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ROOSEVELT ISLAND TIDAL ENERGY PROJECT

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Final Kinetic Hydropower Pilot License Application

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Verdant Power, LLC
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APPENDIX B OF RMEE PLANS –

SUMMARY OF RITE PROJECT DIDSON OBSERVATIONS

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RMEE Appendix B

Summary of RITE Project DIDSON Observations

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RMEE Appendix B

Summary of RITE Project DIDSON Observations

TABLE OF CONTENTS

1.0 RITE Frame mounted DIDSON: December 2006 to January 2007 – Deployment #1 (B.2-B.5) B-3

2.0 RITE Vessel-mounted DIDSON: September to October 2008 – Deployment #3 (B.6-B.X) B-10

LIST OF FIGURES

Figure B.1 Summary of RITE Demonstration Project Turbine Deployments and DIDSON Observation B-1

Figure B.2 Frame-Mounted DIDSON, Turbine Deployment D1, Profile (units = feet) B-6

Figure B.3 Frame-Mounted DIDSON, RITE Turbine Deployment D1, Plan View B-7

Figure B.4 Frame-Mounted DIDSON Imaging Example in High Resolution Mode B-8

Figure B.5 RITE DIDSON Operational History Deployment D1 - 2006 to 2007 ..... B-9

Figure B.6 Vessel-Mounted DIDSON, Turbine Deployment D3, Plan View B-13

Figure B.7 RITE VAMS DIDSON Mount B-14

Figure B.8 VAMS DIDSON/SBT Monitoring Zone Chart, Turbine Deployment D3, Plan View B-15

Figure B.9 VAMS DIDSON Best Beam Coverage View of RITE KHPS Turbine B-16

Figure B.10 VAMS Observations and Fish Abundance Data from Fixed Hydroacoustic SBT Arrays – Sept. to Oct. 2008 (D#3) B-17

Figure B.11 Summary of RITE VAMS Observations – October to December 2008 ..... B-18

Figure B.12 Significant Fish Observations at RITE from Three VAMS DIDSON Surveys B-19

Figure B.13 Observation of Fish Moving beyond Rotating KHPS Turbine (Pg. 1 of 2) .. B-21

Figure B.13 Observation of Fish Moving beyond Rotating KHPS Turbine (pg 2 of 2) B-22

Figure B.14 Orientation of DIDSON Beam, Fish School and Turbine during 10/21/2008 Observation B-23

Figure B.15A Imagery of a Rotating KHPS Turbine on Tide (no fish) B-24

Figure B.15B Imagery of the KHPS Turbine on Slack, No Rotation (with X cm fish in the bottom/top of water column) B-25

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RMEE Appendix B

Summary of RITE Project DIDSON Observations

The figures and text presented in this Appendix, B.1 through B.15, represent an overview of the body of knowledge on the DIDSON experience with fish movement, behavior and presence observation at the Roosevelt Island Tidal Energy (RITE) project demonstration area. The data represents two efforts of DIDSON observations at RITE over the period October 2006 – January 2007 (stationary) during Deployment #1 and a mobile effort (termed VAMS- Vessel-mounted Aimable Monitoring System) during Deployment #3 in October – December 2008. The purpose of this Appendix is to summarize the lessons learned and rationale supporting the use of the DIDSON in conjunction with other techniques in the RMEE plans proposed for the RITE Pilot Project, Installs A, B and C.

Figure B.1 Summary of RITE Demonstration Project Turbine Deployments and DIDSON Observation

Deploy	KHPS Operating	Days Operating	Number of KHPS	DIDSON Surveys
Deploy 1	12/13/06-1/22/07	41	2	Stationary DIDSON for approx 1 month, but at poor location and resolution.
Deploy 2	4/13/07-6/30/07	78	Up to 6	No DIDSON used, by agreement, low fish abundance period
Deploy 3	9/8/08-10/31/08	53* partial rotation –	2 2 2	VAMS DIDSON survey 10-21-08 VAMS DIDSON survey 11-11-08 VAMS DIDSON survey 12-17-18 2008

**** See Figure B.11 for summary videos***

*****Summary presented October 2010 and in Final License Application***

Generally, the experience to date ***strongly supports*** using the DIDSON for micro-level monitoring of fish behavior around the operating KHPS turbines, considering the limitations discussed in this Appendix.

Both stationary frame-mounted and mobile VAMS efforts have been executed to date. Verdant initially proposed in the Draft License application (November 2008) a VAMS effort for the RMEE Pilot monitoring plan. However, in consultation with the agencies, a new concept of a stationary bottom mount deployed at 3-week seasonal period appears to be the best compromise for observing Install A and B KHPS machines based on the experiences and lessons learned in the prior efforts.

Specifically, the RITE experience with the DIDSON suggests that the RMEE2 Seasonal Stationary DIDSON Observation plan could prove to be an effective tool if:

- The KHPS observation distances in the East River are ***kept to less than 15 m to maintain the resolution*** needed to adequately view fish behavior and potential interaction with the turbine. The bottom mount design for both Install A and B is consistent with these criteria.
- Flexibility in aiming, as confirmed in the VAMS effort, was important. The bottom mount now ***incorporates servo-aiming capability*** to allow for adjustments to view the KHPS and the bottom and top of the water column.
- The DIDSON is deployed for observational periods of ***approximately3 weeks*** during seasonal fall high abundance periods. The 3-week period is necessary due to the rapid biofouling and high degree of silting found in the East Channel, especially now with an added in-water mechanical servo. Three weeks of observation would yield 500 hours of video, a significantly larger sample than the VAMS could provide.
- The timing of the 3-week period should ***coincide with a high likelihood of fish abundance in the fall season.*** This is supported by the body of information in Appendix A; which was correlated with VAMS DIDSON observation.
- To maximize likelihood of fish interaction observance; this high abundance period can be generally ***timed and predicted based on a working hypothesis of movement and migration*** presented in Appendix A.

These concepts, conclusions and supporting detail are discussed in the text below. Figures B.1 to B.5 summarize the Stationary frame-mounted DIDSON experience in October to January 2007.

Figures B.6 to B.15 summarize the Mobile DIDSON VAMS effort in October to December 2008.

1.0 RITE FRAME MOUNTED DIDSON: DECEMBER 2006 TO JANUARY 2007 – DEPLOYMENT #1 (B.2-B.5)

As discussed in the DLA Volume 2 page E-96, a fixed DIDSON was deployed in December 2006 – January 2007 during turbine Deployment #1 (D1) for a limited period observing a single operating KHPS. The DIDSON was mounted on fish frame (FF) #2, one of eight steel frames holding three fixed hydroacoustic split beam transducers (SBT)s each. FF #2 was deployed so that the DIDSON was located approximately 17 m from Turbine T2, and 29 m to Turbine T1. Approximately +/- 15 degrees of DIDSON yaw and pitch could be controlled from the shoreline using steel flex-control cables.

Verdant Power’s initial DIDSON experience during Deployment D1 was disappointing on several levels:

- **Clarity of fish imaging at T2 (15-17m) was marginal.** In viewing objects over 15 m in distance the DIDSON switches into low-resolution mode, which proved not acceptable for fish monitoring. In addition, it is theorized that the imaging distance is reduced due to a large amount of air bubbles in the water caused by the bridge pilings and rough shoreline. T1 at 29 m could not be seen at all (Figure B.3 and B.4).
- **Survivability issues: Biofouling and silting.** The DIDSON lost imaging quality after about 3 weeks Figure B.5) due to silting and biofouling. An installed silt box apparently remedied the silting problem, but not the biofouling problem, and reduced imaging sensitivity by 3 dB.
- **Instrument issues: Hardware failures and software bugs.** In 2006-2007 the DIDSON still had developmental issues that required troubleshooting, service calls, and

retrievals. The software was very unstable and required many new fixes from the vendor Sound Metrics. The DIDSON instrument suffered from both a power amplifier failure and a lens oil leak which diminished is serviceability (Figure B.5).

- **Post process and Analysis: Extreme volume of data and analysis.** In 2006-2007 the DIDSON software's capability for filtering fish events from no-fish images was limited. 100% of the data had to be manually reviewed for fish events; requiring at least 6 hours per 24 hours of data. It also required data storage of terabytes of data for 24/7 monitoring.
- **Mounting Issues: Deployment/retrieval, and/or aiming of DIDSON was cost prohibitive.** The deployment of the DIDSON on a shore frame, (with other instruments) and with limited aiming capability proved a poor solution for monitoring. Mobilization of vessels, divers, and cranes for maintenance was excessive.

On a positive note the DIDSON did provide some images (of a limited field) for a short (1.5 week) duration in October – November 2006 pre-deployment. Fish activity was clearly seen inshore, within the 2-15 m of the objective – the operating KHPS turbine T2 located at 17 m range (See Figure B.3 and B.4). This imagery confirms the later observations of the fixed hydroacoustics that fish favor the shoreline; in zones not occupied by operating KHPS.

In 2007, Verdant reviewed the use of the DIDSON for future applications with both the manufacturer and the agencies and concluded that:

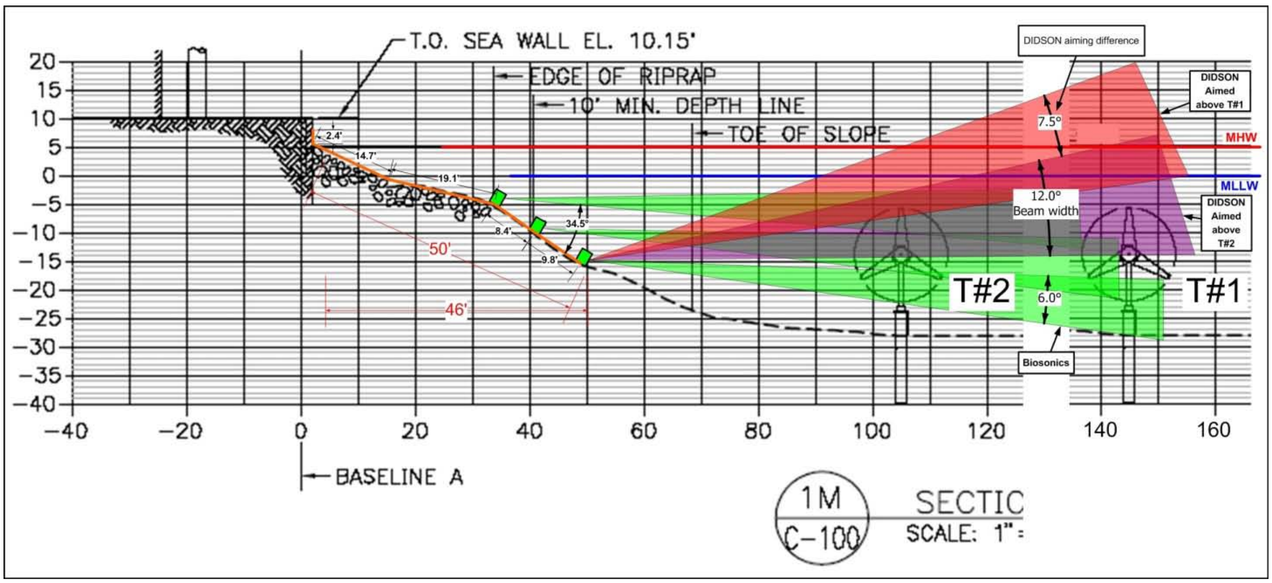
- The DIDSON instrument could be used as an effective tool to observe fish interaction with the KHPS turbines, ***but not as a continuously deployed instrument***. The silt and biofouling in the East River would require the DIDSON to be serviced at a minimum of every 3 weeks, thus limiting the active deployment period on a fixed to 3 weeks. As a footnote, the cost associated with maintenance retrieval and redeployment is approximately $18-20k per effort.
- The field experience also determined that the KHPS observation distances in the East River had to be ***kept to less than 15 m to maintain the resolution*** needed to adequately view fish behavior and potential interaction with the turbine.

- It was important to time-stamp and analyze the fish presence and movement ***in relationship to the tidal conditions.*** The strong influence of the tides on fish presence and abundance shown by the fixed hydroacoustics, as well as the zonal presence and behavior on slack clearly pointed to clarifying observations as to where and when fish were present and active.
- Given that the time for deployment is limited to a 3-week period; and consistent with the seasonal abundance observed with the fixed hydroacoustics; ***seasonal observation with the DIDSON instrument at periods of high abundance*** will most likely yield the best observational data.
- New software (now available from the vendor) might be able to screen fish target (presence) events when deployed in a stationary condition thus reducing active post-processing time. The software is able to screen out the moving turbine from triggering the motion detection software. However, it is still not known if ***turbine turbulence might be interpreted by the motion detection software as fish events***. This issue needs further investigation.
- The ***ability to freely aim the DIDSON*** would be a significant improvement in trying to capture fish interaction with an operating KHPS.

From these new understandings of the equipment and East River limitations, Verdant developed a new protocol for use of the DIDSON at RITE, which was effectuated during Deployment #3 October – December 2008, which is discussed in the following section.

This plot shows the placement of the DIDSON on SBT frame FF #2 during turbine Deployment D1. The theoretical range of the DIDSON's tilt capability is shown by the red and green beams. Although theoretically the DIDSON could image out to T1, the effective range for monitoring fish behavior is actually less than 15 m, which was roughly to the near tip of turbine T1. This limitation severely restricted the DIDSON's value in observing turbine/fish interactions during Deployment #1.

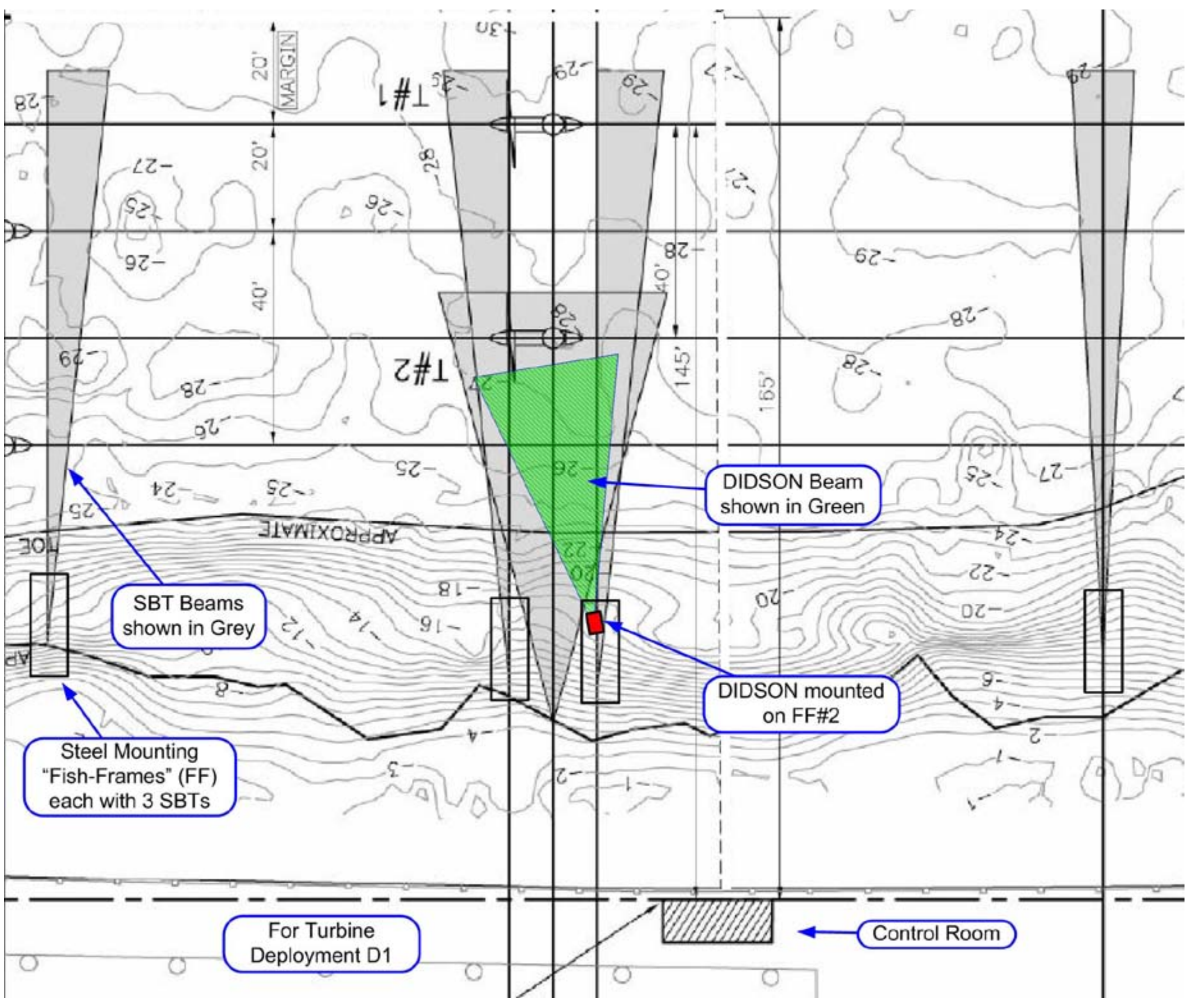
Figure B.2 Frame-Mounted DIDSON, Turbine Deployment D1, Profile (units = feet)



**** Graphic from "The Verdant Power RITE Project- Project Update and Plans for 2008", May 2008, a presentation to agencies.***

This plot shows the placement of the DIDSON on SBT frame FF#2 during turbine Deployment D1 in 2006-2007. The beam of the DIDSON's is shown by the green beam. The SBT beams are shown in grey. Again, the effective beam range for fish monitoring turned out to be 15 m, which barely ensonified turbine T#2 (See next slide).

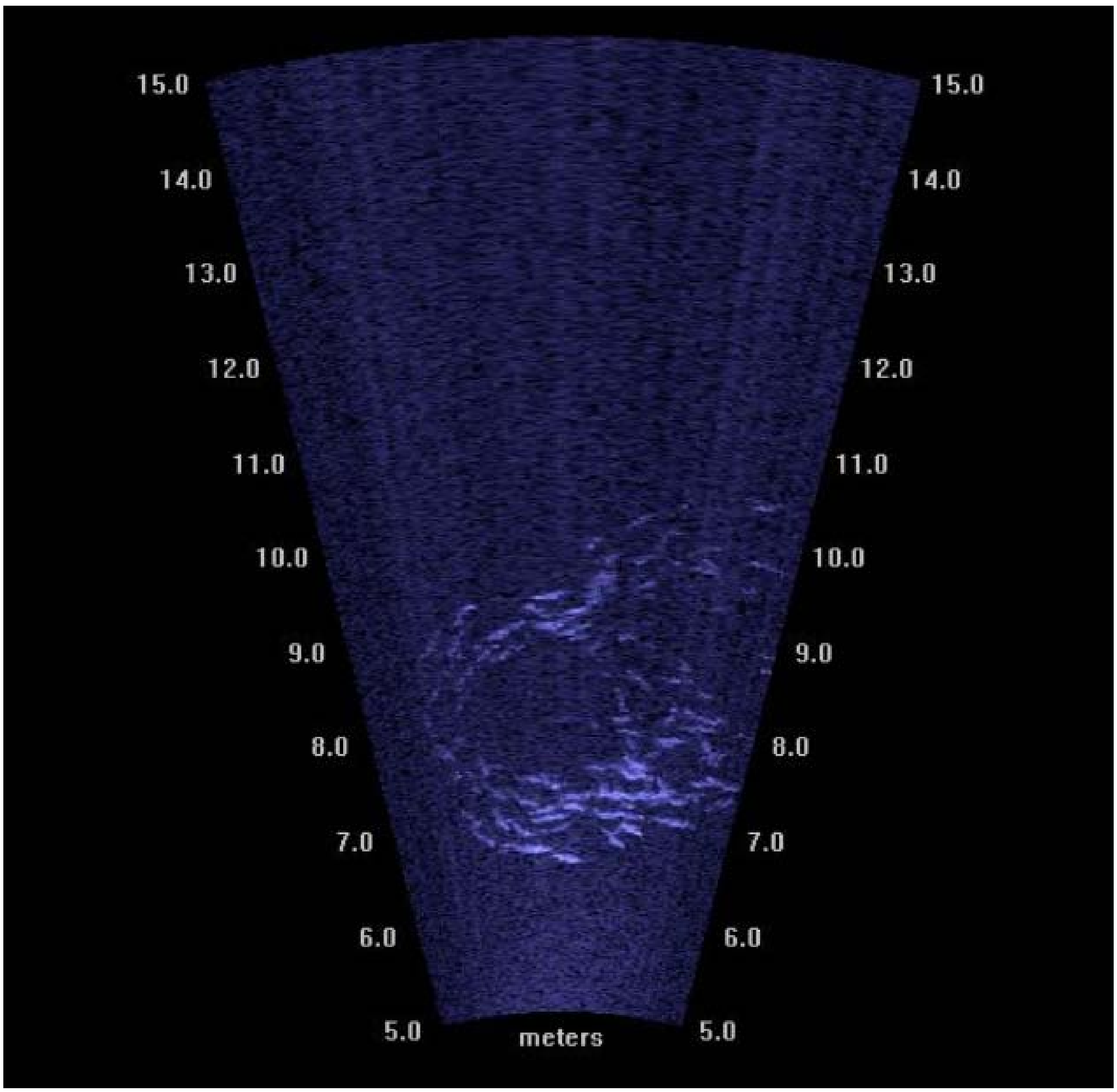
Figure B.3 Frame-Mounted DIDSON, RITE Turbine Deployment D1, Plan View



**** New graphic of orientation of RITE Stationary DIDSON 2006-2007***

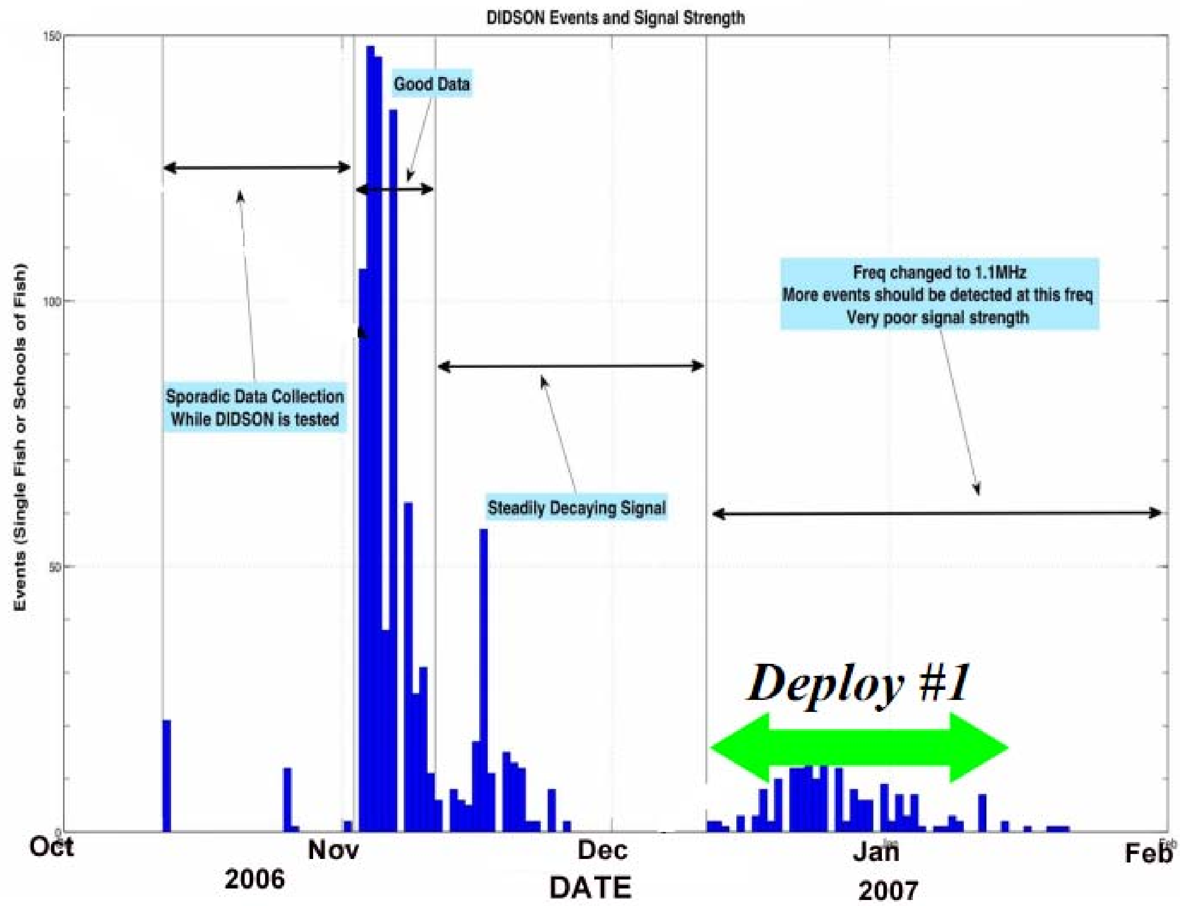
The following is an example of the good quality of fish imaging that was achieved albeit briefly, at distances less than 15 m. At distances greater than 15 m, the DIDSON switches into low frequency mode and the resolution is halved. This is a school of fish, approximately 30 cm in length, swirling 7-10 m from the DIDSON.

Figure B.4 Frame-Mounted DIDSON Imaging Example in High Resolution Mode



***** *Graphic from "The Verdant Power RITE Project - Project Update and Plans for 2008", May 2008, a presentation to agencies.***

Figure B.5 RITE DIDSON Operational History Deployment D1 - 2006 to 2007



**** Graphic from "The Verdant Power RITE Project - Project Update and Plans for 2008", May 2008, a presentation to agencies.***

The timeline shows the life of the DIDSON on SBT frame FF#2 during turbine Deployment #1. It was deployed the week of October 9, 2006, prior to the turbine installs. There appeared to be good imaging until the second week of November (3 weeks) when the image quality starts dropping off (later determined to be due to biofouling and silting and possibly an amplifier failure). In mid-December the KHPS T1 and T2 are installed and begin operating. The DIDSON is switched into low frequency/low resolution mode to try and compensate for weakening image. The DIDSON imaging continues to weaken and the DIDSON is declared inoperable by the end of January. Eventually it is pulled, found to have filled with silt and biofouling. It is redeployed with a silt-box but fails to work due to a power amplifier failure. The use of the DIDSON on the fish frame was suspended by mutual consent of the agencies. The DIDSON, in a mobile configuration that could attempt to get closer to the operating KHPS was proposed for Deployment #3 as the VAMS.

2.0 RITE VESSEL-MOUNTED DIDSON: SEPTEMBER TO OCTOBER 2008 – DEPLOYMENT #3 (B.6-B.X)

In September – October 2008, as part of the demonstration project activities under the Fish Movement and Protection Plan (FMPP), a Mobile DIDSON groundtruthing protocol was conducted. The figures presented below are a summary of those key findings. Verdant collected imaging of fish in proximity of an operating KHPS on both slack, ebb and flood using a mobile technique whereby the DIDSON was mounted on a Vessel-based Aimable Mount for Sonar (VAMS). This protocol was developed as part of the Fish Movement and Monitoring Plan (FMPP) required under joint NYSDEC/USACE permits for the RITE demonstration.

Figures B.6 - B.8 depicts the VAMS system and protocol further described in the February 2009 Report. Verdant Power's second effort, this time with a mobile DIDSON system during Deployment D#3, significantly improved on some of the limitations noted from D1:

- The Figure B.9 shows beam coverage as implemented the September – October 2008 monitoring and clearly shows the ***imaging distance of approximately <12 m proved to ensonify the operating KHPS machines and fish activity/interaction.***
- Figure B.10 shows that in conjunction with the analysis of the 3 years of prior SBT data with respect to tidal flow information (detail resented in Appendix A). ***Verdant can target a 3-week window of likely fish presence and abundance that provides the best time to conduct DIDSON observation.***
- Figure B.11 summarizes fish observations seen during the three VAMS outings, with respect to the observations from the fixed frame hydroacoustics. A relatively ***low density of fish targets are seen in both instruments*** as some evidence or "groundtruthing" to the body of fixed hydroacoustic data.
- Figure B.12 summarizes key video clips from the VAMS effort. Figure B.13 and B.14 describe a sequence of images from the October 2008 VAMS that shows what appears

to be a school of small fish, length approximately 10 cm, approaching the rotating T6P1 turbine and then ***moving and/or swimming up and around the outside of the area of the rotating KHPS turbine blade tip.*** This is the only DIDSON image from the 2008 observations (17 hrs), which clearly showed some an interaction between fish and a rotating KHPS blade.

- Figure B.15A and B.15B are stills of imagery possible with the DIDSON, of both rotating KHPS (no fish present) and non-operating KHPS (slack – fish present).

In general, the second effort of DIDSON use, in a mobile VAMS configuration at RITE was:

- Useful for determining ***size and location of fish in the channel and water column*** (B.11 to B.15)
- Useful for observing and understanding ***reaction to KHPS machines*** (Figures B.13 to B.15)
- An excellent tool for O&M (unintended benefit)
- Highly satisfactory but can still be improved

More importantly, the DIDSON VAMS effort specifically:

- Provided initial video evidence of reaction to KHPS turbines (Figures B.13 to B.15)
- Demonstrated ***potential avoidance behavior*** (Figures B.13 and B.14)
- Enabled individual fish and/or school tracking (Figures B.13 and B.14)
- Visualized the KHPS and rotating rotor plane (Figures B.13 to B15)

These October – December 2008 observations generally:

- Corroborated conclusions of fixed hydroacoustic imaging (Figure B.11)
- Corroborated that ***fish are observed and measured mostly on slack*** (Figures B.12 and B.16)
- Corroborated that ***fish are not generally in the operational zone*** of the KHPS (Figures B.15)

- Confirmed ***low relative fish densities*** (Figure B.11) even in known seasonal high periods

The February 2009 report concludes:

- Active observation is possible with a mobile VAMS (DIDSON/SBT aiming) protocol to observe fish interaction with operating and non-operating KHPS. Its limitations are restricted to daylight on-water efforts and vessel maneuverability.
- The major conclusions of the fixed hydroacoustic study, as discussed in detail in the FERC Draft License Application (Reference 3) pages E-101-108, are largely supported by this body of observation:
  - Daily fish densities are low (per frame ranging from 16 per day to >1,400, with an average around 330). Observations during the VAMS confirmed this still to be true (Figure B.11).
  - Most fish are observed inshore, in waters that are slower and shallower than those the turbines are located in.
    - Fish were not observed generally observed in the turbine zones with the DIDSON/SBT and the KHPS rotating (Figure B.15A).
  - Most fish movement is observed with tides or during transition periods of non-operation – water velocities from slack to 0.8 m/sec, when the turbines are stationary.
    - Fish generally were observed during slack, as supported by the Figures B.11 – B.15
  - Fish are more abundant in non-turbine zones than inline with the turbines, indicating possible avoidance behavior.
    - This was the case in the limited 17hrs of VAMS observation.

This diagram shows the VAMS with a DIDSON and a SBT installed for observations and groundtruthing of previous DIDSON and SBT data. The mount clamped onto the side of a vessel. The control stick on top allowed the instruments to be yawed and pitched to aim them where desired. While aiming the DIDSON, observer wore display goggles to view the DIDSON’s images.

Figure B.6 Vessel-Mounted DIDSON, Turbine Deployment D3, Plan View

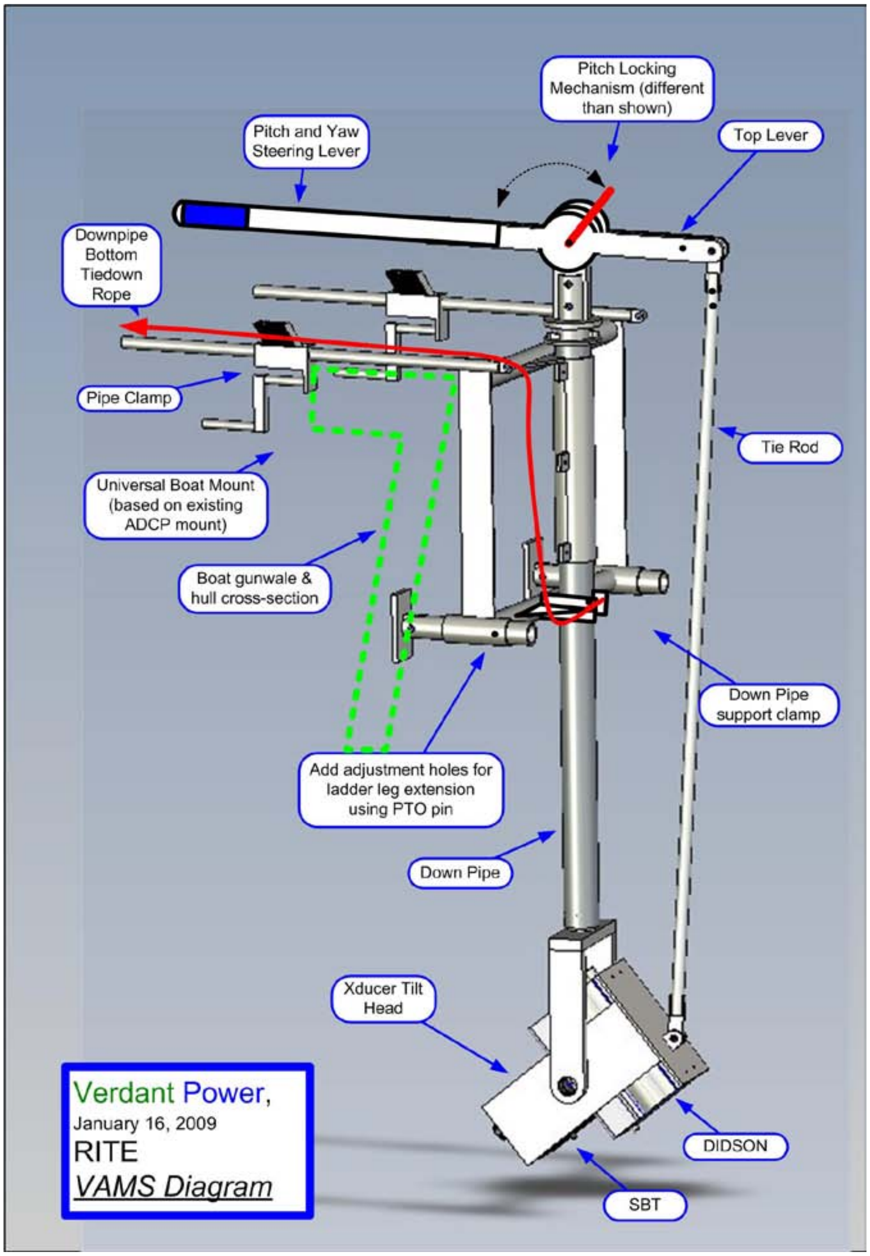
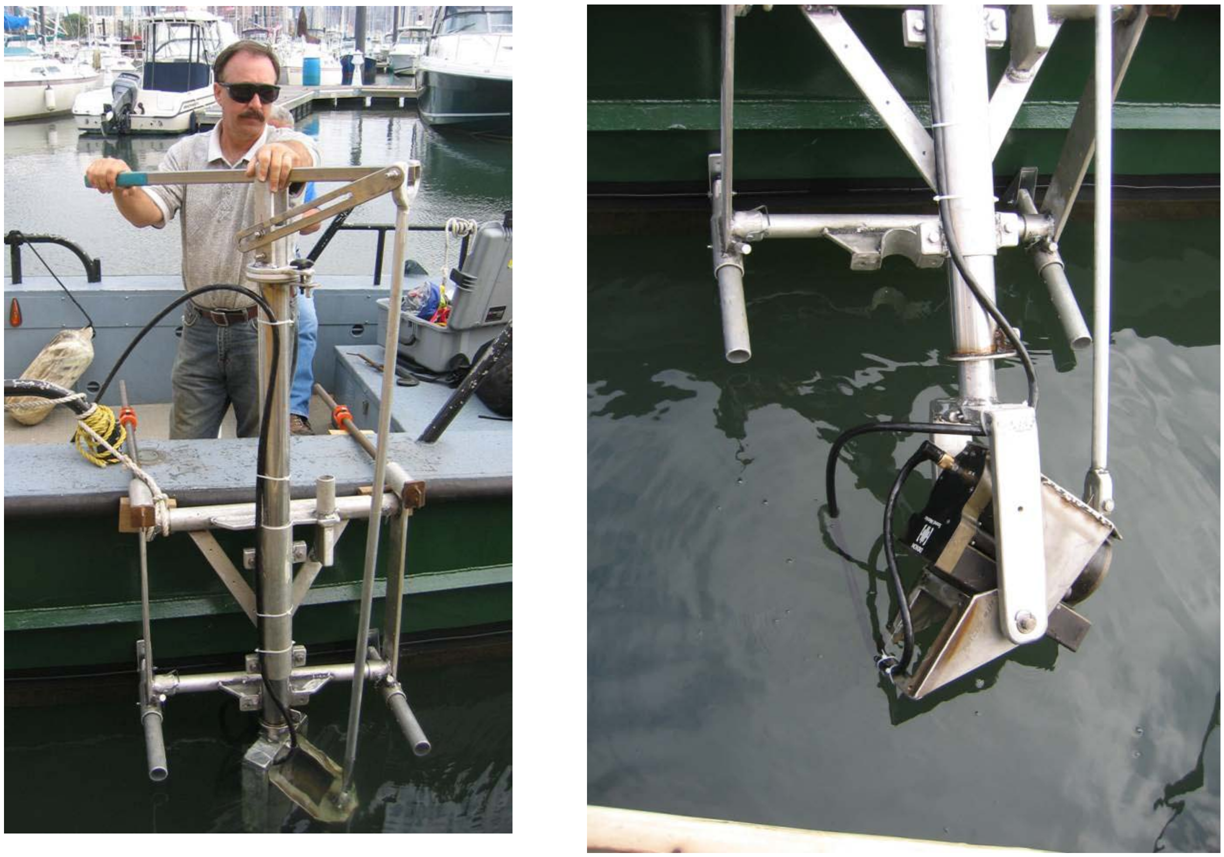


Figure B.7 RITE VAMS DIDSON Mount

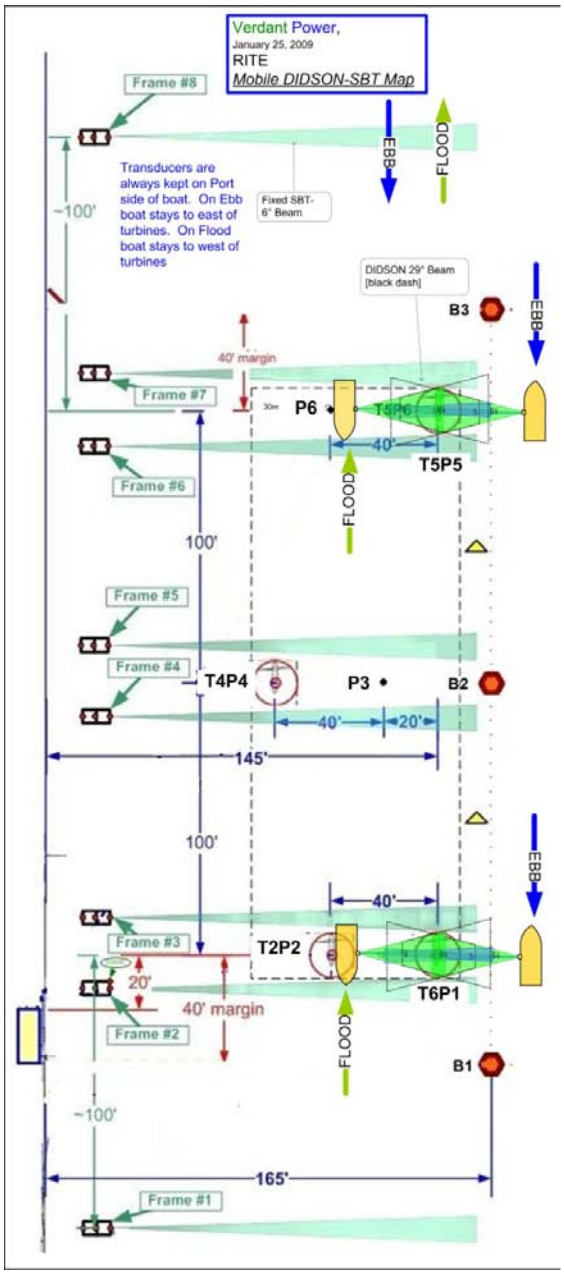


On Left: VAMS shown mounted to boat with the operator holding the aiming lever which controls yaw and pitch of the DIDSON and SBT.

