

Final Technical Report

Federal Agency to which Report is submitted: DOE EERE – Wind & Water Power Program

Recipient: Verdant Power, Inc. (DUNS Number: 798846585)

Award Number: DE-EE0005929

Project Title: Advancement of the Kinetic Hydropower System (KHPS) to Department of Energy (DOE) Technology Readiness Level (TRL) 7/8

Project Period: 12/01/2012 - 11/5/2015

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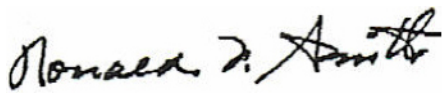
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I. OVERVIEW OF PROJECT OUTCOMES

Project Objective: The objective of this project was to advance Verdant Power's Kinetic Hydropower System (KHPS) to a US Department of Energy (DOE) Technology Readiness Level (TRL) of 7/8. This objective was to be achieved through the following project activity:

- Developing protocols to conduct critical component testing and analysis to progressively validate longevity and reliability parameters for the KHPS and US Marine Hydrokinetic (MHK) devices overall; and conducting a test protocol on one component; and
- Continuing compliance work on approved operational environmental monitoring plans in anticipation of KHPS turbine installation at the Roosevelt Island Tidal Energy (RITE) Project site (East Channel, East River – New York, NY).

Project Goals & Outcomes:

(1) Evaluation of four Generation 5 (Gen5) KHPS turbine critical components (blades, main shaft seal system, brake and gearbox) for longevity and reliability prior to full-scale deployment at RITE. It is anticipated that the results of this testing will inform the manufacturing, materials and service protocols necessary for TRL 7/8 projects and advance technical understanding of components for the MHK industry.

Key Outcomes:

Component testing protocols were developed and reviewed with DOE for the four critical components of the Gen5 KHPS (See Table 2.1). Verdant also selected vendors and locations for testing to be conducted and obtained NEPA clearance for all sites as required.

During the course of the contract, the proprietary main shaft seal assembly test protocol was executed and a final proprietary report was delivered providing critical information on manufacturing and service life of components as part of the contract. Details follow in Section II. Subtask 2.2.

(2) Evaluation of components as part of a cost-effective operation & maintenance (O&M) projection for MHK devices. It is anticipated that, in addition to supporting activities at the RITE Project, this testing will provide DOE with additional data to advance the industry understanding of projected life-cycle costs of MHK devices and arrays.

Key Outcomes: Main Shaft Seal Testing

Evaluation of the main shaft seal was accomplished during the project, supporting the viability of the projected 5-yr service interval (SI). Details follow in Section II. Subtask 2.2.

(3) Continued compliance and implementation of instrumentation that supports the environmental compatibility of MHK devices. It is anticipated that the results of these activities will continue to inform the US regulatory community on the scientifically-based and cost-effective implementation of monitoring at US MHK projects.

Key Outcomes:

Ongoing environmental compliance was undertaken throughout the contract period, and represents a continued understanding of adaptive management practices and development and implementation of monitoring protocols at US MHK projects (See Appendix A for monitoring reports). Additionally, technology transfer of these environmental results was widely distributed to the regulatory and scientific communities (see Presentations & Publications section).

II. TASK ACTIVITY, OUTCOMES & LESSONS LEARNED

TASK 1.0 ENVIRONMENTAL COMPLIANCE AND MONITORING INSTRUMENTATION

The purpose of this task was to maintain regulatory compliance of the RITE Project, executing associated RITE Monitoring of Environmental Effects (RMEE) Plans and developing an environmental instrumentation package specifically for underwater sound monitoring and evaluation of MHK turbines.

Subtask 1.1 Compliance and Monitoring Instrumentation

i. Major Activities

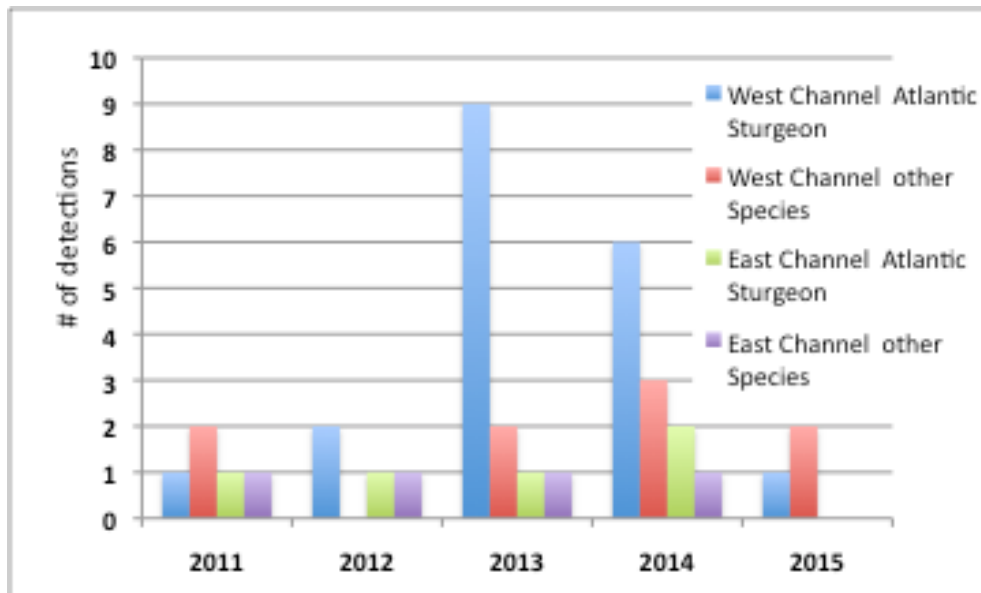
- FERC compliance reporting under Article 401 during 2013-15, specifically for the RMEE-3 Species Characterization Netting Plan, RMEE-4 Tagged Species Detection Plan, and ESA Species annual reports, which generated supporting tech transfer as discussed below. (Latest reports provided as Appendix A).
- Executed and completed RMEE-3 Species Characterization Netting in May 2013 (compliance requirement).
- Ongoing stakeholder consultation on permit revisions with agencies.
- Support to ongoing RMEE-2 Seasonal DIDSON Observation analysis review by ORNL (under a separate DOE contract – see below)
- Maintenance of the mandatory FERC license Article 404 Safeguard Plans, which include the navigational buoy and danger sign system at RITE during 2012-15.
- Maintenance of RMEE-4 equipment and data download and analysis as required by Article 401.
- Other compliance filings as required by FERC during the period.

ii. Key Outcomes/Milestones & Lessons learned

- FERC compliance activities for MHK Pilot projects require significant ongoing support from licensees, and support for these ongoing activities is a necessary cost element for early stage projects, as well as an opportunity for national lab and other educational R&D and support.
- For example, the collaboration by Verdant with a DOE-supported award to Oak Ridge National Laboratory (ORNL), “*Informing a Tidal Turbine Strike Probability Model through Characterization of Fish Behavioral Response using Multibeam Sonar Output*,” to analyze RMEE-2 data has proven to be an excellent effort to support the industry. The results of this project will be presented at the Marine Energy Technology Symposium (METS) 2016.
- Similarly, the RMEE-4 work provides a sound insight to future adaptive management monitoring of macro arrays of MHK turbines. The efforts undertaken under this contract have shown that collaborations with other researchers to understand the presence and movement/migration of ESA species in the presence of KHPS arrays will remain a key effective tool for project developers to meet environmental compliance requirements (Figure 2.1 summarizes RMEE-4 observations). This monitoring has shown limited observation and risk of tagged species in the RITE East Channel location over the almost 5 years of active monitoring, supporting Biological Opinion results.
- Finally, the maintenance of required Safeguard Plans for KHPS arrays, specifically at the RITE site where navigation is key, is a cost component for project development.

Figure 2.1 - RMEE-4 Data Observation (2011-15)

Note: The East Channel receiver was lost due to an ice event in 2015, therefore no data was recorded. The receiver was replaced in August 2015 and data download will resume in 2016.



