New York State Energy Research and Development Authority

# Roosevelt Island Tidal Energy (RITE) Environmental Assessment Project

Final Report
Report 11-04

March 2011

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# Environmental Assessment Project

Final Report

Prepared for the
**New York State**
**Energy Research and**
**Development Authority**


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## ABSTRACT AND KEY WORDS


### ABSTRACT

The purpose of this project was to provide ongoing environmental consultation and monitoring efforts required under the permits for the Roosevelt Island Tidal Energy (RITE) Phase II six-turbine demonstration (RITE Demonstration), advancing the understanding of fish presence, abundance, species characterization and fish interaction with operating kinetic hydropower turbines. This Final Report summarizes the significant accomplishments and achievements of NYSERDA and Verdant Power by providing a history and perspective of the environmental assessment of marine hydrokinetics as well as a detailed discussion of NYSERDA-funded tasks that significantly supported the filing of a Federal Energy Regulatory Commission (FERC) Final Hydrokinetic Pilot License Application (FLA) for the RITE Project (FERC No. P-12611) in December 2010. As a result of this work, Verdant Power's Kinetic Hydropower System (KHPS) (Generation 5 (Gen5)) is planned to be installed, pending permits, in the East Channel of the East River in New York to continue the demonstration of the technology for reliability, longevity, cost-effective O&M and environmental compatibility. The work discussed here includes consultations and the executing of fishery studies and monitoring that observed two operating Gen4 KHPS turbines in the September-November 2008 timeframe, resulting in important data and observations related to the fish interaction with kinetic hydropower turbines at full commercial scale. Also included are the results of consultations with environmental stakeholder agencies during 2009 and through 2010, on the new Gen5 KHPS design and background fishery information and analysis that supports essential fish habitat assessments as well as biological assessments of resident, migrating, and endangered species. As such, it represents a significant body of 'first time' analysis and information on the environmental effects of marine hydrokinetic machines in a tidal application.

**KEY WORDS**
Environmental Effects of Kinetic Hydropower

Environmental Monitoring

Hydrokinetic

KHPS Environmental Assessment

Kinetic Hydropower

Kinetic Hydropower Systems (KHPS)

Marine Hydrokinetic (MHK) industry

RITE

Verdant Power

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**SUMMARY**

In previous New York State Energy Research and Development Authority (NYSERDA)-sponsored projects, Verdant Power, LLC (New York, NY) advanced the state-of-the-art in kinetic hydropower research, and demonstrated the utility and efficiency of an axial-flow turbine in converting the kinetic energy in flowing water into electric power, with concurrent environmental permitting and assessment. A Phase II demonstration (RITE demonstration) of the Verdant technology (Kinetic Hydropower System – KHPS) in 2006-08 at the Roosevelt Island Tidal Energy (RITE) Project in the East River showed that the observed turbine peak efficiency of 38 to 44% was as expected in water current speeds of three to seven feet/sec (1.8 to 4.2 knots), while delivering emission-free, renewable electricity to two commercial end users located on Roosevelt Island.

Under the project reported on here, Verdant Power continued the environmental monitoring efforts required under the permits for the RITE demonstration project, advancing the understanding of fish presence, abundance, species characterization and fish interaction with operating kinetic hydropower machines. This final project report summarizes the significant accomplishments and achievements of NYSERDA and Verdant Power in executing the task activities that significantly supported the filing of a Federal Energy Regulatory Commission (FERC) Final Hydrokinetic Pilot License Application (FLA) for the RITE Project (FERC No. P-12611) in December 2010. The 4-volume content of the FLA is available to the public on Verdant's RITE Project website, www.theriteproject.com, and specifically contains environmental information in Volumes 2 and 4 that represent the body of effort conducted under this Agreement. This final report summarizes the tasks and key results that are contained in the FLA, and the Appendix provides an overview of the project deliverables. In addition to the development and filing of the FLA, during the Agreement term, the project has made key accomplishments, including: 1) conducting fishery studies to characterize and groundtruth the temporal, spatial and some behavioral aspects of fish and avian species interaction near operating KHPS turbines; 2) characterization of the essential fish habitat, and the potential effect of a larger turbine array on these species; 3) the evaluation of potential impacts on protected species; and 4) the development of an ongoing RITE Monitoring of Environmental Effects (RMEE) plan that supports Gen5 KHPS environmental compliance and compatibility.

Overall, this environmental assessment project has laid the groundwork for the commercial deployment and environmental monitoring of the KHPS at the RITE Project and other sites in NYS and the US under the federal and state regulatory system. Additionally, the monitoring protocols and results stand as a model for addressing environmental compatibility issues for application of the Verdant technology at other sites in Canada, the UK and the rest of the world, as kinetic hydropower projects continue to be developed. The application of the KHPS at RITE may ultimately provide a new and indigenous source of clean energy for NYS residents, as well as potentially establish a new stream of economic development for NYS businesses.

# 1 – KINETIC HYDROPOWER TECHNOLOGY AND ENVIRONMENTAL EFFECTS

## *1.1 Kinetic Hydropower Potential*

### *1.1.1 Technologies and Resource*

The world's estimated kinetic hydropower potential from river and tidal sites exceeds 30 GW; and is being aggressively pursued by a variety of kinetic hydropower technology developers at sites worldwide. The U.S. Department of Energy's Marine and Hydrokinetic Technology Database provides up-to-date information on marine and hydrokinetic renewable energy, both in the U.S. and around the world. The database includes wave, tidal, current, ocean thermal energy, and contains information on the various energy conversion technologies, companies active in the field, and development of projects in the water. Depending on the needs of the user, the database can present a snapshot of projects in a given region, assess the progress of a certain technology type, or provide a comprehensive view of the entire marine and hydrokinetic energy industry (www1.eere.energy.gov/windandhydro/hydrokinetic).

The database contains entries for over 250 different technologies and over 465 projects that are active worldwide. Projects are listed according to their status:

- Phase 0 - Never Developed (Permit Surrendered or Unknown status)
- Phase 1 - Siting/Planning
- Phase 2 - Site Development
- Phase 3 - Device Testing/Commissioning [Pilot]
- Phase 4 - Deployed [Grid Connected]

The majority of the projects are in the 0-2 category, with only a handful of the projects and technologies advancing to the Phase 3 or 4 level at this time. Verdant Power's Roosevelt Island Tidal Energy (RITE) project in the East River in New York City is one such project.

### *1.1.2 Verdant Power KHPS Technology*

In order to maximize the application of its technology within this global resource, Verdant Power has designed a Kinetic Hydropower System (KHPS) as a simple and uniquely scalable system that can be operated in tidal, river, and ocean current settings. As represented by the company's current projects, Verdant Power's technology can be applied in sites worldwide, ranging from shallower, near-shore tidal sites, such as the East River in New York (RITE Project), to the high velocity river flow of the St. Lawrence River in Ontario (CORE Project), and the deeper off-shore tidal waters of other sites worldwide.

The KHPS technology is discussed in detail in the RITE Kinetic Hydropower Pilot License Application (P-12611), submitted in December 2010 and available at http://www.theriteproject.com. An overview is also given in Appendix A to this report. A brief summary follows for contextual reference related to environmental assessment.

The KHPS consists of three components:

1) KHPS turbine (Fig. 1), which has four major assemblies:

- A rotor with 3-fixed blades that rotate at a relatively slow and constant speed of approximately 40 revolutions per minute (rpm), with tip-speeds of 35 feet per second. This is well below normal water vessel propeller speeds and conventional hydropower turbine blade speeds.
- A sealed nacelle, pylon and passive yaw mechanism that are hydrodynamically designed to allow the turbine to self-rotate into the prevailing current flow (weathervane) so that the blades are optimally aligned to generate energy.
- An enclosed generator and drivetrain within the nacelle serve as a horizontal-axis custom designed drivetrain unit that integrates the bearing housing with a special long-life planetary gearbox with mechanical shaft seals and a minimum of sealed lubricants.
- A streambed mounting system (single monopile, triframe mount (holds three turbines), or single concrete gravity-based mount).

**Figure 1 – KHPS Turbine**

2) Underwater cabling, which is low voltage shielded cable of short distance, and shoreline switchgear vaults, control room, and interconnection, which are underground or low-profile, small structures;

3) Appurtenant facilities for navigation safety and instrumentation, providing a navigational exclusion zone protected by Private Aides to Navigation (PATON) buoys and lighted warning signs.

The Verdant KHPS technology (4th Generation) was the subject of a demonstrated project from 2006-08, although the regulatory, permitting, and environmental discussions for the effort began in 2003. A summary of the RITE Demonstration and the advancement of the KHPS to the 5th generation (Gen5) is contained in Appendix A to this report. Much of the discussion contained in this report centers on evaluating the environmental effects of the operating KHPS in New York waters, and developing a framework to continue the environmental assessment in a Pilot project at RITE planned for 2011-12.[1]

[1] The RITE Project Final License Application; FERC P-12611; December 2010; 4 Volumes available at http://www.theriteproject.com

*1.1.3 Estimated NYS Commercial Market / Importance to New York State*

The kinetic hydropower potential in New York State is estimated to be on the order of 500-1000 MW. In addition to the East River (East and West Channels), other large New York State kinetic hydropower resources where the KHPS could be implemented include areas within Long Island Sound, the St. Lawrence River and the Niagara River. Implemented in these and other local sites, the KHPS would provide clean renewable energy that would help New York meet its greenhouse gas reduction goals, including Renewable Portfolio Standard goals. The KHPS would also generate locally-sourced energy that would help the state reduce its electricity imports, which made up approximately 85% of energy delivered in the state in 2005.

In addition to energy generation, the commercialization of the KHPS sparked by the proposed demonstration would also benefit the New York State economy, making New York the manufacturing center for a new renewable energy technology with international export potential. In fact, through a project sponsored by NYSERDA (contract #10720), Verdant Power has been in the process of identifying specific New York manufacturing sites for future commercial installations, which would result from this project.

The RITE Project's potential to impact New York City's economy was recently highlighted in a report entitled "New York City's Transformation to a Green Economy," which listed the RITE Project as one of 30 initiatives New York City envisions playing a key role in transforming its economy. Through the RITE Project and previous NYSERDA support, Verdant Power is currently working to make New York a center for this emerging industry and its manufacturing/installation potential in the US and internationally.

***1.2 Environmental Effects Research and Evaluation Assessment***

On a global scale, high level Strategic Environmental Assessments (SEAs) have been conducted for several areas of potential tidal resource, namely Scotland and the Bay of Fundy in Canada, where demonstration and commercial scale activities are ongoing.

In the US, initial activities of generic assessments have been conducted, the most notable being the *Hydrokinetic and Wave Energy Technologies Technical and Environmental Issues Workshop* (2006) (http://hydropower.inl.gov/hydrokinetic_wave), and the December 2009 report: *Report to Congress on the Potential Environmental Effects of Marine and Hydrokinetic Energy Technologies* (www1.eere.energy.gov/windandhydro/pdfs/doe_eisa_633b.pdf)

> Summarizing:
> "This report to Congress was prepared based on peer-reviewed literature, project documents, and both U.S. and international environmental assessments of these new technologies. The information was supplemented by contributions from technology developers and experts in state resource and regulatory agencies as well as non-governmental organizations. Inputs and reviews were also provided by federal agencies including the National Oceanic and Atmospheric

Administration (NOAA), the U.S. Department of the Interior (DOI), and the Federal Energy Regulatory Commission (FERC)."

Continuing:
"This report focuses on potential impacts of marine and hydrokinetic technologies to aquatic environments (i.e., rivers, estuaries, and oceans), fish and fish habitats, ecological relationships, and other marine and freshwater aquatic resources.
Most considerations of the environmental effects have been in the form of predictive studies and environmental assessments that have not yet been verified. While these assessments cannot predict what, if any, impact a given technology may have at a given site, they have been instructive in identifying several common elements among the technologies that may pose a risk of adverse environmental effects:

- Alteration of current and wave strengths and directions
- Alteration of substrates and sediment transport and deposition
- Alteration of habitats for benthic organisms
- Noise during construction and operation
- Generation of electromagnetic fields (EMF)
- Toxicity of paints, lubricants, and antifouling coatings
- Interference with animal movements and migrations, including entanglement
- Strike by rotor blades or other moving parts"

The report also states:
"There is no conclusive evidence that marine and hydrokinetic technologies will actually cause significant environmental impacts, and the possible effects detailed in this report should serve to highlight areas where further information and research is needed."

Additionally, in the Pacific Northwest, a workshop was conducted in March 2010 for the emerging hydrokinetic industry, by the University of Washington, working in conjunction with federal labs, researchers and others to develop a roadmap for the *"Environmental Effects of Tidal Energy Development,"* specifically for the PNW species. A final report is pending and will be available at:
http://www.depts.washington.edu/nnmrec/workshop/index.html.

Beyond these generic studies, US kinetic hydropower developers have been on their own to evaluate, educate and observe environmental impacts at demonstration and pilot sites, in conjunction with the development of their technologies.

## 2 – ENVIRONMENTAL ASSESSMENT OF VERDANT TECHNOLOGY AT RITE

### *2.1 Timeline of advancement of technology and environmental assessment at RITE*

When Verdant first embarked on the development of the RITE project in 2002, there was no U.S. precedent process, either regulatory or environmental, to evaluate this new and emerging technology. Therefore, when in October 2003 Verdant issued its Initial Consultation Document (ICD) under the Federal Energy Regulatory Commission (FERC) Integrated Licensing Process, the discussion of the potential environmental effects was new to all agencies and stakeholders involved at the federal, state and local levels.

In general, the opportunity for a new renewable energy source was well received, but concerns regarding not only the regulatory scheme for grid-connected generation as well as the potential environmental and location aspects of a demonstration that could expand to a commercial project were significant. Moreover, at the time, Verdant's technology was also rapidly advancing from the Alpha3 testing of a scale prototype from a barge to a grid-connected array of six Gen4 KHPS turbines at full scale (5m rotor diameter).

Synchronizing both the development, execution and understanding of environmental effects, under a regulatory system that was not particularly suited to an emerging technology development, and the expected difficulties of advancing a new technology through the "trial and error" first prototype design proved costly, but in the end quite informative on a number of levels.

Overall, the timeline for this concurrent development is shown in Figure 2, where:

- Initial discussions from the ICD focused down to set of possible environmental effects specific to the Verdant technology, the actual site conditions in the East River, and keeping with the short-term demonstration scale. Consultations continued through 2004-05;
- The consultation culminated in the awarding of a NYSDEC/USACE joint permit for the RITE Demonstration, with the definition of eleven study plans[2] to be executed before and during the demonstration – Deployments 1 and 2 in 2006 and 2007. This information was provided in reporting to the agencies through the course of the study execution, and in the RITE Draft Pilot License Application filed by Verdant Power in November 2008;
- Additional consultations in mid 2007 - early 2008 led to the redefinition of the study protocols to be conducted during Deployment 3 of the RITE Demonstration, conducted in the Fall of 2008 (the details of which are the subject of this report); and, finally;
- Based on the results of the above, the lessons learned and the definition of a Pilot project, a set of environmental monitoring plans for RITE, termed the RITE Monitoring of Environmental Effects (RMEE) plans, was developed, reviewed

[2] Verdant's suite of RITE operational study plans included Fisheries (four 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.

and submitted in December 2010 as the ongoing protocol for the RITE Pilot project. The RMEE plans are available at http://www.theriteproject.com as Volume 4 of the RITE Final Pilot License Application.

