (Opinion), concluded the following:

> Opinion of the effects of Verdant Power's Roosevelt Island Tidal Energy (RITE) Project including the Seasonal Species Characterization Netting plan as required by Article 401 of the Pilot License issued on January 23, 2012. In this Opinion, we conclude that the proposed action is likely to adversely affect, but not likely to jeopardize the continued existence of the threatened Gulf of Maine Distinct Population Segment (DPS) of Atlantic sturgeon or the endangered New York Bight, Chesapeake Bay, South Atlantic or Carolina DPSs of Atlantic sturgeon. We also conclude that the proposed action may affect but is not likely to adversely affect shortnose sturgeon or the Northwest Atlantic DPS of loggerhead sea turtles, or Kemp's ridley, green or leatherback sea turtles.

Thus, the acceptance of the RITE license application and results of the RITE 2010 KFIM was affirmed, and a FERC license (P-12611) was issued for the RITE Project.

Table 1. Verdant Power KHPS Fish Interaction Model (KFIM) Parameters

Term	Parameter Description	Relevance	RITE 2010 KFIM	RITE 2020 KFIM
P1	Probability of blade rotation	Specific to the KHPS at water velocity Vw of > 1 m/s; varies with tidal site	P1 = 1 at flows greater than 1 m/s, 0 for all flows less than 1 m/s	**No change**
P2	Distribution of water velocity over the tidal cycle	Vw as measured by ADCPs; varies with tidal site	See measured RITE Vw probability distribution	**No change**
P3	Fish distribution between east and west channel	An assumed distribution in the configuration of the RITE Project	P3 = 0.5	P3 50/50 rule—Concurrent RMEE-4 observations from 2011 - 2018 suggests 23% use the East Channel. **P3 = 0.25 [REF 6]**
P4	Effective KHPS turbine rotor area	A constant for a 5 m blade	P4 = 0.0066	**No change**
P5	Blade interaction with fish passing through turbine disk	Varies with shape of rotor, the Vw and presence of the subject of investigation, and the approach angle	P5 follows formulae discussed below. Two major parameters: (1) 80/20 rule: assumes 80% of fish swim with current, 20% against, for Vw less than or equal to the endurance velocity (Ve) (2) Angle of incidence assumes all fish approach blade from all angles within 180° uniformly	P5 80/20 rule—ORNL work indicates a stronger case for 84%/16% as a setting for P5 [REF 6] P5 Angle of incidence—ORNL work strongly indicates a narrower angel of incidence of +/- 15 degrees [REF 6] **P5 = See modified distribution [REF 6]**
P6	Fish distribution	ESA fish presence in RITE East Channel variation with Vw	P6 = 1 equal likelihood that ESA fish are in east channel	DIDSON and SBT analysis confirms P6 could be lowered. **P6 = See modified distribution [REF 6]**
P7	Fish avoidance behavior	Do fish avoid zones of operating turbine	P7 = 1 conservative, no avoidance	DIDSON data seems to show some avoidance. **Could assume P7 = 0.98 [REF 6]**

5) Rare, Threatened and Endangered Species

a. Objective (2010 FLA and approved in Pilot license):

As required by Article 401 of the Pilot License, Verdant is required to submit annual reports on the monitoring of Rare, threatened and endangered (RTE) species.

b. Advancements since 2012:

i. Methodology: Verdant conducts the RMEE-4 plan for RTE tagged species (Atlantic sturgeon) and records anecdotal observations at the RITE site and environs.

ii. Data and Reporting: Verdant submitted reports in 2012–2019. These reports were provided to the relevant agencies in advance of filing with FERC and comments received were addressed and included, as possible, in the final FERC filings.

c. Observations as of 2020:

i. Summary of RTE Detection at RITE:

1. The outcome of RMEE-4 effort (2011–2020) as described in detail above, has reported on the detection of ESA species. No tagged Atlantic Sturgeon have been detected since 2016.
2. Summary of Marine Mammal Observation at RITE

ii. Opportunistic visual observations and anecdotal news stories from 2011–2020. identified no marine mammals in the vicinity of the RITE Project Area. Additional sightings in the greater New York Harbor were included for completeness.

