FISH MOVEMENT AND PROTECTION ASSESSMENT
ROOSEVELT ISLAND TIDAL ENERGY PROJECT
FERC PROJECT No. 12178
REVISION 6.0 10-14-2005

1. Goal

To develop on-site information to evaluate fish movement and protection aspects for the Roosevelt Island Tidal Energy (RITE) Project, using a pilot study with six experimental units.

2. Introduction and Background

Verdant Power is seeking a Federal Energy Regulatory Commission (FERC) license to generate electrical power using the natural tidal current of the East River in New York City (Figure 1). This RITE Project would be the first of its kind in the world. As such, there is no information from existing projects on which to base an assessment of environmental effects grounded on experience. Verdant thus prepared an assessment of the *potential* impacts of the units on local fish populations in the Supplemental Report Full Environmental Assessment (Verdant 2004) and the Essential Fish Habitat Assessment (DTA 2004a). However, lacking project and site-specific environmental effects information, Verdant proposes to temporarily install six study turbines (six-pack) to conduct in-situ field studies to assess both the efficiency of the turbines relative to their placement in the water column and the effects of the turbines on the surrounding environment and marine life. Information collected as a result of studies performed during the six-pack deployment will provide the best indicator of the reaction of fish and other marine life to the turbines available to date. Verdant submitted a joint permit application for the test six-pack to the New York State Department of Environmental Conservation (NYSDEC) and the Army Corps of Engineers (ACOE) in February 2004. Following the public notice of the application by the ACOE, agency comments were received and Verdant prepared and distributed a “Response to Comments” document on August 5, 2004 (DTA 2004b).

In support of deployment of the six-pack study turbines in the East River, Verdant obtained and reviewed a variety of existing fish data from local sources. We are aware of at least seven fish netting studies within the East River that occurred throughout the 1980’s. Some of these studies were year-long intensive monthly sampling events involving multiple gear types, including bottom and mid-water trawls, gill nets, trap nets, and beach seines. Additional information on fish communities within the East River is also available for the Ravenswood Generating Station within a few hundred yards of the proposed study site. Impingement data were obtained for two full years between 1991 and 1994 with some additional data collected in 2000. This information was summarized in the Ravenswood Generating Station Final Action Report (ASA 2001) and included in Verdant Power’s Response to Comments (DTA 2004b), which was provided to the ACOE and NYSDEC, as well as other appropriate resource agencies in support of the permit application for the six-pack. This fish summary information was further augmented with some more detailed seasonal occurrence data for the Ravenswood Generating Station, two additional power station impingement data sets from both ends of the East River, and some historical fish netting data. This information was summarized in a separate report submitted in December (DTA 2004c). Taken in total, this available existing information is sufficient to characterize fish species (species list and relative abundances) occurring in the East River as well as provide a temporal view of seasonal and annual variations.

Since prototype-scale hydraulic flume testing was not practical, Verdant (at the request of the resource agencies) conducted a probability analysis for the potential for fish in the vicinity of the turbine units to be struck by the turbine blades. This analysis included the cross section of the East Channel that is occupied by the turbines, evasive actions that migrating fish might take around the turbines, the hydraulic streamlines around the blades, and the varying likelihood of fish damage from impact along the length of the blades. Existing information from studies of fish behavior by Oak Ridge National Laboratory and computational fluid dynamics modeling with low head turbines and biological effects of blade strikes (Turnpenny 1998) were reviewed as part of this analysis. While the probability of a potential strike was estimated to be low, factors included in this calculation, such as distribution of fish near the turbines and near the blades need to be determined from field studies. Again, this analysis was provided to the ACOE, NYSDEC, and appropriate resource agencies in Verdant's Response to Comments document (Attachment C of DTA 2004b). That document also included revised study plans (Attachment A) based on the comments received from the resource agencies as well as a revised foot print based on navigation concerns expressed by the Coast Guard (Attachment H).

Following Verdant's submittal of the permit application to conduct studies based on deployment of the six study turbines and the Response to Comments document, resource agencies requested a full year of pre-deployment fish monitoring and netting study to adequately evaluate fish presence and use of the immediate foot print of the six-pack (September 8, 2004 permitting meeting). Based on this request, the results of this pre-deployment study would be required prior to approving the permit to deploy the temporary six study units whose purpose is to evaluate effects to aquatic life. To put the area involved in perspective, the study area encompassed by the turbines is less than 0.8 acre, and the area enclosed by the proposed safety booms is less than 1.2 acres. The actual foot print of the piles supporting the turbines is very small, approximately 3.14 ft^2 per turbine or 18.8 ft^2 total, thus physical disturbance of the river bottom is minimal. The width of the channel at this location is approximately 625 feet with an average depth of 30 feet on the western side of the channel, shallowing up to 20 feet in depth on the eastern side of the channel. Detailed bathymetry data is provided in Figure 2. Based on the diameter of the turbine blades, one row of two turbines will occupy approximately 3% of the cross-sectional area of the East River (the dimension important for migrating fish). In comparison, the East Channel is approximately 2 miles long, and the East River itself is approximately 16 miles in length. The agencies also requested the fish monitoring plan proposed during deployment of the six-pack be revised to provide more details on methodology such as hydroacoustic beam coverage and netting methodologies. We have expanded on both the initial scope of the study and details on methodology and data analysis to address agency comments expressed at several meetings and in agency comment letters.

This is a unique project without precedent for turbines of this design. As such, existing information on fish impacts is not available. The deployment of the test six-pack is essentially a research study to develop answers to the question on environmental effects. We believe that monitoring during deployment of the test six-pack can reasonably answer the environmental concerns outlined by the agencies in their requests. But it is also important to keep in mind that this is a temporary project and will not have any permanent effects. In fact, the test deployment is intended to yield the data now sought by the agencies. These studies will also provide more than one year of pre-project environmental baseline conditions needed for a potential full-scale deployment of the technology and provide data for development of a revised monitoring plan for such a full deployment.

3. Objectives

This detailed study plan describes the objectives and detailed methodology proposed to characterize existing fish populations, their use of the footprint area, their use of the east channel, evaluate effects of the test turbines on individual fish and populations, as well as potential effects based on a larger full-scale deployment. This study is not, however, in lieu of additional studies that may be appropriate during buildout of the larger project.

Data on spatial distributions and abundance of fish species within the east channel will be collected as well as information on fish behavior near the test turbines by tracking a fish's swimming location and direction. Since it is neither reasonable nor possible to track every individual fish that passes through the east channel or the immediate area of the six-pack, the sampling scheme presented here is designed to subsample a reasonable portion of the fisheries population in the east channel to make an assessment of potential project effects.

Specific study objectives include:

1 characterize the use of the six-pack deployment area (near-field) by fish populations
2 characterize the use of the east channel of the East River (far-field) by fish populations on a seasonal basis with emphasis on a potential full deployment field of additional turbines
3 evaluate fish behavior (direction and velocity of swimming) near the individual turbines
4 evaluate the effects of multiple turbines on fish passing through the six-pack turbine field
5 use data gathered from the pilot study to assess the potential effect of a larger turbine array on fish populations in the vicinity of Roosevelt Island

The geographical near-field is defined as the rectangular area immediately surrounding the turbines of 165 x 260 feet while far-fields are defined as the regions outside of this rectangle. We suggest that there will be behavioral differences for fish between the near and far-fields. The behavioral near-field is defined as that area inside which fish sense the turbine units and respond to their presence, while the far-field is outside of the fish response distance. These behavioral fields are anticipated to be dynamic, perhaps changing with tidal flow (and thus operation of the turbines) and day/night conditions.

4. Study Area

The six-pack study field will be located in the East Channel of the East River. The proposed deployment area is 200 feet north of the Roosevelt Island Bridge and adjacent to Roosevelt Island (Figure 1). A safety boom is proposed to surround the six-pack on three sides with the 4th side consisting of a concrete wall abutment on Roosevelt Island. The safety boom area has been modified in order to enclose and protect the northern far-field fixed hydroacoustic array. Based on consultation with the NYDOT regarding scheduled bridge repair work, the southern buoy line will remain perpendicular to the shoreline to allow adequate staging area for repair equipment. Therefore, the enclosed area now surrounds a 165 x 260 foot rectangle area with one triangle of 200 x 165 x 106 feet along the abutment wall (Figure 2) to enclose the northern far-field array. There is a 30 foot streamwise margin and a 20 foot crosswise margin from the center of the pilings of the outside turbines to the safety boom. The turbine rotor blades have a 16.4 foot diameter centered on each piling. The turbines will be deployed in three rows of two with each row set 100 feet apart and the two turbines within each row spaced 40 feet apart on center (Figure 2).

5. Methods

5.1 General Overview

This study will utilize split-beam acoustic techniques in mobile (far-field) and fixed (near-field and far-field) surveys to gather information on fish spatial distributions and abundance, as well as provide fish behavior information by tracking a fish's swimming location and direction. The split-beam technique also provides estimates of individual fish target strength, a measure that roughly corresponds to the physical size of the fish. The mobile surveys will obtain data from multiple transects across the East Channel (Figure 1). A total of four mobile surveys will be conducted on a biweekly basis for two months prior to turbine deployment. Following deployment of the first two turbines, mobile surveys will be conducted on a monthly basis for 12 months, followed by two seasonal surveys during the last six months of the study. Verdant is proposing a two phased approach in the fixed hydroacoustic survey. Phase I consists of 4 fixed arrays around the first set of turbines (Turbines #1 & 2) deployed in November 2005 (or no sooner than two months following start of the mobile surveys); two arrays set just outside the study turbine footprint (far-field) and two arrays on either side of the turbine pair within the footprint (near-field). Note, during deployment of the initial two units, the transducer array that will eventually provide near-field coverage along the southern edge of Turbines 5 and 6 will provide the northern far-field coverage for these initial two Turbines until Turbines 3, 4, 5 & 6 are installed.