On Right: DIDSON shown mounted on bottom pivot.

This chart shows the monitoring locations used by VAMS-mounted DIDSON and SBT. The boat maneuvered adjacent to the two KHPS turbines T5P5 and T6P1, which were operating for part of the observations.

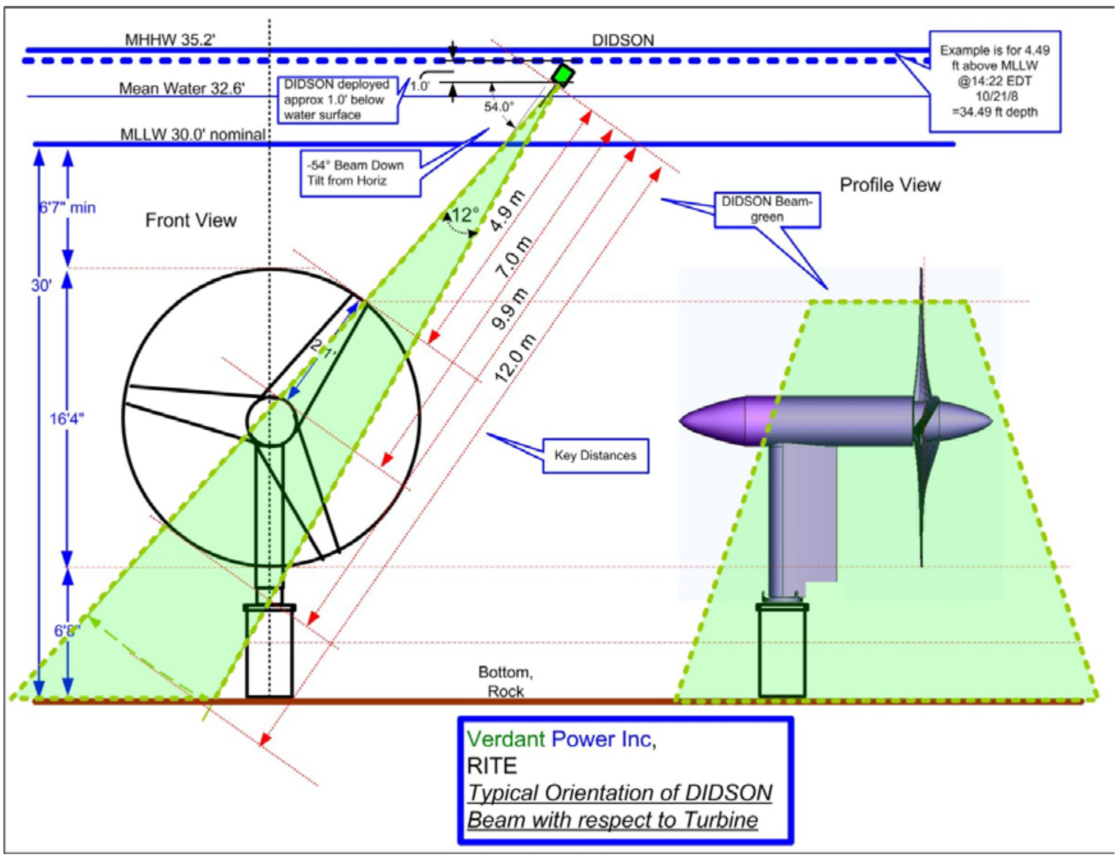
Figure B.8 VAMS DIDSON/SBT Monitoring Zone Chart, Turbine Deployment D3, Plan View



**** Graphic from RITE Fish Movement and Protection Plan (FMPP) Report on DIDSON/SBT Groundtruthing, Feb 2009, Page 14***

This graphic shows the typical boat positioning and resulting beam coverage as implemented during the three VAMS DIDSON observation outings. The original plans were to image from further away so that more of the turbine and surroundings could be imaged at once, but the turbulent water conditions reduced the image clarity at further distances. ***The imaging distance of approximately <12m proved to ensonify the operating KHPS machines and fish activity/interaction.***

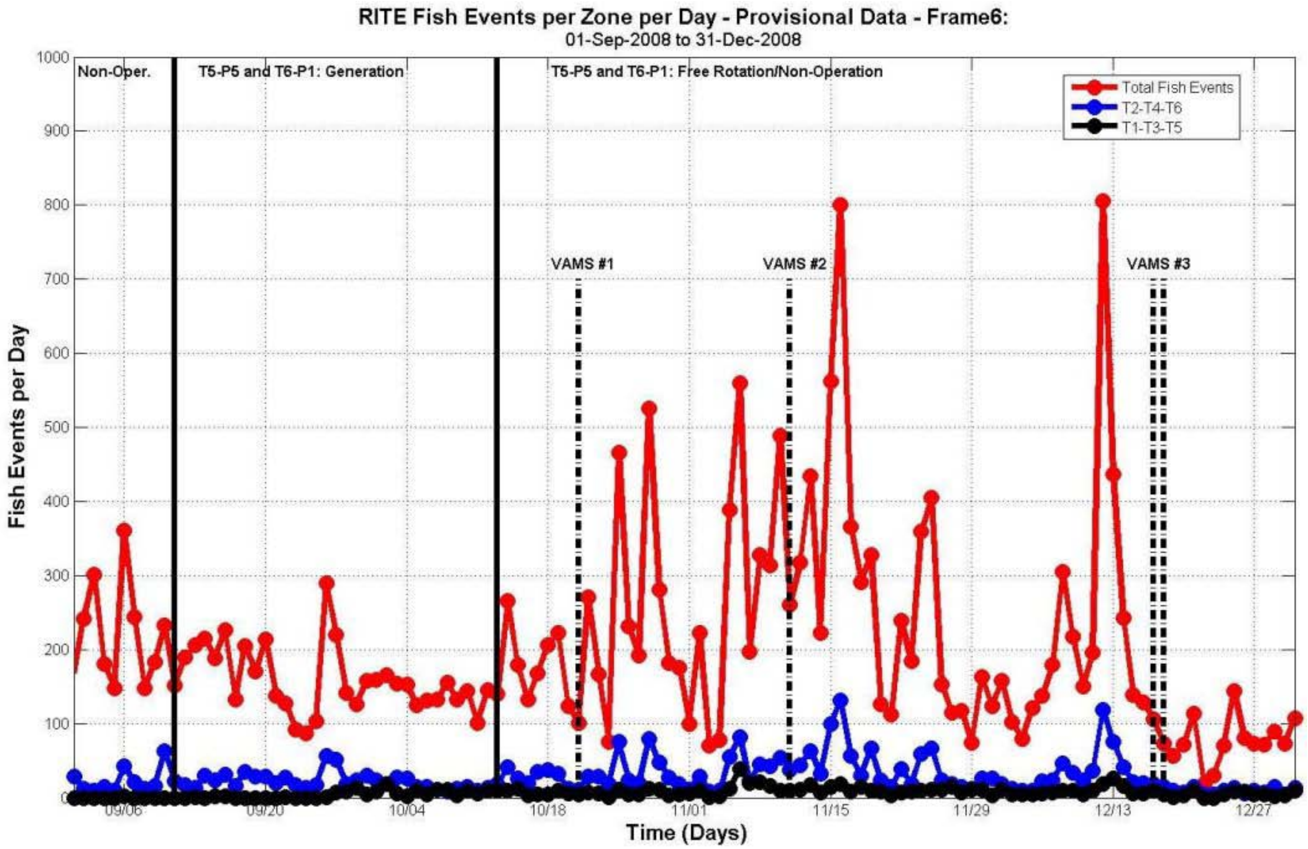
Figure B.9 VAMS DIDSON Best Beam Coverage View of RITE KHPS Turbine



**** Graphic from RITE Fish Movement and Protection Plan (FMPP) Report DIDSON/SBT Groundtruthing, Feb 2009, Page 16***

This graphic details the total number of fish events detected by the fixed SBTs at RITE during the three daily VAMS observation days (shown by dashed lines). Note that on those days the SBTs were turned off. ***Analysis of the SBT data with respect to tidal flow information (Appendix A) can target a 3-week window of likely fish presence and abundance that provides the best time to conduct DIDSON observation.***

Figure B.10 VAMS Observations and Fish Abundance Data from Fixed Hydroacoustic SBT Arrays – Sept. to Oct. 2008 (D#3)



**** Graphic from RITE Fish Movement and Protection Plan (FMPP) Report on DIDSON/SBT Groundtruthing, Feb 2009, Page 2***

This table summarizes the fish observations seen during the three VAMS outings, with respect to the observations from the fixed frame hydroacoustics. A relatively ***low density of fish targets are seen in both instruments*** as some evidence or 'groundtruthing" to the body of fixed hydroacoustic data. UMO refers to unidentified moving object and could be turbulence, debris (highly suspected), or small fish targets (unlikely due to season).

Figure B.11 Summary of RITE VAMS Observations – October to December 2008

Survey	Date	Fixed Frame 24 Hrs	Fixed Frame SBT Encounters in 6 Hrs			Mobile DIDSON Encounters during Survey		
		Total fish event	TOTAL	T2-T4-T6	T1-T3-T5	TOTAL	UMO	Fish
day before	10/20/2008	123	31	8	2	no survey		
VAMS GT #1	10/21/2008		OFF			13 (~ 6 hrs)	1	12
day after	10/22/2008	270	68	3	1	no survey		
day before	11/10/2008	489	82	11	4	no survey		
VAMS GT#2	11/11/2008		OFF			2 (~3 hrs)	0	2
day after	11/12/2008	317	80	10	2	no survey		
day before	12/16/2008	129	32	5	2	no survey		
VAMS GT#3	12/17/08 – 12/18/08		OFF			40 (~8 Hrs)	30	10
day after	12/19/2008	56	14	4	1	no survey		

Note:Data from the fixed frame hydroacoustics is divided by 4 to represent comparable periods.

**** Table from RITE Fish Movement and Protection Plan (FMPP) Report on DIDSON/SBT Groundtruthing, February 2009, Page 34***

This table summarizes the significant video events from on-water VAMS observation fish seen during the three surveys in October, November, and December 2008. The table indicates which turbine was imaged and its operational status.

Figure B.12 Significant Fish Observations at RITE from Three VAMS DIDSON Surveys

VAMS	RITE clip #	Date/Timing/Video clip file	Tide	Key Content	KHPS Status	Relevance
VAMS #1- Oct 2008	1	2008-10-21_142000_HF 142259 school plus 1 intersect rotor B.avi	Flood	Fish school sense and move above rotor; object follows (See Figures 9a and 9b for stills)	T6P1 No-load ~60 rpm (Rotation in profile)	Actual operating KHPS; fish movement and swimming away to avoid rotating blades at higher than loaded speed
	2	2008-10-21_094000_HF 094418 39cm fish.avi	Slack	1 fish ~40 cm moving slowly on bottom	T5P5 Not rotating	Large fish swimming at slack; also profiled in SBT
	3	2008-10-21_143000_HF 143515 19 T5 at normal speed.avi	Flood	No fish observed while rotating	T5P5 at normal load speed ~35 rpm (Rotation in elevation)	Actual operating KHPS at normal load speed during flood
VAMS #2- Nov 2008	4	2008-11-11_121000_HF 121326 T5 at no-load speed.avi	Ebb	No fish observed while rotating	T5P5 at no-load speed ~85 rpm (Rotation in elevation)	Actual operating KHPS at normal load speed during flood
VAMS #3- Dec 2008	5	2008-12-17_150001_HF 150140 18cm fish.avi	Ebb	1 fish ~18 cm below rotor	T6P1 not rotating	Fish observed on tide
	6	2008-12-18_140001_HF 140300 2fish 10cm.avi	Slack	2 fish ~10 cm above rotor	T6P1 not rotating	Fish observed at slack
	7	2008-12-18_150001_HF 150159 1 fish 40cm.avi	Ebb	1 fish ~40 cm on bottom	T2P2 not rotating	Fish observed on tide

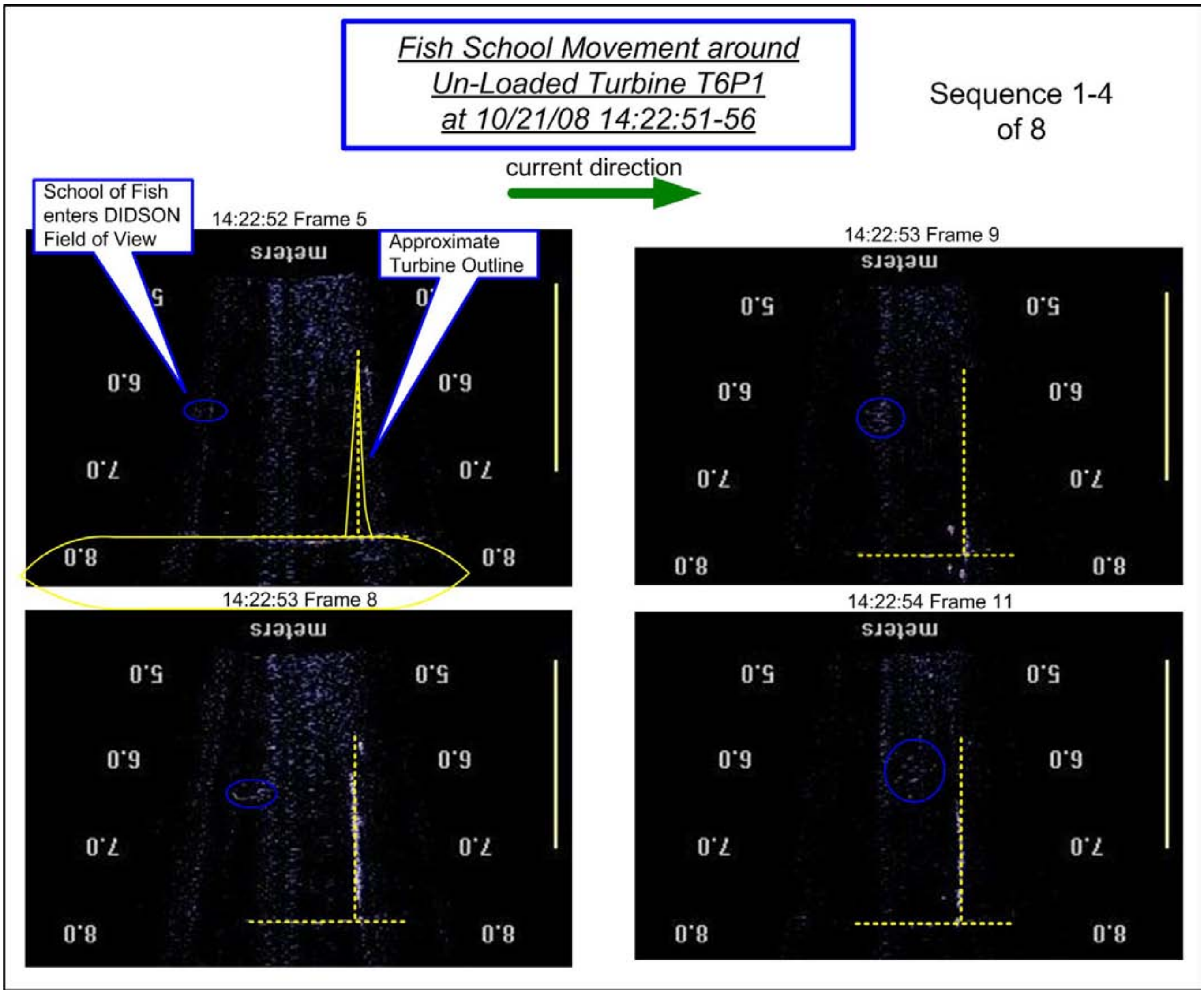
**** From RITE Fish Movement and Protection Plan (FMPP) Report on DIDSON/SBT Groundtruthing, February 2009, Page 31***

These video clips provide the following key results from the VAMS 2008 effort:

- RITE Clip #1 (as detailed below in Figure B.13 and B.14) is the only DIDSON image from the 2008 observations (17 hours), which clearly showed ***some interaction and potentially avoidance behavior with observed fish targets reacting to a rotating KHPS blade,*** as predicted by the hydrodynamic analysis.
- RITE Clips #2 and #6 are at slack tide; ***showing fish present when KHPS are not operating and on the bottom and top of the water column;*** supporting the zonal evidence suggested by the fixed hydroacoustics, that fish do not tend towards the zonal disk area of the KHPS at mid column (Appendix A).
- RITE Clips #3 and #4 are during operation of the KHPS machines and show no fish targets present during ebb and flood tide; supporting the temporal evidence suggested by the fixed hydroacoustics (Appendix A), that ***fish avoid movement on ebb and flood due to high water velocities, and therefore avoid temporal and spatial areas where KHPS are operating.***
- RITE Clips #5 and #7 were taken in December 2008 on ebb and both are found moving in the bottom of the water column on tide. The two KHPS were not operational or rotating at the time of this observation.

The following sequence of eight DIDSON images from the 10/21/08 VAMS DIDSON shows what appears to be a school of small fish, length approximately 10 cm, approaching the rotating T6P1 turbine and then ***moving and/or swimming up and around the outside of the area of the rotating KHPS turbine blade.*** This is the only DIDSON image from the 2008 observations (17 hrs), which clearly showed some interaction between fish and a rotating blade.

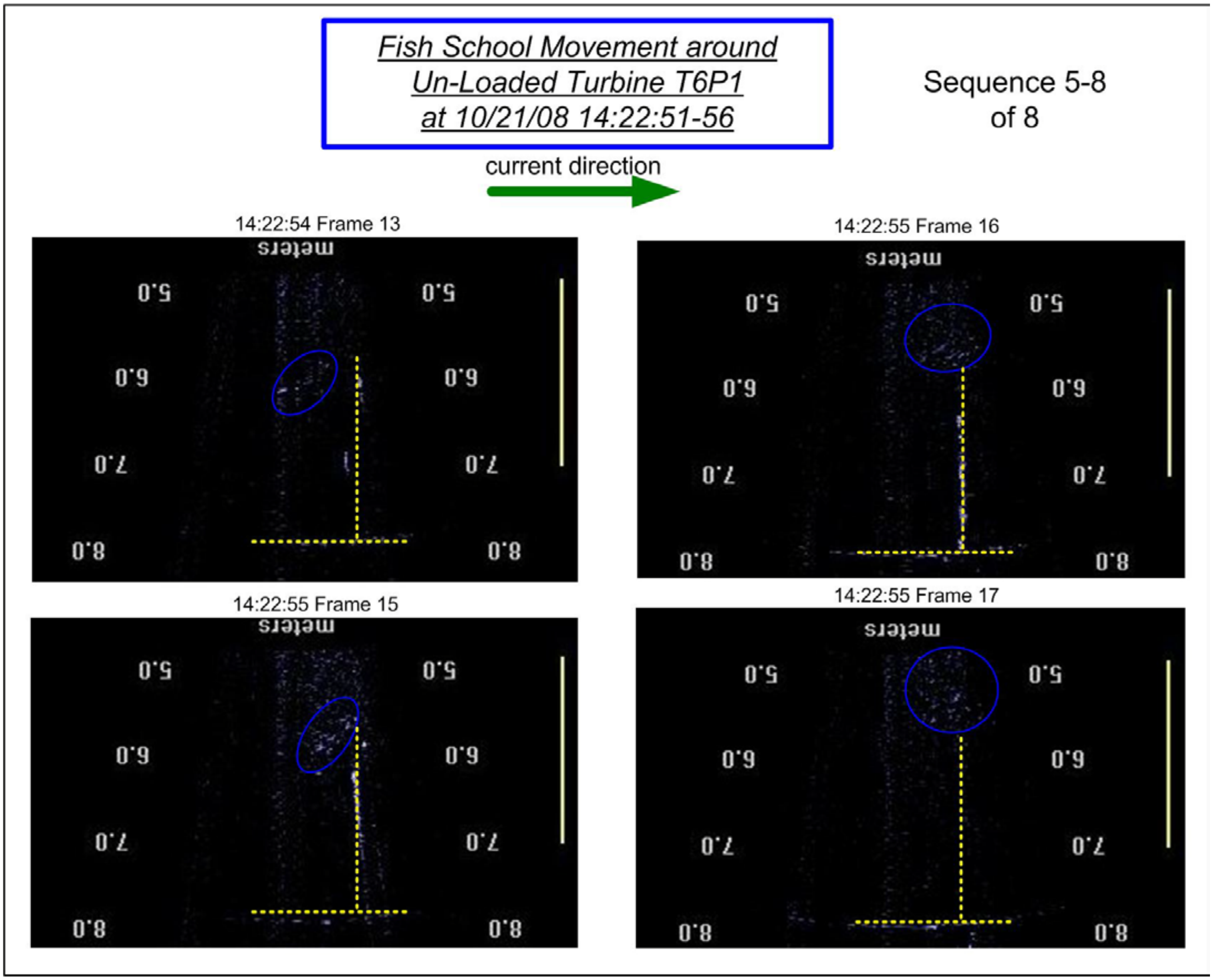
Figure B.13 Observation of Fish Moving beyond Rotating KHPS Turbine (Pg. 1 of 2)



* ***Images from RITE Fish Movement and Protection Plan (FMPP) Report on DIDSON/SBT Groundtruthing, Feb 2009, Page 30***

This sequence is continued from previous page. To better understand the positioning of the fish relative to the turbine see Figure B.13. Note that several seconds after this group of fish passed around the turbine an unidentified object appears to pass beyond the turbine blade.

Figure B.13 Observation of Fish Moving beyond Rotating KHPS Turbine (pg 2 of 2)

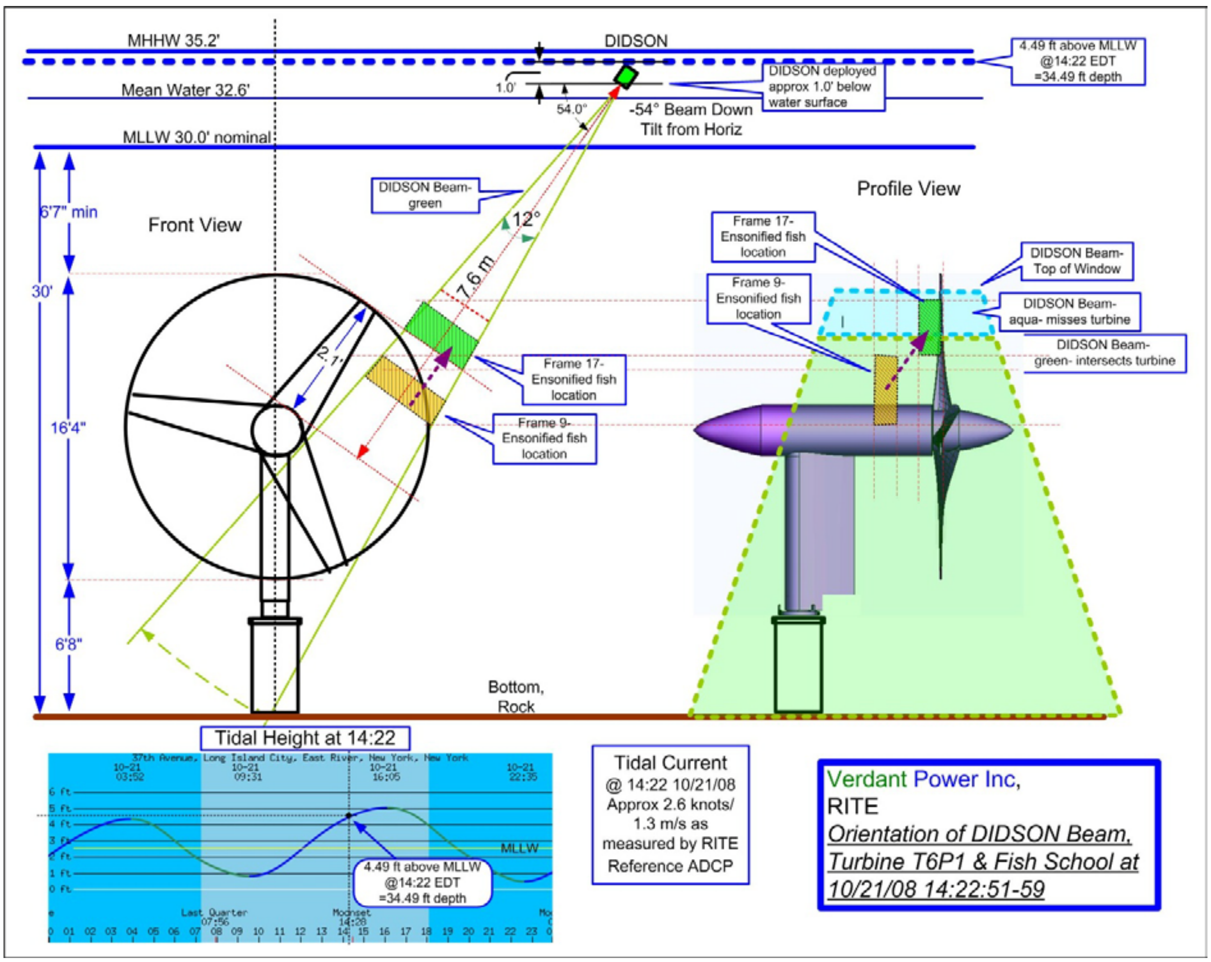


* ***Images from RITE Fish Movement and Protection Plan (FMPP) Report on DIDSON/SBT Groundtruthing, Feb 2009, Page 31***

This diagram shows the orientation of the, DIDSON beam, fish school and turbine blades relative to each other during the turbine-fish interaction event captured on 10/21/2008 at

14:22:52-59 and shown in the image sequence 1-8 in Figure B.13. The diagram geometrically calculates at the time of image frame 9 that the fish school is contained within the yellow rectangular region. The front view shows that except for a small corner, that yellow rectangular region is approaching the turbine disk, thus indicating with high likelihood that some if not all of the school is originally heading toward the turbine. The green rectangular area is the location of the school at image frame 17. The Front View indicates that the green rectangle is completely outside the turbine disk, thus indicating that the ensonified fish school has actively swam and/or passively drifted around the turbine.

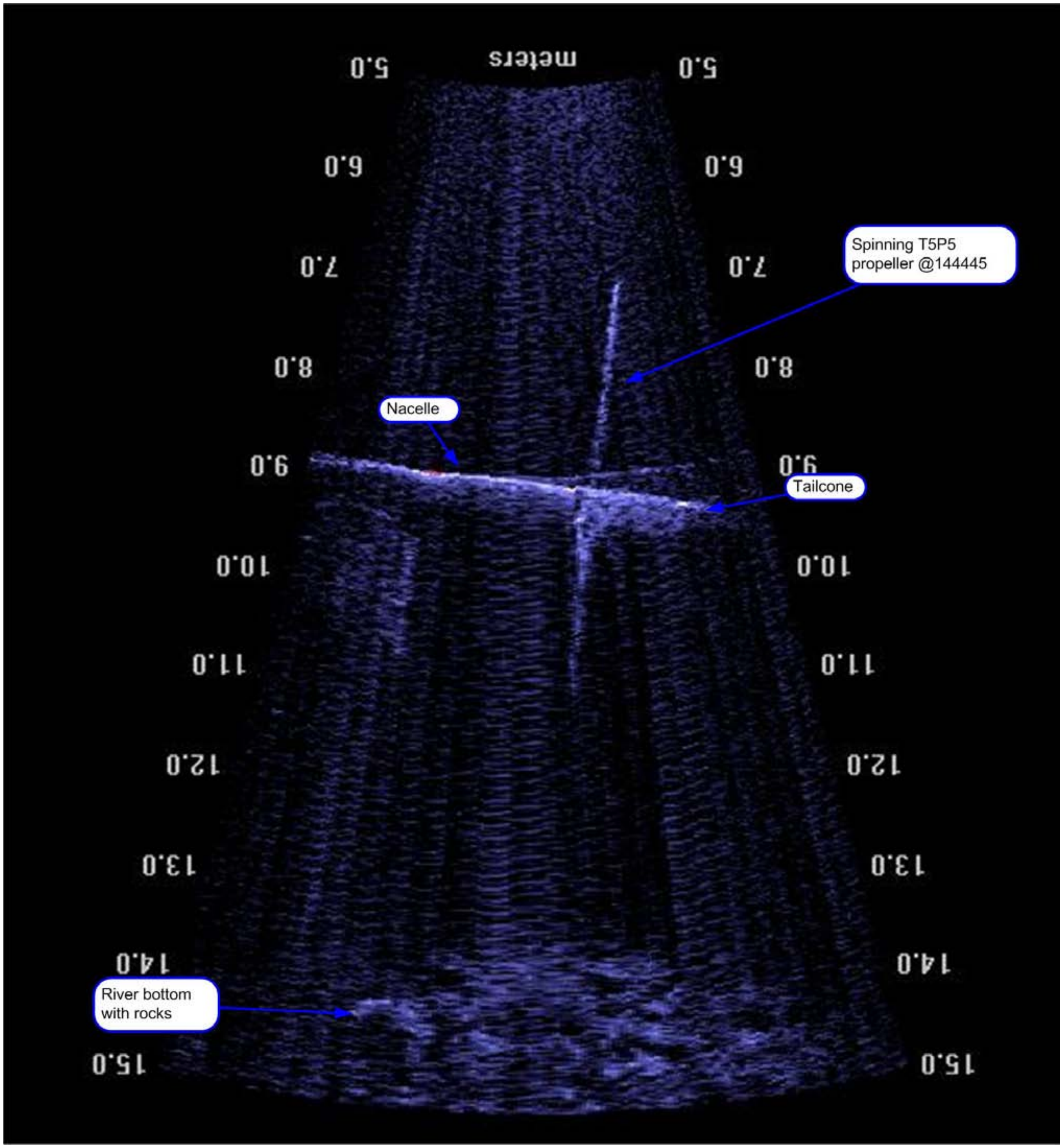
Figure B.14 Orientation of DIDSON Beam, Fish School and Turbine during 10/21/2008 Observation



***** ***Diagram from RITE Fish Movement and Protection Plan (FMPP) Report on DIDSON/SBT Groundtruthing, Feb 2009, Page 29***

This image clearly captured the rotating KHPS at approximately Xm during a X tide. No fish targets were observed in relation to the operating machine during the X second sequence.