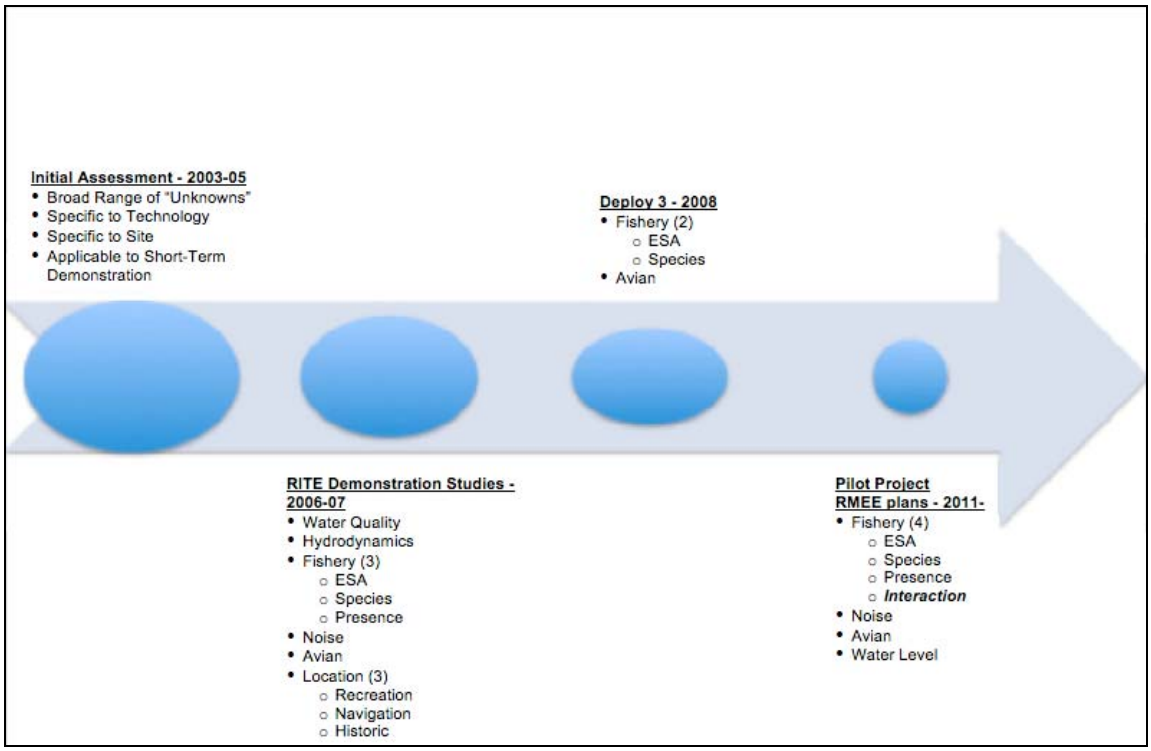


**Figure 2 - RITE Project Environmental Assessment Timeline**

### *2.2 Key Environmental Issues at RITE*

The RITE regulatory and environmental consultation process is detailed in the correspondence logs contained in both the RITE Draft and Final License Applications over a period of years extending back to 2002.

*2.2.1 Initial Environmental Discussions (2002-05)*

When the RITE Project was initiated, outreach was made to a comprehensive list of federal, state and local agencies, as well as interest groups and organizations including those listed below (Please note that this list is not intended to be all-inclusive, nor to preclude any group that is not listed from participating in the ongoing RITE Pilot licensing process).

**New York City, including:**

- Department of Environmental Protection (NYCDEP)
- Department of City Planning (NYCDOP)
- Economic Development Corporation (NYCEDC)

- Community Boards for New York and Queens County
- Roosevelt Island Operating Corporation (RIOC)

**Agencies of the State of New York and Connecticut:**

- New York State Department of Environmental Conservation (NYSDEC):
  - Office of Natural Resources and Water Quality, Division of Fish, Wildlife and Marine Resources (DFWMR)
  - Office of Administration, Division of Environmental Permits (DOEP)
  - Office of Natural Resources and Water Quality, Division of Water (DOW)
  - New York/New Jersey Harbor Estuary Program (NY/NJ HEP)
  - New York Natural Heritage Program (NYSNHP)
- New York State Office of Parks Recreation and Historic Preservation (NYSOPRHP)
- New York State Energy Research and Development Authority (NYSERDA)
- New York Power Authority (NYPA)
- New York State Department of Transportation, Office of General Services (NYSDOT)
- Connecticut Department of Environmental Protection, Long Island Sound Program (LIS)
- New York State Department of State, Division of Coastal Resources (NYSDOS)
- Port Authority of New York/New Jersey

**Agencies of the United States:**

- Federal Energy Regulatory Commission, New York Regional Office (FERC-NYRO)
- U.S. Department of Interior (USDOI), including:
  - U.S. Fish and Wildlife Service (USFWS)
  - U.S. National Park Service (USNPS)
  - Bureau of Indian Affairs (BIA)
- National Marine Fisheries Service (NOAA-NMFS)
- United States Army Corp of Engineers (USACOE)
- United States Environmental Protection Agency (USEPA)
- United States Department of Energy (USDOE)
- United States Coast Guard (USCG)

**Non-Governmental Organizations:**

- Riverkeeper
- New York Rivers United (NYRU)
- National Audubon Society (national and/or local chapters) (NAS)
- American Rivers (AR)
- New York State Conservation Council (NYSCC)
- Natural Heritage Council (NHC)
- Environmental Resources Trust (ERT)
- National Hydropower Association (NHA)

- Low Impact Hydropower Association (LIHA)
- Roosevelt Island Residents Association (RIRA)
- American Council of Renewable Energy (ACORE)
- KeySpan's Ravenswood Power Plant

**Indian Tribes**

- The Delaware Nation

The initial broad range of issues concerns and questions addressed in the ICD (2003) focused on the description of the RITE Project area and the concerns of the above stakeholders and agencies, mostly relative to the new technology of hydrokinetics and 'free-flow' turbines installed without an impoundment. At the time, there was little peer-reviewed literature and/or fieldwork conducted, and Verdant relied on expert support from the US Department of Energy Oak Ridge National Laboratory. A magazine article of the period, "*What's the Future of Instream Hydro?*' by Drs. Charles C. Coutant and Glenn F. Cada of the Oak Ridge National Laboratory, Oak Ridge, TN, published in *HydroReview* magazine (Volume 24, Number 6, October 2005), summarized a broad range of initial concerns, which Verdant addressed through the consultation process. These included concerns that are specific to the kinetic hydropower technology and also to a kinetic hydropower site.

The early consultation focused on education, examining how the new hydrokinetic technology would be installed, operated and maintained and the similarities – and significant differences – from conventional hydropower. Verdant sought to answer many concerns with scientific dialogue about the Verdant technology specifically and the RITE site in urban New York City.

As the RITE consultation continued, it became apparent that many of the concerns were focused on a large commercial project, not the planned demonstration of six 35kW machines for an 18-month period, and so the dialogue became more focused around a NEPA process that allowed prioritized studies to answer concerns.

*2.2.2 Approach to Environmental studies (2006-09)*

A key aspect of the RITE Demonstration (six turbines, 2006-08) was to assess the interactions of Verdant Power's Kinetic Hydropower system (KHPS) with the environment. As the first full-scale kinetic hydropower turbine array in the world, Verdant worked with regulatory agencies and other key local stakeholders to develop and execute a number of study plans[3] that have served as the basis for understanding the interactions and importance of moving forward with pilot and commercial scale projects.

[3] Verdant's suite of eleven study plans at RITE (2005-2008) included Fisheries (two studies -four 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.

During the demonstration, Verdant conducted a number of 'first-time' fish interaction studies to examine biological issues regarding the operation of the KHPS in fast waters.

Verdant Power's experience is that it is useful to consider the following terminology in developing relevant monitoring methods and protocols for its KHPS projects. This process includes examining key biological parameters (e.g. fish movement, migration, etc) and matching monitoring protocols at three different scales:

- Micro scale - in and around an individual turbine (1 diameter (1D) = 5m at RITE), rotating at <40 rpm and only during high velocity periods over 1 m/s. At this scale, resident and migratory fish interaction, as well as micro hydrodynamics are being studied.
- Meso scale - in front/back of the turbine triframe. Here the reaction around a triframe of (3) turbines is being studied, as well as the interdependencies and recovery distance to the next triframe in the array – generally 12D (at RITE) to 20D (other sites) in distance.
- Macro scale - well beyond the triframe (and the fully developed array) extending to points where organisms first sense/encounter the minor hydrodynamic presence of the KHPS array. This is a broader-scale study conducted for longer-term deployments.

During 2005 a set of eleven study plans (partially funded by NYSERDA) was developed (and later executed) to address environmental impact questions within the context of a demonstration project. This served as the basis for beginning to understand the in-situ environmental effects of the Verdant KHPS.

### *2.3 Focused Environmental studies (2006-2009)*

The body of environmental work executed is quite large and to simplify this to a list of key agency and stakeholder concerns is truly unfair, given the long history (2002 - time of writing), and the level of technical discussion and ongoing environmental monitoring that continues at the core of understanding how Verdant's technology will interact with the environment. Nevertheless, in an effort to focus the discussion, Table 1 summarizes what has been resolved through the RITE Demonstration as governed by the National Environmental Protection Act (NEPA) process, and what remains to be studied at the RITE Pilot project with detailed references available in the Final License Application at www.theriteproject.com. The 11 studies and workgroups conducted in the context of the RITE Demonstration were executed, with results reported in the referenced section of the RITE Final License Application (FLA), and with ongoing studies to be conducted during the RITE Pilot, as the six RMEE plans. Five specific activities were conducted under the scope of this NYSERDA contract and are reported on in detail in Section 3 of this report. These include:

- Fishery Studies Groundtruthing
- Stationary Netting
- East River Fish Species Composition Characterization
- Bird Observation
- Protected Species and Habitat Evaluations

**Table 1 - Key Environmental Issues at RITE (Following NEPA structure)**

| DLA studies | issues and concerns | Verdant studies and results [References to discussion in FLA] | Ongoing issues to be addressed in RITE Pilot [References to Volume 4 RMEE plans] |
|---|---|---|---|
| (in 1/2) | Geology: presence and changes in condition of substrate, and potential for sediment transport/deposition. | Sediment Sampling/mapping (2006) [V2; pgs E-31-39] | Pending determination in FERC license |
| 1 | Water Quality: conditions and potential for alteration | Water Quality studies (2005-2006) [V2; pgs E-76-87] | Pending determination in FERC license |
| 2 | Benthic Habitat/ Essential Fish Habitat: conditions and potential for alteration | Benthic and EFH studies [V4 EFH Appendix] | |
| 3 | Hydrodynamics: effect of project operation on water currents; directions and levels | Hydrodynamic Study; (2005-2007) [V2; pgs E-46 -76] | RMEE- Water level monitoring [V2 pg. E-76 and V4 RMEE plans pg. 6] |
| | Aquatic species; Movement; migration and interaction; including strike by rotor blades | Fish Movement and Protection Plan (FMPP) (2006-2009) [V2 pgs E-87-109 and below] | Pending determination in FERC license |
| 4 | Species presence and abundance | [V4 EFH] | RMEE-3 Seasonal Species Characterization Netting |
| 5 | Movement and migration | [V4 Appendix A] | RMEE-1 Seasonal Fixed Hydroacoustics |
| In 5 | Interaction with KHPS and strike by rotor blades | [V4 Appendix B & Biological Assessment] | RMEE-2 Seasonal DIDSON Observation |
| 6 | Underwater Noise; sound levels relative to aquatic species and noise during construction and operation | Underwater Noise Study; (2005-2007) [V2; pgs E-96 -110] | RMEE-6 Underwater Noise Monitoring and Evaluation |
| 7 | Avian (and Terrestrial) Resources: interaction of diving and migrating birds with operating machines | Bird Observation Study; (2005-2008) [V2; pgs E-111- 122] | RMEE-5 Seasonal Bird Observations |

| DLA studies | issues and concerns | Verdant studies and results [References to discussion in FLA] | Ongoing issues to be addressed in RITE Pilot [References to Volume 4 RMEE plans] |
|---|---|---|---|
| 8 | Rare, Threatened, and Endangered Species; specifically interaction of project with ESA listed species: Shortnose Sturgeon; and Sea Turtles | RTE observations (2005-2008) [V2; pgs E-122-131] [V4; ESA for Shortnose Sturgeon; Atlantic Sturgeon[4]; Sea Turtles] | Ongoing ESA consultation with agencies RMEE-4 Tagged Species Detection [V4] |
| 9 | Recreational Resources: location of project with respect to (wrt) recreation (boating) and fishing (recreational) | Convened Recreation Resource Group (2005-2008) [V2; pgs E131-148] | Pending determination in FERC license |
| 10 | Navigation: location of Project wrt navigation (commercial and transport) | Convened Navigation and Security Group (2005-2008) [V2; pgs E-148-158] | Ongoing consultation and RITE Safeguard plans [V3; CEII[5]] |
| In 11 | Aesthetic Resources: Visual effects of the Project infrastructure | Addressed in [V2; pgs E-159-164] | Pending determination in FERC license |
| 11 | Cultural/ Tribal Resources: interaction of the projects with identified resources | Convened Historical and Cultural Resources Group [V2; pgs E-165-176] | Pending determination in FERC license |

[4] Atlantic Sturgeon are pending listing as ESA as of October; 2010.
[5] CEII; Critical Energy Infrastructure Information; Volume 3 of the RITE Final License Application; [not released to the public].

### *2.4 Other Questions and Concerns regarding Hydrokinetic Machines*

As discussed, the history of consultation at RITE (2002-10) has addressed many of the issues and concerns related to the Verdant KHPS and the RITE site. Still, the following are some questions that are relevant to kinetic hydropower development in general. Citations to existing reference material is made for further information.

*Can hydrokinetic machines cause damage to fish and other aquatic animals from water pressure changes, cavitation, shear stress, or turbulence?*

The answer to this question will vary with the type of technology installed. The mechanisms mentioned are largely due to entrainment, entrapment, and entanglement with devices that have moorings, ducts, or shrouds. Please see Reference 6 for a discussion.

Verdant KHPS turbines by design do not have penstocks, ducts, shrouds, intakes, or screens; and as discussed in early consultations for the RITE Project, the damage/injury to fish by water pressure change, cavitation, shear stress or turbulence mechanisms was understood to be not applicable[6]. In particular, the Verdant KHPS turbine rotor is designed to not cavitate under the range of operating conditions.