The split-beam acoustic technology will be supplemented with an innovative but still experimental DIDSON system which uses high definition sonar to produce a near video quality graphic display. This system has greater flexibility in analyzing data around boundary layers but has other limitations which limit its use to supplemental to the hydroacoustic technology. The DIDSON will be evaluated for data collection in the tidal fluctuation zone above one of the turbines. Phase II will be implemented 3 to 4 months later and consists of deployment of the 4 remaining turbines (Turbines #3, 4, 5 & 6). Also at this time two additional fixed hydroacoustic arrays would be installed surrounding each row of turbines installed (Figure 2).

5.2 Fixed Hydroacoustic Survey

To address concerns regarding the immediate deployment area of the study units, fish populations will be monitored continuously using the latest scientific split-beam acoustic technology and techniques. A BioSonics split-beam system using 200 kHz low side lobe narrow-beam (6 degree) transducers will be used in side-looking orientation. Fixed-location transducer arrays will be positioned outside (upstream and downstream) of the six-pack footprint and used as control-monitoring stations. These "control-monitoring" arrays will be positioned outside the direct influence of the turbines but near-field enough to reasonably determine whether the six-pack study area (165 x 260 ft) is being used as a possible passage route through the east channel. The near-field "treatment-monitoring" arrays will be positioned immediately up-current and down-current of the Phase I pair of turbines. Information gathered from these four arrays will be used to determine if fish approaching the turbines are veering away from the field or moving through the turbines by comparing fixed beam acoustic data collected far-field and near-field of the turbine positions. If behavioral changes are observed during this period of target transit, this information will be used to infer specific interactions between the fish targets and the turbine or avoidance of the turbine by the target. The continuous monitoring by the far-field fixed arrays will allow development of the estimated total numbers and approximate size classes of fish approaching the footprint and fish that enter the footprint area as opposed to limited subsampling normally done for most fish collection studies. These fixed arrays will be collecting data on a continuous basis (24 hours per days and seven days per week for 18 months) which will provide extensive detailed data on how fish use this area and interact with the turbines on a diurnal and seasonal basis. This data will be available pseudo-real-time via internet access to allow offsite monitoring (see section 5.4).

While this technology, as well as the specially-designed mounting structures, are considered "state-of-the-art" in monitoring systems given the field conditions (project configuration, water clarity, salinity and tidal range), there are some physical and technical limitations which had to be considered in developing the overall study design.

For this application, the critical limitations are:

- Transducers are only active underwater, exposure to air while active will destroy the unit.
- Data can not be collected past boundary layers of substrate or water surface.
- The transducers transmit a 6 degree angle beam. This translates to beam width of approximately 1 ft in diameter with every ten feet of distance from source.

The primary environmental hurdles are the rise and fall of the tide and an uneven bottom contour, which introduce substantial complications into the design of an efficient hydroacoustic monitoring program. The hydroacoustic beam reflects off the water-air and water-sediment interface, and generates interference such that data will not be usable once that boundary is intersected by the beam. Thus, it is especially difficult to design a monitoring system around a moving target (tidal fluctuation) and a sloping bottom while at the same time trying to maximize vertical coverage of the water column. The area of coverage is narrow at the point of origin (transducer location) and widens at a rate of approximately 1 foot diameter for every 10 feet of distance from the transducer. Thus transducer placement needs to be close to the western shoreline to increase beam width at the turbines but aligned so the transducers are not interfering with each other. An additional significant site-specific concern for this study is the risk of equipment damage. The monitoring equipment (i.e., mounting structure and hydroacoustic equipment) must remain at least eighteen inches below mean lower low water (MLLW) elevation to minimize the potential damage from exposure to air, risk of vandalism, and damage from any navigation activity.

Detailed site-specific bathymetry data was used to develop the transducer array deployment to maximize the area of coverage by the beams in the study area to the greatest extent practicable given the technological and site limitations. Each of four stationary arrays (Phase I) will consist of three split-beam transducers deployed in a manner to provide the highest degree of vertical water column coverage (Figure 3). The transducer arrays will be individually mounted approximately 20 to 50 feet (depending on bottom topography) from the West bank and projected towards the East bank. The top transducer will be aimed so the beam intersects the water surface at MLLW elevation at the outside edge of the rotor blade area for Turbine #1 to maximize possible coverage of the water column over the turbines (Figure 3). Due to the boundary layer interference described earlier, aiming the beam higher to try to capture mean high water (MHW) would result in zero data collection over the turbine except under very high tide conditions <u>when the turbines are not operating</u>. The lower transducer will be aimed to intersect bottom contour just past the outer turbine (#1) to obtain the best coverage below the rotors (Figure 3). Due to bottom contours, it is not possible to aim the beam parallel with the bottom which would be needed to provide near bottom coverage across the entire transect.

Turbine #2 is approximately 105 feet from the West bank and Turbine #1 is 145 feet out from shore. Given these distances and the arrangement described above and in Figure 3, the estimated mean acoustic area of vertical water column coverage of Turbine #1 will be near 100% at MLLW and 86% at MHW. Vertical water column coverage at Turbine #2 is estimated at 76% at MLLW and 65% at MHW. The mean beam width (horizontal coverage) varies with distance from each transducer but is estimated to range from 9.5 feet near the bottom to 11 feet near the surface upstream with the same aerial coverage downstream of Turbine #1. The beam width upstream and downstream of Turbine #2 is expected to range from 5.5 feet near the bottom to 7 feet near the surface. Precise measurements may vary slightly depending on actual on-site equipment mounting locations but minor adjustments in transducer angle and height can be made to compensate for minor field modifications.

This hydroacoustic arrangement will monitor the entire 6 feet of water over Turbine #1 and about 3 to 4 feet over Turbine #2 at MLLW. Data collected on fish distribution in the water column from the far-field array will be compared to the data collected in the near-field of the turbines to determine if fish are avoiding the turbines by moving from mid-water column to passing over the blade area. Due to technological limitations and the fluctuating tidal elevations, it is not practicable to monitor fish at elevations greater than 6 feet over the turbine with hydroacoustic technology. However, in order to address concerns regarding the movement of fish greater than 4 to 6 feet above the turbine blades during higher tidal conditions, Verdant has proposed the use of a new technology, the DIDSON system. DIDSON is a high-definition imaging sonar originally designed for military applications such as diver detection and underwater mine identification. At close ranges, this new class of identification sonar gives near video quality images for identifying objects underwater. The DIDSON is a new, evolving technology, and is as yet unproven. This technology also has limitations, and as such, is only proposed to provide additional coverage at Turbine #2 (Figures 2 and 3). One of the advantages of the DIDSON is the reduced interference at the boundary layer, thus it is more suitable for fluctuating water levels. One of the major limitations is fish location. The position information from a DIDSON is 2D as opposed to the 3D positioning capabilities of the hydroacoustic units. In its standard deployment, the DIDSON is aimed across the river and the computer screen shows a bird's eye view. The X-Y position of fish in the beam is seen but the vertical (depth) position is not discernable. Another significant limitation is the range and resolution of signals, especially for smaller fish. The sonar's range and the image resolution are determined by the frequency of the sonar with lower frequencies having longer range but reduced resolution.

The DIDSON system selected for use in this study is reported to be capable of operating either at 1.8 MHz for close range observations less than 12 m or 1.0 MHz for detecting targets at ranges up to 30 m. It is reported that 5-cm objects can be imaged at ranges between 3 m and 10 m depending on the environment using the 1.8 MHz frequency. Silt or air bubbles in the water can reduce the range. Range and resolution capabilities reported by users appear to vary widely and use of this system is experimental. We expect that the 1.0 MHz will be necessary given the distance and beam width needed to cover the upper water column but both frequencies will be evaluated in the field prior to selecting the final system frequency. The beam will be aimed to cover the water column above Turbine #2 with a small overlap of the turbine blade area. The sonar beam widens out in a 29^{o} angle horizontally and 12^{o} vertically as shown in Figures 2 and 3 and should be able to cover the turbine area in both tidal positions, range dependent. Another significant limitation is data storage. The DIDSON records video-quality data that requires extremely large amounts of disk space (1.8 Gigabytes/hour). Thus most applications use some type of subsampling methodology such as 10 minutes of recording per hour or use of a motion detector. Given the turbine blade movement the motion detection software is not likely to work in this situation. We propose to initially collect continuous data until we can evaluate this in more detail.

We also point out that additional data will be collected during the monthly mobile surveys. The hydroacoustic beam deployed off the mobile survey boat will be positioned just below the surface and aimed across the turbine area from the western side of the study footprint to cover the water column over both Turbines #1 and 2. In addition to the study transects already proposed, data will be collected continuously over the turbine row for 10 to 15 minutes during ebb and flood tides, depending on field conditions and the ability to maintain boat position. This will supplement data collected by the fixed hydroacoustics and should be able to cover the upper water column not covered by the fixed arrays. While this is not continuous 24/7 data, it will determine if fish are using the uppermost part of the water column directly over the turbines which has been brought up as a concern by resource agency personnel. Data collected from the standard pre-set mobile transects will be used to evaluate the use of the upper water column throughout the east channel.

The study plan was also designed to collect sufficient data to evaluate fish movement through multiple rows of turbines using both the upstream and downstream turbine arrays (Turbines #1&2 and 5&6) as well as the two far-field arrays. Information on fish distribution and abundance within the acoustic field (vertically in water column and river cross-section) from the far-field arrays can be used in conjunction with the data collected from the four arrays immediately surrounding the two outer pairs of turbines to evaluate fish movement through multiple rows of turbines. Fish distribution and swimming behavior (speed and direction) entering the first turbine row and exiting the 3rd turbine row will be compared and evaluated for potential effects such as change in water column distribution, increased percentage going through the turbine blade zone (or other zone), and change in swimming behavior. We believe this arrangement would be adequate to evaluate the effect of multiple turbine rows. However, to fully address agency concerns, Verdant has agreed to surround each turbine row installed with hydroacoustic monitoring arrays. Thus data comparisons will be made between all turbine rows installed.