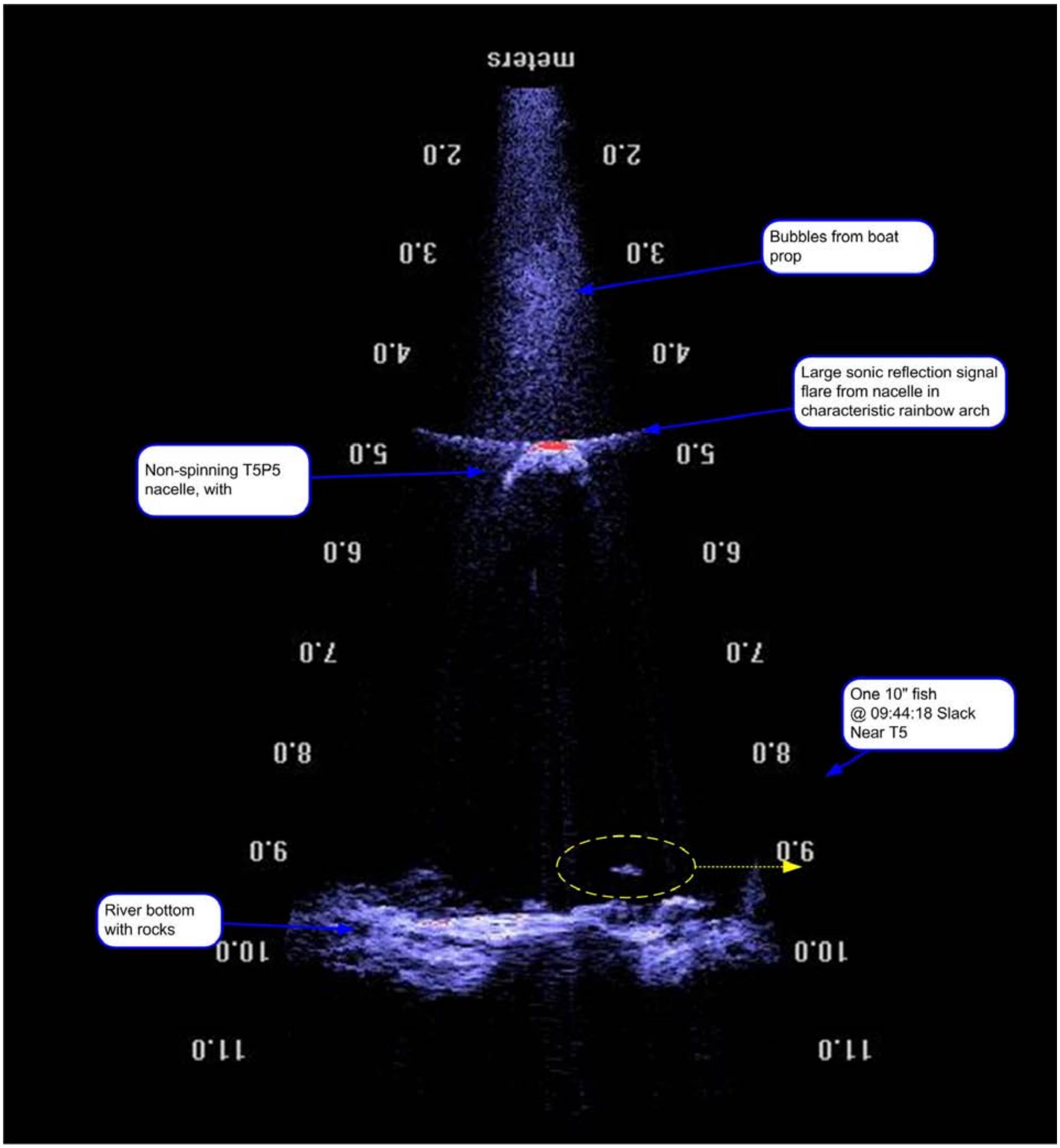
Figure B.15A   Imagery of a Rotating KHPS Turbine on Tide (no fish)



*** Image from RITE Project Environmental Monitoring Report Appendices (CDRLA007) p A12***

This image clearly captured a X cm present during slack within the water column. The KHPS turbine can also be seen but is not operating. The fish image is approximately Xm from the DIDSON.

Figure B.15B Imagery of the KHPS Turbine on Slack, No Rotation (with X cm fish in the bottom/top of water column)



*** *Image from RITE Project Environmental Monitoring Report Appendices (CDRLA007) p A13***

VOLUME 4

ATTACHMENT 1 – ESA

SHORTNOSE STURGEON BIOLOGICAL ASSESSMENT

BIOLOGICAL ASSESSMENT
SHORTNOSE STURGEON

ROOSEVELT ISLAND TIDAL ENERGY PROJECT

FERC NO. 12611

DECEMBER 2010

Prepared by:

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for:

VERDANT POWER

VERDANT POWER

ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT

BIOLOGICAL ASSESSMENT

SHORTNOSE STURGEON

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 PROJECT AREA 2

3.0 DESCRIPTION OF THE PROPOSED ACTION 2

- 3.1 UNDERWATER CABLING 5
- 3.2 CONSTRUCTION AND INSTALLATION SCHEDULE 5
- 3.3 PROJECT OPERATION 7

4.0 STATUS OF AFFECTED SPECIES 8

- 4.1 SHORTNOSE STURGEON LIFE HISTORY 8
- 4.2 STATUS AND TRENDS OF SHORTNOSE STURGEON RANGEWIDE 11
- 4.3 STATUS OF SHORTNOSE STURGEON IN THE ACTION AREA 15

5.0 ENVIRONMENTAL BASELINE 17

6.0 EFFECTS OF THE ACTION 18

7.0 CONCLUSION 21

8.0 LITERATURE CITED 21

VERDANT POWER
ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT
BIOLOGICAL ASSESSMENT
SHORTNOSE STURGEON

1.0 INTRODUCTION

This constitutes the biological assessment of shortnose sturgeon under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531-1543) on the effects of the proposed Verdant Power Island Tidal Energy (RITE) Project in the East River, New York, NY. The RITE Project is proposed to deliver commercial electricity from Verdant Power's Free Flow Kinetic Hydropower System and generate clean renewable energy from the river's tidal currents.

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 are located nearby in the Hudson River. Shortnose sturgeon have been captured near the confluence of the East River and New York Harbor and two shortnose sturgeon tagged in the Hudson River were recaptured in the lower Connecticut River (Savoy 2004). The presence of Hudson River tagged shortnose sturgeon in the Connecticut River may indicate some movement through the East River, however this is only one potential route between the two rivers. In a letter from National Marine Fisheries Service (NMFS) to the Federal Energy Regulatory Commission (FERC) re: Project No. 12611-003 (RITE Project) dated January 8, 2009 indicates that the best available information indicates that occasional transient shortnose sturgeon may be present in the East River.

2.0 PROJECT AREA

The East River is a 17-mile-long tidal strait connecting the waters of the Long Island Sound with those of the Atlantic Ocean in New York Harbor. The East River separates the New York City Boroughs of Manhattan and the Bronx from Brooklyn and Queens. The Harlem River flows from the Hudson River and connects with the East River at Hell Gate. The East River is a saltwater conveyance passage for tidal flow. There is some freshwater influence from the Harlem River and some direct drainage area from the surrounding metropolis, but the river is predominantly controlled by tidal influence.

In February 2005, Verdant conducted a remote sensing survey to document surficial and subsurface riverbed features in the east channel in the area of the experimental units. The survey was conducted using a high-resolution side-scan sonar device at frequencies of 500-kHz and 100-kHz respectively. Detailed images of the riverbed features were generated from data collected from the survey and was included in the report, "Acoustic Remote Sensing Survey for Roosevelt Island Tidal Energy Project," published in March 2005. The study confirmed the presence of boulders and cobbles that were depicted on the side-scan sonar and sub-bottom records. The video coverage did not show any evidence of fine grain soft sediments, thereby precluding any further requirement to obtain sediment samples for grain size and chemical analyses. This was also later confirmed when Verdant drilled the six piles into the bedrock for the demonstration project.

3.0 DESCRIPTION OF THE PROPOSED ACTION

Verdant Power, LLC (Verdant) is proposing to develop the Roosevelt Island Tidal Energy (RITE) Project, East Channel Pilot (RITE East Channel Pilot) under the Federal Energy Regulatory Commission (FERC)'s new Hydrokinetic Pilot Project Licensing Process. The project is located in the East River in New York City. The RITE East

Channel Pilot builds on the successful RITE demonstration that has been operating in the East River for several years. The RITE East Channel Pilot would consist of:

1) a field array of thirty (30), 5-meter diameter axial flow Kinetic Hydropower System (KHPS) turbine-generator units mounted on ten (10) triframe mounts, with a total capacity of 1 MW at 35 KW each;
2) underwater cables from each turbine to five shoreline switchgear vaults, that interconnect to a Control Room and interconnection points; and
3) appurtenant facilities to ensure safe navigation and turbine operation.

The project will be constructed in phases as further described below:

- Install A: Two Gen 5 Turbines on Existing Monopiles from RITE demonstration phase (not covered under RITE Pilot license)
- Install B1: Install Three Gen 5 Turbines on a Tri-frame
- Install B-2: Install up to Three Additional Tri-frames of Three Turbines
- Install C: Install up to Six Additional Triframes (no more than 30 Gen 5 KHPS total)

The Verdant Gen 5 KHPS turbine consists of four major components:

- Rotor with 3 fixed blades;
- Nacelle, pylon and yaw mechanism;
- Generator and drivetrain.
- Riverbed mounting system, (3 KHPS turbines on one tri-frame mount).

The RITE pilot project of 30 KHPS turbines would encompass a project boundary of approximately 21.6 acres, which includes 21.2 acres of underwater land lease and 0.4 acres of shoreline right-of-way for the Control Room, Cable Vaults and two underground transmission lines.

Key KHPS Technology Parameters (RITE Gen 5)

ROTOR	
Rotor hub diameter:	1.0 m
Rotor tip diameter:	5.0 m
Number of blades:	3 - Gen 5
Material of construction:	Rotor: Composite (FRP) construction Rotor Hub: Ductile Iron casting
Pitch control:	No
Yaw control	Passive
Ducted or open rotor:	Open
Solidity ratio:	16% (based on blade frontal area / total rotor area)
Rpm @ full load:	~40 rpm
Rpm limit: no load	Transient, ~20% over full-load velocity until brake fully applied and rotation stopped:
DRIVETRAIN	
Geared drive:	Yes, planetary
Shaft diameter:	0.127m stainless steel (RITE Gen 4 35kW)
Number of bearings:	2 main shaft, tapered roller bearings
Mechanical efficiency:	~93%
Lubrication:	gearbox: synthetic (PAO) gear oil; bearings: synthetic grease
GENERATOR	
Power produced on both ebb and flood tides:	Yes
Generator design:	induction, NEMA B
Synchronous:	near-synchronous
Rpm:	1800
Delivery voltage:	480VAC, 3 phase
Electrical efficiency:	~91.5% - 94.7%; NEMA Nominal 94.5%
Excitation:	self (induction)

3.1 UNDERWATER CABLING

The Verdant KHPS is designed to have limited above-water facilities. The RITE East Channel Pilot will include 480V electrical cables (no hydraulic oil systems) from each of the 30 KHPS turbines. Cables will travel through the pylon assembly of each turbine to the tri-frame mount. For each tri-frame mount, the three turbine cables will be bundled together into a set, which will then be paired with another set and routed from the field, weighted along the riverbed, to five shoreline switchgear vaults (vaults). The individual turbine cable lengths from the turbine-generator to the respective vaults range from 233 to 322 feet, with an average of 282 feet.

3.2 CONSTRUCTION AND INSTALLATION SCHEDULE

For the east channel pilot Verdant intend to use a staged installation procedure to ensure ongoing design validation.

- *Install A: Install Two Gen 5 Turbines on Existing Monopiles*
  - Installation would be accomplished in the fourth quarter of 2011 on existing foundation mountings.
  - This installation would be conducted within the boundaries of the established RITE demonstration project.
  - This effort would be conducted under a proposed modification and extension to the existing NYSDEC/USACE permit (expires May 2012) and the FERC Verdant Order and would not be under a FERC pilot License.
  - This stage of the project would last a minimum operational period of up to 180 days; and include environmental monitoring as described below.
  - Verdant will propose an extension of the existing permit term of 1½ years to November 2013 to allow for flexibility in the schedule; and incorporation of the agreed to 'Install A' monitoring plan.

- *Install B1: Install Three Gen 5 Turbines on a Tri-frame*
  - Install B1 would be governed by the terms of a FERC Pilot License, a new NYSDEC/USACE joint permit, and other requisite permits.

- The initial purpose would be to test the new tri-frame mount component of the technology and prove operation and maintenance techniques.
- The environmental monitoring from Install A continues, adding two additional elements.

- *Install B-2: Install up to Three Additional Tri-frames of Three Turbines Each*
    - Install B-2 would be done under the FERC Pilot License and additional authorizations; and expand the project to up to 12 operating KHPS in 2013.
    - This stage would include an additional element of environmental monitoring within an array of multiple Gen 5 machines to increase the understanding of environmental effects.
    - The experience and lessons learned from the execution of previous RITE Monitoring of Environmental Effects (RMEE) elements will be incorporated into this stage.

- *Install C: Install up to Six Additional Tri-frames (no more than 30 Gen 5 KHPS total)*
    - Incremental build out of the full Pilot project; incorporating the results of technology and environmental testing in previous stages.
    - This would also be done under the FERC Pilot License and additional authorizations and likely completed in 2014.

Based on Verdant's construction experience during the RITE demonstration, the construction periods for the RITE East Channel Pilot are short in duration. The construction installation is approximately 2 days per KHPS turbine, and one tri-frame mount per week, with a single installation crew. Based on this, Install A and B-1 are likely to take 1-2 weeks; Install B-2; 3-4 weeks and Install C; 5-6 weeks. It is anticipated that many of the component parts will be manufactured and assembled at a staging area in the surrounding New York area and floated by barge to the project site.

Other key points of the construction process include:

- Electrical power vaults are likely to be prefabricated offsite, minimizing any local disturbances to the existing area.
- Aggregate ground disturbance is expected to be <1 acre.
- Diver intervention will be minimized, but still needed for shoreline cable weighting and connections.
- The use of four semi-permanent piles to assist in construction deployment and potentially maintenance is under consideration and may or may not be required.

3.3 PROJECT OPERATION

The RITE East Channel Pilot will operate using the natural tidal currents of the East River. The Verdant KHPS captures energy from the flow in both ebb and flood directions by yawing with the changing tide, using a passive weathervaning system with a downstream rotor. As the flow direction changes, hydrodynamic forces on the rotor, nacelle, and pylon all contribute to yaw torque to align the rotor with the flow. There are no sensors, controls, or actuators to yaw the turbine. This design is far simpler than any active system to control turbine yaw or blade pitch, and has far fewer elements to foul or fail. The Gen 5 turbine utilizes a fixed blade design and Verdant considers this to be essential to reliable long-term underwater operation. The upstream pylon assembly, which is faired to provide a clean flow to the rotor, can also provide a degree of protection to the rotor. Turbine yaw is limited at 170° to ensure that the turbine will rotate in the same direction as the tidal current changes to allow a simple power cabling arrangement without slip rings.

4.0 STATUS OF AFFECTED SPECIES

The action being considered in this biological assessment may affect the endangered shortnose sturgeon (*Acipenser brevirostrum*). No critical habitat has been designated for shortnose sturgeon. This section will focus on the status of shortnose sturgeon within the action area, summarizing information necessary to establish the environmental baseline and to assess the effects of the proposed action.

4.1 SHORTNOSE STURGEON LIFE HISTORY

Shortnose sturgeon are benthic fish that are primarily found in the deep channel sections of large rivers. They feed on a variety of benthic and epibenthic invertebrates including molluscs, crustaceans (amphipods, chironomids, isopods), and oligochaete worms (Vladykov and Greeley 1963; Dadswell 1979 *in* NMFS 1998). Shortnose sturgeon have similar lengths at maturity (45-55 cm fork length) throughout their range, but, because sturgeon in southern rivers grow faster than those in northern rivers, southern sturgeon mature at younger ages (Dadswell *et al.* 1984). Shortnose sturgeon are long-lived (30-40 years) and, particularly in the northern extent of their range, mature at late ages. In the north, males reach maturity at 5 to 10 years, while females mature between 7 and 13 years. Based on limited data, females spawn every 3 to 5 years while males spawn approximately every 2years. The spawning period is estimated to last from a few days to several weeks. Spawning begins from late winter/early spring (southern rivers) to mid to late spring (northern rivers) when the freshwater temperatures increase to 8-9^{o}C.

Several published reports have presented the problems facing long-lived species that delay sexual maturity (Crouse *et al.* 1987; Crowder *et al.* 1994; Crouse 1999). In general, these reports concluded that animals that delay sexual maturity and reproduction must have high annual survival as juveniles through adulthood to ensure that enough juveniles survive to reproductive maturity and then reproduce enough times to maintain stable population sizes.

At hatching, shortnose sturgeon are blackish-colored, 7-11 mm long and resemble tadpoles (Buckley and Kynard 1981). In 9-12 days, the yolk sac is absorbed and the sturgeon develop into larvae which are about 15 mm total length (TL; Buckley and Kynard 198l). Sturgeon larvae are believed to begin downstream migrations at about 20 mm TL. Laboratory studies suggest that young sturgeon move downstream in a 2-step migration: a 2 to 3-day migration by larvae followed by a residency period by young of the year (YOY) fish, then a resumption of migration by yearlings in the second summer of life (Kynard 1997). Juvenile shortnose sturgeon (3-10 years old) reside in the interface between saltwater and freshwater in most rivers (NMFS 1998).

In populations that have free access to the total length of a river (*e.g.*, no dams within the species' range in a river: Saint John, Kennebec, Altamaha, Savannah, Delaware and Merrimack Rivers), spawning areas are located at the farthest upstream reach of the river (NMFS 1998). In the northern extent of their range, shortnose sturgeon exhibit three distinct movement patterns. These migratory movements are associated with spawning, feeding, and overwintering activities. In spring, as water temperatures rise above 8^{o}C, pre-spawning shortnose sturgeon move from overwintering grounds to spawning areas. Spawning occurs from mid/late March to mid/late May depending upon location and water temperature. Sturgeon spawn in upper, freshwater areas and feed and overwinter in both fresh and saline habitats. Shortnose sturgeon spawning migrations are characterized by rapid, directed and often extensive upstream movement (NMFS 1998).

Shortnose sturgeon are believed to spawn at discrete sites within a river (Kieffer and Kynard 1993). In the Merrimack River, males returned to only one reach during a 4-year telemetry study (Kieffer and Kynard 1993). Squiers *et al.* (1982) found that during the 3 years of the study in the Androscoggin River, adults returned to a 1-km reach below the Brunswick Dam. Kieffer and Kynard (1993) determined that adults spawned within a 2-km reach in the Connecticut River for three consecutive years. Spawning occurs over channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell *et al.*, 1984; NMFS 1998). Additional environmental conditions associated with spawning activity include decreasing river discharge following the peak spring freshet, water temperatures ranging from 8-12^{o}C, and bottom water velocities of 0.4 to 0.7 m/sec (Dadswell *et al.* 1984; NMFS 1998). For northern shortnose sturgeon, the temperature range for spawning is 6.5-8.0^{o}C. Individual eggs are initially discrete when spawned but become adhesive within approximately 20 minutes of fertilization (Dadswell *et al.* 1984). Between water temperatures of 8 and 12^{o}C, eggs generally hatch after approximately 13 days. The larvae are photonegative, remaining on the bottom for several days. Buckley and Kynard (1981) found week-old larvae to be photonegative and form aggregations with other larvae in concealment.

Adult shortnose sturgeon typically leave the spawning grounds soon after spawning. Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in spring and localized, wandering movements in summer and winter (Dadswell *et al.* 1984; Buckley and Kynard 1985; O'Herron *et al.* 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. YOY shortnose sturgeon are believed to move downstream after hatching (Dovel 1981) but remain within freshwater habitats. Older juveniles tend to move downstream in fall and winter as water temperatures decline and the salt wedge recedes. Juveniles move upstream in spring and feed mostly in freshwater reaches during summer.

Juvenile shortnose sturgeon generally move upstream in spring and summer and move back downstream in fall and winter; however, these movements usually occur in the region above the saltwater/freshwater interface (Dadswell *et al.* 1984; Hall *et al.* 1991). Adult sturgeon occurring in freshwater or fresh water tidal reaches of rivers in summer and winter often occupy only a few short reaches of the total length (Buckley and Kynard 1985). Summer concentration areas in southern rivers are cool, deep, thermal refugia, where adult and juvenile shortnose sturgeon congregate (Flournoy *et al.*1992; Rogers and Weber 1994; Rogers and Weber 1995; Weber 1996). While shortnose sturgeon are occasionally collected near the mouths of rivers and often spend time in estuaries, they are not known to participate in coastal migrations and are rarely documented in their non-natal river.

The temperature preference for shortnose sturgeon is not known (Dadswell *et al.* 1984) but shortnose sturgeon have been found in waters with temperatures as low as 2 to 3^{o}C (Dadswell *et al.* 1984) and as high as 34^{o}C (Heidt and Gilbert, 1978). However, temperatures above 28^{o}C are thought to adversely affect shortnose sturgeon. In the Altamaha River, temperatures of 28-30^{o}C during summer months create unsuitable conditions and shortnose sturgeon are found in deep cool water refuges.

Shortnose sturgeon are known to occur at a wide range of depths. A minimum depth of 0.6 m is necessary for the unimpeded swimming by adults. Shortnose sturgeon are known to occur at depths of up to 30 m but are generally found in waters less than 20 m (Dadswell *et al.*1984; Dadswell 1979). Shortnose sturgeon have also demonstrated tolerance to a wide range of salinities. Mcleave *et al.* (1977) reported adults moving freely through a wide range of salinities, crossing waters with differences of up to 10 ppt within a 2-hour period.

4.2 STATUS AND TRENDS OF SHORTNOSE STURGEON RANGEWIDE

Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973. Although the original listing notice did not cite reasons for listing the species, a 1973 Resource Publication, issued by the U.S. Department of the Interior, indicated that shortnose sturgeon were in peril in most of the rivers of its former range but probably not as yet extinct (USDOI l973). Pollution and overfishing, including by catch in the shad fishery, were listed as principal reasons for the species' decline. In the late nineteenth and early twentieth centuries, shortnose sturgeon commonly were taken in a commercial fishery for the closely related and commercially valuable Atlantic sturgeon. More than a century of extensive fishing for sturgeon contributed to the decline of shortnose sturgeon along the east coast. Heavy industrial development during the twentieth century in rivers inhabited by sturgeon impaired water quality and impeded these species' recovery; possibly resulting in substantially reduced abundance of shortnose sturgeon populations within portions of the species' ranges (*e.g.,* southernmost rivers of the species range: Santilla, St. Marys and St. Johns Rivers). A shortnose sturgeon recovery plan was published in December 1998 to promote the conservation and recovery of the species (NMFS 1998).

Although shortnose sturgeon are listed as endangered range-wide, the final recovery plan recognizes 19 spawning populations occurring throughout the range of the species. These populations are in New Brunswick, Canada (1); Maine (2); Massachusetts (1); Connecticut (1); New York (l); New Jersey/Delaware (l); Maryland and Virginia (1); North Carolina (1); South Carolina (4); Georgia (4); and Florida (2). NMFS has not formally recognized distinct population segments (DPS) of shortnose sturgeon under the ESA. Although genetic information within and among shortnose sturgeon occurring in different river systems is largely unknown, life history studies indicate that shortnose sturgeon populations from different river systems are substantially reproductively isolated (Kynard 1998) and, therefore, should be considered discrete. The 1998 Recovery Plan indicates that while genetic information may reveal that interbreeding does not occur between rivers that drain into a common estuary, at this time, such river systems are considered a single population comprised of breeding subpopulations (NMFS 1998).

Studies conducted since the issuance of the Recovery Plan have provided evidence suggesting that years of isolation between populations of shortnose sturgeon have led to morphological and genetic variation. Walsh *et al.* (2001) examined morphological and genetic variation of shortnose sturgeon in three rivers (Kennebec, Androscoggin, and Hudson). The study determined that the Hudson River shortnose sturgeon population differed markedly from the other two rivers for most morphological features (total length, fork length, head and snout length, mouth width, interorbital width, dorsal scute count, left lateral scute count, and right ventral scute count). Significant differences were found between fish from Androscoggin and Kennebec Rivers for interorbital width and lateral scute counts which suggests that even though the Androscoggin and Kennebec Rivers drain into a common estuary these rivers support largely discrete populations of shortnose sturgeon. The study also found significant genetic differences among all three populations indicating substantial reproductive isolation among them and that the observed morphological differences may be partly or wholly genetic.

Grunwald *et al.* (2002) examined mitochondrial DNA (mtDNA) from shortnose sturgeon in 11 river populations. The analysis demonstrated that all shortnose sturgeon populations examined showed moderate to high levels of genetic diversity as measured by haplotypic diversity indices. The limited sharing of haplotypes and the high number of private haplotypes are indicative of high homing fidelity and low gene flow. The researchers determined that glaciation in the Pleistocene Era was likely the most significant factor in shaping the phylogeographic pattern of mtDNA diversity and population structure of shortnose sturgeon. The Northern glaciated region extended south to the Hudson River while the southern non-glaciated region begins with the Delaware River. There is a high prevalence of haplotypes restricted to either of these two regions and relatively few are shared; this represents a historical subdivision that is tied to an important geological phenomenon that reflects historical isolation. Analyses of haplotype frequencies at the level of individual rivers showed significant differences among all systems in which reproduction is known to occur.

Waldman *et al.* (2002) also conducted mtDNA analysis on shortnose sturgeon from l1 river systems and identified 29 haplotypes. Of these haplotypes, 11 were unique to northern, glaciated systems and 13 were unique to the southern, non-glaciated systems. Only five were common to both. This analysis suggests that shortnose sturgeon show high structuring and discreteness and that low gene flow rates indicated strong homing fidelity.

Wirgin *et al.* (2005) also conducted mtDNA analysis on shortnose sturgeon from 12 rivers (St. John, Kennebec, Androscoggin, Upper Connecticut, Lower Connecticut, Hudson, Delaware, Chesapeake Bay, Cooper, Peedee, Savannah, Ogeechee and Altamaha). This analysis suggested that most population segments are independent and that genetic variation among groups was high.

The best available information demonstrates differences in life history and habitat preferences between northern and southern river systems and given the species' anadromous breeding habits, the rare occurrence of migration between river systems, and the documented genetic differences between river populations, it is unlikely that populations in adjacent river systems interbreed with any regularity. This likely accounts for the failure of shortnose sturgeon to repopulate river systems from which they have been extirpated, despite the geographic closeness of persisting populations. This characteristic of shortnose sturgeon also complicates recovery and persistence of this species in the future because, if a river population is extirpated in the future, it is unlikely that this river will be recolonized.

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. The range extended from the St. John River in New Brunswick, Canada to the Indian River in Florida. Today, only 19 populations remain ranging from the St. Johns River, Florida (possibly extirpated from this system) to the St. John River in New Brunswick, Canada.

The present range of shortnose sturgeon is disjoint, with northern populations separated from southern populations by a distance of about 400 km. The species is anadromous in the southern portion of its range (*i.e.*, south of Chesapeake Bay), while northern populations are amphidromous (fish move between fresh and salt water during some part of life cycle, but not for breeding; NMFS 1998). Population sizes vary across the species' range. From available estimates, the smallest populations occur in the Cape Fear (8 adults; Moser and Ross 1995) and Merrimack Rivers (100 adults; M. Kieffer, United States Geological Survey, personal communication), while the largest populations are found in the St. John (100,000; Dadswell 1979) and Hudson Rivers (61,000; Bain *et al.* 1998). As indicated in Kynard (1998), adult abundance is less than the minimum estimated viable population abundance of 1,000 adults for 5 of 11 surveyed northern populations and all natural southern populations. Kynard (1998) suggests that all aspects of the species' life history indicate that shortnose sturgeon should be abundant in most rivers. As such, the expected abundance of adults in northern and north-central populations should be thousands to tens of thousands of adults. Expected abundance in southern rivers is uncertain, but large rivers should likely have thousands of adults. The only river systems likely supporting populations of these sizes are the St. John, Hudson and possibly the Delaware and the Kennebec Rivers.

4.3 STATUS OF SHORTNOSE STURGEON IN THE ACTION AREA

Shortnose sturgeon occupy the lower Hudson River from late spring through early fall, shortnose sturgeon are dispersed throughout the deep, channel habitats of the freshwater and brackish reaches of the river (Bain 1997). Mollusks, insects and crustaceans make up 25 to 50% of their diet. In the late fall, most or all adult shortnose sturgeon congregate at a single wintering site near Sturgeon Point (river kilometer, rkm, 139) (Bain 1997). In the spring, the sturgeon migrate upstream to spawn and then migrate back downstream to the estuary to forage.

Hudson River shortnose sturgeon spawn in late-April to early May below Troy Dam (Bain 1997) in turbid and shallow water. Eggs adhere to the river bottom, as do the newly hatched larvae (Buckley and Kynard 1981). Hatching size ranges from 7 to 11 mm (Buckley and Kynard 1981). Larvae then move downstream to the Hudson River Estuary (Hoff *et al.* 1988). Juvenile shortnose sturgeon use the tidal reach of the Hudson River.

Data on the shortnose sturgeon population in the Hudson River estuary were obtained from a field studies conducted from 1994 to 1997, a shortnose sturgeon population study conducted by William Dovel and others during the 1970s, and a standardized fish monitoring program by the Hudson River electric utilities (Central Hudson Gas and Electric Corporation, Consolidated Edison Corporation of New York, New York Power Authority, Niagara Mohawk Power Corporation, and Southern Energy New York) (Bain *et al.* 2007). The studies provide shortnose sturgeon data and include population estimates and relative abundance data. Population estimates made in the late 1990s (about 60,000 fish with adults comprising >90% of the population) were compared to those made in the late 1970s and it was concluded the Hudson River population had increased by more than 400% over the period. Data from the Hudson River electric utilities annual trawl survey (1986 to 1997) also indicate more than a fourfold increase in abundance mainly in the adult segment of the population (Bain *et al.* 2007). It was concluded that Hudson River supports the largest population of shortnose sturgeon, and the system may harbor most individuals of the species (Bain *et al.* 2007). Most shortnose sturgeon captured in the Hudson River estuary in research and monitoring programs have been adults. The spawning and wintering habitats of shortnose sturgeon in the Hudson River have been well known since the late 1800s when an intense sturgeon fishery operated in the estuary. The juvenile wintering habitat has been described, but the spatial extent of summer sturgeon habitat had not been documented (Bain *et al.* 2007).

5.0 ENVIRONMENTAL BASELINE

Environmental baselines include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this biological assessment includes the effects of several activities that may affect the survival and recovery of the endangered species in the action area. The activities that shape the environmental baseline in the action area of this consultation generally include: power plant operations, dredging, fisheries, research projects, and water quality.

Since 2000, NMFS has reviewed more than 50 proposed actions (*i.e.*, dredging, shoreline stabilization and docks, pollution discharge permits), potentially affecting shortnose sturgeon in the Hudson River (Bain *et al.* 2007). NMFS has often specified protection measures such as construction timing and design changes to protect the species (Bain *et al.* 2007). Shortnose sturgeon have also benefited from a termination of fishing and other harm caused by capture, handling, and disturbance. Overall, the approach to recovery of shortnose sturgeon in the Hudson River has been to minimize interference with natural population processes and maintain habitat conditions able to support the species (Bain *et al.* 2007).

Shortnose sturgeon in the Hudson River exceed the criteria set by NMFS that a shortnose sturgeon population composed of 10,000 spawning adults is considered large enough to be at a low risk of extinction and adequate for delisting under the U.S. Endangered Species Act (Bain *et al*. 2007). Population estimates over two decades indicate a positive trend in population abundance. Despite the multitude of anthropogenic influences on the Hudson River ecosystem, the shortnose sturgeon population appears to have achieved recovery and may merit removal from the list of threatened and endangered species even in a human dominated ecosystem associated with one of the World's largest and most prominent cities (Bain *et al.* 2007). Other potential sources of impacts in the action area include incidental take in scientific studies, contaminants, water quality from both point and non-point sources, invasive species, dams, hydroelectric and steam electric power plants and future climate change.

6.0 EFFECTS OF THE ACTION

This section examines the likely effects (direct and indirect) of the proposed action on shortnose sturgeon in the action area and their habitat within the context of the species, current status, and the environmental baseline.

The hard-bottom substrate habitat in the project area consists of bedrock, boulders and cobbles with no evidence of fine grain soft sediments. Installation of tri-frame mounts and electric cables for the RITE hydrokinetic turbines may disturb substrate habitat and could result in a temporary increase in turbidity. Because installation of turbines will occur over a short period of time, water quality is expected to return to existing conditions following installation. Due to current velocities within the East River dispersion of re-suspended sediments, if any, would likely occur quickly. The proposed activities associated with this project would not significantly alter any habitat used by fish. There would be little to not impact to food source since epibenthic invertebrates are primarily found in mud and sand environments not hard-bottom bedrock.

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 model determines the probability of a fish entering the East River being struck by a turbine. Structurally, the model determines this strike likelihood by combining various parameters; including the water velocity distribution, the channel geometry; the KHPS physical and operating characteristics; and the specific fish characteristics; size (length in cm); burst speed; and swimming velocity in relationship to water velocity. The model is designed to be customizable and incorporate elements of various parameters as they become known. For example, over the past 3 years Verdant has sampled at the RITE site they have demonstrated that fish move with the tide in the east channel and are most abundant at slack tide. Since the turbines do not operate in currents less than 1 m/s there is no risk to fish during the period of their highest abundance which occurs over 27% of the tidal cycle. This type of site-specific knowledge is incorporated as parameters in the model.

The model at present assumes very little fish behavior. With regard to shortnose sturgeon, very little is known about their abundance, distribution or behavior in the East River since none have been recorded there. Unknowns include their spatial distribution throughout the river, the directions, shapes, and timing of their paths in the East River. The RITE Monitoring of Environmental Effects (RMEE) Plans were designed to improve site-specific knowledge which can then be incorporated in the model.

The model uses 9 parameters and is applied to calculate the strike probability for one turbine, Install A (2 turbines), Install B-1, (one tri-frame, 3 turbines), Install B-2, (4 tri-frames, 12 turbines), and Install C (10 tri-frames, 30 turbines). For turbines in a tri-frame, another probability parameter is added to reflect the number of turbines, and their spacing in the turbine field. The turbines in the field are treated as if the fish had an equal opportunity to go through all 30. In reality because the turbines are grouped together in

3’s on a tri-frame, it would be likely that a fish going through one turbine in a tri-frame would not be lined up to pass through either of the other two turbines. However it is difficult to quantify this interaction, so the simple but worst case of treating the turbines as independent is modeled. The strike probability for 1 tri-frame is simply the strike probability for a single turbine multiplied by the number of turbines in the single tri-frame, 3. A complete description of the model parameters including descriptions of all assumptions, constants and variables can be found in Attachment A.

Since NMFS and NYSDEC agree only occasional transient shortnose sturgeon may be present in the East River, it was assumed that 10% of the NYBDPS shortnose sturgeon would ever likely transit the river. Considering 10% of the Hudson River shortnose sturgeon population equates to over 6,000 fish, 10% appeared to be a conservative assumption. This percentage is applied to the final strike probability calculation. The RITE project specific fish interaction model resulted in a blade strike probability for shortnose sturgeon at 1 turbine to be 0.008%; Install A (2 turbines) to be 0.015%, Install B-1, (one tri-frame,) to be 0.023%, Install B-2, (4 tri-frames) to be 0.091%, and Install C (10 tri-frames) to be 0.28%.

The model only determines the probability of a strike by a turbine blade, not the probability of mortality. The model does differentiate between a strike that is determined to be too slow to cause any injury, and one that could cause injury or mortality. Strikes that are deemed too slow to cause any injury are treated as non-strikes. While there is some early injury and mortality studies of turbine blades on smaller fish (Amaral *et al.* 2008), predictions of mortality for the larger fish are left out of the model at present. Thus the output of the model is a strike probability, not an injury or mortality probability. Amaral *et al.* (2008) tested the effects of leading edge turbine blade on fish strike survival and injury. They found very high survival for white sturgeon at mean blade speeds ranging from 10.6 to 12.2 m/s which is comparable to the Verdant RITE outer edge blade speed of 10.5 m/s. Sturgeon strikes were tested for different body regions and found total blade strike survival was 100% for sturgeon struck in the head and caudal region and 97.4% for those struck in the midsection for fish that ranged from 100 to 150 mm. White sturgeon exhibited less mortality than comparable sized rainbow trout indicating that their cartilaginous skeleton and armored scutes make sturgeon less susceptible to blade strike injury than typical boney fishes (Amaral *et al.* 2008).

7.0 CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under NMFS jurisdiction, the environmental baseline for the action area, the effects of the action, and the cumulative effects, it is concluded that the proposed action is not likely to jeopardize the continued existence of shortnose sturgeon. Because no critical habitat is designated in the action area, none will be affected by the proposed action.