Subtask 1.2 RMEE-6 Underwater Sound Monitoring and Evaluation Plan

i. Major Activities

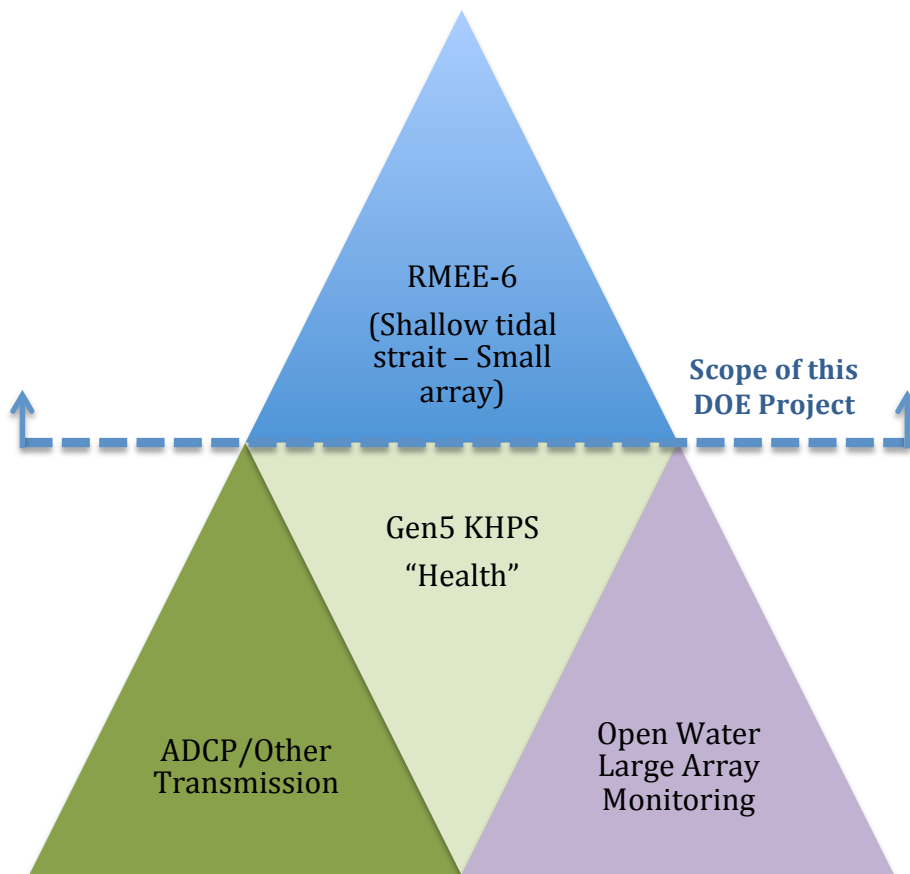
- Initial kickoff meeting with IBM personnel at RITE in July 2013 generated task report outline and work plan.
- Activities were reported in October 2013 Task 1.2 proprietary report to DOE.
- Design adaptation and data interface to be developed by IBM-Galway Bay personnel to fit the requirements of the RMEE-6: RITE Underwater Noise Monitoring and Evaluation system.

ii. Key Outcomes/Milestones

- An overview of the opportunities for using noise observations for turbine health as well as environmental compliance was presented during the DOE peer review event in February 2014. The key points as noted in Figure 2.2 are:
 - Implementing the RMEE-6 noise observation via a short cable-to-shore system at the RITE site – a shallow (10 m) “noisy” site – will assist in understanding cost-effective noise monitoring in the presence of operating turbines. However the noisy environment (proximate commercial barge navigation, subway tunnel and bridge noise) and shallow cross section limit biological observation.
 - It is likely, but beyond the scope of this project, that noise signatures of operating turbines may contribute to evaluation of the health of multiple turbines in the array. This area is one for further exploration as multiple MHK units are in operation.

- Noise monitoring equipment has its most useful opportunity in monitoring larger offshore arrays where cabling is not possible, possibly mounting and transmitting noise data as well as ADCP data to shore for analysis. Again, an opportunity beyond the scope of this project.
- Cost-effective noise monitoring of KHPS arrays remains a key area of investigation for MHK systems and projects.

Figure 2.2 - RMEE-6 Underwater Sound Monitoring Opportunities at MHK Projects



TASK 2.0 GEN5 KHPS TURBINE COMPONENT TESTING

The purpose of this task was to conduct pre-production testing on four major components of the Gen5 KHPS turbine with a focus on evaluating longevity and reliability. The approach was to design a test protocol, fabricate the test component, build and/or modify a test stand, execute the testing protocol and report on the results.

Task Activity

In December 2013 Verdant delivered for DOE review a test protocol document. Table 2.1 is a summary of the critical component test protocols.

Subtask 2.1 Testing of Production-Class Composite Blade

Scope: Verdant Power, in conjunction with the blade manufacturer, will produce a production-class composite blade for static and fatigue testing, which will advance component manufacture for longevity and reliability in a TRL 7/8 project.

i. Major Activities

- As a follow-up activity based on the results of the Gen5c rotor in-water test (IWT) under a prior DOE award, Verdant pursued design changes with the University of Minnesota (under an NSF grant). As a result, Verdant plans for this commercial version modification (Gen5d) to be the blade that will undergo testing.
- Initiated contracting activities with NREL for composite blade testing, including discussions on testing parameters, techniques and scheduling with Scott Hughes at NREL.
- Developed subtask test protocol, and review with DOE completed January 2014.
- Began QMS coordination for first article production and testing with composite blade vendor Energetx, which, during the course of the contract, ceased operations. Verdant has subsequently contracted with Composite Builders (Grandville, MI) to complete the major component supply function as part of the supply chain for the Gen5 KHPS.
- In a separate activity, NREL requested Verdant's participation in a confidential validation of the new HydroFAST code. In October 2014, Verdant provided NREL with the entire package of FAST files (input and output files) associated with its Gen5 KHPS turbine and the resulting loads document, including the post-processed static and fatigue load estimates. These composite blade design tools supported by NREL were de-funded during the contract period, therefore Verdant has applied for continued NREL support of this activity under the DOE Small Business Voucher pilot program.

ii. Key Outcomes/Milestones

- Due to closing of Energetx in 2013, Verdant Power conducted a pre-qualification and technical RFP for a replacement blade manufacturer, with a new vendor (Composite Builders) contracted in November 2015 to provide the test article.
- Blade fabrication and testing steps are underway, including materials testing, and test plans are being updated for execution in 2016.
- Protocol preparation was completed, however testing did not commence at NREL during the contract period. Testing will be required to validate SI, with NREL a preferred candidate to conduct this testing. The composite blade test protocol is summarized in Table 2.1.

Subtask 2.2 Shaft Seal Testing

Scope: The main shaft seal is unique to the Gen5 KHPS turbine and has been designed for long-term service in saltwater. To evaluate seal material and barrier fluids for compatibility and longevity, testing would be conducted under the Verdant Power manufacturing Quality Management System (QMS) on a test stand, likely at the seal manufacturer. This testing would simulate operating conditions including accelerated start/stop cycles, and evaluate different materials for effectiveness in a TRL 7/8 project.

i. Major Activities

- Obtained EERE NEPA clearance for component testing at Garlock facility.
- A main shaft seal test stand design and protocol was developed in conjunction with project partner Manufacturing Resources Inc. (MRI) and reviewed by DOE in January 2014.
- Completed development of shaft seal test stand build at MRI with checkout in December 2014 for transport to Garlock.
- The shaft seal was tested per the protocol during January - April 2015.
- Verdant delivered to DOE a completed Test Report detailing testing activities and results in accordance with the contract in July 2015.

ii. Key Outcomes/Milestones

- Testing of the proprietary Verdant Gen5 KHPS main shaft seal was completed under Subtask 2.2 of the project. The test was performed successfully, with the Gen5 KHPS seal assembly demonstrating a leak rate low enough to protect the turbine gearbox from water intrusion for the full 5-year SI target under reasonable assumptions.
- The following summarizes the setup and results of the seal test:

Gen5 KHPS Shaft Seal Test Setup & Results

Test Period: 11 weeks

Total Operating Time: 1676.4 hours, 69.9 days (116% of the 60-day target)

Speed: 160 rpm (4x normal)

Shaft Rotations: 15.8 million = 20.1% of the 5-year SI

Start/Stops: 1 per hour (6x normal); Total of 1663 = 22.8% of the SI

Duty Cycle: 99.2% (59.5 mins ON, 0.5 mins OFF)

Total ON Time: 1662.5 hours, 69.3 days

Total OFF Time: 13.9 hours

These very significant test operational periods should give a good view as to any wear that would affect the achievability of the desired 5-year SI.

Inspection Results: No measureable wear of carbon or bronze faces.

The conclusions from the testing were that the measured leakage rate was well below the capacity of the system, and the seal wear would not be a limiting factor. There are a number of additional conservatisms in this arrangement. The overall conclusion from the testing is that the proprietary Verdant Gen5 KHPS seal arrangement, utilizing the Garlock Klokure dual carbon/bronze seal components, will fully prevent river/sea water from affecting the performance of the bearings and gearbox for the desired SI of 5 years.