Appendix A-1: Related Publications

Fisheries

1) "Tagged Species Detection: Approach to Monitoring Marine Species at Marine Hydrokinetic Projects," Tomichek, C., Colby, J., Adonizio, M.A., Frisk, M., Dunton, K., Fox, D., Jordaan, A., Proceedings of the 2nd Marine Energy Technology Symposium, April 2014.
2) "Fish Behavioral Response During Hydrokinetic Turbine Encounters: Applying Multi beam Hydroacoustics Results to a Fish-Turbine Interaction Model," Bevelhimer, M., Scherelis, C., Colby, J., Tomichek, C., Adonizio, M.A., Proceedings of the 3rd Marine Energy Technology Symposium, April 2015.
3) "Parameter Updates to Probabilistic Tidal Turbine Fish Interaction Model," Tomichek, C., Colby, J., Bevelhimer, M., Adonizio, M.A., Proceedings of the 4th Marine Energy Technology Symposium, April 2016.
4) "Informing a Tidal Turbine Strike Probability Model through Characterization of Fish Behavioral Response using Multibeam Sonar Output," Bevelhimer, M., Colby, J., Adonizio M.A., Tomichek, C., Scheleris, C., ORNL/TM -2016 219, July 2016.
5) "Hydroacoustic Assessment of Behavioral Responses by Fish Passing Near an Operating Tidal Turbine in the East River, New York," Bevelhimer, M., Scherelis, C., Colby, J., Adonizio M.A., Transactions of the American Fisheries Society, Vol. 146, Issue 5, 2017.

Appendix B: Overview of RMEE Plans 5–7

While outside the scope of the RITE Environmental Assessment Project (Agreement No. 20802), for completeness, Verdant Power is supplying information on the three additional RITE Monitoring of Environmental Effects (RMEE) plans underway at the RITE Project during Install B-1. Together with the plans outlined in the project Final Report, these activities form the full environmental assessment of an operating hydrokinetic energy pilot project.

I. RMEE-5 Plan: Bird Observation

A. Background and Objectives

The objective of the RMEE-5 Plan under Article of the RITE FERC License is as follows:

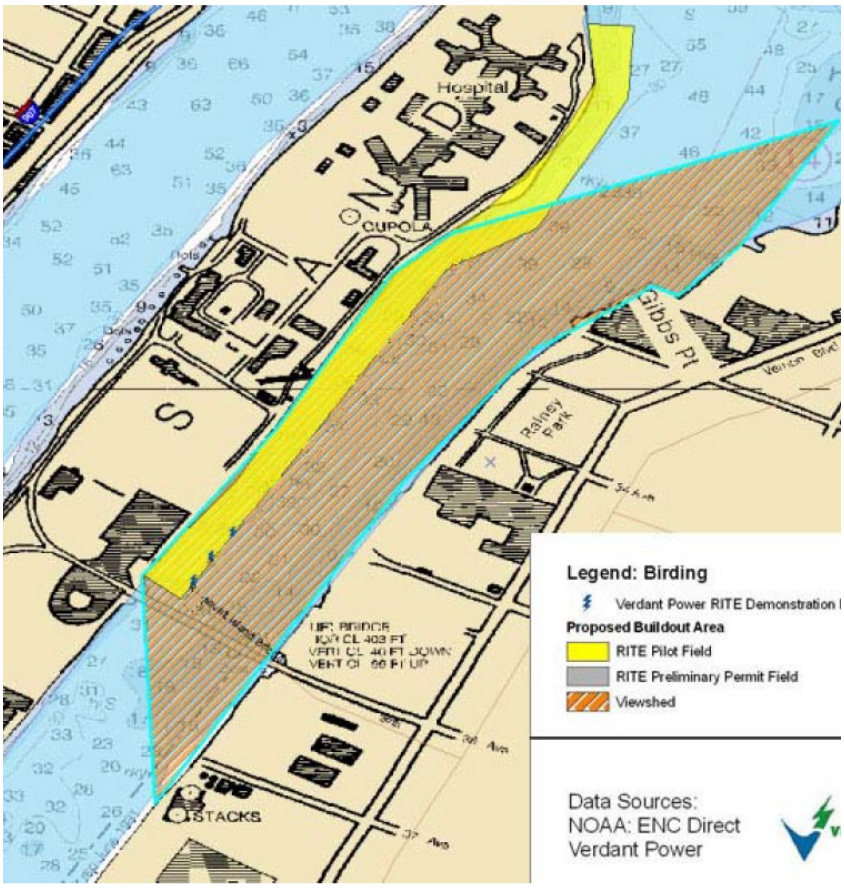
Observe bird presence and activity near the RITE Project boundary in order to:

1. Provide additional observations on the potential effects of the operating KHPS on diving bird populations.
2. Provide additional insights into potential effects of operating KHPS on the fish, e.g. increased bird activity in and around the RITE operating field could be an indication of increased injury and mortality of fish.