As described in detail above, the study design and transducer layouts have maximized the acoustic coverage "*to the greatest extent practicable*" given site conditions and technological limitations outlined above. We emphasize that all relevant strata (through, above, below, and to the sides of the turbine blades) are being thoroughly monitored to allow for an evaluation of fish movement around and through the turbines; the primary goal of the fish monitoring plan. It is not necessary, practical, or feasible to conduct a study which monitors the entire water column over every turbine for 24/7 over an 18-month study period. It is not absolutely necessary to sample 100% of the population in order to evaluate population estimates and determine trends. It is standard scientific principle to subsample populations, or in this case area, in order to determine estimates of fish distribution, movement and behavior in and around the turbines.

While it is not possible to track every single fish (represented by a target acoustic signal) through the study area, given the volume of continuous data to be collected over an 18 month duration we believe it will be adequate to evaluate the movement and behavior of fish in and around the turbines. We believe the sample locations in the study plan detailed here will provide the information needed to assess both the use of the proposed study footprint by east channel fish populations and also provide the information needed to evaluate any effects the turbine operation may have on fish populations. This is a long-term study and likely adjustments to the plan may be appropriate as the data analysis proceeds. Verdant Power and their fisheries consultants will be working closely with resource agencies fisheries staff to evaluate the data and study protocols.

5.3 Mobile Hydroacoustic Survey

A mobile survey will allow Verdant to collect fish distribution information in the study area in a relatively short period of time. A mobile survey will be conducted every two weeks in the two months prior to installation of the Phase I turbine pair for a total of four mobile surveys. The pre-deployment mobile transects will include transects within 1,000 feet of the six-pack area. The goal is to identify distribution patterns of fish abundance both across the channel and within the water column prior to turbine installation. The mobile survey will be repeated in the same locations following installation of the Phase I test units. The distribution and movement patterns of fish will again be assessed and then compared to the pre-deployment patterns. The post-deployment mobile transects include additional transects in the far-field, up to 2000 feet north and 4500 feet south of the six-pack foot print (Figure 1). Post-deployment mobile surveys will be conducted once a month for the first 12 months following turbine installation to assess seasonal changes in fish occurrence, distribution, and abundance. Following a full year of collecting monthly data, mobile surveys will be conducted on a seasonal basis for the duration of the 18-month post-deployment study for a total of 20 months of fish monitoring effort. Timing for the seasonal surveys will be determined from the previous year's data as well as historical data of fish occurrence at nearby power station intakes. This would result in a total of 18 mobile surveys (4 pre-deployment, 12 months, 2 seasons).

The additional transects further from the study area will provide a baseline of fish distribution information in the area of the proposed full field build-out. Data analyzed from both near-field and far-field hydroacoustic monitoring can then be used in the design of the future build out schematics. As noted above, the additional mobile survey transects will be conducted in the proposed full build-out field once the 18 month study begins. As presented in Section 5.2, in addition to the mobile survey data, data from the fixed arrays will also provide information on fish movement patterns in the study area on a continuous basis for the entire 18 month study.

Data Collection

Mobile hydroacoustic surveys are being proposed, pre- and post deployment of the six-pack turbines. The hydroacoustic surveys will utilize a BioSonics dual-frequency split-beam scientific echo sounder using 200 kHz and 420 kHz narrow beam transducers with low side lobes. A detailed description of the acoustic monitoring equipment being used in the study is included in Appendix A and also includes Biosonics industry standard calibration protocols. The 200 kHz transducer will provide longer range information than the 420 kHz transducer because the signal can travel farther before being absorbed by the saline conditions. The 200 kHz frequency is on the outer edge of the auditory range of Alosids found in the area. Both transducers will be used during data collection and closely monitored to ensure that the 200 kHz frequency is not affecting the natural patterns of fish movement. When the transducers are mounted in the vertical position (looking down), the entire water column traveled will be ensonified and information will be collected all the way to the bottom of the channel. The hydroacoustic system measures range to targets (or depth of the bottom) with an accuracy greater than 2 cm. The second transducer will be deployed to collect data in a side-looking orientation. The range of the 420 kHz data is expected to be 30 m given the high absorption of the water passing through the channel. We anticipate target detection ranges in excess of 100 m on the 200 kHz transducer. The data from the initial mobile surveys will be evaluated to determine if a single transducer, the 200 kHz frequency, can reasonably be used to collect the fish distribution and abundance data.

A Trimble ProXRS GPS data collection unit connected to the acoustic system will collect positional data to geo-reference all acoustic data. Navigation software will be used on a separate laptop linked to GPS guide the traverse across the river along predetermined transects.

The pre-deployment surveys will consist of eight mobile hydroacoustic surveys, four surveys during the day and the other four surveys at night. These surveys will occur every two weeks, and are expected to occur on September 18/19th, October 6/7th and 19/20th, and November 2/3rd, weather permitting. Depending on the time needed to conduct one complete set of transects and associated netting activities, the night survey may be initiated the same evening, or the evening prior to or following the daytime survey. This data set will allow us to compare day and night fish distributions in the channel. Furthermore, since fish tend to be more dispersed at night, a night survey may provide better information on individual fish sizes and fish flux (#/area/time).

A total of 12 pre-deployment transects related to the geographic far-field are proposed, replicated three times from shore to shore across the east channel (Figure 1). Pre-deployment transects perpendicular to the shore would be placed at 100, 250, 500, and 1000 feet upstream and downstream from the test site. Two more transects replicated three times from shore to shore across the east channel would be placed at the midpoint between the proposed location of each pair of turbines in the six-pack test array. Two 2000 foot transects parallel to the shore (single pass) on either side of the test site (if possible depending on channel conditions) would also be collected to provide better spatial resolution in the fish distribution maps.

The post-deployment surveys will occur after the Phase I pair of turbines from test six-pack have been installed and are operational. These surveys will consist of the two mobile surveys (day and night) and will use the same transects and replicates (as close as possible) to the original locations in the pre-deployment surveys after taking into account safety issues at the test site. If possible, depending on channel conditions, two transects replicated three times would be placed at the midpoint between each pair of turbines in the array perpendicular to the shore. In addition, the hydroacoustic beam deployed off the mobile survey boat will be positioned just below the surface and aimed across the turbine area from the western side of the study footprint to cover the water column over Turbines #1 and 2. Data will be collected continuously over the turbine row for 10 to 15 minutes during ebb and flood tides at higher tidal elevations, depending on field conditions and the ability to maintain boat position. This will supplement data collected by the fixed hydroacoustics and should be able to cover the upper water column not covered by the fixed arrays. Additional transects post-deployment will be placed at 1500 and 2000 feet north and south of the study area and 2500, 3500, and 4500 feet south of the study area to look at distribution patterns in the far-field of the future build-out field. This represents a total of 15 perpendicular mobile transects. The number and location of post-deployment transects may be modified if a behavioral near/far-field is observed during the initial sampling of post-deployment transects. Two 6500 foot transects parallel to the shore (single pass) on either side of the test site (if possible depending on channel conditions) would also be collected to provide better spatial resolution in the fish distribution maps. However, fish occurrence and abundance in the near field will rely primarily on data from the fixed arrays.

5.4 Hydroacoustic Analysis

Analysis of acoustic data will be accomplished in sequential steps.

Echo Extraction. Software will read the acoustic data from the echo sounder and search for patterns in the acoustic waveform characteristic of echoes from individual targets. The echo extraction algorithm first tests the signal intensity, and then compares the shape of the candidate echo with a theoretical echo shape. If the candidate echo passes these first tests, the duration of the echo (pulse duration) is then compared to the duration of the pulse transmitted into the water. For each echo that passes all tests, the date, time, range to echo, echo intensity, and many additional measures are obtained and written to file. All accepted echoes are then passed to the trace formation step.

Trace Formation. As a target passes through the sound field, many echoes may be obtained sequentially. The resulting pattern is displayed on an echogram as a fish trace, but this interpretation involves considerable processing by the eye and brain of the observer. This step of spatial correlation must be accomplished by the processing software – the algorithm may be represented as a "connect-the-dots" process. Echoes are spatially correlated if they are sequential in time and at essentially the same range. The trace is considered complete when no more candidate echoes are available. Measurements and calculations representing each trace include date, time, mean intensity, mean range, change in range, and a host of other parameters. For split-beam data, the mean target strength, direction of travel, and target speed are also calculated. Each accepted trace is then passed to the next analytical step.

Trace Filtering. A series of tests are applied to each target trace to determine if it represents valid data or if it is to be discarded. For example, a trace may be formed from a target lying on the bottom, producing a horizontal line on the echogram. Such traces are usually not considered valid, and are discarded. Traces may be kept or discarded based on range, velocity, target strength, direction of travel, or many other descriptors. Accepted traces are then incorporated into the project data set.

Data Summaries and Interpretations. Fish count data may be summarized by hour or day to show time-series abundance values, by hour of day to provide diel distribution, by range bin to provide distribution by range, by target strength to show the acoustic size distribution, or by many other methods. Such summaries are useful to provide population spatial characteristics (horizontal and vertical distributions) and temporal distributions (run timing, time-series data, diel distributions)

Other descriptors will be obtained by comparing spatial and/or temporal summaries between arrays. For example, a change in horizontal distribution measured by an array immediately up-current from a turbine as compared to a horizontal distribution from immediately down-current suggests that an attraction or avoidance response is caused by the turbine. Such changes can be determined statistically – we use the Kolmogorov-Smirnoff test to determine if distributions are statistically equivalent or different. If the trajectory of a fish passing at the range of the rotor changes from up-current to down-current, the interpretation would be that the individual has sensed the turbine and has responded, or has been stunned or injured and exhibits a resulting change in swimming behavior. These and other comparisons will provide strong evidence of how fish populations respond to and are affected by the turbines. Temporal changes between arrays will be used to evaluate delay times in the study footprint.

Mobile Survey Data
Acoustic data collected from mobile surveys will be processed with echo extraction and trace formation (fish counting) software. The echo integration technique will be used when fish schools are detected. All survey data will be tagged with Latitude/Longitude from the system GPS. Maps of fish distribution will be created and presented in a Graphical Information System (GIS) environment. Comparisons will be made between maps for any changes in patterns of fish distribution before and after the installation of the test six-pack and during the period of monitoring.