Verdant did incorporate observation for fish/injury into the Fish Monitoring and Protection study plans during the RITE Demonstration. No effects from these mechanisms have been observed to date [FLA, Vol. 2, pg.E-96]. Blade strike as a potential damage/injury mechanism is still under study at RITE, but no evidence through 9,000 operating hours has been observed.

*Can hydrokinetics cause changes in water temperature and thermal stratification or changes in dissolved gases or chemistry?*

Given the extremely energetic and dynamic conditions of high velocity water necessary for the technology, thermal, or chemistry issues are unlikely at a small scale. While mixing phenomenon is important at a large scale, the literature points to concerns only when significantly larger arrays are being considered.

As discussed in the RITE FLA, mixing in the water column in high velocity water has been studied by Verdant at the micro, meso, and macro scales. The effects are extremely limited and water quality parameters are not considered an issue at the RITE site [FLA, Vol. 2, pg.E-82].

The total maximum theoretical heat input to the water from all turbine-related methods is de minimus. Any effect from both rotating and locked turbine rotors would be to increase mixing and reduce stratification, but will also be slight, relative to this already highly turbulent and well-mixed resource.

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[6] To be absolutely accurate there are changes in water pressure across the Gen5 KHPS machine at a micro scale – however, these pressure changes are orders of magnitude less than those that in many conventional hydropower facilities.

*Can the machines 'heat-up' the water through friction?*
This is primarily a theoretical question of moving machines acknowledging an 'effect', but at the scale of installations contemplated in the marine kinetic hydropower industry it is considered de minimus.

The transformation of mechanical to electrical energy within the turbine nacelle is associated with mechanical and electrical losses on the order of 6% of the power generated, which is ultimately rejected from the turbine as heat. Heat transfer is through the nacelle to the high velocity water at the micro scale, with volumes that result in immeasurable temperature rise in the water at the meso scale. As discussed in the RITE FLA, energy extraction or transfer is proven as an infinitesimally de minimus effect [FLA, Vol. 2, pg.E-17].

*What about issues related toxicity of paints and antifouling coatings?*
Marine industry paints and antifouling coatings have been used for years in various applications. As noted in the literature, the type and toxicity will vary with the coating technology used. At the RITE project, the turbines have been coated with standard marine copper-based antifouling paint. Verdant is working to convert to non-toxic coatings as soon as possible, as new coating developments and application methods allow. Most likely in the medium term, the copper-based coating will be replaced by non-toxic silicone-based coatings. Please see Appendix A for KHPS design considerations. Due to these design considerations, short-term installation, and high dynamic velocities, it is generally agreed that the RITE Project does not pose any toxicity concerns.

*Is there an issue with machine lubricants getting into the water?*
As with any on-water activity, discharge from vessels servicing a hydrokinetic project is always a possibility during the installation and maintenance activities, but the risk is the same as any with any vessel, and precautions are in effect and spill incidents are regulated. Machine lubricants and their containment will vary widely with the hydrokinetic technology installed. Please see Reference 6 for further discussion.

At RITE, the KHPS turbine (Gen5) uses a single common circulating lubricant for its gearbox and main bearings and will contain about 34-38 liters (9-10 gal) of food-grade lubricant. This is primarily contained within the gearbox, with secondary containment by the nacelle itself. All static (o-ring) seals are redundant. The only dynamic seal, the mainshaft seal, is a dual seal assembly, with high performance face seals both containing the lubricant and excluding seawater. Between these two seals is a food-grade barrier fluid chamber. See Appendix A for KHPS design considerations.

*Are there potential issues with respect to generation of electromagnetic fields (EMF)?*
As discussed in the literature, EMF considerations will vary widely with the technology installed and the length, voltage and design of the underwater cables, however it is still likely to be less than existing sources of underwater cables for other power and telecommunications services. Please see Reference 6 for a discussion.

At the RITE Project, the KHPS electromechanical parts are of low voltage and fully contained within a sealed box within the nacelle with air partially insulating the machines from the nacelle wall to the water. As such, very little leakage of EMF is expected. The underwater cables at RITE are low voltage (480V), low power (35kW rated) relative to other cables in the river, and short (<250feet) [FLA, Vol. 1, pg. A-13]. Due to these design considerations, the short-term installation, and high dynamic velocities, it is generally agreed that the RITE Project does not pose any EMF concerns.

## 3 – ENVIRONMENTAL ASSESSMENT AT RITE THROUGH 2010

### *3.1 Environmental Assessment conducted 2006-07*

A key aspect of the RITE Demonstration (2006-08) was to assess the interactions of Verdant Power's KHPS with the environment. As the first full-scale kinetic hydropower array in the world, Verdant worked with regulatory agencies and other key local stakeholders to develop and execute a number of study plans that have served as the basis for understanding the interactions and importance of moving forward with pilot and commercial scale projects. During the demonstration Verdant conducted a number of 'first-time' fish interaction studies to examine biological issues regarding the operation of the KHPS in fast waters.

### *3.2 Environmental Assessment conducted 2008-09*

#### *3.2.1 Fishery Studies Groundtruthing*

To answer ongoing questions about the data collection and interpretation of the fixed, mobile and Dual-frequency Identification Sonar (DIDSON) technologies used in previous phases of the RITE Demonstration (under the 11 study plans, or the 'RITE Fish Movement and Protection Plan (FMPP)'), in 2008 Verdant Power developed a new test protocol in conjunction with the resource agencies to groundtruth the fishery presence, abundance and behavior in the RITE Project site area. This test protocol was contained in an updated RITE Fish Movement & Protection Plan (FMPP - version 7.5 dated July 2008), as approved by the New York State Department of Environmental Conservation (NYSDEC) and the US Army Corps of Engineers (USACE) to obtain the permit necessary for Deployment 3 of the RITE Demonstration in September 2008.

The Verdant Power-developed Vessel-mounted Aimable Monitoring System (VAMS) used both a Split beam Biosonic transducer (SBT) and a DIDSON system to observe fish movement and behavior in and near operating turbines in the fall of 2008. The test protocol and data collection effort was designed and implemented by Verdant Power with assistance from Dr. Kevin Boswell of Louisiana State University and other fishery biologists. The protocol was designed to observe fish interaction, on a limited basis, while concurrently using both mobile surveys and downward-looking DIDSON hydroacoustic technology, coupled with an SBT in the vicinity of the two operating turbines in the project field in the East River. Figure 3 shows the viewing coverage.

The data and video collected from the groundtruthing surveys in September - October 2008 were evaluated by the biologists and agencies and offered the first view of fish interactions with the KHPS turbines in parallel with the fixed hydroacoustic tracking

systems installed. Three VAMS groundtruthing efforts with 15-17 hours of video and data taken from a DIDSON and less from the SBT. This data provided information about fish movement and presence in and around the operating turbines, as well as the use of the project footprint area, the use of the East Channel of the East River, and to evaluate effects of the turbines on individual fish and populations. Results of the VAMS groundtruth mobile surveys were presented to the agencies in three separate webinar conferences during March to July 2009.

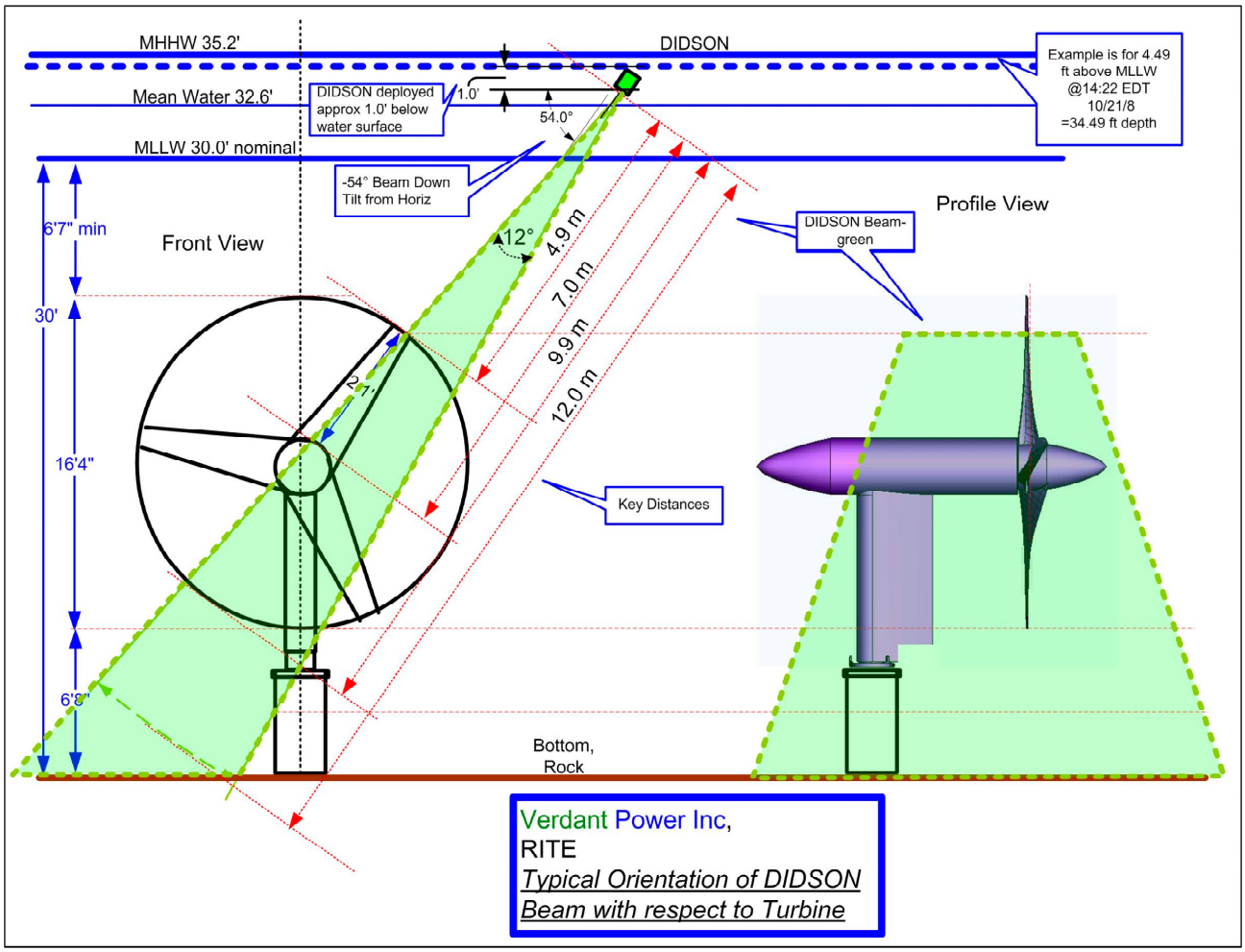


**Figure 3 - VAMS Coverage of RITE KHPS Turbines (Gen4, 5m rotor)**

Though best efforts were made, thorough and rigorous scientific groundtruthing of the fixed hydroacoustics using the VAMS could not be accomplished, though a very general order of magnitude comparison could be made. While Verdant acknowledges that three short sampling periods do not represent proof positive, the remarkable magnitude correlation does allow Verdant to propose that the fixed-frame data generally did produce viable zonal data for the RITE Demonstration as compared to a mobile technique that is planned for the proposed RITE Pilot project. This provides some small level of further confidence in the body of results from the fixed hydroacoustic information.

More importantly, the VAMS effort specifically:

- Provided initial video evidence of reaction to KHPS turbines
- Demonstrated potential avoidance behavior
- Enabled individual fish and/or school tracking
- Visualized the KHPS and rotating rotor plane

These observations generally:

- Corroborated conclusions of fixed hydroacoustic imaging
- Corroborated that fish are observed and measured mostly on slack
- Confirmed that fish are not generally in the operational zone of the KHPS
- Confirmed low relative fish densities

The specially designed VAMS met, if not exceeded, expectations. Many lessons learned will make the protocol useful for the operational monitoring of operating KHPS turbines.

In general, the protocol was:

- Useful for determining size and location of fish in the channel and water column
- Useful for observing and understanding reaction to KHPS turbines
- An excellent tool for O&M (unintended benefit)

As a final significant result, Verdant had hoped that the fixed hydroacoustics could act as a signal when it was best to conduct field studies at periods of high fish abundance using the VAMS by measuring weekly event data changes. Still, the variability was too high to act as a predictor. Instead, a theory for predicting appropriate fish high density periods was advanced and seemingly provides an excellent correlation of tidal velocity with fish presence a good signal for appropriate on-water work. This hypothesis is advanced in Volume 4 Appendix A of the RITE FLA and suggests that, based on the evidence presented in Figures A.23 and A.24, targeted seasonal fish monitoring should occur during periods of minimum tide strength. These periods occur during the half moon and are further minimized with an apogee occurrence in close proximity. While a somewhat intuitive conclusion, the data correlation of fixed hydroacoustics with DIDSON observation on the temporal tidal observation is a significant outcome of this task.

The 2008-09 results have been incorporated into the RITE FLA filed in December 2010 and provided to the NYSERDA Project Manager. Specifically, the results are contained in Volume 2, Exhibit E and Volume 4, Appendices A and B.

*3.2.2 Stationary Netting*

The original intent of this task was to conduct stationary fish netting efforts immediately downstream of the operating KHPS turbines during a period of tidal generation and relatively high fish abundance, which occurs in the fall period (September- December) as verified by the previous fixed hydroacoustics (Figure 3). The purpose of this netting was to groundtruth the fish size and species data being collected from the fixed hydroacoustic system and verify if any strike or injury was occurring during periods of operation of the KHPS – the theory being that if large-scale injury was occurring during periods of

elevated fish abundance, then a net subsample of the turbine flow would capture a portion of injured fish.

Verdant Power deployed two KHPS Gen4 turbines in September 2008 (Deployment 3) and intended to execute the stationary netting plan, deploying an 18-foot balloon midwater trawl of large mesh size as optimally as possible (given high current velocities and vessel configuration) downstream of an operating turbine in a manner approved by NYSDEC. The netting was intended to take place just north of operating Turbine 5 (T5) during a high seasonal fish period – October/November/early December 2008. It was anticipated that nets would be deployed for three 1-2 day sampling periods, resulting in a total of approximately 12 man-days of activity. Resource agency staff concurred that the greatest concern for potential fish strikes was for the larger fish and the large mesh would be effective in collecting any passively drifting (injured or dead) fish while actively swimming fish may avoid the net opening.

The two turbines, which had been operated underwater during Deployment 2 for an extended period and retrofitted with updated blades, operated successfully through October 17, 2008 but then ceased to operate due to electrical faults. With joint agency agreement, the stationary netting was postponed until such time as operating turbines were back in the water, at a time of high fishery abundance to accomplish the objectives.

By mutual agreement, NYSERDA and Verdant have elected to postpone this effort, and have negotiated a new scope contained in the RITE Monitoring of Environmental Effects (RMEE) plan 3, Stationary Netting. This work will be accomplished as part of a subsequent NYSERDA Agreement once the Gen5 KHPS is installed at RITE in 2011-2012. The full seasonal netting effort of RMEE-3 is contained in Volume 4 of the RITE FLA, including objectives, methods, equipment, and analysis protocol.