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ROOSEVELT ISLAND TIDAL ENERGY PROJECT
FERC NO. 12611

KHPS-FISH INTERACTION MODEL

DECEMBER 2010

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ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT

KHPS-FISH INTERACTION MODEL

TABLE OF CONTENTS

1.0 OVERVIEW 1

2.0 MODEL INTRODUCTION 1

2.1 DESCRIPTION OF PARAMETERS 3

2.1.1 P1: Probability of Blade Rotation 3

2.1.2 P2: Distribution of Water Velocity over the Tidal Cycle 4

2.1.3 P3: Fish Distribution 5

2.1.4 P4: Turbine Rotor Area 5

2.1.5 P5: Blade Interaction with Fish 7

2.1.6 P6: Fish Distribution 10

2.1.7 P7: Avoidance Behavior 10

2.1.8 Overall Probability of Strike 11

2.2 ARRAY AND FULL FIELD EFFECTS 11

3.0 CONCLUSIONS 14

LIST OF TABLES

Table 1. Parameters contained within the KHPS-Fish Interaction Model. 2

Table 2. Species specific parameters used in the KHPS-Fish Interaction Model for RITE. 9

Table 3. Probability of strike for a single turbine. 11

Table 4. Overall KHPS-Fish strike probabilities for proposed RITE Pilot Project. 12

LIST OF FIGURES

Figure 1. Probability of Gen 5 KHPS turbine rotation. 4
Figure 2. Velocity distribution at the RITE site in the East River. 4
Figure 3. Diagram showing rotor ejection zone. 6
Figure 4. Fish speed with respect to water velocity at the RITE site. 8
Figure 5. Probability of strike for fish passing through turbine disk. 10
Figure 6. Comparative KHPS-Fish strike probabilities for proposed RITE Pilot Project for various length fish. 13

VERDANT POWER

ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT

KHPS-FISH INTERACTION MODEL

1.0 OVERVIEW

In response to a request from the National Marine Fisheries Service (NMFS), Verdant and Kleinschmidt developed an in-stream kinetic hydropower turbine (KHPS)-fish interaction model for the East River in New York. The overall intention of this model is to quantify the risk that Verdant's KHPS turbines present to fish at the proposed Roosevelt Island Tidal Energy (RITE) Pilot Project in the East River in New York. This document provides a description of the model and presents and explains the assumptions made.

This is a simple, probability based model that determines the overall risk of a turbine blade striking a fish (blade strike). This model concentrates upon the turbine interaction with the Shortnose Sturgeon and Atlantic Sturgeon as these are protected species of interest in the area. However, comparative results are also generated for species identified in the Essential Fish Habitat Assessment that was performed as part of Verdant’s Final Pilot License Application.

2.0 MODEL INTRODUCTION

During the previous RITE demonstration, Verdant collected a large quantity of information on the spatial and temporal presence and abundance of typical resident and migrating fish commonly present at the project site, as detailed in Exhibit E. However, for the sturgeon species of interest, there has been no available supporting evidence to identify any particular temporal or spatial distribution, other than communication from NMFS that there is a chance that they may at times be present in the East River. As a result, one of the primary assumptions used in the development of this model is that any sturgeon that are present would be distributed evenly throughout the East River.

Additionally, based upon comments from NMFS, we are assuming that any sturgeon that may be present are using the East River as a migratory route to transit back and forth between Long Island Sound and the Hudson River. This behavioral assumption allows us to state that any particular fish is present because they are making a transit of river, rather than because this is their resident habitat.

These assumptions allow us to use a straightforward 2D model. The model uses a simple product of probabilities to provide an overall determination of the likelihood of blade strike. For simplicity, we have provided the following subdivision of items within this model that will have a contribution to the probability of a blade strike.

Table 1. Parameters contained within the KHPS-Fish Interaction Model.

Term	Parameter Description
P1	Probability of blade rotation
P2	Distribution of water velocity over the tidal cycle
P3	Fish distribution between East & West Channel
P4	Effective KHPS rotor area
P5	Blade interaction with fish passing through turbine disk
P6	Fish Distribution
P7	Fish Avoidance Behavior

Most of these parameters will vary as a function of water velocity and this has been presented in the following section. The overall probability of blade-strike can therefore be calculated as

$$P_T = \sum_{0}^{Vw=max} P_1 \times P_2 \times P_3 \times P_4 \times P_5 \times P_6 \times P_7$$

This equation simply states that the overall probability is a product of all the probabilities summed across all the water velocities of interest.

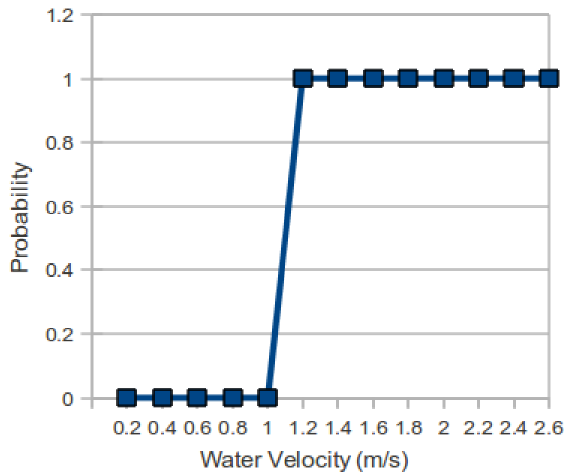
2.1 DESCRIPTION OF PARAMETERS

A description of the parameters, assumptions made and justifications is provided in the following section. This section includes consideration for the probability of strike from a single turbine only. This is then expanded into the effect of the full field in the final section.

2.1.1 P1: Probability of Blade Rotation

A unique characteristic of the Verdant design is that for the water velocities present at the site, the rotor will turn at a near constant speed of 40 rpm independent of the water velocity. In addition, the turbine features an automatically operated brake that will stop the turbine from rotating when water flow velocities are too low to generate power. This means that during times when the flow is below 1 m/s the turbine will not be rotating and will therefore not pose a risk. This is illustrated in Figure 1 which shows the probability of rotation as a function of water velocity.

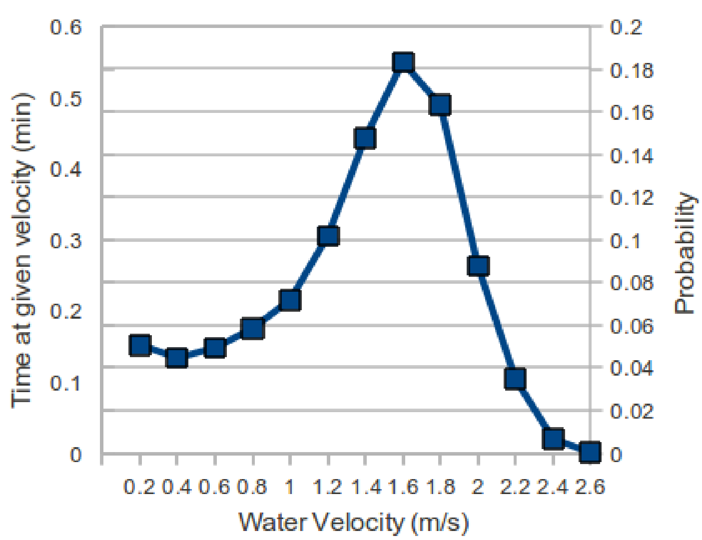
Figure 1. Probability of Gen 5 KHPS turbine rotation.



2.1.2 P2: Distribution of Water Velocity over the Tidal Cycle

The environment in the East River provides for a predictable, but constantly changing flow profile. The speed at which the water moves has a significant impact upon the risk of the fish being struck. As the turbine rotor will turn at a constant rate, faster water flows will incur a lower chance of strike as the fish will be carried through the rotor disk faster.

Figure 2. Velocity distribution at the RITE site in the East River.



In the absence of further information on ESA species of interest, the model assumes that there is an even distribution of fish over time; therefore, a fish could transit the channel during any particular part of the tidal cycle. Therefore the probability of a given flow condition will influence the chance of strike. Figure 2 shows the probability of certain flow speeds which have been generated from flow data collected by Verdant at the RITE site. These have been arbitrarily subdivided into 0.2 m/s bins.

2.1.3 P3: Fish Distribution

The East River bifurcates to flow around Roosevelt Island, forming the east and west channels. The cross sectional area of the channels is roughly equal (both channels have a similar width of approximately 240m and depth of 10m). The West Channel has a slightly higher average flow speed and the volume of water passing through both channels is equal to within approximately 5%. Combined with the even fish distribution assumption explained earlier, it reasonably follows that half of any fish present will transit via the west channel and will therefore not be affected by the turbines present in the east channel.

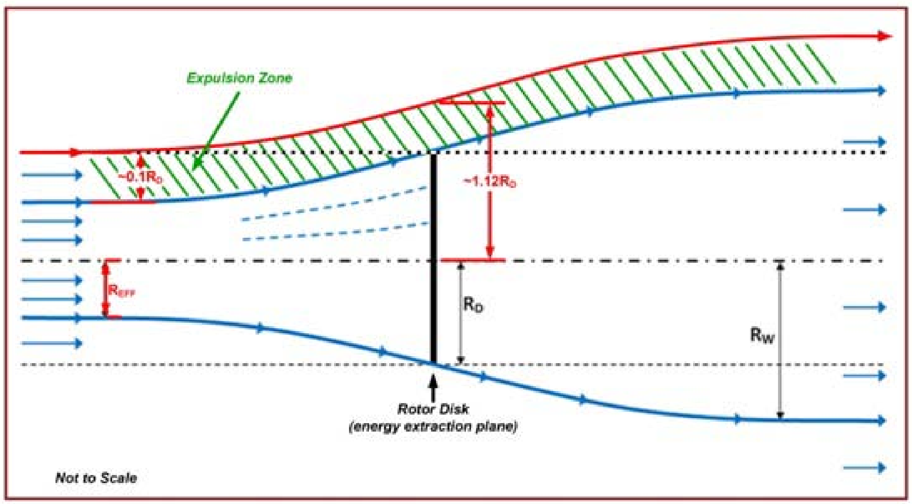
The model includes a probability of 0.5 (50%) to represent the equal likelihood that the fish will take the east channel (and be at risk) over the west channel (and have no risk). This probability is fixed and is not dependent upon the water velocity.

2.1.4 P4: Turbine Rotor Area

With a 2D model the turbine(s) will occupy a certain percentage of the cross sectional area of the river, therefore the probability that a fish will transit through the turbine area will be given by the ratio of overall channel cross sectional area to turbine area.

While the turbine disk area can be given by a standard calculation of area $(A = \pi \times r^2)$ hydrodynamic theory states there will be a volume of water incident on the disk that will be ejected due to the energy extraction function. This effect causes water to flow slower through the rotor than around it. Figure 4 shows this effect in profile and illustrates this 'ejection zone'. Any fish present in this zone will be moved away from the rotor. The existence of this effect has been acknowledged in the literature.[i,ii]

Figure 3. Diagram showing rotor ejection zone.



The cross sectional area of Verdant's 5m diameter turbine is 19.63m^2, while the ejection zone has been calculated at 3.7m^2. This gives an effective turbine area of 15.93m^2.

The profile of the east channel of the East River is well known and for the purposes of this model is approximated to be a square channel with a width of 240m and an average depth of 10m.

This ratio is a constant value and does not vary with water velocity. It is calculated as 0.0066.

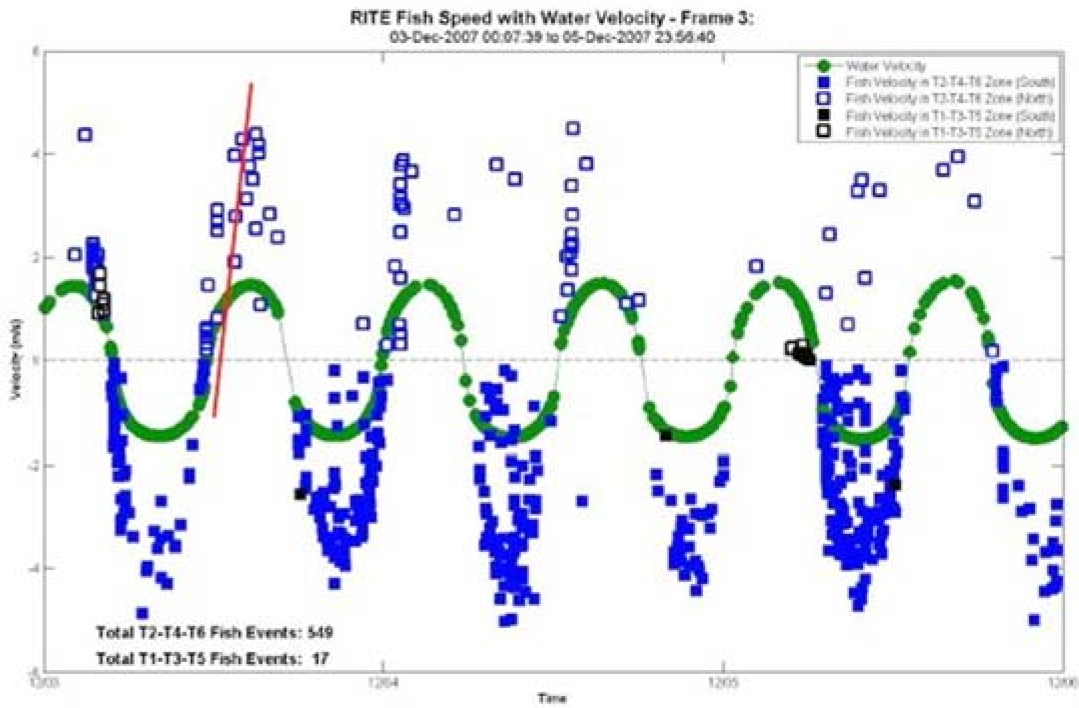
2.1.5 P5: Blade Interaction with Fish

For fish that will be incident upon the rotor, parameter P5 provides the probability of the blade impacting the fish (at any point on its body). This quantity is determined only by the speed of the fish approaching the turbine, the length of the fish, the rotational speed of the turbine blades and the angle that the fish is approaching the turbine.

The primary assumption included in this parameter is that a fish will try to avoid the turbine blades by swimming at its maximum burst speed through the rotor. Based upon the body of data collected during the RITE demonstration, it may be possible to justify some additional spatial or zonal avoidance behavior, however because there is no specific data available on the sturgeon species of interest no additional avoidance behavior is accounted for in the present model. The speed of the fish through the rotor will therefore be given only by the species maximum burst speed plus the water velocity.

Fish likely swim through the east channel in both directions. However, as illustrated in Figure 4, Verdant has collected a quantity of information on fish movements at the RITE east channel site which support the assumption that fish will typically be swimming with the current, especially at times of high current. From this data we have made the assumption that when the water velocity is less than the regular endurance speed for a particular species, then 80% of fish will be swimming with the current and 20% against. For times when the water velocity is greater than the regular endurance speed, all fish will be swimming with the current.

Figure 4. Fish speed with respect to water velocity at the RITE site.



** Presented in "FERC Draft License Application – Volume 2 – Exhibit E"*

Finally, the angle that the fish will approach the turbine disk is not known, therefore it is assumed that fish will be incident upon the rotor disk from an even distribution of angles (±90°) centered on the direction of transit (upstream or downstream). As the angle of incidence for the fish moves away from perpendicular, the effective length of the fish reduces, however its velocity through the rotor is also reduced.

For a given water velocity and fish species, the probability of strike for a fish incident on the turbine disk can be given by the following.[iii]

$$V_{apparent} = V_w + (V_b \sin(\theta))$$

$$L_{apparent} = L \sin(\theta)$$

$$P_{strike} = nR \times \left(\frac{L_{apparent}}{V_{apparent}} \right)$$

Where:

V_w = Water velocity
V_b = Species burst speed
L = Species nominal length
n = number of blades
R = Rotational speed (revolutions per second)
θ = Angle of incidence

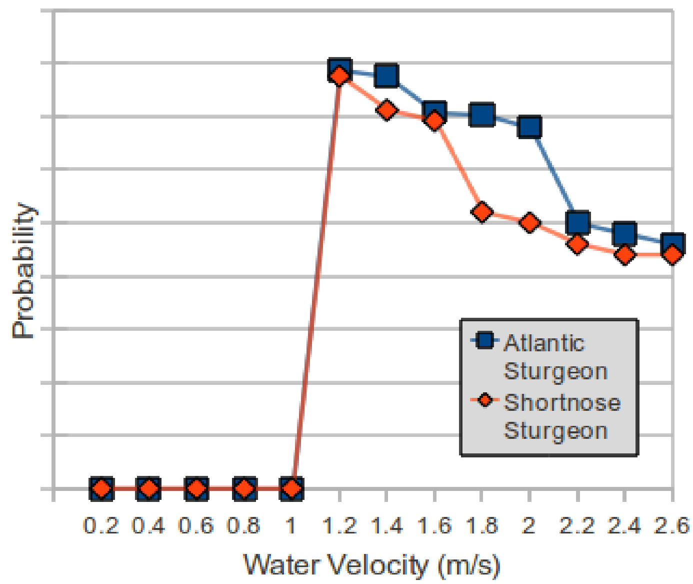
This equation is highly dependent upon the species specific parameters used for the fish, such as swim speed and overall length. The mean length of Shortnose and Atlantic sturgeon in Long Island Sound was reported to be 104 cm and 88 cm, respectively. [iv,v] These lengths were used in the model since it is assumed any migratory sturgeon traversing the East River are heading to or returning from Long Island Sound. Swim velocities can be categorized into endurance swimming speeds and burst swimming speeds. Unfortunately swim speeds for these species are less well determined, although it can be supported that a good approximation for the burst swim speed may be taken as 4 (four) times the nominal length per second.[vi] Endurance swim speed can typically be seen as being half of the burst swim speed. Table 2 provides the following species specific parameters that were used in the model.

Table 2. Species specific parameters used in the KHPS-Fish Interaction Model for RITE.

Species	Common Length (cm)	Endurance Swim Speed (Ve) (m/s)	Burst Swim Speed (Vb) (m/s)
Shortnose Sturgeon	88	1.76	3.52
Atlantic Sturgeon	104	2.08	4.16

As discussed above, water velocity will affect the probability for strike and it can be seen in Figure 5 how the probability varies with velocity and species. For velocities less than 1 m/s the turbine is not rotating, therefore values are zero.

Figure 5. Probability of strike for fish passing through turbine disk.



2.1.6 P6: Fish Distribution

This category is included for completeness. As described above, in the absence of further information on ESA fish species, the model assumes an even distribution of ESA fish in the East River. Therefore, P6=1 for all velocities. As information is learned from the proposed monitoring plans this parameter can potentially be modified.

2.1.7 P7: Avoidance Behavior

Again, this is included for completeness. This model takes a conservative approach and assumes no avoidance behavior other than assuming the fish will speed up to avoid being struck. This increase in velocity in included in parameter P5. Therefore, P7=1 for use in the current model. As information is learned from the proposed monitoring plans this parameter can potentially be modified.

2.1.8 Overall Probability of Strike

The parameters discussed here each vary with water velocity; therefore, it is difficult to easily illustrate the calculation. Spreadsheets are provided in Appendix A which detail the calculations. The results for a single turbine are provided in Table 3 below.

Table 3. Probability of strike for a single turbine.

Term	Probability of Strike
Atlantic Sturgeon	0.09%
Shortnose Sturgeon	0.08%

2.2 ARRAY AND FULL FIELD EFFECTS

Increasing the number of installed turbines will naturally increase the probability of strike. The proposed project will be installed in a series of steps as detailed in the license application. These are summarized below.

Stage	Size of Complete Field (not to exceed)
Install A:	Two KHPS turbines installed on existing monopoles
Install B-1:	Three KHPS turbines installed on one triframe[1] mount
Install B-2:	Twelve KHPS turbines installed on 4 triframe mounts
Install C:	Thirty KHPS turbines installed on 10 triframe mounts

1 The triframe is a riverbed structure that will mount three turbines in a triangular configuration. When installed on the frame, the turbines will each be spaced approximately 2 diameters apart.

The most conservative estimate for the impact of the full field of thirty KHPS turbines is to multiply the single unit probability by the number of installed units. However this assumption does not take into account the physical location of the KHPS turbines. This is a worst case assumption that may be over conservative. As the KHPS turbines will be clustered in a single location, any fish entering the full array would likely try to leave the area once passing close to or through a small number of units. Nevertheless, there is little validated or published data to support this assumption and as a result this model assumes no inherent avoidance of the array.

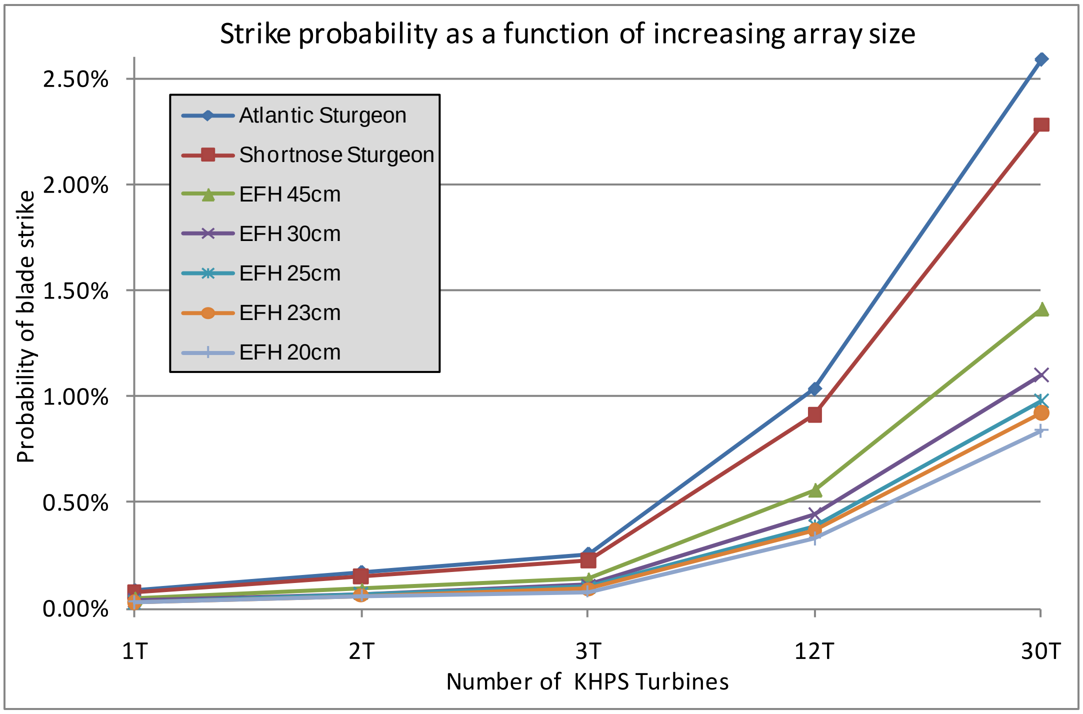
The strike probabilities for Atlantic and Shortnose sturgeon are presented for the full field in Table 4 below.

For the purposes of comparison, the model was run for a number of smaller essential fish habitat (EFH) species of varying length and these results are presented in Figure 6. This is overlaid as a comparison with the Atlantic and Shortnose sturgeon strike probabilities.

Table 4. Overall KHPS-Fish strike probabilities for proposed RITE Pilot Project.

Species	**Single Turbine**	**Install A (2 Turbines)**	**Install B-1 (3 Turbines)**	**Install B-2 (12 Turbines)**	**Install C (30 Turbines)**
Atlantic Sturgeon	0.09%	0.17%	0.26%	1.03%	2.59%
Shortnose Sturgeon	0.08%	0.15%	0.23%	0.91%	2.28%

Figure 6. Comparative KHPS-Fish strike probabilities for proposed RITE Pilot Project for various length fish.



3.0 CONCLUSIONS

This KHPS turbine-fish interaction model provides a summary of the assumptions used and methods applied to calculate the probability of a blade strike (with respect to the RITE pilot project) upon two ESA species of sturgeon in the East River, New York. While the investigation of fish interaction with operating KHPS turbines in terms of temporal and spatial abundance has been underway at the RITE site since 2007, the assumptions used in this model have attempted to take a conservative view. The staged installation and environmental monitoring program proposed by Verdant is intended to refine the body of knowledge in this area and improve the predictions made by this model.

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APPENDIX A

KHPS-Fish Interaction Model Output

Probability of blade interaction for Atlantic Sturgeon in the East River

Constants (Single Rotor)

L	104	cm (Common Length)
Vb	4.16	m/s (Burst Velocity)
Ve	2.08	m/s (Assumption)
n	3	blades
w	40	rpm
R	2.5	m (Turbine Rotor Radius)
D	10	m (River Avg Depth)
W	240	m (River Avg Width)
L	3700	m (River Avg Length)
Ar	19.625	m2 (Turbine Rotor Swept Area)
Aw	2400	m2 (East River Cross-sectional Area - W x D)
Ae	3.7	m2 (Expulsion Area)

	Vw	TOTAL PROBABILITY	2.6 m/s	2.4 m/s	2.2 m/s	2 m/s	1.8 m/s	1.6 m/s	1.4 m/s	1.2 m/s	0 to 1 m/s	NOTES:
SITE	**P1**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**Probability given a Rotation Condition (P = 1 if Vw > 0)**
	P2		**0.0002**	**0.0067**	**0.0347**	**0.0878**	**0.1631**	**0.1831**	**0.1477**	**0.1017**	**0.2749**	**Water Velocity Distribution (Measured at RITE)**
	P3		**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**East/West Channel Split (Fish Evenly Split Between East and West Channel)**
KHPS	**P4**		**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**Impact Area of Rotor Coverage ((Ar - Ae)/Aw)**
	Vf Max		6.76 m/s	6.56 m/s	6.36 m/s	6.16 m/s	5.96 m/s	5.76 m/s	5.56 m/s	5.36 m/s		Vf Max = Vw + Vb fish swimming with current
	P5.Vf Max		**0.23**	**0.24**	**0.25**	**0.26**	**0.28**	**0.29**	**0.30**	**0.32**		
	Vf Min		N/A	N/A	N/A	-2.16 m/s	-2.36 m/s	-2.56 m/s	-2.76 m/s	-2.96 m/s		Vf Min = Vw - Vb fish swimming against current
	P5.Vf Min		**0**	**0**	**0**	**0.66**	**0.64**	**0.61**	**0.74**	**0.69**		
	P5.Current		**1**	**1**	**1**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**	**Fish Swimming with the Current**
	P5		**0.23**	**0.24**	**0.25**	**0.34**	**0.35**	**0.35**	**0.39**	**0.39**	**0**	**Blade Interaction (Function of Water Velocity, Fish Burst Speed and Fish Length)**
FISH	**P6**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**Fish Distribution (Uniform Fish Distribution)**
	P7		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**Avoidance behavior (P = 1 When No Fish Avoid Turbines)**
	P8		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**Endurance behavior (50% of Fish Downstream of Rotor Cannot Approach Turbine if Vw > Ve)**
1 TURBINE	**P =**	**0.09%**	**0.000000**	**0.000005**	**0.000029**	**0.000099**	**0.000191**	**0.000215**	**0.000190**	**0.000133**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 1 TURBINE**
INSTALL A	**P9.A**		**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**Number of Operating KHPS**
2 TURBINES	**P.A =**	**0.17%**	**0.000000**	**0.000011**	**0.000058**	**0.000198**	**0.000381**	**0.000430**	**0.000380**	**0.000266**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 2 TURBINES**
INSTALL B-1	**P9.B-1**		**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**Number of Operating KHPS**
3 TURBINES	**P.B-1 =**	**0.26%**	**0.000001**	**0.000016**	**0.000086**	**0.000297**	**0.000572**	**0.000645**	**0.000570**	**0.000399**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 1 Tri-Frame (3 TURBINES)**
INSTALL B-2	**P9.B-2**		**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**Number of Operating KHPS**
	P10.B-2		**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**Array Avoidance (P = 1 if No Fish Avoid Arrays, P = 0.5 if Fish Leave Array Half Way Through)**
12 TURBINES	**P.B-2 =**	**1.03%**	**0.000002**	**0.000064**	**0.000345**	**0.001188**	**0.002286**	**0.002581**	**0.002282**	**0.001595**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 4 Tri-Frames (12 TURBINES)**
INSTALL C	**P9.C**		**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**Number of Operating KHPS**
	P10.C		**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**Array Avoidance (P = 1 if No Fish Avoid Arrays, P = 0.5 if Fish Leave Array Half Way Through)**
30 TURBINES	**P.C =**	**2.59%**	**0.000005**	**0.000161**	**0.000864**	**0.002971**	**0.005715**	**0.006452**	**0.005705**	**0.003989**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 12 Tri-Frames (30 TURBINES)**

Probability of a Blade Interaction for Shortnose Sturgeon in the East River

Constants (Single Rotor)

L	88	cm (Common Length)
Vb	3.52	m/s (Burst Velocity)
Ve	1.76	m/s (Assumption)
n	3	blades
w	40	rpm
R	2.5	m (Turbine Rotor Radius)
D	10	m (River Avg Depth)
W	240	m (River Avg Width)
L	3700	m (River Avg Length)
Ar	19.625	m2 (Turbine Rotor Swept Area)
Aw	2400	m2 (East River Cross-sectional Area - W x D)
Ae	3.7	m2 (Expulsion Area)

	Vw	TOTAL PROBABILITY	2.6 m/s	2.4 m/s	2.2 m/s	2 m/s	1.8 m/s	1.6 m/s	1.4 m/s	1.2 m/s	0 to 1 m/s	NOTES:
SITE	**P1**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**Probability given a Rotation Condition (P = 1 if Vw > 0)**
	P2		**0.0002**	**0.0067**	**0.0347**	**0.0878**	**0.1631**	**0.1831**	**0.1477**	**0.1017**	**0.2749**	**Water Velocity Distribution (Measured at RITE)**
	P3		**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**East/West Channel Split (Fish Evenly Split Between East and West Channel)**
KHPS	**P4**		**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**Impact Area of Rotor Coverage ((Ar - Ae)/Aw)**
	Vf Max		6.12 m/s	5.92 m/s	5.72 m/s	5.52 m/s	5.32 m/s	5.12 m/s	4.92 m/s	4.72 m/s		Vf Max = Vw + Vb fish swimming with current
	P5.Vf Max		**0.22**	**0.22**	**0.23**	**0.25**	**0.26**	**0.27**	**0.29**	**0.30**		
	Vf Min		N/A	N/A	N/A	N/A	N/A	-1.92 m/s	-2.12 m/s	-2.32 m/s		Vf Min = Vw - Vb fish swimming against current
	P5.Vf Min		**0**	**0**	**0**	**0**	**0**	**0.65**	**0.62**	**0.74**		
	P5.Current		**1**	**1**	**1**	**1**	**1**	**0.80**	**0.80**	**0.80**	**0.80**	**Fish Swimming with the Current**
	P5		**0.22**	**0.22**	**0.23**	**0.25**	**0.26**	**0.35**	**0.36**	**0.39**	**0**	**Blade Interaction (Function of Water Velocity, Fish Burst Speed and Fish Length)**
FISH	**P6**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**Fish Distribution (Uniform Fish Distribution)**
	P7		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**Avoidance behavior (P = 1 When No Fish Avoid Turbines)**
	P8		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**Endurance behavior (50% of Fish Downstream of Rotor Cannot Approach Turbine if Vw > Ve)**
1 TURBINE	**P =**	**0.08%**	**0.000000**	**0.000005**	**0.000026**	**0.000073**	**0.000141**	**0.000210**	**0.000174**	**0.000131**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 1 TURBINE**
INSTALL A	**P9.A**		**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**Number of Operating KHPS**
2 TURBINES	**P.A =**	**0.15%**	**0.000000**	**0.000010**	**0.000053**	**0.000146**	**0.000281**	**0.000420**	**0.000349**	**0.000262**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 2 TURBINES**
INSTALL B-1	**P9.B-1**		**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**Number of Operating KHPS**
3 TURBINES	**P.B-1 =**	**0.23%**	**0.000000**	**0.000015**	**0.000079**	**0.000218**	**0.000422**	**0.000631**	**0.000523**	**0.000393**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 1 Tri-Frame (3 TURBINES)**
INSTALL B-2	**P9.B-2**		**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**Number of Operating KHPS**
	P10.B-2		**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**Array Avoidance (P = 1 if No Fish Avoid Arrays, P = 0.5 if Fish Leave Array Half Way Through)**
12 TURBINES	**P.B-2 =**	**0.91%**	**0.000002**	**0.000059**	**0.000318**	**0.000874**	**0.001689**	**0.002522**	**0.002094**	**0.001571**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 4 Tri-Frames (12 TURBINES)**
INSTALL C	**P9.C**		**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**Number of Operating KHPS**
	P10.C		**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**Array Avoidance (P = 1 if No Fish Avoid Arrays, P = 0.5 if Fish Leave Array Half Way Through)**
30 TURBINES	**P.C =**	**2.28%**	**0.000005**	**0.000147**	**0.000794**	**0.002184**	**0.004221**	**0.006306**	**0.005234**	**0.003928**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 12 Tri-Frames (30 TURBINES)**

ATLANTIC STURGEON BIOLOGICAL ASSESSMENT

BIOLOGICAL ASSESSMENT
ATLANTIC STURGEON

ROOSEVELT ISLAND TIDAL ENERGY PROJECT

FERC NO. 12611

DECEMBER 2010

Prepared by:

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VERDANT POWER

VERDANT POWER
ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT
BIOLOGICAL ASSESSMENT
ATLANTIC STURGEON

TABLE OF CONTENTS

1.0 INTRODUCTION 1
2.0 PROJECT AREA 2
3.0 DESCRIPTION OF THE PROPOSED ACTION 2
- 3.1 UNDERWATER CABLING 5
- 3.2 CONSTRUCTION AND INSTALLATION SCHEDULE 5
- 3.3 PROJECT OPERATION 7

4.0 STATUS OF AFFECTED SPECIES 8
- 4.1 ATLANTIC STURGEON LIFE HISTORY 8
- 4.2 STATUS AND TRENDS OF ATLANTIC STURGEON RANGEWIDE ... 9
- 4.3 STATUS OF ATLANTIC STURGEON IN THE ACTION AREA 11

5.0 ENVIRONMENTAL BASELINE 12
6.0 EFFECTS OF THE ACTION 14
7.0 CONCLUSION 17
8.0 LITERATURE CITED 17

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VERDANT POWER
ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT
BIOLOGICAL ASSESSMENT
ATLANTIC STURGEON

1.0 INTRODUCTION

This constitutes the biological assessment of Atlantic sturgeon under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531-1543) on the effects of the proposed Verdant Power Island Tidal Energy (RITE) Project in the East River, New York, NY. The RITE Project is proposed to deliver commercial electricity from Verdant Power's Free Flow Kinetic Hydropower System and generate clean renewable energy from the river's tidal currents. 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.

2.0 PROJECT AREA

The East River is a 17-mile-long tidal strait connecting the waters of the Long Island Sound with those of the Atlantic Ocean in New York Harbor. The East River separates the New York City Boroughs of Manhattan and the Bronx from Brooklyn and Queens. The Harlem River flows from the Hudson River and connects with the East River at Hell Gate. The East River is a saltwater conveyance passage for tidal flow. There is some freshwater influence from the Harlem River and some direct drainage area from the surrounding metropolis, but the river is predominantly controlled by tidal influence.

In February 2005, Verdant conducted a remote sensing survey to document surficial and subsurface riverbed features in the east channel in the area of the experimental units. The survey was conducted using a high-resolution side-scan sonar device at frequencies of 500-kHz and 100-kHz respectively. Detailed images of the riverbed features were generated from data collected from the survey and was included in the report, “Acoustic Remote Sensing Survey for Roosevelt Island Tidal Energy Project,” published in March 2005. The study confirmed the presence of boulders and cobbles that were depicted on the side-scan sonar and sub-bottom records. The video coverage did not show any evidence of fine grain soft sediments. This was also later confirmed when Verdant drilled the 6 piles into the bedrock for the demonstration project.

3.0 DESCRIPTION OF THE PROPOSED ACTION

Verdant Power, LLC (Verdant) is proposing to develop the Roosevelt Island Tidal Energy (RITE) Project, East Channel Pilot (RITE East Channel Pilot) under the Federal Energy Regulatory Commission (FERC)’s new Hydrokinetic Pilot Project Licensing Process. The project is located in the East River in New York City. The RITE East Channel Pilot builds on the successful RITE demonstration that has been operating in the East River for several years. The RITE East Channel Pilot would consist of:

1. a field array of thirty (30), 5-meter diameter axial flow Kinetic Hydropower System (KHPS) turbine-generator units mounted on ten (10) triframe mounts, with a total capacity of 1 MW at 35 KW each;
2. underwater cables from each turbine to five shoreline switchgear vaults, that interconnect to a Control Room and interconnection points; and
3. appurtenant facilities to ensure safe navigation and turbine operation.

The project will be constructed in phases as further described below:

- Install A: Two Gen 5 Turbines on Existing Monopiles from RITE demonstration phase (not covered under RITE Pilot license)
- Install B1: Install Three Gen 5 Turbines on a Tri-frame
- Install B-2: Install up to Three Additional Tri-frames of Three Turbines
- Install C: Install up to Six Additional Triframes (no more than 30 Gen 5 KHPS total)

The Verdant Gen 5 KHPS turbine consists of four major components:

- Rotor with three fixed blades;
- Nacelle, pylon and yaw mechanism;
- Generator and drivetrain; and
- Riverbed mounting system, (3 KHPS turbines on one tri-frame mount).