B. RMEE-5 Execution (Install B-1)

To accomplish the execution of the RMEE-5 Bird Observation Plan and consistent with protocols used in the Gen4 KHPS demonstration (2006–2008), Verdant Power will conduct dawn to dusk observations of bird activity proximate to the RITE Project Boundary as shown in Figure B.1.

Figure B.1 RMEE-5 Bird Observation Viewshed at RITE



Observation under RMEE-5 will focus on bird species common to the New York State region, including the double crested cormorant, diving ducks, tern species, brown pelican, loons, gannets, scaup, bald eagle, and Canada goose. As with the Gen4 demonstration, Verdant Power will not record the activity of sparrows, seagulls, and pigeons.

Of the above listed species, most are migrating birds known to migrate in the fall and spring. The double crested cormorant is the only resident bird. The bird observations during the Gen4 KHPS demonstration, during periods of spring and fall migration and pre- and post-turbine deployment, did not indicate the presence of many of the common New York State species listed above, except double crested cormorant, Canada goose, and two diving ducks.

Bird observation data will be reported in an ongoing summary study log, which will include the following components:

- Time of Day
- Number of birds observed by species
- Activity—flying, dive/float, perched
- Proximity to the turbine array and operational status of the turbines
- Tidal cycle information—ebb, flood or slack
- Any notes or observations that would indicate interaction with the KHPS turbines (if operating)

All observations will be made from the shore adjacent to the RITE East Channel KHPS turbine field.

As per the RITE FERC License, seasonal spring and fall observation are required totaling 11 days. As such, Verdant Power plans to conduct the following monitoring periods under the RMEE-5 Plan:

- **Fall 2020 (five days): two days in September and three days in October 2020, with turbines operating.**
- **Spring 2021 (two days): one day in March and one day in April 2021, with turbines operating.**
- **Summer 2021 (four days): one day in each month of May—August 2021, with turbines operating.**

C. RMEE-5 Plan Reporting

As required by the RITE FERC License, analysis of data is due for agency comment by February 15 of the year following observation and will be used to answer the fundamental biologic questions for bird observation in the presence of operating turbines. The final report, including agency comments received then filed with FERC by March 15 of the same year. Based on this schedule, Verdant Power will issue results of the Fall 2020 RMEE-5 Bird Observation by March 15, 2021.

II. RMEE-6 Plan: Underwater Noise Monitoring and Observation

A. Background and Objectives

The objective of the RMEE-6 Plan under Article 401 the RITE FERC License, as annotated by Verdant is as follows:

> Determine the noise signature from 6-30 operating Gen5 KHPS turbines and use this information to verify or refute the initial finding that the machines do not emit noise at levels that would cause harm to aquatic resources. This task will include a review of the data on representative species and the physics of sound propagation in shallow water to establish the appropriate spatial and frequency limits for monitoring.

Additionally, the RMEE-6 Plan includes the following requirements:

