OCS Study
BOEM 2019-027

Field Observations During Wind Turbine Installation at the Block Island Wind Farm, Rhode Island

US Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs

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May 2019

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Prepared under BOEM Award
Contract No. M15PC00002,
Task Order No. M16PD00025
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U.S. Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs

DISCLAIMER

Study concept, oversight, and funding were provided by the US Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, DC, under Contract Number M15PC00002, Task Order No. M16PD00025. This report has been technically reviewed by the Bureau of Ocean Energy Management, and it has been approved for publication. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the US government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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CITATION

HDR. 2019. Field Observations During Wind Turbine Installation at the Block Island Wind Farm, Rhode Island. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2019-027. 292 pp.

ABOUT THE COVER

Cover photo: Block Island Wind Farm Facility Wind Turbine 3 Construction and all five completed Wind Turbines. Courtesy of HDR RODEO Team.

ACKNOWLEDGMENTS

The HDR RODEO Team includes the following subcontractors (in alphabetical order):

- Arthur Popper, Ph.D.
- Clark Group, LLC
- EA Engineering Science & Technology, Inc.
- Fugro Marine GeoServices, Inc.
- Fugro GB Marine Ltd.
- H.T. Harvey & Associates
- Loughine Limited
- Subacoustech Environmental.

Significant additional technical support for the monitoring effort was provided by the following institutions:

- Marine Acoustics, Inc.
- University of Rhode Island
- Woods Hole Oceanographic Institution
- Blue Land Media.

Vessel services for visual monitoring were provided by Hula Charters.

Assistance and support from all team members is greatly appreciated.

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List of Abbreviations and Acronyms

BIWF	Block Island Wind Farm
BOEM	Bureau of Ocean Energy Management
dB	decibel(s)
DOI	Department of the Interior
FSP	Field Sampling Plan
ft	foot/feet
Hz	Hertz
km	kilometer(s)
LB	lift boat
m	meter(s)
mi	mile(s)
m/s	meters per second
MLLW	mean lower low water
mm	millimeter(s)
m/s	meter(s) per second
µPa	micropascals
RODEO	Real-Time Opportunity for Development Environmental Observations
SLM	sound level meter
WTG	wind turbine generator

Editorial Note

To facilitate presentation, review, and perusal of the large quantity of observations and data generated under Task Order M16PD00025, the task order deliverable was divided into the following four standalone documents:

1. **Field Observations during Wind Turbine Installation at the Block Island Wind Farm, Rhode Island (BOEM 2019-027)** – reports on the methods, observations, data analyses, results, and conclusions from environmental monitoring conducted at the BIWF under BOEM's RODEO Program during the *assembly of the wind turbine generator components (turbine towers, nacelles, and blades*).

2. **Field Observations during Wind Turbine Operations at the Block Island Wind Farm, Rhode Island (BOEM 2019-028)** – reports on the methods, data analyses, results, observations, and conclusions from environmental monitoring conducted at the BIWF under BOEM's RODEO Program during *turbine operations*.

3. **Underwater Acoustic Monitoring Data Analyses for the Block Island Wind Farm, Rhode Island (BOEM 2019-029)** – reports on the methods, observations, results, and conclusions from additional analyses of underwater acoustic monitoring data collected under BOEM's RODEO Program during the *pile driving for securing the turbine foundations to the seabed*.

4. **Benthic Monitoring During Wind Turbine Installation and Operation at the Block Island Wind Farm, Rhode Island (BOEM 2018-047)** – Published in 2018, this report presented the methods, data analyses, results, observations, and conclusions from benthic monitoring conducted in 2017 and 2018 at the Block Island Wind Farm (BIWF) under BOEM's RODEO Program.

Executive Summary

The construction of the Block Island Wind Farm (BIWF), which is located 4.5 kilometers (km) (2.8 miles [mi]) southeast of Block Island, Rhode Island, was completed in two distinct phases. Phase 1 construction began in August 2015 and was completed over an 18-week period. It included installation of five wind turbine foundations on the seabed. Phase 2 construction was completed in two steps. In Step 1, which was initiated in January 2016, submarine power cables were laid on the seabed. In Step 2, which was completed over a two-week period (3 August–18 August) in 2016, a turbine tower, a nacelle, and three blades were assembled on each of the five wind turbine generator (WTG) foundations. The nacelle is a case that houses all of the generating components in a wind turbine, including the generator, gearbox, drive train, and brake assembly.

This report presents methods, observations, data analyses, results, and conclusions from the Bureau of Ocean Energy Management's (BOEM's) RODEO Program environmental monitoring conducted during the assembly of the WTG components on the turbine foundations (i.e. Phase 2, Step 2). Visual observations of construction activities were recorded and airborne noise monitoring was conducted.

Visual Observations

The purpose of visual monitoring was to 1) document visibility of construction activities during the assembly of the turbine towers and installation of the nacelles and blades from selected onshore and offshore locations; and 2) generate a real-time record of the construction-related impact-producing activities, and where possible, quantify such activities. Installation and assembly of turbine towers, nacelles, and blades at WTG 2, 3, and 4 were observed and recorded during this monitoring from strategically selected onshore (Southeast Lighthouse) and offshore (survey vessel) locations.

Data were recorded at early morning, mid-day, sunset, and during significant changes in meteorological conditions (rain, fog, etc.). Observations were recorded on each day of active construction, and included taking a series of photographs from a fixed location, at the same angle, using a constant camera zoom setting. Video recordings were made as necessary to document unusual sightings or infrequent occurrences. Relevant information about the size, type and number of construction vessels, and other impact-producing factors, was also recorded. Key visual monitoring observations are listed below:

- Far fewer challenges were encountered during Phase 2, Step 2 construction as compared to Phase 1 construction. The biggest issue was delays due to adverse weather conditions. On windy days especially, construction had to be suspended because of potential risk from crane operations.

- Assembly of the WTG components on the foundations (Phase 2, Step 2) was completed in approximately 2 weeks, which was faster than the 18 weeks required for Phase 1 construction.

- The L/B *Brave Tern* provided a superior at-sea construction platform. The ability to lift the deck above sea waves and provide a stable construction platform for crane operations avoided or greatly reduced delays from weather-related high sea states.

- Phase 2 construction was more streamlined as compared to Phase 1 construction, in part due to use of Lift Boats (Lift Boat) as construction platforms and supply tenders. Overall, the construction footprint around the WTGs was reduced due to the use of LB. The derrick barges used as supply vessels during Phase 1 construction required multiple tugs to remain on standby for both positioning and anchoring, which was not as efficient as using LB.

- Only four vessels were used (three lift boats and the crew tender *Atlantic Pioneer*) during Phase 2, as compared to the 16 vessels that supported Phase 1 construction. Fewer vessels anchoring on site also resulted in less damage to the seabed.

- The Lift Boat were able to quickly transition from one turbine to the next as compared to Phase 1 during which a lot more time was needed to reposition the derrick barges during Phase 1. Also, the smaller Lift Boat only required approximately 15 minutes to jack up once in position.

- Average time to install one tower section and one blade was approximately 312 minutes and 220 minutes, respectively. Total time spent at each turbine was approximately 3 days.

- Compared to Phase 1 construction, during which local boat traffic was impacted, Phase 2 construction had no influence on the local fishing traffic.

Airborne Noise Monitoring

Airborne noise monitoring was conducted over nine days (7 to 15 August 2016) during the installation of the tower sections on the WTG foundations using Larson David model 831 sound level meters. Environmental and meteorological conditions were also recorded during airborne noise monitoring. Simultaneous measurements were made at one onshore (Southeast Lighthouse) and one offshore location (a sound level meter mounted on the deck of the research vessel R/V *McMaster*).

The monitoring results indicated that at no point during the tower lifting operations construction noise was audible or detectable at the onshore monitoring location. Measurements taken around the lift boat during lifting of the tower sections indicated that the primary source of airborne noise was the barge engines and this noise was characterized by a continuous hum. No noise was detected on Block Island under any wind conditions.

At offshore locations, the noise levels were influenced by the wind direction. Upwind of the Lift Boat, the noise was almost inaudible above background levels within 750 meters (m; 0.5 mi) of the barges. Downwind, the hum from the engines was still audible at nearly 3,000 m (1.9 mi) with a background noise level of approximately 45 decibels (dB) LA90. The noise was reasonably tonal with a peak at 40 Hertz and a noise level of 56 dB at 2,750 m (1.7 mi) at this 1/3rd octave band center frequency and quickly dropped below the ambient noise outside this frequency band. Given favorable conditions, including wind and low background noise, this noise could plausibly be audible beyond this distance.

Under calm conditions, noise from the lift boat was still clearly audible at 1,350 m (0.8 mi) and is likely to be audible beyond this point. Overall, downwind propagation of airborne noise from barge operations during the tower section lifts was generally in line with measurements taken during the Phase 1 construction piling.

Video Documentation

A short video vignette was produced to provide an overview of the BIWF project. The video described the BIWF facility and emphasized the importance of the different types of monitoring conducted under the BOEM’s RODEO Program. The video team also captured time lapse footage of the installation of two blades. Individual images were captured every 10 seconds from the vantage point of the second floor window at Southeast Lighthouse, and were subsequently processed into video. The vignette was completed with full color correction, professional narration, sound mixing and mastering. It was created in high definition broadcast quality and provided to BOEM in 1080HD and 720HD H.264 video files for easy distribution. The video will serve as a useful tool during the planning of future offshore facilities in the United States, and could also be used for media outreach, educational projects, and social media messaging.

The data, results, conclusions, and recommendations presented in this report were generated for BOEM by the HDR RODEO Team under IDIQ Contract M15PC00002, Task Order M15PD00025.

1 Introduction

This report presents methods, observations, data analyses, results, and conclusions from real-time environmental monitoring surveys conducted in and around the Block Island Wind Farm (BIWF) Project Area (**Figure 1**) during the installation of the wind turbines. The turbines were installed during the second BIWF construction phase on foundations that had been previously anchored on the seabed during the first phase of construction. This monitoring was conducted under the Bureau of Ocean Energy Management's (BOEM's) Real-Time Opportunity for Development Environmental Observations (RODEO) Program.

1.1 The RODEO Program

The purpose of the RODEO Program is to make direct, real-time measurements of the nature, intensity, and duration of potential stressors during the construction and initial operations of selected proposed offshore wind facilities. The purpose also includes recording direct observations during the testing of different types of equipment that may be used during future offshore development to measure or monitor activities and their impact producing factors.

BOEM conducts environmental reviews, including National Environmental Policy Act analyses and compliance documents for each major stage of energy development planning which includes leasing, site assessment, construction, operations, and decommissioning. These analyses include 1) identification of impact producing factors (stressors) and receptors such as marine mammals and seafloor (benthic) habitats, and 2) evaluation of potential environmental impacts from the proposed offshore wind development activities on human, coastal, and marine environments. The analyses require estimations of impact-producing factors such as noise and the effects from the stressor on the ecosystem or receptors. Describing the impact-producing factors requires knowledge or estimates of the duration, nature, and extent of the impact-generating activity. Since there have been no offshore facilities constructed in the US prior to BIWF, model predictions will be primarily used to forecast likely impacts from future projects.

The RODEO Program data may be used by BOEM as inputs to analyses or models that evaluate the effects or impacts from future offshore wind turbine construction and operations, as well as facilitate operational planning that would reduce potential impacts to the greatest extent possible. The understanding and insights gained from the BIWF monitoring program data analyses will help BOEM to identify, reduce, and mitigate environmental risks in the future, and significantly increase the efficiency and efficacy of BOEM's regulatory review process for offshore wind development in the US. Finally, data collected by the BIWF monitoring program will support prioritization of future monitoring efforts and risk retirement. For example, if the BWIF monitoring data indicates that likelihood of impacts from a particular project development phase is low or inconsequential, then such phases may not be monitored during future projects.

It is important to note that the RODEO Program is not intended to duplicate or substitute for any monitoring that may otherwise be required to be conducted by the developers of the proposed projects. Therefore, RODEO monitoring was limited to selected parameters only. Also, RODEO Program monitoring is coordinated with the industry and is not intended to interfere with or result in delay of industry activities.

The BIWF is the first facility to be monitored under the RODEO Program. All monitoring surveys were implemented in accordance with a pre-approved Field Sampling Plan (FSP), which included a project-specific Health and Safety Plan (**Appendix A**). **Table 1** identifies the types of field data collected under the RODEO Program during construction and/or initial operations of this facility.

Figure 1. **BIWF project area.**

Table 1. RODEO Program monitoring conducted at the BIWF.

Phase	Key Activities	Dates	Monitoring Surveys	Comment
Construction Phase 1	• Steel jacket foundations were installed on the seabed using two different types of hammers. Both derrick barges and a lift boat were used as construction platforms. Piles were installed with a 13.27° rake from the vertical.	26 July–26 October 2015.	• Visual observations and documentation of the construction activities. • Airborne noise monitoring associated with pile driving. • Underwater sound monitoring associated with pile driving. • Seabed sediment disturbance and recovery monitoring through bathymetry surveys conducted immediately after construction was completed and in approximately 3-month intervals for one year. • Turbine platform scour monitoring through installation of two scour monitoring devices on selected WTG foundations. • An Acoustic Wave and Current Profiler was also deployed within the project area.	Results, conclusions and recommendations from Construction Phase 1 monitoring were presented in the report entitled "*Field Observations during Wind Turbine Foundation Installation at the Block Island Wind Farm, Rhode Island. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, OCS Study BOEM 2018-029 (HDR 2018a)*."
Construction Phase 2	• WTGs were installed on the steel foundations.	3 August–18 August 2016.	• Airborne noise monitoring. • Visual observations and documentation of activities.	Results, findings, conclusions, and recommendations from the Phase 2 Construction Monitoring are presented in the report entitled: "*Field Observations During Wind Turbine Installation at the Block Island Wind Farm, Rhode Island, OCS Study BOEM 2019-027 (HDR 2019a)*."

Phase	Key Activities	Dates	Monitoring Surveys	Comment
	• Submarine transmission power cables connecting Block Island and mainland were laid using a jet plowing in the offshore portions and horizontal directional drilling in the near shore area.	3 June–26 June 2016.	• Visual observations and documentation of the cable laying activities and of turbine installation from both on shore and off shore locations. • Still photography and filming of portions of trenching operations for cable laying. • Seabed sediment disturbance monitoring. • Post-construction seabed recovery through bathymetry surveys.	For details see report entitled: "*Observing Cable Laying and Particle Settlement During the Construction of the Block Island Wind Farm. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, OCS Study BOEM 2017-027 (Elliot et al. 2017).*
Operational Phase	• Testing of the newly installed turbines. • Testing of the submarine transmission power cables.	Operational testing conducted from 29 August–30 November 2016.	• Visual observations of the operational wind farm from on shore and off shore locations at varying distances.	Results, conclusions, and recommendations from monitoring conducted during turbine operations are presented in an accompanying report entitled: "*Field Observations during Wind Turbine Operations at the Block Island Wind Farm, Rhode Island, OCS Study BOEM 2019-028 (HDR 2019b).*"
	• Facility operations.	Wind farm operation began on 2 December 2016.	• Airborne noise monitoring. • Underwater sound monitoring. • Seabed sediment disturbance and recovery monitoring.	
			• Benthic monitoring.	Results, conclusions, and recommendations from this monitoring are presented in an accompanying report entitled: "*Benthic Monitoring During Wind Turbine Installation and Operation at the Block Island Wind Farm, Rhode Island, OCS Study, BOEM 2018-047 (HDR 2018b).*"

Phase	Key Activities	Dates	Monitoring Surveys	Comment
Follow-on Data Analyses	• Additional in-depth analyses were conducted using data collected during construction Phase 1.	28 July– 31 December 2019	• No field surveys. Only desk-top data analyses and preliminary 3-dimensional modeling with were conducted during this phase.	Results, finding, conclusions and recommendations from the additional data analyses are presented in an accompanying report entitled: "*Underwater Acoustic Monitoring Data Analyses for the Block Island Wind Farm, Rhode Island, OCS Study BOEM 2019-029 (HDR 2019c).*"

1.2 Block Island Wind Farm Construction Activity Characterization

The BIWF is the first offshore wind farm in the U.S., located 4.5 kilometers (km) (2.8 miles [mi]) southeast of Block Island, Rhode Island. Water depth in the wind farm area is approximately 30 meters (m) (98.4 feet [ft]). The five-turbine, 30-megawatt facility is owned and operated by Deepwater Wind Block Island, LLC[1]. Power from the turbines is transmitted to Block Island. A 32 km (19.9 mi) transmission submarine power cable transfers excess power from Block Island to the mainland. This cable is buried under the ocean floor and makes landfall on the mainland, north of Scarborough Beach at Narragansett. The five turbines are designated as wind turbine generator (WTG) 1 to WTG 5.

BIWF construction began in August 2015, and was completed in a phased manner by the end of November 2016. Phase 1 construction was completed over an 18-week period and it included installation of five wind turbine foundations on the seabed. The steel jacket of each foundation was lowered onto the seabed by a crane. Then individual piles, each of which measured between 1.4 and 1.7 m (4.6 and 5.6 ft) in diameter, were placed into the guide holes at jacket corners. Impact (percussive) pile driving was used to drive the piles incrementally into the seabed. The piles were driven to their final penetration design depth of 76.2 m (250 ft) or until refusal, whichever came first.

A transition deck was then placed on top of the jacket and bolted in place to complete the foundation. **Figure 2** shows a schematic of a fully assembled WTG foundation; a photograph of the assembled WTG 5 foundation is shown in **Figure 3**. Key observations from the RODEO Program environmental monitoring conducted during construction Phase 1 are presented a separate report entitled "*Field Observations during Wind Turbine Foundation Installation at the Block Island Wind Farm, Rhode Island*" (HDR 2018).

Phase 2 construction was completed in two steps. In Step 1, which was initiated in January 2016, submarine power cables were laid on the seabed. See report entitled "*Observing Cable Laying and Particle Settlement during the Construction of the Block Island Wind Farm*" (Elliott et al. 2017) for a detailed description of the RODEO Program environmental monitoring conducted during this step.

In Step 2, which was conducted over a two-week period in August 2016, a turbine tower, a nacelle[2], and three blades were assembled on each of the five WTG transition decks. During this assembly, the first of three turbine tower sections was bolted in place on each transition deck and then the other two sections were sequentially placed on top of the first section. A nacelle was then connected to the top of the tower and three blades were installed on the nacelle. The schematic in **Figure 4** shows a fully assembled WTG 1. A photograph of the completed WTG 1 is shown in **Figure 5**.

The completed turbines are 181 m (594 ft) above mean lower low water (MLLW) at their highest elevation and the nacelle is approximately 106 m (348 ft) above MLLW. Each blade is 73 m (240 ft) and has a blade swept area of 17,806 m^2 (4.4 acres). The lowest blade elevation is 31 m (101 ft) MLLW. The jackets that support the turbines are designed to withstand a Category III hurricane. During severe weather conditions, the blades are locked into place and prevented from rotating.

Three Lift Boats were utilized during the assembly of the towers, nacelles, and blades. The primary platform was the Fred Olsen Windcarrier L/B *Brave Tern*, a 7,600-ton (16,755,131-pound) cargo capacity Republic of Malta-flagged vessel. This vessel is 132 m (433 ft) in length and 39 m (127 ft) wide, equipped with three deck cranes, and has four legs that are 92.4 m (303.1 ft) in length and capable of extending 70.5 m (231.3 ft) below the ship baseline.

[1] Deepwater Wind was acquired by Ørsted of Denmark in 2018 and is now known as Ørsted US Offshore Wind.

[2] The Nacelle is a case that houses all of the generating components in a wind turbine, including the generator, gearbox, drive train, and brake assembly.

Two smaller sister Lift Boats, the L/B *Paul* and L/B *Caitlin* with matching dimensions and capacity, were used as supply ships. Both vessels are 42.15 m (138.3 ft) in length and 26 m (85 ft) in width, and they have three legs that are 72 m (236 ft) in length and capable of jacking up to a maximum depth of 55 m (180 ft) of water. The L/B *Caitlin* was used to transport the three tower sections to each foundation. The nacelles and turbine blades were transported on the L/B *Paul*. Assembly of the different sections and pieces was performed using the cranes on the L/B *Brave Tern*.

Operational testing of the facility was conducted from August through November 2016, and the initial operations commenced on 2 December 2016.

1.3 Report Organization

Key results, observations, and conclusions from each type of environmental monitoring are summarized in individual sections in this report. Raw data and detailed discussions from each type of monitoring are contained in technical reports, which are provided as digital appendices to this summary report. This report is organized as follows:

- **Section 1** presents an overview of the BIWF Facility and the RODEO Program, and includes a summary description of activities conducted during each phase of construction.
- **Section 2** contains methods and key observations from the onshore and offshore visual monitoring conducted during Phase 2 construction.
- **Section 3** is a description of the onshore and offshore airborne noise monitoring conducted during Phase 2 construction.
- **Section 4** describes the process of producing a B-roll and Vignette.
- **Section 5** lists the references cited in the report.

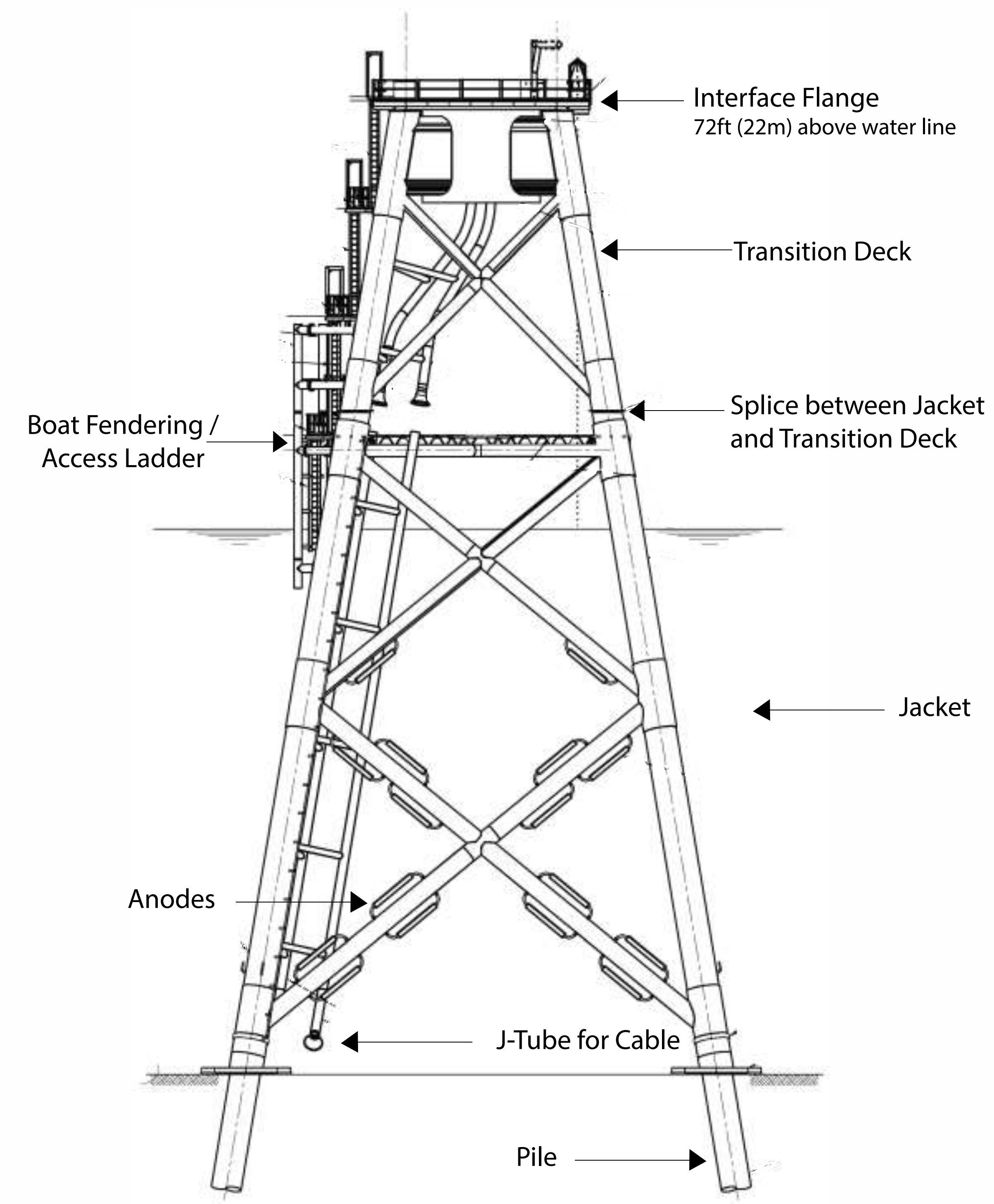

Figure 2. **Schematic showing a fully assembled WTG foundation (courtesy Deepwater Wind).**

Figure 3. Fully assembled WTG 5 foundation

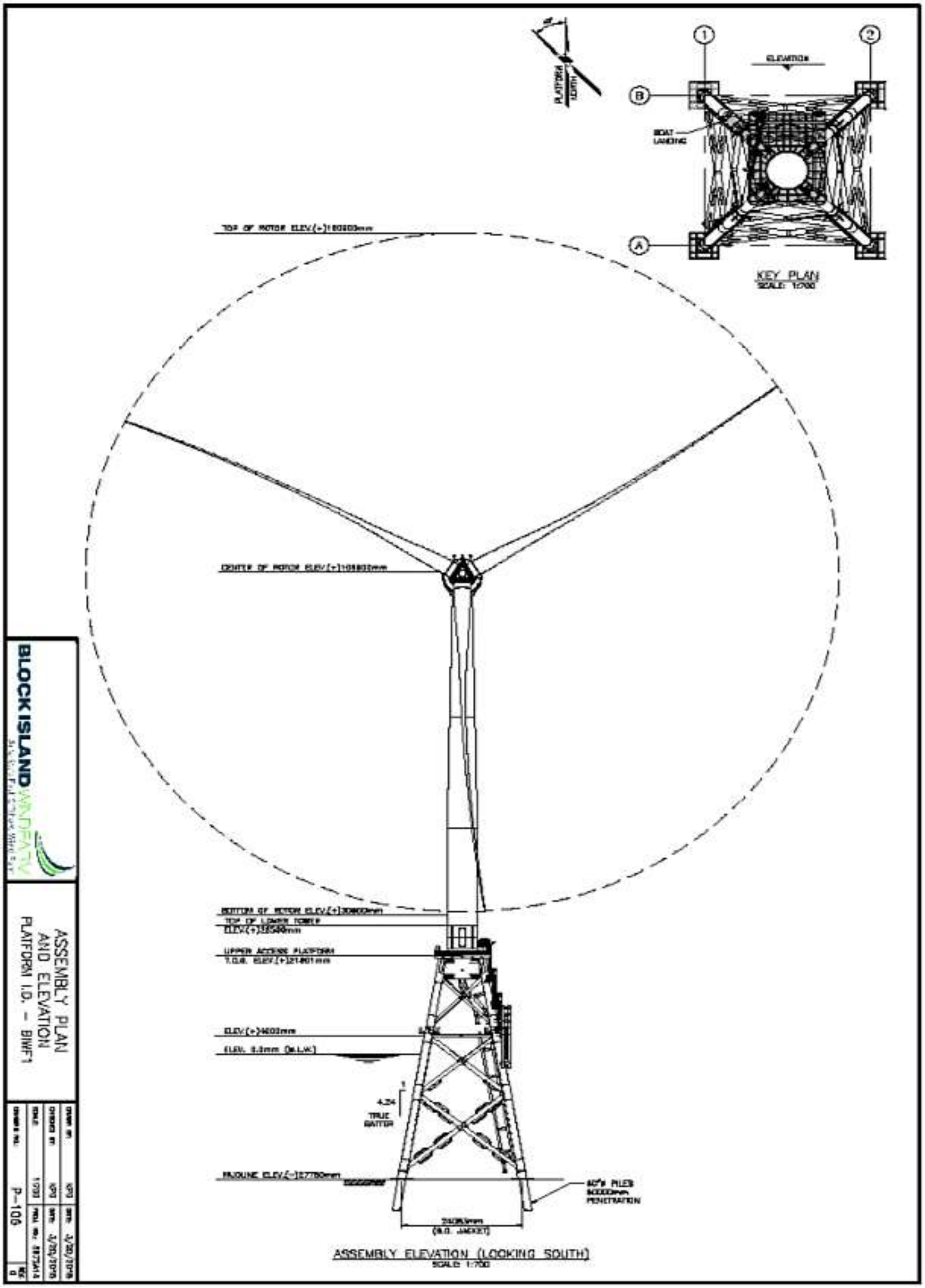

Figure 4. Schematic showing a fully assembled WTG.

Figure 5. Fully assembled WTG 1.