The RITE pilot project of 30 KHPS turbines would encompass a project boundary of approximately 21.6 acres, which includes 21.2 acres of underwater land lease and 0.4 acres of shoreline right-of-way for the Control Room, Cable Vaults and two underground transmission lines.

Key KHPS Technology Parameters (RITE Gen 5)

ROTOR	
Rotor hub diameter:	1.0 m
Rotor tip diameter:	5.0 m
Number of blades:	3 - Gen 5
Material of construction:	Rotor: Composite (FRP) construction Rotor Hub: Ductile Iron casting
Pitch control:	No
Yaw control	Passive
Ducted or open rotor:	Open
Solidity ratio:	16% (based on blade frontal area / total rotor area)
Rpm @ full load:	~40 rpm
Rpm limit: no load	Transient, ~20% over full-load velocity until brake fully applied and rotation stopped:
DRIVETRAIN	
Geared drive:	Yes, planetary
Shaft diameter:	0.127m stainless steel (RITE Gen 4 35kW)
Number of bearings:	2 main shaft, tapered roller bearings
Mechanical efficiency:	~93%
Lubrication:	gearbox: synthetic (PAO) gear oil; bearings: synthetic grease
GENERATOR	
Power produced on both ebb and flood tides:	Yes
Generator design:	induction, NEMA B
Synchronous:	near-synchronous
Rpm:	1800
Delivery voltage:	480VAC, 3 phase
Electrical efficiency:	~91.5% - 94.7%; NEMA Nominal 94.5%
Excitation:	self (induction)

3.1 UNDERWATER CABLING

The Verdant KHPS is designed to have limited above-water facilities. The RITE East Channel Pilot will include 480V electrical cables (no hydraulic oil systems) from each of the 30 KHPS turbines. Cables will travel through the pylon assembly of each turbine to the tri-frame mount. For each tri-frame mount, the three turbine cables will be bundled together into a set, which will then be paired with another set and routed from the field, weighted along the riverbed, to five shoreline switchgear vaults (vaults). The individual turbine cable lengths from the turbine-generator to the respective vaults range from 233 to 322 feet, with an average of 282 feet.

3.2 CONSTRUCTION AND INSTALLATION SCHEDULE

For the east channel pilot Verdant intend to use a staged installation procedure to ensure ongoing design validation.

- *Install A: Install Two Gen 5 Turbines on Existing Monopiles*
  - Installation would be accomplished in the fourth quarter of 2011 on existing foundation mountings.
  - This installation would be conducted within the boundaries of the established RITE demonstration project.
  - This effort would be conducted under a proposed modification and extension to the existing NYSDEC/USACE permit (expires May 2012) and the FERC Verdant Order and would not be under a FERC pilot License.
  - This stage of the project would last a minimum operational period of up to 180 days; and include environmental monitoring as described below.
  - Verdant will propose an extension of the existing permit term of 1½ years to November 2013 to allow for flexibility in the schedule; and incorporation of the agreed to 'Install A' monitoring plan.

- *Install B1: Install Three Gen 5 Turbines on a Tri-frame*
  - Install B1 would be governed by the terms of a FERC Pilot License, a new NYSDEC/USACE joint permit, and other requisite permits.

- The initial purpose would be to test the new tri-frame mount component of the technology and prove operation and maintenance techniques.
- The environmental monitoring from Install A continues, adding two additional elements.

- *Install B-2: Install up to Three Additional Tri-frames of Three Turbines Each*
  - Install B-2 would be done under the FERC Pilot License and additional authorizations; and expand the project to up to 12 operating KHPS in 2013.
  - This stage would include an additional element of environmental monitoring within an array of multiple Gen 5 machines to increase the understanding of environmental effects.
  - The experience and lessons learned from the execution of previous RITE Monitoring of Environmental Effects (RMEE) elements will be incorporated into this stage.

- *Install C: Install up to Six Additional Tri-frames (no more than 30 Gen 5 KHPS total)*
  - Incremental build out of the full Pilot project; incorporating the results of technology and environmental testing in previous stages.
  - This would also be done under the FERC Pilot License and additional authorizations and likely completed in 2014.

Based on Verdant's construction experience during the RITE demonstration, the construction periods for the RITE East Channel Pilot are short in duration. The construction installation is approximately 2 days per KHPS turbine, and one tri-frame mount per week, with a single installation crew. Based on this, Install A and B-1 are likely to take 1-2 weeks; Install B-2; 3-4 weeks and Install C; 5-6 weeks. It is anticipated that many of the component parts will be manufactured and assembled at a staging area in the surrounding New York area and floated by barge to the project site.

Other key points of the construction process include:

- Electrical power vaults are likely to be prefabricated offsite, minimizing any local disturbances to the existing area.
- Aggregate ground disturbance is expected to be <1 acre.
- Diver intervention will be minimized, but still needed for shoreline cable weighting and connections.
- The use of four semi-permanent piles to assist in construction deployment and potentially maintenance is under consideration and may or may not be required.

3.3 PROJECT OPERATION

The RITE East Channel Pilot will operate using the natural tidal currents of the East River. The Verdant KHPS captures energy from the flow in both ebb and flood directions by yawing with the changing tide, using a passive weathervaning system with a downstream rotor. As the flow direction changes, hydrodynamic forces on the rotor, nacelle, and pylon all contribute to yaw torque to align the rotor with the flow. There are no sensors, controls, or actuators to yaw the turbine. This design is far simpler than any active system to control turbine yaw or blade pitch, and has far fewer elements to foul or fail. The Gen 5 turbine utilizes a fixed blade design and Verdant considers this to be essential to reliable long-term underwater operation. The upstream pylon assembly, which is faired to provide a clean flow to the rotor, can also provide a degree of protection to the rotor. Turbine yaw is limited at 170° to ensure that the turbine will rotate in the same direction as the tidal current changes to allow a simple power cabling arrangement without slip rings.

4.0 STATUS OF AFFECTED SPECIES

The action being considered in this biological assessment may affect the proposed for listing Atlantic sturgeon (*Acipenser oxyrinchus*). This section will focus on the status of Atlantic sturgeon within the action area, summarizing information necessary to establish the environmental baseline and to assess the effects of the proposed action.

4.1 ATLANTIC STURGEON LIFE HISTORY

Atlantic sturgeon occur along the northwest Atlantic Coast from Labrador south the northern Florida (Collette and MacPhee, 2002). Atlantic sturgeon are distinguished from shortnose sturgeon by their small mouth, presence of bony scutes between the anal fin base and the lateral scute row, a double row of scutes behind the anal fin and by their pale intestine. They are anadromous and juveniles may spend several years in freshwater in some rivers however others move to brackish waters when water temperatures drop in the fall (Scott and Crossman, 1973). Atlantic sturgeon appear to spend limited time within their natal rivers except during spawning. Subadults leave their natal river at age 4-7 (Collette and MacPhee, 2002), but occasionally as early as age 2 (Bain 1997). Atlantic sturgeon use coastal habitats and nearshore environment for extended period of time, however little is known of their coastal movements or preferences (Savoy 2007).

Atlantic sturgeon have been aged to 60 years, however, this should be taken as an approximation as the only age validation study conducted to date shows variations of ±5 years (ASSRT 2007). Sturgeon populations show variation with faster growth and earlier age at maturation in more southern systems (ASSRT 2007). Atlantic sturgeon mature in South Carolina at 5-19 years, in the Hudson River at 11-21 years and in the Saint Lawrence River at 22-34 years (ASSRT 2007). The average age at which 50% of maximum lifetime egg production is achieved estimated to be 29 years, approximately 3-10 times longer than for other bony fish species examined (ASSRT 2007).

Atlantic sturgeon are generally found in areas of little or no current throughout much of their lives and tend to occupy more saline environments than the shortnose sturgeon. Currents are encountered by adults during upstream spawning migrations and spawning occurs where water flow is fairly strong (Gilbert 1989). Substrate preference varies according to life stage and proximity to the spawning season (Gilbert 1989).

Atlantic sturgeon are opportunistic benthic feeders (Scott and Crossman, 1973). In marine or estuarine waters, they feed on polychaetes, isopods, decapods crustaceans, amphipods, gastropods, bivalves and fishes. Sturgeons are indiscriminate feeders and search for prey by rooting along the bottom with their snouts using barbells (Gilbert 1989).

Fecundity of the Atlantic sturgeon increases with age and body size and ranges from 800,000 to 3.76 million eggs (Collette and MacPhee, 2002). Size at maturity and spawning time varies with latitude. In the Hudson River males mature at about 9 years and females about 10 years. Their eggs are demersal and adhesive. Males migrate to the spawning areas earlier in the year and spend longer time there than females (Collette and MacPhee 2002). Males may spawn every year but females do not and have spawning intervals of about 3 years (Collette and MacPhee, 2002).

4.2 STATUS AND TRENDS OF ATLANTIC STURGEON RANGEWIDE

Historically, Atlantic sturgeon were present in approximately 38 rivers in the United States from St. Croix, ME to the Saint Johns River, FL, of which 35 rivers have been confirmed to have had a historical spawning population. Atlantic sturgeon are currently present in approximately 32 of these rivers, and spawning occurs in at least 20 of them (ASSRT 2007). Studies have consistently found populations to be genetically diverse and indicate that there are between 7 and 10 populations that can be statistically differentiated (ASSRT 2007). However, there is some disagreement among studies, and results do not include samples from all rivers inhabited by Atlantic sturgeon. There are only two Atlantic sturgeon populations for which size estimates are available, the Hudson River and the Altamaha River populations. In 1995, sampling crews on the Hudson River estimated that there were 9,500 juvenile Atlantic sturgeon in the estuary. Since 4,900 of these were stocked hatchery-raised fish, about 4,600 fish were thought to be of wild origin. The mean annual number of spawning adults was estimated at 870 (600 males and 270 females). The Altamaha River supports one of the healthiest Atlantic sturgeon populations in the Southeast, with over 2,000 subadults captured in research surveys in the past few years, 800 of which were 1 to 2 years of age. The population appears to be stable (ASSRT 2007).

Historically, over fishing has led to declines in Atlantic sturgeon abundance (ASSRT 2007). A large commercial fishery in the U.S. subsisted for Atlantic sturgeon from the 1950s through the mid-1990s. Since a 1998 fishing moratorium there have been few surveys to assess any changes in abundance. Bycatch of sturgeon is a continuing danger in the ocean environment (ASSRT 2007).

Besides over fishing, Atlantic sturgeon face additional threats in their estuarine and freshwater habitats, including habitat degradation and loss from various human activities such as dredging, dams, water withdrawals, and other development. Other habitat impediments including locks and dams and ship strikes (ASSRT 2007). Although there are no known diseases threatening Atlantic sturgeon populations, there is concern that non-indigenous sturgeon pathogens could be introduced through aquaculture operations.

The Atlantic sturgeon is managed under a Fishery Management Plan implemented by the Atlantic States Marine Fisheries Commission (ASMFC). In 1998, the ASFMC instituted a coast-wide moratorium on the harvest of Atlantic sturgeon, which is to remain in effect until there are at least 20 protected age classes in each spawning stock (anticipated to take up to 40 or more years) (ASSRT 2007). NMFS followed the ASMFC moratorium with a similar moratorium for Federal waters. Amendment 1 to ASMFC's Atlantic sturgeon Fishery Management Plan also includes measures for preservation of existing habitat, habitat restoration and improvement, monitoring of bycatch and stock recovery, and breeding/stocking protocols (ASSRT 2007).

4.3 STATUS OF ATLANTIC STURGEON IN THE ACTION AREA

The New York Bight distinct population segment (NYB DPS) includes all Atlantic sturgeon whose range occurs in watersheds that drain into coastal waters, including Long Island Sound, the New York Bight, and Delaware Bay, from Chatham, MA to the Delaware-Maryland border. Within this range, Atlantic sturgeon have been documented from the Hudson and Delaware rivers as well as at the mouth of the Connecticut and Taunton rivers, and throughout Long Island Sound. There is evidence to support that spawning occurs in the Hudson and Delaware Rivers. Evidence of Atlantic sturgeon spawning in the Connecticut and Taunton Rivers is not available (ASSRT 2007). The majority of historical spawning habitat is accessible to the NYB DPS (ASSRT 2007). However, whether Atlantic sturgeon spawning habitat in these rivers is fully functional is difficult to quantify.

Troy Dam, the first dam on the Hudson River at river km 246, is the northern extent of the Atlantic sturgeon spawning and nursery habitat. Mature males begin to move up the Hudson River when water temperatures reach 5.6 to 6.1^{o}C and females appear at the spawning sites when temperatures are about 12.2 to 12.8^{o}C. Spawning occurs a few weeks after fish arrive at the spawning sites (Gilbert 1989). Females move downstream and out of the Hudson River soon after spawning but males remain until fall Gilbert 1989). In the Hudson River larval and juvenile Atlantic sturgeon remain upstream from May to July, but move downstream to congregate in deep water when the water temperature drops below 20^{o}C (Gilbert 1989).

Juvenile Atlantic sturgeon may make long oceanic excursions, tagged juveniles form the Hudson River have been recaptured from Nantucket, MA and as far south as North Carolina (Gilbert 1989).

Polychaetes comprised over 50% of the prey items retrieved from Atlantic sturgeon in Long Island Sound (Savoy 2007). The second most ubiquitous prey item were pea crabs.

The only abundance estimate for adult Atlantic sturgeon belonging to the NYB DPS is 870 spawning adults per year for the Hudson River subpopulation, based on data collected from 1985–1995 (ASSRT 2007). In addition, the current number of spawning adults may be higher given that the estimate is based on the time period prior to the moratorium on fishing for and retention of Atlantic sturgeon.

5.0 ENVIRONMENTAL BASELINE

Environmental baselines include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this biological assessment includes the effects of several activities that may affect the survival and recovery of the endangered species in the action area. The activities that shape the environmental baseline in the action area of this consultation generally include: power plant operations, dredging, fisheries bycatch, research projects, and water quality.

Known threats to Atlantic sturgeon in the Project area include effects to riverine habitat (dredging, water quality, and vessel strikes) as well as threats that occur throughout their marine range (fisheries bycatch) (ASSRT 2007). Bycatch is the primary threat for the NYB DPS of Atlantic sturgeon, and specific regulatory measures to address it have not been implemented. Subadult and adult Atlantic sturgeon in the Project area may be incidentally caught in fisheries that occur throughout their marine range. Fisheries that result in bycatch of Atlantic sturgeon, including the monkfish gillnet fishery (ASSRT 2007). Dams for hydropower generation, flood control, and navigation have the potential to affect Atlantic sturgeon by impeding access to spawning and foraging habitat, modifying free-flowing rivers to reservoirs, and altering downstream flows and temperatures (ASSRT 2007). Environmental impacts of dredging include direct removal or burial of organisms, elevated turbidity or siltation, contaminant resuspension, noise or disturbance, alterations to hydrodynamic regime and physical habitat, and loss of riparian habitat (ASSRT 2007). Water quality can be affected by industrial activities, forestry, agriculture, and land development. Any of these can affect sturgeon at various life stages depending on the extent of the threat and the life stage affected (ASSRT 2007).

The most recent EPA Coastal Condition Report identified that coastal water quality was fair overall for waters south of Cape Cod through Delaware (ASSRT 2007). However, sampled sites in Massachusetts and Rhode Island were generally scored as good while waters from Connecticut to Delaware received fair and poor ratings (ASSRT 2007). In particular, the report noted that most of the Northeast Coast sites that were rated as poor for water quality were concentrated in a few estuarine systems, including New York/New Jersey Harbor, some tributaries of the Delaware Bay, and the Delaware River (ASSRT 2007). Significant increases in abundance and distribution of shortnose sturgeon within the Hudson and Delaware Rivers suggest that improvements in water quality have resulted in benefits to the species. Available evidence further suggests that existing water quality in these rivers and surrounding estuaries is not impeding reproduction of shortnose sturgeon that occur there.

6.0 EFFECTS OF THE ACTION

This section examines the likely effects (direct and indirect) of the proposed action on Atlantic sturgeon in the action area and their habitat within the context of the species, current status, and the environmental baseline.

The hard-bottom substrate habitat in the project area consists of bedrock, boulders and cobbles with no evidence of fine grain soft sediments. Installation of tri-frame mounts and electric cables for the RITE hydro kinetic turbines may disturb substrate habitat and the water column. These activities could result in a temporary increase in turbidity. Because installation of turbines will occur over a short period of time, water quality is expected to return to existing conditions following installation. Due to current velocities within the East River dispersion of re-suspended sediments, if any, would likely occur quickly. The proposed activities associated with this project would not significantly alter any habitat used by fish. There would be little to not impact to food source since polychaetes are primarily found in mud and sand environments not hard-bottom bedrock.

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 model determines the probability of a fish entering the East River being struck by a turbine. Structurally, the model determines this strike likelihood by combining various parameters; including the water velocity distribution, the channel geometry; the KHPS physical and operating characteristics; and the specific fish characteristics; size (length in cm); burst speed; and swimming velocity in relationship to water velocity. The model is designed to be customizable and incorporate elements of various parameters as they become known. For example, over the past 3 years Verdant has sampled at the RITE site they have demonstrated that fish move with the tide in the east channel and are most abundant at slack tide. Since the turbines do not operate in currents less than 1 m/s there is no risk to fish during the period of their highest abundance which occurs over 27% of the tidal cycle. This type of site-specific knowledge is incorporated as parameters in the model.

The model at present assumes very little fish behavior. With regard to Atlantic sturgeon, very little is known about their abundance, distribution or behavior in the East River since none have been recorded there. Unknowns include their spatial distribution throughout the river, the directions, shapes, and timing of their paths in the East River. The RITE Monitoring of Environmental Effects (RMEE) Plans were designed to improve site-specific knowledge which can then be incorporated in the model.

The model uses 9 parameters and is applied to calculate the strike probability for one turbine, Install A (2 turbines), Install B-1, (one tri-frame, 3 turbines), Install B-2, (4 tri-frames, 12 turbines), and Install C (10 tri-frames, 30 turbines). For turbines in a tri-frame, another probability parameter is added to reflect the number of turbines, and their spacing in the turbine field. The turbines in the field are treated as if the fish had an equal opportunity to go through all 30. In reality because the turbines are grouped together in 3's on a tri-frame, it would be likely that a fish going through one turbine in a tri-frame would not be lined up to pass through either of the other two turbines. However it is difficult to quantify this interaction, so the simple but worst case of treating the turbines as independent is modeled. The strike probability for one tri-frame is simply the strike probability for a single turbine multiplied by the number of turbines in the single tri-frame, 3. A complete description of the model parameters including descriptions of all assumptions, constants and variables can be found in Attachment A.

Since only occasional Atlantic sturgeon may transit the East River as NMFS indicates they are not likely to occur in large numbers, it is assumed that 10% of the NYBDPS Atlantic sturgeon would ever likely transit the river. Considering no Atlantic sturgeon have ever been recorded in the East River, 10% appeared to be a conservative assumption. This percentage is applied to the final strike probability calculation. The RITE project specific fish interaction model resulted in a blade strike probability for Atlantic sturgeon at one turbine to be 0.009%; Install A (2 turbines) to be 0.017%, Install B-1, (one tri-frame,) to be 0.026%, Install B-2, (four tri-frames) to be 0.103%, and Install C (10 tri-frames) to be 0.259%.

The model only determines the probability of a strike by a turbine blade, not the probability of mortality. The model does differentiate between a strike that is determined to be too slow to cause any injury, and one that could cause injury or mortality. Strikes that are deemed too slow to cause any injury are treated as non-strikes while there is some early injury and mortality studies of turbine blades on smaller fish (Amaral *et al.* 2008), predictions of mortality for the larger fish are left out of the model at present. Thus the output of the model is a strike probability, not an injury or mortality probability. Amaral *et al.* (2008) tested the effects of leading edge turbine blade on fish strike survival and injury. They found very high survival for white sturgeon at mean blade speeds ranging from 10.6 to 12.2 m/s which is comparable to the Verdant RITE outer edge blade speed of 10.5 m/s. Sturgeon strikes were tested for different body regions and found total blade strike survival was 100% for sturgeon struck in the head and caudal region and 97.4% for those struck in the midsection for fish that ranged from 100 to 150 mm. White sturgeon exhibited less mortality than comparable sized rainbow trout indicating that their cartilaginous skeleton and armored scutes make sturgeon less susceptible to blade strike injury than typical boney fishes (Amaral *et al.* 2008).

7.0 CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under NMFS jurisdiction, the environmental baseline for the action area, the effects of the action, and the cumulative effects, it is concluded that the proposed action is not likely to jeopardize the continued existence of NYB DPS Atlantic sturgeon.

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ROOSEVELT ISLAND TIDAL ENERGY PROJECT
FERC NO. 12611

KHPS-FISH INTERACTION MODEL

DECEMBER 2010

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ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT

KHPS-FISH INTERACTION MODEL

TABLE OF CONTENTS

1.0 OVERVIEW 1

2.0 MODEL INTRODUCTION 1

2.1 DESCRIPTION OF PARAMETERS 3

2.1.1 P1: Probability of Blade Rotation 3

2.1.2 P2: Distribution of Water Velocity over the Tidal Cycle 4

2.1.3 P3: Fish Distribution 5

2.1.4 P4: Turbine Rotor Area 5

2.1.5 P5: Blade Interaction with Fish 7

2.1.6 P6: Fish Distribution 10

2.1.7 P7: Avoidance Behavior 10

2.1.8 Overall Probability of Strike 11

2.2 ARRAY AND FULL FIELD EFFECTS 11

3.0 CONCLUSIONS 14

LIST OF TABLES

Table 1. Parameters contained within the KHPS-Fish Interaction Model. 2

Table 2. Species specific parameters used in the KHPS-Fish Interaction Model for RITE. 9

Table 3. Probability of strike for a single turbine. 11

Table 4. Overall KHPS-Fish strike probabilities for proposed RITE Pilot Project. 12

LIST OF FIGURES

Figure 1. Probability of Gen 5 KHPS turbine rotation. 4

Figure 2. Velocity distribution at the RITE site in the East River. 4

Figure 3. Diagram showing rotor ejection zone. 6

Figure 4. Fish speed with respect to water velocity at the RITE site. 8

Figure 5. Probability of strike for fish passing through turbine disk. 10

Figure 6. Comparative KHPS-Fish strike probabilities for proposed RITE Pilot Project for various length fish. 13

VERDANT POWER

ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT

KHPS-FISH INTERACTION MODEL

1.0 OVERVIEW

In response to a request from the National Marine Fisheries Service (NMFS), Verdant and Kleinschmidt developed an in-stream kinetic hydropower turbine (KHPS)-fish interaction model for the East River in New York. The overall intention of this model is to quantify the risk that Verdant's KHPS turbines present to fish at the proposed Roosevelt Island Tidal Energy (RITE) Pilot Project in the East River in New York. This document provides a description of the model and presents and explains the assumptions made.

This is a simple, probability based model that determines the overall risk of a turbine blade striking a fish (blade strike). This model concentrates upon the turbine interaction with the Shortnose Sturgeon and Atlantic Sturgeon as these are protected species of interest in the area. However, comparative results are also generated for species identified in the Essential Fish Habitat Assessment that was performed as part of Verdant’s Final Pilot License Application.

2.0 MODEL INTRODUCTION

During the previous RITE demonstration, Verdant collected a large quantity of information on the spatial and temporal presence and abundance of typical resident and migrating fish commonly present at the project site, as detailed in Exhibit E. However, for the sturgeon species of interest, there has been no available supporting evidence to identify any particular temporal or spatial distribution, other than communication from NMFS that there is a chance that they may at times be present in the East River. As a result, one of the primary assumptions used in the development of this model is that any sturgeon that are present would be distributed evenly throughout the East River.

Additionally, based upon comments from NMFS, we are assuming that any sturgeon that may be present are using the East River as a migratory route to transit back and forth between Long Island Sound and the Hudson River. This behavioral assumption allows us to state that any particular fish is present because they are making a transit of river, rather than because this is their resident habitat.

These assumptions allow us to use a straightforward 2D model. The model uses a simple product of probabilities to provide an overall determination of the likelihood of blade strike. For simplicity, we have provided the following subdivision of items within this model that will have a contribution to the probability of a blade strike.

Table 1. Parameters contained within the KHPS-Fish Interaction Model.

Term	Parameter Description
P1	Probability of blade rotation
P2	Distribution of water velocity over the tidal cycle
P3	Fish distribution between East & West Channel
P4	Effective KHPS rotor area
P5	Blade interaction with fish passing through turbine disk
P6	Fish Distribution
P7	Fish Avoidance Behavior

Most of these parameters will vary as a function of water velocity and this has been presented in the following section. The overall probability of blade-strike can therefore be calculated as

$$P_T = \sum_{0}^{Vw=max} P_1 \times P_2 \times P_3 \times P_4 \times P_5 \times P_6 \times P_7$$

This equation simply states that the overall probability is a product of all the probabilities summed across all the water velocities of interest.

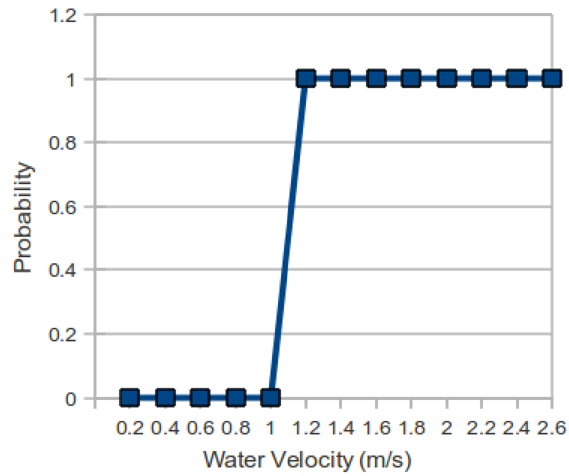
2.1 DESCRIPTION OF PARAMETERS

A description of the parameters, assumptions made and justifications is provided in the following section. This section includes consideration for the probability of strike from a single turbine only. This is then expanded into the effect of the full field in the final section.

2.1.1 P1: Probability of Blade Rotation

A unique characteristic of the Verdant design is that for the water velocities present at the site, the rotor will turn at a near constant speed of 40 rpm independent of the water velocity. In addition, the turbine features an automatically operated brake that will stop the turbine from rotating when water flow velocities are too low to generate power. This means that during times when the flow is below 1 m/s the turbine will not be rotating and will therefore not pose a risk. This is illustrated in Figure 1 which shows the probability of rotation as a function of water velocity.

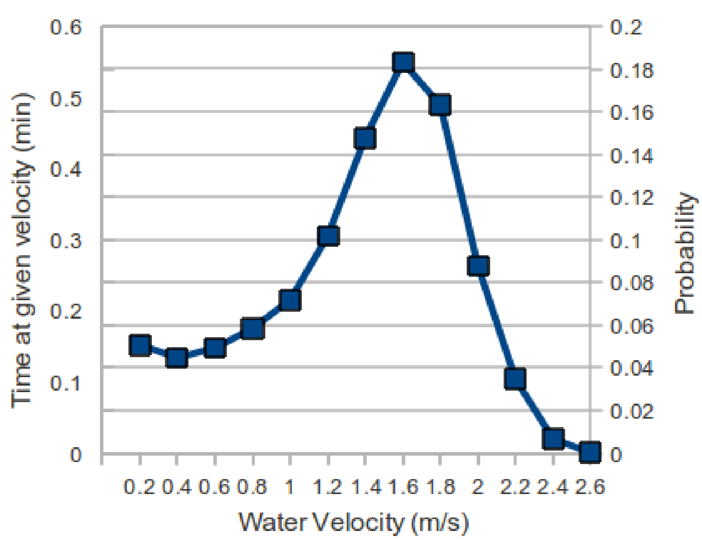
Figure 1. Probability of Gen 5 KHPS turbine rotation.



2.1.2 P2: Distribution of Water Velocity over the Tidal Cycle

The environment in the East River provides for a predictable, but constantly changing flow profile. The speed at which the water moves has a significant impact upon the risk of the fish being struck. As the turbine rotor will turn at a constant rate, faster water flows will incur a lower chance of strike as the fish will be carried through the rotor disk faster.

Figure 2. Velocity distribution at the RITE site in the East River.



In the absence of further information on ESA species of interest, the model assumes that there is an even distribution of fish over time; therefore, a fish could transit the channel during any particular part of the tidal cycle. Therefore the probability of a given flow condition will influence the chance of strike. Figure 2 shows the probability of certain flow speeds which have been generated from flow data collected by Verdant at the RITE site. These have been arbitrarily subdivided into 0.2 m/s bins.

2.1.3 P3: Fish Distribution

The East River bifurcates to flow around Roosevelt Island, forming the east and west channels. The cross sectional area of the channels is roughly equal (both channels have a similar width of approximately 240m and depth of 10m). The West Channel has a slightly higher average flow speed and the volume of water passing through both channels is equal to within approximately 5%. Combined with the even fish distribution assumption explained earlier, it reasonably follows that half of any fish present will transit via the west channel and will therefore not be affected by the turbines present in the east channel.

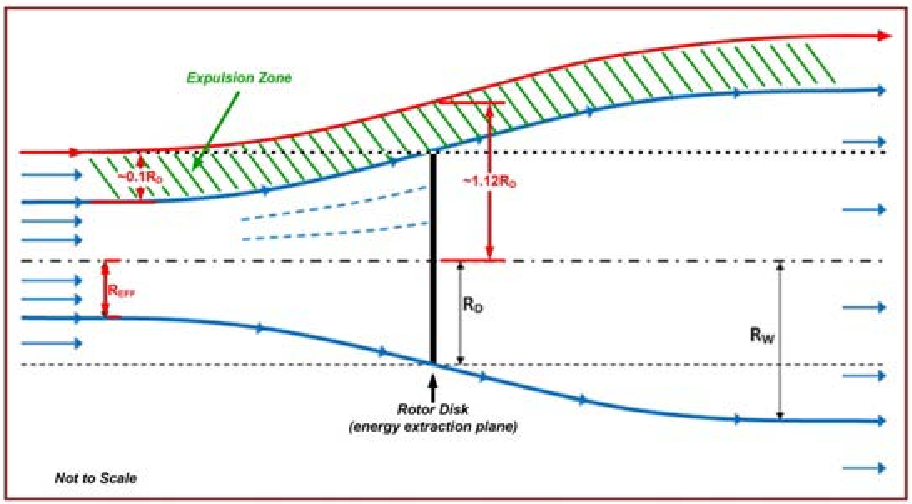
The model includes a probability of 0.5 (50%) to represent the equal likelihood that the fish will take the east channel (and be at risk) over the west channel (and have no risk). This probability is fixed and is not dependent upon the water velocity.

2.1.4 P4: Turbine Rotor Area

With a 2D model the turbine(s) will occupy a certain percentage of the cross sectional area of the river, therefore the probability that a fish will transit through the turbine area will be given by the ratio of overall channel cross sectional area to turbine area.

While the turbine disk area can be given by a standard calculation of area $(A = \pi \times r^2)$ hydrodynamic theory states there will be a volume of water incident on the disk that will be ejected due to the energy extraction function. This effect causes water to flow slower through the rotor than around it. Figure 4 shows this effect in profile and illustrates this 'ejection zone'. Any fish present in this zone will be moved away from the rotor. The existence of this effect has been acknowledged in the literature.[i,ii]

Figure 3. Diagram showing rotor ejection zone.



The cross sectional area of Verdant's 5m diameter turbine is 19.63m^2, while the ejection zone has been calculated at 3.7m^2. This gives an effective turbine area of 15.93m^2.

The profile of the east channel of the East River is well known and for the purposes of this model is approximated to be a square channel with a width of 240m and an average depth of 10m.

This ratio is a constant value and does not vary with water velocity. It is calculated as 0.0066.

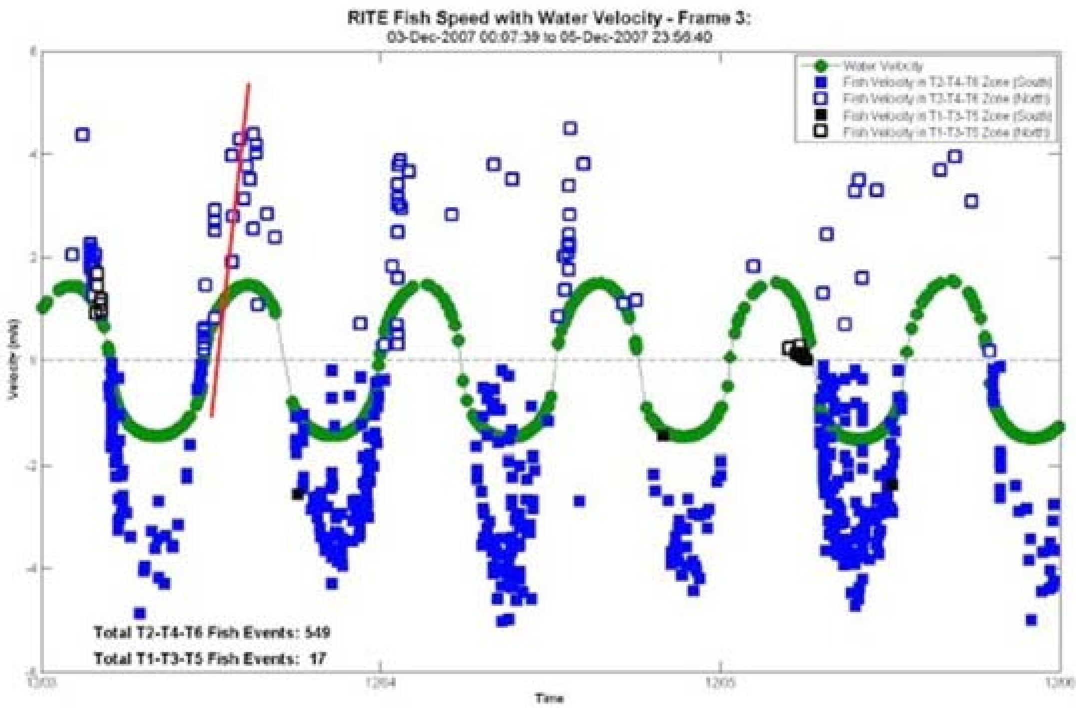
2.1.5 P5: Blade Interaction with Fish

For fish that will be incident upon the rotor, parameter P5 provides the probability of the blade impacting the fish (at any point on its body). This quantity is determined only by the speed of the fish approaching the turbine, the length of the fish, the rotational speed of the turbine blades and the angle that the fish is approaching the turbine.

The primary assumption included in this parameter is that a fish will try to avoid the turbine blades by swimming at its maximum burst speed through the rotor. Based upon the body of data collected during the RITE demonstration, it may be possible to justify some additional spatial or zonal avoidance behavior, however because there is no specific data available on the sturgeon species of interest no additional avoidance behavior is accounted for in the present model. The speed of the fish through the rotor will therefore be given only by the species maximum burst speed plus the water velocity.

Fish likely swim through the east channel in both directions. However, as illustrated in Figure 4, Verdant has collected a quantity of information on fish movements at the RITE east channel site which support the assumption that fish will typically be swimming with the current, especially at times of high current. From this data we have made the assumption that when the water velocity is less than the regular endurance speed for a particular species, then 80% of fish will be swimming with the current and 20% against. For times when the water velocity is greater than the regular endurance speed, all fish will be swimming with the current.

Figure 4. Fish speed with respect to water velocity at the RITE site.



** Presented in "FERC Draft License Application – Volume 2 – Exhibit E"*

Finally, the angle that the fish will approach the turbine disk is not known, therefore it is assumed that fish will be incident upon the rotor disk from an even distribution of angles (±90°) centered on the direction of transit (upstream or downstream). As the angle of incidence for the fish moves away from perpendicular, the effective length of the fish reduces, however its velocity through the rotor is also reduced.