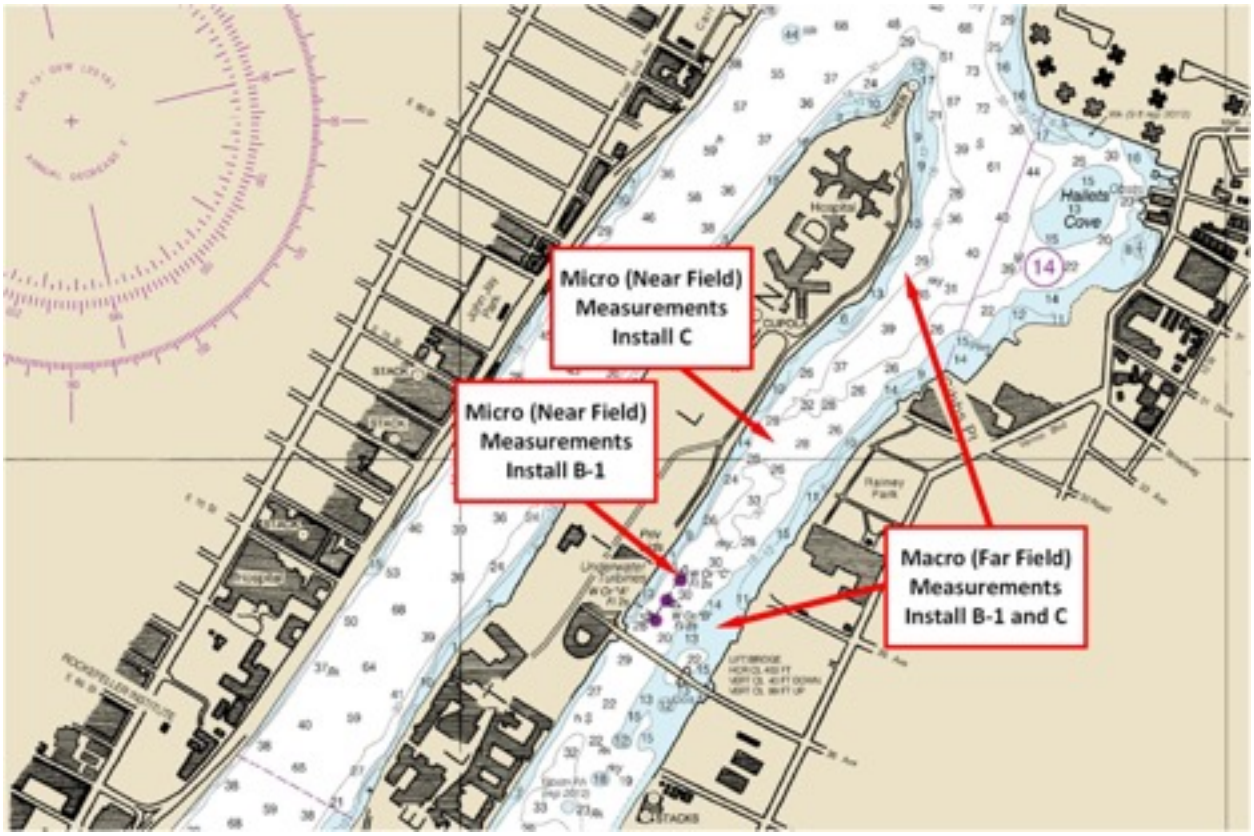
- Stationary deployment at the TriFrame site for one month
- Two far-field locations for one week each
- Reporting, due in Feb/March of each year following observation

B. RMEE-6 Execution (Install B-1)

While no additional studies have been conducted since the license issuance on underwater noise, Verdant has explored practical hydrophone applications for accomplishing the RMEE-6 study, including consultation with researchers active in this area and consistency with evolving International standards[18]

Accordingly, and as per IEC standards, a SNAP Loggerhead Instruments hydrophone will be deployed 100 meters north of the TriFrame to collect 30 days of data in the presence of operating turbines. This data will be retrieved, and the hydrophone system will then be redeployed for far-field noise analysis in one-week deployments at two locations as shown in Figure B.2.

Figure B.2 Underwater Noise Monitoring and Observation at RITE



The coordinates for hydrophone placement are as shown in Table B.1.

Table B.1 RMEE-6 Hydrophone Coordinates (Design, Install B-1)

Hydrophone	Coordinates (Lat./Long.) WGS84		Notes
Near-field	40°45′56.27″N	73°56′41.09″W	
Far-field #1	40°45′50.31″N	73°56′40.48″W	East of array
Far-field #2	40°46′11.34″N	73°56′25.07″W	North of array

C. RMEE-6 Reporting

As required by the RITE FERC License, analysis of data is due for agency comment by February 15 of the year following observation and will be used to answer the fundamental biologic questions of underwater noise in the presence of operating turbines. The final report, including agency comments received then filed with FERC by March 15 of the same year. Based on this schedule, Verdant Power will issue the first results of the RMEE-6 Plan by March 15, 2021.

III. RMEE-7 Plan: Recreation Monitoring

A. Background and Objectives

The objective of this plan, as required by the NYSDEC Water Quality Certification (Permit ID 2-6204-01510/003) condition #17 and by extension the RITE FERC License is as follows:

> …Monitor recreation use to determine whether installation of the project turbines is affecting recreation use in the project area, in C=consultation with the New York City Department of Parks and Recreation, the New York State Office of Parks and Recreation and Historical Preservation, the National Park Service, and the Recreational Study Group and to provide Annual reporting of monitoring studies, at a minimum to include the collection of annual recreation use data.