Figure 2.3 - Main Shaft Seal Test Control Screen

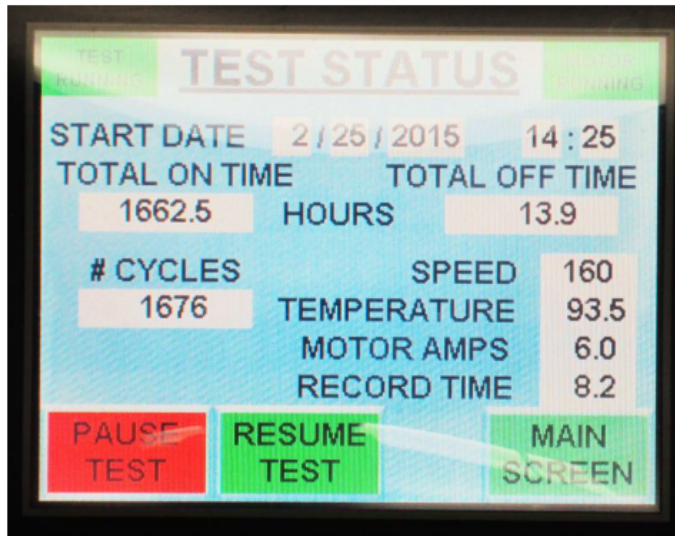


Figure 2.4 - Photo of Main Shaft Seal Test Arrangement



Figure 2.5 - Condition of Tested Outer Carbon Seal Face Compared to New Face



Subtask 2.3 Generator Brake Testing

Scope: The Gen5 KHPS failsafe-type brake is a new component added since the Gen4 design iteration. Manufacturing design and accelerated testing operation for longevity testing would be conducted under the Verdant QMS system, on a test stand that simulates speed and inertia and allows accelerated lifetime testing of stop cycles. This testing would evaluate the reliability and longevity of a critical operational component in the KHPS.

i. Major Activities

- Completed EERE NEPA clearance for component testing at Baldor facility.
- Completed development of Gen5 KHPS Brake test protocol with Baldor/Stromag.
- Review of test protocol with DOE completed January 2014.
- NREL conducted design review in 2014 and was supportive of the Verdant Gen5 KHPS gearbox design and failsafe brake, as well as the selection of the Stromag failsafe brake.
- Began QMS coordination for first article production and testing with vendor.

ii. Key Outcomes/Milestones

- Protocol preparation was completed, however testing did not commence during the contract period. Testing will be required to validate SI. The brake test protocol is summarized in Table 2.1.

Subtask 2.4 Gearbox Dynamometry Testing

Scope: The Gen5 KHPS turbine Gearbox/Generator design requires dynamometry bench testing during manufacturing to evaluate longevity and reliability. The Gen5 turbine gearbox is the critical path manufacturing activity and the gearbox, which has been uniquely designed for long service intervals, will have enhanced longevity testing on the dynamometry bench, followed by parts and lubricant inspection to identify any weaknesses. This requires the non-recurrent engineering (NRE) set-up, the building of the gearbox and the set-up of the bench test, and the release for installation. Verdant would also conduct further bench tests for accelerated time following a protocol that would provide meaningful data on the design life of this critical component, in advance of deployment in a TRL 7/8 project.

i. Major Activities

- Completed EERE NEPA clearance for component testing at Winsmith facility.
- Review of test protocol with DOE completed January 2014.
- NREL conducted design review in 2014 and was supportive of the Verdant Gen5 KHPS gearbox design and failsafe brake. Due to its unique loadpath, an outstanding recommendation was to use non-torque (off-axis) loading when possible during dynamometer testing of the gearbox. This helps clear the way for the Gen5 KHPS gearbox prototype manufacture and testing. NREL planned to explore whether its small (225kW) dynamometer could be enhanced to provide such loads.

ii. Key Outcomes/Milestones

- A commitment to the Gen5 KHPS gearbox final design. QMS manufacture and 60-day test stand protocol represents the critical path for the Gen5 KHPS turbine readiness at TRL 7/8. This pathway is expected to take at least 12-18 months once initiated and is significantly longer than the expected <1 month in-water installation (construction) period for the RITE Project.
- Protocol preparation was completed, however testing did not commence during the contract period. Testing will be required to validate SI. The gearbox test protocol is summarized in Table 2.1.

Table 2.1 - Gen5 KHPS Key Component Test Protocols

KHPS Component Protocol (Testing Location – Type)	Design Service Interval (SI)	Significance	Details
Composite Blades (5m) (NREL – Static and fatigue)	Evaluate 5-year SI/ 20-year life in 60-day protocol representing 100% of 20-year fatigue life	Prior work and testing (DOE AWPP) identified opportunities for improved mounting and manufacturing techniques	• Environmental conditioning of blade 30-60 days in saltwater • Seal the blade during testing • Static and fatigue testing of one blade as per IEC wind blade test standard 64100-23 ~2 million cycles • Fatigue test to 200% of life (if possible) • Static test to failure
Shaft Seal Assembly¹ (Garlock – Simulate real-world conditions; Measure leakage and wear rates)	Evaluate 3-5 year SI in saltwater in 60-day protocol representing approximately 20% of the 5-year SI	Could drive service interval requirement if leak rates are too high under tidal performance; must verify that leak and wear rates support SI	• Test parameters measure: Rotations, cumulative runtime, water vessel pressure, temperatures (W, BF), shaft speed, #Start/Stop cycles, drive motor current (drag) • Manually: Measure leak volumes (daily): W in BF, BF into inner chamber (gearbox) • After Test: Disassembly and inspection for carbon and metal seal material loss; predict leak rates, seal wear-life estimate
Generator Brake (Baldor – Accelerated stop/start for function and wear)	Verify 5-year SI over 30-45 day protocol equivalent to start/stops of 111% of 20-year life	Repeated cyclical stop/start measured for wear, longevity	• Initial Test Measurements: Time to reach full speed; stop times • Testing: Stop times; brake and motor temperatures, cumulative cycles; torque (optional), stop speed curves, fade, wear-life estimate, other observations relating to reliability and longevity • After Test: Brake disassembly and complete inspection

¹ Shaft Seal Assembly testing was conducted as per the test protocol at Garlock (Palmyra, NY) during Jan-Apr 2015. A proprietary Task Report was submitted to DOE under the contract in July 2015.

Gearbox (Winsmith – Dynamometry and accelerated wear)	Verify 5-year SI over 90 days at 1.5x speed, representing 10% of 5-yr SI	Primary component driving cost; need to test lubrication system, project wear, verify SI, determine 5-yr refurbishment requirements	• During test measure: Speed, rotations, temperatures strains • After Test: Disassembly and complete inspection for wear, oil test • Develop wear-life estimate, SI suitability, other observations relating to reliability and longevity
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TASK 3.0 GEN5 MANUFACTURE AND QMS

The purpose of this task was to conduct the Gen5 KHPS component manufacture for pre-production testing under an evolving Quality Management System (QMS). The approach was to provide the components for testing based on this system and document the design and/or production changes required for first article production on four major components of the Gen5 KHPS turbine, with a focus on longevity and reliability.

Subtask 3.1 QMS Release for Testing and Production

i. Major Activities

- Provided necessary QMS coordination with 4 major component procurement and test facilities as follows.
- Task 2.1 Composite Blades – As discussed earlier, a replacement of the blade fabricator was undertaken during the contract period, requiring pre-qualification of new potential US vendors, the issuance of an RFP for the design and manufacturing under QMS procedures, and review of the responses. Negotiation of specifics for NREL testing was also conducted with Scott Hughes for an enhanced blade testing protocol per the contract.
- Task 2.2 Main Shaft Seal – Completed QMS procurement and test stand testing at the Garlock facility. Additionally, in advance of this effort, Verdant submitted and received clearance for testing under the EERE NEPA requirements of the contract in February 2014.
- Task 2.3 Generator Brake – Ongoing discussions with Baldor for QMS procurement and testing at its facility. Additionally, in advance of this effort, Verdant submitted and received clearance for testing under the EERE NEPA requirements of the contract in February 2014.
- Task 2.4 Gearbox – Ongoing discussions with Winsmith for QMS procurement and testing at its facility. Additionally, in advance of this effort, Verdant submitted and received clearance for testing under the EERE NEPA requirements of the contract in February 2014.

ii. Key Outcomes/Milestones & Lessons Learned

- Verdant QMS and supply chain development for component manufacture and logistical delivery continues.
- Pre-qualification and selection of a replacement blade manufacturer was completed. This effort underscores the need for QMS as commercial manufacturing progresses.
- Task 2.2 Main Shaft seal testing provided meaningful input to DOE on service intervals of critical components for O&M.

III. PRESENTATIONS & PUBLICATIONS

2013

- Verdant Power participated in three presentations at the Global Marine Renewable Energy Conference (GMREC) in Washington, DC in April 2013 highlighting project activities.
- “Bringing Kinetic Hydropower from Demonstration to Market;” Dean Corren; Society of Naval Architects and Marine Engineers (SNAME) Marine Technology (MT); May 2013.
- In September 2013, Verdant Power participated in a two-day training in San Jose, CA on Sandia National Laboratory’s augmented version of the US EPA’s Environmental Fluid Dynamics Code (EFDC).
- “The Effect of an Extreme Storm on a Kinetic Hydropower Installation;” D. Corren, J. Colby, MA. Adonizio; AGU Fall Conference; San Francisco, CA; December 2013.
- “Temporal Variation of Velocity and Turbulence Characteristics at a Tidal Energy Site;” B. Gunawan, V.S. Neary, J. Colby; AGU Fall Conference; San Francisco, CA; December 2013.