2 Visual Monitoring

The purpose of the Phase 2, Step 2 visual monitoring was to 1) document visibility of construction activities during the assembly of the turbine towers and installation of the nacelles and blades from selected onshore and offshore locations, and 2) generate a real-time record of the construction-related impact-producing activities, and where possible, quantify such activities. Installation and assembly of turbine towers, nacelles, and blades at WTGs 2, 3, and 4 were observed and recorded during this monitoring. All field activities were conducted in accordance with a BOEM-approved Field Sampling Plan, which included a project-specific Health and Safety Plan (**Appendix A**).

Visual monitoring was conducted by a team of four observers. The team arrived on site on 5 August 2016, and a site reconnaissance was conducted on the following day. On-site training was conducted by the Field Team Leader to ensure consistency in describing activities and recording observations by the observers. Monitoring was conducted from 7 to 16 August, 2016. A dedicated onshore observer also served as the field safety coordinator and maintained contact with the construction vessel via VHF communications.

Construction activities were observed from strategically-selected onshore and offshore locations, and data were recorded at early morning, mid-day, sunset, and during significant changes in meteorological conditions (rain, fog, etc.). Observations were recorded on each day of active construction, and included taking a series of photographs from a fixed location, at the same angle, using a constant camera zoom setting. Video recordings were made as necessary to document unusual sightings or infrequent occurrences. Relevant information about the size, type and number of construction vessels, and other impact-producing factors, was also recorded in accordance with the BOEM-approved FSP. Visual monitoring field logs are shown in **Appendix B**.

2.1.1 Onshore Monitoring

The WTG coordinates and their distance from Block Island are listed in **Table 2**. The Southeast Lighthouse is the closest onshore location on Block Island to the wind farm, and an observation station was set up on the lighthouse grounds (**Figure 6**). The lighthouse is situated on top of Mohegan Bluff at the southeastern corner of the island at an elevation of approximately 75 m (246 ft) above mean sea level and approximately 4.8 km (roughly 3.1 mi) away from the BIWF. From the lighthouse grounds, the survey team had a clear unobstructed view of the turbines as they were being assembled on the foundations. Access to the lighthouse grounds was coordinated through the Southeast Lighthouse Foundation.

Table 2. WTG coordinates and distance from Block Island.

WTG	Latitude (Deepwater Wind 2016)	Longitude (Deepwater Wind 2016)	Distance from Block Island
1	41° 7.546’ N	71° 30.451’ W	4.6 km (2.3 mi)
2	41° 7.193’ N	71° 30.837’ W	4.7 km (2.9 mi)
3	41° 6.883’ N	71° 31.270’ W	4.8 km (3.0 mi)
4	41° 6.609’ N	71° 31.744’ W	5.0 km (3.1 mi)
5	41°6.380’ N	71°32.258’ W	5.2 km (3.2 mi)

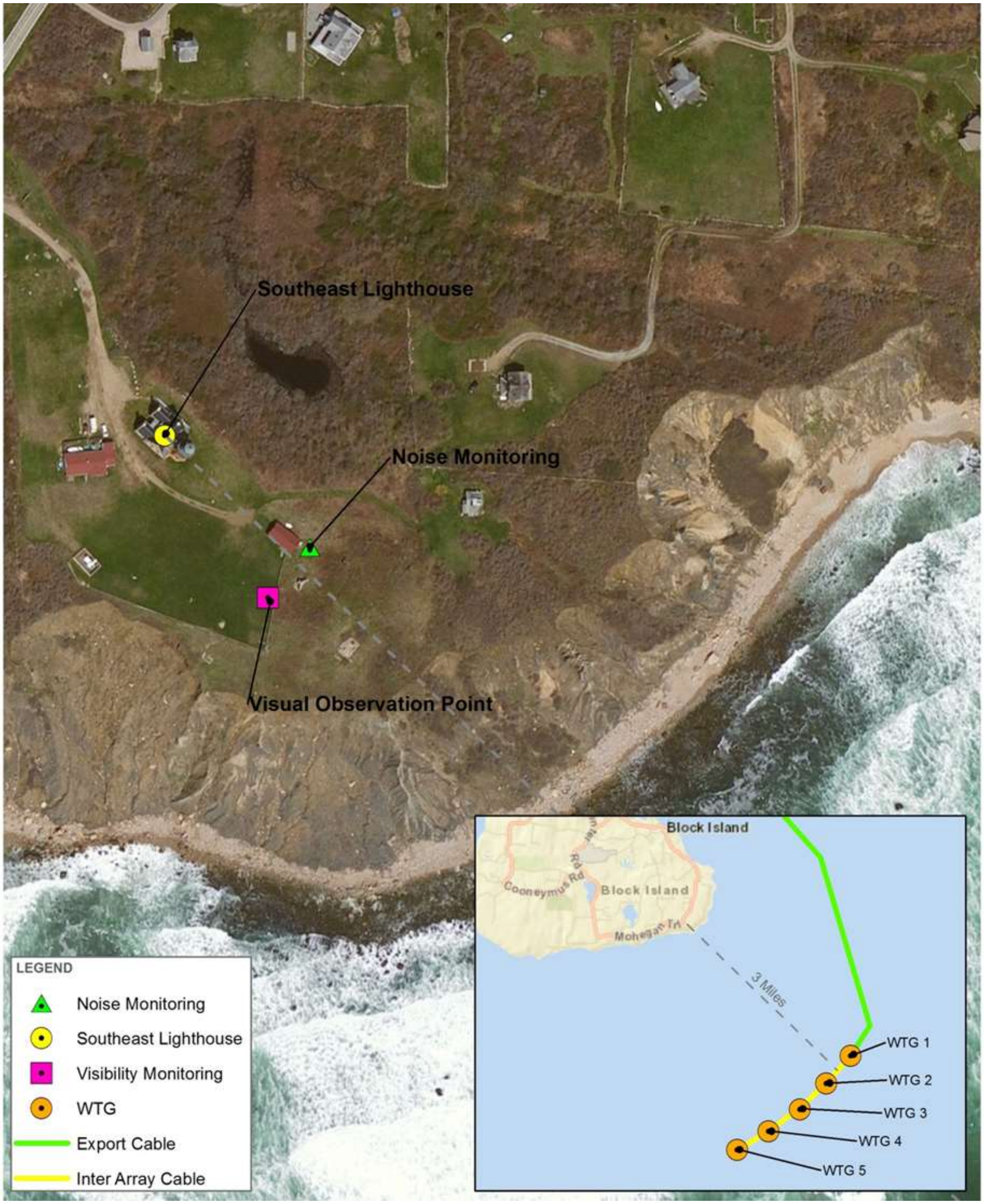

Figure 6. Location of visual monitoring station on the Southeast Lighthouse grounds.

Observations were recorded from a fixed location on the lighthouse grounds (41º09º.17’N, 071º33.097’W), which was adjacent to the wooden boundary fence along the southern edge. From this location, the monitoring team had a direct line of sight and clear view of the construction site (**Figure 7**).

Figure 7. Visual monitoring location on the grounds of the Southeast Lighthouse. Two turbines can be seen in the background.

During each recording event, a set of still photographs and high-resolution video of turbines and construction activities was recorded from the monitoring location using a Canon 5D Mark III camera with a 70- to 200-millimeter (mm) telephoto lens. The telephoto lens was wide enough to capture ambient lighting and environmental conditions and had the capability of zooming in for closer images. To ensure that photographs taken at different times could be compared side-by-side, the same camera angle and a constant zoom setting was used, and the camera was mounted on a tripod to maintain image consistency.

Observations were recorded using a customized iPad application (App), which was specially created for this project using the database platform FileMaker Go. A screenshot of the iPad app input screen is shown in **Figure 8**. The app was field tested prior to the monitoring survey, and standardized data entry procedures were used for data entry to ensure consistency among field observers. Observers took a photograph and then recorded the photograph frame number along with notes on activity observed, time, and weather conditions. Meteorological data recorded included wind direction, sea state, cloud cover, and humidity. These data were verified, quality checked, edited if needed, and backed up on a dedicated hard drive at the end of each day.

Figure 8. Sample data log screen from the iPad App.

2.1.2 Significant Events Affecting Documentation of Visual Observations

The project area experienced rain and fog from 10 to 12 August 2016; this limited visibility from the shoreline, because of which data could not be recorded during this period. High winds on both 10 and 12 of August prevented crane operations and therefore construction activities were suspended. Construction was also halted on 13 August around mid-day due to high winds.

Also, on several mornings there was a slight haze around the foundations, which affected the quality of photo and video images captured. Typically the fog disappeared by early afternoon, at which point the turbines were clearly visible. A view of WTG 1, 2, and 3 from the Southeast Lighthouse monitoring station under morning foggy weather (left panel) and the same afternoon after the fog had cleared (right panel) are shown in **Figure 9**. A view of the same three turbines from the offshore monitoring vessel under morning foggy conditions (left panel) and clear afternoon conditions (right panel) are shown in **Figure 10**.

Figure 9. View from the Southeast Lighthouse monitoring station under foggy (left panel) and clear (right panel) weather conditions.

Note: WTGs 1, 2, and 3 are not visible from shore during the morning foggy conditions, but were visible once the fog dissipated in the early afternoon.

Figure 10. WTGs 1 and 2 as seen under morning foggy (left panel) and clear afternoon conditions (right panel) from the offshore monitoring vessel.

2.1.3 Offshore Monitoring

Visual observations were also recorded from an offshore location that was closer to the turbines than the onshore location, using a locally chartered fishing vessel, the *Hula Dog*. The F/V *Hula Dog* is a 27-foot-long vessel equipped with a center console outfitted onboard navigation system, depth sounder, and U.S. Coast Guard-approved safety equipment (**Figure 11**). Observations were made on each day of active construction and the monitoring schedule was guided by information received from Deepwater Wind and the Notice to Mariners published by the Rhode Island Coastal Resources Management Council. This notice typically listed planned construction activities for the following day and was distributed daily via email to stakeholders, local fishermen, and recreational boaters.

Figure 11. Charter Vessel F/V *Hula Dog*.

The U.S. Coast Guard established an approximately 457.2 m (1,500 ft or 500-yard) safety zone around each turbine foundation. All vessel traffic not directly supporting the construction was prohibited from entering the restricted area. Note that the restriction was only in effect when activities were occurring around a particular turbine and that the zone effectively moved with each turbine. The first notice of the safety zone was issued on 17 July 2015 and the restriction remained in effect until first week of October 2016. The offshore monitoring vessel stayed outside the safety zone during the entire survey period.

During the offshore monitoring, Fujinon 10 × 50 marine binoculars were used to observe construction activities. Still photographs and high resolution video were recorded using a Canon 5D EOS with a 100 to 400 mm lens. The telephoto lens allowed the observers to see and photograph names and features of the construction vessels and construction activities at close quarters. ICOM M36 portable VHF radios were used for monitoring construction activities, weather, and maintaining communication among the onshore and offshore observers.

Data on the types and number of vessels deployed, chronology and duration of activities, and other relevant information for use in evaluating impact-producing factors were recorded in the field using the iPad app. Meteorological conditions that affected visibility of the construction activities were noted. Incidental observations of recreational boat traffic (fishing vessel, yachts, etc.) and marine mammal sightings were also recorded.

2.2 Visual Monitoring Observations Summary

Seven vessels were used during Phase 2 construction (**Table 4**); as compared to 16 vessels that supported the first construction phase. On a typical day, the L/B *Brave Tern* would be elevated next to a WTG foundation with the smaller Lift Boat *Paul* and *Caitlin* standing by in close proximity. The smaller Lift Boat primarily served as supply vessels and for ferrying tower sections and blades to the construction site.

Table 3. Vessels supporting Phase 2 construction.

Vessels	Length (m)	Breadth (m)	Function
L/B *Brave Tern*	132	39	Primary at-sea construction platform
L/B *Paul*	42	26	Derrick crane barge

Vessels	Length (m)	Breadth (m)	Function
L/B *Caitlin*	42	26	Supply ship
Atlantic Pioneer	21		Crew transfer vessel
F/V *Lindsey E*	10.97	4.24	Project management and visitor transport from Block Island to construction site
L/B *Michael Eymard*	42	22	National Grid cable protection
F/V *Hula Dog*	8.23	2.83	Visual observation vessel

The 21 m (70 ft) water jet powered catamaran (*Atlantic Pioneer*), was used to transport workers from the shore to the construction site. This crew tender is the first U.S. flagged specialized crew transfer vessel and is dedicated to supporting offshore wind farm construction and maintenance. It transported workers from Quonset Point to the project site. Crews were transferred to the turbine platforms by placing the vulcanized rubber center bow against the tower. This specialized bow prevents vertical movement allowing safe transfer of passengers. Other vessels on site included the F/V Lindsey E, which was primarily used to ferry the project management team and visitors to the construction site. The L/B Michael Eymard was also present and it was used to survey the National Grid submarine cable.

A series of photographs are presented below to illustrate some of the noteworthy events that were recorded during Phase 2 construction. The placement of the tower sections on the WTG 3 foundation is shown in **Figures 12**, **13** and **14**. In **Figure 12**, the crane on the L/B *Brave Tern* is seen positioned next to the turbine foundation. L/B *Caitlin* is positioned to south of the L/B *Brave Tern* with one tower section stored on the deck. A close-up view of the first tower section being placed on the WTG 3 foundation is shown in **Figures 13**; fully assembled WTG 1 and 2 are seen in the background. Placement of the first tower section on the WTG transition deck is clearly seen in **Figure 14**; a partial view of the workers on the deck provides a scale for the tower section.

Figure 15 shows a nacelle prior to it being lifted off the deck of the L/B *Brave Tern*. Lifting and placement of the nacelle on WTG 4 is shown in **Figures 16** and **17**. The worker positioned in the blade opening of the nacelle can be used as a scale for **Figure 17**. All three turbine blades to be installed on a given tower were stored and transported to the site on the L/B *Paul* (**Figure 18**). Each blade was 73 m (240 ft) in length and weighs 29 tons (58,000 pounds). The blades were lifted from L/B *Paul* using a specially designed cradle, which was attached to the crane (**Figure 18**). Placement of the blade into the nacelle at WTG 4 using the specialized cradle is shown in **Figures 19** and **20**. Fully assembled WTG 1, 2 and 3 are seen in **Figure 21**. Significant events that occurred during Phase 2 construction are summarized in **Table 4**, and approximate installation times for the various components are listed in **Table 5**.

Figure 12. Placing the tower section at WTG 3.

Figure 13. Close-up view of tower installation at WTG 3.

Figure 14. Close up of tower installation at WTG 3.

Figure 15. Nacelles stored on the deck of L/B Brave Tern.

Figure 16. **Lifting nacelle off the deck of L/B Brave Tern.**

Figure 17. **Nacelle placed on top of tower section.**

Figure 18. **L/B Brave Tern lifting turbine blades from L/B Paul.**

Figure 19. **Attaching blade to nacelle at WTG 4.**

Figure 20. Worker securing blade to nacelle.

Figure 21. Completed WTGs 3, 2, and 1.

Table 4. August 2016 significant events.

Date	Summary of Activity
8/7	Installed two blades at WTG 2.
8/8	Installed tower section to foundation at WTG 3. Nacelle was installed overnight.
8/9	Installed two blades at WTG 3. Third blade was installed overnight.
8/10	No construction due to heavy wind and rain.
8/11	Foggy with rain. Installed first section of tower at WTG 4.
8/12	No construction due to high winds.
8/13	Installed second section of tower at WTG 4 at dawn. No other construction due to winds.
8/14	Attempted to install nacelle at WTG 4 during the day, but too windy. Nacelle was installed overnight.
8/15	Installed two blades at WTG 4. Third blade was installed overnight.
8/16	L/B *Brave Tern* transitioned to WTG 5.

Table 5. Approximate Installation time for WTG Components.

WTG	Component Installed	Start Time	End Time	Approximate Elapsed Time (minutes)
WTG 2	Blade 1	1024	1206	182
WTG 2	Blade 2	1326	1546	220
WTG 3	Tower Section	1305	1700	395
WTG 3	Blade 1	1132	1528	396
WTG 3	Blade 2	1628	1749	121
WTG 4	Tower Section	1213	1443	230
WTG 4	Nacelle	1100	1344	244
WTG 4	Blade 1	0928	1045	117
WTG 4	Blade 2	1250	1429	179

Over 1,400 photographs were taken from the onshore and offshore monitoring stations. These photographs illustrate the types of activities that occurred during the construction. They were provided to BOEM on a DVD and are available upon request. **Appendix B**, **Tables B-1** and **B-2** provide a key to the photo logs. **Table B-3** summarizes meteorological data recorded during the monitoring.

2.3 Visual Observations: Highlights and Lessons Learned

Key observations from the RODEO Program visual monitoring conducted at the BIWF during installation of the turbine towers, nacelles, and blades on the WTG foundations are listed below:

- Far fewer challenges were encountered during Phase 2, Step 2 construction as compared to Phase 1 construction. The biggest issue was delays due to adverse weather conditions. On windy days especially, construction had to be suspended because of potential risk from crane operations.

- Assembly of the WTG components on the foundations (Phase 2, Step 2) was completed in approximately 2 weeks, which was faster than the 18 weeks required for Phase 1 construction.

- The L/B *Brave Tern* provided a superior at-sea construction platform. The ability to lift the deck above sea waves and provide a stable construction platform for crane operations avoided or greatly reduced delays from weather-related high sea states.

- Phase 2 construction was more streamlined as compared to Phase 1 construction, in part due to use of Lift Boats as construction platforms and supply tenders. Overall, the construction footprint around the WTGs was reduced due to the use of LB. The derrick barges used during Phase 1 construction required multiple tugs to remain on standby for both positioning and anchoring, which was not as efficient as using LB.

- Only four vessels were used (three lift boats and the crew tender *Atlantic Pioneer*) during Phase 2, as compared to the 16 vessels that supported Phase 1 construction. Fewer vessels anchoring on site also resulted in less damage to the seabed.

- The lift boats were able to quickly transition from one turbine to the next as compared to Phase 1 during which a lot more time was needed to reposition the derrick barges during Phase 1. Also, the smaller lift boat only required approximately 15 minutes to jack up once in position.

- Average time to install one tower section and one blade was approximately 312 minutes and 220 minutes, respectively.

- During the observation period, Phase 2 construction activities did not seem to influence local fishing traffic as compared to Phase 1 construction during which visual observations had indicated that local boat traffic was seemed to be impacted.

3 Airborne Noise Monitoring

The construction and operation of an offshore wind farm will necessarily generate noise from sources such as transportation of construction equipment and materials, operation of construction equipment including pile driving, and operation of the assembled wind turbines. Since 1) the purpose of the RODEO Program is to make direct, real-time measurements of the nature, intensity, and duration of potential stressors during the construction and operations of offshore wind facilities and 2) both airborne noise and underwater sound could potentially be major stressors, therefore an elaborate airborne noise and underwater sound monitoring program was undertaken during the construction and operational phases of the BIWF. The objective of the program was to collect real-time data that would be used to improve model predictions of likely impacts associated with future offshore wind facilities.

Methods, results, and conclusions from airborne noise monitoring conducted during the construction Phase 1 were previously reported (HDR 2017). Methods, results, and conclusions from airborne noise monitoring conducted during the installation of the tower sections on the WTG foundations are presented in this section[3].

Airborne noise monitoring was conducted over nine days (7 to 15 August 2016) using Larson David model 831 sound level meters (SLMs). The meters were calibrated prior to the field deployment for the complete frequency range and measurements were confirmed before and after readings were taken using a field calibrator at 1,000 Hertz (Hz). Environmental and meteorological conditions were noted during the monitoring, including air temperature, wind speed and direction, precipitation, humidity, cloud cover, sea state and any other significant environmental features (e.g., fog). All noise measurements are reported as decibels (dB) relative to 20 micropascals[4] (μPa).

Results and major findings from the monitoring are summarized below. Key terminology related to airborne noise assessment methods is defined in **Appendix C**. Additional details on the methods and results are presented in Section 6 of the technical report contained in **Appendix D**.

3.1 Survey Methods

Simultaneous measurements were made at one onshore (Southeast Lighthouse) and one offshore location (on a survey vessel). The onshore monitoring location was located on the grounds of the lighthouse along the southern boundary (**Figure 6**). The location was selected taking into account the prevailing wind direction during summer, pedestrian traffic, and other ambient noise sources (lawn maintenance equipment, vehicles, etc.). The SLM was mounted on a tripod near the edge of the cliff and in direct line of sight of the project area. Windscreens were deployed throughout the monitoring period. The background noise at the monitoring location was dominated by rustling foliage and distant waves, sporadic voices from lighthouse pedestrian traffic, and the occasional light aircraft.

Offshore measurements were recorded by a SLM mounted on the deck of the research vessel R/V *McMaster*, operated by the University of Rhode Island. A microphone and a high performance windscreen was fixed to a steel frame over the top of the vessel wheelhouse and connected to an SLM with a 5 m (16.4 ft) extension lead. The microphone was fixed to the top of the vessel wheelhouse (**Figure 22**). During the measurement periods, the survey vessel engines and other equipment that could interfere with the acoustic measurements were turned off and the boat was allowed to drift passively.

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[3] Methods, results, and conclusions from airborne noise monitoring conducted wind turbine operations are presented in an accompanying document entitled "*Field Observations During Wind Turbine Operations at the Block Island Wind Farm, Rhode Island, OCS Study BOEM 2019-028*." (HDR 2019b).

[4] Approximately the quietest sound a human can hear on land.

Figure 22. Survey boat R/V *McMaster*; SLM mounted on the deck.

Offshore measurements were taken on a series of transects centered on the construction activity. The transects were chosen either to line up with one of the onshore monitoring stations or were coincident with a particular wind direction. Each transect began at the edge of the offshore safety exclusion zone (457 m [500 yards]) and continued until the vessel reached land or an impassable region of water, or the construction noise was no longer audible or detectable. Acoustic data were recorded at intervals starting at around 500 m (457 yards) and doubling in distance (500 m, 1 km, 2 km, 4 km, etc.) along with details of the boat's position and other relevant information.

Measurements on the vessel were conducted with specific attention paid to wind conditions. Distances from the lift boats were measured using a laser range-finder that was accurate up to 1,000 m (3,281 ft) and calculated using GPS coordinates relative to the turbine locations.

3.2 Survey Results

Results from the airborne noise monitoring are discussed below. Where appropriate or relevant, the values are compared to results previously reported for monitoring conducted during construction Phase 1 piling.

At no point during the tower lifting operations was construction noise audible or detectable at the onshore monitoring location. Detailed analysis was therefore conducted only using data collected from the offshore monitoring platform. These data were analyzed to identify the source level and geometric spreading loss coefficient. A transition point at 700 m (230 ft) between spherical spreading (N=20) and another attenuation coefficient, which was determined based on wind direction, was used. Note that as low frequency noise from the barges was dominant and measurements were taken over a maximum of 3 km (1.9 mi), no atmospheric absorption element was included as this would have an effect of less than 1 dB. The most useful datasets were the ones recorded on downwind transects.

3.2.1 Transect 1: Downwind

Figure 23 below shows the measured time history on the first day. The left side of the chart between 12:00 and 13:00 is effective ambient noise; two small vessels passing at 12:15 and 12:55 caused temporary increases in the background noise level of the order of 4 dB LA90[5],1 minute. The average background noise level was 46 dB LA90, 1 hour. The right side of the graph shows a downwind transect during the lifting of one of the turbine blades.

[5] LA90 = level exceeded for 90% of the time under consideration.

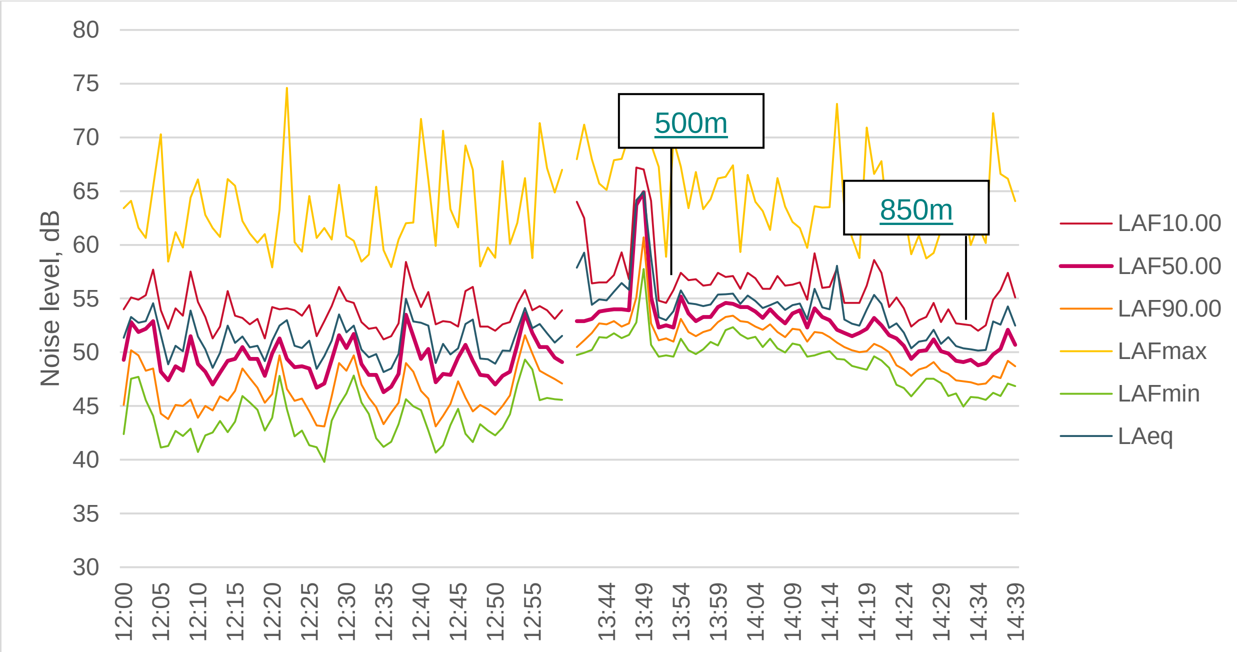

Figure 23. Noise measurements taken on 7 August 2016 at WTG 2, including blade lift (Receiver Level [R>700 m]: SL = 108 dB LAeq, N = 6).

A horn on the L/B *Brave Tern* was sounded at approximately 13:50 and the drift transect was undertaken shortly afterwards. This was a short transect, from 500 to 850 m (1,640 to 2,788 ft). The machinery is a continuous, low-level hum, relative to the background noise offshore. In this time the noise level dropped from 55 dB LAeq[6], 1 minute to 50 dB LAeq, 1 minute with a clear but gentle reduction in noise over the drifting period.

Although the LAeq metric typically is used for the reporting of operational noise, here the LAeq is susceptible to contamination by the ambient noise, primarily movement of water and wave slap on the side of the vessel. The statistical LA50 metric may be better to identify the continuous noise, which represents the noise level exceeded for 50 percent of the time the sample is taken and is less sensitive to sudden increases in noise level, unlike the LAeq. Using this metric, the noise level drops from 54 dB LA50, 1minute at 500 m to 49 dB LA50, 1 minute at 850 m (2,788 ft). Also, for this sample, although the LA50 'smooths out' spurious signals (see the spike in the LAeq at 14:15, which was caused by an unexpected radio transmission), the reduction using the two metrics is approximately the same.

The calculated source level is presented in the standard LAeq metric. This was calculated based on the LA50 value plus 1 dB, which was found to be the average difference between the measured LAeq and LA50 when noise from the L/B *Brave Tern* was dominant and uncontaminated by extraneous noise, close to the barge.

3.2.2 Transect 2: Downwind

The chart in **Figure 24** shows a downwind drift with few contaminating events on August 8. The benefit of the LA50 metric can be seen better on this transect, where radio communications significantly influenced the LAeq noise level at 10:31 and the ambient noise, primarily the action of waves, keeps the LAeq at approximately 50 dB, but the LA50 falls 5 dB further. The noise level at the start of the drift, at

[6] LAeq is the equivalent sound level in decibels equivalent to the total A-weighted sound energy measured over a stated period of time.

250 m (820 ft) from the L/B *Brave Tern* was 56 dB LA50 and at the end of the drift, at 1,150 m (3773 ft), the noise level had fallen to 46 dB LA50.

This was the closest position where a noise sample was taken under ideal conditions and the gentle downward slope of the noise levels in **Figure 24** illustrates this point. With the combination of relative vicinity to the L/B *Brave Tern* and conditions, this was considered the best position to determine a source level. Using the assumption of a propagation loss of 20 log(r) in the 'nearfield,' an estimated source level of 106 dB LAeq, 1 m was calculated.

3.2.3 Transect 3: Upwind

Comparative measurements were taken upwind of the L/B *Brave Tern*, to identify the limits of audibility and noise propagation over water under these conditions. **Figure 25** shows an upwind transect, beginning the drift at 450 m and ending at 1,050 m. The sudden increases at the start and the end of the transect was caused by engine noise from the survey vessel. A small increase in noise can be seen over the course of the transect, despite moving farther from the vessel. The increase was caused by an increase in ambient noise; the wind speed had increased from 1.5 meters per second (m/s) in the morning to 4 m/s here.