### *3.3.3 East River Fish Species Composition Characterization*

An important aspect of the understating of the fish interaction with an operating KHPS turbine is not only the presence, abundance and behavior, but the species characterization of fish in the channel. As discussed in the FLA Exhibit E (Volume 2), Verdant Power has collected historical data in an around the East River to gain an understanding of fish species composition and relative abundance information, particularly for young-of-year (YOY) and yearling fish. While the fixed hydroacoustics system significantly relates information on the size, abundance, and presence of fish, the historical information must be synthesized into an understanding of the species composition to aid in the interpretation of images from the high-resolution acoustic monitoring system, which will be employed in the RITE Pilot project.

Building on the analysis of historical impingement data from steam fire generating stations in and around the RITE Project, Verdant's fishery biologists (Kleinschmidt Associates (KA)) were able to provide a complete characterization of the fish species composition to support the FLA. These results are contained in Exhibit E Volume 2 and Volume 4 Attachment 2 of the FLA. A short summary is presented below.

The East River, in the vicinity of RITE, supports a variety of fish species, notably, winter flounder (Pseudopleuronectes americanus), Atlantic tomcod (Microgadus tomcod), striped bass (morone saxatilis), and grubby (Myoxocephalus aenaeus). Other fish that may be found in high numbers include the bay anchovy (Anchoa mitchilli), Atlantic silversides (Menidia menidia), blueback herring (Alosa aestivalis), northern pipefish (Syngnathus fuscus), and Atlantic menhaden (Brevoortia tyrannus). Most species are seasonal and migrate through the East River to overwintering areas offshore or spawning grounds further upriver. The two relatively common fish species found in the East River over most life stages are the Atlantic silverside and northern pipefish.

The New York Bight watershed provides important habitat for numerous migratory species, including American eel, alewife, American Shad, Atlantic menhaden, Atlantic sturgeon, Atlantic tomcod, bay anchovy, blueback herring, rainbow smelt, shortnose sturgeon and striped bass. The East River is believed to be used by migratory species as a passageway and as a temporary seasonal habitat (USFWS, 1997; Henderson, 2002). In addition to this description, specific essential fish habitat discussions for eighteen species known to be present in the project area are described in Volume 4 of the FLA and summarized as part of Task 5 below.

*3.3.4 Bird Observation*

Concurrent with deployment of the RITE Demonstration turbines (2006-08), Verdant Power completed bird observation surveys of the demonstration area and reported on those surveys in various supporting reports. Most recently, a summary of activities is contained in the RITE FLA, Volume 2, Exhibit E. As part of this NYSERDA Agreement, Verdant Power executed a study plan developed in conjunction with agency personnel, to document the following information regarding birds on a routine basis:

- location in relation to the study turbines
- number and species of birds observed
- time of day observed, and
- feeding and diving activities.

Bird observation is considered key when KHPS turbines are operating to assess the availability of food as a result (or lack) of injury or mortality from the rotors. The results of the Bird Observation activity, as outlined in the FLA includes the following observations:

- Table 2 below is a summary of bird observations conducted under this Agreement.
- Verdant Power specifically performed five days of spring migration observations in 2006, and four days of bird observations during fall migration in 2008. The surveys were performed during Spring migration on March 13 to 17, 2006 without the KHPS turbines operating. Fall migration surveys were then performed again on October 16, 17, 29, 30 of 2008 when turbines were rotating. The purpose of these additional observations was to obtain additional data during potential migration periods. Spring and fall migration also coincided with other bird observations in April 2007 (pre-Deployment 2), May 2007 (post-Deployment 2),

August 2008 (pre-Deployment 3), and September 2008 (post-Deployment 3). No specific migratory species were observed.

The FLA summarizes two key findings:
(1) *"Birds were observed around the demonstration project to determine if the KHPS units adversely impact diving birds associated with the East River; Verdant Power believes that the body of developed knowledge does not show any signs of impact on diving birds. This detailed effort in and around the RITE project demonstration site and the general area of the proposed RITE Pilot License did not show any material difference in pre-and post-operation bird activity. The presence of more geese flying through the area in post-deployment during the fall of 2008 can be attributed to seasonal migration patterns. Observations during the operation of the RITE Demonstration KHPS units also did not indicate any increased attraction of diving birds to the site, which may have been expected if the turbines impacted fish in the area."*

(2)*"Based on the observations made at the RITE demonstration project over an intermittent period from December 2006 through and including November 2008 Verdant Power does not believe that the project area is a particularly significant bird migration pathway for resting or feeding because of the urban nature of the location, the limited amount of green space, and the fast currents present.* (Volume 2, page E-121)

**Table 2 - Bird Observation Data at RITE**

| | | | Double Crested Cormorants | | | Canada Geese | Mallard Ducks |
|---|---|---|---|---|---|---|---|
| Birding History | Days | Hours | Flying | Dive/Float | Perched | Flying | Flying |
| Spring Migration–2006 | 5 | 50 | 3 | 2 | 0 | 12 | 0 |
| Pre-D2 – 2007 - April | 5 | 50 | 83 | 32 | 0 | 16 | 0 |
| Post-D2 – 2007 - May | 5 | 50 | 81 | 7 | 1 | 7 | 2 |
| Pre-D3 – 2008 - Aug | 7 | 50 | 105 | 53 | 2 | 60 | 0 |
| Post-D3 – 2008 - Sept | 6 | 50 | 138 | 39 | 4 | 285 | 0 |
| Fall Migration - 2008 | 4 | 40 | 74 | 32 | 1 | 180 | 0 |

*3.2.5 Protected Species and Habitat Evaluations*
*Protected Species*
Through ongoing consultation regarding the deployment of the demonstration turbines, NOAA Fisheries, NYSDEC, and the US Fish and Wildlife Service (USFWS) have indicated that Atlantic sturgeon (a candidate species for Endangered Species Act (ESA) listing - expected October 2011), endangered shortnose sturgeon, threatened and endangered sea turtles, and harbor seals (protected under the Marine Mammal Protection Act) could be present in the area of the RITE Project. At the recommendation of NYSDEC, Verdant Power has implemented a formal procedure for observations of protected species to be recorded during the bird observation and hydroacoustic studies. Through the RITE Demonstration deployments, no observations have been recorded. As outlined in the RITE FLA (Volume 2, Exhibit E), Verdant Power has summarized information on Rare Threatened and Endangered (RTE) data and conducted initial

consultations. The RITE FLA also contains three Biological Assessments (BA) for review by FERC and the agencies. If the USFWS determines that a Biological Assessment for listed threatened or endangered species pursuant to Section 7 of the Endangered Species Act is needed, the material developed under this NYSERDA Agreement would allow Verdant Power to develop a formal Biological Assessment.

Regarding the two fish species of sturgeon, as requested by the agencies, a key element of the BA is a KHPS-Fish Interaction Model that evaluates the potential for KHPS blade strike based on common lengths of the two endangered species. The development of this model is detailed in the FLA, Volume 4 Attachment 1. The salient results for the two sturgeon species are summarized below:

- *"After reviewing the best available information on the status of endangered and threatened species the shortnose sturgeon (Acipenser brevirostrum) the environmental baseline for the action area, the effects of the Verdant project, and the cumulative effects, it is concluded that the proposed action is not likely to jeopardize the continued existence of shortnose sturgeon. While no shortnose sturgeon have been recorded in the East Channel of the East River, a large population of shortnose sturgeon, estimated to be about 60,000 fish, is located nearby in the Hudson River. In a letter from National Marine Fisheries Service (NMFS) to the Federal Energy Regulatory Commission (FERC) re: Project No. 12611-003 (RITE Project) dated February 8, 2009 indicates that the best available information indicates that occasional transient shortnose sturgeon may be present in the East River. Adverse effects of hydrokinetic turbines were analyzed to determine their potential to cause injury or mortality. Flow shear, rapid pressure changes, low absolute pressure, abrasion and grinding associated with fish passage through conventional hydro turbine are not of concern for most hydrokinetic designs (Amaral et al. 2010). Blade strike is expected to be the primary mechanism of injury and mortality for fish that comes into direct contact with hydrokinetic turbines. To analyze blade strike impacts on shortnose sturgeon, a RITE project specific fish interaction model was developed. The RITE project specific fish interaction model resulted in a blade strike probability for shortnose sturgeon at one turbine to be 0.008% for fish of common length 88 cm and burst speed of 3.52m/s."*
- *"After reviewing the best available information on the status of proposed endangered species the Atlantic sturgeon (Acipenser oxyrinchus); specifically the New York Bight, distinct population segment (NYB DPS) the environmental baseline for the action area, the effects of the Verdant project, and the cumulative effects, it is concluded that the proposed action is not likely to jeopardize the continued existence of NYB DPS Atlantic sturgeon. At present, Atlantic sturgeon are not listed under the ESA; however, a proposed listing determination was published in the Federal Register on October 6, 2010. NMFS expects the listing (if deem warranted) to occur in or about October 2011. While no Atlantic sturgeon have been recorded in the East Channel of the East River, they are known to occur in the Hudson River and Long Island Sound. Savoy and Pacileo (2003) speculated without evidence that juvenile Atlantic sturgeon may use the East River to move between the Hudson River and western Long Island Sound.*

*The presence of Atlantic sturgeon in western Long Island Sound may indicate some movement through the East River; however, this is only one potential route between the Hudson River and Long Island Sound. Adverse effects of hydrokinetic turbines were analyzed to determine their potential to cause injury or mortality. Flow shear, rapid pressure changes, low absolute pressure, abrasion and grinding associated with fish passage through conventional hydro turbine are not of concern for most hydrokinetic designs (Amaral et al. 2010). Blade strike is expected to be the primary mechanism of injury and mortality for fish that comes into direct contact with hydrokinetic turbines. To analyze blade strike impacts on Atlantic sturgeon, a RITE project specific fish interaction model was developed. The RITE project specific fish interaction model resulted in a blade strike probability for Atlantic sturgeon at one turbine to be 0.009% for fish of common length 104 cm and burst speed of 4.16 m/s."*

At the time of this writing (February 2011), these conclusions regarding the two sturgeon species are under review by NOAA agencies.

Regarding Sea Turtles, the FLA, Volume 4 Attachment 3 contains the full Biological Assessment, summarizing:

"*There are four species of sea turtles that are known to use the coastal waters of New York. The loggerhead turtle (Caretta caretta), Kemp Ridley's turtle (Lepidochelys kempii), green turtle (Chelonia mydas), and leatherback turtle (Dermochelys coriacea) are known to use habitat in Long Island Sound and New York Harbor. These turtles are protected by the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531-1543).*

- Loggerhead turtle, are not known to use the East River. Studies have consistently shown that the species migrate south following foraging habitat along the Atlantic Coast of Long Island. This has been observed from GPS tracking of sea turtles, including loggerhead turtles, captured in Long Island Sound (Morreale and Standora, 1998; RFMRP, 2010). The habitat in the East River is not likely suitable for foraging opportunities for the loggerhead turtle. Therefore, the RITE Project would not likely affect the habitat or individual loggerhead turtles.
- Juvenile Kemp's Ridley turtles are known to forage in the Long Island Sound and along the Atlantic coast of Long Island; however, Kemp's Ridley turtles are not known to use the East River. The species likely migrate south following foraging habitat along the Atlantic Coast of Long Island. This has been observed from GPS tracking of sea turtles,including Kemp's Ridley turtles, captured in Long Island Sound (Morreale and Standora, 1998; RFMRP, 2010). The habitat in the East River is not likely suitable for foraging opportunities for the Kemp's Ridley turtle. Therefore, the Verdant Project would not likely affect the habitat or individual Kemp's Ridley turtles.
- The green turtle is known to forage in the Long Island Sound and along the Atlantic coast of Long Island. The foraging opportunities for this turtle are concentrated in the bays on the north side of Long Island. Similar to Kemp Ridley's and loggerhead turtles, the green turtle migrates south or out to sea

during the winter. The migration routes observed from GPS tracking show that this turtle does not use the East River (Morreale and Standora, 1998; RFMRP, 2010). The habitat in the East River is not likely suitable for foraging opportunities and therefore the green turtle does not use this channel as a migration route. The Verdant Project would likely not affect the habitat or individual green turtles because the East River does not provide suitable habitat for the green turtle.

- The leatherback turtle is a pelagic turtle. It has been observed using the open water areas of the Long Island Sound and off the coast of Long Island. The shallow channel of the East River is likely not suitable habitat for this open water species; therefore the Verdant Project would likely not have an impact.

At the time of this writing (February 2011) these conclusions regarding sea turtles are under review by NOAA agencies.

Regarding Marine Mammals, Volume 4 Attachment 3 of the FLA specifically, provides environmental impact assessment information needed by NOAA Fisheries to determine if an Incidental Take Authorization for harbor seals is required. Summarizing from the FLA:

> *"The harbor seal (Phoca vitulina) is known to use the Long Island Sound and New York Harbor for habitat. The harbor seal is protected by the Marine Mammal Protection Act of 1972 (16 U.S.C. 1531-1543). … Harbor seal distribution is linked to the locations of the haul-out sites mainly along the Atlantic Coast of Long Island and Long Island Sound. Lone seals and small haul out locations are known in New York Harbor. Humans have also been known to harass sea mammals, and the high human population densities and development surrounding the East River would likely deter harbor seals from using the East River (NMFS, 2010). Harbor seals in the East River would likely be a very rare and publicized occurrence.*
>
> *The rare occurrence of harbor seals at the mouth of the East River indicates that this is not typical habitat for the harbor seal. Therefore, the Verdant Project would not likely affect the habitat or individual harbor seals."*

At the time of this writing (February 2011) this conclusion regarding harbor seals is under review by NOAA agencies.

*Essential Fish Habitat (EFH)*

The Magnuson-Stevens Fishery Conservation and Management Act gave National Marine Fisheries Service (NMFS) the authority and responsibility for the protection of Essential Fish Habitat (EFH), which is defined as marine habitat essential to the health and production of federally managed species in marine and estuarine waters. As contained in the FLA (Volume 4 Attachment 2), Verdant Power and its contractor, KA, completed an EFH assessment for the RITE Project. The EFH evaluated the known specific habitat requirements for each of the listed managed species with designated habitat in the EFH area, which includes the East River, New York, and any potential

project impacts to this habitat. Development of the EFH included information from the benthic habitat survey (existing habitat), mobile and fixed hydroacoustic fish surveys (fish species composition), and review of scientific literature in conjunction with project turbine deployment and operational information to assess potential project effects.

The findings of the EFH assessment conducted for the proposed RITE Pilot project was to examine the EFH and EFH-managed species within the area influenced by the proposed project within the East River, including those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The EFH assessment includes a description of the proposed action; an analysis of the effects on EFH, EFH-managed species, and their major food sources; an evaluation of the effects of the proposed action on EFH and EFH-managed species; and proposed mitigation measures selected to minimize expected project effects if applicable.