Fixed-Location Data
Scientific acoustic systems are designed for quantitative measurement and are fully calibrated and stable in acoustic performance over long period of time. Fixed-location techniques were introduced by BioSonics in 1980, and have been continually refined since. The use of scientific acoustic techniques to monitor fish in the vicinity of the proposed tidal turbines has strong precedent. The equipment has been fully accepted by FERC in a host of licensing activities, and generates legally and scientifically defensible data.

The modern generation of X-series digital echo sounders builds upon this foundation and provides systems ideally suited for autonomous operation and continuous monitoring. The interpretation expertise gained across several decades of studies has been incorporated into real-time analysis software.

Analytical Approach

<u>Echo Detection</u>. Each transducer in an array transmits sound and measures echoes. The split-beam technique allows determination of the 3-dimensional position of each fish echo – range, X-position, and Y-position. The acoustic size (Target Strength or TS) of each echo is also measured, in addition to echo shape and echo quality values.

<u>Fish Recognition</u>. Echo sounders produce measurements of echoes – a time-series of echoes is produced as a fish swims or is carried through the acoustic sound field. These echoes are spatially and temporally correlated in the second analytical step, and one record per fish trace is written to an output file. Fields in this record include date, time, range to fish, TS, Standard Deviation of TS, direction of travel, fish velocity, and several others.

<u>Inter-Array Measurements</u>. Detected fish will typically travel through one array as they approach a turbine, and be detected by a second or third array as they exit the area of the turbine. Many of the parameters listed in the previous paragraph may be compared between arrays to look for responses to the turbines.

Netting data will be used to assign species information to the acoustic size classes and allocate percentages of the fish community to size classes of fish. This will allow us to calculate densities of fish at different size classes.

5.5 Proposed Acoustic System Threshold Definitions and Values

Introduction

Monitoring Control Software will continually monitor the fish counts coming from the arrays, and compare a variety of measurements to determine if an alert condition exists. This type of software is complex; its ability to detect fish and classify events will improve following initial installation and setup.

The fixed scientific acoustic arrays to be installed at the Roosevelt Island Tidal Energy Project will monitor passage of targets through the study footprint. A variety of target types are expected, as are a certain range of target behaviors. If target numbers, types, and behaviors surpass threshold values, the acoustic system concludes that biological resources are at risk and informs on-site or remote project managers. The system communicates with the project through a two-tiered strategy. When specified thresholds are surpassed, the system issues a "Project Alert" message. When other specified thresholds are surpassed or when the "Project Alert" condition is maintained for a specified number of hours, the system then issues a "Project Alarm" message. Under the "Project Alarm" condition, project managers are obligated to "Initiate a Consultation" with agency and oversight personnel to determine appropriate response and/or resolve the Alarm Condition.

A family of acoustic measurements is continually calculated for each fish detected to test against alert and alarm thresholds. Each individual measurement represents a certain event or behavior, and the "severity" of the event is used to define when an Alert or Alarm Condition is raised.

Definitions of Alert Types

1) <u># Large Target Detections.</u> The number of fish greater than –30 dB (corresponding roughly to a 45 cm fish) passing through the zone of risk is calculated for each individual hour by the paired arrays surrounding the turbine position. Modeling studies have indicated that the number of fish impacted by the turbine blades is on the scale of a fraction of a percent. The count of large fish will be multiplied by a conservative strike rate of 0.01. If this product (# large fish X 0.01) surpasses a value of **10 fish per hour**, an "Alert Condition" will be raised.

2) <u># Large, High Velocity Detections.</u> Diving birds produce a large acoustic signal, and swim at high velocities. A target traveling at a velocity greater than **2 meters per second** will be labeled as high velocity. If the number of high velocity targets greater than –40 dB is greater than 1 target per hour, an "Alert Condition" will be raised.

3) <u># Large, Low Velocity Detections.</u> The acoustic characteristics of a signal reflected from a turtle is anticipated to be large and moving relatively slowly. A target traveling **less than 0.2 meters per second** is considered as exhibiting slow velocity. If the number of low velocity targets with target strength **greater than –20 dB** exceeds **1 detection per day**, if the target

behavior is consistent through all arrays, and if large debris is not visually observed, an "Alert Condition" will be raised. Floating debris may also trigger this "Alert Condition" without visual observation. It is hoped that the hydroacoustic system will be operated for some time prior to the summer season when rare turtles may be expected to occur in the East River and the acoustic signal of debris may be characterized sufficiently to allow distinction from a turtle acoustic signal.

4) # Small Target Detections. The number of fish smaller than –30 dB and passing through the zone of risk is calculated for each individual hour by the paired arrays surrounding the turbine position. The count of small fish will be multiplied by a conservative strike rate of 0.01. If this product surpasses a value of **100 fish per hour** (in recognition of the schooling behavior for many species of smaller fish), an "Alert Condition" will be raised.

5) Trace Behavior Change, Velocity. The behavior of each fish tracked through the paired arrays on the up current and down currant side of each turbine pair will be evaluated. If the **velocity changes by more than 25%,** the acoustic system will infer that this target has been influenced during its journey through the zone of risk. An "Alert Condition" will be raised if more than **1 detection per square meter per hour** shows influenced behaviors.

6) Trace Behavior Change, Target Strength (TS). If the target reflective characteristics change as a fish passes through the turbine blades, the acoustic system interprets that this target has been influenced, perhaps detrimentally. The acoustic system measures both the mean TS and TS variability. Both should remain consistent between the up-current and down-current arrays if the fish is not influenced during its passage. An "Alert Condition" will be raised if the **mean TS changes by more than 10 dB** or if the **Standard Deviation of the TS measurement changes by a factor greater than 5**.

7) Behavioral Change, Vertical Distribution. If a target senses and avoids the turbine blades by diving or swimming toward the surface, it may move into regions of higher predation and show increased mortality. A vertical shift is defined as a change in **depth of more than 2 meters** between the paired acoustic arrays. An "Alert Condition" is raised if fish greater than –30 dB are detected at depths above or below the turbine blades, and if the **number of fish smaller than –30 dB and exhibiting a vertical shift is greater than 15 percent of total number counted.**

8) Behavioral Change, Horizontal Distribution. If a target senses and avoids the turbine blades by swimming toward or away from the shore, it may move into regions of higher predation and show increased mortality. A horizontal shift is defined as a change in **distance from shore of more than 2 meters** between the paired acoustic arrays. An "Alert Condition" is raised if fish greater than –30 dB are detected at ranges inshore or offshore of the turbine blades, and if the **number of fish smaller than –30 dB and exhibiting a horizontal shift is greater than 5 per hour**.

Alarms

An "Alarm Condition" is raised if any of the following occur"
8 Type 1 Alerts in 24 hours
8 Type 2 Alerts in 24 hours
4 Type 3 Alerts in 24 Hours

12 Type 4 Alerts in 24 Hours
4 Type 5 Alerts in 24 Hours
4 Type 6 Alerts in 24 Hours
8 Type 7 Alerts in 24 Hours
8 Type 8 Alerts in 24 Hours

All Alert conditions that do not surpass the 24 hour threshold value are reset after 24 hours. If an Alarm Condition is raised, it initiates a consultation with the oversight agencies and the resolution of this condition must be negotiated. It is important to understand that these values are very preliminary until a baseline of hydroacoustic signals can be established. If it is determined that the Alarm Condition relates to an actual impact on the resources, then Verdant will consider initiating a Turbine stop scenario until a final determination of effects can be resolved.

Monitoring Reports

The Monitoring Control Software will automatically generate reports summarizing fish passage by distance from shore and by water depth. Although specific reporting values are under discussion, hourly reports are proposed at this time for each day. Additional reports to be considered are direction of travel and TS distribution per day. These reports will also contain a record of any alert and alarm conditions generated.

Internet Access

Access to daily reports and selected summary graphics will be provided over the Internet. Daily reports may be downloaded as text files.

5.6 Netting Survey

Fish collections using trawl net gear cannot be conducted in many areas where hydroacoustics can be employed. This is especially true for the east channel which has many security and navigation issues as well as hazardous sampling conditions (debris and swift currents). However, some netting data are necessary to identify the acoustic signals recorded. Therefore, netting surveys will run concurrently with the hydroacoustic surveys to provide species and length-frequency information, and to supplement the interpretation of the more abundant hydroacoustic data. The fish collection data for transects near the six-pack study area will also be used to analyze the continuous data collected from the fixed hydroacoustic arrays.

A netting survey will run concurrently with the mobile surveys, but not so concurrent as to disrupt fish distribution for the hydroacoustics surveys. The fish collection vessel will be equipped with GPS and capable of deploying a 16 or 30 foot bottom trawl. Net mesh size will be no larger than 1.5 inch stretch net with a 0.5 inch stretch cod end. Fish trawling (bottom and/or mid-water depending on fish aggregations) will be conducted following completion of each transect by the hydroacoustic vessel in the immediate vicinity of the transect. Cross channel bottom trawling is not feasible or safe to conduct. Thus, two trawl samples will be conducted parallel to shore that include the hydroacoustic transect(s) as much as possible. This will be adequate to provide the hydroacoustic surveys with species, relative abundance, and length classes for the hydroacoustic data analysis. Trawl locations may be adjusted based on site conditions and results of the hydroacoustic data. For example, if the hydroacoustic data indicates targets (potential fish) occur at mid-water column depth, the trawl will be deployed in a manner to best sample that depth. The purpose of the netting activities is to sample the fish identified by the hydroacoustic and provide species identification and size. However, some netting effort will also be conducted regardless of hydroacoustic data to confirm that no or few fish occur in the area.

All collected fish will be identified to species and counted. A representative sub-sample of each species will be measured (lengths and weights) to provide a representative length-frequency histogram. Netted fish information will be used to partition the acoustic signals into size classes and assign species information to the acoustic size classes to develop algorithms to calculate acoustic fish lengths and density. This survey is not intended to be a complete netting study but to "groundtruth" the hydroacoustic data. Due to the hazardous sampling conditions and increased security issues (e.g., location of KeySpan facility), final sample netting location will need to be determined by the vessel's captain. It may not be possible to conduct trawling at all hydroacoustic transect locations. Some transect adjustments may be necessary depending on field conditions. Due to safety issues, netting at night may be limited to mid-water trawling. Dawn or dusk netting may occur to collect species information for the night surveys. The difficulty of such work in the swift tidal currents and associated safety issues have constrained the netting to a role as an adjunct to hydroacoustics, which is the primary study technique.