For a given water velocity and fish species, the probability of strike for a fish incident on the turbine disk can be given by the following.[iii]

$$V_{apparent} = V_w + \left(V_b \sin(\theta)\right)$$
$$L_{apparent} = L \sin(\theta)$$
$$P_{strike} = nR \times \left(\frac{L_{apparent}}{V_{apparent}}\right)$$

Where:

V_w = Water velocity
V_b = Species burst speed
L = Species nominal length
n = number of blades
R = Rotational speed (revolutions per second)
θ = Angle of incidence

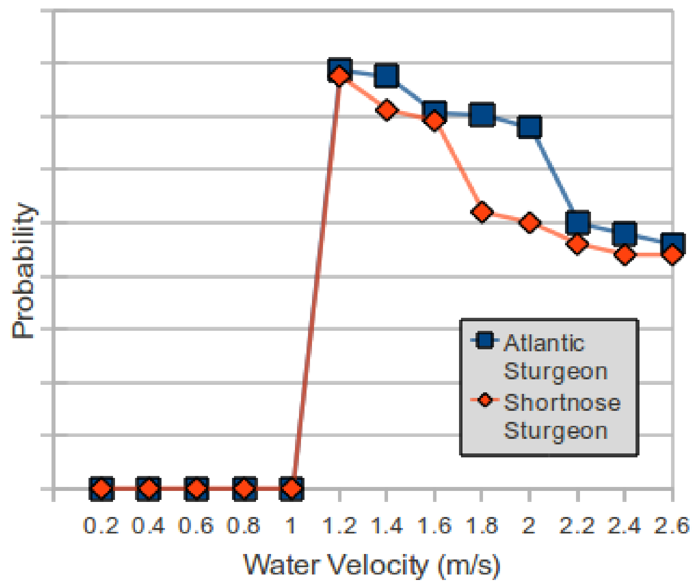
This equation is highly dependent upon the species specific parameters used for the fish, such as swim speed and overall length. The mean length of Shortnose and Atlantic sturgeon in Long Island Sound was reported to be 104 cm and 88 cm, respectively. [iv,v] These lengths were used in the model since it is assumed any migratory sturgeon traversing the East River are heading to or returning from Long Island Sound. Swim velocities can be categorized into endurance swimming speeds and burst swimming speeds. Unfortunately swim speeds for these species are less well determined, although it can be supported that a good approximation for the burst swim speed may be taken as 4 (four) times the nominal length per second.[vi] Endurance swim speed can typically be seen as being half of the burst swim speed. Table 2 provides the following species specific parameters that were used in the model.

Table 2. Species specific parameters used in the KHPS-Fish Interaction Model for RITE.

Species	Common Length (cm)	Endurance Swim Speed (Ve) (m/s)	Burst Swim Speed (Vb) (m/s)
Shortnose Sturgeon	88	1.76	3.52
Atlantic Sturgeon	104	2.08	4.16

As discussed above, water velocity will affect the probability for strike and it can be seen in Figure 5 how the probability varies with velocity and species. For velocities less than 1 m/s the turbine is not rotating, therefore values are zero.

Figure 5. Probability of strike for fish passing through turbine disk.



2.1.6 P6: Fish Distribution

This category is included for completeness. As described above, in the absence of further information on ESA fish species, the model assumes an even distribution of ESA fish in the East River. Therefore, P6=1 for all velocities. As information is learned from the proposed monitoring plans this parameter can potentially be modified.

2.1.7 P7: Avoidance Behavior

Again, this is included for completeness. This model takes a conservative approach and assumes no avoidance behavior other than assuming the fish will speed up to avoid being struck. This increase in velocity in included in parameter P5. Therefore, P7=1 for use in the current model. As information is learned from the proposed monitoring plans this parameter can potentially be modified.

2.1.8 Overall Probability of Strike

The parameters discussed here each vary with water velocity; therefore, it is difficult to easily illustrate the calculation. Spreadsheets are provided in Appendix A which detail the calculations. The results for a single turbine are provided in Table 3 below.

Table 3. Probability of strike for a single turbine.

Term	Probability of Strike
Atlantic Sturgeon	0.09%
Shortnose Sturgeon	0.08%

2.2 ARRAY AND FULL FIELD EFFECTS

Increasing the number of installed turbines will naturally increase the probability of strike. The proposed project will be installed in a series of steps as detailed in the license application. These are summarized below.

Stage	Size of Complete Field (not to exceed)
Install A:	Two KHPS turbines installed on existing monopoles
Install B-1:	Three KHPS turbines installed on one triframe[1] mount
Install B-2:	Twelve KHPS turbines installed on 4 triframe mounts
Install C:	Thirty KHPS turbines installed on 10 triframe mounts

1 The triframe is a riverbed structure that will mount three turbines in a triangular configuration. When installed on the frame, the turbines will each be spaced approximately 2 diameters apart.

The most conservative estimate for the impact of the full field of thirty KHPS turbines is to multiply the single unit probability by the number of installed units. However this assumption does not take into account the physical location of the KHPS turbines. This is a worst case assumption that may be over conservative. As the KHPS turbines will be clustered in a single location, any fish entering the full array would likely try to leave the area once passing close to or through a small number of units. Nevertheless, there is little validated or published data to support this assumption and as a result this model assumes no inherent avoidance of the array.

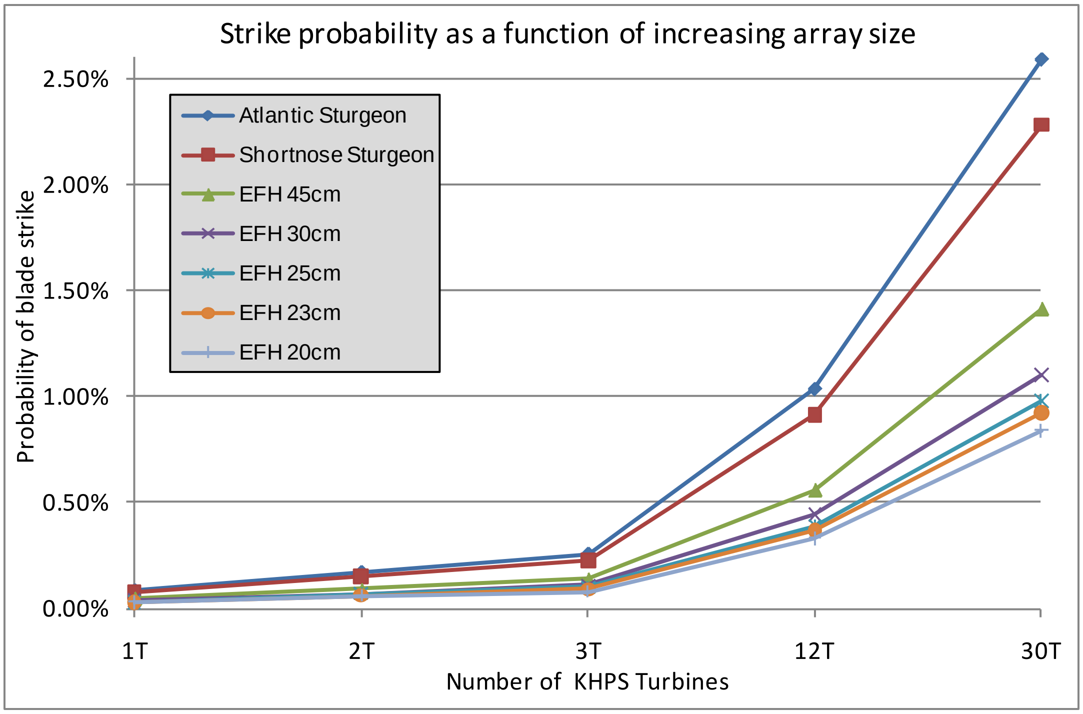
The strike probabilities for Atlantic and Shortnose sturgeon are presented for the full field in Table 4 below.

For the purposes of comparison, the model was run for a number of smaller essential fish habitat (EFH) species of varying length and these results are presented in Figure 6. This is overlaid as a comparison with the Atlantic and Shortnose sturgeon strike probabilities.

Table 4. Overall KHPS-Fish strike probabilities for proposed RITE Pilot Project.

Species	**Single Turbine**	**Install A (2 Turbines)**	**Install B-1 (3 Turbines)**	**Install B-2 (12 Turbines)**	**Install C (30 Turbines)**
Atlantic Sturgeon	0.09%	0.17%	0.26%	1.03%	2.59%
Shortnose Sturgeon	0.08%	0.15%	0.23%	0.91%	2.28%

Figure 6. Comparative KHPS-Fish strike probabilities for proposed RITE Pilot Project for various length fish.



3.0 CONCLUSIONS

This KHPS turbine-fish interaction model provides a summary of the assumptions used and methods applied to calculate the probability of a blade strike (with respect to the RITE pilot project) upon two ESA species of sturgeon in the East River, New York. While the investigation of fish interaction with operating KHPS turbines in terms of temporal and spatial abundance has been underway at the RITE site since 2007, the assumptions used in this model have attempted to take a conservative view. The staged installation and environmental monitoring program proposed by Verdant is intended to refine the body of knowledge in this area and improve the predictions made by this model.

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APPENDIX A

KHPS-Fish Interaction Model Output

Probability of blade interaction for Atlantic Sturgeon in the East River

Constants (Single Rotor)

L	104	cm (Common Length)
Vb	4.16	m/s (Burst Velocity)
Ve	2.08	m/s (Assumption)
n	3	blades
w	40	rpm
R	2.5	m (Turbine Rotor Radius)
D	10	m (River Avg Depth)
W	240	m (River Avg Width)
L	3700	m (River Avg Length)
Ar	19.625	m2 (Turbine Rotor Swept Area)
Aw	2400	m2 (East River Cross-sectional Area - W x D)
Ae	3.7	m2 (Expulsion Area)

	Vw	TOTAL PROBABILITY	2.6 m/s	2.4 m/s	2.2 m/s	2 m/s	1.8 m/s	1.6 m/s	1.4 m/s	1.2 m/s	0 to 1 m/s	NOTES:
SITE	P1		1	1	1	1	1	1	1	1	0	**Probability given a Rotation Condition (P = 1 if Vw > 0)**
	P2		0.0002	0.0067	0.0347	0.0878	0.1631	0.1831	0.1477	0.1017	0.2749	**Water Velocity Distribution (Measured at RITE)**
	P3		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**East/West Channel Split (Fish Evenly Split Between East and West Channel)**
KHPS	P4		0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	**Impact Area of Rotor Coverage ((Ar - Ae)/Aw)**
	Vf Max		6.76 m/s	6.56 m/s	6.36 m/s	6.16 m/s	5.96 m/s	5.76 m/s	5.56 m/s	5.36 m/s		Vf Max = Vw + Vb fish swimming with current
	P5.Vf Max		**0.23**	**0.24**	**0.25**	**0.26**	**0.28**	**0.29**	**0.30**	**0.32**		
	Vf Min		N/A	N/A	N/A	-2.16 m/s	-2.36 m/s	-2.56 m/s	-2.76 m/s	-2.96 m/s		Vf Min = Vw - Vb fish swimming against current
	P5.Vf Min		**0**	**0**	**0**	**0.66**	**0.64**	**0.61**	**0.74**	**0.69**		
	P5.Current		1	1	1	0.80	0.80	0.80	0.80	0.80	0.80	**Fish Swimming with the Current**
	P5		0.23	0.24	0.25	0.34	0.35	0.35	0.39	0.39	0	**Blade Interaction (Function of Water Velocity, Fish Burst Speed and Fish Length)**
FISH	P6		1	1	1	1	1	1	1	1	1	**Fish Distribution (Uniform Fish Distribution)**
	P7		1	1	1	1	1	1	1	1	1	**Avoidance behavior (P = 1 When No Fish Avoid Turbines)**
	P8		1	1	1	1	1	1	1	1	1	**Endurance behavior (50% of Fish Downstream of Rotor Cannot Approach Turbine if Vw > Ve)**
1 TURBINE	P =	0.09%	0.000000	0.000005	0.000029	0.000099	0.000191	0.000215	0.000190	0.000133	0	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 1 TURBINE**
INSTALL A	P9.A		2	2	2	2	2	2	2	2	2	**Number of Operating KHPS**
2 TURBINES	P.A =	0.17%	0.000000	0.000011	0.000058	0.000198	0.000381	0.000430	0.000380	0.000266	0	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 2 TURBINES**
INSTALL B-1	P9.B-1		3	3	3	3	3	3	3	3	3	**Number of Operating KHPS**
3 TURBINES	P.B-1 =	0.26%	0.000001	0.000016	0.000086	0.000297	0.000572	0.000645	0.000570	0.000399	0	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 1 Tri-Frame (3 TURBINES)**
INSTALL B-2	P9.B-2		12	12	12	12	12	12	12	12	12	**Number of Operating KHPS**
	P10.B-2		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**Array Avoidance (P = 1 if No Fish Avoid Arrays, P = 0.5 if Fish Leave Array Half Way Through)**
12 TURBINES	P.B-2 =	1.03%	0.000002	0.000064	0.000345	0.001188	0.002286	0.002581	0.002282	0.001595	0	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 4 Tri-Frames (12 TURBINES)**
INSTALL C	P9.C		30	30	30	30	30	30	30	30	30	**Number of Operating KHPS**
	P10.C		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**Array Avoidance (P = 1 if No Fish Avoid Arrays, P = 0.5 if Fish Leave Array Half Way Through)**
30 TURBINES	P.C =	2.59%	0.000005	0.000161	0.000864	0.002971	0.005715	0.006452	0.005705	0.003989	0	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 12 Tri-Frames (30 TURBINES)**

Probability of a Blade Interaction for Shortnose Sturgeon in the East River

Constants (Single Rotor)

L	88	cm (Common Length)
Vb	3.52	m/s (Burst Velocity)
Ve	1.76	m/s (Assumption)
n	3	blades
w	40	rpm
R	2.5	m (Turbine Rotor Radius)
D	10	m (River Avg Depth)
W	240	m (River Avg Width)
L	3700	m (River Avg Length)
Ar	19.625	m2 (Turbine Rotor Swept Area)
Aw	2400	m2 (East River Cross-sectional Area - W x D)
Ae	3.7	m2 (Expulsion Area)

	Vw	TOTAL PROBABILITY	2.6 m/s	2.4 m/s	2.2 m/s	2 m/s	1.8 m/s	1.6 m/s	1.4 m/s	1.2 m/s	0 to 1 m/s	NOTES:
SITE	**P1**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**Probability given a Rotation Condition (P = 1 if Vw > 0)**
	P2		**0.0002**	**0.0067**	**0.0347**	**0.0878**	**0.1631**	**0.1831**	**0.1477**	**0.1017**	**0.2749**	**Water Velocity Distribution (Measured at RITE)**
	P3		**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**East/West Channel Split (Fish Evenly Split Between East and West Channel)**
KHPS	**P4**		**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**0.0066**	**Impact Area of Rotor Coverage ((Ar - Ae)/Aw)**
	Vf Max		6.12 m/s	5.92 m/s	5.72 m/s	5.52 m/s	5.32 m/s	5.12 m/s	4.92 m/s	4.72 m/s		Vf Max = Vw + Vb fish swimming with current
	P5.Vf Max		**0.22**	**0.22**	**0.23**	**0.25**	**0.26**	**0.27**	**0.29**	**0.30**		
	Vf Min		N/A	N/A	N/A	N/A	N/A	-1.92 m/s	-2.12 m/s	-2.32 m/s		Vf Min = Vw - Vb fish swimming against current
	P5.Vf Min		**0**	**0**	**0**	**0**	**0**	**0.65**	**0.62**	**0.74**		
	P5.Current		**1**	**1**	**1**	**1**	**1**	**0.80**	**0.80**	**0.80**	**0.80**	**Fish Swimming with the Current**
	P5		**0.22**	**0.22**	**0.23**	**0.25**	**0.26**	**0.35**	**0.36**	**0.39**	**0**	**Blade Interaction (Function of Water Velocity, Fish Burst Speed and Fish Length)**
FISH	**P6**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**Fish Distribution (Uniform Fish Distribution)**
	P7		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**Avoidance behavior (P = 1 When No Fish Avoid Turbines)**
	P8		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**Endurance behavior (50% of Fish Downstream of Rotor Cannot Approach Turbine if Vw > Ve)**
1 TURBINE	**P =**	**0.08%**	**0.000000**	**0.000005**	**0.000026**	**0.000073**	**0.000141**	**0.000210**	**0.000174**	**0.000131**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 1 TURBINE**
INSTALL A	**P9.A**		**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**Number of Operating KHPS**
2 TURBINES	**P.A =**	**0.15%**	**0.000000**	**0.000010**	**0.000053**	**0.000146**	**0.000281**	**0.000420**	**0.000349**	**0.000262**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 2 TURBINES**
INSTALL B-1	**P9.B-1**		**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**Number of Operating KHPS**
3 TURBINES	**P.B-1 =**	**0.23%**	**0.000000**	**0.000015**	**0.000079**	**0.000218**	**0.000422**	**0.000631**	**0.000523**	**0.000393**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 1 Tri-Frame (3 TURBINES)**
INSTALL B-2	**P9.B-2**		**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**Number of Operating KHPS**
	P10.B-2		**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**Array Avoidance (P = 1 if No Fish Avoid Arrays, P = 0.5 if Fish Leave Array Half Way Through)**
12 TURBINES	**P.B-2 =**	**0.91%**	**0.000002**	**0.000059**	**0.000318**	**0.000874**	**0.001689**	**0.002522**	**0.002094**	**0.001571**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 4 Tri-Frames (12 TURBINES)**
INSTALL C	**P9.C**		**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**Number of Operating KHPS**
	P10.C		**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**Array Avoidance (P = 1 if No Fish Avoid Arrays, P = 0.5 if Fish Leave Array Half Way Through)**
30 TURBINES	**P.C =**	**2.28%**	**0.000005**	**0.000147**	**0.000794**	**0.002184**	**0.004221**	**0.006306**	**0.005234**	**0.003928**	**0**	**Total Probability of Fish/Blade Interaction at Each Flow Speed - 12 Tri-Frames (30 TURBINES)**

SEA TURTLES BIOLOGICAL ASSESSMENT

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ROOSEVELT ISLAND TIDAL ENERGY PROJECT

FERC NO. 12611

DECEMBER 2010

Submitted by:

VERDANT POWER

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ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT

SEA TURTLE BIOLOGICAL ASSESSMENT

TABLE OF CONTENTS

1.0 INTRODUCTION 1
2.0 PROJECT AREA 1
3.0 DESCRIPTION OF THE PROPOSED ACTION 3
4.0 PROJECT OPERATION 5
5.0 STATUS OF AFFECTED SPECIES 5
5.1 LOGGERHEAD TURTLE 5
5.1.1 Life History 5
5.1.2 Status and Trends Rangewide 7
5.1.3 Status in the Action Area 9
5.1.4 Environmental Baseline 10
5.1.5 Effects of the Action 11
5.2 KEMP'S RIDLEY TURTLE 11
5.2.1 Life History 11
5.2.2 Status and Trends Rangewide 13
5.2.3 Status in the Action Area 13
5.2.4 Environmental Baseline 14
5.2.5 Effects of the Action 14
5.3 GREEN TURTLE 15
5.3.1 Life History 15
5.3.2 Status and Trends Rangewide 16
5.3.3 Status in the Action Area 17
5.3.4 Environmental Baseline 17
5.3.5 Effects of the Action 18
5.4 LEATHERBACK TURTLE 18
5.4.1 Life History 18
5.4.2 Status and Trends Rangewide 19
5.4.3 Status in the Action Area 19
5.4.4 Environmental Baseline 20
5.4.5 Effects of the Action 20
6.0 LITERATURE CITED 20

VERDANT POWER

ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT

SEA TURTLE BIOLOGICAL ASSESSMENT

1.0 INTRODUCTION

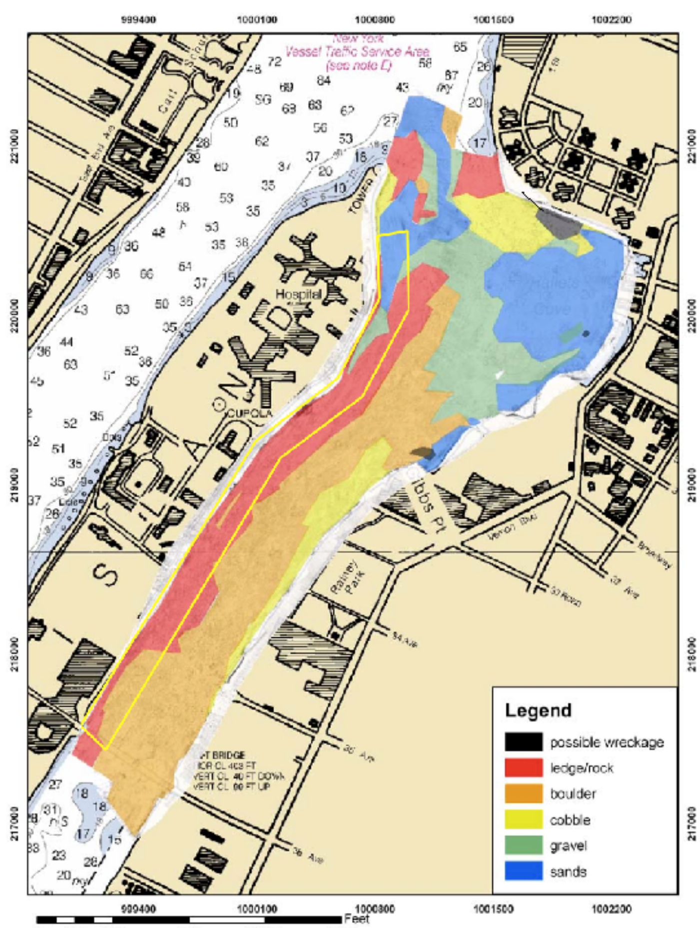
There are four species of sea turtles that are known to use the coastal waters of New York. The loggerhead turtle (*Caretta caretta*), Kemp Ridley's turtle *(Lepidochelys kempii)*, green turtle (*Chelonia mydas*), and leatherback turtle *(Dermochelys coriacea)* are known to use habitat in Long Island 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). Due to the relatively close proximity of the proposed Verdant Power Roosevelt Island Tidal Energy (RITE) Project in the East River, New York, a Biological Assessment is being prepared to analyze the potential for effects to protected species. The RITE Project is proposed to deliver commercial electricity from Verdant Power's Free Flow Kinetic Hydropower System and generate clean renewable energy from the river's tidal currents.

2.0 PROJECT AREA

The East River is a 17-mile-long tidal strait connecting the waters of the Long Island Sound with those of the Atlantic Ocean in New York Harbor. The East River separates the New York City Boroughs of Manhattan and the Bronx from Brooklyn and Queens. The Harlem River flows from the Hudson River and connects with the East River at Hell's Gate. The East River is a saltwater conveyance passage for tidal flow. There is some freshwater influence from the Harlem River and some direct drainage area from the surrounding metropolis, but the river is predominantly controlled by tidal influence.

In February 2005, Verdant conducted a remote sensing survey to document surficial and subsurface riverbed features in the east channel in the area of the experimental units. The survey was conducted using a high-resolution side-scan sonar device at frequencies of 500-kHz and 100-kHz respectively. Detailed images of the riverbed features were generated from data collected from the survey and was included in the report, “Acoustic Remote Sensing Survey for Roosevelt Island Tidal Energy Project,” published in March 2005. The study confirmed the presence of boulders and cobbles that were depicted on the side-scan sonar and sub-bottom records. The video coverage did not show any evidence of fine grain soft sediments (Figure 2-1). This was also later confirmed when Verdant drilled the six piles into the bedrock for the demonstration project.

Figure 2-1. Substrate mapping in the east channel of the East River.



Throughout the last several years, Verdant Power has implemented a formal procedure for observations of sea turtles to be recorded during the bird observation and on and near water activities associated with the operation of the RITE demonstration project and during execution of on-water studies. Verdant Power also attempted to evaluate the occurrence of sea turtles in conjunction with performing the Fish Movement and Protection Study with the fixed hydroacoustics in January to June 2007, in conjunction with the deployment of the study units (Verdant, 2007). While it was recognized that evaluating the occurrence of sea turtles was difficult; Verdant Power attempted using the hydroacoustics to observe large, slow moving targets that would be representative of a sea turtle. This technique did not yield any observations and this protocol was abandoned by mutual agency consent in August 2007 (Verdant, 2008).

In addition to the fixed hydroacoustics, Verdant Power also made efforts to conduct incidental observations of sea turtles in conjunction with other field studies -- namely monthly mobile hydroacoustic studies (pre-2005; and post-deployment for 6 months in January through June 2007) and during execution of the bird observation hours. No occurrences of sea turtles were logged (Verdant, 2007). Verdant Power personnel operating during the three deployments (December 2006 through and including November 2008; discontinuous) were also asked to observe and record any unusual aquatic observances and the control room logs show no recorded data related to sea turtles. No incidental observations of sea turtles were made concurrent with the other >500 hours of other field studies conducted. A review of other intake data from area power plants; specifically Ravenswood and Astoria yielded no sea turtle observations in the 17 years of historical record reviewed (Verdant, 2008).

3.0 DESCRIPTION OF THE PROPOSED ACTION

Verdant Power, LLC (Verdant) is proposing to develop the RITE Project, under the Federal Energy Regulatory Commission (FERC)'s new Hydrokinetic Pilot Project Licensing Process. The RITE Project builds on the successful RITE demonstration that has been operating in the East River for several years. The RITE East Channel Pilot would consist of:

1. a field array of thirty (30), 5-meter diameter axial flow Kinetic Hydropower System (KHPS) turbine-generator units mounted on ten (10) triframe mounts, with a total capacity of 1 MW at 35 KW each;
2. underwater cables from each turbine to five shoreline switchgear vaults, that interconnect to a Control Room and interconnection points; and
3. appurtenant facilities to ensure safe navigation and turbine operation.

The Project will be built in three major phases:

- Install A: Two Gen 5 Turbines on Existing Monopiles for testing purposes this will be done under existing permits and not under the pilot license
- Install B1: Install Three Gen 5 Turbines on a Tri-frame
- Install B-2: Install up to Three Additional Tri-frames of Three Turbines
- Install C: Install up to Six Additional Triframes (no more than 30 Gen 5 KHPS total)

The Verdant Gen 5 KHPS turbine consists of four major components:

- Rotor with three fixed blades
- Nacelle, pylon and yaw mechanism
- Generator and drivetrain
- Riverbed mounting system, (3 KHPS turbines on one tri-frame mount)

The RITE pilot project of 30 KHPS turbines would encompass a project boundary of approximately 21.6 acres, which includes 21.2 acres of underwater land lease and 0.4 acres of shoreline right-of-way for the Control Room, Cable Vaults and two underground transmission lines.

4.0 PROJECT OPERATION

The RITE East Channel Pilot will operate using the natural tidal currents of the East River. The Verdant KHPS captures energy from the flow in both ebb and flood directions by yawing with the changing tide, using a passive weathervaning system with a downstream rotor. As the flow direction changes, hydrodynamic forces on the rotor, nacelle, and pylon all contribute to yaw torque to align the rotor with the flow. There are no sensors, controls, or actuators to yaw the turbine. This design is far simpler than any active system to control turbine yaw or blade pitch, and has far fewer elements to foul or fail. The Gen 5 turbine utilizes a fixed blade design and Verdant considers this to be essential to reliable long-term underwater operation. The upstream pylon assembly, which is faired to provide a clean flow to the rotor, can also provide a degree of protection to the rotor. Turbine yaw is limited at 170° to ensure that the turbine will rotate in the same direction as the tidal current changes to allow a simple power cabling arrangement without slip rings.

5.0 STATUS OF AFFECTED SPECIES

5.1 LOGGERHEAD TURTLE

5.1.1 Life History

The Northwest Atlantic population of loggerhead turtles has an extensive home range with individuals found as far north as Nova Scotia (Ernst and Lovich, 2009). These turtles inhabit different areas as they enter different life cycles. Post-hatchlings frequent the waters along the continental shelf floating in accumulations of Sargassum, where they eat mostly hydroids and copepods (Witherington, 2002). At approximately 2 to 5 years loggerheads transition into shallow water as juveniles to feed in the continental shelf waters from Cape Cod to the Caribbean eating crabs and mollusks (Burke *et al*., 1993; Morreale and Standora, 1998). Juvenile turtles that arrive in the waters around Long Island in June or July and remain active through October. As temperatures drop below 15°C the turtles are forced to migrate away from the North Atlantic coast (Morreale and Standora, 1998). Those that do not leave the area will fall victim to the rapidly declining water temperatures and will become hypothermic, resulting in death. This regularly occurs along Long Island and it would not be unusual to find over one hundred dead or dying turtles stranded on the beaches or floating in the waters due to cold shock (Morreale *et al.*, 1992).

Turtles in the Long Island population are in a transitional stage from the oceanic surface feeding phase as post-hatchlings to the juvenile benthic feeding stage. The annual occurrence of juvenile loggerhead turtles is common within Long Island Sound and the eastern bays of Long Island. While in the coastal waters the loggerhead turtle remains relatively confined in the shallower bays. The turtles spend most of their time within areas that provide benthic crustaceans for forage. The loggerhead turtle diet primarily consists of macrocrustaceans and they specifically forge for spider crabs (*Libinia emarginata*). The abundant and highly productive foraging opportunities in Northeastern waters allow these turtles to rapidly grow and increase biomass before heading south (Morreale and Standora, 1998).

At the end of the foraging season in Long Island, loggerhead turtles make directed movements to eastern Long Island and travel south using one of two routes. The turtles were documented by GPS tracking to either travel along the southern shore of Long Island or swim to deeper waters off the coast before heading south (Morreale and Standora, 1998). Additional GPS tracking studies have demonstrated similar migration patterns away from Long Island Sound (RFMRP, 2010). Rare occurrences of adult loggerheads have shown that these turtle may return north to forage in future years. The turtles will continue this north and south migration, following the warm waters, to forage until sexual maturity. Once the turtles reach sexual maturity they return to their natal nesting grounds in tropical climates (Morreale and Standora, 1998). The population of turtles from the Northwest Atlantic nest primarily along the coast of the United States from southern Virginia through Alabama (Conant *et al*., 2009).

The majority of nesting activity occurs from April through September, with a peak in June and July. Five recovery units (subpopulations) have been identified based on genetic differences and a combination of geographic distribution of nesting densities and geographic separation. These recovery units are: Northern Recovery Unit (Florida/Georgia border through southern Virginia), Peninsular Florida Recovery Unit (Florida/Georgia border through Pinellas County, Florida), Northern Gulf of Mexico Recovery Unit (Franklin County, Florida, through Texas), Greater Caribbean Recovery Unit (Mexico through French Guiana, The Bahamas, Lesser Antilles, and Greater Antilles), and Dry Tortugas Recovery Unit (islands located west of Key West, Florida) (NMFS and FWS, 2008). Based on satellite telemetry studies and flipper tag returns the non-nesting adult females in the Long Island area are likely from the Northern Recovery Unit (Conant *et al*., 2009).

5.1.2 Status and Trends Rangewide

In 1978 the loggerhead turtle was listed as threatened throughout its worldwide range (43 FR 32800). Presently, this is under review because the United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) have determined that there are nine distinct population segments (DPS) of loggerhead turtles, and seven of these populations should be listed as endangered and the remaining two would be listed as threatened under the Endangered Species Act (ESA) (USFWS, 2010). The population of loggerhead turtles found in the Long Island area is considered to be part of the Northwest Atlantic population. This population is one of the candidate populations for endangered status.

The ESA requires a review of listed species at least once every 5 years. The 5-year review is an assessment of a listed species to determine whether its status has changed since the time of its listing such that it should be delisted or classified differently than its current status. The most recent 5-year review was completed in 2007 (NMFS and USFWS, 2007c). The 2007 review shows that only two loggerhead nesting aggregations have greater than 10,000 females nesting per year: Peninsular Florida, United States and Masirah Island, Oman. Nesting aggregations with 1,000 to 9,999 females nesting annually are Georgia through North Carolina (U.S.), Quintana Roo and Yucatán (Mexico), Brazil, Cape Verde Islands (Cape Verde), Western Australia (Australia), and Japan. Smaller nesting aggregations with 100 to 999 nesting females annually occur in the Northern Gulf of Mexico (U.S.), Dry Tortugas (U.S.), Cay Sal Bank (The Bahamas), Tongaland (South Africa), Mozambique, Arabian Sea Coast (Oman), Halaniyat Islands (Oman), Cyprus, Peloponnesus (Greece), Zakynthos (Greece), Crete (Greece), Turkey, and Queensland (Australia).

It was during the 2007 review that data indicated a possible separation of populations by ocean basins (NMFS and USFWS, 2007c). Based on the new information and the need for further analysis NMFS and FWS recommended that no change in listing status was warranted. They committed to fully assemble and analyze all relevant information before deciding listing status for DPS units (Conant *et al*., 2009). The population of loggerhead turtles found in Long Island would be a subpopulation of the new proposed Northwest Atlantic DPS.

The population of ocean dwelling loggerhead turtles is unknown, but based on the decline in nesting it is assumed to also be declining. Based on population models completed for a 2009 review of the loggerhead DPS, the Northwest Atlantic Ocean DPS is likely to continue declining, even under the scenario of the lowest anthropogenic mortality rates (Conant *et al*., 2009). These declines are largely due to mortality of juvenile and adult loggerheads from fishery bycatch that occurs throughout the North

Atlantic Ocean. Although efforts have been made to reduce loggerhead bycatch, it is unlikely that this source of mortality can be sufficiently reduced across the range of the DPS because of the diversity and magnitude of the fisheries operating in the North Atlantic and the lack of available bycatch reduction technologies. Therefore, the review concluded that the Northwest Atlantic Ocean DPS is currently at risk of extinction (Conant *et al*., 2009).

The Northwest Atlantic DPS has been separated into five recovery units. The turtles from Long Island are a component of the Northern Recovery Unit. The Northern Recovery Unit is defined as loggerheads originating from nesting beaches from the Florida-Georgia border through southern Virginia (the northern extent of the nesting range). The loggerhead nesting trend from daily beach surveys in the Northern Recovery Unit showed a significant decline of 1.3% annually since 1983. Nest totals from aerial surveys conducted by SCDNR showed a 1.9% annual decline in nesting in South Carolina since 1980. Overall, there is strong statistical evidence to suggest the Northern Recovery Unit has experienced a long-term decline (NMFS and USFWS, 2008).

5.1.3 Status in the Action Area

The Long Island Sound is a seasonal home to both adult and juvenile loggerhead turtles. The juvenile age classes utilize the shallower bays of the Long Island Sound and eastern Long Island. The adult loggerhead turtles are found along the southern coast of Long Island (Sadove and Cardinale, 1993). The turtles will inhabit the Sound from June to October feeding mostly on spider crabs (Morreale and Standora, 1998; Burke *et al*., 1993). The spider crab can be found in areas with fine substrates, indicative of calmer waters (Perry and Larson, 2004). The East River's bed is predominantly comprised of ledge/rock and bolder substrates (Figure 2-1). The lack of suitable substrate in the East River for the turtles most prolific food source would suggest that the turtles would not enter the river due to the lack of foraging habitat. When water temperatures drop in the fall many juvenile turtles migrate away from the Sound and those that do not migrate succumb to hypothermia (Morreale *et al*., 1992). Based on GPS tracking of several individual turtles in the Long Island Sound, the turtles migrate out to the Atlantic Ocean and either head out to the pelagic zone or south along the coast of Long Island (Morreale and Standora, 1998; RFMRP, 2010). No migratory routes have been observed using the East River.

The population of turtles using the Long Island area is likely declining. In a study conducted from 1987-1992, turtles were collected from established pound nets throughout Long Island Sound. Additional research from 2002-2004 used a subset of the pound nets sampled during the earlier study period. Comparisons across the two study periods reveal a sharp decline in the percentage of turtle captures that were loggerheads from 59% of total captures from 1987-1992 to less than 4% of total captures during 2002-2004. In addition to the decline in relative proportions of loggerheads, the absolute number of loggerheads captured also declined - only two loggerheads were captured over the entire 3-year period. Potential explanations for this decline include shifts in loggerhead foraging areas and/or increased mortality in pelagic or early benthic stage/age classes (Morreale *et al*., 2005).

5.1.4 Environmental Baseline

Environmental baselines include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this biological assessment includes the effects of several activities that may affect the survival and recovery of the endangered species in the action area. As with all the sea turtles, one of major causes of decline is incidental capture in fishing gear, primarily in longlines and gillnets, but also in trawls, traps and pots, and dredges. In addition, the historic and present threat of direct harvest of loggerhead turtle eggs, juveniles, and adults for food is also a primary threat to this species (NMFS, 2010).