In reviewing the proposed RITE Pilot project, designated EFH occurs in the area of the proposed area for various life stages (eggs, larvae, juveniles, adults) of 18 species. Four species have designated EFH for every life stage: windowpane flounder, winter flounder, scup and king mackerel. In addition, various life stages of red hake, Atlantic herring, bluefish, Atlantic butterfish, Atlantic mackerel, summer flounder, black sea bass, Spanish mackerel, Cobia, sand tiger shark, sandbar shark, clearnose skate, little skate and winter skate have been identified as having EFH requirements in the area of the RITE Project. None of these managed stocks are federally or state-listed endangered or threatened. Species having EFH requirements in the vicinity of RITE are summarized in Table 3 below.

**Table 3 - Essential Fish Habitat Designated Species for the East River**

| Species | | Eggs | Larvae | Juveniles | Adults |
|---|---|---|---|---|---|
| Red Hake | (Urophycis chuss) | | X | X | X |
| Winter Flounder | (Pseadopleuronectes americanus) | X | X | X | X |
| Windowpane flounder | (Scopthalmus aquosus) | X | X | X | X |
| Atlantic herring* | (Clupea harengus) | | X | X | X |
| Bluefish* | (Pomatomus saltatrix) | | | X | X |
| Atlantic butterfish* | (Peprilus triacanthus) | | X | X | X |
| Atlantic mackerel* | (Scomber scombrus) | | | X | X |
| Summer flounder | (Paralicthys dentatus) | | X | X | X |
| Scup | (Stenotomus chrysops) | X | X | X | X |
| Black sea bass* | (Centropristus striatus) | | | X | X |

| | | | | | |
|---|---|---|---|---|---|
| King mackerel | (Scomberomorus cavalla) | X | X | X | X |
| Spanish mackerel | (Scomberomorus maculatus) | | X | X | X |
| Cobia | (Rachycentron canadum) | X | X | X | X |
| Sand tiger | (Odontaspis Taurus) | X | X | | |
| Sandbar shark | (Chatcharinus plumbeus) | | X | | X |
| Clearnose skate | (Raja eglanteria) | | | X | X |
| Little skate | (Leucoraja erinacea) | | | X | X |
| Winter skate | (Leucoraja ocellata) | | | X | X |

* five species evaluated with the KHPS-Fish interaction model

A full discussion of the results for each life cycle and species is presented in the FLA, Volume 4 Attachment 2, and the reader is directed to interpret the results directly. In summary:

Since Winterpane and Summer Flounder, Scup, and the three species of skate are found in bottom habitats and the KHPS turbines are proposed to be located off the bottom, turbine strikes are not expected for this species. No impacts to EFH for skates are anticipated from this project.

The King and Spanish mackerel species -- Cobia, sand tiger and sandbar shark -- are not expected to occur within the New York/New Jersey Harbor Estuary except as occasional transient individuals. Therefore, it is unlikely that this species would be found in the project area and EFH for these species will not be affected by the project.

For the remaining five species, the common length size of the fish were evaluated using the KHPS-Fish interaction model with the following results:

- At their average size range of 20 cm the probability of an Atlantic herring being struck by a turbine blade for one rotor is 0.03%.
- At their average size range of 23 cm (Collette and MacPhee, 2002) the probability of an Atlantic butterfish being struck by a RITE turbine blade for one rotor is 0.03%
- At their average size range of 25 cm (Collette and MacPhee, 2002) the probability of a black sea bass being struck by a turbine blade for one rotor is 0.03%
- At their average size range of 30 cm (Collette and MacPhee, 2002) the probability of an Atlantic mackerel being struck by a turbine blade for one rotor is 0.04%

- At an adult bluefish (inshore) 45 cm length the probability of strike at one turbine is 0.05%, Install A (two turbines) is 0.09%,

This relationship is shown on Figure 4 for a single KHPS turbine and projected probabilities for multiple KHPS turbines in the field.

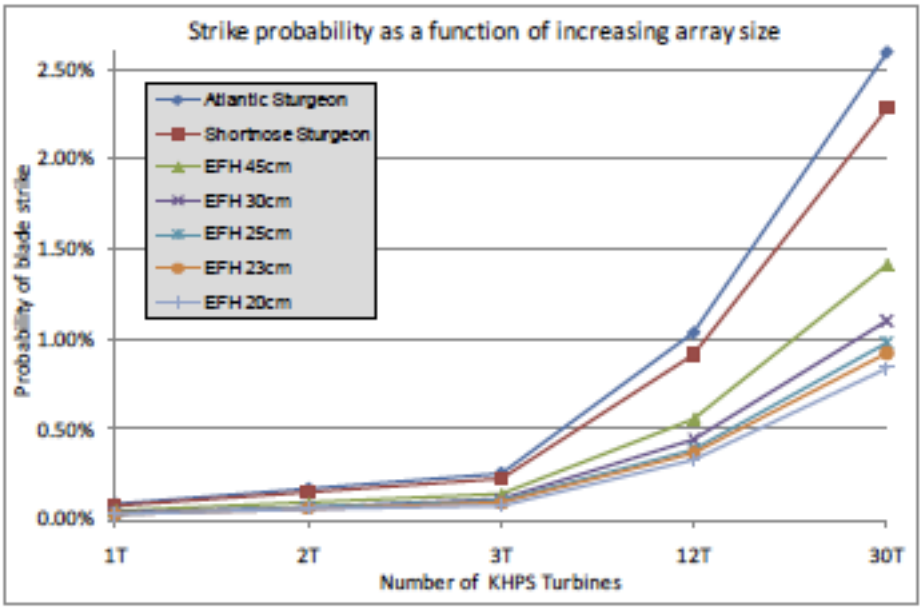


**Figure 4 - RITE KHPS- Fish Interaction Probabilities**

Therefore, in general, given the large populations of these species and no observed injury and mortality associated with the Verdant KHPS turbines, it is unlikely that any effects to EFH are expected for any life stage of these species.

At the time of this writing (February 2011) these conclusions regarding EFH are under review by the agencies.

## 4 – NEXT STEPS FOR ENVIRONMENTAL ASSESSMENT AT RITE

### *4.1 Results of Environmental Monitoring at RITE*

Given the complexities of both the installation and operation of a new kinetic hydropower technology and the application of relatively new and advanced techniques and protocols for in-water environmental monitoring, the project led to many useful observations and lessons learned. In developing a process for monitoring marine kinetic hydropower machines, Verdant has found it useful when discussing the studies and protocols to consider the following terminology:

- Micro scale - in and around an individual turbine (1 diameter (1D) = 5m at RITE), rotating at <40 rpm and only during high velocity periods over 1 m/s. At this scale, resident and migratory fish interaction, as well as micro hydrodynamics are being studied.

- Meso scale - in front/back of the turbine triframe. Here the reaction around a triframe of (3) turbines is being studied, as well as the interdependencies and recovery distance to the next triframe in the array – generally 12D (at RITE) to 20D (other sites) in distance.
- Macro scale - well beyond the triframe (and the fully developed array) extending to points where organisms first sense/encounter the minor hydrodynamic presence of the KHPS array. This is a broader-scale study conducted for longer-term deployments.

The studies and protocols proposed in the RITE Monitoring of Environmental Effects (RMEE) plans for the RITE Pilot project (FLA, Volume 4) reflect considerations for techniques at all three of these scales.

Clearly, matching micro, meso, and macro scale monitoring methods to the harsh conditions of the high velocity in-water environment of the East Channel of the East River, makes it challenging to provide useful answers to agency and stakeholder questions. The four scientific tasks undertaken through this NYSERDA-sponsored project – Fishery data groundtruthing, Bird observation, Essential Fish Habitat (EFH) characterization, and evaluation of Endangered Species Act (ESA) interactions – all have provided significant understanding to the continuum of monitoring that will be required in the Pilot phase of the RITE Project. Verdant Power continues along with the agencies to evaluate whether the project methodologies – both the technological capabilities and deployment design – will be able to track and evaluate movement of targets through multiple rows of turbines under these harsh site conditions.

The success metrics for this NYSERDA-sponsored project, as provided in the Agreement, state; "… *that the study methodology will be considered successful if the Contractor is able to (1) develop the data necessary to answer specific questions regarding whether fish (represented by acoustic targets) sense the turbine structures and how they move around or through them, and (2) discern how those fish that pass through the turbine blade zone are affected."*

Through the data collection in late 2008 and discussions in 2009, and more recently during consultations in October and November 2010, the reviewing agencies appear to have increasing confidence that the techniques employed during this project provided useful information regarding the movement of fish near the operating KHPS. Completion of the studies under the Agreement and formal consultations, as described in this Final Report, details much of the scientific work that provides support to the filing of the RITE FLA and the encompassing RMEE plans. These negotiated staged monitoring plans provide a basis and framework for the continuing evaluation of the commercialization of the KHPS technology in New York State waters. As a result, the RITE Project is likely to be the first hydrokinetic project to advance to this stage of regulatory approval in the US, and as such has been a significant success. A positive reaction and ongoing negotiation culminating in the award of a FERC Pilot Kinetic Hydropower License for the project would provide the most positive outcome of the project.

### *4.2 RITE Monitoring of Environmental Effects (RMEE) Plans*

The RITE Pilot project site would be located within a US Coast Guard approved buoyed exclusion zone to recreational and commercial activity along the east side of Roosevelt Island, north of the Roosevelt Island bridge. Under permits issued by NYSDEC and USACE, the RITE Demonstration collected data on the fish resources and found few if any effects from the operation of the demonstration turbines on aquatic resources. For the Pilot project, a set of aquatic resource monitoring plans, known as the RITE Monitoring of Environmental Effects (RMEE) plans and contained in Volume 4 of the FLA, has been developed in consultation with federal and state agencies. It will also maintain consistency with the intent of the New York Waterfront Revitalization Plan.

The RMEE is a comprehensive suite of monitoring plans to evaluate the effects of operating KHPS turbines. Verdant Power is proposing this RMEE as a multi-year program, conducted throughout the staged development (Installs A, B1/2, and C) of the RITE Pilot, with appropriate reporting and decision points at each stage. As part of the operational monitoring, Verdant Power will also install and record water velocity and level data with use of Acoustic Doppler Current Profiler (ADCP) devices, which will inform the evaluation of hydrodynamics of the machines and array.

Specifically, the RMEE plans include:

**RMEE-1: Seasonal Fixed Hydroacoustics** - The deployment of seasonal fixed hydroacoustic instruments provide a picture, albeit incomplete, on species, on the meso and macro presence and abundance of fish targets in the Pilot area, and movement of fish relative to a turbine field at the meso and macro scales at a known migration period. Coupled with other elements of this plan, the interaction and effects of an operating KHPS can start to be understood.

**RMEE-2: Seasonal DIDSON Observation Monitoring** - The deployment of seasonal Dual-Frequency Identification Sonar (DIDSON), a multi-element sonar that provides video-like images of underwater objects is to 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 to build the understanding of fish interaction near operating machines.

**RMEE-3: Seasonal Species Characterization Netting** - 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 species characterization information in the area of the RITE pilot, and to support the interpretation of the past and future DIDSON monitoring and hydroacoustic evaluations above.

**RMEE-4: Tagged Species Detection** - 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. Little is known of the presence and pattern of these ESA species in the vicinity of the Pilot project, and so this data will support further understanding of the effects of the operation of the RITE Pilot project.

**RMEE-5: Seasonal Bird Observation** - The objective of this plan is to observe bird presence and activity near the RITE Project boundary in order to provide additional observations on the potential effects of the operating KHPS on diving bird populations, and also to provide additional insights into potential effects of operating KHPS on the fish (i.e. increased bird activity in and around the RITE operating field could be an indication of increased injury and mortality of fish).

**RMEE-6: Underwater Noise Monitoring and Evaluation** - The objective of this study is to 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.

The execution of this suite of environmental plans with operating KHPS turbines in place at RITE will provide ongoing evidence as to the environmental compatibility of this new technology with the environment.

*RITE Demonstration Environmental Monitoring*

As referenced above, Verdant used, and adapted, several different techniques during the 2006-08 RITE Demonstration. This was a multi-faceted approach to achieving a scientific understanding of the environmental fishery interactions at the scales mentioned above. A brief synopsis of the methods and respective utility follows:

*Fixed Hydroacoustics*: An array of 24 split-beam transducers (SBT) around the KHPS array (micro/meso field) provide continuous data in a format that requires complex algorithms and QA/QC and groundtruthing to ascertain abundance, presence, and, potentially, behavior (with long data sets). System has the downside of not being able to distinguish species and is a relatively expensive technique. However, a key lesson learned was that fewer SBTs may provide an adequate sense of the presence and abundance (as well as target size) of migration pattern observation at the meso/macro scale for Pilot operating arrays. The large body of information developed by this 24-transducer array developed presence and abundance data as presented in the RITE Draft License Application. Two significant findings were developed from this body of information:

- Data collected during all three RITE Demonstration Deployments demonstrated that resident and migrating fish avoid zones of presence of the turbines and tended to populate inshore and slower moving water zones. Some possible avoidance behavior was noted at the meso scale when turbines were operating.
- Data collected about zonal and tidal spatial and temporal presence suggests that fish behavior is influenced in the channel predominately by the natural tidal currents and only secondarily by the presence of rotating KHPS turbines.

Fish are observed active at slack tide and transitions from slack to ebb and flood, and less when the turbines are operating (water velocities over 0.8 m/s).

*Mobile Hydroacoustics*: Multiple day and night transects using an SBT were run over a period of 14 months to attempt to characterize fish size and usage of the macro area around the Demonstration for presence/abundance and migration patterns. As detailed in the Draft License Application (page E-97), the mobile data was not generally useful since it represented a "snapshot" in a variable environment with no information on species only size. It was an expensive (over $250,000) effort that yielded little knowledge and was mutually abandoned as a useful tool.

*Stationary and Mobile DIDSON*: The use of a Dual-IDentification SONar (DIDSON) system, which uses high definition sonar to produce a near video quality graphic display, in both short-term stationary observation modes was employed at RITE with varying degrees of success. Stationary deployment was at a distance from the operating KHPS and while providing exceptional in-shore video, is only useful for short-term (2-3 wk) deployments, since both hardware and software have significant maintenance costs as well as video interpretation and analysis costs for an effective study. An alternative use for this expensive device was mutually designed by Verdant in conjunction with the agencies that employed specially designed Vessel-mounted Aimable Monitoring System (VAMS) incorporating both an SBT and DIDSON mounted in a downward looking orientation to observe an operating turbine.

During October 2008, with two turbines operating, the VAMS was deployed and video taken with a concurrent DIDSON camera and SBT, observing resident and migrating fish present in waters during slack, when the turbines were not operating. The observations also showed that fish were not present when the velocity of the water increased to greater than 0.8m/s and the machines were operating. Moreover, video did also observe, on one occasion, fish passing by the slowly rotating machine blades along hydrodynamic flowlines, as predicted by free-body science. These observations, coupled with data gathered from the long-term stationary 24-SBT array around the six demonstration units, act as groundtruthing to the observations of fish behavior and interaction with operating turbines that, as mentioned above, begin to lead to a body of scientific support that fish are not present in abundance near the zones of operating Verdant Power KHPS, due to a combination of accelerated currents and detection/passage around machine flow lines when the KHPS are operating.