2014

- MA. Adonizio presented project information at the February 2014 DOE Water Power Program Peer Review; Arlington, VA.
- J. Colby participated in an EMEC “Standards and Guidelines for Marine Renewables (Wave and Tidal) Review and Development Workshop” in Edinburgh, Scotland; March 25, 2014.
- R. Smith and J. Colby participated as panelists and moderators at GMREC/METS conference in April 2014 in Seattle, WA. Presentations (related to project activities) included:
 - “Superstorm Sandy and the Verdant Power RITE Project” – presented by J. Colby;
 - “Tagged Species Detection: Approach to monitoring marine species at Marine Hydrokinetic Projects,” presented by C. Tomichek, Kleinschmidt Associates (project partner);
 - “Determining the Spatial Coherence of Turbulence at MHK Sites,” developed by L. Kilcher, NREL; J. Thompson, University of Washington; and J. Colby.
- MA. Adonizio and D. Corren presented project information at EMEC and at the All- Energy 2014 Conference (UK); May 18-21, 2014.
- IEC PT62600-301 Meeting – River Energy Resource Assessment and Characterization; J. Colby; Atlanta, GA; July 2014.
- SolarFest 2014; D. Corren; Tinmouth, VT; July 2014.
- BOEM Workshop – MHK Focus Day; J. Colby; Sacramento, CA; July 2014.
- R. Smith and T. Taylor participated in the 2014 American Energy & Manufacturing Competitiveness (AEMC) Summit; Washington, DC; September 2014.
- R. Smith and T. Taylor participated in the E&E Offshore Energy Seminar; New York, NY; September 2014.
- IECRE Management Committee – US Delegate on Marine Energy; J. Colby; Boulder, CO; September 2014.
- OWET Conference – Presentations on RITE/MHK Environmental Monitoring, Adaptive Management; J. Colby; Portland, OR; September 2014.
- J. Colby presented at SES Webinar, “IEC TC114 and the IECRE System, International Standards and Conformity Assessment activities relating to the Marine Energy industry;” October 15, 2014.
- J. Colby presented at Science on the Sound, “The Marine Energy Industry, Global Progress and Opportunities;” November 2014; Renewable Ocean Energy Research Symposium; Wanchese, NC.

2015

- R. Smith presented at the DC Wharton Club's Green Business Forum, "Tapping the Energy in Water;" March 2015.
- R. Smith and MA. Adonizio served as panelists at the International Marine Renewable Energy Conference (IMREC) and Marine Energy Technology Symposium (METS); Washington, DC; April 27-29. Efforts of the subject DOE project were highlighted in three papers presented by Verdant personnel at this conference:
 - "Fish Behavioral Response during Hydrokinetic Turbine Encounters: Applying Multibeam Hydroacoustics Results to a Fish-Turbine Interaction Model;" M. Bevelhimer, C. Scherelis, J. Colby, C. Tomichuk, MA. Adonizio;
 - "Improvements to Probabilistic Tidal Turbine - Fish Interaction Model Parameters;" C. Tomichuk, J. Colby, MA. Adonizio;
 - "Marine Energy Industry Challenges & Collaborative Efforts For Solutions;" MA. Adonizio, J. Colby, D. Corren.
- Verdant Power participated with the Marine Energy Council (MEC) to respond to DOE request for LCOE priorities; May 2015.
- R. Smith participated in the DOE East Coast MHK Regulator Workshop; Washington, DC; May 2015.

IV. WORK PRODUCTS/DELIVERABLES

Deliverable	Public	Limited Rights Data to DOE under Award
2013		
RITE Compliance Update to Agencies; Apr 2013	X	
In-Water Test (IWT) Report (Aug - Sept 2012); Apr 2013		X
2012 Provisional Report - Seasonal DIDSON Observation (RMEE-2); Apr 2013	X	
2012 Provisional Report - Tagged Species Detection (RMEE-4); Apr 2013	X	
Subtask 2.1 Report: Analysis of Rotor Load and Dynamometry Data (Jan 2013); Apr 2013		X
Subtask 2.2 Report: Seal Test Design; Apr 2013		X
Subtask 1.2 Report: RMEE-6 Underwater Sound Monitoring and Evaluation Plan-1; Jul 2013		X
Subtask 2.3 Report: Brake Test Design; Jul 2013		X
Subtask 1.2 Report: RMEE-6 Underwater Sound Monitoring and Evaluation Plan-2; Oct 2013		X
Subtask 2.1 Report: Composite Blade Test Design; Oct 2013		X
Subtask 2.4 Report: Gearbox Test Design; Oct 2013		
2014		
RITE Compliance Update to Agencies; Jan 2014	X	
Task 2 Interim Report & Discussion Document for DOE Test Plan Review; Jan 2014		X

Deliverable	Public	Limited Rights Data to DOE under Award
2013 Monitoring of RTE Species Annual Report; Apr 2014	X	
2013 Seasonal Species Characterization Netting (RMEE-3) Annual Report; Apr 2014	X	
2013 Tagged Species Detection (RMEE-4) Annual Report; April 2014	X	
Notes from DOE Component Test Protocol Review/Task 2 Supplemental Report; Apr 2014		X
Summary of UMINN/NSF Composite Blade Activities; Jul 2014		X
Summary of NREL Gearbox Planned Design Review; Jul 2014		X
Tech Transfer Report: EMEC and All-Energy 2014 (May 2014); Jul 2014	X	
Subtask 2.2 Report: Main Shaft Seal Test Progress; Oct 2014		X
Overview of NREL HydroFast Support; Oct 2014		X
Task 2.2 Main Shaft Seal Test Matrix; Oct 2014		X
2015/16		
RITE Compliance Update to Agencies; Jan 2015	X	
DOE Gearbox Review: Design Review of the Verdant Gen5 Drivetrain (Sept 2014); Jan 2015		X
Subtask 2.2 Report: Main Seal Shaft Test Progress; Jan 2015		X
Subtask 2.1 Report: Blade Test Progress; Apr 2015		X
Subtask 2.2 Report: Main Shaft Seal Test Progress; Apr 2015		X
Subtask 2.2 Gen5 KHPS Main Seal Shaft Test Final Report (June 2015); Jul 2015		X
2014 Monitoring of RTE Species Annual Report (filed Sept 2015); Jan 2016	X	
2014 Tagged Species Detection (RMEE-4) Annual Report (filed Sept 2015); Jan 2016	X	
2015 Monitoring of RTE Species Annual Report [DRAFT-Mar 2016]; Apr 2016	X	
2015 Tagged Species Detection (RMEE-4) Annual Report [DRAFT-Mar 2016]; Apr 2016	X	

APPENDIX A:

RITE Monitoring of Environmental Effects (RMEE) Reports (DRAFT ver. Mar 2016)
RITE Project (FERC No. P-12611)



Re: Roosevelt Island Tidal Energy (RITE) Project (FERC No. P-12611) Pilot Project License (January 23, 2012) and NYSDEC Permit #2-6204-01510/00003 Water Quality Certification (WQC) (December 12, 2011)

2015 Annual Report - Monitoring of Rare, Threatened and Endangered (RTE) Species

Verdant Power hereby submits this 2015 annual report in accordance with Article 401 - Commission Approval, Notification, and Filing of Amendments of the above captioned FERC Pilot Project License for the RITE Project and NYSDEC WQC permit condition 14:

WQC Condition 14. Monitoring Rare, Threatened, and Endangered Species

Upon FERC License issuance, the licensee shall continue to monitor for rare, threatened and endangered species in the project area. The permittee shall submit annual reports by February 15 of each year. The report shall include, at a minimum:

- 1) a list of any rare, threatened, or endangered species observed at the project over the previous year;*
- 2) the date, time, and duration the species was present in the project area;*
- 3) a discussion of whether the installed project or any project features appeared to be impacting the observed species;*
- 4) information on any actions taken or proposed by the permittee to limit impacts on those species.*

FERC further requires that the report be filed with the Commission incorporating comments from relevant agencies.

Marine Mammal Protection Act (MMPA)

Additionally, as noted in the FERC Pilot Project License, discussion points 37 and 38 (pages 10 and 11), Verdant is directed to work with NMFS to satisfy the conditions of the MMPA, and is hereby using this filing as ongoing consultation effort.