The L/B *Brave Tern* was barely audible at the closest position, up to approximately 500 m (1,640 ft) but was lost in ambient noise beyond this. No attenuation coefficient could be identified under these conditions and at this range, with any noise from the L/B *Brave Tern* rapidly lost in the background.

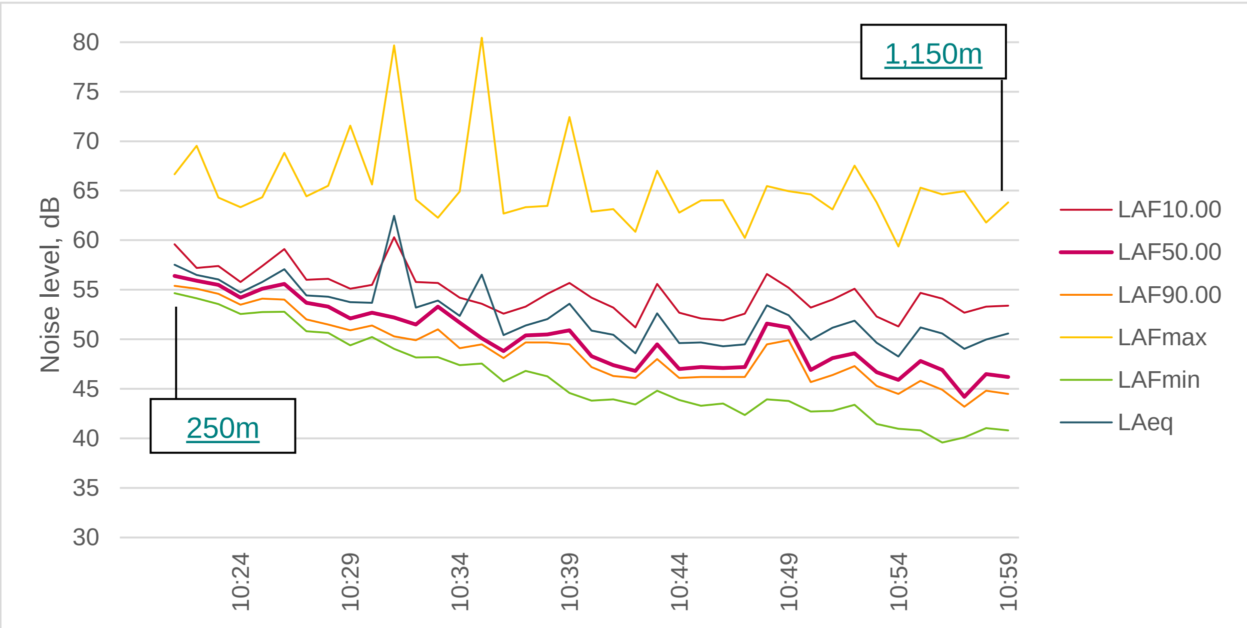

Figure 24. Noise measurements taken on 8 August 2016 downwind transect at WTG 3, including tower lift (Receiver Level [R>700 m]: SL = 105 dB LAeq, N=6).

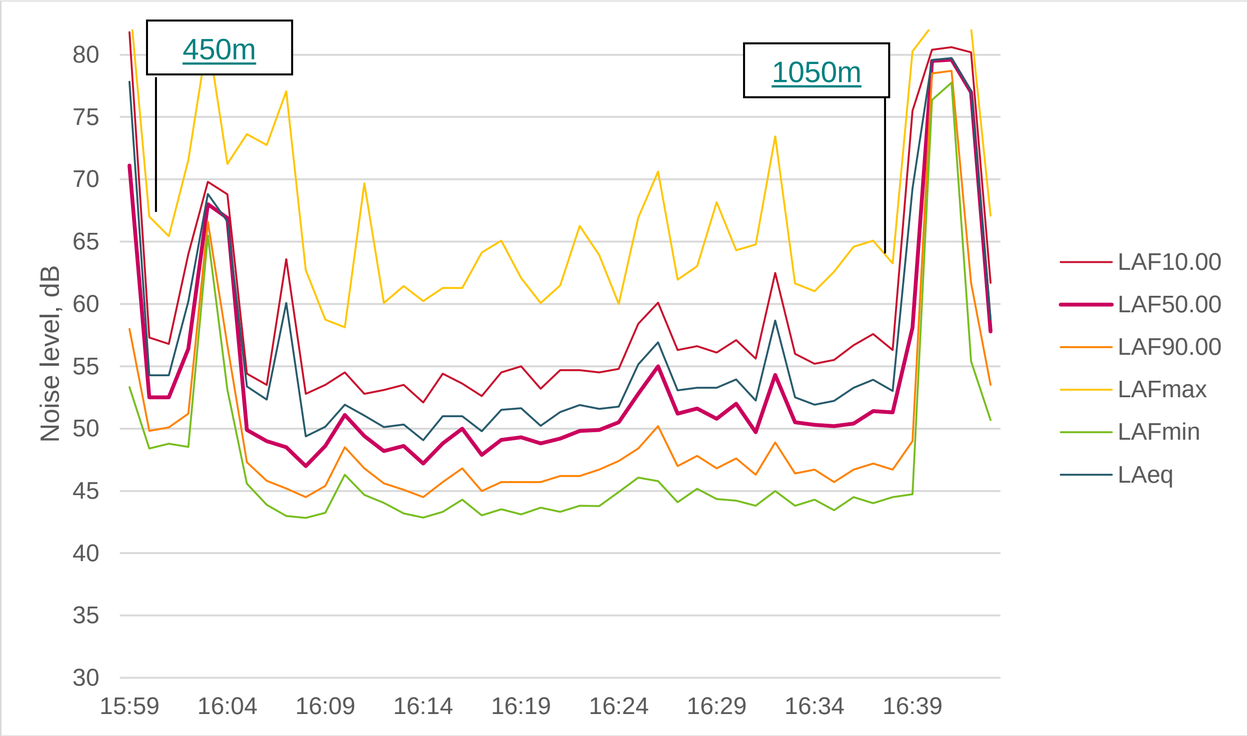

Figure 25. **Noise measurements taken on 8 August 2016 upwind transect at WTG 3, including tower lift and survey vessel engine noise.**

3.2.4 Transect 4: Calm

Wind conditions on 9 August were calm, and measurements were taken in the vicinity of the L/B *Brave Tern* with little influence from any extraneous noise, particularly any wave noise. The drift began at 650 m (2,133 ft) from the L/B *Brave Tern* and ended at 1,350 m (4,429 ft), and noise from the barge was clear at all times in the absence of significant wind or wave action.

There was a slight downward trend in the noise detected from the L/B *Brave Tern* over this 50-minute period. A doubling in the distance led to, at most, a 3 dB reduction in the noise. This small effect may be because of light, variable winds higher above the water causing fluctuations, or small changes in the noise output from the engines.

These calm conditions provided a good opportunity to present the frequency spectrum from the L/B *Brave Tern* in the absence of wind or wave noise. **Figure 26** shows the 1/3rd octave center-frequency band spectrum measured at 750 m (2,461 ft), when the engine noise was clear. It is clearly dominated by low frequency tonal noise with a peak at 40 Hz.

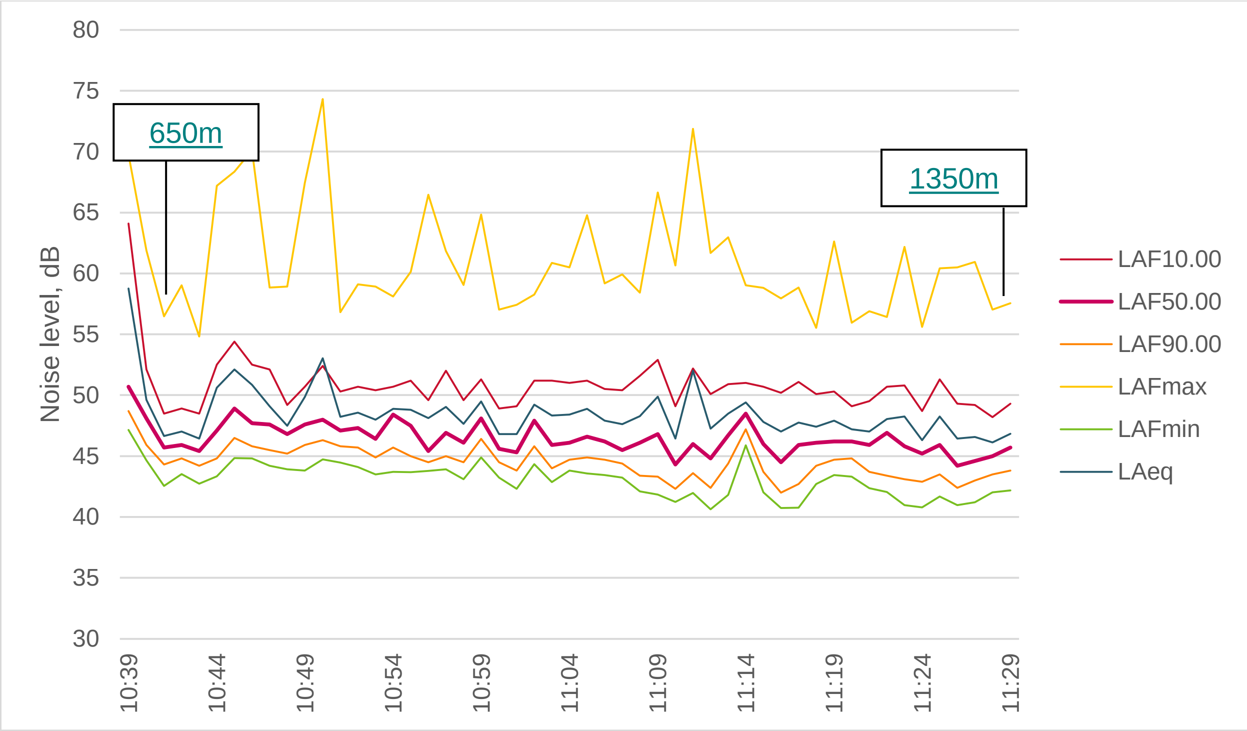

Figure 26. Noise measurements taken on 9 August 2016, calm to downwind conditions, at WTG 3, including blade lift (Receiver Level [R>700 m]: SL = 106 dB LAeq, N=12).

The fit of N for the calm wind conditions here (N=12) is somewhat lower than during construction Phase 1 piling, where an estimate of N=19 was estimated. This is likely to be due to the noise from the L/B *Brave Tern* being very close to the level of background noise, especially as a result of the impact of the A-weighting, which reduces the influence of low frequencies. A closer inspection of the data to identify the geometric absorption coefficient at 40 Hz was undertaken using measurements recorded on 9 August (**Figure 27**).

There is much greater separation between the time-history for the 40 Hz 1/3 octave band center frequency and the background noise and this shows a much more rapid attenuation. In fact, a 'fit' of much greater than N=20 seems appropriate, with the 40 Hz band possibly reaching close to the background at around 11:10 (although it was still subjectively audible at this position). This does suggest that if the noise was better separated from the background (i.e., it was louder) then the fit to the LA50 would be greater than N=12, and closer to the value identified in calm conditions during piling.

3.2.5 Transect 5: Downwind

An extended downwind transect was recorded on August 15 from 600 m to 2,750 m (9022 ft) at 10:30. This is shown in **Figure 28**. The seas were relatively quiet with good periods without any contribution to the extraneous noise, so the L/B *Brave Tern* was audible at all times.

While crane movements were continuous in the period above, the crane only began lifting a blade at 09:56. At the time there was no subjective increase in the noise at this time and no change can be seen in the measurements in **Figure 28** (or the following **Figure 29**).

A reduction of approximately 5 dB can be seen between 09:25 and 10:05, from 600 m to 2.1 km (1,969 ft to 1.3 mi). After this time, there is no significant further reduction in the measured overall noise level, due to the influence of background noise from the water movement.

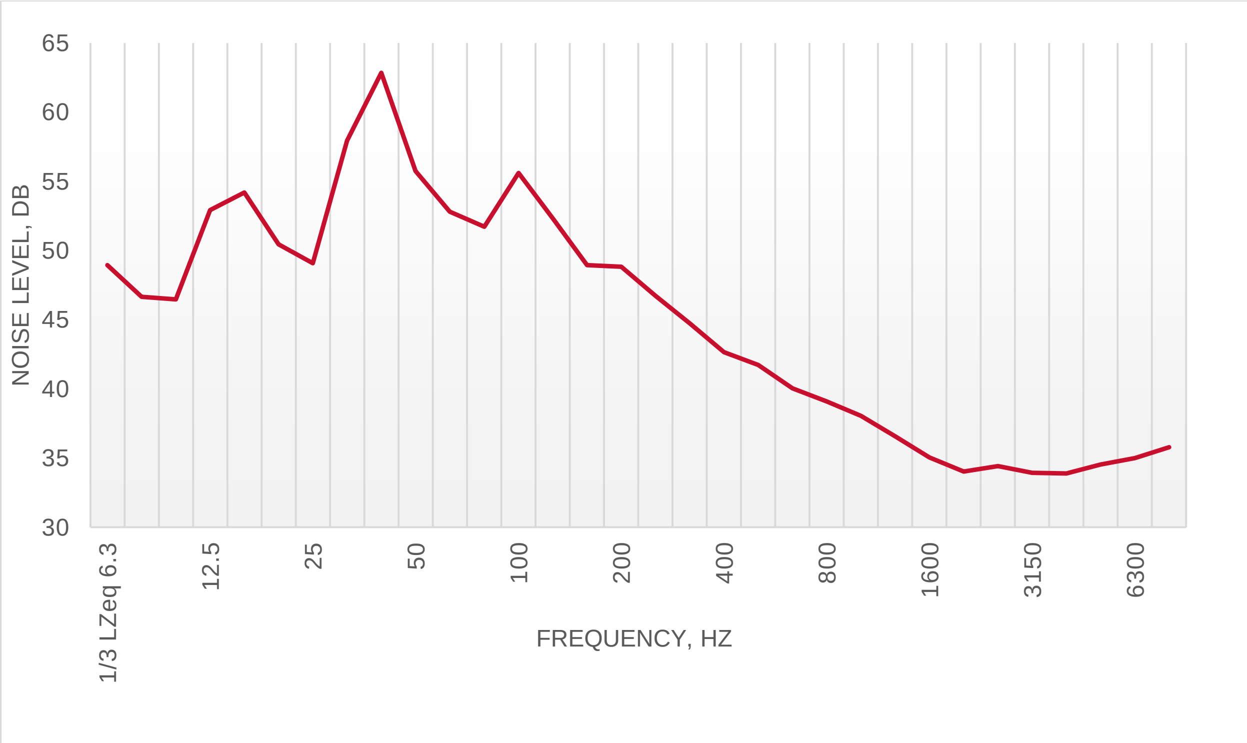

Figure 27. Noise frequency spectrum taken on August 9th 2016 calm conditions at WTG 3.

The tonality of the noise from the L/B *Brave Tern* was identified in the spectrum in **Figure 28**. The ambient noise in general is fairly broadband so to focus on the audibility of the noise, the peak frequency (40 Hz) was isolated and placed alongside two frequencies outside of the noise from the machinery (25 Hz and 100 Hz). This is shown in **Figure 29**.

The 40 Hz tone is nearly 10 dB above the surrounding frequency bands when close to the L/B *Brave Tern* and so clearly audible. Between 2,000 and 2,750 m (1.2 and 1.7 mi) any attenuation in the noise with distance is minimal and the level of the tone is similar to the ambient noise, although as it remains slightly elevated it is still audible. This represents the greatest distance measured during the survey at which the noise was detectable, although as can be seen in the variation (or lack thereof) after 10:00 in **Figure 30** the noise from the L/B *Brave Tern* cannot be discerned when looking at the overall A-weighted noise levels.

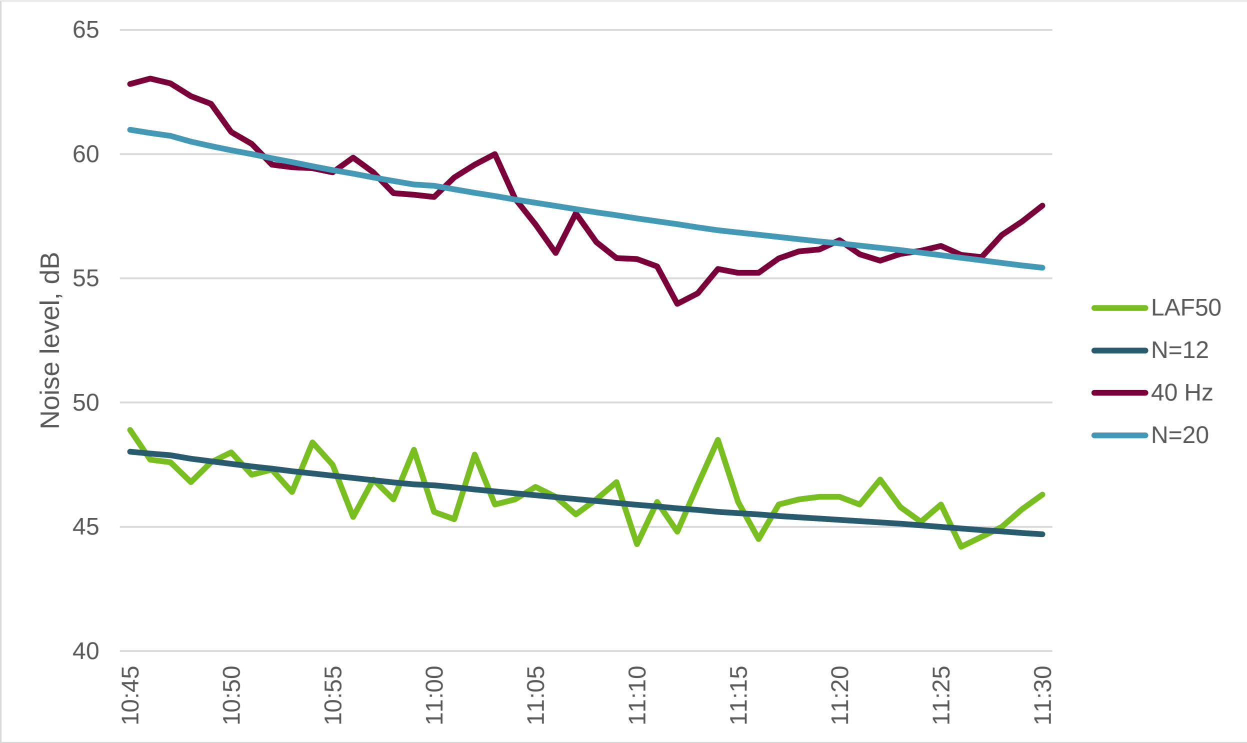

Figure 28. Transects with fits to LA50 and 40 Hz Leq on August 9th 2016 calm conditions at WTG 3.

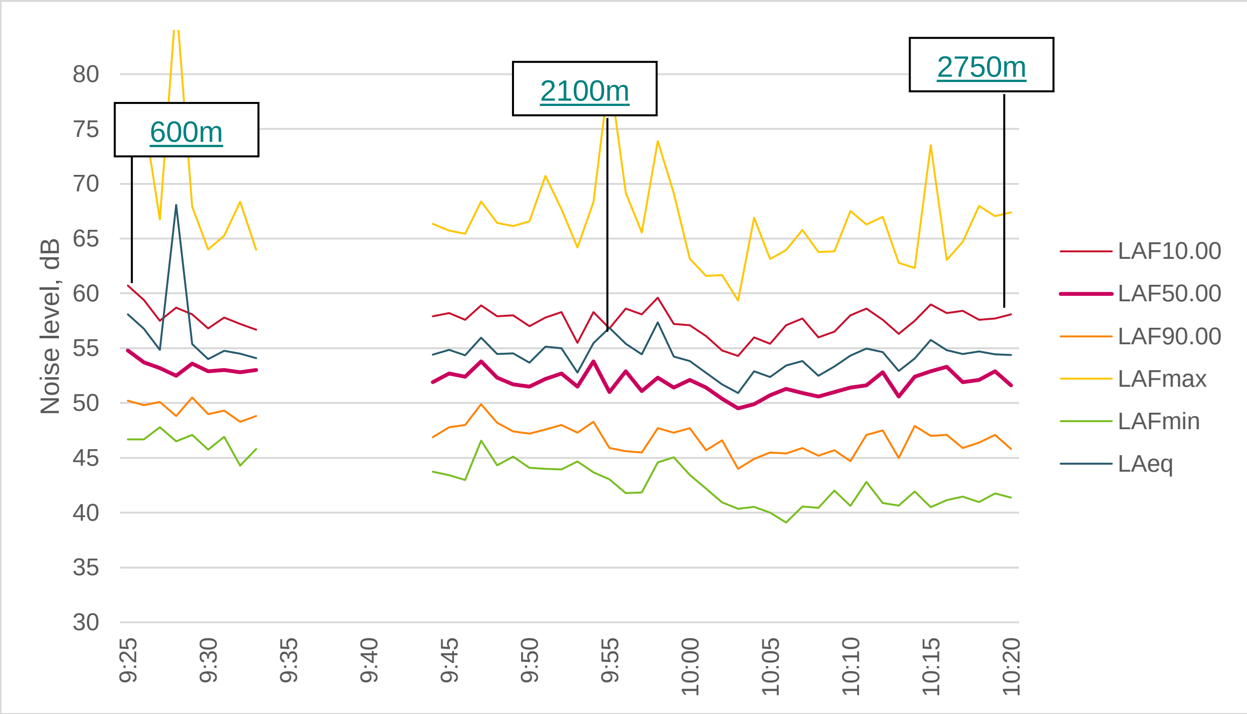

Figure 29. Long distance drift downwind of WTG 4 during blade lift. Note: spurious noise from a passing vessel and helicopter between 9.33 and 9.44 has been removed. August 15 2016. Receiver Level [R>700m]: SL = 112 dB LAeq, N = 6.

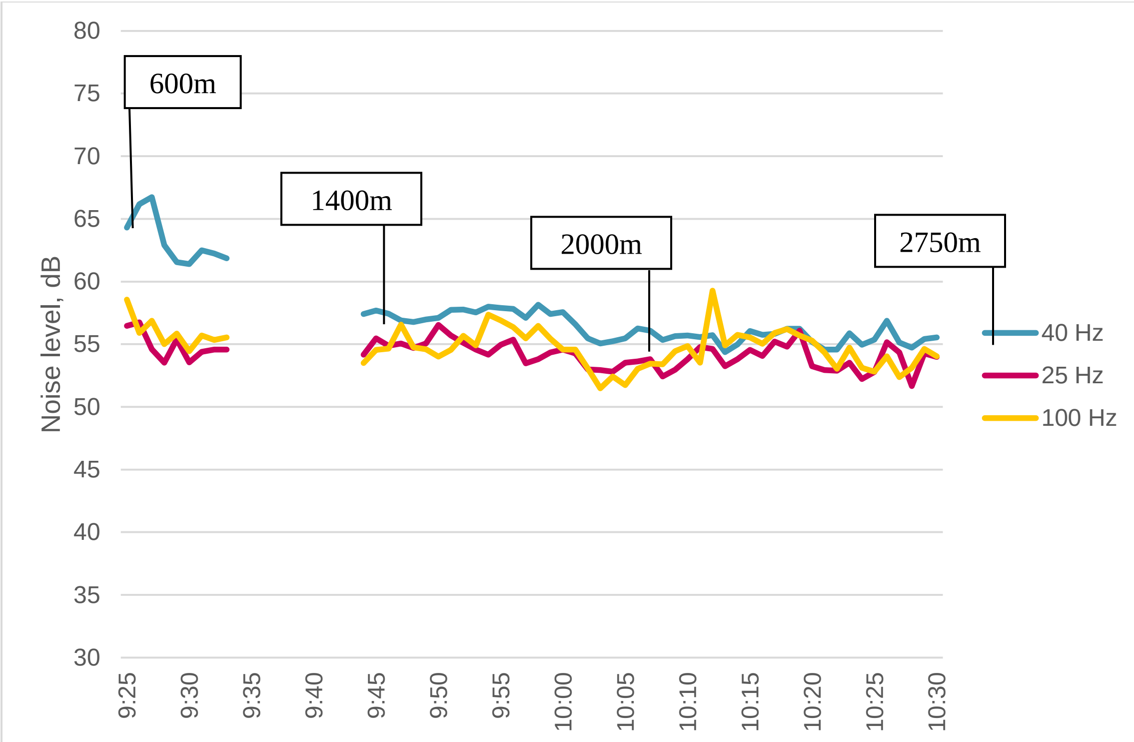

Figure 30. 1/3rd octave band time history. Drift on August 15 between 600 m and 2,750 m. Note: spurious noise from a passing vessel and helicopter between 9.33 and 9.44 has been removed.

3.2.6 Measurements around L/B *Caitlin*

The L/B *Caitlin* was positioned adjacent to the L/B *Brave Tern* for storage of turbine and tower parts prior to lifting in position. It remained static while the lifting operations were underway and produced a continuous noise from its engines. On 15 August, a continuous westerly 3 meters per second (m/s) breeze was blowing and this provided an opportunity to sample the noise levels in all orientations to the noise source relative to the wind direction. **Table 6** shows these collated noise levels.

Noise from L/B *Caitlin* engines was clearly audible downwind, not audible upwind and could occasionally be detected subjectively in crosswinds. The variation in noise levels shown in **Table 6** reflect this, although there may also be a directionality to the noise from the engines which cannot be identified at the distance of the survey vessel. It should be noted that the survey vessel was slightly closer to L/B *Caitlin* in the downwind sample at 15:21. Given spherical noise spreading at this range, if the noise was sampled at 510 m (1,673 ft) as at the other positions, this could lead to a 2 dB reduction in the 400 m (1,312 ft) sample.

The LA90 noise metric, which is often used for measurement of background noise and susceptible to continuous noise sources but not infrequent, impulsive noises, may be the most reliable for identifying the noise from L/B *Caitlin*. As there was no impulsive noise produced by L/B *Caitlin*, the high LAmax[7] noise level on the upwind and one downwind sample (15:51) indicate some contamination of the noise, which leads to spurious increases in the noise level of other metrics, especially the LAeq and LA10. If the noise continues for a long enough period the LA50 will also be affected.

[7] A-weighted, maximum, sound level.

Table 6. Noise levels sampled around L/B *Caitlin*, collated by relative wind direction.

Time	Distance	LAF10 dB	LAF50 dB	LAF90 dB	LAFmax dB	LAFmin dB	Laeq dB	Wind
13:42	n/a	54.7	47.9	44.7	71.6	42.2	54.9	Background
15:05	510 m (1673 ft.)	54.7	48.9	45.5	78.6	42.8	57.4	Upwind (W)
14:56	520 m (1706 ft.)	54.3	51.6	49.7	57.3	47.6	52.1	Crosswind (S)
15:32	510 m (1673 ft.)	55.6	52.3	50.9	62.1	49.9	53.4	Crosswind (S)
15:11	510 m (1673 ft.)	53.2	50.6	47.8	57.0	45.2	51.0	Crosswind (N)
15:13	510 (1673 ft.) m	55.6	49.7	46.8	61.2	44.4	51.9	Crosswind (N)
15:21	400 m (1312 ft.)	57.3	55.0	53.0	61.4	51.6	55.5	Downwind (E)
15:51	340 m (1116 ft.)	82.9	59.5	53.0	84.6	51.2	78.1	Downwind (E)

However, as the noise levels upwind and crosswind were found to be inaudible or barely audible respectively, direct comparison between the different conditions would be inappropriate. Assuming L/B *Caitlin* is acting as an effective point source, as it will appear at a distance, the source noise level is approximately 107.5 dB LAeq, 1 minute, based on the lower level measured downwind.

3.3 Discussion and Summary

Airborne noise measurements taken around the L/B *Brave Tern* and L/B *Caitlin* during the lifting of the tower sections have shown that the noise emanates primarily from the barge engines and is characterized by a continuous hum. The measurements recorded were within range of what would be reasonably expected. However, the character and volume of the noise is likely to be specific to the respective barges and should not be assumed to be directly transferrable to other barges or vessels.

The direction of the wind during construction is critical for propagation of airborne noise. Around the L/B *Brave Tern*, upwind, the noise levels during crane operations were subjectively inaudible above background noise within 750 m (0.5 mi). At this time background noise was approximately 45 dB LA90. Downwind, the hum from the engines was still audible at nearly 3,000 m (1.9 mi) with background noise levels also at approximately 45 dB LA90. The noise was reasonably tonal with a peak at 40 Hz and a noise level of 56 dB at 2,750 m (1.7 mi) at this 1/3rd octave band center frequency and quickly dropped below the ambient noise outside this frequency band. Given favorable conditions, including wind and low background noise, this noise could plausibly be audible beyond this distance. However, at no time was noise from the L/B *Brave Tern* detectible on Block Island during lifting operations, approximately 5 km (3.1 mi) away.