5.7 Fish Migration Studies

Verdant understands that the potential impact to fish migration patterns may not be able to be fully extrapolated from the studies to be performed on the six-pack. Therefore, in addition to the studies proposed above, Verdant anticipates performing additional fish monitoring throughout deployment of the full field, and that such studies will involve a continuation of the seasonal monitoring described above. The fish migration studies will be developed in consultation with agency representatives and study participants once the initial six-pack studies are complete and will be further defined in the FERC License Application. Verdant anticipates that such studies would be a condition of a future FERC license. Further development of a long-term methodology is premature at this time.

6. Bird Observations

Based on comments received from agency representatives, Verdant will perform pre and post-deployment bird observations. Observations will be made by Project scientists and possibly by local residents who are familiar with the study area and associated bird species. As practical, the observations will coincide with the fish studies, although this is not absolutely necessary. A project log will be maintained that will record approximate number of birds, species of birds, time of day, feeding activities (if applicable), diving activities (if applicable), proximity to the study area, and any observations that would indicate interaction with the study units (post deployment). When applicable, Verdant will include the bird observation log in the report to be provided to agencies representatives.

Study Objectives

The primary objective of the bird observation study will be to determine if the turbines adversely impact diving birds associated with the east channel. In addition, any other impacts to birds will be noted. A secondary objective of the study will be to show whether the study turbines attract diving birds to the site. This may serve as an indication of impacts to fish or a shift in fish swimming patterns.

Pre-deployment Observations

Observations of bird activity will be performed prior to deployment of the study units. Pre-deployment observations will consist of the following:

- At approximately the same time of the four pre-deployment mobile fish surveys to occur during September, October, and November of 2005, Verdant will perform a dawn to dusk bird observation survey. Approximately every 15 days (over the course of two months from September through November) Verdant will perform a 10 hour (daylight dependent) bird survey, resulting in 40 hours of survey observations. Data to be recorded is described below.

- In addition to the four surveys described above, during the five days prior to deployment of the study units, Verdant will perform dawn to dusk bird observation surveys for approximately 10 hours per day (daylight dependent), resulting in 50 hours of bird observations.

In all, Verdant will collect approximately 90 hours of bird observation data prior to deploying the study units. All observations will be made from the shore adjacent to the deployment area. The observer will be equipped with binoculars and a camera. Photographs will be taken as available; however, the photographs are intended to supplement the observations and the recorded data (see below) – the observer will not be responsible for photo-documenting every bird observed.

Post-deployment Observations

Observations of bird activity will be done following deployment of the study units. Post-deployment observations will consist of the following:

- During the five days following deployment of the study units, Verdant will perform dawn to dusk bird observation surveys for approximately 10 hours per day (daylight dependent), thus resulting in 50 hours of survey observations. Data to be recorded is described below.

- In addition to the five days of survey observations described above, dawn to dusk survey observations will be conducted monthly during the 18-month deployment period. Therefore, approximately every 30 days (from November 2005 through April 2007) Verdant will perform on average a 10-hour (daylight dependent) bird survey, resulting is approximately 180 hours of survey observations. Data to be recorded is described below.

- In addition to the post-deployment survey observations described above, Verdant will perform five consecutive days of bird survey observations in April 2006, October 2006, and April 2007 for a total of 15 days of bird survey observations. The purpose of these additional 15 days of observations will be to obtain additional observations during potential migration periods. Verdant will consult with the NYSDEC and the United States Fish and Wildlife Service to select the beginning date for the three five-day periods. Such consultation shall occur prior to the first day of the month proceeding the observation month (e.g., March 1, 2006 for the April 2006 observation period). It is Verdant's responsibility to initiate the consultation. A start date must be selected by the three parties prior to the tenth day of the month proceeding the observation month (e.g., March 10, 2006 for the April 2006 observation period). Consistent with the other post-deployment surveys, the observations will consist of dawn to dusk observations (averaging approximately 10-hours per day), and result in approximately 150 hours of survey observations. Data to be recorded is described below.

In all Verdant will collect approximately 380 hours of bird observation data during deployment of the study units. As with the pre-deployment observations, all observations will be made from the shore adjacent to the deployment area. The observer will be equipped with binoculars and a camera. Photographs will be taken as available; however, the photographs are intended to supplement the observations and the recorded data (see below). The observer will not be responsible for photo-documenting every bird observed.

In addition to the observations described above, Verdant personnel will document observations of diving birds in the vicinity of the study area in the project log as observed. Such observations will be forwarded to Verdant's Project Biologist and will be included in the biweekly report to be forwarded to agency personnel. These observations are intended in supplement the formal observations and are not the primary means of observing bird activities associated with the Project. However, if Verdant personnel are on site, they will take advantage of their presence and report pertinent information to the Project Biologist.

Observation Documentation

Verdant understands the importance of documenting and reporting observations resulting from the bird surveys. A project log will be maintained that will record the approximate number of birds, the species of birds, time of day, feeding activities, diving activities, proximity to the six units (study area during pre-deployment), tidal direction, and any observations that would indicate interaction with the study units. Estimated counts of diving birds using the project area, including observations of activities such as feeding or resting will be made. In addition, the observer will document the operational status of the units (operating or not operating) during the observation period. Verdant will include a copy of the bird observation log in the appropriate biweekly reports to be provided to resource agency representatives.

7. Noise Evaluation

Verdant Power is approaching the noise (sound) issue in three ways: (1) it has evaluated the scientific literature on sound and fish to better understand the issues (Appendix B), (2) it plans to obtain sound measurements from the test six-pack (study outlined below), and (3) it will then evaluate the likely effects of the emitted sounds on the aquatic life of the East River. There is actually a fairly large scientific literature on aquatic sound and fish, particularly the estuarine species likely found in the East River such as American shad and river herrings. Little is known about underwater noise generated by an underwater turbine; however, this information would be important for evaluating the effects of an installation.

Verdant will perform a noise (acoustic) evaluation in conjunction with the initial deployment of the test turbines. The objective of this study is to evaluate the sensitivity of aquatic life with known acoustic sensitivities to sounds potentially resulting from the operation of the study units. As indicated in previous submittals to the Federal and State permitting agencies, Verdant believes that the units will not produce sound within a range that would adversely impact marine life. However, Verdant agrees that measurements need to be collected to verify this preliminary determination.

The noise evaluation methodology consists of the following activities:

- The general study design is to measure sounds of the operating units in a single mobile survey at various points on three lines radiating horizontally from the six-pack exclusion boom (to 500 feet upstream, downstream, and cross-channel from the exclusion boom at the unit depth) and vertically (surface to bottom, at the exclusion boom upstream, downstream, and cross-channel).

- Horizontal transects are to be sampled every 20 feet for approximately half the distance (260 feet) and then every 50 feet (starting at 300 feet) to a total distance of 500 feet.

- Vertical measurements are to be taken at 5-ft intervals (or as close as possible in high current).

These measurements would establish both the source sound close to the test turbines and quantify the attenuation of sounds with distance from the units.

In order to compare potential noise resulting from operation of the six study units, the same measurements (horizontal and vertical from the study units) will be collected prior to operating the units or when the units are in a locked (slung) position. These baseline measurements will be compared with the measurements collected while the six units are operating.

Sounds are to be detected with high-quality hydrophones capable of quantitative detection of frequencies 500 Hz to 150 kHz at quantified sound intensities. Sound data are to be recorded to a laptop computer and analyzed in the laboratory by a sound frequency analysis program. Sounds that are produced by the turbines will be related to the known sound sensitivities of local species for which data exists. The noise measurements will be collected within 14 days of deploying the sixth study unit. Verdant will provide the permitting agencies with the study results within 30 of data collection.

A draft report on noise study will be prepared separate from the fish monitoring report in order to distribute the information as soon as it is available. The final report will be included in the final fish monitoring report as an appendix. The report will present the results of the noise survey and evaluate these results by comparing noise levels to information on known acoustic ranges and effects based on literature review. Some of this information is presented in Appendix B to this study plan but a more complete review will be conducted as part of the noise study and incorporated into the study report.

8. Hydrodynamic Survey

To address the agencies' concern about the turbine array and its potential impact on flow patterns which may affect predator/prey relationships, Verdant will collect velocity and turbulence intensity measurements around the turbines to evaluate changes in velocities and the potential formation of eddy currents around the turbine arrays. Velocity profiles will be collected in transects around the turbine pairs and outside of the influence of the turbine array using an ADCP (Acoustic Doppler Current Profiler). The transects will be collected pre- and post-deployment of the six-pack turbine array but final location will be dependent on access and maneuverability around the turbine arrays. Transects perpendicular and parallel to the shore will be collected around the turbines while maintaining a slow boat speed to achieve a high horizontal resolution. Both average velocities and their variation will be reported. The data will be compared to evaluate changes in flow patterns. The post-deployment data will be evaluated to characterize flow and turbulence patterns around the turbines during varying turbine operations due to tidal changes. Information on fish occurrence within the study area, collected as part of the hydroacoustic study, will also be evaluated to discern if any fish aggregations are visible within any detectable zone of influence.

9. Study Status Reports

Verdant is very concerned with responding to resource agency concerns regarding the nature of the proposed RITE project and hopes to work closely in a cooperative manner as the studies move forward. To facilitate this consultation, biweekly status reports will be distributed to the consulting regulatory agencies, including but not necessarily limited to the ACOE, NYDEC, NOAA/NMFS, and USFWS. The status reports will outline the work completed on the studies since the last update, study results (as they are available), work scheduled during the next two-week period, and a summary of the work completed to date and what remains to be done. This status report will include all ongoing studies proposed as part of the six-pack testing efforts, not just the fish monitoring study. The status report will be distributed by email unless a hardcopy is specifically requested. Further, Verdant will have staff available to answer any questions regarding the studies as they are ongoing.