From these lessons learned, Verdant is focused on developing a cost effective operational monitoring plan for the 300-turbine RITE Pilot that will embody both SBTs for abundance and timing of migration patterns in the meso/macro scale, and also some use of VAMS for micro/meso scale observation of operating machines. Clearly the VAMS does provide limited field exceptional quality visual images of fish behavior near the machines for short-term deployments (a few days at a time). Its limitation is the difficulty in maintaining vessel position in the fast moving waters. A short-term DIDSON – or video camera deployment – may be the best option <u>when KHPS turbines are operating and if there is a high abundance of fish present.</u> These deploy/retrieve and analyze

exercises are $25-50,000 each plus the cost of the equipment, which in the case of the DIDSON is more than $125,000. Therefore, it is important to weigh the likelihood of fish presence with the cost and safety concerns of the exercise, and the value of the data to be collected.

*Baseline and Before and After Comparisons*

While 'Baseline' and 'Before and After' comparisons was the initial environmental approach for studying the RITE Demonstration, Verdant's experience (and opinion) is that this concept is generally not applicable for studying effects of demonstration or pilot scale installations. While attempted at RITE (2005-09), the dynamic nature of the fast water does not allow for clean before-and-after observations, as in a river/dam environment. Most of the conclusions found at RITE (at considerable expense) were at such a de minimus level that Verdant finds it hard to embrace or justify further effort on such pre- and post-installation comparisons. Findings included:

- *Fishery studies* – as detailed above, demonstrated that the most information was obtained not pre- and post-deployment, but through comparisons between operating and not-operating observations. Little was learned of snapshot baseline information.
- *Hydrodynamics* – pre- and post-model and field hydrodynamics were examined at all three scales (micro, meso and macro) as documented in a Verdant scientific paper[7]. Wake, pressure gradients, water level and velocity changes were documented, but at such low levels as to have minimal effects, even as predicted for a 30-turbine field, and as to be well below the precision available for most measurement devices.
- *Underwater Noise* – pre- and post-deployment studies found that aquatic species are presently living with noise levels generated by the existing navigable environment that is on par with the noise levels generated by a few and even up to 30 KHPS turbines. The likely impact on East River fish species indicate that the noise generated by the turbine array though audible to most species, would not cause injury.
- *Water Quality and Benthic* – pre-deployment studies were conducted and, based on the results, the consulting parties agreed that post-deployment studies would yield little additional information.
- *Bird Observation* – An exception to Verdant's comments regarding pre- and post-deployment studies is the Bird Observation study, which was conducted to assess whether the operation of KHPS turbines attracts diving birds to the site, an indicator of impacts to fish or a shift in fish swimming patterns. Through studies conducted during all three operating KHPS periods (2006-08), no apparent change in bird abundance, reaction or accumulation was

[7] Colby, J. A., Adonizio, M. A., 2009, Hydrodynamic Analysis of Kinetic Hydropower Arrays, Waterpower XVI, no. 204. July 2009.

noted. Still, Verdant contends that visual observations of bird activity may be a useful tool moving forward with larger arrays as an indication of increased fish activity or bird feeding in a macro sense.

In summary, the RITE Demonstration developed a body of scientific observation of fishery interaction with KHPS turbines operating at full scale, using a variety of techniques modified over the course of the three-year project. The lessons learned from this demonstration are important for moving the kinetic hydropower industry forward, and applicable to developing a scientific yet proportionately cost-effective plan for observing key stressor/receptor relationships for both pilot and commercial projects.

## 5 – REFERENCES


1. Colby, J. A., Adonizio, M. A., 2009, Hydrodynamic Analysis of Kinetic Hydropower Arrays, Waterpower XVI, no. 204. July 2009.
2. Coutant, Charles C, and Cada Glenn F. , *"What's the Future of Instream Hydro?'* Oak Ridge National Laboratory, Oak Ridge, TN. published in HydroReview magazine; Volume 24, Number 6, October 2005.
3. Final report pending April 2011; *Environmental Effects of Tidal Energy Development A Scientific Workshop (* http://depts.washington.edu/nnmrec/workshop/docs.html)
4. Marine Renewable Strategic Environmental Assessments:
   -Bay of Fundy 2008: http://www.offshoreenergyresearch.ca/OEER/
   -Scotland 2007 http://www.seaenergyscotland.co.uk/
5. US Department of Energy, Wind and Waterpower Program; *Hydrokinetic and Wave Energy Technologies Technical and Environmental Issues Workshop* (2006) (http://hydropower.inl.gov/hydrokinetic_wave)
6. US Department of Energy, Wind and Waterpower Program; *Report to Congress on the Potential Environmental Effects of Marine and Hydrokinetic Energy Technologies*. (December 2009) www1.eere.energy.gov/windandhydro/pdfs/doe_eisa_633b.pdf
7. Verdant Power, LLC. The RITE Project Final Kinetic Hydropower Pilot License Application; FERC P-12611; December 2010; 4 Volumes available at www.thereiteproject.com and the FERC/regulatory docket at www.ferc.gov

# APPENDIX A:
# RITE DEMONSTRATION & GEN5 KHPS OVERVIEW

**Verdant Power**
**RITE Demonstration & Gen5 KHPS Overview**

The Roosevelt Island Tidal Energy (RITE) Project is situated in the East Channel of the East River in New York, New York. Since 2002, Verdant Power has conducted pre-commercial testing and demonstration of its Kinetic Hydropower System (KHPS) technology through the project, ranging from prototype analysis to full-scale grid-connected demonstrations of advanced generation designs.

This work is in preparation for a full commercial pilot project at the site, expected to be commissioned in 2012, based upon the receipt of a Federal Energy Regulatory Commission (FERC) Hydrokinetic Pilot License, and other authorizing permits.

## I. Technology

***Kinetic Hydropower System (KHPS)***

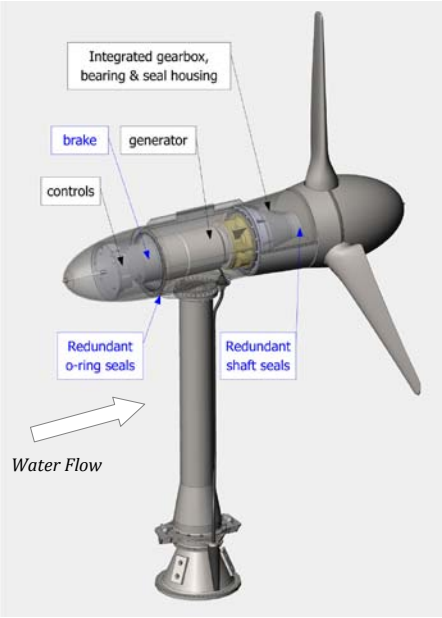


**Fig. 1 - KHPS Turbine – Internal Cutaway (Gen5 - 2010)**

Verdant Power's Kinetic Hydropower System (KHPS) utilizes an open, three-bladed turbine (Fig. 1) to capture the kinetic energy in fast-flowing rivers and tides (min 2.0 m/s). For tidal applications, a downstream rotor configuration is used, with the turbine assembly yawing (through a limited angle) on its pylon to align with the flow. The turbine rotor turns at a nearly constant, slow rate (~40 rpm), which is increased within the turbine nacelle by a custom-designed unitized drivetrain and gearbox to drive a customized induction generator. The power is connected to the electric grid via a simple and dependable control system. Various systems can be used to mount the turbines to suit site conditions.

Through early stage lab and in-water prototype testing, Verdant Power advanced the KHPS through a fourth generation (Gen4) design as of 2006. During 2006-08, Verdant Power conducted a grid-connected demonstration of a full-scale Gen4 KHPS at the RITE Project, generating operational and environmental data required to apply for a pilot commercial license, and to advance the KHPS to a commercial class design. Based on this data, Verdant Power completed and submitted its Pilot License Application to FERC in 2010. Verdant Power also completed design of its Gen5 KHPS, which is planned for in-water demonstration in 2011, ahead of full commercial operations planned to begin in 2012, based on receipt of a FERC license and other permits.

## II. RITE Demonstration – Gen4 KHPS (2006-08)

During 2006-08, Verdant Power demonstrated a grid-connected Gen4 KHPS array comprised of six, full-scale, 5m diameter rotor turbines. The RITE Demonstration was conducted as part of the RITE Project in the East Channel of the East River, 200 feet north of the Roosevelt Island Bridge and adjacent to Roosevelt Island. The six turbines were deployed in three rows of two,

with each row set 100 ft apart and the turbines within each row spaced 40 ft apart on center (Fig. 2). The foundation mounting system for the demonstration turbines was a pile top mount onto six driven monopiles embedded in the riverbed. A safety exclusion zone surrounded the turbines on three sides, with the Roosevelt Island seawall forming the fourth side. (Figs. 3 & 4).

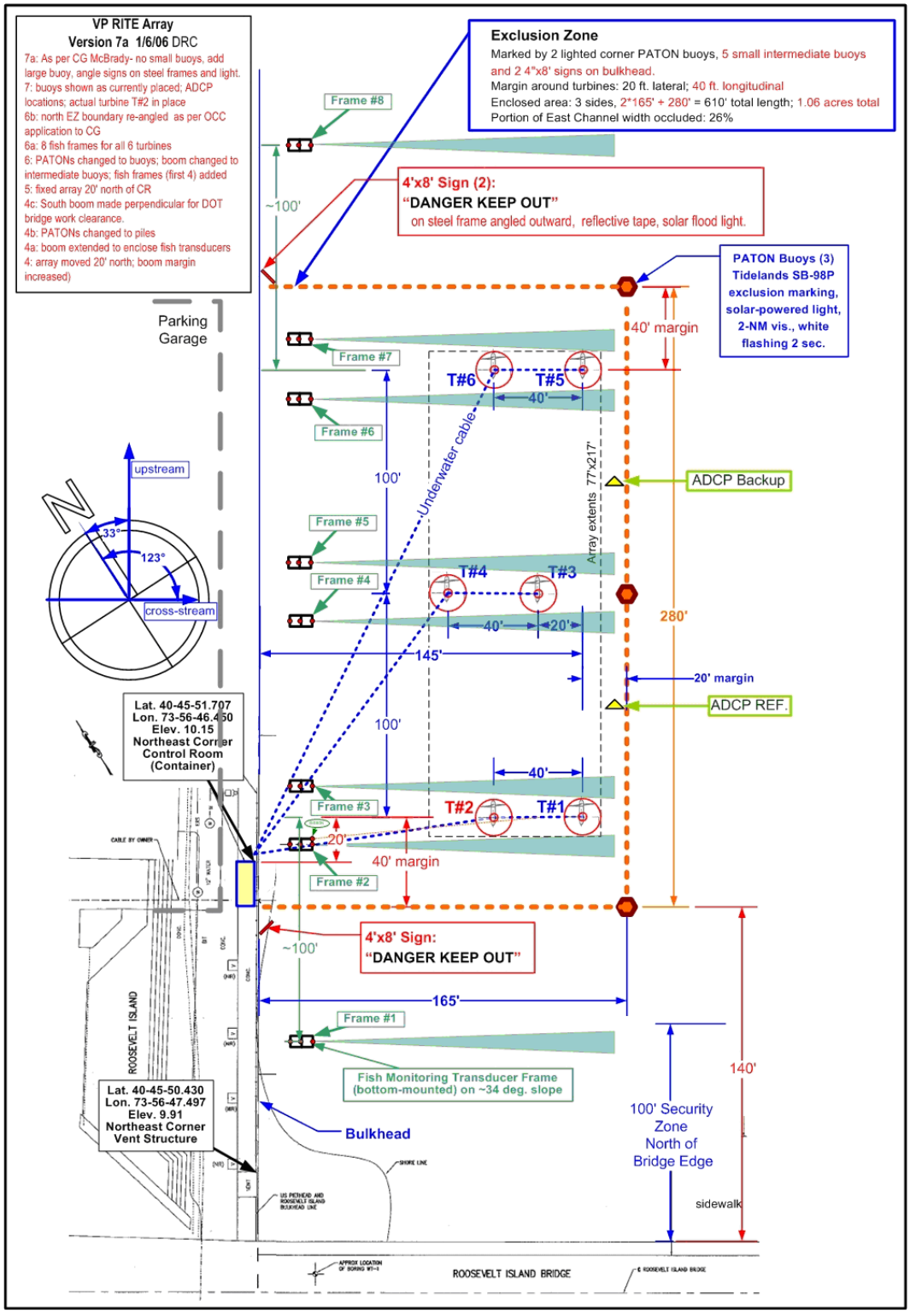


**Fig. 2 - RITE Demonstration Turbine Array Configuration**


**Fig. 3 - RITE Demonstration Site (Aerial View)**


**Fig. 4 - RITE Demonstration Site and Surrounding Area**

Five of the turbines included in the RITE Demonstration were equipped with induction generators rated at 35kW each, and one was a fully instrumented dynamometry version of the turbine used to load and test rotors and other turbine components. Under the 2005 "Verdant Order[1]," Verdant Power was allowed to transmit energy from the generating turbines for test purposes (without receiving revenue) to two adjacent end-users: a Gristedes Supermarket and the Roosevelt Island Operating Corporation (RIOC) "Motorgate" Parking Facility (Fig. 4).

Verdant Power received all operating permits, licenses, and easements for the installation of the demonstration field of turbines and appurtenant facilities, including permits from the New York State Department of Environmental Conservation (NYSDEC), US Army Corps of Engineers (USACE), FERC, and the New York State Office of General Services, among others. In addition, a suite of extensive study plans and environmental monitoring was conducted during the demonstration in consultation with the National Oceanic and Atmospheric Administration (NOAA) – National Marine Fisheries Service (NMFS), the US Fish and Wildlife Service (USFWS), the Environmental Protection Agency (EPA), and the US Coast Guard (USCG). The full body of environmental documentation is contained in Exhibit E of Verdant Power's Hydrokinetic Pilot License Application to FERC (P-12611), available for download at http://www.theriteproject.com.

The RITE Demonstration was conducted in three deployments over a two-year period (described below), and resulted in the following operational milestones:

- Proof of the complete water-to-wire system, with the delivery of approximately 70MWH of energy to commercial end users with no power quality problems;
- Rotor efficiencies from 41% to 52% in 2.2 m/s to 1 m/s flow respectively;
- Water-to-wire efficiencies (including all losses) up to 41%
- Approximately 9,000 turbine-hours of operation;

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[1] *Verdant Power LLC*, 111 FERC ¶61,024, *order on reh'g* 112 FERC ¶61,143 (2005)

- Meeting or exceeding projections for hydrodynamic, mechanical and electrical performance;
- Fully bidirectional operation – passive yawing with high efficiency on both ebb and flood tides;
- Automatic control and continuous, unattended operation;
- No fouling or damage from debris;
- No observation of fish injury or mortality, nor irregular bird activity indicating possible fish harm during the operation of the machines;
- Execution of environmental studies[2] that developed important data regarding the environmental effects of operating KHPS.