Under calm conditions, noise from the *Brave Tern* was still clearly audible at 1,350 m (0.8 mi) and is likely to be audible beyond this point. The noise appears to attenuate more slowly than during piling in calm winds, although this is likely to be partly due to the low frequency of this engine noise, compared to the much higher frequencies present in the piling noise.

Using the same assumption as during piling, that ‘nearfield’ sound propagation follows a 20 log(r) geometric spreading loss, the source level (at 1 m from the engine) for the L/B *Brave Tern* is approximately 105 to 108 dB LAeq,1min. The same spreading coefficient was seen beyond the transition point as during piling, with N = 6 downwind and N = 12 in calm conditions. The value for N in calm conditions is likely to be higher in reality as the measured noise levels will be influenced by the ambient noise, as they were only marginally above the background. An investigation into the attenuation with range of the 40 Hz 1/3 octave band only showed a value of N = 20. A value of N could not be calculated under upwind conditions.

Similar calculations for the L/B *Caitlin* show that the source level is 107.5 dB LAeq, 1 m, which suggests that the smaller barge is slightly louder. This could be due in part to the difference in height of the two sources: the L/B *Brave Tern* is a jack-up barge which was approximately 30 m (98 ft) above the surface of the water during measurements, whereas L/B *Caitlin* was on the water. The position of the engine outlet, the source of the noise, above the barge's deck may benefit from some shielding from the deck itself. However, as the deck and engine outlet will be at elevation during the operations, the measurements were appropriate.

3.4 Conclusions

The propagation of airborne noise from the L/B *Brave Tern* during the tower section lifts is in line with measurements taken during piling downwind. Under other wind orientations, noise from the barge was quiet enough out to 1 km (0.6 mi) to be significantly influenced by the ambient noise. No noise was audible beyond 500 m (1,640 ft) when upwind. No noise was detected on Block Island under any wind conditions.

Future studies should attempt to investigate noise levels closer to the noise source to verify the initial spherical spreading assumption and improve confidence in the source noise levels. The source noise level will change with the equipment in use, an important consideration given the large variety of foundations currently in use or proposed for offshore wind turbines. Measurements could be recorded either from a vessel, where safe to do so, or by potentially setting up a SLM on the deck of the construction barge.

4 B-roll and Final Vignette

A short video vignette was produced to provide an overview of the BIWF project (**Appendix E**). The video described the BIWF facility and emphasized the importance of the different types of monitoring conducted under BOEM's RODEO Program. Since the BIWF is the first offshore wind facility in the U.S., telling the story in a simple manner using site-specific video footage was important to help the general public, stakeholders, and the media understand the issues related to the construction and operations of this historic project.

Filming took place during two, four-day, trips. The first trip coincided with the final stages of construction of the wind turbines and the second trip was conducted during operational testing phase. Additional video footage was captured during the sediment sample collection for benthic monitoring and during the submarine cable installation. In addition to the B-roll footage, interviews were conducted with selected scientists that were involved in the environmental monitoring activities.

The video team also captured time lapse footage of the installation of two blades taken from the second floor window at Southeast Lighthouse. Individual images were captured every 10 seconds that were subsequently processed into video. This information was used to describe the scope and general environment of the construction phases of the project.

The vignette was completed with full color correction, professional narration, sound mixing and mastering. It was created in high definition broadcast quality and provided to BOEM in 1080HD and 720HD H.264 video files for easy distribution. Libraries of the footage were delivered to BOEM on hard drives (one master and one backup). The video will serve as a useful tool during the planning of future offshore facilities in the U.S. It could also be used for media outreach, educational projects, and social media messaging.

5 References

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Appendix A: Field Sampling Plan

Real-Time Opportunity for Development Environmental Observation (RODEO)

Final Field Plan for Monitoring Phase II Construction Activities at the Block Island Wind Farm

Contract No. M15PC00002,
Task Order No. M16PD00006

May 6, 2016

Prepared for:

BOEM
Bureau of Ocean Energy Management

Bureau of Ocean Energy Management
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Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
BITS	Block Island Transmission System
BIWF	Block Island Wind Farm
BLM	Blue Land Media
COR	Contracting Officer Representative
dB	decibel(s)
dB re 1 μPa RMS	decibels referenced to 1 micro Pascal root mean square
DWW	Deepwater Wind
DMON	Digital acoustic monitoring
FAA	Federal Aviation Administration
HASP	Health and Safety Plan
HDD	horizontal directional drilling
Hz	Hertz
MAI	Marine Acoustic, Inc.
MBES	Multibeam Echosounder
NUWC	Naval Undersea Warfare Center
RODEO	Real-time Opportunity for Development Environmental Observations
SHRU	Several Hydrophone Receive Units
SSS	Side Scan Sonar
TO	Task Order
URI	University of Rhode Island
WTG	Wind Turbine Generator
WHOI	Woods Hole Oceanographic Institution

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1 Introduction and Background

Task Order (TO) M16PD00006 was issued to HDR on February 4, 2016, following BOEM BSEE award of an IDIQ Contract for Real-time Opportunity for Development Environmental Observations (RODEO). This Firm-Fixed-Price TO requires HDR to develop a Field Plan (Plan) to observe Phase II construction and initial operational activities associated with the Block Island Wind Farm (BIWF). The Plan is required to address the following key areas:

- Evaluation of visual activities during and after construction
- Evaluation of sediment disturbance and recovery
- Effects of mitigating measures or abatement measures
- Evaluate monitoring technologies or techniques
- Assessment of sound environment during construction.

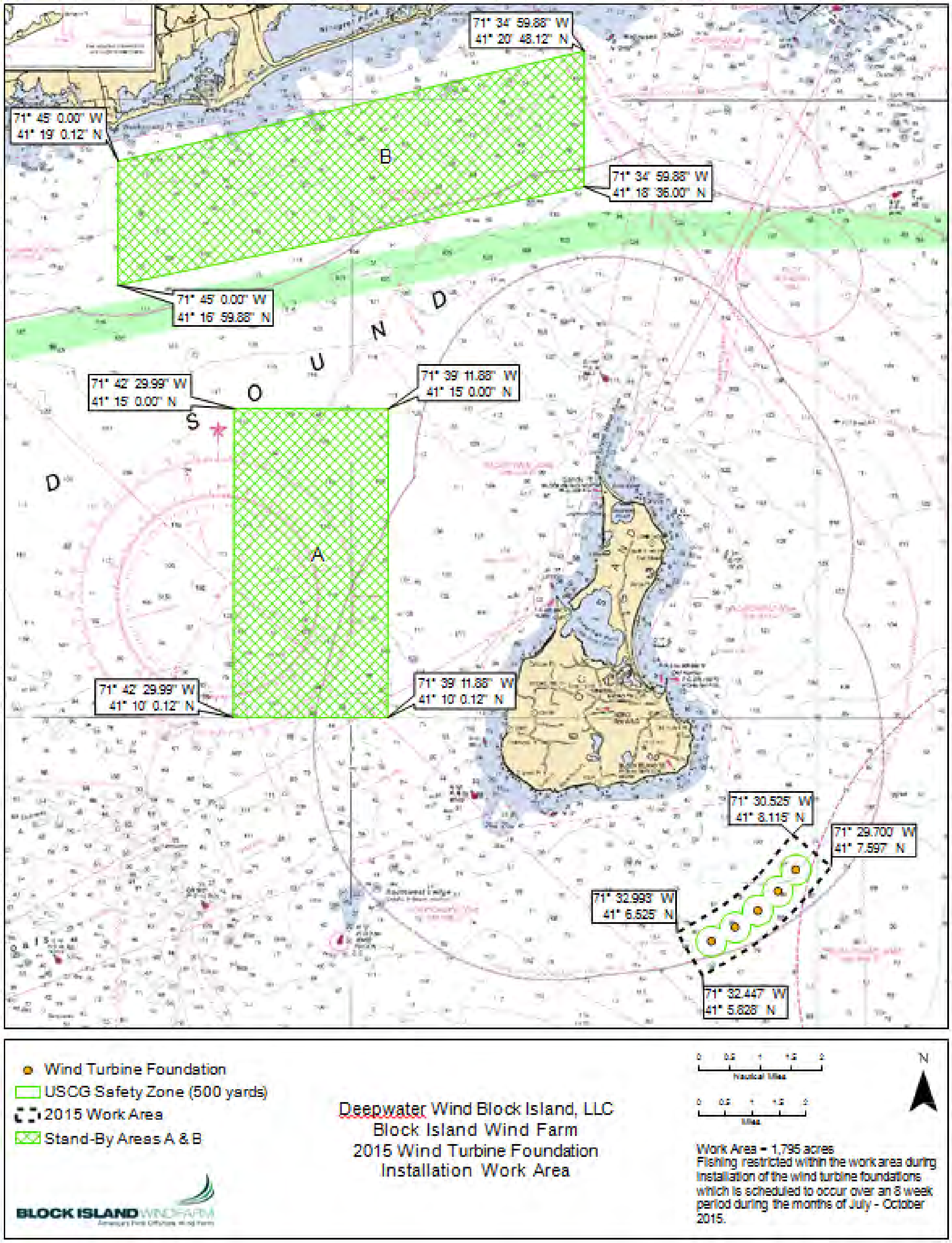
In addition, HDR is also required to provide in the Plan a process for coordinating monitoring and resulting data with other ongoing activities and a process for coordination of monitoring efforts with the industry.

1.1 Background, Purpose and Scope

The BIWF is America's first offshore wind farm, and it is being constructed by Deepwater Wind (DWW) Block Island, LLC approximately 3 miles off the coast of Block Island, which is located approximately 16 miles south of the Rhode Island mainland (**Figure 1**). BIWF consists of five, 6-MW Alstom Haliade 150 wind turbine generators (WTGs), a submarine cable interconnecting the WTGs (hereafter referred to as Inter-Array Cable), and a 34.5-kilovolt (kV) transmission cable from the northernmost WTG to an interconnection point on Block Island (hereafter referred to as Export Cable). Once completed, the five turbines will produce 30-megawatts for Block Island residents, and the mainland will receive the additional power.

BIWF construction began in July 2015, is occurring in a phased manner, and will be completed towards the end of 2016. During the recently completed Phase I construction, five steel jacket foundations were installed over 18 weeks from July 26 to October 26, 2015. The HDR Team developed and implemented a Phase I construction activity monitoring plan. Under this plan, the team maintained a visual record of the activities that occurred during Phase I construction including the types and numbers of vessels deployed, the chronology and duration of activities, and other relevant information for use in evaluating impact-producing factors. The Team also measured underwater sound and airborne noise generated during construction, both at onshore and offshore locations.

The HDR Team learned many lessons during Phase I construction. The primary hurdle was constantly changing construction schedule. Construction delays began when a barge damaged the first jacket after installation. Additionally, the original crane barges were unable to provide a steady platform for pile driving activities.



Source: Deepwater Wind Block Island LLC

Figure 1. BIWF Work Area

DWW's construction contractor, Crowley Marine, was able to eventually drive piles successfully from the surface crane barge but ultimately, a large "jack-up" vessel, the L/V Robert, arrived and proved a more successful and efficient platform for piling. The HDR team maintained communications with DWW during delays and ultimately developed a trusting partnership that greatly enhanced critical monitoring coordination.

Phase II construction will occur in 2016 and will include installing power transmission cables and the WTGs on the foundations that were installed during Phase I. National Grid will build and operate the infrastructure needed to connect the electric grid. Following the completion of Phase II construction, operational testing is scheduled towards the end of 2016.

1.1.1 Purpose of the Field Plan

This Field Plan describes for BOEM's consideration a suite of acoustic (underwater and/or airborne), sediment-related, and visual monitoring options that may be undertaken to identify and quantify the stressors or impact-producing factors that may be associated with the Phase II construction process (i.e., the characteristics of the proposed project that may cause an impact). The actual parameters monitored in the field during Phase II construction will be determined in consultation with the BOEM Project Manager. Phase II will include the following major construction activities:

1. **Sea2shore Cable Installation** – which is scheduled to start in June 2016, by National Grid, and will include construction/installation of the following components
    a. **Inter-array Cable**: Submarine cable connecting the WTGs.
    b. **Export Cable**: Cable connecting northern most WTG to Block Island.
    c. **Block Island Substation**: This will be located in New Shoreham on Block Island, and it will include approximately 0.8 mile of underground cable from the beach to the new substation.
    d. **Block Island Transmission System** (BITS): This includes a bi-directional approximately 20-mile submarine cable from Block Island to Scarborough State Beach in Narragansett and 3.5 miles of underground cable from Scarborough State Beach to the Dillon's Corner substation. The BITS will deliver power both to and from the Rhode Island mainland to Block Island.
2. **Turbine Installation** – This includes installation of turbine towers, blades, nacelles on the foundations that were constructed during Phase I, and it is scheduled to occur over 4 weeks in the summer of 2016. Each WTG consists of three sections. GE is currently manufacturing the lower sections at the Port of Providence facility. Final assembly of the turbine units will be completed at Quonset Point.
3. **Turbine Operational Testing** – WTG operational testing will be conducted during the fourth quarter of 2016.

Per guidance from BOEM, monitoring proposed in this Field Plan:

1. Does not duplicate or substitute for compliance monitoring that is required to be performed by the construction contractors,
2. Is compatible with scheduled construction
3. Is designed for providing additional information necessary for BOEM analysts to fully analyze the scope and extent of environmental impacts that may result from the construction activities and provide data to improve the accuracy of models and analysis criteria used to establish current monitoring controls and mitigations.

1.2 Monitoring Objectives

The objectives of the monitoring proposed to be conducted under this Plan include the following:

- Evaluation of visual activities during and after construction
- Evaluation of sediment disturbance and recovery during and after construction
- Evaluation of mitigating measures or abatement measures
- Assessment of sound environment during construction.

This Plan also includes mechanisms for the following:

- Ensuring that a process is in place for coordinating with other ongoing activities
- Providing a process for coordination of the team's efforts with the industry
- Providing sufficient safety procedures to protect personnel during monitoring activities.

1.3 Tasks and Subtasks

The scope of work for TO M16PD00006 consists of the following two tasks:

1.3.1 Task 2.4.1 – Provide Overall Project Management

HDR has assembled a qualified team expert of experts to assist in preparing this Field Plan. Key personnel and their areas of expertise are listed below:

1. HDR, Anwar Khan (Program Manager)
2. HDR, Jamey Elliott (Project Manager)
3. HDR, Randy Gallien, Craig Johnson (Technical Advisors)
4. HDR, Michael Richlen, (Marine Acoustician)
5. FUGRO, Kevin Smith, (Lead Sediment Engineer)
6. Subacoustech Environmental Ltd Tim Mason, (Acoustic Specialist)
7. University of Rhode Island (URI), Dr. Jim Miller, (Marine Acoustician)
8. Marine Acoustic, Inc. (MAI), Dr. Kathleen Vigness-Raposa (Acoustic Specialist)
9. Marine Acoustic, Inc. (MAI), Dr. Adam Frankel, (Acoustic Specialist)
10. Marine Acoustic, Inc. (MAI), Jennifer Giard, (Acoustic Specialist)
11. Woods Hole Oceanographic Institution's (WHOI's) Ocean Acoustics & Signal Lab, Art Newhall, (Acoustic Specialist)
12. Woods Hole Oceanographic Institution's (WHOI's) Ocean Acoustics & Signal Lab, YT Lin, (Acoustic Specialist)
13. Woods Hole Oceanographic Institution's (WHOI's) Ocean Acoustics & Signal Lab, Dr. Mark Baumgartner, (Acoustic Specialist)

14. University of Maryland, Arthur Popper, (Technical Advisor)
15. Blue Land Media (BLM), Walter Rissmeyer, (Producer)

1.3.2 Task 2.4.2 – Prepare a Field Plan for Data Collection

The Draft Field Plan presented in this document represents the first of two deliverables for Task 2.4.2. This Plan will be finalized by addressing comments and input received from BOEM. Field Plan implementation will be covered under a separate task order. To facilitate and manage implementation, Task 2.4.2 is divided into the following subtasks:

- 2.4.2.1 – Monitoring Associated with Sea2Shore Cable Installation
- 2.4.2.2 – Monitoring Associated with Turbine Installation
- 2.4.2.3 – Monitoring Associated with Turbine Operational Testing
- 2.4.2.4 –Acoustic Analysis of Existing Phase 1 Data
- 2.4.2.5 – Demonstration of Whale Detection and Feasibility of Marine Mammal Tracking
- 2.4.2.6 – Video Production
- 2.4.2.7 – Publications, Presentations and Outreach
- 2.4.2.8 – Technical Approaches for Environmental Review for Offshore Wind Energy Facilities

Specific activities that will be conducted under each subtask are described in detail in **Section 2**.

1.4 Schedule

The schedule of activities and deliverables for the Field Plan are listed in **Table 1**.

Table 1. Tentative Schedule for Implementing BIWF Phase II Construction Field Plan

Task	Action	Due Date
2.4.2.1 Sea2Shore Cable Installation	Monitoring	June 2016
2.4.2.1 Sea2Shore Cable Installation	Draft Underwater Sound Monitoring Report	TBD
2.4.2.1 Sea2Shore Cable Installation	Final Airborne Noise Monitoring Report	TBD
2.4.2.2 Turbine Installation	Monitoring	June 2016
2.4.2.2 Turbine Installation	Draft Turbine Installation Report	TBD
2.4.2.2 Turbine Installation	Final Turbine Installation Report	TBD
2.4.2.3 Turbine Operational Testing	Monitoring	TBD
2.4.2.3 Turbine Operational Testing	Draft Turbine Operational Testing Report	TBD
2.4.2.3 Turbine Operational Testing	Final Turbine Operational Testing	TBD

Task	Action	Due Date
2.4.2.4 Acoustic Analysis of Existing Phase I Data	Draft Phase 1 Acoustic Analysis Report	NLT 6 months after award
2.4.2.4 Acoustic Analysis of Existing Phase I Data	Final Phase 1 Acoustic Analysis Report	NLT 30 days after comments
2.4.2.5 DMON	Draft DMON Report	TBD
2.4.2.5 DMON	Final DMON Report	TBD
2.4.2.6 Video Production	Draft Vignette	TBD
2.4.2.6 Video Production	Final Vignette	TBD
2.4.2.7 Presentation	Present Effects of Noise on Aquatic Life	10-16 July 2016
2.4.2.8 Industry Coordination	Coordination	Upon award

1.5 Industry Coordination

During Phase II monitoring, close coordination will be required with National Grid, DWW and TetraTech. The HDR project manager will be responsible for ensuring this coordination. Prior to commencing any fieldwork, efforts will be coordinated with the BOEM Contracting Officer Representative COR, DWW and/or National Grid. The project manager will check in every morning with either DWW or the National Grid Manager to get an update on the activities planned for the day and their nature and duration. The project manager will share this information with all members of the HDR Team monitoring personnel to ensure that data collection is conducted in real-time when the construction activities are actually in progress.

1.6 Government-Furnished Information:

The following government-furnished information will facilitate finalization of the Draft Plan and subsequent implementation:

- Full details of construction methodology, especially:
    - installation methodology (equipment, procedures and predicted duration)
    - other activities (e.g., horizontal drilling)
- Timescales and program for each site
- Any planned mitigation or abatement
- Any specific requirements from BOEM acoustic modelers for data they wish to have for model verification
- Details of compliance monitoring required and proposed to be conducted by the construction contractors
- National Grid boring data along cable transect.
- Jasco's hydroacoustic data collected as part of the DWW mitigation plan.

2 BIWF Phase II Construction Monitoring Field Plan

This section contains a description of the monitoring activities that will be conducted under each of the eight subtasks.

2.1 Subtask 2.4.2.1 – Monitoring Associated with Sea2Shore Cable Installation

The HDR Team will monitor the submarine cable installation from Block Island Town Beach to Scarborough State Beach. The submarine cable will cover a distance of approximately 20 miles once complete. It estimated that laying the submarine cable would take approximately 27 days commencing in June 2016. The construction schedule is shown in **Figure 2**, and the cable route is shown in **Figure 3**.

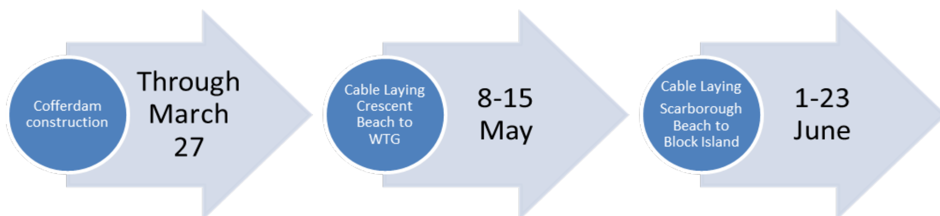
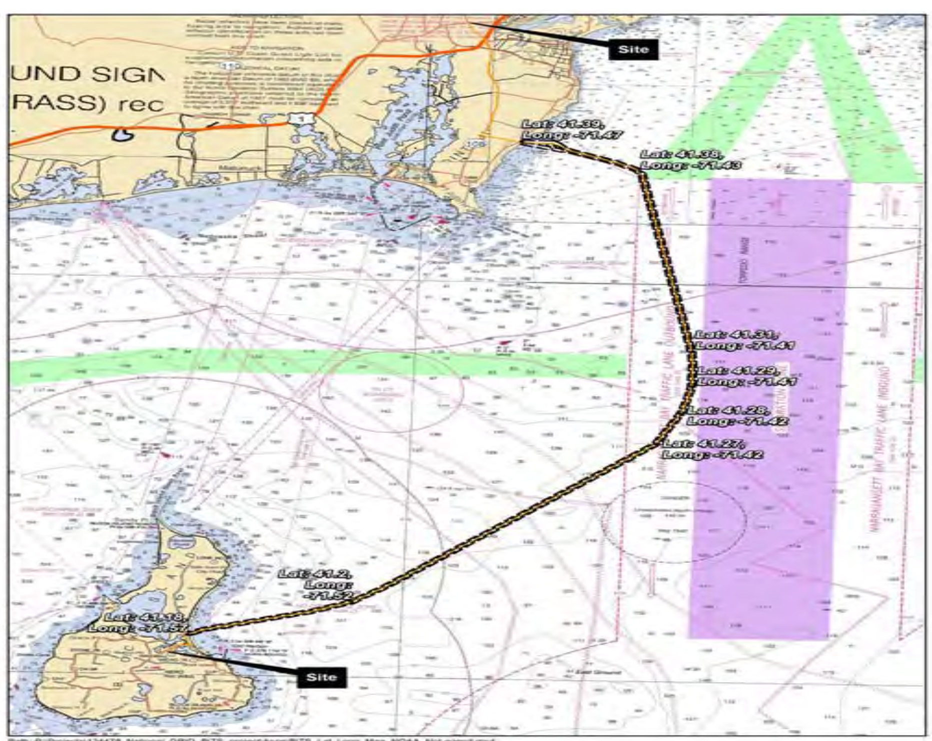


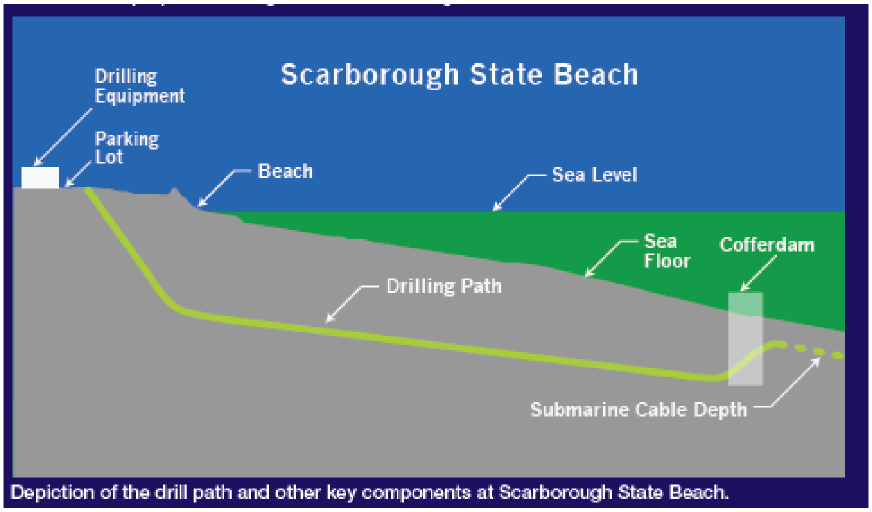
Figure 2. Tentative Schedule for Sea2Shore Cable Installation



Source: National Grid

Figure 3. Cable Route from Mainland

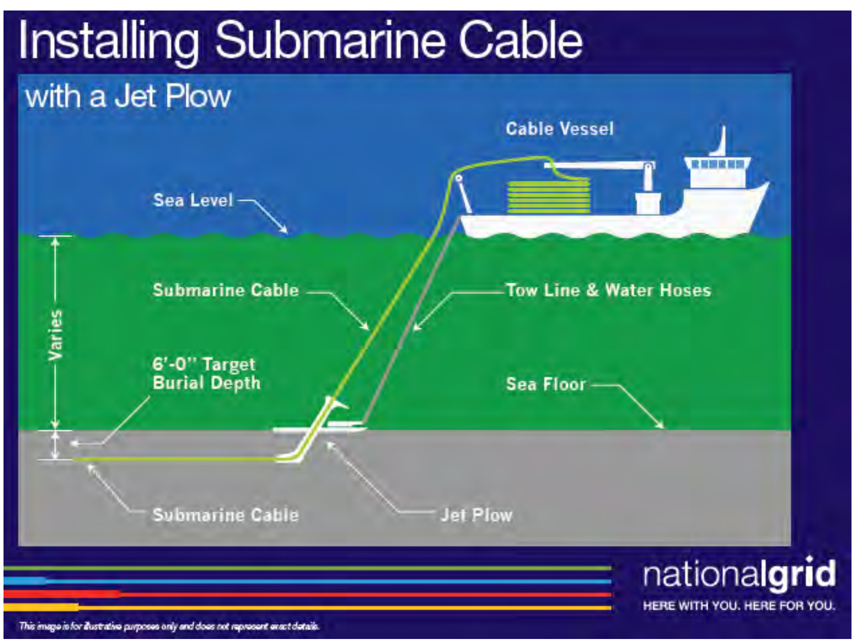
The inner-array and export cable will be installed using a jet plowing method in the offshore area and horizontal directional drilling (HDD) technique in the shoreline nearshore area. Temporary cofferdams will be constructed at Scarborough State Beach and Block Island to allow HDD to connect the submarine cable to shore (**Figure 4**).



Source: National Grid

Figure 4. Drill Path at Scarborough State Beach.

The submarine cable will be fed through a jet plow once in the water. The plow liquefies the soil using water jets. The plow is hollow and the cable passes through it and will be buried approximately 6ft below the seabed (**Figure 5**). The disturbed area is expected to fill back as the sediment settles naturally. A cable vessel will pull the jet plow to connect the mainland at Scarborough State Beach to Town Beach at Block Island. The proposed cable route covers a distance of approximately 20 miles.



Source: National Grid

Figure 5. Installing Submarine Cable with a Jet Plow.

Four types of monitoring are recommended under Subtask 2.4.2.1:

1. Acoustic
2. Sediment recovery and disturbance
3. Benthic
4. Visual.

Specific activities related to these four monitoring areas are discussed below.

2.1.1 Sediment Disturbance and Recovery Monitoring

Installation of all three sets of cables will disturb the seafloor sediment. HDR Team member FUGRO will monitor 1) sediment disturbances associated with these construction activities and 2) post-construction sediment recovery.

The inter-array and export cable will be installed using a jet plowing method in the offshore area and HDD technique in the shoreline nearshore area. In order to mitigate seafloor disturbance, a jet plowing technique will be utilized and will be supported by a dynamically positioned vessel to avoid anchoring and spud-can seafloor disturbance. Plans are to install the cable to a depth of 2 meters below the seafloor except at two cable crossings. Concrete blankets will be used to provide separation and cable protection at the two cable crossings.

Jet plowing utilizes high-pressure water streams to fluidize seabed sediments and excavate a trench. During fluidization of the seabed sediments, sediments are temporarily introduced into the water column until they settle out. Therefore, jet plowing can impact the environment by temporarily increasing turbidity levels in the water column, inducing sedimentation of excavated sediments outside the trench that cover the nearby seafloor, and disturb the seafloor in the trench zone. Those processes and effects are further described in a BOEM funded research report "Seabed Scour Considerations for Offshore Wind Development on the Atlantic OCS, Technology Assessment and Research Study No. 656."

From FUGRO experiences, seabed scars and berms corresponding to the route of the installation tool and the placement of anchors of vessels used in the construction are usually visible using multibeam techniques but disappear relatively rapidly depending on the levels of natural seabed disturbances/weathering, rates of infilling by transient bedload and frequency of high wind/wave events. Trenches in more cohesive substrates such as chalk or clay, may of course be longer lived or permanent. Fine sediments ejected from the trench during the installation may be transported within the tidal currents and deposited over adjacent seabed areas to form a temporary thin fine sediment veneer, which may be visible in Side Scan Sonar (SSS) data as temporary areas of lower reflectivity or observed in multibeam backscatter data. This veneer will add to the volume of the natural bedload already in flux through the area. Subsequent tidal movements continuously re-mobilize and disperse and dilute this additional fine bedload sediment to background levels over time.