B. RMEE-7 Execution (Install B-1)

To accomplish the execution of the RMEE-7 plan during Install B-1, as consistent with the requirements of the WQC#17 and RITE FERC License, Verdant Power will conduct recreational monitoring at three locations in the vicinity of the RITE Project site as shown on Figure B.3.

Figure B.3 RMEE-7 Recreation Observation Locations

All observations will be made from the shore adjacent to the RITE East Channel KHPS field and will be reported in an ongoing summary study log to include the following components:

- Location (one of three specified locations)
- Date: one of the five days prescribed (Memorial Day, July 4th, Labor Day, and two summer weekdays)
- Weather Conditions: temperature, windspeed, precipitation
- Observer: name and affiliation
- Scope: observe (two hours) recreational activity at each location
- General observations and photos if applicable
- Any recreational or shoreline fishing
- Vessel activity, type,[19] and location (East or West Channel)
- Proximity to the turbine array and operational status of the turbines
- Tidal cycle information—ebb, flood, or slack during observation
- Any notes or observations that would indicate recreational being affected by the operating KHPS field

C. RMEE-7 Reporting

As required by the RITE FERC License, analysis of data is due for agency comment by February 15 of the year following observation and will be used to answer the fundamental biologic questions of whether installation of the project turbines is affecting recreation use in the project area. The final report, including agency comments received then filed with FERC by March 15 of the same year. Based on this schedule, Verdant Power will issue the first results of the RMEE-7 Plan by March 15, 2022.

Appendix C: Technology Transfer

Overview of Technology Transfer

Verdant Power conducted the following activities during the course of the project to disseminate and heighten the discoverability of project activities and results within the hydrokinetic industry, the scientific community, and among New York State residents and the broader public.

I. Participation in Industry Events and Organizations[20]

- Fourth Annual Global Marine Renewable Energy Conference; Washington, DC; Apr 27–29, 2011.
- U.S. Department of Energy, EERE Marine and Hydrokinetic Environmental Research Webinar Series, “Kinetic Hydropower Operational Monitoring Strategies and Technologies for Pilot Arrays;” September 14, 2011.
- Ocean Renewable Energy Group (OREG) 2011 Annual Conference; November 1–2, 2011.
- NREL Advanced Marine Renewable Energy Instrumentation Experts Workshop; Broomfield, CO; April 5–7 2011.
- Fisheries and Oceans Canada Workshop; Montreal, QC; January 31–February 1, 2012.
- Fifth Annual Global Marine Renewable Energy Conference; Washington, DC; April 24–26, 2012.
- New York State Hydrokinetic Generation Environmental Policy Workshop; White Plains, NY; May 17, 2012.
- HydroVision International 2012, "Stakeholder Outreach and Involvement: The RITE Experience" presentation; Louisville, KY; July 19, 2012.
- International Conference on Ocean Energy (ICOE 2012); Dublin, Ireland; October 15–19, 2012.
- NREL Marine and Hydrokinetic Instrumentation, Measurement & Computer Modeling Workshop; Broomfield, CO; 9–11, July 2012.
- Sixth Annual Global Marine Renewable Energy Conference; Washington, DC; April 2013.
- American Geophysical Union Fall Conference; San Francisco, CA; December 11, 2013.
- GMREC VII Conference; Seattle, WA; April 2014.
- All-Energy Exhibition and Conference; Aberdeen, Scotland; May 21–22, 2014
- BOEM Workshop—MHK Focus Day; Sacramento, CA; July 2014.
- OWET Conference—Presentations on RITE/MHK Environmental Monitoring, Adaptive Management; Portland, OR; September 2014.
- 2015 International Marine Renewable Energy Conference (IMREC) and Marine Energy Technology Symposium (METS); Washington, DC; April 27–29, 2015.
- 2016 International Marine Renewable Energy Conference (IMREC) and Marine Energy Technology Symposium (METS); Washington, DC; April 25–27, 2016.
- Fifth Annual North Carolina Renewable Ocean Energy Symposium; Skyco, NC; March 2016.