10. Study Report

Verdant will be in consultation with the resource agencies while the study is ongoing. Understanding that this is a long term study of an experimental technology and that some adjustments to the study plan may be appropriate, multiple detailed interim study reports will be submitted in addition to the biweekly status reports. The first interim report will be submitted a minimum of 30 days prior to installation of Turbines 3 - 6 for Phase II of the project. The report will include a summary of all data and observations recorded during the required 2 month pre-deployment survey period and the first 2 months of operation of Turbines #1 and 2 (Phase I). This should allow enough time to refine threshold values for alert conditions in consultation with the agencies and propose more definitive threshold levels based on actual site-specific data. The report will provide a discussion of the effectiveness of the pre-deployment survey in terms of characterizing the species and lifestages that are present in the project location, and an evaluation of the effectiveness of the monitoring program including a thorough description of all measures taken to calibrate and adjust the monitoring equipment, and to remedy any deficiencies.

The NYSDEC permit conditions state that additional interim reports will be submitted at 6, 12, and 18 months after the effective permit date and a final study report will be submitted within 24 months of study initiation. Given those conditions, the 6 month report may actually coincide with the first interim report, depending on actual turbine installation date. We interpret the intent here is to provide post-deployment data with all six turbines, thus propose the following schedule. The second interim report will be submitted 6, 12, and 18 months following deployment of Phase I turbines. This report schedule may be adjusted depending on the timing of Phase II (deployment of Turbines 3 - 6), so that a detailed interim report will be submitted to include the first two months of Phase II data analysis. However, any schedule adjustment must be approved by the permitting agency NYSDEC. The final study report will be submitted within 24 months of the initial turbine deployment. We fully expect that we will be able to prepare a preliminary assessment of project effects, especially near-field behavior, during the first few months of operation. The additional information will build on the data collection efforts and account for seasonal variation in fish species occurrence and potential migration effects.

The reports will consist of distribution maps of fish in horizontal and vertical space for all surveys (day and night). Comparisons will be made between maps for any changes in patterns of fish distribution before and after the installation of the test six-pack and during the period of monitoring.

The reports will also include tables summarizing the near-field data analysis from the fixed arrays. The tables will provide information on individual fish behavior as they approach the turbines and move through them. Analysis will provide individual fish counts, and representative direction of movement and swimming speeds.

The fish netting data will be tabulated to provide species lists, relative abundance, and length classes for each sampling event, separated out by near and far-field of the study footprint. Data will be evaluated for diurnal and seasonal changes in species occurrence, relative abundance, and distribution.

Data collected from the other aspects of this study, such as bird observations, noise evaluation, and hydrodynamic survey will also be included as separate sections of the study report and included in the overall project impacts evaluation.

11. Study Schedule

Pre-deployment studies (assuming deployment date of mid-November, 2005)

late Sept-early Nov –Conduct four mobile hydroacoustic fish monitoring surveys (every two weeks)
Bird observations
Hydrodynamic survey
Noise survey

Post-deployment studies (2005-2007)

Nov -Install Turbines 1 and 2 and the first 4 transducer arrays
Start continuous monitoring with four fixed-location hydroacoustic arrays
Continue bird observations
Dec 2005 – Dec 2006 Continue mobile hydroacoustic surveys on a monthly basis

Jan/Feb - Submit first draft interim study report (covers 2 months pre- and 2 months post-deployment)

Spring 2006 - Install additional turbines and surround each row with additional fixed hydroacoustic arrays

(timing dependent on interim study report review and weather conditions)

Repeat noise and hydrodynamic surveys

Submit second draft interim study report

May 2006 - Submit third draft interim study report (dependent on turbine deployment date)

Nov 2006 - Submit fourth draft interim study report (dependent on turbine deployment date)

May 2007 - Submit final draft interim study report (dependent on turbine deployment date)

Dec 2006 – May 2007 Conduct two seasonal mobile hydroacoustic surveys

Nov 2007 Submit draft final report (includes entire 20 month hydroacoustic study as well as noise, bird and hydrodynamic studies)

12. References

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Devine Tarbell and Associates, Inc. (DTA). 2004b. Response to Comments Public Notice No. 2003-004402-Y3 Roosevelt Island Tidal Energy Project (FERC NO. 12178). Prepared for: Verdant Power, LLC, New York, NY.

Devine Tarbell and Associates, Inc. (DTA). 2004c. Summary of Aquatic Resource Information for the East River, New York Relevant to the Roosevelt Island Tidal Energy Project (FERC NO. 12178). Prepared for Verdant Power, LLC, New York, NY.

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Verdant Power, LLC. 2004. Supplemental Report Full Environmental Assessment Form for Phase II of the Roosevelt Island Tidal Energy Project (FERC NO. 12178). Verdant Power, LLC. New York, NY.