HDD technique will be used to install the cable at the shore crossings. HDD activities are only anticipated to affect the seafloor where the cable exits onto the seafloor and transitions into the trenching installation.

The HDR Team noted that DWW is required to conduct a post-cable lay survey within 14 days of completion and that DWW plans to conduct a multibeam echosounder (MBES) and sub-bottom profiler Compressed High-intensity Radar Pules survey after the cable is installed to document post-lay trench conditions, confirm back-filling of the trench, and determine depth of burial for the cable. The HDR Team will evaluate their proposed survey methods and equipment, and if warranted, recommend a survey program that will be capable of monitoring seafloor disturbance, spoil piles, etc.

If not already collected by DWW, the Team will consider collection of pre-construction MBES and SSS to allow comparison and assessment of post construction effects. This is important to differentiate the effects of natural transient fine sediment deposition from deposition by construction related sediment plume. We have assumed that the post-cable lay multibeam survey conducted by DWW will be of sufficient resolution to identify the trench and associated features. If the DWW survey data are deemed to be too low of resolution (i.e., binned at a large size) to define the trench, then we would request that our first survey be moved forward and conducted to document post-construction conditions.

The HDR Team will:

1. Record the extent of disturbance during cable laying, and the influence of bottom type on sediment disturbance and recovery rates using video imagery from cable lay and burial operations performed by the contractor or monitor.
2. Assess the variability of sediment disturbance with water depth for the distance from interfield turbine installations and landward to nearshore HDD using MBES and SSS.
3. Monitor seabed conditions periodically to evaluate changes in burial depth and scour, and periods of anomalously high seabed mobility associated with storm events using MBES and SSS.
4. Assess the reduction or elimination of sediment disturbance and mobility in areas of mitigation such as seabed protection.

Sediment disturbance monitoring and assessment will include the following steps:

1. Literature study comparing European standards for monitoring with United States Offshore Wind sites for applicability and repeatability.
2. Monitoring conducted using periodic marine surveys. Marine surveys will collect MBES bathymetry, MBES backscatter, and SSS data. The surveys will be conducted nominally at three -month intervals during fair-weather periods (summer and early fall) and then before/after winter. Initiation of this survey sequence will depend on when the cable installation is completed. Sediment grab sampling will be conducted along the cable route and used to constrain analysis of backscatter and SSS data.

   The Team will evaluate novel uses of backscatter acquisition and processing, such as angular response analysis, to pioneer new comparative and quantitative techniques using multibeam backscatter metrics as proxies for seabed physical condition. This represents an opportunity to evaluate a new means and methods for best practices in monitoring seafloor disturbance/recovery from wind farm cable trenching and for supporting technical NEPA disciplines.

Surveys will be conducted from cable reception pits at the HDD exit points to cable reception point location. We note those locations are within state waters; however, those locations represent complex areas where scour/erosion protection needs are not well understood.

After each survey, a report will be prepared that describes our assessment of the seafloor recovery from trenching activities, changes in seafloor conditions at the cable crossing locations that have implemented scour protection, and observed changes in extent of trench plume sediment deposition.

3. Preparation of an interpretative and assessment report. A report will be prepared that summarizes our assessment of the comparison between backscatter and SSS data for use in seafloor condition monitoring. Both technologies have advantages and limitations. For example, SSS data are widely used in practice to map seafloor conditions but the data and results are difficult to quantify in a repeatable manner. However, multibeam backscatter data offer a quantifiable method for interpreting seafloor bottom conditions. We will assess the two types of data and provide an assessment of their application for use in monitoring seafloor disturbance and recovery. The report will summarize our assessment of seafloor recovery rates and how they vary along the alignment with respect to water depths, seafloor sediment type, and in areas where migrating bedforms are observed. The report will also describe if the cables are observed to become exposed and describe our observations of seafloor recovery or changes where scour protection has been placed and at the cable crossing locations.
4. Evaluating potential “best practices” for differing monitoring technologies and monitor methods.
5. Field testing of various market available equipment for monitoring quality and maintenance.
6. Determination of the optimal frequency of monitoring both on recurrent intervals and before/after major storm events.
7. Demonstration of the potential re-use of the data acquired to inform other technical NEPA disciplines such as marine archaeology and ecology (i.e. distribution of fish critical habitat or sensitive or protected reefs / seagrass habitat).
8. Sediment plume turbidity monitoring and sedimentation.

During jetting, water is released through a series of nozzles at a high pressure on the lead face of the jet-plough device. The high-pressure water fluidizes the seabed sediments and causes the sediments to transition into a state of suspension in the water column, thus temporarily excavating a trench-like depression. The cable falls into the excavated trench as the jet-plow moves along the cable route on the seabed. The sediments excavated and placed into a temporary state of suspension by the high-pressure jets, eventually settle out of the water column and infill the trench, thus burying the cable. Not all of the sediments will settle out back into the trench.

In order to understand the dispersion of a sediment plume from seabed disturbance resulting from jet-plowing (or dredging) multiple factors need to be assessed:

- The extent of the plume
- The concentration of particulate material within the plume
- The particle size distribution of the material to understand settlement rates
- Distribution of settled material on the seabed

In addition, the following complexities will be considered during monitoring to ascertain the impact of the sediment plume: (1) the injection point of the sediment plume is constantly moving; (2) current patterns mean that pattern of dispersion will vary over the tidal cycle and throughout the lunar cycle; and (3) wave conditions may cause significant re-suspension of the bed material potentially masking any single from the anthropogenic activity.

Recommended Monitoring Method – Swath Bathymetry/ADCP/OBS-WS

From previous experience of similar projects, FUGRO has developed an approach that uses a mobile monitoring vessel with the following equipment suite. This preferred monitoring method is Swath Bathymetry/ADCP/OBS-WS:

- **Swath Bathymetry system**: using the water column backscatter data the structure of the plume can be discerned and its extent.
- **Acoustic Doppler Current Profile (ADCP)**: provides both flow information in 0.5 – 1.0 m bins throughout the water column and acoustic return data within the plume (from each beam separately) allowing estimates of concentration within the plume to be made.
- **Optical Backscatter Sensor / Water Sampler (OBS-WS)**: vertical profiles through the plume can be collected using an Optical Backscatter sensor combined with pressure (depth) data is used to ascertain the sediment concentration within the plume and its vertical structure, water samples are collected alongside in order to assist in the calibration of both the optical and acoustic backscatter data and to obtain data on the particle size distribution of the sediment plume.

The above approach can provide robust data about the sediment plume and its distribution, however seabed deposition levels are not directly obtained, the accuracy of measures of seabed level is such that a potential change of up to 1 cm will not be discernible form background fluctuations. However, this will be estimated based on the suspended sediment data and particle size distributions ascertained above, combined with the current flow information form the acoustic profiler.

This mobile method will allow the monitoring vessel to maneuver into a position down current from the trenching activity and monitor during peak tidal flow and slack-tide conditions. Sediment plumes are expected to extend further from the jet-plow during peak tidal flow conditions than during slack tide. Capturing those conditions with a seafloor mounted system will be difficult due to the challenge of predicting when the jet-plow would pass a forecasted position precisely at a peak tidal flow condition (when sediment plume would extend furthest from the plow).

The aim of this approach is to design a survey pattern that will allow the plume to be mapped spatially and temporally, FUGRO will gain an understanding of the time/distance the plume travels in suspension prior to settling.

2.1.2 Visual Monitoring

Visual monitoring of Phase II construction activities will be conducted from selected onshore and offshore locations.

Onshore Visual Monitoring

During cable installation, a dedicated onshore observer will record the following from the points to be determined on Block Island and Scarborough Beach:

- Visibility of construction activities from shoreline while cable laying vessel is within range
- The types of lighting used at the construction site and what can be seen from the shoreline
- Meteorological conditions that affect visibility from shore including humidity.

Data will be recorded daily at sunrise, mid-day, sunset, and during significant changes in meteorological conditions (e.g., rain, fog, etc.) during each day that construction takes place. The observations will include a set of photos taken from a fixed point, at the same angle, and using a constant zoom setting on the camera. Video recordings will be made as necessary to document unusual sightings or infrequent occurrences. HDR will use iPads with custom database application to standardize data entry. This database was developed for Phase I construction and utilizes Filemakergo ®.

Offshore Visual Monitoring

A second dedicated observer will be located offshore on a boat adjacent to the cable laying vessel during cable installation and record the following:

- Number, size, and type of construction vessels
- Size and location of deployed anchors
- Number and nature of lighting used at the site
- Type of construction activities being conducted and duration of each activity.

Where possible, the observer will also record relevant information including incidental observations on the occurrence of marine species and other activities (e.g., fishing vessels, recreational vessels). Offshore observation location will occur such that the survey vessel will remain outside the exclusionary zone (to be determined) and not interfere with the construction activities or with transit of the construction vessels. Construction activity observations will be recorded using a field data log sheet and a photo log will be maintained.

2.2 Subtask 2.4.2.2 – Monitoring Associated with Turbine Installation

The following types of monitoring will be conducted in association with the turbine installation:

1. Airborne Noise
2. Sediment
3. Benthic
4. Visual.

Specifics activities related to these four monitoring areas are discussed below.

2.2.1 Airborne Noise Monitoring

Acoustic monitoring will include measuring and recording changes in airborne noise levels. A sound level meter will be positioned at the Southeast Lighthouse. This location will provide a direct line of sight to the WTGs. Sound readings will be acquired in conjunction with visual surveys.

Data on background noise levels was acquired in the winter in the absence of either operational turbines or construction machinery. Wind speeds were high at this time, which, while representing a realistic condition (and appropriate for wind turbine operation), should be supplemented by an opportunity out-of-season at low wind speeds. Additional acquisition of background noise levels at the Southeast Lighthouse will be attempted under these conditions in April 2016 during cable installation acoustic monitoring once the activities exceed the range of detection.

2.2.2 Sediment Disturbance and Recovery Monitoring

Construction equipment used to install the turbines (e.g., tower, blades, and nacelle) is anticipated to utilize a lift boat. It is unclear at this time what other specific support construction equipment will be used. It is anticipated that support barges using anchoring systems may be used. Spud-can penetration and anchoring will disturb the seafloor.

Seafloor disturbance and recovery monitoring due to spud-can and anchoring during turbine installation are anticipated to be included in Task Order 3 monitoring. Task Order 3 monitoring includes conducting multibeam surveys to map the seafloor in the wind turbine area.

2.2.3 Benthic Monitoring

Benthic habitats likely to be affected by turbine installation will most likely be limited to the depressions on the seabed that are created due placement of the feet of the jack-ups causing displacement, compaction, and abrasion effects on benthic fauna and flora. Subsequent infilling of the depressions via slumping of the sidewalls and/or natural bedload transport processes will occur allowing faunal and floral communities to recover over time.

The HDR Team will collect geophysical data to determine the extents of the physical effects (depressions) on the seabed. These data will then be ground-truthed by seabed video to provide a visual record of the extents of the seabed physical impacts and associated effects on epifaunal communities. Subsequent surveys will record the infilling and erosion of these physical impacts and the recovery of affected epifaunal assemblages.

The geophysical and camera surveys can be performed in tandem from the same vessel platform to rationalize survey effort. Fugro and HDR will consider the program of routine engineering monitoring, such as cable burial or scour monitoring, performed by DWW with a view to further rationalize the overall field monitoring effort.

2.2.4 Visual Monitoring

The Visual Impact Assessment prepared by DWW evaluated the visual character of the individual turbines from a 30-mile radius. Several mitigation measures were implemented during the planning phase including: reduced number of turbines, turbines that will be of uniform design and without any logos; turbines that are white to blend in with sky and eliminates need for Federal Aviation Administration (FAA) daytime warning lights; FAA warning lights will have the longest off-cycle permitted. The Assessment concluded that no further mitigations were required once operational.

Onshore Visual Monitoring

Visual observations of construction activities from the shoreline will be logged during the turbine assembly and operational phase. The real-time data collected through the implementation of the approved field plan will provide additional information necessary for BOEM's evaluation of environmental effects of future facilities and generate data to improve the accuracy of models and analysis criteria employed to establish monitoring controls and mitigations.

During the operational testing, a dedicated onshore observer will record the following from the Southeast Lighthouse:

- Visibility of construction activities from shoreline
- The types of lighting used at the construction site and what can be seen from the shoreline
- Meteorological conditions that affect visibility from shore including humidity.

Data will be recorded daily at sunrise, mid-day, sunset, and during significant changes in meteorological conditions (rain, fog, etc.) during each day that construction takes place. The observations will include a set of photos taken from a fixed point, at the same angle, and using a constant zoom setting on the camera. Video recordings will be made as necessary to document unusual sightings or infrequent occurrences.

After observations are documented from the SE Lighthouse, the observer will transition to a to be determined location, and record activities occurring in Stand-by Area A. This area is located approximately 2 nautical miles to the west of Block Island and it will serve as a staging area for vessels or used during work stoppage due to weather or sea states.

In addition, visual monitoring will include night time surveys be conducted 2 hours after sunset to record and characterize types of lighting visible from shore for up to two nights. A Canon 7D camera setup on a tripod to accommodate the required slow shutter speed that is necessary to capture images will be utilized to photograph operational activities.

The last scheduled ferry departs Block Island at 7:30PM, therefore this monitoring will require 2 days lodging on Block Island. Furthermore, four nighttime observations will be recorded from the mainland to determine if the FAA Warning Lights installed on the turbines are visible. Ideally, these observations will occur under a variety of meteorological conditions (cloudy, clear, rain, fog, etc.).

Offshore Visual Monitoring

A second dedicated observer will be located offshore on a boat adjacent to jackets during the turbine assembly, and operation testing:

- Number, size, and type of construction vessels
- Size and location of deployed anchors
- Number and nature of lighting used at the site
- Type of construction activities being conducted and duration of each activity.

Where possible, the observer will also record relevant information including incidental observations on the occurrence of marine species and other activities (fishing vessels, recreational vessels, etc.). The offshore observation location will be selected such that the monitoring vessel will not interfere with the construction activities or with transit of the construction vessels. Observations will also be made at least once per survey day of the Stand by Area A. Construction activity observations will be recorded using an iPad with pre-formatted field logs.

2.3 Subtask 2.4.2.3 – Monitoring Associated with Turbine Operations

The following types of monitoring will be conducted in association with the turbine operational testing:

1. Acoustic,
2. Sediment disturbance and recovery monitoring
3. Benthic, and
4. Visual.

Specifics activities related to these four monitoring areas are discussed below.

2.3.1 Acoustic Monitoring

Acoustic monitoring will include measuring and recording changes in underwater sound and airborne noise levels.

Underwater Sound Monitoring

Detailed monitoring observations of the underwater sound and vibration emissions of the operational WTGs will be undertaken, using the same basic procedure are during construction. It is expected that the survey vessel will be able to approach the turbines at much closer range than during construction. This will be necessary, as the operational sound and vibration levels are expected to be significantly lower than during construction.

Medium to long-term samples of underwater sound will be taken as a baseline in the absence of underwater sound-producing machinery associated with the wind farm development. This is important to gauge the impact of the underwater sound during construction, and is critical for the comparative investigation of the sound output and propagation during the operational phase of the wind farm, as operational sound tends to be much closer to the ambient noise levels than construction.

A single underwater long-term acoustic monitor will be located in the vicinity of one of the WTG jackets. A distance of 750 meters is proposed towards the outside of the turbine array to avoid contamination from multiple turbines. The monitor will remain in situ for a period of 2 months, after which it will be recovered, downloaded, batteries recharged or replaced, redeployed for another 2 months, and then approximately for a final 2 months.

During installation, maintenance and removal operations for the long-term underwater noise monitor, transect measurements will be undertaken in the same manner as during earlier construction processes. These attended vessel-based measurements will sample over different periods of the year, ideally under similar wind and sea conditions. This will capture variations in noise and seabed vibration propagation under natural seasonal conditions, whereas the long-term monitor will capture variations caused by changes in wind and sea states. The transects will begin as close as permissible to the operational turbines and will continue until the turbines are no longer detectable. It is not expected to be possible to acquire attended noise measurements safely on the vessel at high wind conditions, and the wave noise under these conditions around the vessel would cause artificially high noise levels.

It should be noted that a 750-m distance from the operational turbine for the fixed monitor was selected to be equivalent to the distance measured during previous construction periods. However, where attended measurements show that the operational turbine noise levels are not significantly above the background noise, the fixed underwater noise monitor will be relocated closer to the turbine.

In addition, the HDR Team would deploy a Several Hydrophone Receive Unit (SHRU) mooring with four hydrophones similar to that deployed in the 2015 construction phase. The SHRU mooring would allow measurement of seabed vibration and particle motion contributing to essential data for analyses of future wind farms.

Airborne Noise Monitoring

In common with the previous construction monitoring programs, airborne noise will be sampled simultaneously with the underwater noise from a sound level meter situated on the survey vessel and at the Southeast Light. Special consideration will be given to amplitude modulation of the noise emissions from the turbine and how this and low frequency noise varies with distance, a key concern currently being investigated in its effects on people living near onshore wind turbines. More uniform conditions available in the offshore environment offer a unique opportunity to study this without the natural interruptions that exist on land.

Transects will be selected to study, as well as possible with the wind conditions and wind farm layout, the noise from a single turbine and from the entire array. Measurements will be taken in different wind directions but concentrating on downwind conditions. Opportunities to sample offshore under high wind conditions are unlikely to be possible for safety reasons but where an opportunity exists, will be sampled at the Southeast Lighthouse

2.3.2 Sediment Disturbance and Recovery Monitoring

TBD - with receipt of more description of initial operational testing activities

2.3.3 Benthic Monitoring

BOEM has guidelines for habitat monitoring surveys pursuant to 30 CFR § 585. Proposed methodologies for benthic monitoring will therefore have consideration to these guidelines. Recommendations for future iterations of the BOEM guidance and comparison with that used in Europe will be provided.

Post construction monitoring (recovery assessment) will utilize the same sampling stations that were sampled during the pre-construction survey and should be conducted at the same time of year to avoid effects of seasonal variation. Sampling and lab testing methods need to be comparable between pre and post survey occasions also.

The scale over which the monitoring will take place needs careful consideration and will be proportional to the questions being asked and level of concern raised. Medium- and large-scale monitoring campaigns have so far not been able to detect significant change in benthic conditions attributable to the construction and operation of offshore wind farms in Europe. However, local effects of offshore wind farms on benthos have generally not been studied and remain poorly understood, although there is some evidence emerging of benthic modifications relating to increased sediment enrichment over time as a result of the fall and accumulation of biomass from fouling organisms (such as mussels) from the turbine and foundations. Whilst the area of effect around each turbine might be quite small, say up to 50 or 100 m, the cumulative effect of benthic modification around 100 or 200 turbines on any one habitat may be considerable.

HDR team member FUGRO propose a series of monitoring studies to study potential near field benthic modification as a result of the fall of biomass from the turbines and foundation and associated sediment enrichment. The data derived from this monitoring will determine the extent and timescales for benthic modification through sediment enrichment and will allow BOEM to extrapolate the potential consequences of future larger developments on the US continental shelf on benthic ecology.

We will select two turbines, representing different habitat types, at Block Island for study. At each turbine seabed video and quantitative grab samples will be collected at 20-, 50- and 100-meter distances from the base of the turbine foundation, subject to the presence and spread of scour protection material at the base of the foundation and in collaboration with DWW. Sample stations will be orientated in line with the dominant tidal current flow and perpendicular to the current. The hypothesis tested in this instance will relate to the presence of a gradient of enrichment effects along the axis of the dominant tidal flow with minimal or no effects occurring on the seabed perpendicular to the direction of current flow. **Figure** 6 illustrates the proposed near field benthic sampling arrangement around each turbine.

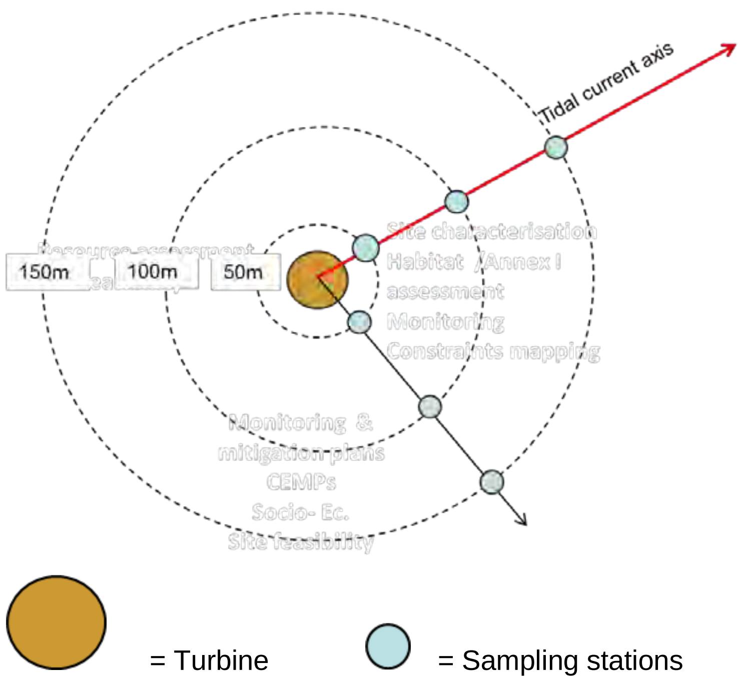


Figure 6. Indicative near field benthic ecology sampling station arrangement

Current meters from the benthic vessel prior to the initial sampling to establish the axis of the principal tidal current flow. However, it is recommended to use the data collected during the site assessment and impact assessment as well as any contemporaneous AWACS (or similar) deployment to predict the principal flow directions.

In addition to the turbine sample stations, two reference areas, located outside of the predicted influences of the offshore wind farm and in comparable substrate and depth conditions, will be selected and surveyed. Three stations shall be positioned within each reference area and sampled using the same methods. Data from the reference areas will allow assessment of benthic change attributable to the operation of the wind farm against the natural variation

Samples will be collected in triplicate to increase statistical rigor. The total number of samples will be 18 per turbine location (total 36 samples for 2 turbines) and 9 per reference area (18 samples for 2 reference areas) (total 54 samples).

Analyses will include macrofaunal species identification and enumeration, particle size distribution analysis and organic content. Species diversity and biomass metrics together with suitable enrichment indicators will be calculated for assessment of change over time. Video surveillance of sediment habitat conditions and associated epibenthos will also be collected at each sampling station for assessment of effects on these community components.

It is expected that any sediment enrichment and benthic modification will develop over a comparatively long time (years) and only once mature fouling communities have developed on the turbines and foundations. Following a preliminary survey soon after the installation of the turbines to collect baseline information, subsequent surveys may be undertaken relatively infrequently to allow for the accumulation of fallen biomass and development of associated enrichment and benthic modification. HDR and Fugro will consider aligning this monitoring program with the long term engineering monitoring or maintenance visits undertaken by DWW to rationalize the survey effort.

Re-locating sample stations with a high degree of accuracy will be important so that repeat samples are collected at the same point along the gradient of change for comparison between monitoring occasions. Differential GPS (dGPS) with navigational layback with accuracy of 1 – 3 m will be used for position fixing and finding during the proposed monitoring. As a further aid to position finding during repeat monitoring, the skipper of the survey vessel will have a heads up display. This will show each sampling station with a 5 – 10 m buffer and the vessel's relative position to each station. Once the vessel is within the required buffer area, the sampler is deployed and the seabed sample will be collected. From experience, it is known that proficient skippers in shallow waters achieve 10 m or less horizontal accuracy and frequently achieve < 5 m accuracy.

Fugro's own analysis of positioning accuracy during a recent project in 60 m depths in the eastern English Channel showed horizontal accuracy of < 5 m was commonly achieved. Application of an USBL fitted to the grab and the use of a dynamic positioning vessel can further improve positioning accuracy but can prove prohibitively expensive. Positioning options will be discussed with BOEM and will need to consider DWW's compliance monitoring methods.

2.3.4 Visual Monitoring

The Visual Impact Assessment prepared by DWW evaluated the visual character of the individual turbines from a 30-mile radius. Several mitigation measures were implemented during the planning phase including: reduced number of turbines, turbines that will be of uniform design and without any logos; turbines that are white to blend in with sky and eliminates need for FAA daytime warning lights; FAA warning lights will have the longest off-cycle permitted. The Assessment concluded that no further mitigations were required once operational.

Onshore Visual Monitoring

Visual observations of operational activities from the shoreline will be logged during the turbine operational phase. The real-time data collected through the implementation of the approved field plan will provide additional information necessary for BOEM's evaluation of environmental effects of future facilities and generate data to improve the accuracy of models and analysis criteria employed to establish monitoring controls and mitigations.

During the operational testing, a dedicated onshore observer will record the following from Southeast Lighthouse:

- Visibility of operational activities from shoreline in the vicinity of the turbines.
- The types of lighting used at the operational site and what can be seen from the shoreline during night time monitoring.
- Meteorological conditions that affect visibility from shore including humidity.

Data will be recorded daily at sunrise, mid-day, sunset, and during significant changes in meteorological conditions (e.g., rain, fog) during each day that operations takes place. The observations will include a set of photos taken from a fixed point, at the same angle, and using a constant zoom setting on the camera. Video recordings will be made as necessary to document unusual sightings or infrequent occurrences.

After observations are documented from the SE Lighthouse, the observer will transition to a to be determined location, and record activities occurring in Stand-by Area A located approximately 2 nautical miles to the west of Block Island. Stand-by Area A is a staging area for vessels or used during work stoppage due to weather or sea states.

In addition, monitoring will include nighttime surveys be conducted 2 hours after sunset to record and characterize types of lighting visible from shore for up to two nights. A Canon 7D-camera setup with a tripod to accommodate the required slow shutter speed necessary to capture images will be utilized to photograph operational activities. The last scheduled ferry departs Block Island at 7:30PM, therefore this monitoring will require 2 days lodging on Block Island. Furthermore, four nighttime observations will be recorded from the mainland to determine if the FAA Warning Lights installed on the turbines are visible. Ideally, these observations will occur in a variety of meteorological conditions (cloudy, clear, rain, fog, etc.).

Offshore Visual Monitoring

A second dedicated observer will be located offshore on a boat adjacent to jackets during the turbine assembly, and operation testing:

- Number, size, and type of construction vessels
- Size and location of deployed anchors
- Number and nature of lighting used at the site
- Type of operational activities being conducted and duration of each activity.

Where possible, the observer will also record relevant information including incidental observations on the occurrence of marine species and other activities (e.g., fishing vessels, recreational vessels). The offshore observation location will be selected such that the vessel will not interfere with the operational activities or with transit of the construction vessels. Observations will be recorded using an iPad with pre-developed field logs.

2.4 Subtask 2.4.2.4 – Acoustic Analysis of Existing Phase I Data

As part of the BIWF Phase I construction-monitoring efforts, HDR Team members from the University URI, MAI, and WHOI designed and deployed acoustic and seismic monitoring systems during pile driving for the construction of the Block Island Wind Farm. This construction involved driving 20 piles 60 m into the seabed and the HDR Team was able to successfully measure the underwater signals generated by the pile driving both in the water column and in the sediment. The systems included two vertical hydrophone array moorings with SHRUs for data collections and storage.

Also, a seabed vibration monitoring system consisting of a three-axis geophone and tetrahedral hydrophone array were deployed. Lastly, a towed array of hydrophones was deployed from a research vessel that collected acoustic signals during pile driving at various ranges on two different days. An initial review of the data is underway and preliminary results indicate a fully successful data collection effort.

HDR team member URI proposes to analyze the data collected during the pile driving activities by DWW at the Block Island Wind Farm in 2015. The hydrophone and geophone calibrations will be incorporated into the calculation of acoustic field and particle velocity at all sensors. Based on the construction log, the received acoustic signatures will be correlated with the appropriate pile and the hammer strike.

The main focus of the URI efforts will be on the data from the geophysical sled consisting of the three-axis geophone and the tetrahedral hydrophone array. URI will lead the effort to estimate the particle velocities on the seafloor (from the three-axis geophone data) and in water (approximately 1 m from the seafloor using the data from the tetrahedral array). In addition, URI will also coordinate the modeling and data analysis efforts of WHOI and MAI and contribute towards interpreting the spatial variation of the levels measured by different systems (URI, MAI and WHOI). URI will also lead the effort in collecting and consolidating the available environmental information to facilitate the modeling efforts. These data include sound speed profiles from CTD data, bathymetry and geoacoustic information.

URI will also consider and include acoustic data gathered by DWW subcontractor Tetratech, Inc. Tetratech collected acoustic data during complete construction of wind turbine #3 using both real-time and static techniques. Tetratech is also conducting long term monitoring via static recorders. Data will be included in URI's analysis assuming release of information in a timely manner by DWW.