While the full implementation of the RITE Pilot Project License Install B-1 (3 KHPS and a TriFrame) will not commence until after the “transition period” through 2017, Verdant has commenced construction of the project by maintaining a Control Room and ancillary equipment, conducting an in-water test (IWT) of the Gen5 rotor component of the KHPS during August-September 2012, and also beta testing environmental equipment. Additionally, Verdant has begun the monitoring process in accordance with the FERC license and NYSDEC WQC permit terms, particularly since the company voluntarily implemented the RITE Monitoring of Environmental Effects (RMEE) Plan-4, Tagged Species Detection since 2011 and has observations to report.

RTE Observation in the RTE Project Area

Six federally listed species have the potential to interact with the project:

- the threatened green turtle and loggerhead turtle
- the endangered shortnose sturgeon and Atlantic sturgeon (listed January 2012)
- the endangered Kemp's ridley turtle and leatherback turtle

Under the RMEE-4 Tagged Species Detection plan, Verdant implemented data collection of tagged species in the vicinity of the RTE Project in May 2011 (See Figure 1), and continued this plan through 2014. Verdant downloaded data from the Vemco receivers in August 2015 as shown on Table 1-2015 below. During the period NO operating KHPS were installed, however the two east channel VEMCO receivers were lost in February 2015 due to an extreme ice event. A new receiver and test tag were deployed in August 2015 to maintain continuity of data. Additionally, Verdant did conduct RMEE-3 Species characterization netting in May 2013, under appropriate NYSDEC and NOAA scientific collection permits (no ESA species were collected). This compliance work is partially funded from a grant from NYSERDA and the cooperation of researchers who tag the fish is greatly appreciated.

Figure 1. RTE Project P-12611 RMEE-4 VEMCO Receiver Locations



Table 1-2015 RITE Project P-12611 RMEE-4 Tagged Species Detection May 2011 to August 2015

Receiver Download Date	RITE East Channel				West Channel	
	VR2W RITE N	VR2W RITE S	VR2W-E RITE M	East Detections	VR2W-W	West Detections
5/12/11	Deployed	Deployed	--	Begin RMEE-4	--	
6/9/11	28 days	28 days	--	1 AS ¹ ; 1 SB	--	
8/17/11	70 days	70 days	--	No tagged fish were detected	Deployed	Begin RMEE-4
12/19/11	--	--	--	No data download	111 days	1 AS ; 2 SB
5/21/12	278 days	278 days	--	1 AS ; 1 SB	154 days	2 AS
8/18/12	89 days	--	--	No tagged fish were detected	--	No tagged fish were detected
8/27/13	374 days	463 days	--	1 AS ; 1 alewife	463 days	9 AS ; 2 American shad
7/21/14	328 days	328 days	--	2 AS ; 1 SB ; 1 Unknown species	328 days	6 AS ; 3 Unknown species
8/27/15	lost 2/15	lost 2/15	Deployed	No Data since July 2014	402 days	1 AS , 2 SB 10 Unknown species
Total Elapsed Time	1167 days	1167 days	--		1457 days	
Total Fish detected				10 East		38 West
Total Atlantic Sturgeon detected				5 East * data lost		19 West
Total Striped Bass detected				3 East		4 West
Total other species detected				1 East		2 West
Total unknown/unidentified tags				1 East		13 West

Tagged Species Data Collected

Data has been collected since May 2011 from two Vemco receivers in the East Channel of the East River proximate to the RITE site (VR2W RITE N and VR2W RITE S), and a single receiver in the West Channel (VR2W-W). Two Test Tags (TT-1 & 2) are also deployed for data quality verification (see Figure 1). A full report of all recorded identifications is filed concurrent with this report as the 2015 RMEE-4 Annual Report.

Summary of RTE Detection at RITE

2015 Annual Report of Rare, Threatened and Endangered (RTE) Species at RITE Project:

Based on the above data, Verdant Power hereby reports that monitoring of Rare, Threatened and Endangered (RTE) Species during the period January - December 2015 observed:

- No operating KHPS turbines were active during the period
- No RTE species were collected during the May 2013 RMEE-3 Species Characterization Netting conducted by Verdant Power contractors Kleinschmidt Associates and Normandeau.
- A total of 5 detections of tagged Atlantic Sturgeon have occurred in the East Channel of the East River within 400m of the receivers between May 2011 and July 2014. (data was lost for 2015)

¹ AS= Atlantic Sturgeon; SB=Striped Bass

- 19 detections of tagged Atlantic Sturgeon have occurred in the West Channel of the East River within 400m of the receiver between May 2011 and August 2015. This is a separate body of water distinct from the RITE project.
- Based on the above information no actions were taken or are proposed by Verdant to limit impacts on those species – other than continued tagged species detection monitoring program in 2016.

Beyond the tagged species monitoring, there were no specific other visual observations of RTE species in the vicinity of the RITE Project by Verdant Power technicians during 2015.

Summary of Marine Mammal Observation at RITE

In accordance with the permits, Verdant Power hereby reports any visual observations of marine mammal species in the vicinity of the RITE Project. For the record, prior reports and anecdotal news stories of Marine Mammal (MM) sightings are retained in this report.

2015 MM Observations:

There were no specific other visual observations of marine mammal species in the vicinity of the RITE Project by Verdant Power technicians during 2015.

2014 MM Observations:

There were no specific other visual observations of marine mammal species in the vicinity of the RITE Project by Verdant Power technicians during 2014.

2013 MM Observations:

There were no specific other visual observations of marine mammal species in the vicinity of the RITE Project by Verdant Power technicians during 2013.

On January 25, 2013 news agencies reported a dolphin stranded in the 1.8 mile long Gowanus canal that subsequently died and was removed. The Gowanus Canal is in Brooklyn tributary to New York Harbor. The Environmental Protection Agency says storm water runoff, sewer outflows and industrial pollutants have made it one of the most extensively contaminated water bodies in the U.S. The location is approximately 16 km from the RITE Project and the siting is noted anecdotally.

The Northeast Regional Office of the NOAA Fisheries Service confirmed to news agencies that the stranded mammal was a short-beaked common dolphin, which is known for a dark gray cape on its back.

From www.thegothamist.com (March 17, 2013):

On Wednesday [3/13/13], a dolphin was spotted swimming around in the East River near 96th Street. Then on Friday, a dolphin was spotted on the other side of the East River near Astoria. Officials from the Riverhead Foundation weren't sure whether it was the same dolphin or a second one, but members of the North Brooklyn Boat Club took to the water yesterday and confirmed there are TWO dolphins

currently hanging out in the East River. And like a lot of Manhattan residents, the bottlenose dolphin from the Upper East Side has moved to Greenpoint.

"We paddled out today and saw the dolphin further south—near Greenpoint," North Brooklyn Boat Club member Willis Elkins told us. Despite the snowy conditions, they spotted the second dolphin uptown: "Kayakers from our club also spotted a second, and smaller, dolphin north from where we were in the canoe—near the Queensboro Bridge on the West Channel," he said. "The dolphin appeared healthy and quite active— we followed it around for over an hour and got within about 20' on a few occasions."

Both of these sightings are in the West Channel and not proximate to the RITE Project Boundary in the East Channel. For reference – the Queensboro Bridge is 60th Street and the RITE Project is located in line with 72nd Street but in the opposite channel.

2012 MM Observations:

There were no specific other visual observations of marine mammal species in the vicinity of the RITE Project by Verdant Power technicians during 2012.

Superstorm Sandy occurred on October 29, 2012, causing significant disruption in the New York harbor waterway system.

2011 MM observations:

There were no specific other visual observations of marine mammal species in the vicinity of the RITE Project by Verdant Power technicians during 2011.

The New York Post (November 19, 2011) reported *"a young harbor seal hauled itself up on a rock behind Gracie Mansion yesterday and stayed there to soak up the rays and snooze for about two hours. Then it slipped back into the East River and swam off."*

Gracie Mansion abuts the west shore of the West Channel of the East River approximately 3 km from the RITE Project site on the opposite side of Roosevelt Island. Harbor seals are not a listed species in New York, and the siting is noted anecdotally.



Re: Roosevelt Island Tidal Energy (RITE) Project (FERC No. P-12611) Pilot Project License (January 23, 2012) and NYSDEC Permit #2-6204-01510/00003 Water Quality Certification (WQC) (December 12, 2011)

2015 Annual Report - Tagged Species Detection (RMEE-4)

In accordance with Article 401 - Commission Approval, Notification, and Filing of Amendments of the above captioned FERC Pilot Project License for the RITE Project, Verdant Power hereby submits its report under the implementation of the RITE Monitoring of Environmental Effects (RMEE) plans and specifically NYSDEC WQC condition 13:

WQC Condition 13. Tagged Species Detection Annual Report: Draft report by February 15 of each year that monitoring occur¹

While the full implementation of the RITE Pilot Project License will not commence until the Install B-1 (3 KHPS on a TriFrame) as required by the Pilot license planned for 2017, Verdant has voluntarily implemented this plan including the reporting and agency review process specified in the January 2012 RITE Pilot License. Specifically:

Article 401 (b) Requirement to File Reports

*Prior to filing the annual reports with the Commission, **the licensee shall submit the reports to the agencies identified in each plan and allow a minimum of 30 day for the agencies to review and comment on the reports.** The final reports shall include copies of any comments received and the licensee shall address all comments and recommendations received from the agencies. If the licensee does not adopt a recommendation, the report shall include the licensee's reasons based on project-specific information. The Commission reserves the right to require changes to the monitoring plans, project operations, or facilities based on the information contained in the reports and any other available information.*

* The March 15 due date to file the reports with the Commission allows sufficient time for the licensee to incorporate any review comments it receives from the New York DEC.