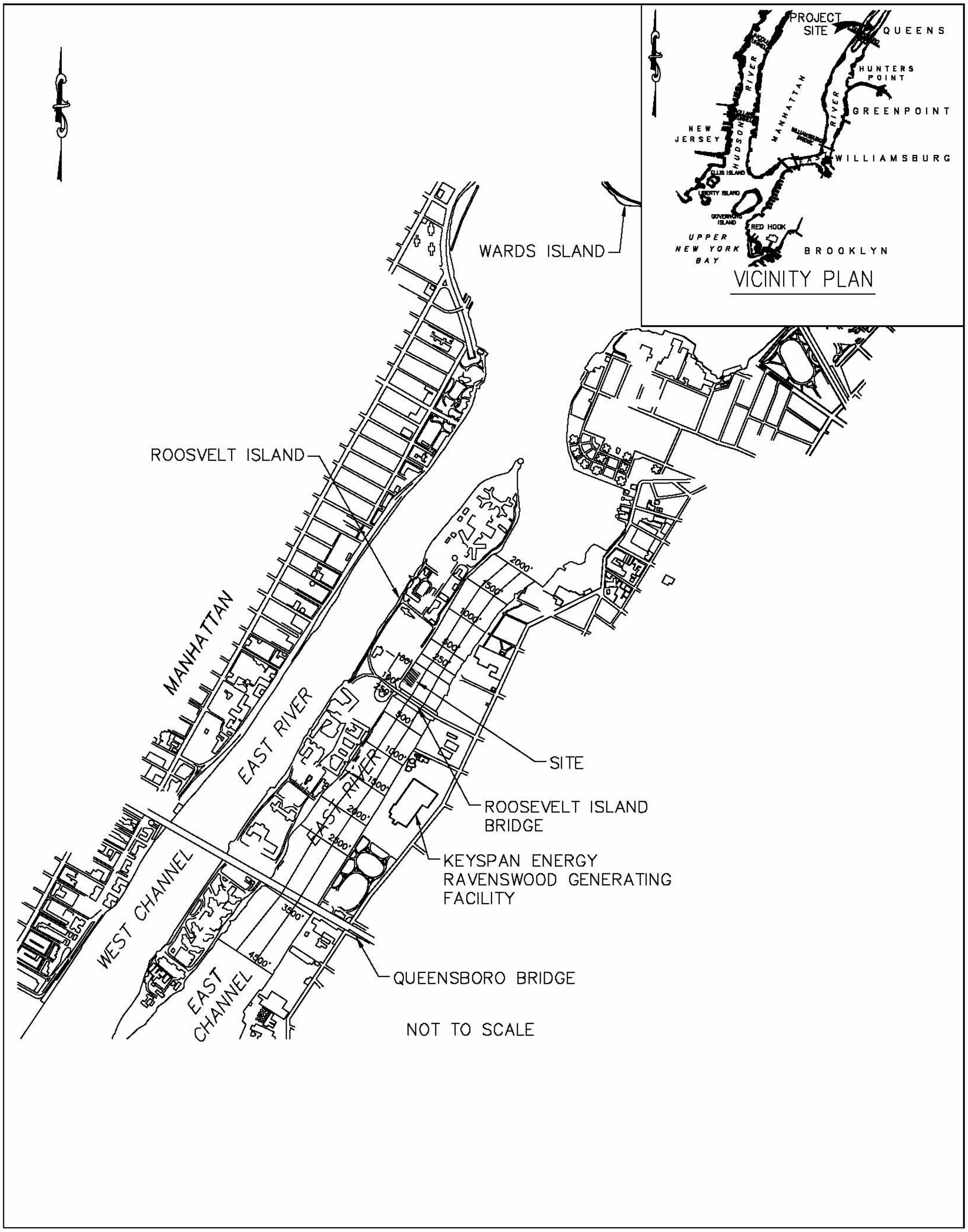
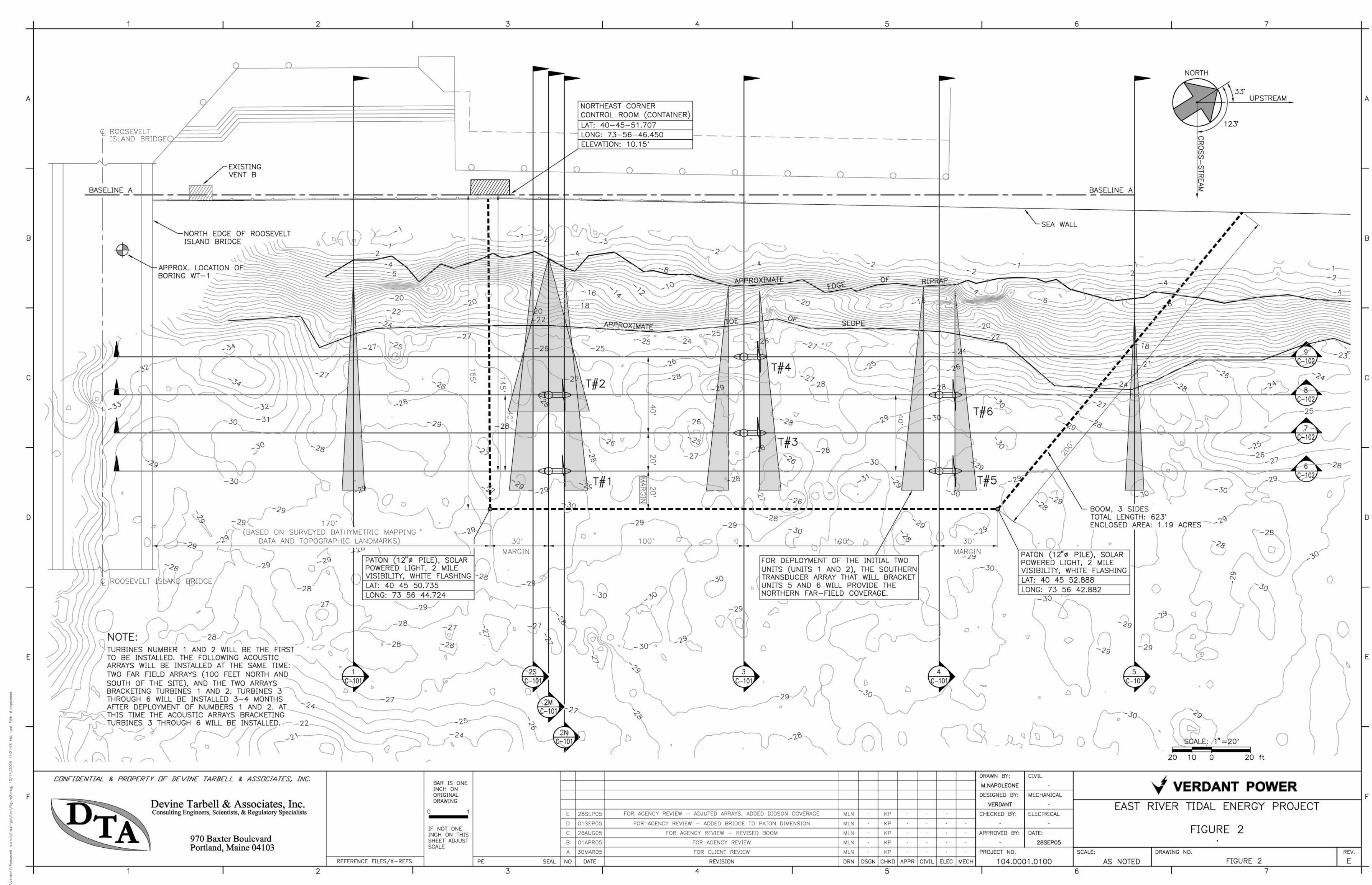
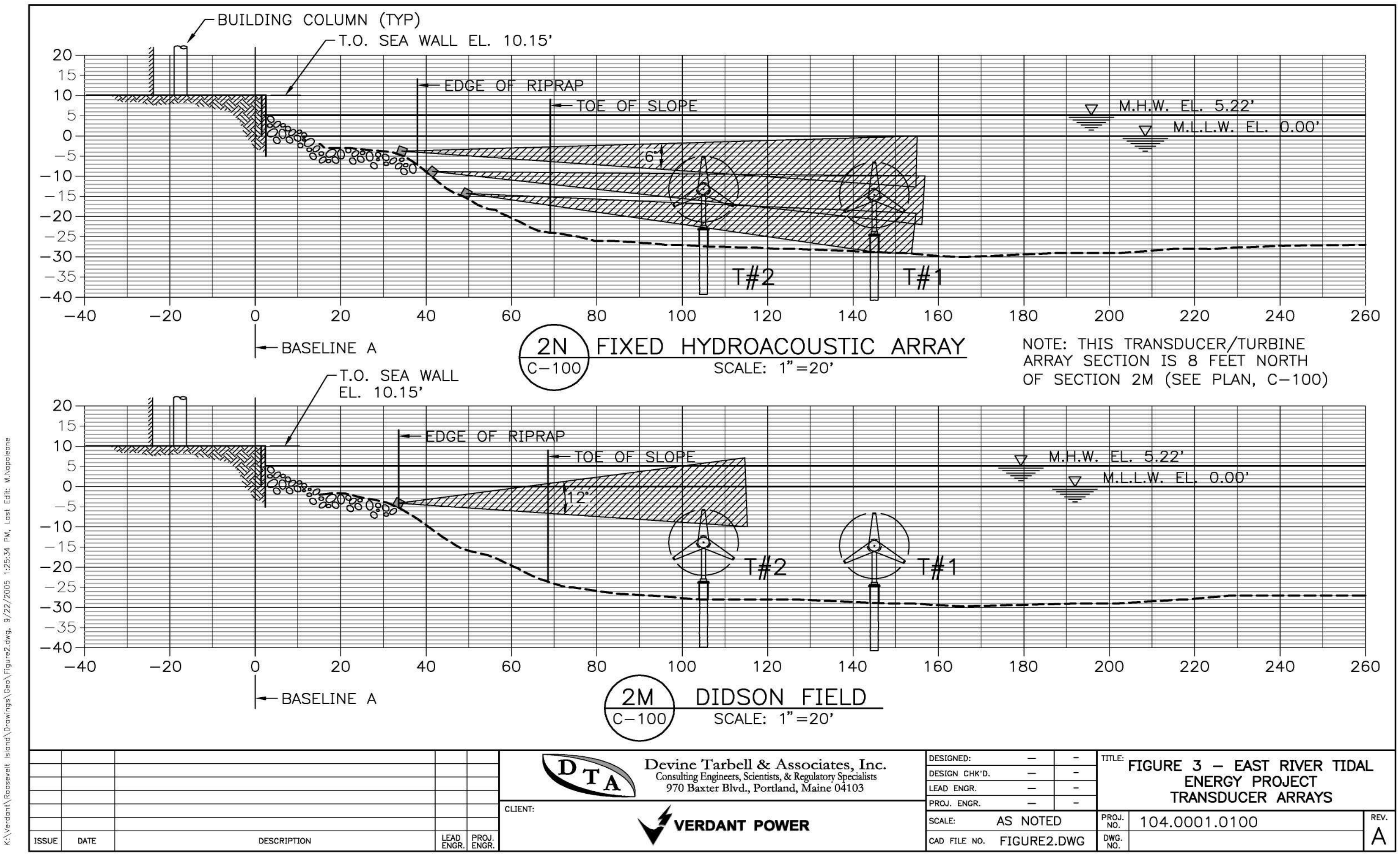


Figure 1. Proposed deployment area of the six-pack study field, East channel of the East River, New York, NY,


NORTHEAST CORNER CONTROL ROOM (CONTAINER)
LAT: 40-45-51.707
LONG: 73-56-46.450
ELEVATION: 10.15'
NORTH
UPSTREAM
CROSS-STREAM
℄ ROOSEVELT ISLAND BRIDGE
EXISTING VENT B
BASELINE A
SEA WALL
NORTH EDGE OF ROOSEVELT ISLAND BRIDGE
APPROX. LOCATION OF BORING WT-1
APPROXIMATE EDGE OF RIPRAP
APPROXIMATE TOE OF SLOPE
T#1
T#2
T#3
T#4
T#5
T#6
MARGIN
BOOM, 3 SIDES
TOTAL LENGTH: 623'
ENCLOSED AREA: 1.19 ACRES
(BASED ON SURVEYED BATHYMETRIC MAPPING DATA AND TOPOGRAPHIC LANDMARKS)
PATON (12"ø PILE), SOLAR POWERED LIGHT, 2 MILE VISIBILITY, WHITE FLASHING
LAT: 40 45 50.735
LONG: 73 56 44.724
FOR DEPLOYMENT OF THE INITIAL TWO UNITS (UNITS 1 AND 2), THE SOUTHERN TRANSDUCER ARRAY THAT WILL BRACKET UNITS 5 AND 6 WILL PROVIDE THE NORTHERN FAR-FIELD COVERAGE.
PATON (12"ø PILE), SOLAR POWERED LIGHT, 2 MILE VISIBILITY, WHITE FLASHING
LAT: 40 45 52.888
LONG: 73 56 42.882
NOTE:
TURBINES NUMBER 1 AND 2 WILL BE THE FIRST TO BE INSTALLED. THE FOLLOWING ACOUSTIC ARRAYS WILL BE INSTALLED AT THE SAME TIME: TWO FAR FIELD ARRAYS (100 FEET NORTH AND SOUTH OF THE SITE), AND THE TWO ARRAYS BRACKETING TURBINES 1 AND 2. TURBINES 3 THROUGH 6 WILL BE INSTALLED 3-4 MONTHS AFTER DEPLOYMENT OF NUMBERS 1 AND 2. AT THIS TIME THE ACOUSTIC ARRAYS BRACKETING TURBINES 3 THROUGH 6 WILL BE INSTALLED.
SCALE: 1"=20'
CONFIDENTIAL & PROPERTY OF DEVINE TARBELL & ASSOCIATES, INC.
Devine Tarbell & Associates, Inc.
Consulting Engineers, Scientists, & Regulatory Specialists
970 Baxter Boulevard
Portland, Maine 04103
BAR IS ONE INCH ON ORIGINAL DRAWING
IF NOT ONE INCH ON THIS SHEET ADJUST SCALE
E 28SEP05 FOR AGENCY REVIEW - ADJUTED ARRAYS, ADDED DIDSON COVERAGE
D 01SEP05 FOR AGENCY REVIEW - ADDED BRIDGE TO PATON DIMENSION
C 26AUG05 FOR AGENCY REVIEW - REVISED BOOM
B 01APR05 FOR AGENCY REVIEW
A 30MAR05 FOR CLIENT REVIEW
DRAWN BY: M.NAPOLEONE
DESIGNED BY: VERDANT
PROJECT NO. 104.0001.0100
DATE: 28SEP05
VERDANT POWER
EAST RIVER TIDAL ENERGY PROJECT
FIGURE 2
SCALE: AS NOTED
DRAWING NO. FIGURE 2
REV. E