The KHPS operated during the RITE Demonstration stands as the world's first grid-connected array of tidal turbines. Key support for the RITE Demonstration was provided by the New York City Economic Development Corporation and the New York State Energy Research and Development Authority (NYSERDA), which also supported earlier prototype testing and has committed to future funding for the Commercial Pilot Project.

*Below is a detailed overview of the RITE Demonstration deployments and respective results.*

**A. RITE Demonstration Deployment #1**
**(Dec 2006 - Jan 2007)**

Installation of first two KHPS turbines: "T1" - the fully instrumented dynamometry version of the turbine and "T2" - the first of the 5 grid-connected generator (35kW) turbines. Results were as follows:

- Pre-deployment environmental studies conducted and stationary fish monitoring equipment (fixed hydroacoustics) installed;
- T1 and T2 installed on Dec. 11 and 12, respectively (Fig. 5)
- T2 operated superlatively between Dec 12 - Jan 21, 2007, generating power continuously into the grid on both flood and ebb tides and proving the functionality of every system and subsystem, including:
    - Continuous operation with 100% availability over 155 tides;
    - Fully bidirectional operation;
    - Water-to-wire efficiencies reaching over 40%;
    - No observation of fish injury, allowing regulators to approve 6-turbine install
    - 10 MWH of energy delivered with power quality problems

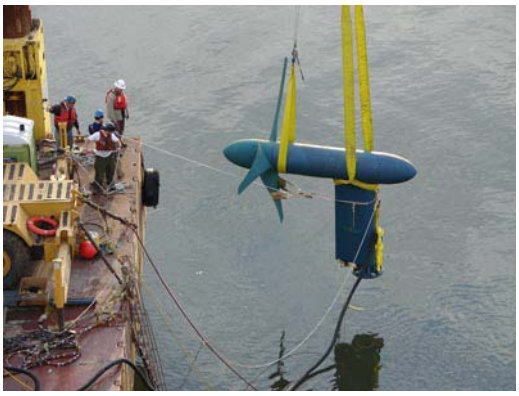

**Fig. 5 – KHPS Turbine 1 (T1) Deployed December 11, 2006 (East River; New York, NY)**

[2] A suite of eleven environmental studies and plans were executed during the RITE Demonstration, including both fixed and mobile hydroacoustics; bird observation for fish interaction; water quality; benthic habitat; hydrodynamics; underwater noise; recreation; cultural resources; navigation safety; and consultations on rare and endangered species.

**B. RITE Demonstration Deployment #2 (Feb - July 2007)**

During the course of Deployment #1, a failure of the rotor blades (Gen4a - Fiberglass Reinforced Plastic) required extraction of T1 and T2. The Gen4a rotor engineering design and manufacturing was assessed and updated rotors (Gen4b) were designed and fabricated of solid cast Aluminum alloy (AlMag 35). Deployment #2 proceeded with original turbine assemblies retrofitted with Gen4b blades. Results as follows:

- Six turbines installed to make up full grid-connected array, a world first (Figs. 6 & 7);
- Array successfully demonstrated every aspect of the KHPS design to be successful at the 5m rotor diameter level;
- Between April 18 and June 20, 2007 the array logged 7,128 turbine-hours of operation with 45 MWH+ of energy to commercial end users;
- Operational and environmental data was collected in accordance with monitoring plans, again with no observed fish injury or mortality;
- Analysis of longitudinal and horizontal wake interaction for energy production conducted, with original spacing (6 Diameters) proven, as expected, too close for optimal energetic production, leading to a revised spacing of 12D for Deployment #3.

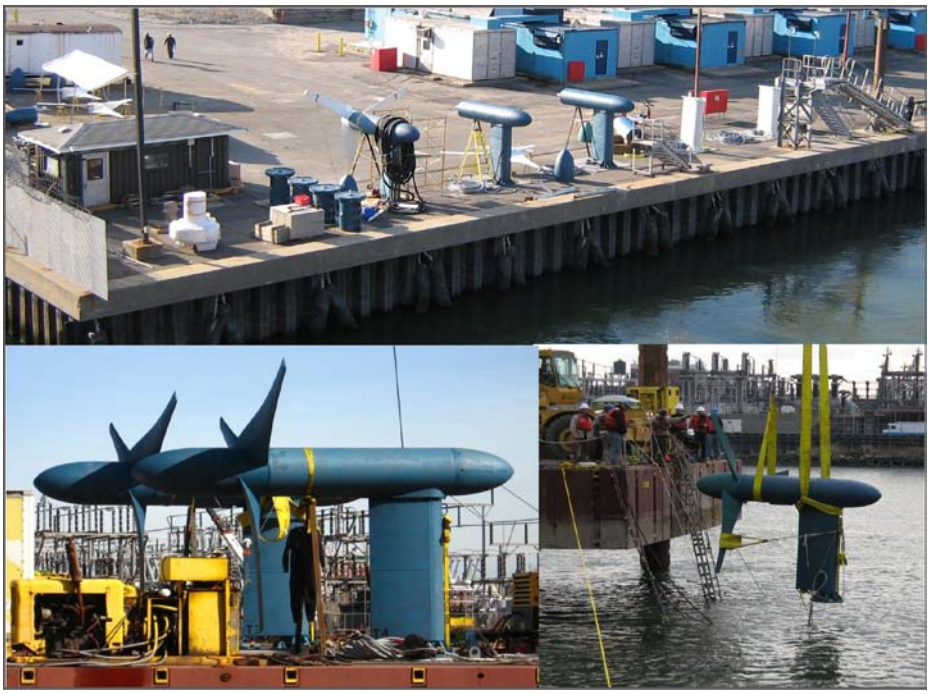

**Fig. 6 – RITE Demonstration Deployment #2 - Turbine Assembly and Installation**

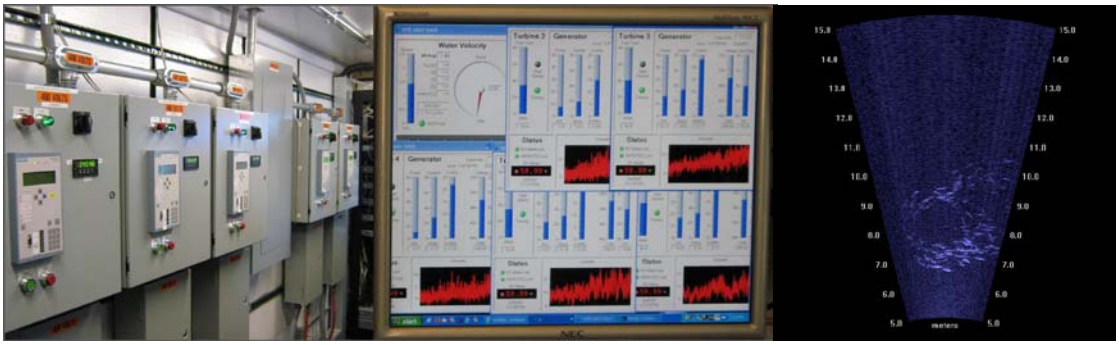

**Fig. 7 – RITE Project Control Room equipped with Switchgear, Turbine Data Acquisition System and Environmental Monitoring Equipment**

**C. RITE Demonstration Deployment #3 (July 2007 – November 2008)**

After sustained operation of the six-turbine array, a weakness in the rotor hub was detected and turbines were removed from service. Gen4b rotors were re-engineered to improve strength and hub connections. An updated rotor (Gen5a) and hub was developed improving the design with a test case manufactured and subjected to a comprehensive testing regimen at the US Dept of Energy's National Renewable Energy Laboratory (NREL) wind energy test facility (Fig. 8). The Gen5a rotor assembly passed NREL tests successfully without incident and were retrofitted onto two existing turbines and re-installed for demonstration. Results were as follows:

- Turbines equipped with Gen5a rotors delivered 12 MWH of energy and logged approximately 1,000 hours of grid-connected operation (Fig. 9).
- Gen5a rotors met or exceeded expectations in terms of reliability and efficiency.
- 'Retrieve and redeploy' operations were achieved during 2-slack period (a key milestone for commercial O&M).
- Environmental monitoring again confirmed no evidence of fish injury, during a period of increase seasonal fish presence and abundance. Environmental data collected supported the filing of a Draft License Application in November 2008.
- The RITE Demonstration was completed in October of 2008 and the KHPS turbines were removed and inspected in November 2008.

**Fig. 8 – Gen 5a Rotor Assembly Testing Conducted at National Renewable Energy Laboratory**

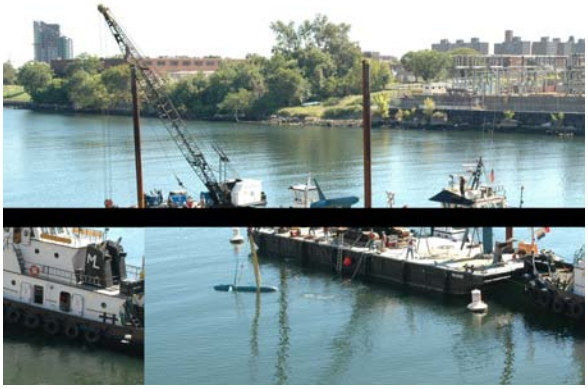

**Fig. 9 - RITE Demonstration Deployment #3 - Two Turbines Retrofitted with Gen5a Rotors**

**III. Commercial Class KHPS (Generation 5)**

Based on operating experience of the Gen4 units operated during the RITE Demonstration, Verdant Power developed a commercial class Gen5 KHPS turbine (Figs. 10 & 11). While the Gen4 units proved excellent performance in converting the energy in the tidal currents into grid-connected power, the Gen5 KHPS turbine is a design advancement aimed at high reliability, longevity, and cost-effective commercial manufacturing. Key design enhancements of the Gen5 turbine include the following, and are discussed briefly below:

i. Composite Fiber Reinforced Polymer (FRP) Blades and Ductile Iron Hub Casting
ii. Casting for Pylon/Nacelle Connection
iii. Integrated Gearbox and drivetrain
iv. Failsafe Brake

v. Redundant Dynamic and Static Sealing
vi. Non-toxic Fouling-Release Coating System

The end result is a Gen5 KHPS turbine and balance-of-system design that optimizes renewable energy generation, while dramatically improving commercial viability and enhancing environmental compatibility.

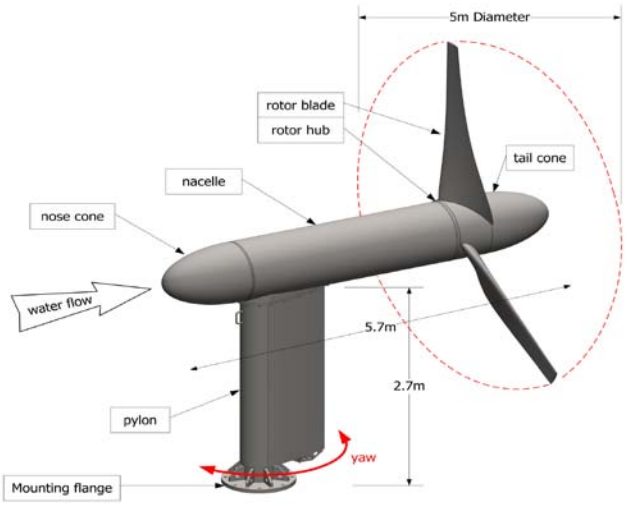


**Fig. 10 - Gen4 KHPS Turbine**

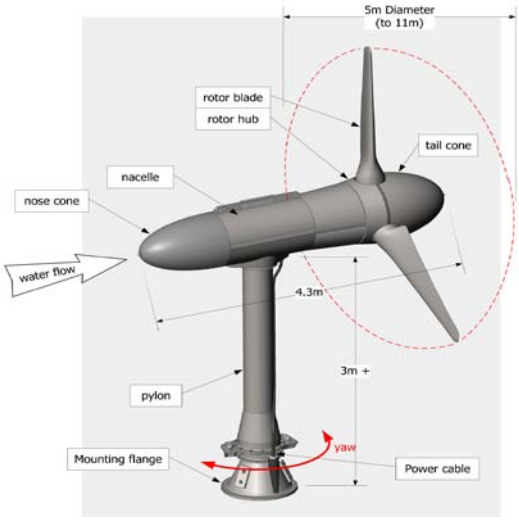


**Fig. 11 - Gen 5 KHPS Turbine**

*i. Composite (FRP) Blades and Ductile Iron Hub Casting*

Verdant Power conducted a full rotor design cycle to develop new blades fabricated from composite materials (FRP) with more strength, durability, ready scalability to larger sizes, particularly the 10m class turbine and better resistance to seawater corrosion than the previous generation (Fig. 12). The updated blades will also be capable of lower-cost production in volume. This design work included hydrodynamic and structural modeling and analysis and is followed by extensive strength and fatigue testing and full-scale in-water hydrodynamic dynamometry testing (at RITE 2011).

**Fig. 12- KHPS Composite Turbine Rotor**

This work has been supported in part by awards from the US Department of Energy (DOE) and in partnership with the DOE's National Renewable Energy Laboratory and Sandia National Labs, as well as the University of Minnesota's St. Anthony Falls Laboratory, and others.

*ii. Casting for Pylon / Nacelle Connection*

The pylon/nacelle connection for the Gen5 turbine has been redesigned as a casting for improved strength, along with cost-effectiveness in volume production. This casting eliminates the original steel tube and many fabrication and assembly steps. The overall nacelle shape has been reduced in length by approximately 25%.

*iii. Integrated Gearbox/Shaft/Seals/Bearings*

In place of the former off-the-shelf drivetrain components, the Gen5 turbine features a custom-designed unit that integrates the bearing housing with a special long-life planetary gearbox (Fig. 13). At the rotor end, this unit also incorporates high-performance mechanical shaft seals (now made redundant), and at the high-speed end, an adapter for direct mounting of the generator. The generator shaft further drives a direct-mounted failsafe brake (discussed below). The unit's cast iron housing mates directly to the pylon/nacelle casting and all o-ring seals are of redundant pressure-capable design.

This new design will provide necessary reliability and longevity for commercial operation. It will also simplify maintenance and speed near-site final assembly, deployment and on-site retrieval.