The following represents the draft 2015 report under the RMEE-4 plan, Tagged Species Detection.

¹In addition, as a condition of the NYSDEC WQC (#14) and as incorporated in the license for the project, Verdant is required to make a report of any Rare, Threatened, and Endangered Species observations at the project site. This report is made separately.

Report of RMEE-4 Plan Activities – January 2015 to December 2015

1.0 Objectives

As stated in the RMEE-4 plan (Version 3.2 December 2010), the purpose of this effort is:

To provide new and unique detections on the potential presence of the proposed ESA listed Atlantic sturgeon², 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.

This activity is undertaken earlier than required by the project permits and licensee, as part of partially funded effort supported by the New York State Energy Research and Development Authority (NYSERDA) for Environmental Assessment at RITE (Agreement No. 20802). The effort relies on the collaborative support from Dana Allen at VEMCO for identification of the tag owners/researchers. Additionally, the continued cooperation of the researchers that tag the species is required to maximize the utility.

2.0 Methods and Equipment

2.1 Equipment

Verdant Power has installed three (3) VEMCO VR2W receivers in and around the RITE Project, as shown in Figure 2-1.³ Two of the receivers, VR2W RITE N and VR2W RITE S, were deployed in May 2011 in the East Channel of the East River from existing PATON buoys at the current RITE Project site. The third receiver, VR2W-W, was deployed in August 2011 in the West Channel of the East River using a concrete bottom mount, adjacent to an unused water taxi pier on Roosevelt Island.

Early in 2015, due to severe ice conditions in the East Channel of the East River, both VR2W RITE N and VR2W RITE S were lost. A replacement VEMCO VR2W receiver was deployed from the existing PATON Middle in August, 2015 named VR2W-E. Figure 2-1A shows the new East Channel deployment location. No operating KHPS turbines were deployed in 2015.

The two receivers have approximately 15 months of battery life and storage for 10⁶ detections. The primary receive frequency is 69 kHz. The RMEE-4 plan specified up to four receivers to be installed in the East Channel as the RITE Project Pilot project advanced to up to 30 KHPS deployed.

2.2 Data Quality Control

A. Continuity of Data: To confirm receiver operation throughout the data collection period, two unique test tags, TT-1 and TT-2 were deployed for data quality control.

² 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)

³ The installation of the VEMCO receivers is covered under two amendments to the existing RITE NYSDEC/USACE permits and an approval by the NY OGS for instruments on NYS land.

- TT-1 was deployed in the East Channel from an existing PATON buoy equally spaced between VR2W RITE N and VR2W RITE S. TT-1 is currently deployed on the same PATON buoy as VR2W-E.
- TT-2 was deployed in the West Channel attached to the concrete bottom mount with VR2W-W.

The detection of a signal from both test tags, continuously present near the respective receivers, confirms continuous receiver operation throughout the reporting period. The most recent data download represents the period July 2014 through August 2015 and unfortunately only data in the West Channel, due to the loss of East Channel receivers.

B. Verification of Range: To verify the range of detection of the East Channel receivers, Verdant conducted a mobile survey using a test tag in August 2011 that covered a significant reach of the East River proximate to the RITE Project site and East Channel receivers (See Figure 2-3). A unique test tag was launched at Halletts Cove (Point 1N) and suspended in the water down the eastern shoreline of the channel to point 4N crossing the channel to point 2S and proceeding up the west side of the channel to point 7N and then hauled out at Hallett's Cove. The VEMCO data was then downloaded from the VR2W RITE N and VR2W RITE S receivers and analyzed. As shown on Figure 2-3, the estimated range of each receiver is 400 m (1300') in all directions, larger than the river width at each deployment location. This exercise confirms the applicability of the two locations to detect tagged species as they pass in proximity to the RITE Project site; and also indicates the appropriate location for future deployments to cover the entire East Channel during the full deployment.

C. Limitations:

- 1) A similar exercise cannot be conducted in the West Channel to verify range, since it is the main NYC navigation channel and small vessel movement in this pattern would be hazardous.
- 2) An acknowledged limitation of the RMEE-4 plan is that a "detection event" as described below indicates that a tagged fish was somewhere in the range of the receivers – as noted on Figure 2. The exact location both within the water column and within the cross section, and thus proximity to the KHPS machines, cannot be achieved with this installed system. A detection event means that a tagged fish came within 400m of the proposed site of the operating KHPS.
- 3) As previewed in the 2014 report, and continuing with this report, the effectiveness of the tagged species detection protocol relies on the cooperation of researchers identifying the detected tags. As noted below, Verdant has made every effort to contact known researchers to identify species and lengths however the lack of response significantly limits the completion of the data set.

3.0 Monitoring Data Analysis

3.1 Data Collection

A summary of receiver downloads and tagged species detection history is provided in Table 3-1. Details on the 2014-2015 data set are provided in Section 6. Both East Channel VR2W RITE N and VR2W RITE S were deployed in May 2011 and lost due to an ice event in February 2015. A single receiver and test tag

was deployed in August, 2015 on the middle buoy. The West Channel receiver (VR2W-W) was deployed in late August 2011 and remains in operation. Data collection continues in 2016 with these two receivers, with data continuity verified from the two test tags. Since 2011:

- **4 different tagged species have been detected; Atlantic Sturgeon (AS), Striped Bass (SB), American shad, alewife**
- **40 unique tags have been detected; representing a total of 48 fish; with 14 unknown/unidentified**
- **The predominance of the detections is in the West Channel of the East River 38 to 10 in the East Channel where the RITE project is sited**

The maintenance of this detection station requires the retrieval of each receiver (with a diver) for onshore data transmission via blue-tooth link. Data download times are relatively short (< 10 min) and receivers are immediately redeployed following successful transmission. Yearly battery replacement and maintenance are required for proper operation at a cost in excess of \$5,000 per data retrieval, not including analysis time.

Table 3-1 – RITE RMEE-4 Summary of Tagged Species Detection: May 2011 - August 2015

Receiver Download Date	RITE East Channel				West Channel	
	VR2W RITE N	VR2W RITE S	VR2W-E RITE M	East Detections	VR2W-W	West Detections
5/12/11	Deployed	Deployed	--	Begin RMEE-4	--	
6/9/11	28 days	28 days	--	1 AS ⁴ ; 1 SB	--	
8/17/11	70 days	70 days	--	No tagged fish were detected	Deployed	Begin RMEE-4
12/19/11	--	--	--	No data download	111 days	1 AS ; 2 SB
5/21/12	278 days	278 days	--	1 AS ; 1 SB	154 days	2 AS
8/18/12	89 days	--	--	No tagged fish were detected	--	No tagged fish were detected
8/27/13	374 days	463 days	--	1 AS ; 1 alewife	463 days	9 AS ; 2 American shad
7/21/14	328 days	328 days	--	2 AS ; 1 SB ; 1 Unknown species	328 days	6 AS ; 3 Unknown species
8/27/15	lost 2/15	lost 2/15	Deployed	No data since July 2014 (data lost)	402 days	1 AS , 2 SB 10 Unknown species
Total Elapsed Time	1167 days	1167 days	--		1457 days	
Total Fish detected				10 East		38 West
Total Atlantic Sturgeon detected				5 East (data lost)		19 West
Total Striped Bass detected				3 East		4 West
Total other species detected				1 East		2 West
Total unknown/unidentified tags				1 East		13 West

⁴ AS= Atlantic Sturgeon; SB=Striped Bass

3.2 Tagged Species identification

During the development of the RMEE plans in the fall of 2010, the opportunity for Verdant to participate in a macro study of tagged species detection at the RITE site was facilitated by the existence of the Atlantic Cooperative Telemetry (ACT) Network. Tag identification efforts are coordinated with Tom Savoy, CT DEP, as the coordinator for the ACT Network and Dana Allen at VEMCO. The process includes:

- Screening of the data to ensure test tag detection and isolate possible tags
- Transmittal of the tags for verification through ACT and VEMCO (per ACT agreement researchers share identification anonymously)
- Researcher contact to identify tag, species, length and release date and location⁵
- Summary and reporting in relationship to RITE site and tidal conditions

To date this effort has been moderately effective in the mutual provision of detection events to the researchers in the ACT network in exchange for specific species and size identification of fish of interest at the RITE site. A summary of the unique tags identified in 2015 is provided in Tables 6-1 E and 6-1-W below. Per the guidance of VEMCO, individual tag identifications with only a single detection should be considered as false detections. VEMCO recommends one pair of detections less than thirty minutes apart: <http://www.vemco.com/education/faqs.php#q34>.