- 2017 International Marine Renewable Energy Conference (IMREC) and Marine Energy Technology Symposium (METS); Washington, DC; May 1–3, 2017.
- 2017 Ocean Energy Europe Conference; Nantes, France; October 2017.
- 2017 Annual International Tidal Energy Summit; London, UK; November 2017.
- 2018 International Marine Renewable Energy Conference (IMREC) and Marine Energy Technology Symposium (METS); Washington, DC; April 30–May 2, 2018.
- International Conference on Ocean Energy 2018; Cherbourg, France; June 12–14, 2018.
- HydroVision 2018; Charlotte, NC; June 26–28, 2018.
- Oceanology International Americas Conference; San Diego, CA; February 25–26, 2019.
- 2019 International Marine Renewable Energy Conference (IMREC) and Marine Energy Technology Symposium (METS); Washington, DC; April 1–3, 2019.
- 2019 Offshore Technology Conference; Houston, TX; May 2019.

II. Publications/Presentations

"A Review of Regulatory and Policy Requirements for Hydrokinetic Power Projects in New York State," Final Report No. 12-27c; Pace Energy and Climate Center for New York State Energy Research and Development Authority; December 2012.

"Marine and Hydrokinetic Technology Background and Perspective for New York State," New York State Energy Research and Development Authority, Marine and Hydrokinetic Environmental Policy Workshop Final Report No. 12-27b; Ocean Renewable Energy Coalition and Verdant Power; December 2012.

"New York State Hydrokinetic Generation Environmental Policy Workshop Post-Workshop Analysis," Final Report No. 12-27; Beacon Institute for Rivers and Estuaries, Clarkson University for New York State Energy Research and Development Authority; December 2012.

"Tagged Species Detection: Approach to Monitoring Marine Species at Marine Hydrokinetic Projects", Tomichek, C., Colby, J., Adonizio, M.A., Frisk, M., Dunton, K., Fox, D., Jordaan, A., Proceedings of the 2nd Marine Energy Technology Symposium, April 2014.

"Fish Behavioral Response During Hydrokinetic Turbine Encounters: Applying Multi-beam Hydroacoustics Results to a Fish-Turbine Interaction Model," Bevelhimer, M., Scherelis, C., Colby, J., Tomichek, C., Adonizio, M.A., Proceedings of the 3rd Marine Energy Technology Symposium, April 2015.

"Improvements to Probabilistic Tidal Turbine-Fish Interaction Model Parameters", Tomichek, C., Colby, J., Adonizio, M.A., Proceedings of the 3rd Marine Energy Technology Symposium, April 2015.

"Parameter Updates to Probabilistic Tidal Turbine – Fish Interaction Model", Tomichek, C., Colby, J., Bevelhimer, M., Adonizio, M.A., Proceedings of the 4th Marine Energy Technology Symposium, April 2016.

"Informing a Tidal Turbine Strike Probability Model through Characterization of Fish Behavioral Response using Multibeam Sonar Output", Bevelhimer, M., Colby, J., Adonizio M.A., Tomichek, C., Scheleris, C., ORNL/TM-2016-219, July 2016.

"Hydroacoustic Assessment of Behavioral Responses by Fish Passing Near an Operating Tidal Turbine in the East River, New York", Bevelhimer, M., Scherelis, C., Colby, J., Adonizio M.A., Transactions of the American Fisheries Society, Vol. 146, Issue 5, 2017.

"Multi-resolution large-eddy simulation of an array of hydrokinetic turbines in a field-scale river: The Roosevelt Island Tidal Energy project in New York City," Chawdhary, S., Angelidis, D., Colby, Corren, D., Shen, L., Sotiropoulos, F. Water Resources Research, Vol. 54, Issue 12, 2018.

III. Participation in Online Databases

Tethys (https://tethys.pnnl.gov/)

Verdant Power has participated in the Tethys platform since its inception in 2009, providing searchable information on the Project with a focus on regulatory and environmental monitoring activities. Named after the Greek titaness of the sea, Tethys was developed in 2009 by the Pacific Northwest National Laboratory to facilitate the exchange of information and data on the environmental effects of wind and marine renewable energy technologies and to serve as a commons for wind and marine renewable energy practitioners and therefore enhance the connectedness of the renewable energy community as a whole.