In summary, the major tasks URI will focus on are:

1. **Pile schedule, check pile rake, construct log of pile number and leg number vs. time**: Analyze the acoustic and particle velocity data and correlate it with the pile driving schedule and appropriate hammer impact on individual piles. We will tabulate the pile rake associated with the acoustic signatures addressing the potential cause of sound pressure level variation with rake.
2. **Incorporate the exact calibration of acoustic and particle velocity sensors**: Extract the correct absolute levels. Based on the hammer type, investigate the difference in the levels of sound radiated from hammer impacts. Characterize the

background sound and compare this with the data collected during the SAMP studies. Then, calculate the Kurtosis of the data to investigate the changes this metric as a function of range and pile rake. Subacoustech will also reanalyze their data acquired in respect of Kurtosis.

3. **Environmental data coordination**: Collect and consolidating the available environmental information to facilitate the three-dimensional modeling of the acoustic field. These data include sound speed profiles from CTD data, bathymetry and geoacoustic information. The Team will gather available environmental data from sources such as Ocean Special Area Management Plan, other surveys and coring from the location, site characterization by construction contractors, etc.
4. **Coordinate the three-dimensional modeling efforts**: URI will coordinate with WHOI, MAI and potentially Sandia National Laboratory. The pile rake information from task 1 and the environmental data from task 3 will be inputs to the three-dimensional models. WHOI will assemble all of the data collected during the pile driving activities; we will start to create a three dimensional sound propagation numerical model that incorporates oceanographic conditions, bathymetric variation and seabed properties. After WHOI completes the data assembling, we will use the experimental data to fine-tune the numerical model. The goal is to use the numerical model to fill the measurement gaps and construct the 3D soundscape, especially to calculate the Kurtosis of sound pressure distributions. We realize this modeling work will be a group effort, and WHOI will be collaborating with URI and MAI. URI will assist in creating the underwater soundscape by assimilating the data and model results. Investigate the effect of water depth, bathymetry, temperature, sea state, and sediment type on the sound propagation using the model. Estimate the sound levels at 750 m and compare this with BIWF measurements taken by Tim Mason at Subacoustech and with European measurements from comparable water depths, pile diameters and hammer energies. We have been contact with personnel from Sandia and they have shown interest in this collaboration. Sandia has computational capability along with both commercial and in- house modeling tools applicable to this problem. Details of this collaboration will be part of this task.
5. **Particle velocity on the seabed and in water**: URI will examine particle velocity calculation using the data from a three-axis geophone and acoustic data from the tetrahedral array. This will be done in coordination with Steve Crocker at the Naval Undersea Warfare Center.
6. **Pile driving data analyses**: In addition**,** BOEM will task Naval Undersea Warfare Center **(**NUWC) (Dr. Steve Crocker) to analyze the data collected on the tetrahedral array during the pile driving activities by DWW at the Block Island Wind Farm in 2015. NUWC tasking should include a requirement for coordination with URI in the analysis of tetrahedral array data for estimating the particle velocity. Preliminary analysis indicates that the data are of high quality for this estimation of particle velocity.
7. **Actual sound pattern**: Determine the actual sound pattern at the various locations comparing the background sound 30 minutes before the impulsive pile driving signals, followed by an hour of background sound level measurements. The analysis will include the energy measured at the piles by DWW to understand the effect of pile energy to received levels. This will be repeated for all available pile driving events.

2.5 Subtask 2.4.2.5 – Demonstration of Whale Detection and Feasibility of Marine Mammal Tracking

Passive acoustic monitoring has become a standard methodology for assessing the occurrence and distribution of marine mammals; however, surprisingly little research has been conducted on the detection range of different species' vocalizations, and how that detection range varies with environmental conditions (e.g., ocean conditions, water depth, sediment type), signal type, passive acoustic monitoring system, and platform (e.g., moored buoy, autonomous underwater vehicle). To effectively use passive acoustics to monitor marine mammals, an understanding of the area over which the monitoring system can detect each species of interest is absolutely critical.

WHOI engineers and scientists have built a system based on the digital acoustic monitoring (DMON) instrument to record, detect, classify, and remotely report in near real time the calls of marine mammals from moored buoys. The system concept has been demonstrated in several recent pilot projects, and ready to integrate the technology into Regional Ocean observing systems. To encourage and facilitate this integration, we must evaluate the efficacy of the near real-time acoustic detections (work underway now) and characterize the detection range for species of interest.

A WHOI buoy equipped with a DMON reporting system is presently operating near Nomans Land Island, Massachusetts and detecting various species of whale. (See http://dcs.whoi.edu) WHOI propose to deploy a second DMON system near the Block Island Wind Farm site. WHOI will use playbacks to verify our estimates of species-specific detection ranges in coordination with the URI and Marine Acoustics, Inc. There is a substantial need in the marine mammal research and conservation community for rigorous acoustic propagation studies that will be enable by this second system. **Figure 7** shows the configuration of the DMON system.

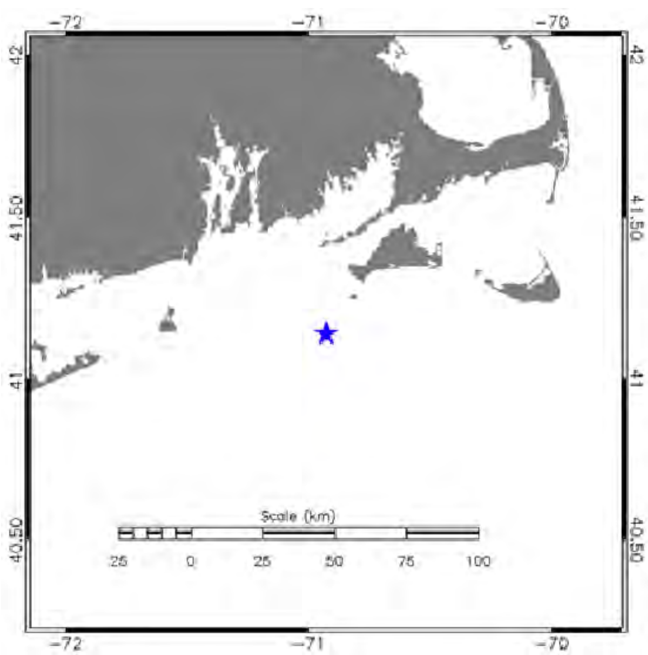


Figure 7. Location of the presently operating DMON system is shown by the star off Nomans Land Island Massachusetts.

The URI contribution to this task will be to coordinate the playback experiments, organize the boat deployment, and assist in the system design and in data analysis.

A fin whale was detected on the 15 km SHRU mooring on November 4, 2015, as shown in **Figure 8**. The data shown at http://dcs.whoi.edu/nomans0315/nomans0315.shtml for the Nomans Land Island DMON also detected fin whales call during the same period, showing the potential of joint detection and hence the possibility for localization.

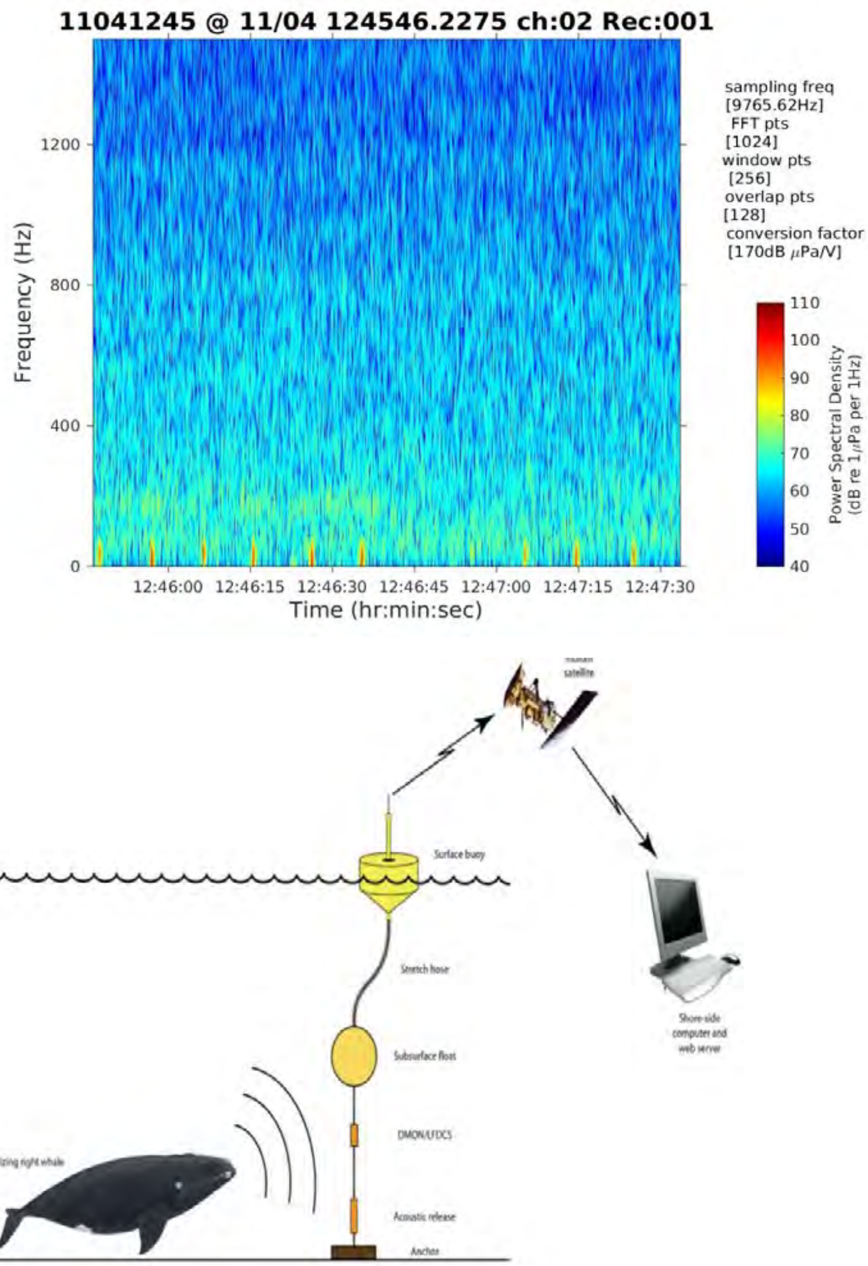


Figure 8. Spectrogram of the acoustic data recorded on the 15-km vertical array mooring on November 4, 2015 showing fin whale calls centered at 20 Hz.

Note: Fin whale calls (indicated by the vertical red lines about every 10 seconds) were also detected on the same day by the WHOI DMON system near Nomans Land Island, Massachusetts shown at **http://dcs.whoi.edu/nomans0315/nomans0315.shtml**.

2.6 Subtask 2.4.2.6 – Video Production

HDR proposes high definition b-roll footage of BOEM funded work be captured during the installation and testing of the turbines, as well as of the monitoring activities designed to assess the impact of the project to learn about offshore wind. Having professional video to document construction and the monitoring of the acoustic and visual impacts would be an asset during public meetings regarding future wind farms construction, for public outreach and are ideal for inclusion on various related websites. A potential future task order could include the production of a short vignette on the wind farm construction process.

HDR potential team member, BLM is uniquely positioned to execute this subtask of the task order. BLM is a full-service video and multimedia content producer focusing on documentary, arts, educational, and nonfiction entertainment programming for broadcast and cable television and informational communications for corporate and government clients. BLM offers complete production services and operates standard-definition and high-definition production and postproduction facilities and offers 4K production capabilities using the RED ONE Digital Cinema Camera. BLM has direct, ongoing experience in creating videos for Navy training and outreach purposes. BLM has previously completed Marine Species Awareness Training Video, Environmental Stewardship Outreach Video, and Environmental Compliance and Stewardship Vignettes for the Navy. If Government is receptive to this subtask, HDR will immediately initiate the process of adding BLM to the RODEO Team.

We recommend three filming trips of approximately 5 days of filming each (total 15 days filming). The first trip would be to document the cable installation, the second trip would be to cover the mounting of the turbines and the third trip would be to cover the installation of the blades and initial testing. During each trip, the production team would spend time documenting the construction as well as related monitoring activities. Beyond collecting footage of construction and fieldwork, the team would also conduct interviews of key team members to gather their insight into the process and results. This would provide a broad overall perspective of the process and outcomes.

After completing the filming, the team would isolate selected footage to create a media library for BOEM's use that would be sorted by month, activity and participants. This will provide easy access to the material for creating short sequences or sharing selected imagery with media or other parties.

In addition to the video captured during these trips, it is recommended that the video production team also develop a series of short animations that illustrate specific elements of the project. For instance, a short animation might illustrate how the cable is installed, showing the ship at the surface feeding the cable to the sled at seafloor burying the cable. Another animation could show how the electricity is collected from the turbines, through the cable array, through the various connecting cables and substations and ultimately flowing through the grid to power homes and industry. Additional animations would demonstrate the acoustic monitoring and show how the team is able to precisely measure sound levels and determine possible impacts. The animations, used alone as part of presentations at public meetings and other outreach, will help make complex systems that cover large geographic areas easy to understand and share with the public. In addition, the animations can be used as part of short vignettes and documentary projects that help tell the broader story of the projects activities.

There is a lot of interest in this project and by documenting it carefully through high definition video and informative animations and graphics, we are creating the building blocks necessary to make sure the story can be told clearly and with full information. Misinformation can quickly take hold in the absence of a full understanding of how the project is implemented and the careful monitoring in place. Collecting strong visual imagery that tells the story helps make sure the tools are available to provide easily understood depictions of the construction process, testing and monitoring.

2.7 Subtask 2.4.2.7 – Publications, Presentations, and Outreach

HDR team member URI will organize the effort to document the results in the form of conference presentations, and journal articles. Special attention will be devoted to the generation of information in the form of graphics and associated reports for communication to the non-governmental organizations, other federal and state agencies, and the public as required.

URI proposes that Dr. Miller present a paper concerning the measurement of the sound during pile driving at the Block Island Wind Farm at the Effects of Noise on Aquatic Life meeting, which will take place July 10-16, 2016 in Dublin, Ireland.

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3 Field Plan Implementation

3.1 Construction Schedule

The tentative schedule for BIWF Phase II construction is as follows:

1. **Sea2Shore Cable Installation** – scheduled to start in June 2016 and projected to be completed over 27 days.
2. **Turbine Installation** – scheduled to occur over four weeks in the summer of 2016.
3. **Turbine Operational Testing** – WTG operational testing will be conducted during the fourth quarter of 2016.

3.2 Coordination with the DWW and Construction Contractors

Prior to start of the monitoring activities, the HDR Team will coordinate through BOEM with DWW and National Grid to identify limitations that the monitoring team will be working under. These limitations could include areas that are off-limit for surveying due to Health and Safety considerations.

After the start of monitoring, periodic discussions will be held with the on-site construction contractors to ensure that both teams are fully aware of each other's activities and that vessel traffic is appropriately coordinated.

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4 Healthy and Safety Plan

All field activities will be conducted in accordance with the guidance contained in the HASP (**Attachment A**). The objective of the HASP is to define the requirements and designate protocols to be followed during the field data collection. Applicability extends to HDR RODEO Team personnel and visitors, inclusive of client personnel and representatives. Work performed by the HDR Rodeo Team and subcontractors will comply with applicable Occupational Safety and Health Administration laws and regulations. Through careful planning and implementation of corporate and site-specific health and safety protocols, HDR will strive for zero accidents and incidents on the project.

The HDR Team Program Management Staff is committed to the health and safety of each employee that participates in the field data collection effort. It is essential that all Task Managers and Field Supervisors insist on the maximum safety performance and awareness of all employees under their direction, by enthusiastically and consistently administering all health and safety rules and regulations.

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5 Permitting

Any additional permitting requirements for monitoring will be investigated and pursued by the HDR Team. HDR will provide BOEM notification of the permit requirements and the scope associated with acquisition and a request for a modification to the scope of work to address the necessary resources.

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6 Literature Cited

Hitchcock, D.R. and S. Bell. 2004. Physical impacts of marine aggregate dredging on seabed resources in coastal deposits. Journal of Coastal Research 20(1): 101-114.

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A

Draft Health and Safety Plan

Health and Safety Plan

Real Time Opportunity for Development of Environmental Observations (RODEO)

Monitoring Phase II Construction Activities at the Block Island Wind Farm

Block Island, RI

M15C00002 –
Task Order M16PD00006

Prepared by:

HDR

Athens AL Project Office
300 North Madison Street, Athens AL 35613

May
2016

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SIGNATURE PAGE

Monitoring Phase II Construction Activities at the Block Island Wind Farm

Contract M15C00002
Task Order M16PD00006

HEALTH AND SAFETY PLAN

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Project Manager:	Jamey Elliott	256-777-2766
Environmental Sciences & Planning Director:	Brian K. Hoppy	610-909-0351
HDR EOC Health and Safety Manager:	Daniel Sciarro	720-236-5104
Preparation Date:	May 2016	
Expiration Date:	May 2017	

APPROVALS

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Acronyms and Abbreviations

°C	Degrees Celsius
°F	Degrees Fahrenheit
AHA	Activity Hazard Analysis
BPM	Beats per minute
COR	Contracting Officer's Representative
EPIRB	Emergency Position-Indicating Radio Beacon
ESPD	Environmental Sciences & Planning Director
GPS	Global Positioning System
HASP	Health and Safety Plan
HP	Horse Power
MMO	Marine Mammal Observer
MOB	Man Overboard
NASBLA	National Association of Boating Law Administrators
OSHA	Occupational Safety and Health Administration
PIC	Principle-In-Charge
PFD	Personal Flotation Device
PjM	Project Manager
PM	Program Manager
PPE	Personal Protective Equipment
HSM	Safety Director
SOP	Standard Operating Procedure
SOW	Statement of Work
SPF	Sun Protection Factor
SSHO	Site Safety and Health Officer
QA/QC	Quality Assurance Quality Control
USCG	U.S. Coast Guard
UV	Ultraviolet
UVA	Ultraviolet A
UVB	Ultraviolet B

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Table 1. Emergency Contact List

Department	Telephone Numbers
United States Coast Guard First District Coast Guard	Main Phone: 617-223-8515 Emergency phone: 617-223-8555 Radio Channel VHF # 16
Marine Forecast - Norfolk:	Block Island Weather http://forecast.weather.gov/shmrn.php?mz=anz237&syn=anz200 NOAA weather marine VHF: channel 1marine VHF: channel 21
24-Hr Emergency Department:	Dial 911
WorkCare Incident Intervention:	888-449-7787
Hospitals:	Block Island Medical Center 6 Payne Road New Shoreham, RI 02807 Ph: 401-466-2974 Kent Hospital General Hospital 227 Centerville Rd Warwick, RI 02886 Ph: 401-737-7000
Emergency Responders	Police Department…………911 Fire Department……………911 Ambulance……………..……911
In Event of Emergency, call for help as soon as possible	Give the following information: 1) **Where you are.** Address, cross streets, or landmarks 2) **Phone Number** you are calling from 3) **What happened** – type of injury, accident 4) **How many persons** need help 5) **What is being done** for the victim(s) 6) **You hang up last**. Let whomever you called hang up first.
HDR Project Manager:	Jamey Elliott 256-777-2766 James.B.Elliott@hdrinc.com)
Project Coordinator:	Michael Richlen 808-388-7312 Michael.Richlen@hdrinc.com
HDR Program Manager:	Anwar Khan 954-494-2084 Anwar.Khan@hdrinc.com)
HDR Principle-In-Charge:	Randy Gallien 256-998-2441 Dennis.Gallien@hdrinc.com
HDR Environmental Sciences & Planning Director	Brian Hoppy 484-612-1131 Brian.Hoppy@hdrinc.com
HDR EOC Safety Manager	Daniel Sciarro 303-643-6724 Daniel.Sciarro@hdrinc.com
See vessel details for boats (**Appendix C**)	Lead Captains: *HDR Vessel* – Michael Richlen (cell): 808-388-7312 Other vessel contacts
Poison Control Center:	800-222-1222
Chemical Transportation Emergency Center:	800-424-9300
Emergency Centers:	National Response Center 800-424-8802
	CHEMTREC 800-424-9300

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1. Introduction

HDR has prepared this Health and Safety Plan (HASP) to cover field and vessel observations during cable installation and wind turbine generator (WTG) construction and operational testing. HDR will maintain and update the plan as necessary during the course of the work, based on direction received from the Contracting Officer (CO) or authorized representative. This plan will be a “living” document and will be administrated by HDR project management team. This document is applicable to activities and services performed and/or provided by HDR during Phase II construction activities associated with Block Island Wind Farm.

1.1 Plan Objective

The objective of this plan is to define the HDR safety and health requirements and designate project safety responsibility for protocols to be followed for all field staff during onshore on offshore vessel observations during the installation of wind turbine generator (WTG) foundations. Applicability extends to HDR personnel and visitors inclusive of client personnel and representatives. Work performed under this contract will comply with applicable Federal and State Occupational Safety and Health (OSHA) laws and regulations. Through careful planning and implementation of corporate and site-specific health and safety protocols, HDR will strive for zero accidents and incidents on the project.

1.2 Health and Safety Policy Statement

HDR’s management is committed to the health and safety of each and every employee. There is no place at HDR for an employee who will not work safely or who will endanger the health and safety of his fellow workers. It is essential that all Managers and Supervisors insist on the maximum safety performance and awareness of all employees under their direction, by enthusiastically and consistently administering all health and safety rules and regulations. It is HDR’s policy to take the necessary actions, in engineering, planning, designing, assigning and supervising work operations, to create a safe work-site. HDR will:

- Maintain safe and healthful working conditions
- Provide and assure the use of all necessary personnel protection equipment to ensure the safety and health of site employees
- Require that site work be planned to provide a range of protection based on the degree of hazards encountered under actual working conditions
- Provide site workers with the information and training required to make them fully aware of known and suspected hazards that may be encountered and of the appropriate methods for protecting themselves, their co-workers and the public at large.

1.3 Project Health and Safety Expectations

The health and safety of workers, clients and the public and the protection of the environment are a fundamental responsibility assumed by HDR under this contract. HDR will:

- Promote project health and safety with an objective of zero lost-time accidents
- Manage activities in a proactive way that effectively increases the protection of HDR site workers, the public and the environment
- Reduce health and safety risk by identifying and eliminating hazards from site activities
- Carry out site activities in a manner that complies with all applicable safety, health and environmental laws and regulations.

The success of our health and safety program is ensured by our ability to seamlessly integrate our health and safety procedures into a site-specific document that establishes safe and healthy work conditions for on-site operations.

1.4 Project Health and Safety Compliance Program

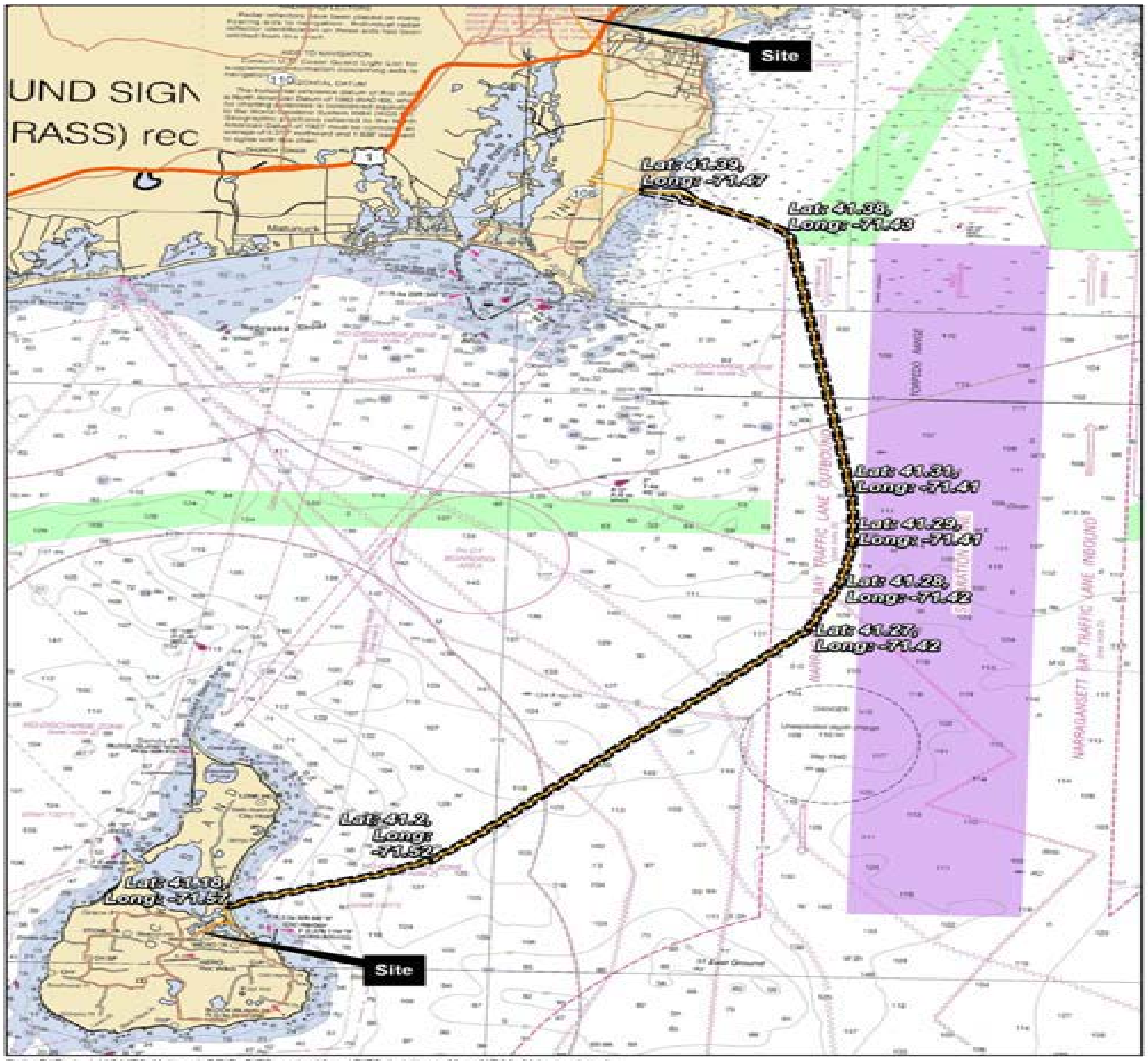
Compliance with the requirements of applicable Federal and state laws will be accomplished through a combination of written programs, employee training, workplace monitoring, and system enforcement. HDR and regular inspections by supervisors and health and safety personnel as well as the culture of ownership and total involvement in the health and safety program will produce an atmosphere of voluntary compliance. However, disciplinary action for violations of project requirements will be taken, when necessary.

The safe and efficient work practices of this company require a spirit of teamwork and cooperation from all employees. Also required are uniform standards of expected behavior. Employees who refuse or fail to follow the standard set forth by this plan, the HDR Corporate Health and Safety Program, and/or Regulatory standards will subject themselves to disciplinary action up to, and including discharge. In cases not specifically mentioned, employees are expected to use good judgment and refer any questions to their supervisors.

1.5 Safety and Health Plan Revisions

The development and preparation of this HASP has been based on site-specific information provided to HDR. Should any unforeseen hazard become evident during the performance of the work, the Project Manager (PjM) shall notify the Health and Safety HSM Manger (HSM) both verbally and in writing for resolution as soon as possible. In the interim, HDR project staff will take necessary actions to maintain safe working conditions in order to safeguard on-site personnel, visitors, the public, and the environment.

No changes to the HASP will be allowed until the hazard has been reviewed and changes approved by the HDR HSM and PjM. Changes to the HASP will be documented and submitted to the Contracting Officer Representative (COR). The final approval will be accompanied by a formal addendum to the HASP.



Path: P:\Projects\134478_National_GRID_BITS_project\Apps\BITS_Lat_Long_Map_NOAA_NoLegend.mxd

Figure 1. Overview of work area.