BUILDING COLUMN (TYP)
T.O. SEA WALL EL. 10.15'
EDGE OF RIPRAP
TOE OF SLOPE
M.H.W. EL. 5.22'
M.L.L.W. EL. 0.00'
6"
T#2
T#1
BASELINE A
2N C-100 FIXED HYDROACOUSTIC ARRAY
SCALE: 1"=20'
NOTE: THIS TRANSDUCER/TURBINE ARRAY SECTION IS 8 FEET NORTH OF SECTION 2M (SEE PLAN, C-100)
T.O. SEA WALL EL. 10.15'
EDGE OF RIPRAP
TOE OF SLOPE
M.H.W. EL. 5.22'
M.L.L.W. EL. 0.00'
12"
T#2
T#1
BASELINE A
2M C-100 DIDSON FIELD
SCALE: 1"=20'
Devine Tarbell & Associates, Inc.
Consulting Engineers, Scientists, & Regulatory Specialists
970 Baxter Blvd., Portland, Maine 04103
CLIENT:
VERDANT POWER
ISSUE DATE DESCRIPTION LEAD ENGR. PROJ. ENGR.
DESIGNED: DESIGN CHK'D. LEAD ENGR. PROJ. ENGR.
SCALE: AS NOTED
CAD FILE NO. FIGURE2.DWG
TITLE: FIGURE 3 – EAST RIVER TIDAL ENERGY PROJECT TRANSDUCER ARRAYS
PROJ. NO. 104.0001.0100
DWG. NO.
REV. A

Appendix A

Detailed Description, Acoustic Monitoring Equipment

The BioSonics Model DT-X scientific grade digital echo sounder will be used to monitor an array of 3-4 split-beam transducers aimed horizontally across the East River. Details of this model are given at WWW.BioSonics.Com.

Echo Sounder

Digital Design, stable and linear over time
Self Noise typically lower than –140 dB
1000 Watt RMS Transmit Power
Pulse Repetition Rates 0.1 – 30 pulses per second or Externally Triggered
Pulse Duration 100 – 1000 msec, user selected
160 dB of Analog Dynamic Range prior to TVG
Time-Varied Gain (TVG) digitally applied to displays and analysis algorithms

Transducers

Narrow beam, first side lobe typically suppressed to below –30 dB one way.
Beam directivity extremely steep-sided – allowing data collection near boundaries
200 kHz acoustic frequency, Absorption ~0.05 dB/meter
Typical Detection Range, 3-inch fish in salt water, 100 m
Anodized housing, plastic connector for corrosion control

System Control

Real-Time Display of high resolution color echogram per transducer
Intuitive User Interface for configuration, control, display, and data storage
Ethernet-compatible, wired or wireless
Environmental case houses electronics
Embedded computer running Linux OS controls hardware
Connections provided for GPS, Integrated Orientation Sensor
Designed for automated and/or autonomous operation

Equipment Calibration

Biosonics, the manufacturer of the hydroacoustic equipment proposed for this study, has a standard QA/QC protocol which is considered the industry standard (http://www.biosonicsinc.com/doc_library/docs/DTXcalibration2e.pdf). They also have an established production calibration procedure which is a required component of their manufacturing quality assurance and quality control program. Every two years, a QA/Technical Audit of their calibration facility is performed by Pacific Northwest National Laboratory, operated by Battelle for the U.S. Department of Energy. Compliance standards are based on The American Society of Mechanical Engineers (ASME) Quality Assurance Program Requirements.

These practices are routinely acknowledged as the industry standard for all of Biosonics' Hydroacoustic work on Army Corps of Engineers operated Columbia River system Hydroelectric Dams. BioSonics has been conducting these hydroacoustic surveys and practicing these calibration methods for over twenty five years. All phases of this scope of work including; calibration, installation, statistical sub-sampling, analysis and reporting are routinely reviewed and accepted by numerous state and federal agencies such as the National Marine Fisheries Service prior to study authorization.

The field use of tungsten carbide spheres is the only industry standard method of field calibration used for scientific hydroacoustic systems. We are not aware of the use of any other devices for field calibration such as models or replicas of fish. Furthermore, these types of targets would not provide consistent or scientifically valid target strength information.

Appendix B

Scientific Literature on Sound and Fish
Prepared by Chuck Coutant (ORNL) with revisions by Mary McCann and Kipp Powell (DTA)

There has been a recent upsurge in interest related to the effects of anthropogenic sounds in the aquatic environment and potential effects on aquatic life (NRC 1994, Richardson 1995, Popper 2003). The sounds of boats (Scholik and Yan 2002a, Wales and Heitmeyer 2002) and seismic explorations (McCauley 1994), McCauley et al. 2003) have been of particular concern. Because the sensory receptors for sound in fish and mammals are similar, many of the concerns for damage have been extrapolated to fish. Despite concerns, aquatic animals live in a naturally noisy environment and are variously adapted to accommodate and use this sensory realm (Myrberg 1980, Popper 2003).

It has been shown that all species of fish (both bony and cartilaginous) that have been tested are able to hear (Popper 2003). Fish have species-specific hearing ranges in terms of both sound frequency given in Herz (Hz; previously known as cycles per second) and volume given in decibels (dB) referenced to 1 microPascal (1µPa). The volume reference is used to allow investigators to compare levels recorded in the aquatic environment at different places and times. For comparison, the reference value in air is 20 µPa, which is the threshold level of human hearing at 1,000 Hz. Fishes can generally be divided into one of two hearing guilds, hearing specialist and non-hearing specialists. Species considered hearing specialists can detect sounds to over 3,000 Hz, with best hearing sensitivity from about 300-1,000 Hz, however some fishes of the Alosinae family can detect ultrasonic sounds to over 200,000 Hz (Popper 2003). In contrast, the majority of fishes do not have known hearing specializations and only detect sounds up to 500 to 1,000 Hz, with best hearing from 100-400 Hz (Popper 2003). Popper (2003) surmised that fishes, like most animals, glean a good deal of information about their environment from sounds that might include waves, currents, and other diverse sources.

Aquatic organisms are not only affected by a particular frequency or a specific volume but rather a combination of frequency and volume. For example, American shad (*Alosa sapidissima)* do not respond to a frequency of approximately 400 Hz until the volume is about 110 dB re: 1µPa. Most non-hearing specialist fish respond to frequencies in the 100-200 Hz range at a volume of 70-90 dB re 1µPa. Some marine species, such as toothed whales, use sonar signals to locate prey. These signals are generally between 70 to 140 kHz and levels up to 228 dB re: 1µPa (Plachta and Popper 2003). Most likely as an adaptation, prey species such as Alosinae are able to detect these higher frequencies. The alewife (*A. pseudoharengus*) will swim away from echosounders, suggesting they can also detect the direction of the ultrasound (Plachta and Popper 2003). Exposure to loud noises can reduce sensitivity of a fish's hearing, analogous to the effects in humans. Sholick and Yan (2002a) demonstrated that noise from an outboard boat engine impaired the hearing of a hearing specialist, the fathead minnow. There was less effect on a hearing generalist, the bluegill sunfish.

Some species founding estuaries have especially acute hearing thresholds and sensitivity to frequencies far beyond those of most species. Species like the goldfish and catfish can detect sounds over 3,000 Hz. Most notably, fishes of the family Alosinae, including American shad and blueback herring (*A. aestivalis*), can detect ultrasonic sounds to over 200,000 Hz (Mann et al. 2001). These shad and herring appear to have developed such high sensitivity in order to avoid predation by marine mammals (Mann et al. 2001, Plachta and Popper 2003). The importance of these high frequency sounds is understandable when we recognize that low frequency sounds are rapidly attenuated in water and only the high frequency sounds penetrate more than a few meters from most sources (Rogers and Cox 1988).

Additional information on sound effects on fish resulted from studies conducted in search of sound systems that can be used to repel fish from power plant and hydropower intake structures. Blueback herring avoided sounds of 110,000 and 140,000 Hz at source levels of 180 dB in net pens at the Richard B. Russell Dam, Savannah River, Georgia-South Carolina (Nestler et al. 1992). Broadband sound of 122,000-128,000 Hz at a source level of 190 kB successfully excluded alewife from the intake of the James A. FitsPatrick Nuclear Power Plant on Lake Ontario but were ineffective for bay anchovy (Ross et al. 1993, 1996), where it is now the accepted control mechanism for minimizing fish impingement on intake screens. Sound of various frequencies is being tested and used for behavioral guidance of several fish species (Coutant 2002). Maes et al. (2004) conducted sound deterrent studies for the Doel nuclear power plant in the Scheldt Estuary for a wide range of estuarine species. The acoustic fish deterrent system tested low frequencies of 20-600 Hz at 178 dB re: 1µPa. The researchers found that species without swimbladders showed no or a moderate response while species with swimbladders or an accessory structure which increased the hearing ability, would avoid the intake (Maes et al. 2004). The species effectively repelled included gobies (*Pomatoschistus* sp.) and herring (*Clupea harengus*), smelt (*Osmerus eperlanus*), sole (*Solea solea*), and flounder (*Platichthys flesus*). Species that were not deflected by these frequencies include sand dab (*Limanda limanda*), pipefishes, sticklebacks and mullets. The authors cautioned that extrapolation of their results needs to consider local conditions, including water velocity and background noise.

The underwater acoustic environment is inherently loud as a result of ambient sounds and an increasing amount of noise from anthropogenic sources. In most cases the sounds produced by humans are relatively low in frequency, with the bulk of the energy below 1,000 Hz (Popper 2003). With this in mind we also know that only higher frequency sounds propagate beyond a few meters from the source in shallow waters and is virtually negligible in deeper offshore habitat (Popper 2003).

This sampling of the recent scientific literature demonstrates the need to evaluate whether a turbine such as being proposed in the East River has the potential to produce sounds that could affect migrating American shad, blueback herring and alewife as well as other migrating fish. Marine mammals and turtles are known to be extremely rare in the project area but should be included in the evaluation also. The effect likely would be most pronounced if sound is produced in the high frequency range. Such sound, if present above background levels, could deter adult and juvenile shad and herring from passing the project in the east channel site. Even hearing generalists might be affected if the sounds are very loud. None-the-less, such sounds should be placed in the context of currently accepted, but demonstrably detrimental, sound on the East River, such as from outboard motors and other navigation.

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