OES-Environmental (https://tethys.pnnl.gov/about-oes-environmental)

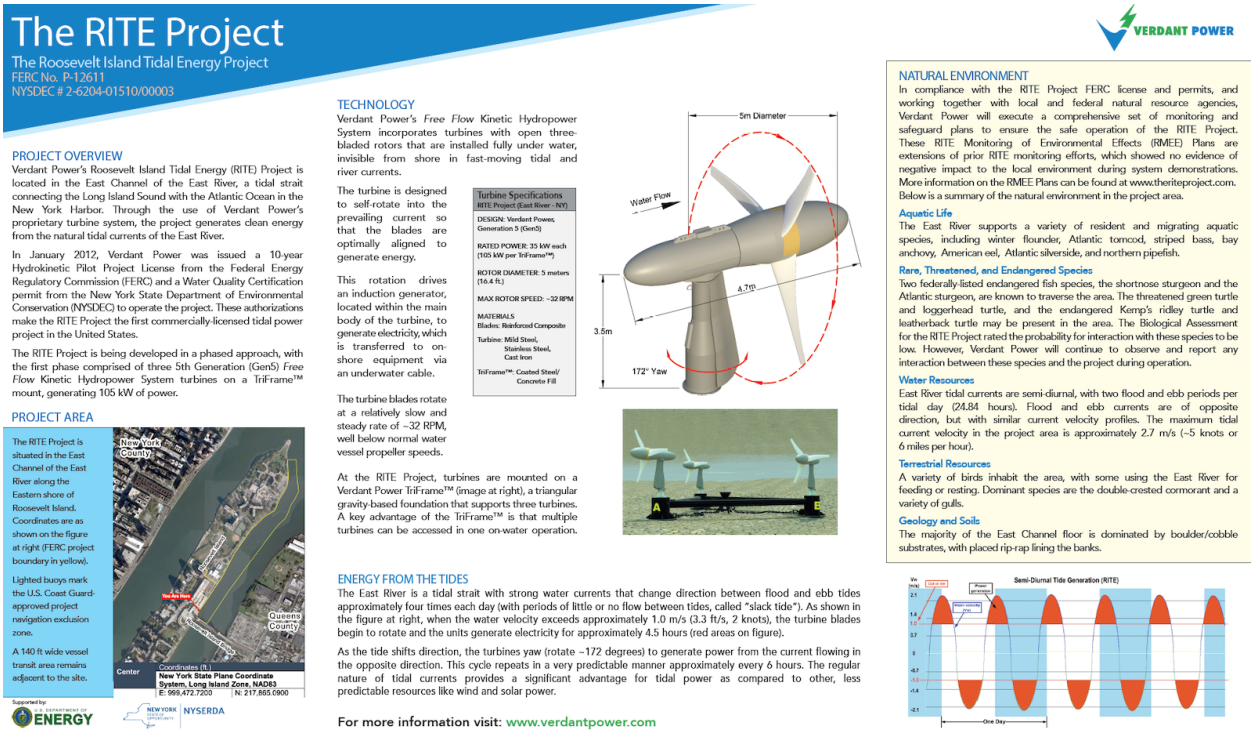
Verdant Power also provides information on the Project to the OES-Environmental database, an international collaborative project focused on gathering and disseminating information and connecting marine energy practitioners from around the world. One of the objectives of OES-Environmental is

to collect metadata on marine energy projects and research studies from around the world, all of which can be found exclusively in the Tethys knowledge base and map viewer.

IV. Onsite Project Information Tools: RITE Information Board

Since its inception, the RITE Project site has received visitors on a regular basis, ranging from members of the general public to industry partners to high-profile public leaders. In order to provide information on the project to these visitors and general passersby, Verdant Power developed and has maintained an updated onsite Informational Board that provides an overview of project objectives, the deployed technology, project plans, and an overview of the natural environment in the project area. Depicted below, the RITE Project informational board is mounted to the exterior of the RITE Control Room and lists NYSERDA as a major sponsor of the initiative.

Figure C-1. RITE Project Informational Board



Endnotes

[1] FERC Order issuing Pilot License (No. P-12611); January 2012.

[2] Verdant Power, LLC Final Pilot License Application - RITE Project, Volume 4: RITE Monitoring of Environmental Effects (RMEE) Plans, Appendices A & B.

[3] Install B-1 operations were conducted under a concurrent NYSERDA project (No. 18785) and a US Department of Energy Award (No. DE-EE0007349).