2. Organization and Responsibilities

All personnel are responsible for continuous adherence to this HASP during the performance of their work. The project personnel identified in the sections below have been designated as competent persons and will assume the authority and responsibility of their assignments herein. While the HDR Safety and Health Department directs and supervises the overall Safety, Health and Environmental Program, the responsibility for safety and health extends throughout our organization from top management to every employee. For this reason, it is each person's duty to notify project management personnel if a hazardous condition is identified and to make a "stop work" call if the condition represents an immediate danger to life or health., The Chief Scientist can make a further determination in consultation with the PM and/or PIC. The following are the HDR project personnel positions and responsibilities for this project:

• *Environmental Sciences & Planning Director*	Brian Hoppy
• *Program Manager*:	Anwar Khan
• *Project Manager:*	Jamey Elliott
• *Health and Safety Manager*	Daniel Sciarro
• *Project Coordinator:*	Michael Richlen
• *Observers*:	Michael Richlen Jamey Elliott URI Grad Student URI Grad Student URI Grad Student
• *Vessel Skippers*:	Michael Richlen Mark Deakos *TBD Charter*

2.1 Project Manager

The PjM reports directly to the PM and directs and manages the survey team in execution of the project activities in compliance with all contract and technical requirements. Technical direction will be given to the PjM by the Chief Scientist and changes to survey methodology will be approved by the Chief Scientist prior to PjM implementing. The PjM responsibilities include direction of data gathering and serving as the first line manager responsible for team safety. The PjM will ensure that survey personnel are briefed on QA/QC requirements, survey design, and ship safety requirements prior to embarking on each survey day. The PjM will support the Chief

Scientist and ensure any safety concern is brought to the attention of the Chief Scientist and will support the Chief Scientist in assessment of the situation and in implementing any required mitigation actions. The PjM will conduct daily tailgate safety meetings and necessary oversight of operations to ensure that health and safety requirements are continuously observed and implemented. The PM directs and manages all aspects of the project in compliance with all contract and technical requirements. The PM's responsibilities include serving as the primary liaison with the Contracting Officer Representative. The PM implements health and safety policy. He may request assistance from corporate resources at any time. He is specifically responsible for:

- Ensuring that appropriate health and safety training is provided on any equipment received
- Immediately reporting to the Chief Scientist/Site Safety and Health Officer (SSHO) and SD any incident that results in injury or death
- Ensuring regular updates of the Activity Hazard Analysis (AHAs)
- Implementing specific checklists and timelines to ensure full implementation of this HASP
- Ensuring self-audits are conducted at the start of the project
- Monitoring proper use and maintenance of specified personal protective equipment and communication equipment
- Maintaining a high level of health and safety awareness among team members and communicate pertinent matters to them promptly.
- Implementing health and safety training requirements at the Site.
- Ensuring that appropriate health and safety training is provided on any equipment received.
- Immediately reporting to the HSM, any incident that results in serious injury or damage to equipment.

2.2 Monitoring Coordinator

The Monitoring Coordinator/ SSHO reports directly to the PjM and directs and manages technical aspects of the survey in compliance with all contract task order procedural and technical requirements. The Monitoring Coordinator responsibilities include direct communication with the PjM as necessary during monitoring survey activities. The Monitoring Coordinator may assist with preparing all draft correspondence, submittals, and other documentation required for the project and submits to the PjM for approval and transmittal to the COR. The Monitoring Coordinator may help with the preparations of reports and documentation and provides technical and safety direction to the PjM and inspection personnel during execution of the survey. The Monitoring Coordinator serves as the SSHO and will make on-the-spot decisions concerning safety concerns and has the authority to terminate the survey as necessary to ensure safety of the crew and team. The Monitoring Coordinator will prepare immediate and follow-on incident reports and will coordinate with the PjM and/or PIC as soon as practicable to obtain decisions on ultimate safety incident resolution as well as follow all the responsibilities outlined below.

2.3 Site Safety and Health Officer

Have the authority to ensure site compliance with specified health and safety requirements, Federal OSHA regulations and all aspects of the HASP. This includes, but is not limited to: AHA, air monitoring; use of Personal Protective Equipment (PPE), decontamination site control; standard operating procedures (SOP) used to minimize hazards; safe use of engineering controls; the emergency response plan; confined space entry procedures; spill containment program; and preparation of records. This will be accomplished by performing a daily safety and health inspection and documenting results on the Site Safety Inspection Form, located in Appendix A.

- Stop work activities if unacceptable health or safety conditions exist, and take necessary action to re-establish and maintain safe working conditions.
- Consult and coordinate any modifications to the HASP with the PjM and/or the PIC.
- Conduct accident investigations and prepare accident reports.
- Review results of daily inspections and document health and safety findings in the Daily Safety Inspection Log.
- Consult with the PjM and/or the PIC at the earliest opportunity to safely do so, concerning safety incidents.
- Coordinate health and safety activities with the boat captains and any other subcontractor(s) to ensure that the planned work objectives reflect adequate health and safety considerations.
- Perform site-specific training and briefing sessions for employees prior to the start of field activities at the site and a briefing session each day before starting work.
- Promote proper use and maintenance of specified personal protective equipment and communication equipment.

2.4 Health and Safety Manager

The Health and Safety Manager (HSM) will:

- Assist the development and oversight of the HASP.
- Be available for consultation during project emergencies.
- Ensure accident reporting and investigations are completed.

- Provide consultation as needed to ensure that this HASP is fully implemented.
- Coordinate any modifications to the HASP with the PM as needed.
- Provide HDR personnel with support for upgrading/downgrading of the level of personal protection.
- Assist in evaluating and recommending changes to engineering controls, work practices, and PPE.
- Approve the HASP by signature

2.5 Program Manager

The PM reports directly to the PIC and will:

- Be responsible for the development and oversight of the HASP
- Be available for consultation during emergencies
- Provide consultation as needed to ensure that the HASP is fully implemented and fully supported
- Provide first tier approval of any modifications to the HASP coordinate those changes with the PIC for final approval prior to implementation and HSM approval
- Ensure necessary resources are available to provide adequate personal protection and training to all survey team members
- Augment the PIC during his absence or unavailability.

2.6 Principle-In-Charge

The PIC and ESPD have final approval of the HASP. The PIC will coordinate with the HSM as necessary and will make recommendations relative to needed project safety requirements.

The PIC will:

- Evaluate all safety incidents to ensure appropriate actions are taken in a timely manner
- Provide guidance for recommended changes to the Marine Species Monitoring HASP
- Provide guidance to the HSM, PM, and Chief Scientist as necessary as to any needed changes, revisions, or modifications necessary to this HASP.

2.7 Environmental Sciences & Planning Director

The ESPD will coordinate with the PIC as necessary and will assist in decisions relative to safety requirements and programmatic safety measures necessary to ensure protection of all survey personnel. The ESPD will:

- Evaluate all safety incidences to ensure appropriate actions are taken in a timely manner
- Provide approval for all programmatic changes to the Marine Species Monitoring HASP
- Provide guidance to the PM and Chief Scientist as necessary.

3. Boating Safety

HDR employees must recognize the inherent hazards associated with working in and around water, whether directly exposed through wading/swimming, or potentially exposed while performing services on surface watercraft or near water bodies. This HASP presents information and guidelines on the safe performance of work on or near water, where the possibility of drowning exists and conforms to the requirements of 29 CFR 1926.106 – Working Over or Near Water, 29 CFR 1926.802 – Cofferdams, and 29 CFR 1926.605 – Marine Operations and Equipment [Barges].

NOTE: *Activities in many states are regulated by state OSHA plans, which may have certain requirements that differ, and are more stringent than the Federal requirements presented here. When performing services in these state plan areas, HDR will comply with the state promulgated OSHA regulations. It is not anticipated these will differ significantly from the Federal-based regulations presented herein.*

In addition to this HASP (Reference the HDR Corporate H&S Program, Boating Water Safety Procedure #18 for further guidance on boating and water safety).This HASP applies to all HDR personnel at HDR client sites and at HDR facilities. All employees that perform surface services on or around water, where the potential for drowning exists, will be impacted by this plan. Section 13 of the HDR Procedure #18 addresses certain boating & water operations associated with the use of large open water craft. The PjM shall determine if any project task under this HASP will subject HDR personnel to water hazards, and incorporate appropriate preplanning into the project design. Preplanning includes the identification and acquisition of necessary equipment (PFDs, skiffs, etc.) and the verification that exposed personnel have the knowledge and training to correctly use the equipment.

3.1 Definitions

Personal Flotation Device (PFD) – Equipment designed to prevent drowning. The United States Coast Guard (USCG) is the approving agency and divides all PFDs into 5 current classifications. Three classes are approved for HDR use – Class III, IV and V. Types III and V are designed to be worn as apparel around the body during all times of exposure, and are commonly referred to as "life vests, life preservers, float coats, or float suits." Type IV are circular life rings designed to be thrown to personnel who are in the water, as a rescue measure. All vessel personnel are required to wear an automatically inflated PFD at all times while on the boat. Any personnel who are required to board the vessel for short periods of time and do not have automatically inflated PFD will be provided a Class III or V PFD by the vessel's captain.

Ring Buoy – Type IV life ring, with a retrieval rope attached.

NOTE: For cold weather work on boats, or on floating docks where the risk of falling into the water is present, if the water plus air temperature is less than 43.3 degrees Celsius (℃) a float coat or a float suit must be worn in lieu of a vest-type PFD.

Simply stated: Water temperature + air temperature < 43.3 ℃ = float coat or suit required. If this is contradictory to the heat stress brought on by wearing float coats or suits, then float coats or suits will not be worn. However, lifejackets will continue to be worn at all times.

Emergency Position Indicating Radio Beacon (EPIRB) – ACR GlobalFix™ iPro GPS EPIRB offers the latest in marine electronic life-saving technology. The iPro allows you to interface your onboard GPS to ensure that your latitude/longitude (LAT/LON) are stored inside so the coordinates are transmitted in the first data burst. iPro's internal GPS is optimized for cold starts and will pinpoint your exact location faster than standard GPS enable EPIRBs.

3.2 Marine Radio

Marine radios transmit along VHF/FM frequencies and are much more reliable than Citizen's Band (CB) radios. In addition to this more advanced technology, Marine Radios have designated channels that are monitored 24/7. Channel 16 is the international channel for all distress calls.

3.3 Medical Support

Emergency contingency information including on-site emergency contacts and offsite medical arrangements are summarized on the Emergency Contacts page of this HASP. If an injured individual is ambulatory, they should be transported to the nearest marina where medical services can obtain access.

3.4 Emergency Radio Calls/ Distress

3.4.1 How to Call for Help:

- Makes sure you radio is transmitting on Channel 16.

3.4.2 If you are in distress:

- Call "MAYDAY, MAYDAY, MAYDAY".

3.4.3 If you are not in distress:

- Call "Coast Guard".

3.4.4 What to tell the USCG:

- Your location or position
- Exact nature of the problem or emergency

- Number of people on board
- Your boat's name, registration, description, and safety equipment on board.

3.4.5 When to Call Back:

- A medical emergency develops
- A storm approaches
- Your boat begins to take on water
- Your last reported position changes.

3.4.6 Emergency VHF/FM CHANNELS

The following are some useful Channels to know, the most important of which is:

CHANNEL 16 VHF/FM 2182 kHz HF/SSB for international distress, safety and calling.

Table 2. Radio Calls

Channel Number MHz	Ship Transmit	Ship Receive MHz	Use
16	156.800	156.800	International Distress, Safety and Calling. Ships required to carry radio, USCG, and most coast stations maintain a listening watch on this channel.
21A	157.050	157.050	USCG only
22A	157.100	157.100	USCG Liaison and Maritime Safety Information Broadcasts. Broadcasts announced on channel 16.
13	156.650	156.650	Ships >20m length maintain a listening watch on this channel in US waters.

3.5 Over-Water Safety Requirements

Whenever work is conducted from the barge or monitoring vessels, there is an inherent risk of falling off and being immersed in water, with a risk of drowning or hypothermia. To minimize the risk of drowning hazards, the following will be performed:

- All HDR personnel on a boat, barge, or on the pier will be required to wear a Personal Flotation Device (Type III or V)
- The pier and boats will have tools and equipment organized in a manner to minimize trip/fall hazards.

3.6 Sinking/Flooding

In the unlikely event a hull is compromised, personnel will immediately evacuate the barge or boat and go to shore. All personnel are required to wear personal flotation devices when on the boat. Under no circumstances will personnel endanger one's own life to attempt to save another.

3.7 Man Overboard

All personnel are required to wear personal flotation devices when on the boat. In the unlikely event a person falls overboard, personnel will immediately assist using the following directions. Under no circumstances will personnel endanger one's own life to attempt to save another.

- Immediately throw a lifebuoy and attachment overboard. Immediately throw any other items that float over to assist in marking the spot.
- Raise the alarm by shouting: "MAN OVERBOARD" (Even if you are the only one left aboard, shouting "man overboard" may provide reassurance to the person in the water). If there are others on board, instruct a crew member to watch the person in the water and point continuously.
- Start your recovery maneuver. If possible note your position – most GPS units have a MOB function - it may prove vital if contact is lost with the person in the water.

  REMEMBER the MOB function records where the person fell overboard - he/she will drift away with the tide.
- If you are the only person remaining on board, do not leave the deck as you may become disorientated and lose sight of the person in the water.

4. Heat Disorders

All crew will be familiar with the signs of dehydration, heat stress, heat stroke, and sunburn. Crew will need to take their own ample water supply on the survey vessel at all times and the SSHO will encourage everyone to drink plenty of liquids. In the event of someone demonstrating signs of heat disorders, they will be placed in a cool environment and allowed to cool down following the first aid treatment provided below, as needed and appropriate. Sun exposure is also a serious concern. All team members will be required to have sunglasses and sunscreen (SPF 15 or greater) readily available to avoid sun blindness and sunburn.

4.1 Heat-Related Illnesses

There are four typical types of heat-related illnesses (result of heat strain) resulting from prolonged exposure to high thermal environments (stressor which causes the strain). These are described in the sections below.

4.1.1 Heat Rash (Prickly Heat)

Heat rash is a painful temporary condition caused by clogged sweat pores. Heat rash is caused by the plugging of sweat ducts due to the swelling of the moist keratin layer of the skin which leads to inflammation of the sweat glands. Heat rash appears as tiny red bumps on the skin and can impair sweating, resulting in diminished heat tolerance. Signs and symptoms include:

- Tiny raised blustered red blisters or small pimples
- Pricking sensations, or itching during heat exposure
  - Most likely to occur on the neck and upper chest, in the groin, under the breasts, and in elbow creases.

Heat rash is usually a mild, temporary condition, although it decreases the body's ability to tolerate heat, as well as being a nuisance.

Treatment: Heat rash can usually be cured by providing cool areas; body powder may also help absorb moisture.

4.1.2 Heat Cramps

Heat cramps are characterized by painful intermittent spasms of the voluntary muscles following hard physical work in a hot environment. Heat cramps usually occur after heavy sweating, and often begin at the end of the workday. The cramps are caused by a loss of electrolytes, principally salt. This results in fluids leaving the blood and collecting in muscle tissue, resulting in painful spasms. Symptoms include muscle pain or spasms in the abdomen, arms, or legs.

Heat syncope is a condition caused by pooling of the blood in the extremities, usually related to activities where the person stands without moving for a period of time or sudden rising from a sitting or lying position. Factors that may contribute to heat syncope include dehydration and lack of acclimatization. The reduced blood volume to the head can cause fainting, which may in turn cause injuries. Symptoms include:

- Light-headedness
- Dizziness
    - Fainting.

4.1.3 Treatment:

Increase water ingestion. Eat normally throughout the day to replace electrolytes.

4.1.4 Heat Exhaustion

Heat exhaustion occurs when the body's regulatory system is not functioning efficiently. Symptoms of heat exhaustion include:

- Heavy sweating
- Extreme weakness or fatigue
- Low blood pressure
- Rapid pulse
- Dizziness, confusion
- Nausea
- Clammy, moist skin
- Pale or flushed complexion
- Muscle cramps
- Normal or slightly depressed body temperature
    - Fast and shallow breathing.

This is the most common form of serious heat illness encountered during employment activities. Any worker who is a victim of heat exhaustion may not be exposed to a hot working environment for an absolute minimum of 24 hours and, if fainting has occurred, the victim should not return to work until authorized by a physician.

Treatment: Move victim to a cool area, loosen clothing, and place in a head-low (shock prevention) position, and provide rest and plenty of fluids. Do not give coffee, tea or alcoholic beverages.

4.1.5 Heat Stroke

This is the most serious heat disorder and is life-threatening. Heat stroke is a true medical emergency. This results when the body's heat-dissipating system is overwhelmed and shuts down (thermoregulatory failure). Heat stroke results in a continual rise in the victim's deep core body temperature, which is fatal if not checked. Symptoms may include:

- Hot, dry skin; no perspiration
- Hallucinations
- Chills
- Throbbing headache
- High body temperature
- Confusion and/or dizziness
- Slurred speech
  - Unconsciousness may occur.

4.1.6 Treatment:

Call 911. First aid consists of immediately moving victim to a cool area; cool the body slowly by immersion in tepid (slightly warm) water or sponging the body with tepid water; treat for shock and obtain immediate medical assistance. Treatment response time is critical when assisting a victim of heat stroke! Do not give coffee, tea or alcoholic beverages.

4.2 General Heat Stress First Aid

First aid for heat stress conditions consists of proper evaluation of their condition, cooling the victim down, and rehydration. Specific actions which should be taken include:

- First-aid trained persons should be summoned to assist in evaluation of the victim's condition
- If heat stroke is suspected, outside medical responders should be immediately contacted, as this condition should be considered immediately life-threatening. **Call 911** immediately
- Impermeable clothing should be removed as soon as possible following the required decontamination steps, unless the delay could compromise the victim's health
- The victim's clothing should be loosened to aid air circulation
- The victim should be moved to a shaded, cooler location, preferably air-conditioned
- The victim should sit, or lie down if they are dizzy or at risk of losing consciousness

- The victim should be encouraged to drink cool water if they are not nauseous or losing consciousness
- The victim may be cooled down further by:
  - Moistening the head, neck, torso and clothing with tepid water
  - Spraying, sponging, or showering them with tepid water
  - Fanning their body, gently
  - To minimize the risk of shock, do not drench them with cold water, use tepid water, unless advised to do so by medical personnel.

4.3 Prevention of Heat Disorders

It is interesting to note that if a person works continually, for about a week, in a hot environment, he/she tolerates much hotter conditions than initially. This process of adjustment is termed "acclimatization". Acclimatization is essential if work is to be frequently performed in hot environments. Essentially, in acclimatized workers, their core body temperatures and heart rates are slower than non-acclimatized workers, and they sweat more but with less salt loss. Acclimatization to heat can, however, be lost almost as rapidly as it is acquired, if the worker is removed from the hot environment for a few days.

In order to prevent the onset of heat-related disorders, HDR employees should rely on the physiological monitoring methods described above, and practice the following good health measures.

4.3.1 Provision of Water (or other drinking fluids)

Fluids are a key preventative measure to minimize the risk of heat related illnesses. Each employee should have at least one quart per employee per hour for the entire shift. Each vehicle will carry at least 5 gallons of drinking water. This must be replenished at the beginning of each day. In addition, each employee is responsible for having a container (such as a Camelback or other means) so they can carry water with them throughout the day.

Coffee, tea and other warm and caffeinated beverages must be avoided. In addition, sport drinks and electrolyte replacement drinks are to be consumed in very limited quantities (one per day) as these contain sugar, which utilizes the bodies' water reserves to digest, thus dehydrating the individual.

Employees are encouraged to maximize water intake and realize that thirst is not an adequate indicator of sweat loss. Water should be consumed at a target rate of one cup every 20 minutes at a minimum.

If water containers are being shared by employees disposable/single use drinking cups need to be provided, or employees may use their own cup. In addition, a supervisor or designated employee shall be assigned to monitor the quantity and condition of the water. When water levels within a container drop below 50%, the water needs to be replenished.

4.3.2 Access to Shade (Rest Area)

Access to rest and shade or other cooling measures are important preventative steps to minimize the risk of heat related illnesses. Employees suffering from (or exhibiting symptoms of) heat illness or believing a preventative recovery period is needed, will be provided access to an area with shade that is either open to the air or provided with ventilation or cooling for a period of no less than five minutes. Such access to shade shall be permitted at all times.

The rest area should be shaded from the sun. Air-conditioned construction offices, trailers and work vehicles make good rest areas. When possible, rest areas should be readily accessible and near supplies of drinking fluids.

4.3.3 Additional Health Measures

To help prevent the onset of heat-related disorders, HDR employees should practice additional good health measures, such as:

- The workers should be as physically fit as possible. This is especially important concerning hot work. Obesity predisposes individuals to heat disorders.
- Older workers are at a disadvantage in hot work because the aging process results in a sluggish response of sweat glands, resulting in a less effective control of body temperature.
- A victim of a heat-related disorder is permanently predisposed to suffering a recurrence.
- Every worker is unique in his/her ability to handle heat. Work/rest periods should be based on the individual's capacity to safely handle the heat, not on a predetermined or inflexible time length.
- Alcohol has been commonly associated with the occurrence of heat-related disorders. Alcohol reduces heat tolerance.
  - Inform female workers of the possible adverse consequences of hot work while pregnant, due to elevated core body temperatures.

4.4 Emergency Assistance Procedure

Employees are directed to immediately report to their SSHO, symptoms or signs of heat illness in themselves, or in co-workers. Employees should not delay in reporting these observations.

To help ensure proper medical care is provided with minimal delay, SSHO shall take the following steps:

- Providing First Aid: Should an HDR employee exhibit signs of possible heat illness, the treatment procedures described above should be implemented.

Contacting EMS: If emergency medical service (EMS) is required, the HDR field supervisor (or a designee) shall contact EMS using the procedures presented in Table 1. Once contact is established, stay on the phone with EMS to provide clear and precise directions to the work site.

4.5 Sunburn Prevention

Ultraviolet (UV) rays are a part of sunlight that is an invisible form of radiation. UV rays can penetrate and change the structure of skin cells. There are three types of UV rays: ultraviolet A (UVA), ultraviolet B (UVB), and ultraviolet C (UVC). UVA is the most abundant source of solar radiation at the earth's surface and penetrates beyond the top layer of human skin. Scientists believe that UVA radiation can cause damage to connective tissue and increase a person's risk for developing skin cancer. UVB rays penetrate less deeply into skin, but can still cause some forms of skin cancer. Natural UVC rays do not pose a risk to workers because they are absorbed by the Earth's atmosphere.

Light-colored sand reflects UV light and increases the risk of sunburn. At work sites with these conditions, UV rays may reach workers' exposed skin from both above and below. Workers are at risk of UV radiation even on cloudy days. Many drugs increase sensitivity to sunlight and the risk of getting sunburn. Some common ones include thiazides, diuretics, tetracycline, doxycycline, sulfa antibiotics, and nonsteroidal anti-inflammatory drugs, such as ibuprofen. Creosote, often found on or in wood used for piers and railroad ties, can increase sensitivity to sunlight.

Sunburn is an often painful sign of skin damage from spending too much time outdoors without wearing a protective sunscreen. Years of overexposure to the sun lead to premature wrinkling, aging of the skin, age spots, and an increased risk of skin cancer. In addition to the skin, eyes can get burned from sun exposure. Sunburned eyes become red, dry, and painful, and feel gritty. Chronic exposure of eyes to sunlight may cause pterygium (tissue growth that leads to blindness), cataracts, and perhaps macular degeneration, a leading cause of blindness.

4.5.1 Symptoms:

Symptoms may include:

- Red, warm, and tender skin
- Swollen skin
- Blistering
- Headache

- Fever
- Nausea
  - Fatigue.

4.5.2 First Aid:

There is no quick cure for minor sunburn, but symptoms can be treated with the following:

- Aspirin, acetaminophen, or ibuprofen to relieve pain and headache and reduce fever
- Drinking plenty of water helps to replace fluid losses
- Cool baths or the gentle application of cool wet clothes on the burned area may also provide some comfort
- Workers with sunburns should avoid further exposure until the burn has resolved
- Additional symptomatic relief may be achieved through the application of a topical moisturizing cream, aloe, or 1 percent hydrocortisone cream
  - A low-dose (0.5 percent-1 percent) hydrocortisone cream, which is sold over the counter, may be helpful in reducing the burning sensation and swelling and speeding up healing.

4.5.3 If blistering occurs:

- Lightly bandage or cover the area with gauze to prevent infection
- The blisters should not be broken, as this will slow the healing process and increase the risk of infection
- When the blisters break and the skin peels, dried fragments may be removed and an antiseptic ointment or hydrocortisone cream may be applied
- Seek medical attention if any of the following occur
- Severe sunburns covering more than 15 percent of the body
- Dehydration
- High fever (>101℉)
  - Extreme pain that persists for longer than 48 hours.

4.5.4 Prevention:

Take the following steps to protect yourself from exposure to UV radiation:

- Provide shaded or indoor break areas.
- Wear sunscreen with a minimum Sun Protection Factor (SPF) of SPF 15.

- SPF refers to the amount of time that persons will be protected from a burn. The SPF rating applies to skin reddening and protection against UVB exposure.
- SPF does not refer to protection against UVA. Products containing Mexoryl, Parsol 1789, titanium dioxide, zinc oxide, or avobenzone block UVA rays.
- Sunscreen performance is affected by wind, humidity, perspiration, and proper application.
- Old sunscreens should be thrown away because they lose their potency after 1-2 years.
- Sunscreens should be liberally applied (a minimum of 1 ounce) at least 20 minutes before sun exposure. Special attention should be given to covering the ears, scalp, lips, neck, tops of feet, and backs of hands.
- Sunscreens should be reapplied at least every 2 hours and each time a person gets out of the water or perspires heavily. Some sunscreens may also lose efficacy when applied with insect repellents, necessitating more frequent application when the two products are used together.
- Follow the application directions on the sunscreen bottle.
- Another effective way to prevent sunburn is by wearing appropriate clothing.
- Dark clothing with a tight weave is more protective than light-colored, loosely woven clothing.
  - High-SPF clothing has been developed to provide more protection for those with photosensitive skin or a history of skin cancer.

Workers should also wear wide-brimmed hats and sunglasses with almost 100 percent UV protection and with side panels to prevent excessive sun exposure to the eyes.

5. Hypothermia Prevention & First Aid

This project has the potential to be ongoing in the cooler months of October through May. The information provided reviews the different cold related illness, prevention and first aid requirements.

5.1 Hypothermia

When exposed to cold temperatures, your body begins to lose heat faster than it can be produced. Prolonged exposure to cold will eventually use up your body's stored energy. The result is hypothermia, or abnormally low body temperature. A body temperature that is too low affects the brain, making the victim unable to think clearly or move well. This makes hypothermia particularly dangerous because a person may not know it is happening and will not be able to do anything about it.

5.1.1 Symptoms

Symptoms of hypothermia can vary depending on how long you have been exposed to the cold temperatures.

5.1.2 Early Symptoms

- Shivering
- Fatigue
- Loss of coordination
  - Confusion and disorientation.

5.1.3 Late Symptoms

- No shivering
- Blue skin
- Dilated pupils
- Slowed pulse and breathing
  - Loss of consciousness.

5.1.4 First Aid

Take the following steps to treat a worker with hypothermia:

- Alert the Field Team Leader and request medical assistance.
- Move the victim into a warm room or shelter.
- Remove their wet clothing.
- Warm the center of their body first-chest, neck, head, and groin-using a blanket

or other available items; or use skin-to-skin contact under loose, dry layers of blankets, clothing, towels, or sheets.

- Warm beverages may help increase the body temperature, but do not give alcoholic beverages. Do not try to give beverages to an unconscious person.
- After their body temperature has increased, keep the victim dry and wrapped in a warm blanket, including the head and neck.
  - If victim has no pulse, begin CPR.

5.2 Cold Water Immersion

Cold water immersion creates a specific condition known as immersion hypothermia. It develops much more quickly than standard hypothermia because water conducts heat away from the body 25 times faster than air. Typically people in temperate climates don't consider themselves at risk from hypothermia in the water, but hypothermia can occur in any water temperature below 70 degrees Fahrenheit (℉). Survival times can be lengthened by wearing proper clothing (wool and synthetics and not cotton), using a personal flotation device (life vest, immersion suit, dry suit), and having a means of both signaling rescuers (strobe lights, personal locator beacon, whistles, flares, waterproof radio) and having a means of being retrieved from the water..

5.3 Frostbite

Frostbite is an injury to the body that is caused by freezing. Frostbite causes a loss of feeling and color in the affected areas. It most often affects the nose, ears, cheeks, chin, fingers, or toes. Frostbite can permanently damage body tissues, and severe cases can lead to amputation. In extremely cold temperatures, the risk of frostbite is increased in workers with reduced blood circulation and among workers who are not dressed properly.

5.3.1 Symptoms

Symptoms of frostbite include:

- Reduced blood flow to hands and feet (fingers or toes can freeze)
- Numbness
- Tingling or stinging
- Aching
  - Bluish or pail, waxy skin.

5.3.2 First Aid

Workers suffering from frostbite should:

- Get into a warm area as soon as possible.

- Unless absolutely necessary, do not walk on frostbitten feet or toes-this increases the damage.
- Immerse the affected area in warm-not hot-water (the temperature should be comfortable to the touch for unaffected parts of the body).
- Warm the affected area using body heat; for example, the heat of an armpit can be used to warm frostbitten fingers.
- Do not rub or massage the frostbitten area; doing so may cause more damage.
  - Do not use a heating pad, heat lamp, or the heat of a stove, fireplace, or radiator for warming. Affected areas are numb and can be easily burned.

5.4 Trench Foot

Trench foot, also known as immersion foot, is an injury of the feet resulting from prolonged exposure to wet and cold conditions. Trench foot can occur at temperatures as high as 60 ºF if the feet are constantly wet. Injury occurs because wet feet lose heat 25-times faster than dry feet. Therefore, to prevent heat loss, the body constricts blood vessels to shut down circulation in the feet. Skin tissue begins to die because of lack of oxygen and nutrients and due to the buildup of toxic products.