4.0 Schedule and Timing

Per the RMEE-4 plan and subsequent consultations with the agencies, it has been agreed that the collection of data on tagged species will be continuous at the RITE Project site, rather than the April-November timeframe originally proposed. Table 4-1 summarizes the permit and FERC license requirements.

Verdant has voluntarily begun this study well in advance of the requirements to establish the efficacy of the monitoring protocol and provide quantitative data. During September 2012, a 2-week in-water test of the new Gen5 KHPS rotor was conducted. Install A, the first operation of Gen5 KHPS is currently scheduled for 2017 and as such would have five years of data prior to monitoring operating turbines. This is only achievable due to the generous support of NYSERDA and the continuation of cooperation from the ACT Network.

Table 4-1 - RMEE-4 Tagged Species Detection (as licensed)

RMEE-4	Install A (2 Turbines)	Install B-1 (3 Turbines - Tri- Frame) RITE PILOT License	Install B-2 (+9 Turbines) RITE PILOT License	Install C (+18 Turbines) RITE PILOT License
VEMCO Receivers	Year round data collection; data download 2X per year	Year round data collection; data download 2X per year	If study continues	If study continues

⁵As stated in the RMEE-4 plan, as of December 2010 it was estimated that approximately 950 Atlantic and shortnose sturgeon and 2,000 striped bass are tagged with VEMCO tags in the ACT network.

5.0 Remedial Measures

No remedial measures are indicated by the results of the monitoring conducted in the RMEE-4 thus far. However a significant component of the viability of the plan was identified.

Verdant Power notes that in June 2013, we were advised that funding for the ACT network will cease operation in December 2013. A successor network; Mid Atlantic Telemetry Observation System (MATOS) has been proposed, but no further structural or participation effort has been forthcoming. Further, in identifying tags for the reporting periods there is a reluctance to share data as a result of ongoing activities outside the cooperative agreement in the Hudson and East Rivers.

This uncertainty associated with the ongoing cooperation from fish taggers and the scientific community to support Verdant's efforts of detection could result in a re-evaluation of the RMEE-4 plan and the suspension of activities at RITE. We encourage NMFS to review the situation and encourage a productive compromise. For 2016, Verdant shall continue data collection efforts despite this uncertainty. However, as shown in Tables 3.1 and 6-2, a significant number of detections are unidentified at this time. Further, the details of the tagged species (length, location, date, etc.) are known for only a fraction of the total detections.

6.0 Results and Reporting

The most recent data download occurred on August 27, 2015 and covered the period July 2014 through August 2015.

East River- East Channel – Table 6-1E

No new data was collected from the East River – East Channel receivers (VR2W RITE N and VR2W RITE S) due to the loss of both receivers in February 2015 in an extreme ice event. In so far as the data collection is voluntary until the Pilot license period, a receiver and test tag were replaced in August 2015.

East River-West Channel – Table 6-1W

All new 2014-2015 data that was collected from the East River – West Channel receiver (VR2W-W) is shown on Table 6-1W representing 402 days of in–water detection time.

Summary of RMEE-4 Tagged Species Detection – May 2011-August 2015

- Data Collection under RMEE-4 is a voluntary program by Verdant Power in advance of permit and license compliance; partially funded by NYSEDA
- Continuous operation of VEMCO receivers at RITE project for over 1,000 days; no data continuity problems including uninterrupted monitoring through Superstorm Sandy (October 2012).
- Two receivers were lost in February 2015; and replaced in August 2015
- Table 3.1 summarizes detections in the East Channel (10) and the West Channel (38) over the period
- Table 6.1 East and West summarize 2014-2015 data as detected

- Table 6.2 provides a summary and normalization of observations, indicating that 25% of the detections are in the RITE East Channel and 75% are in the West Channel where no KHPS are located.
- In general, the following is interpreted from the 4 years of data:
 - Detections occur primarily in the April – June time frame and again in October; although Superstorm Sandy (October 29, 2012) could have affected 2012 data
 - Detections of Atlantic Sturgeon mostly at, or near, slack tide; other species vary
 - Detections are mostly of short (<1 to 2 hr.) duration, implying Atlantic sturgeon are using the East River as a migration route.
- The success of the RMEE-4 plan relies on mutual continued cooperation of tagging researchers and sharing of tag identification. For example in 2015, 10 of 13 total detections have not been identified. Identified species with an unknown length at tagging have been listed as TBD because researchers have not provided the details). This remains an open issue.

Table 6-1E - RITE East Channel (July 2014 – August 2015)

Receivers and data were lost in February 2015 – so no 2015 data is available.

A new receiver (VR2W-E) was deployed in the East Channel in August, 2015.

Table 6-1W - RITE West Channel (July 2014 – August 2015)

Event	Species	Detected	Duration	Tide	Length (cm)
10W-14	UNKNOWN	8/2/14	26 Min. 51 Sec.	End-Flood/Slack	TBD
11W-14	Striped Bass	11/19/14	38 Min.	Start-Ebb/Ebb	97.5
1W-15	UNKNOWN	5/11/15	1 Min. 15 Sec.	Ebb	TBD
2W-15	Striped Bass**	5/25/15	2 Min. 6 Sec.	Flood	TBD
3W-15	UNKNOWN	5/27/15	1 Hr. 20 Min. 42 Sec.	Start-Ebb/Ebb	TBD
4W-15	Atlantic Sturgeon**	5/27/15	35 Min. 40 Sec.	Start-Ebb/Ebb	TBD
5W-15	UNKNOWN	6/3/15	16 Min. 44 Sec.	Slack	TBD
6W-15	UNKNOWN	6/6/15	1 Hr. 52 Min. 17 Sec.	Slack/Start-Ebb/Ebb	TBD
7W-15	UNKNOWN	6/21/15	1 Hr. 37 Min. 9 Sec.	Slack/Start-Ebb/Ebb	TBD
8W-15	UNKNOWN	7/11/15	1 Hr. 52 Min. 1 Sec.	End-Flood/Slack/Start-Ebb/Ebb	TBD
9W-15	UNKNOWN	7/12/15	9 Min. 49 Sec.	Start-Ebb	TBD
10W-15	UNKNOWN	8/4/15	27 Min. 2 Sec.	Start-Ebb/Ebb	TBD
11W-15	UNKNOWN	8/7/15	13 Min. 27 Sec.	Slack	TBD

UNKNOWN indicates data sharing issues with tagging entity as noted

** Species known, size and other tagging details not available

Table 6-2 Distribution of Tagged Species as Detected – East-West Channels

48 total detection (of 40 unique tags) events split non-uniformly – a key parameter in the KHPS Fish interaction Model.

Of the 48 detections; 24 were Atlantic Sturgeon (17 unique tags)

Detections	RITE East Channel	West Channel
48 Total Fish Detections	10 detections 1167 days of data	38 detections 1457 days of data
Total annual average detections of all fish 12.6 Fish Detections per year total	116.7 days per Fish Detection 3.1 Fish Detections per year	38.3 days per Fish Detection 9.5 Fish Detections per year
Distribution of all Fish Detections	25% of all Fish Detections occurred in the East Channel	75% of all Fish Detections occurred in the West Channel
24 Atlantic Sturgeon Detection	5 detections (2 receivers, 1167 days of data) (data lost for 2015)	19 detections (1 receiver, 1457 days of data)
Total annual average Atlantic Sturgeon detections 6.32 Atlantic Sturgeon Detections per year total	291.8 days per Atlantic sturgeon detection 1.56 Atlantic Sturgeon Detections per year	97.1 days per Atlantic sturgeon detection 4.76 Atlantic Sturgeon Detections per year
Distribution of Atlantic Sturgeon Detections	25% of all Atlantic Sturgeon Detections occurred in the East Channel	75% all Atlantic Sturgeon Detections occurred in the West Channel

7.0 RMEE-4 Tagged Species Detection Plan

Responses to specific RMEE-4 Plan Questions:

1. What is the detected presence, distribution, and frequency of tagged fish in the East River during the observation period?

Based on data collected thus far, including the 2014-2015 observations, a total of 24 tagged Atlantic sturgeon have been detected, 10 other tagged species were identified and 14 detections are of unknown species in more than 50 months of data collection. The predominance of the tagged detections is in the West Channel 38 to 10 detections in the East Channel where the RITE project is located.

The presence of tagged fish varies however most detections are short from <1 hour up to 6 hours; and a single observation of a striped bass of over 5 days, generally indicating a movement (at or near slack), rather than a residence pattern.