[4] Key RITE Project Resource Agencies include the New York State Department of Environmental Conservation (NYSDEC), the US Army Corps of Engineers – New York District (USACE), the US Environmental Protection Agency (EPA), NOAA Fisheries, the US Fish & Wildlife Service (USFWS), and FERC.

[5] FERC Order Modifying License Article 401 - FERC P-12611-007; October 2019.

[6] The suite of RITE operational study plans included Fisheries (4 unique protocols); Underwater Noise; Hydrodynamics; Bird Observation; Water Quality Assessment; Benthic Habitat; Rare, Threatened, and Endangered Species Assessment; and Assessments of Recreational Resources, Navigation and Security, and Historical/Cultural Resources.

[7] NYSERDA Roosevelt Island Tidal Energy (RITE) Environmental Assessment Project Final Report 11-04: March 2011 [Based on Gen4 KHPS].

[8] In accordance with FERC license conditions and based on the current license expiration date of December 31, 2021, in December 2019 Verdant Power filed an application for a subsequent project license at RITE. Documents related to the RITE Project relicensing process can be found at www.theriteproject.com

[9] Two of the plans, RMEE 2 and 3 were originally included in the NYSERDA Contract Agreement, and preliminary execution of those plans was conducted in 2012-2013, then suspended until operating Gen5 Turbines were in the water. In September 2019, Verdant requested and FERC approved a modification of the requirements based on the vast body of information developed during the 2012-2013 period as adequate under an adaptive management framework.

[10] Bevelhimer, M., Colby, J., Adonizio M.A., Tomichek, C., Scheleris, "Informing a Tidal Turbine Strike Probability Model."

[11] Tomichek, C., Colby, J., Adonizio, M.A., Frisk, M., Dunton, K., Fox, D., Jordaan, A., "Tagged Species Detection."

[12] Tomichek, C., Colby, J., Adonizio, M.A., "Improvements to Probabilistic Tidal Turbine."

[13] Tomichek, C., Colby, J., Bevelhimer, M., Adonizio, M.A., "Parameter Updates to Probabilistic Tidal Turbine – Fish Interaction Model."

[14] The RMEE-4 Plan was finalized in December 2010. Since that time, on January 31, 2012, the Atlantic Sturgeon in the New York Bight was listed as Endangered (NOAA).

[15] NYSERDA, "Marine and Hydrokinetic Technology Background and Perspective for New York State."

[16] NYSERDA, "A Review of Regulatory and Policy Requirements for Hydrokinetic Power Projects in New York State."

[17] Beacon Institute for NYSERDA, "New York State Hydrokinetic Generation Environmental Policy Workshop Post-Workshop Analysis."

[18] The International Electrotechnical Commission (IEC) under Technical Committee (TC) 114: Marine energy—Wave, tidal and other water current converters has progressed the development of IEC Technical Specification (TS) 62600-40, "Acoustic characterization of marine energy converters." Approved 2019-03-09, publication pending.

[19] Vessel type is defined as (1) Marina vessels included small, medium and large vessels, including Government vessels, and sailboats; (2) Commercial vessels included water taxis, ferries, tour boats and tugs/barges, (3) Put-in vessels included jet skis, kayaks, paddle boards and canoes.

[20] Travel and public gathering restrictions due to the COVID-19 pandemic forced the cancellation and/or postponement of several key industry events, severely limiting opportunities for formal technology transfer during 2020.

NYSERDA, a public benefit corporation, offers objective information and analysis, innovative programs, technical expertise, and support to help New Yorkers increase energy efficiency, save money, use renewable energy, and reduce reliance on fossil fuels. NYSERDA professionals work to protect the environment and create clean-energy jobs. NYSERDA has been developing partnerships to advance innovative energy solutions in New York State since 1975.

To learn more about NYSERDA's programs and funding opportunities, visit nyserda.ny.gov or follow us on Twitter, Facebook, YouTube, or Instagram.

New York State Energy Research and Development Authority

17 Columbia Circle
Albany, NY 12203-6399

toll free: 866-NYSERDA
local: 518-862-1090
fax: 518-862-1091

info@nyserda.ny.gov
nyserda.ny.gov

State of New York
Andrew M. Cuomo, Governor

New York State Energy Research and Development Authority
Richard L. Kauffman, Chair | Doreen M. Harris, President and CEO