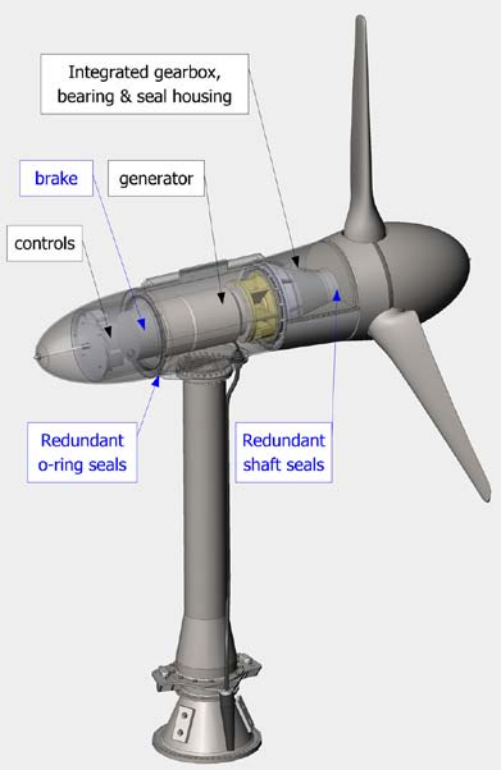


**Fig. 13 – Gen5 KHPS Turbine (Internal)**

*iv. Failsafe Brake*

Under normal power generation operation, KHPS turbine rotors (which have fixed blades) rotate at a nearly constant speed of approximately 40 RPM, with tip-speeds on the order of 10.5 m/s (34.5 fps) – a very slow rate, especially in comparison to vessel propellers. By design, the blades do not cavitate. The Gen5 turbine includes a brake, unlike the previous Gen4 turbine.

The Gen5 brake, limits the rotation rate (and the thrust loads on the rotor blades, turbine, mounting structure, and foundation). The brake is a "failsafe" type (spring-applied, electrically-released), so the default, unpowered position of the brake is "on" and the rotor is stopped. The brake is automatically controlled so that the rotors are only released to rotate when they are ready to generate, both in terms of adequate water speed (as indicated by a pair of array ADCPs), and all electrical parameters of the KHPS and the grid. This eliminates all pre- and post-generation rotation, avoiding rotation at speeds higher than normal generation speed, and reducing the total time the rotors actually rotate.

The Gen5 turbine brake is electrically released automatically during normal generation, and is automatically spring-applied on any failure of the generator, cable, control system, interconnection or the electrical grid itself. Under a condition of any malfunction of the generator or electrical system, the brake power is removed, returning it to the "on" position and stopping the rotor within a few seconds. Additionally, the turbine specification requires that even on loss of load at full power generation, the brake application will limit the transient (a few seconds) rotor speed to a maximum of 20% above normal speed prior to rotor stoppage. The brake can also be manually applied via a remote signal from shore that cuts power to any generator. This mode is useful during commissioning testing and for maintenance operations.

During normal operation, the Gen5 turbines begin rotating at approximately 1 m/s and automatically connect to the grid line to generate electricity through the range of water speeds.

At the end of the tide, as the water velocity slows and power output drops, the turbines are automatically disconnected from the grid.

It should be noted that operation of the brake beyond the basic control functions described above (i.e. electrical system faults or testing) can shorten the life of both the brake and the turbine. Accordingly, there is no provision for integrating the brake operation with a signal from another type of instrumentation. This operation is not advisable due to the limitations of the sensing devices and sensing strategy, and the effect on the life of the turbines.

*v. Redundant Dynamic and Static Sealing*

The KHPS turbine uses a single common circulating lubricant for its gearbox and main bearings. The gearbox and bearing oil chamber are designed to operate at 50% fill and contain approximately 34-38 liters (9-10 gal) of lubricant. The lubricant is a Mobil SHC 100% synthetic (PAO-type), ISO grade 220 gear oil. This is suited to the severe conditions with potential moisture, and has good seal compatibility, corrosion and oxidation resistance, and thermal stability for long life between changes.

For containment of this oil, and exclusion of seawater, the main shaft has dual high-performance mechanical face seals – one to contain the oil in the oil chamber and one to exclude the external water. Between the two face seals is a chamber that would allow any leakage of either to accumulate in a closed container within the nacelle, which itself is sealed with redundant o-ring seals. Upon initial deployment, the nacelle will contain a dry gas charge that will partially balance the water pressure at the deployment centerline depth. During operation, the net pressure under water will tend to force water into the nacelle. Sensors will detect any leakage as well as water ingress into the oil, at which point the turbine can be shut down and ultimately retrieved and maintained.

*vi. Non-toxic Fouling-Release Coating System*

Most of the KHPS turbine and mounting structure must be coated to prevent corrosion and biofouling. For the Gen4 system, this generally involved using an epoxy coating for corrosion protection, and outer copper-based coating for anti-fouling. For the Gen5 system, a new coating system will be used that is non-toxic, with Verdant Power proposing to use one of the following coating systems at the time of writing:

1. Silicone (E.g. Hempel Hempisil X3) - This system involves relatively standard epoxy coating for corrosion and mechanical protection followed by the application of a “tie” coat and then a coating of silicone. The silicone surface mechanically resists biofouling.
2. Ecospeed (Subsea Industries, Hydrex) - This is a unique system that uses a single coating material for both corrosion protection and to provide a mechanically non-fouling surface. The material incorporates glass platelets in a vinylester resin matrix. This material would likely require more frequent cleaning.

Both systems are applied with standard painting equipment, and provide for an entirely non-leaching, non-toxic coating.

## IV. RITE 'Install A' – Gen5 KHPS Demonstration

In 2011, Verdant Power will install two Gen5 KHPS turbines for grid-connected demonstration at the RITE Project site prior to planned Pilot commercial development. The Gen5 turbines will be installed on two existing monopiles used in the RITE Demonstration and will be operated and monitored for a minimum of 180 days. As with the RITE Demonstration, the effort will be conducted under the FERC 'Verdant Order' and a modified and extended joint NYSDEC/USACE permit, with energy generated from the turbines delivered to the same commercial end users that participated in the Gen4 Demonstration (Gristedes and Motorgate).

Based upon this demonstration, and the receipt of a FERC Hydrokinetic Commercial Pilot License, this RITE 'Install A' will be followed by successive installations of additional turbines[3] to comprise the proposed 30-turbine, 1 MW commercial RITE Project (See Fig. 14, Table 1).

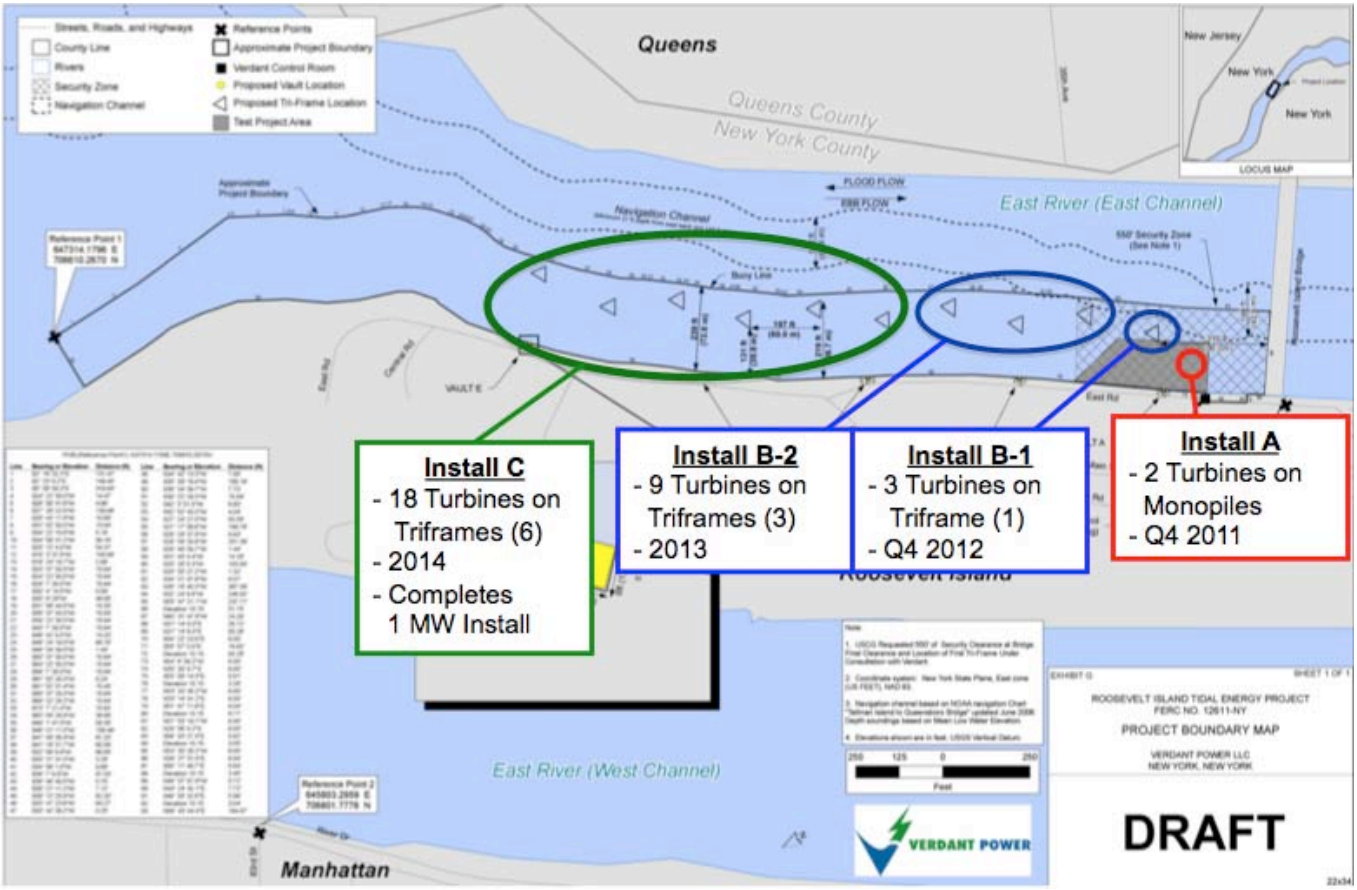


**Fig. 14 – RITE Project Commercial Installation Plan - DRAFT**

[3] Verdant Power expects to utilize a triangular 'triframe' anchoring device capable of supporting three turbines each for Installs B & C at RITE.

**Table 1. RITE Installation Plan**

| Element/Features | RITE Demonstration | Install A | Install B-1 | Install B-2 | Install C |
|---|---|---|---|---|---|
| **Installed Capacity** | 175 kW | 70 kW | 105 kW | 420 kW | 1,050 kW |
| **Installation Dates** | 2006 - 08 | 4Q 2011 | 4Q 2012 | 2013 | 2014 |
| **# of KHPS Turbines/Mounting** | 6 (Gen4) on monopiles | 2 (Gen5) on monopiles | 3 (Gen5) on 1 triframe | 9 (Gen5) on 3 triframes | 18 (Gen5) on 6 triframes |
| **Regulatory Authority** | NYSDEC/USACE joint permit | NYSDEC/USACE joint permit | FERC Pilot License; and other permits | FERC Pilot License; and other permits | FERC Pilot License, and other permits |
| **Navigation Security** | 3 lighted buoys[4] | 3 lighted buoys | 3 lighted buoys | 4 lighted buoys | 6 lighted buoys |
| **Cabling** | 6 direct to Onshore Control Room | 2 direct to Onshore Control Room | 3 bundled to Onshore Control Room | 4 bundled to 2 Shoreline Vaults, to Control Room | 10 bundled to 5 Shoreline Vaults, to Control Room |
| **Interconnection** | Direct to load | Direct to load | Metered interconnection | Metered interconnection at Vault B | Metered interconnection at Vault B |
| **Water Resource Instrumentation** | Stationary ADCP | 2 stationary ADCPs | 2 stationary ADCPs | 3 stationary ADCPs | 3 Stationary ADCPs |
| **Environmental Effects Monitoring** | Multiple studies and monitoring under FMPP[5] | Proposed RMEE[6] Plans (Install A) | Proposed RMEE Plans (Install B-I) | Proposed RMEE plans (Install B-2) | Proposed RMEE Plans (Install C) |

[4] Private Aids to Navigation (PATON)
[5] Negotiated term of permit embodied in RITE Fish Monitoring and Protection Plan (FMPP) Versions 6.0 and 7.5
[6] Proposed RITE Monitoring of Environmental Effects (RMEE) plans - 6 progressive study plans to analyze fish interaction and effects. See Volume 4 of the RITE Final License Application.

## APPENDIX B:

## SUMMARY OF PROJECT DELIVERABLES

**TASK 1: Fishery Studies Groundtruthing**

Text in the FERC Final License Application (FLA) (See Volume 2 Exhibit E and Volume 4 Appendices A&B to the RMEE plans) that describes the body of work accomplished under this task.

**TASK 2: Stationary Netting**

Protocols for RMEE-3 Stationary Netting (See RITE FLA, Volume 4) to be conducted during the proposed RITE Pilot Project in 2011-2102.

**TASK 3: East River Fish Species Composition**

Text in the RITE FLA (See Volume 2 Exhibit E and Volume 4 Attachment 2) that supports the BA and the EFH as well as the body of prior fishery observations and studies with hydroacoustics.

**TASK 4: Bird Observation**

Text in the RITE FLA (See Volume 2 Exhibit E) describes the body of work accomplished under this task.

**TASK 5: Protected Species and Habitat Evaluations**

Biological Assessments (BA) for RITE Project (FLA Volume 4 Attachment 1- ESA and Attachment 3 - MMPA) that provides BA for ESA species and marine mammals for FERC and agency NEPA review.

Essential Fish Habitat (EFH) FLA Volume 4 Attachment 2 provides a description of the essential fish habitat derived from a variety of informational sources.

**TASK 6: Project Evaluation**

Completion of the RITE FLA, which is a summary of the current and prior funded NYSERDA environmental support work.[8]

**TASK 7: Reporting and Tech Transfer**

- Status Reports document activities and expenditures for the project
- Meetings were held as required by the project schedule and updates
- Technology Transfer, through website, conferences, and presentations
- Final Report provides a detailed overview of project accomplishments, deliverables, major events and results from the project

Verdant Power provided progress reports and updates to the NYSERDA Project Manager throughout the contract. The requisite Final Report is provided herein. Verdant Power oversaw project operations, budgeting, invoicing, and reporting activities, including entering into and managing subcontract agreements. Meetings and site visits were held to provide updates on project activities during the project.

[8] NYSERDA contracts; 8609, 8609-1; and 9892; (2004 - 2009)

The filing of the four-volume FERC Final License Application (FLA) for the RITE Pilot Project under P12611 in December 2010 represents the entire body of environmental work and summary of all activities undertaken for the project, and specifically all of the tasks under this Agreement.

Over the course of the project Verdant Power also made public presentations encompassing the information developed under this Agreement as follows:

- Global Marine Energy Conference; Washington, DC; April 2009; Seattle Washington 2010
- Waterpower XIII; Spokane, WA, 2009
- Global Marine Energy Conference; Seattle Washington 2010
- HydroVision 2010; Charlotte, NC, 2010
- Advanced Energy Research Technology Exposition and Conference (AERTEC) Conference; October 2009 & November 2010; New York.

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# Roosevelt Island Tidal Energy (RITE) Environmental Assessment Project

March 2011

**State of New York**
Andrew M. Cuomo, Governor

**New York State Energy Research and Development Authority**
Vincent A. Delorio, Esq., Chairman | Francis J. Murray, Jr., President and CEO