5.1.5 Effects of the Action

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 turtle, 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 Verdant Project would not likely affect the habitat or individual loggerhead turtles.

5.2 KEMP'S RIDLEY TURTLE

5.2.1 Life History

The Kemp's Ridley turtle has one of the smallest most restrictive home ranges among sea turtles with adults mainly inhabiting the Gulf of Mexico. Juveniles however, have an extensive home range encompassing the waters from Mexico to Nova Scotia (Ernst and Lovich, 2009; NMFS, 1992). The primary nesting grounds for the Kemp's Ridley turtle includes the western Gulf of Mexico, primarily in the Mexican state of Tamaulipas. The turtle also regularly nests in Veracruz, Mexico, Texas and infrequently in a few other U.S. states (NMFS *et al*., 1992).

Once hatchlings emerge from these beaches in the Gulf of Mexico they make their way to open ocean. Hatchlings inhabit floating Sargassum beds in the open ocean, generally drifting with ocean currents. While in this community the hatchlings feed on sargassum and invertebrates associated with the algae. As they grow they become juveniles that have been divided into two populations, one that remains in the northern Gulf of Mexico, and another that uses the Gulf Stream of the Western Atlantic.

The juvenile turtles that use the Gulf Stream of the Western Atlantic will use the ocean habitats for approximately 2 years when they will move inshore to shallow waters and become benthic invertebrate feeders. The main characteristics that define the areas inhabited during the juvenile near shore stage are somewhat protected, temperate waters, shallower than 50m (NMFS *et al*., 1992). The habitat usually contains sea grass beds and sandy to muddy substrates (Morealle and Standora, 1992). These turtles will predominantly feed on crabs, mollusks, and benthic invertebrates (Ernst and Lovich, 2009; Burke *et al*., 2006). This foraging behavior is known to occur as far north as New England, including Long Island Sound. The distribution of Kemp's Ridley is related to the availability of their primary food source. In Long Island the primary food source is the nine-spined spider crab (*Libinia emarginata*) (Burke *et al*., 1993).

Juvenile turtles that inhabit northern waters of the Atlantic Ocean are forced to migrate south when water temperatures decline. Based on GPS tracking of several individual Kemp's Ridley turtles in the Long Island Sound, most migrate out to the Atlantic Ocean and either head out to the pelagic zone or south along the coast of Long Island (Morreale and Standora, 1998; RFMRP, 2010). No migratory routes have been observed using the East River. Turtles that fail to migrate succumb to hypothermia and will die (Morreale *et al*., 1992). The Kemp Ridley's turtle will continue this north and south migration, following the seasonal warmer water temperatures to forage and grow until they are adults.

The adult Kemp's Ridley is rarely found outside the Gulf of Mexico (NMFS *et al*., 1992). The adults show similar foraging behavior as the juveniles. The adults spend most of their time in near shore habitats feeding primarily on crabs, specifically spider crabs. Adult turtles will mate near their natal nesting beaches and typically nest from April to July (NMFS *et al*., 1992).

5.2.2 Status and Trends Rangewide

The USFWS lists the Kemp's Ridley turtle as endangered throughout its entire range under the December 2, 1970 Endangered Species Act (35 FR 18319). The primary nesting population is concentrated in the western Gulf of Mexico. Nesting has been the primary indicator of species population success because oceanic populations are too difficult to census. Since the mid-1980s, the number of nests observed at Rancho Nuevo (Tamaulipas, Mexico) and nearby beaches has increased 14-16% per year. In 2009, the total number of nests recorded at Rancho Nuevo and adjacent beaches exceeded 20,000, which represents about 8,000 females nesting during the 2009 nesting season. For Texas, from 2002-2009, a total of 771 Kemp's ridley nests have been documented on the Texas coast. This represents a large increase from the 81 nests that were known from 1984-2001. Population models predict the population will grow 12-16% per year assuming current survival rates within each life stage remain constant. The population could attain at least 10,000 nesting females in a season by 2015, which is the first recovery goal for the species (NMFS *et al*., 1992).

5.2.3 Status in the Action Area

Similarly to the loggerhead turtle, the Kemp's Ridley has been known to inhabit the Long Island Sound in its juvenile stage, but has not been documented in the East River. The heaviest used areas include the bays and inlets on the eastern side of Long Island, but other bays along the Long Island Sound and Atlantic coast are also used (Sadove and Cardinale, 1993). As with the loggerhead turtle, the Kemp's Ridley turtle feeds primarily on spider crabs which prefer sandy muddy substrates (Perry and Larson, 2004; Burke *et al*., 1993). These benthic substrates are not readily available in the East

River (Figure 2-1). The lack of foraging habitat suggests that the turtle will avoid entering the East River.

Although the nesting population of Kemp's Ridley turtles has increased, the juvenile population in the waters around Long Island has not yet grown. In studies completed from 1987-1992 Kemp's Ridley turtles were captured at a rate of 4-14 turtles per year. During a 2003 follow up study only six turtles were captured with a similar sampling effort (Morreale *et al*., 2005). The low capture rate was attributed to a shift in foraging territory or perhaps unknown mortalities to the post-hatchling and oceanic juvenile phase. Kemp's Ridley turtle remains the second most abundant sea turtle in the Long Island area.

5.2.4 Environmental Baseline

Environmental baselines include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this biological assessment includes the effects of several activities that may affect the survival and recovery of the endangered species in the action area. Similar to the loggerhead turtle, one of major causes of decline is incidental capture in fishing gear, primarily in longlines and gillnets, but also in trawls, traps and pots, and dredges. In addition, the historic and present threat of direct harvest of Kemp's Ridley eggs, juveniles, and adults for food is also a primary threat to this species (NMFS, 2010).

5.2.5 Effects of the Action

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 turtle 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 turtle, 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.

5.3 GREEN TURTLE

5.3.1 Life History

Similar to the other sea turtles, green turtles (*Chelonia mydas*) emerge from beach nests and swim for pelagic waters to feed on small plants and animals near the surface of the ocean. Once the juveniles reach approximately 5 to 6 years they leave the pelagic habitat and travel to nearshore foraging grounds. It is juvenile turtles such as these that are feeding in the Long Island area (Morreale *et al*., 1992). Unlike the other sea turtles, the green turtle is primarily an herbivore and will feed almost exclusively on sea grasses and algae (NMFS, 2010). The distribution of the juvenile green turtles is likely related to submerged aquatic vegetation such as *Ulva sp*. and *Codium sp.* (Sadove and Cardinale, 1993). Juvenile and adult foraging habitat are typically quiet, shallow (3-5 m), well-lit places, ideal for algal and sea grass production (Ernst and Lovich, 2009). Juvenile turtles that inhabit northern waters of the Atlantic Ocean are forced to migrate south when water temperatures decline. Turtles that fail to migrate succumb to hypothermia and will die without human intervention (Morreale *et al*., 1992). Based on GPS tracking of several individual green turtles in the Long Island Sound, the green turtles migrate out to the Atlantic Ocean and either head out to the pelagic zone or south along the coast of Long Island (Morreale and Standora, 1998; RFMRP, 2010). No migratory routes have been observed using the East River.

As breeding adults, the green turtles will migrate between foraging grounds and nesting grounds every few years. The largest nesting sites (≥500 nesting females per year) are located in Ascension Island, Australia, Brazil, Comoros Islands, Costa Rica, Ecuador, Guinea-Bissau, Eparces Islands, Indonesia, Malaysia, Oman, Philippines, Saudi Arabia, Seychelles Islands, Suriname, Hawaii. The green turtles from Long Island are thought to primarily originate from the Florida nesting population (Morreale *et al*., 2005). The Florida nesting population is an endangered sub-population that is currently growing (NMFS & USFWS, 2007a).

5.3.2 Status and Trends Rangewide

The USFWS lists the Green turtle as threatened throughout its entire range under the July 28, 1978 Endangered Species Act (43 FR 32800). The breeding populations in Florida and along the Pacific Coast of Mexico are listed as endangered. Critical habitat has been designated for this species on Culebra Island, Puerto Rico. The green turtle has a circumglobal distribution with major nesting beaches in more than 80 countries worldwide (NMFS & USFWS, 2007a)

The overall nesting status of the green turtle population was evaluated during the 5-year review completed in 2007 (NMFS & USFWS, 2007a). Nesting abundance was evaluated at 46 nesting concentrations from 11 ocean regions worldwide. The nesting abundance trends were evaluated using 23 populations that were representative of the rangewide population. The study estimated that between 108,761 to 150, 521 females nest each year among the 46 sites. The study found that from the 23 sites evaluated for nesting abundance trends that 10 nesting sites were increasing, nine were stable, and four were decreasing. The data show that overall the nesting population is increasing, particularly in the Pacific, Western Atlantic, and Central Atlantic Ocean. The breeding population in the Western Atlantic and Caribbean are all stable or increasing.

5.3.3 Status in the Action Area

Similar to the other hard-shelled sea turtles, the green turtle is primarily distributed in the eastern bays and inlets of Long Island (Sadove and Cardinale, 1993). The population of green turtles has likely increased in the Long Island area. During sea turtle studies of Long Island from 1987 to 1992 green turtles were caught at a rate of 0 to 9 individual per year. In the 2003 and 2004 seasons, green turtles were caught at a rate of 12 and 19 individuals, respectively. This is likely an indication that the juvenile population of green turtle has increased around Long Island. The increase in juveniles around Long Island may be a direct result of the increased nesting observed in Florida, from 1,700 in 1989 to 7,000 in 2002 (Morreale *et al.*, 2005).

As with the other sea turtles, the green turtle must migrate from Long Island when water temperatures decline. Based on GPS tracking of several individual sea turtles in the Long Island Sound, including green turtle, most migrate out to the Atlantic Ocean and either head out to the pelagic zone or south along the coast of Long Island (Morreale and Standora, 1998; RFMRP, 2010). No migratory routes have been observed using the East River. Turtles that fail to migrate succumb to hypothermia and will die (Morreale *et al.*, 1992). The green turtle will continue this north and south migration, following the seasonal warmer water temperatures to forage and grow until they are adults. Once the green turtles are adults they do not seem to use the Long Island area for habitat (Morreale *et al.*, 2005).

5.3.4 Environmental Baseline

Environmental baselines include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this biological assessment includes the effects of several activities that may affect the survival and recovery of the endangered species in the action area. The principal cause of the population decline to green turtle is the harvesting of eggs and adults on nesting beaches and juveniles and adults on feeding grounds. In addition, incidental capture of the sea turtles in fishing gear is also an ongoing threat to the species. A disease known as fibropapillomatosis is also causing mortality in green turtles (NMFS, 2010).

5.3.5 Effects of the Action

The green turtle are 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 migrate 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.

5.4 LEATHERBACK TURTLE

5.4.1 Life History

The leatherback turtle is one of the most widely distributed reptiles in the world (NMFS, 2008). Like both the Kemp Ridley's and loggerhead turtles, leatherback hatchlings inhabit floating *Sarassum* beds found in the open ocean. Unlike the other hard-shelled sea turtle species, leatherbacks do not move to the coastal waters when they mature, in fact they are rarely observed in shallow waters of bays and estuaries (Ernst and Lovich, 2009; Starbird *et al*., 1993). Adult leatherback turtles can be found in open or coastal waters eating jellyfish in the coastal waters of the Eastern United States, including the Long Island Sound but will nest in the tropics (NMFS, 2008). One Leatherback caught in Long Island was tagged while nesting on Yalimapo Beach in French Guiana 2 years prior. Leatherbacks found in Long Island are typically adults and are considered a rare occurrence (Morreale and Standora, 1998).

5.4.2 Status and Trends Rangewide

The USFWS listed the leatherback turtle as endangered throughout its entire range under the ESA on December 2, 1970 (35 FR 8491). The NMFS has designated Sandy Point, St. Croix, United States Virgin Islands and areas off the United States west coast as designated critical habitat for this species (NMFS, 2010).

An estimated 34,000-94,000 adult leatherback turtles use the North Atlantic. Leatherbacks foraging in the North Atlantic have been shown to originate from the western Atlantic breeding population. The nesting populations in the western Atlantic Ocean has been increasing or stable. Major nesting beaches in the western Atlantic Ocean occur in Florida; St. Croix, U.S. Virgin Islands; Puerto Rico; Costa Rica; Panama; Colombia; Trinidad and Tobago; Guyana; Suriname; French Guiana; and southern Brazil (NMFS and USFWS, 2007b).

5.4.3 Status in the Action Area

Leatherback turtles are rarely found in the Long Island area. The annual population off the coast of Long Island is likely only in the hundreds each year. They are found off the coast mostly during the summer and early fall. A larger population of leatherback turtles is seen further north in the Gulf of Maine. Generally, the leatherback is a pelagic foraging species and therefore is even more rarely seen in the Long Island Sound or in shallow waters where the Sound enters the East River (Sadove and Cardinale, 1993). Since the leatherback turtle is a pelagic species, the East River would not be suitable habitat.

5.4.4 Environmental Baseline

Environmental baselines include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this biological assessment includes the effects of several activities that may affect the survival and recovery of the endangered species in the action area. Similar to the other sea turtles, one of major causes of decline is incidental capture in fishing gear, primarily in longlines and gillnets, but also in trawls, traps and pots, and dredges. In addition, the historic and present threat of direct harvest of eggs, juveniles, and adults for food is also a primary threat to this species (NMFS, 2010).

5.4.5 Effects of the Action

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.

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VOLUME 4

ATTACHMENT 2 – EFH

ESSENTIAL FISH HABITAT ASSESSMENT

ROOSEVELT ISLAND TIDAL ENERGY PROJECT

FERC NO. 12611

DECEMBER 2010

Prepared by:

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VERDANT POWER

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ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT

ESSENTIAL FISH HABITAT ASSESSMENT

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 EFH-MANAGED SPECIES 2

3.0 PROJECT DESCRIPTION 2

3.1 UNDERWATER CABLING 6

3.2 CONSTRUCTION AND INSTALLATION SCHEDULE 6

4.0 PROJECT OPERATION 8

5.0 LIFE HISTORY DESCRIPTIONS AND ASSESSMENTS OF EFH SPECIES 8

5.1 RED HAKE 9

5.2 WINTER FLOUNDER 11

5.3 WINDOWPANE FLOUNDER 12

5.4 ATLANTIC HERRING 14

5.5 BLUEFISH 16

5.6 ATLANTIC BUTTERFISH 17

5.7 ATLANTIC MACKEREL 18

5.8 SUMMER FLOUNDER 19

5.9 SCUP 21

5.10 BLACK SEA BASS 23

5.11 KING MACKEREL 24

5.12 SPANISH MACKEREL 25

5.13 COBIA 26

5.14 SAND TIGER SHARK 26

5.15 SANDBAR SHARK 27

5.16 CLEARNOSE SKATE 27

5.17 LITTLE SKATE 28

5.18 WINTER SKATE 29

6.0 LITERATURE CITED 30

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ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT

ESSENTIAL FISH HABITAT ASSESSMENT

1.0 INTRODUCTION

The purpose of this document is to present the findings of the Essential Fish Habitat (EFH) assessment conducted for the proposed Verdant Power RITE Project in the East River, NY as required by the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSA) (amended in 1976 and 1998). This EFH assessment is based on the regulations implemented in the United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) EFH Final Rule, 50 Code of Federal Regulations (CFR) Part 600 (NOAA 2002). The objective of this EFH assessment is to describe how the actions of the proposed RITE Project may affect EFH and EFH-managed species within the area influenced by the proposed Project. According to NOAA National Marine Fisheries Service (NMFS), EFH within the East River includes those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.

This report was prepared to meet the requirements described by the NMFS to comply with the MSA. 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.

2.0 EFH-MANAGED SPECIES

The MSA set forth a mandate for NMFS, regional Fishery Management Councils (FMC), and other federal agencies to identify and protect EFH for economically important marine and estuarine fisheries. NOAA (2002) defines EFH as:

> "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: 'Waters' include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; 'substrate' includes sediment, hardbottom, and structures underlying the waters, and associated biological communities; 'necessary' means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and 'spawning, breeding, feeding, or growth to maturity' covers a species' full life cycle."

EFH-designated species and life history stages in the proposed Project Waterway were identified based on a list in the NOAA Guide to Essential Fish Habitat Designations in the Northeastern United States (NOAA 2005).

3.0 PROJECT DESCRIPTION

The East River is a 17-mile-long tidal strait connecting the waters of the Long Island Sound with those of the Atlantic Ocean in New York Harbor. The East River separates the New York City Boroughs of Manhattan and the Bronx from Brooklyn and Queens. The Harlem River flows from the Hudson River and connects with the East River at Hell Gate. The East River is a saltwater conveyance passage for tidal flow. There is some freshwater influence from the Harlem River and some direct drainage area from the surrounding metropolis, but the river is predominantly controlled by tidal influence.

In February 2005, Verdant conducted a remote sensing survey to document surficial and subsurface riverbed features in the east channel in the area of the experimental units. The survey was conducted using a high-resolution side-scan sonar device at frequencies of 500-kHz and 100-kHz respectively. Detailed images of the riverbed features were generated from data collected from the survey and was included in the report, "Acoustic Remote Sensing Survey for Roosevelt Island Tidal Energy Project," published in March 2005. The study confirmed the presence of boulders and cobbles that were depicted on the side-scan sonar and sub-bottom records. The video coverage did not show any evidence of fine grain soft sediments. This was also later confirmed when Verdant drilled the 6 piles into the bedrock for the demonstration project.

Verdant Power, LLC (Verdant) is proposing to develop the Roosevelt Island Tidal Energy (RITE) Project, East Channel Pilot (RITE East Channel Pilot) under the Federal Energy Regulatory Commission (FERC)'s new Hydrokinetic Pilot Project Licensing Process. The project is located in the East River in New York City. The RITE East Channel Pilot builds on the successful RITE demonstration that has been operating in the East River for several years. The RITE East Channel Pilot would consist of:

1) a field array of thirty (30), 5-meter diameter axial flow Kinetic Hydropower System (KHPS) turbine-generator units mounted on ten (10) triframe mounts, with a total capacity of 1 MW at 35 KW each;
2) underwater cables from each turbine to five shoreline switchgear vaults, that interconnect to a control room and interconnection points; and
3) appurtenant facilities to ensure safe navigation and turbine operation.

In addition, the expected build-out of this project is intended to be in line with the following phases:

- Install A: Two Gen 5 turbines on existing monopiles from RITE demonstration phase
- Install B1: Install three Gen 5 turbines on a tri-frame

- Install B2: Install up to three additional tri-frames of three turbines each
- Install C: Install up to six additional tri-frames (no more than 30 Gen 5 KHPS units total)

The Verdant Gen 5 KHPS turbine consists of four major components:

- Rotor with three fixed blades;
- Nacelle, pylon, and yaw mechanism;
- Generator and drivetrain; and
- Riverbed mounting system, (3 KHPS turbines on one tri-frame mount).

The RITE pilot project of 30 KHPS turbines would encompass a project boundary of approximately 19.91 acres, which includes 18.84 acres of underwater land lease and 1.02 acres of shoreline right-of-way for the control room, cable vaults and two underground transmission lines.

Key KHPS Technology Parameters (RITE Gen 5)

ROTOR	
Rotor hub diameter:	1.0 m
Rotor tip diameter:	5.0 m
Number of blades:	3 - Gen 5
Material of construction:	Rotor: Composite construction Rotor Hub: Ductile Iron casting
Pitch control:	No
Yaw control	Passive
Ducted or open rotor:	Open
Solidity ratio:	16% (based on blade frontal area / total rotor area)
Rpm @ full load:	~40 rpm
Rpm limit: no load	Transient, ~20% over full-load velocity until brake fully applied and rotation stopped:
DRIVETRAIN	
Geared drive:	Yes, planetary
Shaft diameter:	0.127m stainless steel (RITE Gen 4 35kW)
Number of bearings:	2 main shaft, tapered roller bearings
Mechanical efficiency:	~93%
Lubrication:	gearbox: synthetic gear oil; bearings: synthetic grease
GENERATOR	
Power produced on both ebb and flood tides:	Yes
Generator design:	induction, NEMA B
Synchronous:	near-synchronous
Rpm:	1800
Delivery voltage:	480VAC, 3 phase
Electrical efficiency:	~91.5% - 94.7%; NEMA Nominal 94.5%
Excitation:	self (induction)

3.1 UNDERWATER CABLING

The Verdant KHPS is designed to have limited above-water facilities. The RITE East Channel Pilot will include 480V electrical cables (no hydraulic oil systems) from each of the 30 KHPS turbines. Cables will travel through the pylon assembly of each turbine to the tri-frame mount. For each tri-frame mount, the three turbine cables will be bundled together into a set, which will then be paired with another set and routed from the field, weighted along the riverbed, to five shoreline switchgear vaults. The individual turbine cable lengths from the turbine-generator to the respective vaults range from 233 to 322 feet, with an average of 282 feet.

3.2 CONSTRUCTION AND INSTALLATION SCHEDULE

Verdant intends to use a staged installation procedure to ensure ongoing design validation.

- *Install A: Install Two Gen 5 Turbines on Existing Monopiles*
  - Installation would be accomplished in the fourth quarter of 2011 on existing foundation mountings.
  - This installation would be conducted within the boundaries of the established RITE demonstration project.
  - This effort would be conducted under a proposed modification and extension to the existing NYSDEC/USACE permit (expires May 2012) and the FERC Verdant Order and would not be under a FERC pilot License.
  - This stage of the project would last a minimum operational period of up to 180 days; and include environmental monitoring as described below.
  - Verdant will propose an extension of the existing permit term of 1½ years to November 2013 to allow for flexibility in the schedule; and incorporation of the agreed to 'Install A' monitoring plan.
- *Install B1: Install Three Gen 5 Turbines on a Tri-frame*
  - Install B1 would be governed by the terms of a FERC Pilot License, a new NYSDEC/USACE joint permit, and other requisite permits.
  - The initial purpose would be to test the new tri-frame mount component of the technology and prove operation and maintenance techniques.

- The environmental monitoring from Install A continues, adding two additional elements.

- *Install B-2: Install up to Three Additional Tri-frames of Three Turbines Each*
  - Install B-2 would be done under the FERC Pilot License and additional authorizations; and expand the project to up to 12 operating KHPS units in 2013.
  - This stage would include an additional element of environmental monitoring within an array of multiple Gen 5 units to increase the understanding of environmental effects.
  - The experience and lessons learned from the execution of previous RMEE elements will be incorporated into this stage.

- *Install C: Install up to Six Additional Tri-frames (no more than 30 Gen 5 KHPS total)*
  - Incremental build out of the full Pilot project; incorporating the results of technology and environmental testing in previous stages.
  - This would also be done under the FERC Pilot License and additional authorizations and likely completed in 2014.

Verdant expects the construction periods for the RITE East Channel Pilot to be short. Ultimately, Verdant's in-water production rates are estimated to be approximately three turbines and one tri-frame mount per week. It is anticipated that many of the component parts will be manufactured and assembled at a staging area in the surrounding New York area and floated by barge to the project site.

Other key points of the construction process include:

- Electrical power vaults are likely to be prefabricated offsite, minimizing any local disturbances to the existing area.
- Aggregate ground disturbance is expected to be <1 acre.
- Diver intervention will be minimized, but still needed for shoreline cable weighting and connections.
- The use of four semi-permanent piles to assist in construction deployment and potentially maintenance is under consideration and may or may not be required.

4.0 PROJECT OPERATION

The RITE East Channel Pilot will operate using the natural tidal currents of the East River. The Verdant KHPS captures energy from the flow in both ebb and flood directions by yawing with the changing tide, using a passive weathervaning system with a downstream rotor. As the flow direction changes, hydrodynamic forces on the rotor, nacelle, and pylon all contribute to yaw torque to align the rotor with the flow. There are no sensors, controls, or actuators to yaw the turbine. This design is far simpler than any active system to control turbine yaw or blade pitch, and has far fewer elements to foul or fail. The Gen 5 turbine utilizes a fixed blade design and Verdant considers this to be essential to reliable long-term underwater operation. The upstream pylon assembly, which is faired to provide a clean flow to the rotor, can also provide a degree of protection to the rotor. Turbine yaw is limited at 170° to ensure that the turbine will rotate in the same direction as the tidal current changes to allow a simple power cabling arrangement without slip rings.

5.0 LIFE HISTORY DESCRIPTIONS AND ASSESSMENTS OF EFH SPECIES

In reviewing the proposed Project, designated EFH occurs in the area of the proposed RITE Project 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, sandtiger 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 1 below and discussed in the following paragraphs. Additional discussion on the duration and magnitude of potential impacts to EFH and designated species associated with construction and operation of the RITE development is also provided.

Table 1. Species identified as having EFH requirements in the vicinity of the proposed Steel Point development.

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 shark (*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

An analysis of EFH for each fish species and life stage for the East River, including the likelihood that the species would occupy the project area, as shown in Table 1 is summarized below.

5.1 RED HAKE

Red hake is a bottom-dwelling fish that lives on sand and mud bottoms along the continental shelf from southern Nova Scotia to North Carolina (concentrated from the southwestern part of the Georges Banks to New Jersey). The East River is designated as EFH for larvae, juvenile, and adult red hake. Spawning adults and eggs are common in marine portions of most coastal bays between Rhode Island and Massachusetts. Spawning occurs from May to June in the New York Bight (Steimle *et al.*, 1999a). Red hake eggs are pelagic and range from the Middle Atlantic Bight to the Gulf of Maine. Eggs are found on the edge of the continental shelf during the cooler months and across the continental shelf during the warmer months. The characteristics of the habitat in which red hake eggs are commonly found are not well understood because red hake eggs occur with, and are indistinguishable from, the eggs of other hake species (Steimle *et al.*, 1999a).

The typical habitat for red hake larvae is sea surface temperatures between 8 and 23°C, depths between 10 and 200 meters and salinities greater than 0.5 ppt. Larvae are most often observed from May through December, with peaks in September and October. Although larvae have been reported from the Hudson River Estuary, they are most abundant at the middle and outer continental shelf throughout the Middle Atlantic Bight (Steimle *et al.*, 1999a). While red hake larvae do have the potential to occur in the East River, these individuals would be transient on the basis of habitat preferences. Shelter is a critical habitat requirement for red hake. In the autumn, young juveniles descend from the water column to the bottom and seek sheltering habitat in depressions in the sea floor. Juveniles are found on shell covered substrates, and prefer water temperatures below 16°C, depths of less than 100 meters, and a salinity range of 31 to 33 ppt (Steimle *et al.*, 1999a). This is greater salinity than is typical in the vicinity of the project site. In the Hudson- Raritan Estuary red hake were collected at depths between 5 and 50 meters. Red hake are very sensitive to low DO (Steimle *et al.*, 1999a). In particular, juveniles are sensitive to DO levels less than 4.2 mg/L, and would likely not tolerate summer minima conditions that occur occasionally in the East River.

Adults are found in bottom habitats of sand and mud, and they prefer water temperatures below 14°C, depths from 15 to 365 meters, salinities between 31 and 34 ppt, and a more open water environment than the project areas. Red hake adults are sensitive to hypoxia, and prefer DO levels greater than 6 mg/L (Steimle *et al.*, 1999a), and as noted for juveniles, may not tolerate summer minima conditions the project areas.

Amipods, decapods and polychaetes are dominant prey for this species (Collette and MacPhee 2002). Lack of sediment in the project area would limit the availability of these prey items.

Adult red hake were collected during impingement studies at the Ravenswood plant on the Queens side of the East River. If present in the project area, adults of this species are expected to be transient, likely during the spring and fall when DO is above 4.2 mg/L, prior to winter migrations to deeper waters. The project area is likely at the upper portion of the geographic range for juveniles and adults and would constitute a small portion of the EFH for this species. Overfishing is not currently occurring for the southern stock of red hake, the stock that occurs within the New York/New Jersey Harbor (NMFS, 2002). No effects to EFH from the project are expected for any life stage of red hake.

5.2 WINTER FLOUNDER

Winter flounder can be found from Labrador to North Carolina but most commonly in estuaries from the Gulf of St. Lawrence to the Chesapeake Bay including the Lower Hudson (Collette and MacPhee, 2002). It is a fairly small, thick flatfish that is abundant in the Lower Hudson Estuary, where it is a resident (Collette and MacPhee, 2002). The East River is designated as EFH for eggs, larvae, juvenile, and adult winter flounder.

Habitat and environmental conditions in the East River are typical for all life stages of winter flounder. All life stages were collected during impingement and entrainment studies conducted at the Ravenswood plant. All life stages are expected to occur at the Project site. Spawning adults and eggs are often observed from February to June, and larvae are observed from March to July. Eggs, juveniles, and adults prefer bottom habitats of mud or fine grained sand, and larvae are found in both bottom habitats and in the water column (Collette and MacPhee, 2002). Winter flounder are particularly susceptible to pollution (Grosslein and Azarovitz, 1982). The eggs are laid directly on the substrate and therefore any toxins in the sediment can affect their viability. This species' close association with sediments also potentially exposes the fish to sediment toxins. Grosslein and Azarovitz (1982) noted that few larvae survived in polluted estuaries, and that winter flounder were entirely absent from polluted sections of the New York/New Jersey Harbor. The primary prey for winter flounder is polychaetes (Collette and MacPhee, 2002), which would be limited in the project area because of the lack of sediment.

Installation of tri-frame mounts for the turbines would disturb substrate habitat and the water column. These activities could result in a temporary increase in turbidity. However, winter flounder has adapted to relatively harsh estuarine conditions and can avoid highly turbid conditions that are temporary in nature. Because installation of turbines will occur over a short period of time, water quality is expected to return to existing conditions following installation. Due to current velocities within the East River dispersion of re-suspended sediments, if any, would likely occur quickly. In addition, the narrow dimensions of the proposed turbines at the site reduces the amount of habitat affected by shading, and proposed construction activities would not significantly alter the habitat used by fish. Since winter flounder are found in bottom habitats and the turbines are proposed to be located off the bottom, turbine strikes are not expected for this species. No impacts to EFH for winter flounder are anticipated from this project.

5.3 WINDOWPANE FLOUNDER

Windowpane flounder is found from the Gulf of St. Lawrence to South Carolina and has its maximum abundance in the New York Bight. Windowpane flounder are generally found offshore on sandy bottoms in water between 50 and 80 meters deep, and close inshore in estuaries just below the mean low water mark. They migrate onshore in the shallow shoal water in the summer and early autumn as water temperatures increase, and migrate offshore during the winter and early spring months when temperatures decrease (Chang *et al.*, 1999). Habitat and environmental conditions in the East River are typical for all life stages of windowpane flounder. The East River is designated as EFH for eggs, larvae, and juvenile and adult windowpane flounder.

Windowpane flounder eggs, larvae, juveniles, and adults were collected during impingement and entrainment studies conducted at the Ravenswood plant on the Queens side of the East River. Windowpane flounder spawn within the mid-Atlantic Bight from April to December in the bottom waters with temperatures ranging from 8.5 to 13.5°C. Spawning peaks occur in May and then again in the autumn in the southern portion of the Bight. The buoyant eggs and larvae that settle to the bottom are found predominately in the estuaries and coastal shelf water for the spring spawned eggs, and in the coastal shelf waters alone for those eggs spawned in the autumn. Windowpane eggs are found floating in the water column at temperatures of generally between 5 to 20°C; specifically at 4 to 16°C in spring (March through May), 10 to 16°C in summer (June through August), and 14 to 20°C in autumn (September through November), and within depths less than 70 meters (Chang *et al.*, 1999). Larvae are typically found in the area of the estuary where salinity ranges from 18 to 30 ppt in the spring and on the shelf in the autumn. Juvenile windowpane flounder were found year round in both the shelf waters and in the Hudson-Raritan Estuary. Larvae are found at similar temperature and depth as the egg stage of this species, particularly at 3 to 14°C in the spring, 10 to 17°C in the summer, and 13 to 19°C in the autumn (Chang *et al.*, 1999).

Within the Hudson-Raritan estuary, juvenile fish were fairly evenly distributed but seemed to prefer the deeper channels in the winter and summer. They were most abundant where bottom water temperatures ranged from 5 to 23°C, depths ranged from 7 to 17 meters; salinities ranged from 22 to 30 ppt, and dissolved oxygen concentrations ranged from 7 to 11 mg/L. Similarly, adults were evenly distributed year-round, preferring deeper channels in the summer months. Adults were collected in bottom waters where temperatures ranged from 0 to 23°C, depths were less than 25 meters, salinity ranged from 15 to 33 ppt, and dissolved oxygen ranged from 2 to 13 mg/L. Windowpane flounder forage on activity swimming prey such as mysids (Collette and MacPhee, 2002).

As noted above for winter flounder, no significant adverse impacts are expected to occur from the installation of tri-frame mounts for the turbines, other than a temporary increase in turbidity. Because installation of turbines would occur over a short period of time, water quality is expected to return to existing conditions following installation. Due to current velocities within the East River dispersion of re-suspended sediments would likely occur quickly. In addition, because the narrow dimensions of the proposed turbines at the site reduces the amount of habitat affected by shading, proposed construction activities would not significantly alter the habitat used by fish. Since windowpane flounder are found in bottom habitats and the turbines are proposed to be located off the bottom turbine strikes are not expected for this species. No impacts to EFH for windowpane flounder are anticipated from this project.

5.4 ATLANTIC HERRING

Atlantic herring is a planktivorous marine species that occurs throughout the Northwestern Atlantic waters from Greenland to North Carolina. They are most abundant north of Cape Cod and relatively scarce in waters south of New Jersey. Atlantic herring rarely move into fresh water (Smith, 1985). Juvenile and adult herring undergo complex north-south migrations and inshore-offshore migration for feeding, spawning, and overwintering. They spawn once a year in late August to November, in the coastal ocean waters of Gulf of Maine and Georges Banks. This species never spawns in brackish water. Post-spawn, the adults migrate to the New York Bight to overwinter from December to April. The autumn migration to overwintering areas is done in tight schools while the spring migration to spawning areas is much more dispersed. NOAA (Stone *et al.*, 1994) indicates that larvae, juvenile, and adult Atlantic herring are common within the mixing zone portion of the Hudson River/Raritan Bay Estuary and are known to occur in the East River (NOAA, 2001). In addition, adults of this species were collected during impingement studies at the nearby Ravenswood plant in the East River. The East River is designated as EFH for larvae, juvenile, and adult Atlantic herring. Larvae are generally found in pelagic waters with temperatures below 16°C, water depths from 50 to 90 meters, and salinities of about 32 ppt. Juveniles and adults prefer pelagic waters and bottom habitats with water temperatures below 10°C, at water depths of 15 to 135 meters and 10 to 130 meters, respectively, and salinity ranges of over 26 ppt. Juveniles overwinter in deep bays. In the Hudson- Raritan estuary NEFSC bottom trawl surveys, adults collected were most abundant at 3 to 6°C at depths ranging from 4.5 to 13.5 meters. Preferred salinities for the Atlantic herring occur at 28 ppt and greater (Reid *et al.*, 1999).

The Atlantic herring stock complex in the northeastern United States is considered under-utilized with the exception of the portion in the Gulf of Maine (Reid *et al.*, 1999) and is not overfished (NMFS, 2002). Habitat areas affected by the RITE Project make up a small portion of EFH for this species and potential impacts to these areas would not adversely affect the Atlantic herring fishery. Atlantic herring are found in the water column, are planktonic filter feeders (Collette and MacPhee, 2002) and would not be disturbed by installation of the tri-mount turbines. Impacts due to turbine strikes are not expected to be a concern for this species. At their average size range of 20 cm (Collette and MacPhee, 2002) the probability of an Atlantic herring being struck by a turbine blade for 1 rotor is 0.03%, Install A (2 turbines) is 0.06%, Install B-1, (one tri-frame,) is 0.08%, Install B-2, (4 tri-frames) is 0.33%, and Install C (10 tri-frames) is 0.84% (Attachment A). No impacts to EFH for any life stage of Atlantic herring are anticipated from this project.

5.5 BLUEFISH

Bluefish is a carnivorous marine fish that occurs in temperate and tropical waters on the continental shelf and in estuarine habitats around the world. In North America, bluefish live along most of the Atlantic coastal waters from Nova Scotia south, around the tip of Florida, and along the Gulf Coast to Mexico (Fahay *et al.*, 1999). The East River is designated as EFH for juvenile and adult bluefish.