As discussed in the Biological Assessment- Atlantic sturgeon (contained in the RITE Final License Application (FLA), Volume 4), assumes that Atlantic sturgeon use the East River to move between the Hudson River, New York Harbor and Long Island Sound. Data collected for over 4 years confirm that Atlantic sturgeon and other tagged fish use the East River as a migration route. However, as discussed in the limitations of this plan—detection does not equate to an interaction since the detection is within 400m of the receiver and no depth or channel location or distribution is possible with the current configuration.

Seasonal frequency in the data seems to detect an April - June increase in detections over the 4 years of data; however a fall migration does not appear in 2012 or 2013. The next data download (date TBD 2016) covering the fall 2015 and potentially the fall 2016 may be more illuminating.

2. What can be postulated from this data as to the potential interaction of these species with operating KHPS?

The lengths of the identified tagged Atlantic sturgeon are consistent with, and perhaps slightly larger than, the assumptions in the 2010 KHPS-Fish Interaction Model (KFIM) (RITE FLA, Volume 4) for common length (104 cm) of the species. However this may be an artifact of the size of the tagged fish and not representative of the actual size of the migrating fish. The detected occurrences of Atlantic sturgeon in the East River, with relatively short residence times near slack, continue to confirm the low probability of interaction with operating turbines since the turbines are not operated at slack tide.

Additionally, the P3 model parameter (Fish Distribution) incorporated an equal likelihood (50%) that fish will take the East Channel (and be at potential risk being near the operating project) over the West Channel (and have no risk from the operating project). This distribution – now over a four-year period seems to indicate a bias now towards the West Channel of 10 events East versus 38 events West. We note this observation that the trend is tending towards less risk to the species than assumed in the model.

Concurrent work by Oak Ridge National Laboratory (ORNL), Verdant Power and Kleinschmidt Associates during 2015, which is the subject of a scientific paper to be presented at the Proceedings of the 4th Marine Energy Technology Symposium (METS2016) April 25-27, 2016, Washington, D.C. entitled; *"PARAMETER UPDATES TO PROBABILISTIC TIDAL TURBINE – FISH INTERACTION MODEL"* which updates the 2010 KFIM model to a 2015 version suggesting some improvements to the parameters based on data collection in 2012-2015.

The limited number of detections of large fish of any species continues to support Verdant fixed hydroacoustic and VAMS data taken at RITE (2006-10) and confirm measurements of fish length distributions. Longer residence times were observed when detections were within an hour of slack tide, significantly lowering the potential impact, as KHPS turbines will be non-operational for most of that time.

3. What, if anything, should be changed in the protocol for 2016 and beyond in Installs B and C to improve detection and evaluation?

The modification to a year-round data collection protocol has been made at the request of the agencies. The RMEE-4 plan anticipated four VEMCO receivers, three in the East Channel and one in the West for the Pilot license period. Through July, 2014, Verdant has deployed three VEMCO receivers, two in the East Channel and one in the West. For 2014-2015, due to an extreme ice incident only a single receiver in the West Channel was deployed. Beginning in August 2015, Verdant continues voluntary monitoring with two receivers as currently deployed, one in the East Channel and one in the West Channel.

The deployment and maintenance of VEMCO receivers to provide detection at a unique point in the NY Bight is a costly operation involving equipment, boats and divers. This activity is partially supported by NYSERDA through an environmental assessment project. Based on the experience to date, and the verification of successful battery life of at least 15 months, Verdant schedules the collecting of data when other on-water operations are planned to minimize costs rather than the twice yearly recommendation stipulated in the RMEE-4 plan and the FERC License Article. This is consistent with the low abundance of tagged species detected thus far.

Based on the 50+ months of study, Verdant does not propose any recommended changes to the RMEE-4 plans and protocols for tagged species detection. Continuing data collection up to and including the period of the first operation of Gen5 units at RITE will form a sound basis for evaluation in an adaptive management scheme during Pilot operation. This data collection shall inform any changes for subsequent deployments at RITE should they develop.

However, the ongoing success of this tagged species detection plan relies on the ongoing cooperation and sharing of tagged species identification and size by researchers in the community. While Verdant recognizes that funding for tagging and network maintenance is competitive and at a premium, Verdant encourages continued leadership and funding of these programs by NMFS to advance the research and promulgate the protection of the species. Further, Verdant encourages NMFS to work directly with fish tagging researchers to ensure the transfer of tag details, including species, tagging date, size and location to improve the quality of data collected at the RITE site.

8.0 References Cited

1. Verdant Power, LLC. 2010. Final Pilot License Application - RITE East Channel Pilot, Volume 4: RITE Monitoring of Environmental Effects (RMEE) Plans, Appendices A & B summarizing supporting fishery information, ESA, EFH
2. FERC Order issuing Pilot License- FERC P-12611; January 23, 2012.
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
4. 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

9.0 Agency Comments and Disposition

This draft report is provided to RITE fishery consultation agencies, NYSDEC, USFWS, NMFS, USACE, EPA, FERC in March 2016 for review and comment. The following comments and disposition were received:

- Date/Comment/Disposition - pending comments.

Figure 2-1 –RITE RMEE-4 VEMCO receiver (3) and test tag (2) deployment locations (5/2011 – 7/2014)

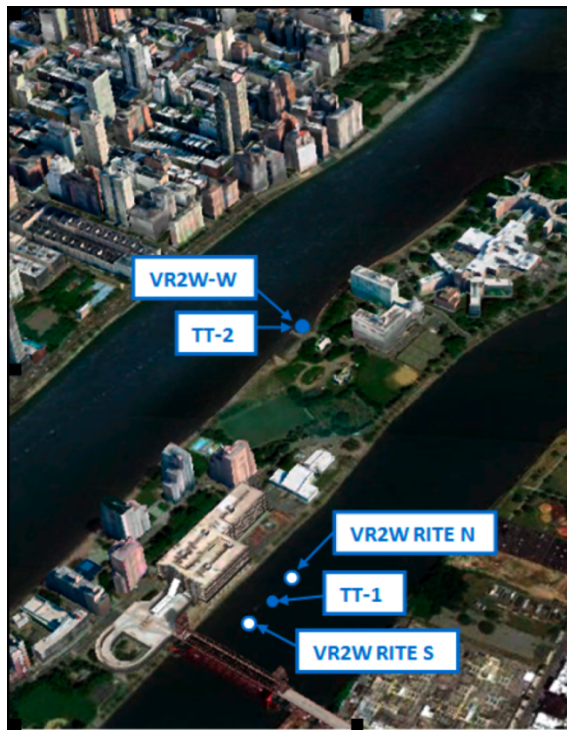


Figure 2-1A. RITE RMEE-4 VEMCO receivers (2) and test tag (2) deployment locations (8/2015 onward)

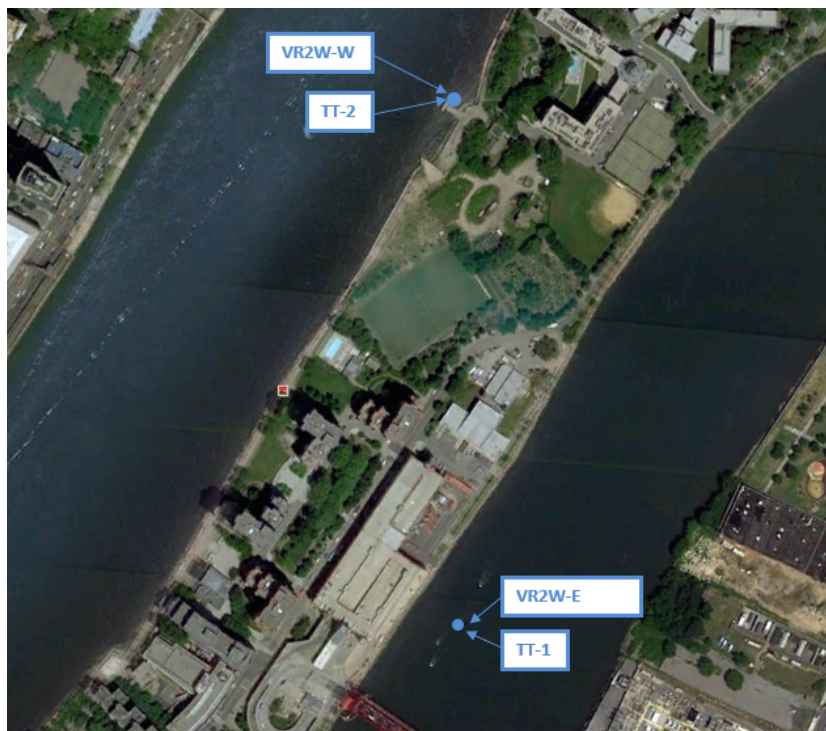


Figure 2-3. - RITE Project VEMCO Receiver Range, Test tag verification – August 2011