Bluefish often migrate to estuaries in the summer months, between April (adults) or May (juveniles), and October. Juveniles inhabit inshore estuaries from May to October, preferring temperatures between 15 and 30°C and salinities between 23 to 33 ppt. Although juvenile and adult bluefish are moderately euryhaline, occasionally they will ascend well into estuaries where salinities may be less than 3 ppt. Juveniles use estuaries as nursery areas and can be found in sand, mud, silt, or clay substrates as well as *Spartina* or *Fucus* beds. Bluefish juveniles are sensitive to changes in temperature where thermal edges apparently serve as important cues to juvenile migration off shore in the winter season (Fahay *et al.*, 1999).

Adult bluefish are pelagic and highly migratory with a seasonal occurrence in Mid-Atlantic estuaries from April to October. They prefer temperatures from 14 to 16°C but can tolerate temperatures from 11.8 to 30.4°C and salinities greater than 25 ppt. Adult bluefish are not uncommon in bays and larger estuaries, as well as coastal waters (Fahay *et al.*, 1999). Juvenile bluefish may be abundant and adults are common within the mixing zone portion of the Hudson River/Raritan Bay Estuary (Stone *et al.*, 1994).

Juvenile bluefish are known to occur in the East River from June to October (NOAA, 2001). Bluefish juveniles and adults were collected during impingement studies conducted at the Ravenswood plant in the East River. No spawning would occur within the project area. Because this species is pelagic and feed on pelagic prey (Collette and

MacPhee 2002), occupying open water areas and not bottom habitat, potential impacts associated with temporary increases in turbidity due to installation of the tri-frames would not be significant. Researchers have tagged and tracked bluefish populations off the East Coast. They found that most adult bluefish with lengths great than 45 cm are found offshore, while smaller juveniles are more likely to be inshore (Shepard *et al.*, 2006). To determine the probability that turbine strikes would be a concern for this species, a 45 cm length and the characteristics of the Verdant turbine were used to calculate the probability of strike at one turbine is 0.05%, Install A (2 turbines) is 0.09%, Install B-1, (one tri-frame,) is 0.14%, Install B-2, (4 tri-frames) is 0.56%, and Install C (10 tri-frames) is 1.41% (Attachment A). Habitat areas affected by the RITE Project make up a small portion of EFH for this species and potential impacts to these areas would not adversely affect the bluefish populations.

5.6 ATLANTIC BUTTERFISH

Butterfish occur from Newfoundland to Florida and are most abundant between southern New England and Cape Hatteras, North Carolina. Throughout its range, butterfish are found over the entire shelf, inshore and offshore. Cooling temperatures associated with late autumn trigger a migration offshore. Butterfish spawning takes place chiefly from May through October in Mid-Atlantic Bight. The times and duration of spawning are closely associated with changes in surface temperatures (Cross *et al.*, 1999). The East River is designated as EFH for larvae, juvenile, and adult Atlantic butterfish. Larvae are found at the surface or in the shelter of the tentacles of large jellyfish, and are more nektonic than planktonic from 10 to 15 mm. Larvae are found at temperatures ranging from 7 to 26°C (although most abundant at 9 to 19°C and at depths less than 120 meters. Both juveniles and adults have similar habitat characteristics. Both are eurythermal and euryhaline and are common often near the surface in sheltered bays and estuaries during the spring to fall months. Juvenile and adult butterfish also often prefer sandy and muddy substrates and temperatures from 3 to 28°C (Cross *et al.*, 1999).

Juvenile and adult butterfish have the potential to occur in the East River site. Adult butterfish were collected during impingement studies conducted at the Ravenswood plant in the East River. Individuals of this species are less likely to be affected by the in-water activities construction and installation than more bottom dwelling fish. Butterfish stock is not overfished or approaching an overfished condition (Cross *et al.*, 1999, NMFS, 2002) and it is considered an underexploited fishery (Cross *et al.*, 1999). 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 1 rotor is 0.03%, Install A (2 turbines) is 0.06%, Install B-1, (one tri-frame,) is 0.09%, Install B-2, (4 tri-frames) is 0.37%, and Install C (10 tri-frames) is 0.92% (Appendix A). No impacts to EFH for any life stage of Atlantic butterfish are anticipated from this project

5.7 ATLANTIC MACKEREL

Atlantic mackerel is a pelagic marine fish that occurs in the western North Atlantic from Labrador to North Carolina. It sustains fisheries from the Gulf of St. Lawrence and Nova Scotia to the Cape Hatteras area. There may be two populations: one occurring in the northern Atlantic and associated with the New England and Maritime Canadian coast and another more southerly population inhabiting the mid-Atlantic coast. Both populations overwinter in the deep waters at the edge of the continental shelf, generally moving inshore (in a northeastern direction) during the spring, and reversing this migration in autumn. The southern population begins its spawning migration by moving inshore between the Delaware Bay and Cape Hatteras and in a northeastern direction along the coast. The timing of the migration and spawn is a result of warming water temperatures. The peak spawn for the southern population occurs off New Jersey and Long Island Sound in April and May. Most spawning occurs in the shoreward half of the shelf and in waters from 7 to 14°C. By June there are schools of juveniles off Massachusetts, and they move into the Gulf of Maine by June and July where they remain for the summer (Studholme *et al.*, 1999).

The East River is designated EFH for juvenile and adult Atlantic mackerel. In the Hudson-Raritan Estuary, juveniles are present from April to December, but are most common from April through June and October through November. Juvenile transformation includes swimming and schooling behaviors starting at 30 to 50 mm, and closely resemble adults when about 1 year of age. In the Hudson-Raritan Bay estuary, juveniles are present in the spring and summer months preferring depths from 4.9 to 9.8 meters, salinity ranges from 26 to 28.9 ppt, dissolved oxygen from 7.3 to 8.0 mg/L and temperatures from 17.6 to 21.7°C (Studholme *et al.*, 1999). In the Hudson-Raritan Estuary, adults are present from April through June and from September through December, most commonly from April to May and from October to November (ACOE, 2000). Adults also prefer salinities of 25 ppt or greater (Studholme *et al.*, 1999). Atlantic mackerel are opportunistic filter feeders (Collette and MacPhee, 2002).

Juveniles and adults are the stages of Atlantic mackerel with the greatest potential to occur within the project areas. Spawning would not occur within this area. Habitat found within the project area does not represent a significant portion of the EFH for this species. The Atlantic mackerel fishery is no longer considered overfished and this stock is now considered underexploited (NMFS, 2002). 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 1 rotor is 0.04% Install A (2 turbines) is 0.07%, Install B-1, (one tri-frame,) is 0.11%, Install B-2, (4 tri-frames) is 0.44%, and Install C (10 tri-frames) is 1.10%. No impacts to EFH for any life stage of Atlantic mackerel are anticipated from this project.

5.8 SUMMER FLOUNDER

Summer flounder prefer the estuarine and shelf waters of the Atlantic Ocean and are found between Nova Scotia and southeastern Florida. They are most abundant from Cape Cod, Massachusetts, to Cape Hatteras, North Carolina. Summer flounder usually appear in the inshore waters of the New York Bight in April, continuing inshore in May and June, and reach their peak abundance during the warm summer months of July and August. Summer flounder move offshore for the winter season (Packer *et al.*, 1999). The East River is designated as EFH for larvae, juvenile, and adult summer flounder. Larvae occur in water from 0 to 22°C (32 to 72°F) and are transported to estuarine nurseries by currents. Juvenile summer flounder are well adapted to the temperature and salinity ranges present in estuarine habitats. They are distributed throughout the New York-New Jersey Harbor Estuary prior to late summer and are more concentrated in sea grass beds as opposed to tidal marshes in the late summer and early autumn (ACOE, 2000). Salinity preference within the New Jersey area for this species was found between 20 to 30 ppt. In the Mid-Atlantic Bight, larvae were found at depths from 10 to 70 meters (32.8 to 229.6 feet). Greater densities of young fish were found in or near inlets (Packer *et al.*, 1999).

Juvenile summer flounder are able to withstand a wide range of temperatures (greater than 11°C) and salinities from 10 to 30 ppt. Juveniles can be found on mud and sand substrates in flats, channels, salt marsh creeks, and eelgrass beds (Packer *et al.*, 1999). Adults often feed in estuaries and shelf waters in the warmer months and are more active during daylight hours since they are primarily visual feeders that feed on fish primarily sand lance and crustaceans (Collette and MacPhee, 2002). Adults inhabit sand substrates usually at depths up to 25 meters, at temperatures ranging from 9 to 26°C in the autumn, 4 to 13°C in the winter, 2 to 20°C in the spring, and 9 to 27°C in the summer. Salinity is known to have minimal effect on distribution in comparison to substrate preference (Packer *et al.*, 1999).

Juvenile and adult summer flounder are known to occur within the East River (NOAA, 2001) and have the potential to occur within project area. Summer flounder adults were collected during impingement studies conducted at the Ravenswood plant in the East River. As discussed with respect to the other flounder EFH, summer flounder is a bottom dwelling species and therefore has a potential to be affected by the temporary increases in turbidity during installation of the tri-frames. As with winter flounder, any temporary changes associated with the project would not significantly impact this fishery since summer flounder are widely distributed in nearby habitats. Since summer flounder are found in bottom habitats and the turbines are proposed to be located off the bottom, turbine strikes are not expected for this species. No impacts to EFH for summer flounder are anticipated from this project.

5.9 SCUP

Scup is a marine fish that occurs primarily on the continental shelf from Cape Cod, Massachusetts to Cape Hatteras, North Carolina. It migrates extensively from inshore summer grounds to offshore winter grounds. Scup arrive in the waters off New Jersey and New York by early May. During the summer months, older fish tend to stay in the inshore waters of the bays while the younger fish are found in the more saline waters of estuaries such as the Hudson-Raritan Estuary. Spawning occurs in May through August with a peak in June and occurs in the estuaries of the New York and New Jersey. Juveniles grow quickly and migrate with the rest of the population to offshore wintering grounds starting in late October and are absent from inshore waters by the end of November (Collette and MacPhee, 2002).

The East River is designated as EFH for eggs, larval, juvenile, and adult scup. Scup eggs are buoyant and are rather small (0.8 to 1.0 mm), hatching in about 2 to 3 days depending on temperature. Most were collected from May-August at depths less than 50 meters (164 feet) and at temperatures ranging from 11 to 23°C (Steimle *et al.*, 1999c). Newly hatched larvae are pelagic and approximately 2 mm long. In approximately three days, diagnostic characters of the species are evident and shortly afterwards the larvae abandon the pelagic phase and become bottom dwelling. They occur at water temperatures ranging from 14 to 22°C and occupy more saline (23 to 33 ppt) portions of bays. They are often found within the water column at depths less than 50 meters (164 feet) (Steimle *et al.*, 1999c). Juveniles from are common during November. By the end of their first year they can reach up to 16 cm. Juveniles inhabit estuarine intertidal areas at depths of 5 to 12 meters particularly areas with sand and mud substrates or mussel and eelgrass beds. Juveniles prefer temperatures from about 9 to 27°C and salinities greater than 15 ppt (Steimle *et al.*, 1999c). Scup males and females reach sexual maturity at age two and reach about 15.5 cm. From April to December, adults can be found inshore along silt, sand, and mud substrates at depths less than 30 meters. Temperature preferences for the adult species range from 6 to 27°C and salinities from 20 to 30 ppt are preferred (Steimle *et al.*, 1999c). Scup are bottom feeders that feed on squid, polychaetes, crustaceans and fish (Collette and MacPhee, 2002).

Juvenile and adult scup are known to occur in the East River (NOAA, 2001) and have the potential to occur within the RITE project area, primarily in the summer and autumn. No spawning would occur within the vicinity of the project area. Adults of the species were collected during impingement studies at the Ravenswood plant in the East River. Although scup have been collected within the vicinity of the project area the EFH for this marine species is primarily in higher salinity areas (ACOE, 1999). Because juveniles and adults tend to occur toward the bottom, in-water construction activities have the potential to temporarily impact scup EFH during the summer and autumn. As with other bottom dwelling fish, temporary habitat changes associated with the project would not impact this fishery since these fish are widely distributed in nearby habitats and the project area constitutes a small portion of the EFH for this species. Since scup are found in bottom habitats and the turbines are proposed to be located off the bottom, turbine strikes are not expected for this species. No impacts to EFH for scup are anticipated from this project.

5.10 BLACK SEA BASS

Black sea bass is a marine species that occurs from Cape Cod, Massachusetts to Cape Canaveral, Florida. The fishery is divided into two populations: one major population above Cape Hatteras, North Carolina, and one below. The northern population migrates seasonally: inshore and north in the spring and offshore and south in the autumn. In the autumn, older fish move offshore sooner and overwinter in deeper waters (73 to 163 meters) than young-of-the-year fish (56 to 110 meters). Black sea bass can tolerate temperatures as low as 6°C but are most abundant in off-shore waters warmer than 9°C and between 20 to 60 meters deep. During the spring migration, adults move to spawning grounds and juveniles move into estuaries. For the northern population spawning generally takes place in the summer, in water 18 to 45 meters deep from the Chesapeake Bay to Montauk (Steimle *et al.*, 1999b). The East River is designated as EFH for juvenile and adult black sea bass. Larvae develop for the most part in continental shelf waters and are most abundant in the southern portion of the Middle Atlantic Bight.

Young-of-the-year (YOY) fish in estuaries occupy bottom habitats with shells, amphipod tubes, and deep channel rubble and have been noted to appear on inshore jetties in late May to early June. In the Hudson River, YOY have been captured in open water and pier areas. Juveniles settle in estuaries and the inner continental shelf growing up to 19 cm. From July to September, YOY inhabit estuarine areas in the Mid-Atlantic Bight at depths from 1 to 38 meters. They prefer rough bottoms and shell patch substrates, and find shelter around manmade structures. Juveniles can be found in water temperatures ranging from 6 to 30°C and salinities ranging from 8 to 38 ppt. The YOY are migratory during some portions of the first year. They migrate out of the estuary and away from inner continental shelf nursery areas during the autumn as water temperatures drop (Steimle *et al.*, 1999b).

Adult black sea bass prefer habitats similar to juveniles and perform similar migratory patterns. Adults also find shelter around piers (Steimle *et al.*, 1999b). NOAA (Stone *et al.*, 1994) indicates that adult and juvenile black sea bass are rare in the mixing zone portion of the Hudson River/Raritan Bay Estuary, but are known to occur in the East River from April to November (NOAA, 2001) and, therefore, have the potential to occur within the RITE project area. Adults were collected during impingement studies at the Ravenswood plant in the East River. Black sea bass feed on crustaceans, fishes, and mollusks (Collette and MacPhee, 2002). The temporary increases in turbidity during the construction period in the project area should not affect this stock and the project area constitutes a small portion of the EFH for this species. At their average size range of 25 cm (Collette and MacPhee, 2002) the probability of an black sea bass being struck by a turbine blade for 1 rotor is 0.03%, Install A (2 turbines) is 0.07%, Install B-1, (one tri-frame,) is 0.10%, Install B-2, (4 tri-frames) is 0.39%, and Install C (10 tri-frames) is 0.98% (Attachment A). Therefore, no effects to EFH are expected for any life stage of black sea bass.

5.11 KING MACKEREL

King mackerel is a marine fish that inhabits Atlantic coastal waters from the Gulf of Maine to Rio de Janeiro, Brazil, including the Gulf of Mexico. There may be two distinct populations of King mackerel. One group migrates from waters near Cape Canaveral, Florida south to the Gulf of Mexico, making it there by spring and continuing along the western Florida continental shelf throughout the summer. A second group migrates to waters off the coast of the Carolinas in the summer, after spending the spring in the waters of southern Florida, and continues on in the autumn to the northern extent of the range. Overall, temperature appears to be the major factor governing the distribution of the species. The northern extent of its range is near Block Island, Rhode Island, near the 20°C isotherm and the 18-meter contour. The East River is designated as EFH for eggs, larvae, juvenile, and adult king mackerel. King mackerel spawn in the northern

Gulf of Mexico and southern Atlantic coast. Larvae have been collected from May to October, with a peak in September. In the south Atlantic, larvae have been collected at the surface with salinities ranging from 30 to 37 ppt and temperatures from 22 to 28°C. Adults are normally found in water with salinity ranging from 32 to 36 ppt. King mackerel would occur only as occasional transient individuals within the New York/New Jersey Harbor Estuary system, and thus EFH for this species would not be affected by this project.

5.12 SPANISH MACKEREL

Spanish mackerel is a marine species that can occur in the Atlantic Ocean from the Gulf of Maine to the Yucatan Peninsula. It is most common between the Chesapeake Bay and the northern Gulf of Mexico from spring through autumn, and then heads south to overwinter in the waters of south Florida. These populations spawn in the northern extent of their ranges (along the northern Gulf Coast and along the Atlantic Coast). The East River is designated as EFH for eggs, larvae, juvenile, and adult Spanish mackerel. Spawning begins in mid-June in the Chesapeake Bay and in late September off Long Island, New York. Temperature is an important factor in the timing of spawning and few spawn in temperatures below 26°C. Studies indicate that Spanish mackerel spawn over the Inner Continental Shelf in water 12 to 34 meters deep. Spanish mackerel eggs are pelagic and about 1 mm in diameter. Most larvae have been collected in coastal waters of the Gulf of Mexico and the east coast of the United States.

Overall, temperature and salinity is indicated as the major factor governing the distribution of this species. The northern extent of their range is near Block Island, Rhode Island, near the 20°C isotherm and the 18 meter contour. During warm years, they can be found as far north as Massachusetts. They prefer water from 21 to 27°C and are rarely found in waters cooler than 18°C. Adult Spanish mackerel generally avoid freshwater or low salinity (less than 32 ppt) areas such as the mouths of rivers. Because this is a marine species that prefers higher salinity waters, only occasional individuals are likely to occur within the project areas. Therefore, EFH for this species would not be affected by this project.

5.13 COBIA

Cobia are large, migratory, coastal pelagic fish that occur from Massachusetts to Argentina, but are most common along the south Atlantic coast of the United States and in the northern Gulf of Mexico (Biesiot *et al.* 1994). In the eastern Gulf, cobia typically migrate from wintering grounds off south Florida into northeastern Gulf waters during early spring (Biesiot *et al.* 1994). They occur off northwest Florida, Alabama, Mississippi, and southeast Louisiana wintering grounds in the fall. Some cobia overwinter in the northern Gulf at depths of 100 to 125 meters (Biesiot *et al.* 1994). The East River is designated as EFH for eggs, larvae, juvenile and adult Cobia. Information on the life history of cobia from the Gulf and the Atlantic Coast of the United States is limited. The Gulf Stream is an essential fish habitat because it provides a mechanism to disperse coastal migratory pelagic larvae. Preferred temperatures are greater than 20 and salinities are greater than 25 ppt. Cobia are likely to occur only as occasional transient individuals within the project area due to its coastal migrations and salinity requirements. No effects to EFH for this species are anticipated.

5.14 SAND TIGER SHARK

The sand tiger is a large, coastal species found in tropical and warm temperate waters throughout the world. It is often found in shallow coastal waters (Collette and MacPhee 2002). The East River is designated as EFH for sand tiger shark larvae (neonates). In North America, the sand tiger gives birth in March and April to two young. This species congregates in coastal areas in large numbers during the mating season This species is not expected to occur within the New York/New Jersey Harbor Estuary except as an occasional transient. Therefore, it is unlikely that this species would be found in the project area and EFH for sand tiger shark would not be affected by the project.

5.15 SANDBAR SHARK

The sandbar shark is a common bottom-dwelling coastal shark in U.S. Atlantic waters (Collette and MacPhee 2002). The East River is designated as EFH for sandbar shark larvae (neonates). The sandbar shark is a slow growing species. Both sexes reach maturity at about 180 cm TL. Estimates of age of maturity range from 15 to 16 years (Collette and MacPhee 2002). Young are born at about 60 cm TL from March to July (Collette and MacPhee 2002) The gestation period lasts about a year and reproduction is biennial (Collette and MacPhee 2002). In the United States, the sandbar shark uses estuarine nurseries in shallow coastal waters from Cape Canaveral, Florida, to the northern extent of the range at Great Bay, New Jersey. The EFH for sandbar shark neonates and early juveniles are shallow coastal areas; nursery areas in shallow coastal waters from Great Bay, New Jersey to Cape Canaveral, Florida, especially Delaware and Chesapeake Bays also shallow coastal waters up to a depth of 50 meters (164 feet) on the west coast of Florida and the Florida Keys. This species is 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 sandbar shark will not be affected by the project.

5.16 CLEARNOSE SKATE

Clearnose skate inhabit bottom habitats with a substrate of soft bottom along the continental shelf and rocky or gravelly bottom, ranging from the Gulf of Maine south along the continental shelf to Cape Hatteras, North Carolina. Generally both juveniles and adults range from the shore to 400 to 500 meters, but they are most abundant at depths less than 111 meters. They occur over a temperature range of 9-30°C, but are most abundant from 9-21°C in the northern part of its range and 19-30°C around North

Carolina. These skates feed primarily on polychaete, amphipods and mysid shrimp (Collette and MacPhee, 2002).

Clearnose skate are commercially important however NMFS determined that clearnose skate is not in an overfished condition, based on stock size assessment. Because recent assessments determined that more information is needed to draw valid conclusions regarding the status of this stock, it is not known whether overfishing is occurring. For clearnose skate, essential fish habitat is described as those areas of coastal and offshore waters (out to the offshore U.S. boundary of the exclusive economic zone).

The East River has been designed as essential fish habitat for juvenile and adult clearnose skates. However, only habitats with soft bottom, rocky or gravelly substrates that occur within the shaded areas would be designated as EFH for both juveniles and adults. As noted above for other benthic fish, no significant adverse impacts are expected to occur from the installation of tri-frame mounts for the turbines, other than a temporary increase in turbidity. Because installation of turbines would occur over a short period of time, water quality is expected to return to existing conditions following installation. Due to current velocities within the East River, dispersion of re-suspended sediments would likely occur quickly. In addition, because the narrow dimensions of the proposed turbines at the site reduces the amount of habitat affected by shading, proposed construction activities would not significantly alter the habitat used by fish. Since clearnose skate are found in bottom habitats and the turbines are proposed to be located off the bottom turbine strikes are not expected for this species. No impacts to EFH for clearnose skate are anticipated from this project.

5.17 LITTLE SKATE

Little skate range from Georges Bank through the Mid-Atlantic Bight to Cape Hatteras, North Carolina. They inhabit bottom habitats with a sandy or gravelly substrate or mud. Full range is from the shore to 137 meters, with the highest abundance from 73-91 meters. Most adults are found between 2-15°C while juveniles frequent areas with water temperatures between 4-15°C. These skates primarily feed on hydrozoan, gastropods and mysids (Collette and MacPhee, 2002).

Little skate are growing in commercial importance as a source of skates wings and are also used to bait lobster traps. NMFS determined that little skate is not in an overfished condition and that overfishing of this stock is not occurring, based on stock size assessment. For little skate, EFH is described as those areas of coastal and offshore waters out to the offshore U.S. boundary of the exclusive economic zone.

The East River has been designed as EFH for juvenile and adult little skates. However only habitats with a sandy or gravelly substrate or mud substrates would be designated as EFH for both juveniles and adults. As noted above for the clearnose skate, no significant adverse impacts are expected to occur from the installation of tri-frame mounts for the turbines, other than a temporary increase in turbidity. In addition, because the narrow dimensions of the proposed turbines at the site reduces the amount of habitat affected by shading, proposed construction activities would not significantly alter the habitat used by fish. Since little skate are found in bottom habitats and the turbines are proposed to be located off the bottom, turbine strikes are not expected for this species. No impacts to EFH for little skate are anticipated from this project.

5.18 WINTER SKATE

Winter skate range from Cape Cod Bay, on Georges Bank, the southern New England shelf, and through the Mid-Atlantic Bight to North Carolina. Range from shoreline to about 400 meters and most abundant at depths below 111 meters. Juveniles are generally found in water temperatures that range from –1.2°C to around 20°C, with most found from 5-15°C, depending on the season. Adults range from –1.2°C to around

20°C, with most found from 5-15°C, depending on the season. These skates primarily feed on hydrozoan, gastropods and mysids (Collette and MacPhee, 2002).

Winter skate are a commercially important species and NMFS has determined that winter skate is in an overfished condition and that overfishing of this stock is occurring, based on stock size assessment. For winter skate, EFH is described as those areas of coastal and offshore waters out to the offshore U.S. boundary of the exclusive economic zone.

The East River has been designed as EFH for juvenile and adult little skates. However only habitats with a substrate of sand and gravel or mud would be designated as EFH for both juveniles and adults. As noted above for the clearnose skate, no significant adverse impacts are expected to occur from the installation of tri-frame mounts for the turbines, other than a temporary increase in turbidity. In addition, because the narrow dimensions of the proposed turbines at the site reduces the amount of habitat affected by shading, proposed construction activities would not significantly alter the habitat used by fish. Since winter skate are found in bottom habitats and the turbines are proposed to be located off the bottom, turbine strikes are not expected for this species. No impacts to EFH for winter skate are anticipated from this project.

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VOLUME 4

ATTACHMENT 3 – MMPA

BIOLOGICAL ASSESSMENT
HARBOR SEAL

ROOSEVELT ISLAND TIDAL ENERGY PROJECT

FERC NO. 12611

DECEMBER 2010

Prepared by:

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VERDANT POWER

VERDANT POWER

ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT

BIOLOGICAL ASSESSMENT

HARBOR SEAL

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 PROJECT AREA 1

3.0 DESCRIPTION OF THE PROPOSED ACTION 3

4.0 PROJECT OPERATION 4

5.0 STATUS OF AFFECTED SPECIES 5

- 5.1 LIFE HISTORY 5
- 5.2 STATUS AND TRENDS RANGEWIDE 5
- 5.3 STATUS IN ACTION AREA 6
- 5.4 ENVIRONMENTAL BASELINE 6
- 5.5 EFFECTS OF THE ACTION 7

6.0 LITERATURE CITED 8

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VERDANT POWER
ROOSEVELT ISLAND TIDAL ENERGY (RITE) PROJECT
BIOLOGICAL ASSESSMENT
HARBOR SEAL

1.0 INTRODUCTION

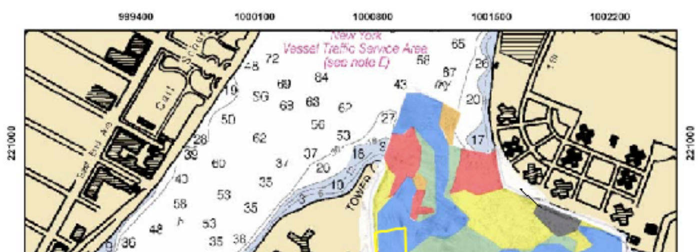
The harbor seal (*Phoca vitulina*) are known to use the Long Island Sound and New York Harbor for habitat. The harbor seal is protected by the Marine Mammal Protection Act of 1972 (16 U.S.C. 1531-1543). Due to the relatively close proximity of the proposed Roosevelt Island Tidal Energy (RITE) Project in the East River, New York, this Biological Assessment has been prepared to analyze the potential for effects to harbor seals from the proposed project. Verdant Power, LLC (Verdant) is proposing the RITE Project to deliver commercial electricity from Verdant Power's Free Flow Kinetic Hydropower System and generate clean renewable energy from the river's tidal currents.

2.0 PROJECT AREA

The East River is a 17-mile-long tidal strait connecting the waters of the Long Island Sound with those of the Atlantic Ocean in New York Harbor. The East River separates the New York City Boroughs of Manhattan and the Bronx from Brooklyn and Queens. The Harlem River flows from the Hudson River and connects with the East River at Hell Gate. The East River is a saltwater conveyance passage for tidal flow. There is some freshwater influence from the Harlem River and some direct drainage area from the surrounding metropolis, but the river is predominantly controlled by tidal influence.

In February 2005, Verdant conducted a remote sensing survey to document surficial and subsurface riverbed features in the east channel in the area of the experimental units. The survey was conducted using a high-resolution side-scan sonar device at frequencies of 500-kHz and 100-kHz respectively. Detailed images of the riverbed features were generated from data collected from the survey and was included in the report, “Acoustic Remote Sensing Survey for Roosevelt Island Tidal Energy Project,” published in March 2005. The study confirmed the presence of boulders and cobbles that were depicted on the side-scan sonar and sub-bottom records. The video coverage did not show any evidence of fine grain soft sediments (Figure 2-1). This was also later confirmed when Verdant drilled the six piles into the bedrock for the demonstration project.

Figure 2-1. Substrate mapping in the east channel of the East River.



Throughout the last several years, Verdant Power has implemented a formal procedure for observations of marine mammals to be recorded during the bird observation and on and near water activities associated with the operation of the RITE demonstration project and during execution of on-water studies such as the monthly mobile hydroacoustic studies (pre-2005; and post-deployment for 6 months in January through June 2007). No occurrences of marine mammals were logged during these activities (Verdant, 2007). Verdant Power personnel operating during the three deployments (December 2006 through and including November 2008; discontinuous) were also asked to observe and record any unusual aquatic observances and the control room logs show no recorded data related to marine mammals. No incidental observations of marine mammals were made concurrent with the other >500 hours of other field studies conducted. A review of other intake data from area power plants; specifically Ravenswood and Astoria yielded no harbor seal observations in the 17 years of historical record reviewed (Verdant, 2008).

3.0 DESCRIPTION OF THE PROPOSED ACTION

Verdant is proposing to develop the RITE Project under the Federal Energy Regulatory Commission (FERC)'s new Hydrokinetic Pilot Project Licensing Process. The RITE Project builds on the successful RITE demonstration that operated in the East River for several years. The RITE East Channel Pilot would consist of:

1. a field array of thirty (30), 5-meter diameter axial flow Kinetic Hydropower System (KHPS) turbine-generator units mounted on ten (10) triframe mounts, with a total capacity of 1 MW at 35 KW each;
2. underwater cables from each turbine to five shoreline switchgear vaults, that interconnect to a Control Room and interconnection points; and
3. appurtenant facilities to ensure safe navigation and turbine operation.

The Project will be built in three major phases:

- Install A: Two Gen 5 turbines on existing monopiles for testing purposes this will be done under existing permits and not under the pilot license
- Install B1: Install three Gen 5 turbines on a tri-frame
- Install B-2: Install up to three additional tri-frames of three turbines
- Install C: Install up to six additional triframes (no more than 30 Gen 5 KHPS total)

The Verdant Gen 5 KHPS turbine consists of four major components:

- Rotor with three fixed blades
- Nacelle, pylon and yaw mechanism
- Generator and drivetrain
- Riverbed mounting system, (3 KHPS turbines on one tri-frame mount)

The RITE pilot project of 30 KHPS turbines would encompass a project boundary of approximately 21.6 acres, which includes 21.2 acres of underwater land lease and 0.4 acres of shoreline right-of-way for the Control Room, Cable Vaults and two underground transmission lines.

4.0 PROJECT OPERATION

The RITE East Channel Pilot will operate using the natural tidal currents of the East River. The Verdant KHPS captures energy from the flow in both ebb and flood directions by yawing with the changing tide, using a passive weathervaning system with a downstream rotor. As the flow direction changes, hydrodynamic forces on the rotor, nacelle, and pylon all contribute to yaw torque to align the rotor with the flow. There are no sensors, controls, or actuators to yaw the turbine. This design is far simpler than any active system to control turbine yaw or blade pitch, and has far fewer elements to foul or fail. The Gen 5 turbine utilizes a fixed blade design and Verdant considers this to be essential to reliable long-term underwater operation. The upstream pylon assembly, which is faired to provide a clean flow to the rotor, can also provide a degree of protection to the rotor. Turbine yaw is limited at 170° to ensure that the turbine will rotate in the same direction as the tidal current changes to allow a simple power cabling arrangement without slip rings.

5.0 STATUS OF AFFECTED SPECIES

5.1 LIFE HISTORY

Harbor seals are non-migratory and inhabit the shores of Eastern Canada, New England and New York, on occasion they can be found as far south as the Carolinas. The majority of harbor seals from the Western North Atlantic Stock breed and have pups in waters north of the New Hampshire/Maine border, although some confirmed cases of breeding and pupping has occurred in Long Island Sound (NMFS, 2009; Sadove and Cardinale, 1993). They will mate at sea and will give birth during the spring and summer. Juvenile and sub-adult harbor seals will often migrate to southern New England and the mid-Atlantic in September though late May (NMFS, 2009). Harbor seals are opportunistic feeders searching both shallow and deep water for fish, shellfish and crustaceans. They inhabit the temperate coastal rocks, reefs and beaches, where they will haul out to thermal regulate, socialize, give birth and rest (NMFS, 2010).

5.2 STATUS AND TRENDS RANGEWIDE

Harbor seals are found on both the eastern and western coasts of the United States. The harbor seals in the action area are a part of the Western North Atlantic Stock or sub-population. This population extends from the eastern Canadian Arctic and Greenland south to southern New England and New York, and rarely to the Carolinas. Since the enactment of the MMPA in 1972 harbor seal populations have stabilized or increased across the species range. The West coast populations have all increased with those in Oregon and Washington at carrying capacity, California populations are stabilizing, the

New England population is increasing as are the southeast Alaska and Bering seas populations. The only population that is not stable or increasing is the population from the Gulf of Alaska (NMFS, 2010).

5.3 STATUS IN ACTION AREA

The harbor seal is a year-round resident and common in the Long Island area (Cresli, 2010). In addition, all age classes of harbor seal are found in Long Island with a more dominant juvenile population. The density of harbor seals increase from November to May, which is related to the southern migration of some juvenile and sub-adult seals (NMFS, 2009). The distribution of these seals is tied directly to the haul-out sites of the region. Harbor seals hauled out in groups basking on any of the 25 major haul-out sites located in the region, the largest of which has over 350 animals (Sadove and Cardinale, 1993; NMFS, 2010). The Population of harbor seals has been documented to be increasing at overwintering haul-out sites from the Maine/New Hampshire border to eastern Long Island (NMFS, 2009).

Harbor seals have recently been observed in New York Harbor. A group of 20 seals were seen on Swinburne and Hoffman Islands near the Verrazano Bridge during a 2009 seal survey (Maher, 2009). Other nearby sightings in New York Harbor included lone seals observed at West 79th Street along the Hudson River Waterfront, as well as Red Hook, Brooklyn (Sullivan, 2008; Baard, 2008). A seal was even observed hauled out at Stuyvesant Cove Park, approximately 2.5 miles south of the Project Area (Solar One, 2009).

5.4 ENVIRONMENTAL BASELINE

Environmental baselines include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this biological assessment includes the effects of several activities that may affect the survival and recovery of the endangered species in the action area. As with all the marine mammals, one of major causes of decline is collision with ships as well as incidental capture in fishing gear, primarily in longlines and gillnets, but also in trawls, traps and pots, and dredges. In addition, the historic and present threat of legal and illegal hunting is a primary threat to seals (NMFS, 2010). The threat of global warming is also affecting these animals as the loss of sea ice may affect their habitat (NMFS, 2010). The NMFS estimates that direct human causes of death or serious injury for the Western North Atlantic Stock to be 477 per year. This does not include undocumented killings of harbor seal that are related to the mariculture industry (*i.e*. salmon farming) and deliberate poaching (NMFS, 2009).

5.5 EFFECTS OF THE ACTION

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.

6.0 LITERATURE CITED

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FINANCIAL ASSURANCE

1.0 FINANCIAL ASSURANCE

Verdant Power assures that, at least 90 days before commencing project construction and installation of the RITE pilot build-out described herein, it will file proof of the purchase of a surety bond, or equivalent financial assurance instrument to cover the entirety of the costs of removing the project in accordance with the Proposed RITE Project Removal and Site Restoration Plan (provided in Volume 3) required by this pilot license and included in this application. Thereafter during the term of the license, Verdant Power will maintain the bond, or equivalent financial assurance. By January 1 of each license year, or as otherwise directed by FERC or its authorized representative, Verdant Power will file proof of the maintenance of the bond, or equivalent financial assurance.

As a condition precedent for the installation of the existing RITE Demonstration project, the joint NYSDEC/ACOE permit required financial assurances that the project could be removed at the expiration of the permit term. Financial assurance to execute such a plan, if necessary, were extended to Verdant in the form of a 10% hold-back of allocated funds by the project's major public funding source, the New York State Energy Research and Development Authority (NYSERDA). This holdback represented approximately $90,000.