5.4.1 Symptoms

Symptoms of trench foot include:

- Reddening of the skin
- Numbness
- Leg cramps
- Swelling
- Tingling pain
- Blisters or ulcers
- Bleeding under the skin
  - Gangrene (the foot may turn dark purple, blue, or gray).

5.4.2 First Aid

Workers suffering from trench foot should:

- Remove shoes/boots and wet socks
- Dry their feet
- Place gauze or other cloth between the toes

- Avoid walking on feet, as this may cause tissue damage.

5.5 Chilblains

Chilblains are caused by the repeated exposure of skin to temperatures just above freezing to as high as 60 ºF. The cold exposure causes damage to the capillary beds (groups of small blood vessels) in the skin. This damage is permanent and the redness and itching will return with additional exposure. The redness and itching typically occurs on cheeks, ears, fingers, and toes.

5.5.1 Symptoms

Symptoms of chilblains include:

- Redness
- Itching
- Possible blistering
- Inflammation
  - Possible ulceration in severe cases.

5.5.2 First Aid

Workers suffering from chilblains should:

- Avoid scratching
- Slowly warm the skin
- Use corticosteroid creams to relieve itching and swelling
  - Keep blisters and ulcers clean and covered.

5.6 Equivalent Chill Temperature

Equivalent Chill Temperature – The Equivalent chill temperature is the temperature that it feels like outside to people and animals. Equivalent chill temperature is based on the rate of heat loss from exposed skin caused by combined effects of wind and cold. As the wind increases, heat is carried away from the body at an accelerated rate, driving down the both the skin temperature and eventually the internal body temperature. Therefore, the wind makes it feel much colder. If the temperature is 0°F and the wind is blowing at 15 miles per hour (mph), the wind chill is -19°F. At this equivalent chill temperature, exposed skin can freeze in 30 minutes.

The Equivalent Temperature Table, presented in **Table 5**, should be reviewed along with local temperature and wind speed data prior to extended work in the cold, and preventative work restrictions and preventions, presented herein, should be followed.

Table 5. Cooling Power of Wind on Exposed Flesh Expressed as Equivalent Temperature (under calm conditions)

Estimated Wind Speed (in mph)	Actual Temperature Reading (°F)											
	50	**40**	**30**	**20**	**10**	**0**	**-10**	**-20**	**-30**	**-40**	**-50**	**-60**
	Equivalent Chill Temperature (ºF)											
Calm	50	40	**30**	**20**	**10**	**0**	**-10**	**-20**	**-30**	**-40**	**-50**	**-60**
5	48	**37**	**27**	**16**	**6**	**-5**	**-15**	**-26**	**-36**	**-47**	**-57**	**-68**
10	40	**28**	**16**	**4**	**-9**	**-24**	**-33**	**-46**	**-58**	**-70**	**-83**	**-95**
15	**36**	**22**	**9**	**-5**	**-18**	**-32**	**-45**	**-58**	**-72**	**-85**	**-99**	**-112**
20	**32**	**18**	**4**	**-10**	**-25**	**-39**	**-53**	**-67**	**-82**	**-96**	**-110**	**-121**
25	**30**	**16**	**0**	**-15**	**-29**	**-44**	**-59**	**-74**	**-88**	**-104**	**-118**	**-133**
30	**28**	**13**	**-2**	**-18**	**-33**	**-48**	**-63**	**-79**	**-94**	**-109**	**-125**	**-140**
35	**27**	**11**	**-4**	**-20**	**-35**	**-51**	**-67**	**-82**	**-98**	**-113**	**-129**	**-145**
40	**26**	**10**	**-6**	**-21**	**-37**	**-53**	**-69**	**-85**	**-100**	**-116**	**-132**	**-148**
Wind speeds greater than 40 mph have little additional effect.	LITTLE DANGER In < hr with dry skin. Maximum danger of false sense of security.				INCREASING DANGER Danger from freezing of exposed flesh within one minute.			GREAT DANGER Flesh may freeze within 30 seconds.				
	Trench foot and immersion foot may occur at any point on this chart											

[shaded] Equivalent chill temperature requiring dry clothing to maintain core body temperature above 36 Celsius (℃; 98.6 ºF) per cold stress threshold limit value (TLV).

* Developed by the U.S. Army Research Institute of Environmental Medicine, Natick, MA.

6. Other Physical Hazards

6.1 Vehicle Safety

Seat belts will be worn at all times when driving and rules of the road will be obeyed while engaged in company business. Drivers must be legally licensed to drive. Personnel will not ride on boats hauled by trailers nor ride in the bed of a pickup truck.

Staff members are required to comply with all Federal, state, and local regulations regarding the use of cellular devices while driving. If a cellular device must be used during vehicle operation, a hands-free device must be used. Under no circumstances is text messaging or any use of a keyboard allowed while operating a vehicle.

6.2 Slips/Trips/Falls

As with all fieldwork sites, caution will be exercised to prevent slips on rain-slick surfaces, stepping on sharp objects, etc. Slip/trip/hit/fall injuries are the most frequent of all injuries to workers. The boat deck will likely be wet so caution must be taken when moving.

All injuries can be prevented by the following prudent practices:

- Spot-check the work area to identify hazards
- Establish and utilize a pathway, which is most free of slip and trip hazards
- Beware of trip hazards such as uneven surfaces or terrain, wet surfaces, slopes
- Carry only loads that you can see over and around
- Communicate hazards to on-site personnel
    - Report and/or remove hazards.

6.3 Housekeeping

Responsibility for good housekeeping rests with each employee and shall be enforced by the SSHO. Keep all work areas clear (including all inside and outside areas). Supplies and material to be used, salvaged, or scrapped shall be stacked out of the way. Clean up all spills immediately to prevent slipping.

When using hoses, cables, or electrical extension cords, which must extend across decks, walkways, or stairs, position them in such a manner as to offer the least interference to people passing. Provide protection such as barricades or an inverted “V” device to prevent damage to the hose, cable, or electrical extension cord.

Clean up the area after each job (task) and at the end of the day. Remove tools and equipment to their proper places. No job is complete until this has been done.

6.4 Sanitation

The majority of vessels shall have a head (toilet) onboard. However, the 730 LE does not. The boat will be brought into shore for those needing to use restroom facilities. In addition, soap and water and/or sanitizer will be available for hand washing prior to eating and drinking on the boat.

6.5 Noise

Noise exposure may have a potential to occur during site observation and monitoring activities, especially when working around vessels and or heavy equipment. Noise has been defined as unwanted sound. The OSHA standard allows 90 decibels [dBA] for a full 8 hours and for a lesser time when the levels exceed 90 dBA. It is usually safe to assume that if you need to shout to be heard at arm's length, the noise level is at 90 dBA or above. Based on the nature of activities to be performed on site, the use of heavy equipment, power tools and other noise producing devices, personnel may be exposed to noise levels in excess of the allowable limits. Therefore, hearing protection will be utilized by personnel operating or working in areas near equipment emitting noise levels at or above 85 dBA. Employees exposed to 85 dBA or a noise dose of 50 percent must participate in the Hearing Conservation program including initial and annual (as required) audiograms. Hearing protection will be maintained in a clean and reliable condition, inspected prior to use and after any occurrence to identify any deterioration or damage, and damaged or deteriorated hearing protection repaired or discarded. In work areas where actual or potential high noise levels are present at any time, hearing protection must be worn by employees working or walking through the area. Areas where tasks requiring hearing protection are taking place may become hearing protection required areas as long as that specific task is taking place. High noise areas requiring hearing protection should be posted or employees must be informed of the requirements in an equivalent manner. When hearing protection must be worn, either ear plugs or ear muffs with an NRR30 will provide adequate protection.

6.6 Electrical Equipment Hazards

Field staff should assume electrical equipment may be live with current and caution should be taken to avoid any contact with potentially "live" electrical equipment. Electrical dangers can include short-circuit arcing faults, shock, or electrocution. Only "Qualified Persons" shall identify "live" electrical equipment. Qualified Person in accordance with OSHA's electrical worker term, describes a person "familiar with the construction and operation of the electrical equipment and the hazards involved." OSHA mandates that workers working on exposed energized electrical components, of 50 volts or more, be trained as a "qualified person"

If employees are "exposed", then the procedures presented in the HDR LOTO Energy Control Plan will be implemented. This is called the Lockout Tagout Program and as part of the program employees will need to be trained if this danger exsist due to

Servicing, Maintenance or Repair (unplanned servicing activities not integral to normal production.) .If these activities expose any part of an employee's body to a hazard caused by the sudden release of stored, potential or residual energy, it is covered by the HDR ECP.

It is important that safe work practices be employed to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts when work is performed near equipment or circuits which are or may be energized and that may affect the safety of HDR employees.

6.7 Energy Control Plan

There are four common types of energy present in energized equipment, which if released unexpectedly, could result in employee injury. These four types of energy are electrical, hydraulic, pneumatic, and mechanical compression. These are discussed below:

Electrical – This is the most common and familiar type of energy source present in many machines, especially fixed industrial equipment. The presence of electrical energy requires that the energized equipment be connected to an outside electrical source, either externally generated (A.C. line current), or internally generated from a stored electrical source (i.e., D.C. Battery). Electricity may also be supplied from outside the system, but stored within it in capacitors and high-capacitance elements that must be discharged or short-circuited and grounded to safely release this energy.

Hydraulic – Hydraulic energy is generated by the compression of fluid, whose resultant pressure generates the equipment movement. Prior to servicing, the stored pressure (potential energy) in hydraulic lines leading to movable equipment parts must be bled off, so as to release the fluid pressure, thus converting the potential energy into safely controlled kinetic energy.

Pneumatic – Pneumatic energy is generated by pressurized or compressed air (or other gas). This high-pressure air, fed to the equipment through a small diameter hose, powers various equipment components. Like hydraulic energy, during machine shutdown, this potential energy remains in the hoses and may be released suddenly, causing injury. Prior to equipment servicing, air pressure in these hose lines must be released to expend the stored energy present in the compressed air. If the line gas is something other than air, the uncontrolled release could pose environmental problems. The release of bulk pure oxygen is prohibited, as static electricity or friction could result in a fire.

Mechanical Compression – A mechanical compression system employs a spring or other type of object, which stores energy by being forcibly compressed during the machines operating cycle, and suddenly releases this energy through the expansion of the spring. This sudden and forcible release of mechanical energy can cause severe injury. This hazard is prevented by the placement of a blocking device against the spring, holding it in place to prevent expansion. The same blocking principle is used to prevent the gravity-caused fall of heavy machine components, when the authorized employee has to place any body part underneath a pneumatic or hydraulically powered component.

6.7.1 Definitions

Affected Employee – An employee who is working in the immediate area of an ongoing lockout event. All affected employees need to be informed of a lockout event prior to initiation, to prevent them from inadvertently attempting to operate the equipment or controls while the authorized employee is performing the lockout. Affected employees are never allowed or authorized to place, alter, or remove any lock out or tag out device.

Authorized Employee – A person who implements a LOTO Procedure on machines or equipment to perform the servicing or maintenance on that machine or equipment. The only person who may remove a lock or tag, under this program, is the authorized employee who originally affixed the lock/tag (For unusual situations, where the lock-affixing authorized employee is physically absent due to personnel change, sudden sickness, etc., Transference of LOTO Responsibility).

Energy Isolating Device – A mechanical switch that physically prevents the transmission of energy. Examples include circuit breaker, disconnect switch, line valve, or positive line block. Some machines may have multiple switches. An energy isolating device must be capable of being locked “out”, to prevent accidental energizing. Thus, pushbutton switches, selector switches, and other control circuit type devices are not energy isolating devices.

Lockout – The placement of a padlock on an energy isolating device, in accordance with this procedure, that maintains the device in the “off” position. This ensures that the energy isolating device and the equipment being controlled cannot be operated until the lock is removed. The lock may be either keyed or combination. If multiple authorized employees must perform simultaneous servicing, each authorized employee must place his/her own lock on a group lockout device, attached to the energy-isolating device.

Lockout Device – Refers to a lock, also called padlock. May be keyed or combination. Keyed locks are preferable. If keyed locks are used, one key is issued to the authorized employee “owning” the lock, and a second is maintained by the employer. All locks used for LOTO purposes must be identifiable as such – they must be identical in either color, size or shape. It is recommended that colored locks be used since other non-LOTO locks of the same size or shape may be present on project sites. Locks designated for this program may never be used for any other purpose (They cannot be used to lock project lockers, for personal security, etc. This defeats the purpose of “instant awareness” afforded by using identically shaped, sized or colored locks in this program.). Lockout devices must indicate the identity of the employee applying the device(s).

Normal Production Operations – The utilization of a machine or equipment as it was intended. Minor repairs or adjustments, made while the machine is operating, that are normal for the operation, and do not require removal of a machine guard, and do not present a hazard, are exempt from this Plan.

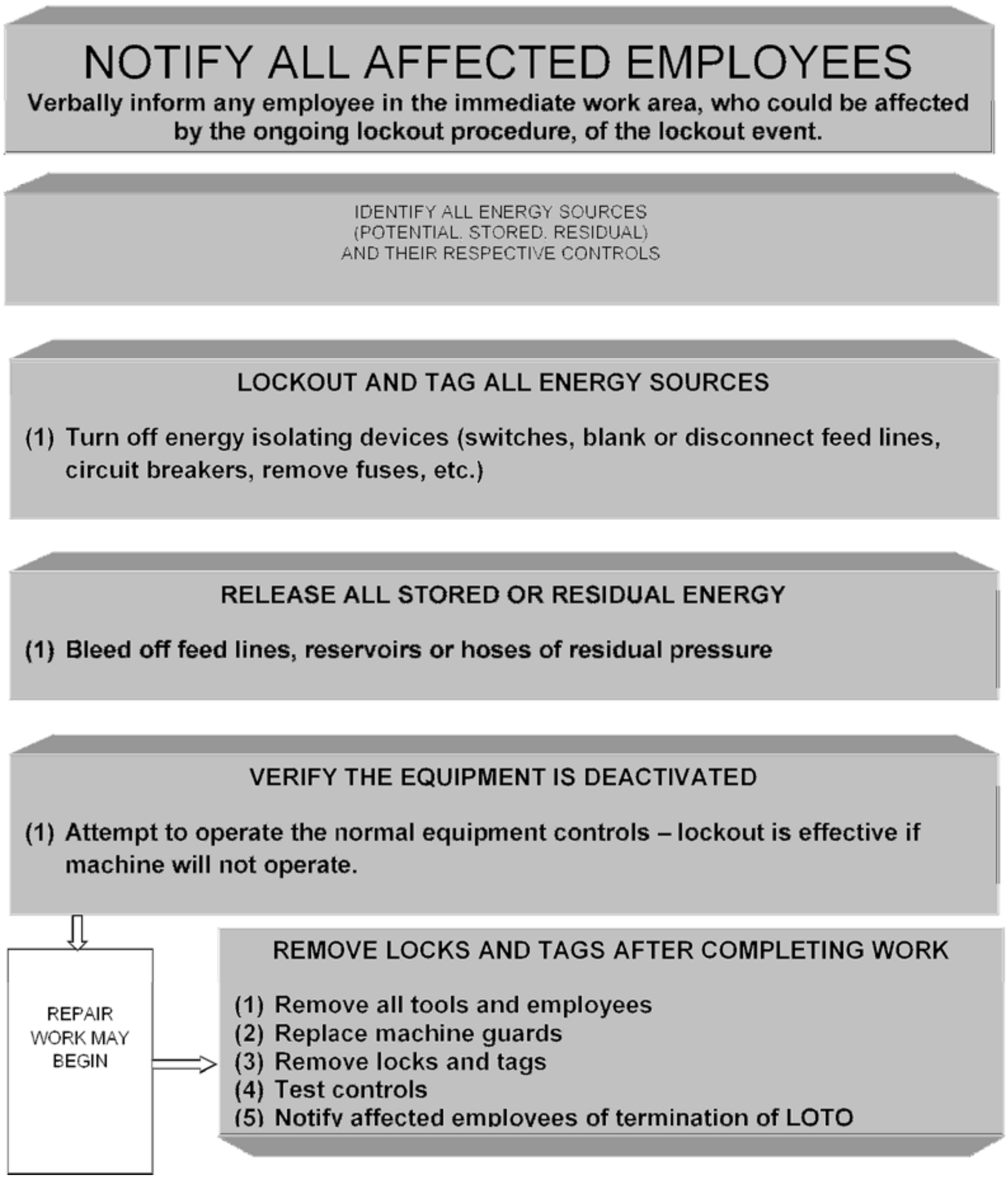
Qualified Person – OSHA electrical worker term, describing a person “familiar with the construction and operation of the [electrical] equipment and the hazards involved.” OSHA mandates that workers working on exposed energized electrical components, of 50 volts or more, be trained as a “qualified person” (If the electrical component is not exposed, then the procedures presented in this energy control plan will serve to adequately lock out the energy source, and the designation of “qualified” does not apply.). This training may be accomplished by classroom training, on-the-job experience, or a combination of both.

Servicing, Maintenance or Repair – Unplanned servicing activities not integral to normal production. If these activities expose any part of an employee’s body to a hazard caused by the sudden release of stored, potential or residual energy, it is covered by this Plan.

Tagout – The placement of a tagout device (tag) on an energy-isolating device, in accordance with this procedure, to indicate that the energy-isolating device and the equipment being controlled may not be operated until the tag is removed by the authorized person who originally placed the tag in position. Used to identify the authorized employee performing the lockout.

Tagout Device – A visually conspicuous standardized warning tag, with a strong attachment mechanism, that contains printed words, such as "DANGER - DO NOT OPERATE and EQUIPMENT LOCKED OUT BY…" and also contains information provided by the authorized employee identifying that employee, the date and time of LOTO initiation. The provided information shall be legibly printed, by a method (pen/pencil) that will not become illegible due to environmental conditions, for the anticipated duration of the LOTO activity. All tags utilized by HDR on a project site will be identical in size, color, etc., to assist employees in immediate recognition. Tags are considered non-reusable. The tag shall be affixed by a non-reusable, self-locking and non-releasable attachment that can withstand at least 50 lb of pressure without breaking. Tagout devices must indicate the identity of the employee applying the device(s).

6.7.2 Energy Control Procedures



6.7.3 Cord and Plug Exceptions to Lockout/Tagout

There is no requirement to perform LOTO on electrical cord and plug equipment, when electricity is the sole source of energy, and where the unexpected energization of the equipment can be controlled by unplugging the cord from the energy source. The unplugged cord must remain within sight, and under the exclusive control of the person performing the repair or maintenance. If visual observation of the cord/plug is not possible, the authorized employee shall affix a lockout device to the plug.

6.7.4 Training

Initial training will be provided to all HDR impacted employees to ensure that the purpose and function of the energy control program are understood and that the knowledge and skills required for the safe application, usage, and removal of the energy controls are acquired by employees. All training and retraining must be documented, signed, and certified. Documentation will be maintained by Corporate Safety. The training shall include the following areas:

- Authorized Employee: Each authorized employee shall receive training in the recognition of applicable energy sources, the type and magnitude of the energy available in the workplace, and the methods and means necessary for energy isolation.
- Affected Employee: Each affected employee shall be instructed in the purpose and use of the energy control procedure.
- Other Employees: All other employees whose work operations are or may be in an area where energy control procedures may be utilized, shall be instructed about the procedure, and about the prohibition relating to attempts to restart or re-energize machines or equipment which are locked out. This provision may apply to outside long-term contracted personnel working in HDR offices.
- Refresher Training: Refresher training shall be conducted whenever a new or revised control method and procedure is introduced, or whenever a deficiency in procedures is noted. HSM

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7. Biological Hazards

The section presents the potential biological hazards that exist at various sites throughout this project. Photographs of the species associated with biological hazards along with prevention and treatment methods are provided.

7.1 Bees, Wasps, and Hornets

Noxious insects are ubiquitous and can be encountered during field activities.

7.1.1 Background:

- Bees build hives in rock crevices and holes in trees.
- Wasps and hornets build nests in man-made structures and other areas where they are protected from the elements.

7.1.2 Prevention:

The following preventative measures should always be taken to minimize the chances of experiencing an insect bite or sting:

- Do not wear perfumes or colognes when performing field activities as they often attract stinging insects.
- Use an insect repellent.
- Wear protective clothing (long sleeves, long pants, and gloves).

7.1.3 Treatment:

The two greatest risks from most insect stings are allergic reaction (which can be fatal) and infection. General guidelines to follow if you experience an insect sting are as follows:

- If you are allergic, carry an Epi Pen and ensure your co-workers are informed of your allergy and the location of the Epi Pen.
- Do not drink a lot of liquid as this can cause vomiting.
- Remove the stinger by gently scraping it out with a blunt-edged object, such as a credit card or dull knife. Do not try to pull it out; this can release more venom into your body.
- For all types of stings, wash the area carefully with soap and water. Do this two to three times a day until the skin is healed.
- Apply a cold pack, an ice pack wrapped in a cloth.
- Apply a paste of baking soda and water for 15 to 20 minutes.
- Over-the-counter acetaminophen products can reduce pain.

- Some over-the-counter antihistamines advertise that they alleviate pain/swelling.
- Any employee who receives multiple stings should seek immediate medical attention.
- Any employee who knows that they are allergic to insect stings/bites should consult their own physician concerning the prudence of carrying self- administered anti-toxin injectable medicine.
- If any sting victim is complaining of a rapid heartbeat or tightness in the chest, keep the individual calm and in the shade. Seek medical attention immediately.

A sting in the mouth or nose warrants immediate medical attention, because swelling can block airways. You should also seek emergency care if you experience any of the following symptoms, which could indicate an allergic reaction:

- Large area of swelling
- Abnormal breathing
- Tightness in throat or chest
- Dizziness
- Hives
- Fainting
- Nausea or vomiting
  - Persistent pain or swelling (over 72 hours).

7.2 Centipedes and Scorpions

Centipedes and scorpions occur throughout the islands.

7.2.1 Treatment:

If you are stung by one of these invertebrates, do the following:

- If the victim is having a severe reaction, notify 911 or other Emergency Medical Services (EMS) assistance.
- Clean the affected area with soap and water.
- Apply cold compress to reduce the pain and swelling and to slow the spread of venom.
- Remove any rings or constricting items, since the bitten area may swell.

- Take steps to slow the rate at which the venom spreads in the victim's body. Have the victim stay still. Place the injured site below the level of the victim's heart and immobilize the injured site in a comfortable position.
- Watch for signs of shock.
- Raise the affected part, if possible.
- Seek medical attention by calling the Incident Intervention Care Team or transporting the victim to the nearest clinic.
- DO NOT apply a tourniquet.
- DO NOT raise the site of the bite above the level of the victim's heart.
- DO NOT give the victim aspirin, stimulants, or pain medication unless directed by a physician.
- DO NOT allow the victim to exercise.

7.3 Venomous Spiders

7.3.1 Treatment of Spider Bites:

Spider bites can be harmful and potentially deadly to humans. If you are bitten, do the following:

- If the victim is having a severe reaction, notify 911 or other EMS assistance.
- Clean the affected area with soap and water.
- Apply a cold compress to reduce the pain and swelling and to slow the spread of venom.
- Remove any rings or constricting items, since the bitten area may swell.
- Take steps to slow the rate at which the venom spreads in the victim's body. Have the victim stay still. Place the injured site below the level of the victim's heart and immobilize the injured site in a comfortable position.
- Watch for signs of shock.
- Raise the affected part, if possible.
- Seek medical attention by calling the Incident Intervention Care Team or transporting to the nearest clinic.
- DO NOT apply a tourniquet.
- DO NOT raise the site of the bite above the level of the victim's heart.
- DO NOT give the victim aspirin, stimulants, or pain medication unless directed by a physician.
- DO NOT allow the victim to exercise.

8. Personal Protective Equipment

Everyone on the survey vessels will have their own PFDs in case of emergency.

Selection of the appropriate PPE is a complex process, which takes into consideration a variety of factors. Key factors involved in this process are identification of the hazards, or suspected hazards, routes of potential exposure to employees (inhalation, skin absorption, ingestion, and eye or skin contact); and the performance of the PPE materials (and clothing seams) in providing a barrier to these hazards. The amount of protection provided by PPE is material-hazard specific. That is, protective equipment materials will protect well against some hazardous substances and poorly, or not at all, against others.

Other factors in this selection process to be considered are matching the PPE to the employee's work requirements and task-specific conditions. The durability of PPE materials, such as tear strength and seam strength, is considered in relation to the employee's tasks. The effects of PPE in relation to heat stress and task duration are a factor in selecting and using PPE.

The standard personal protective equipment for this project is:

- Multiple layers of long pants, including a thermal layer
- Multiple layers of long-sleeved shirts, including a thermal layer
- Mustang survival suit or comparable waterproof outer jacket and shell layer
- Sunglasses, as needed
- Facial mask to prevent wind burn, if needed.

8.1.1 Maintenance of PPE

All PPE will be inspected when received from the distributor, prior to use, and whenever questions arise as to the proper functioning of the equipment. PPE will be inspected for:

- General cleanliness
- Material degradation
- Proper functioning of adjustable, moving, or mechanical parts.

Protective equipment must be stored properly to prevent damage or malfunction due to exposure to moisture, sunlight, damaging chemicals, extreme temperatures, and impact. Many equipment failures can be directly attributed to improper storage.

All PPE must be cleaned by employees prior to storage, according to the manufacturer’s recommendations. PPE will not be stored in a wet condition. PPE hung up to dry will be located in an area free from contamination.

Improperly functioning equipment must be immediately taken out of service, "red-tagged", and stored in a secured location to prevent use by uninformed individuals. Maintenance on PPE will be performed only by authorized service representatives for the specific equipment, or by individuals within the company who are trained and authorized to perform the repairs. Records of inspections and repairs will be kept with the Health and Safety records. These records will be reviewed according to the records review schedule to note any recurring problems.

9. Emergency Response

After first taking necessary precautions for personnel safety, the FPM/SSHO will assess the situation, If it is serious, the affected personnel will be sent or taken to the nearest safe zone or hospital identified at the beginning of this HASP. If the accident is serious enough to endanger life or limb, the HDR FPM/SSHO is to contact emergency personnel at 911 and immediately begin life- saving measures. A response vehicle will be available at all times in the event that immediate transportation to a hospital or emergency care center is necessary for injured person(s).

First aid will be administered to the extent possible while waiting for emergency responders. During the emergency, HDR personnel will take reasonable measures to ensure that no further accidents or injury occurs, including the following:

1. stopping all operations,
2. isolating the area where hazard exists, and
3. keeping a fire extinguisher close at hand for preventive purposes.

Injured persons will be treated at the place they suffered the injury whenever possible. Where it becomes necessary to move a victim, care must be taken not to cause further harm. Victims will be instructed to remain calm until more advanced treatment arrives at their location. While awaiting advanced medical treatment the worker will be monitored and treated for shock symptoms. A first- aid kit located in a company vehicle will be available during all field operations at all times to treat minor cuts, scrapes, and other minor injuries. **Table 14** outlines basic guidelines for employee response to specific emergencies.

If the injury is not life-threatening, the employee will call the Incident Intervention Care Team at:

(888) 449-7787

The Care Team will triage the injury and recommend first aid measures. If needed, the Care Team will locate a clinic and recommend the employee be seen at the local clinic for the injury.

HDR employees with any injury (other than life-threatening) are required to call the medical hotline.

- An occupational nurse or occupational physician provides treatment advice via phone. This could be any of the following:
- If the employee is to be seen by a physician, WorkCare will call ahead to the local clinic or hospital and discuss the case with the treating physician.
- If first aid is the recommended treatment, WorkCare continues to follow up with the employee until they have healed. Continued follow up could be

anywhere from 1-45 days, depending upon the injury.

- WorkCare will notify HDR immediately concerning the injured person. If additional treatment beyond first aid is required, the injured personnel will be transported to the nearest medical center designated in this HASP or a location designated by the WorkCare occupational physician.
- Any injury or illness (whether on or off the job) may require work restrictions after the employee returns to work. If the injury or illness required a visit with a physician, the attending physician must complete an appropriate return to work form and it must be provided to HDR and the onsite SSHO prior to the employee returning to work. The return to work form must be documented in the employee’s file on-site.

Emergency	Response
Medical Emergency	• Always leave the area immediately if it is unsafe • Call the emergency number for assistance • Secure the area and the mechanism of injury (shut down equipment, secure unstable structures) • Render first aid to extent of your training, experience and equipment • Arrange for transport of victim to the nearest medical facility according to the appropriate medical transport guidelines. If the victim's condition is life-threatening, or has the possibility of change during transport, 911 must be called and transport made by ambulance For contact with chemicals, immediately take victim to eyewash or emergency shower, and have person wash area until outside responders arrive, or a minimum of 15 minutes • For inhalation exposures, remove to fresh air • Identify the type and amount of hazardous material released if possible • Contact emergency responders and give necessary information • Prepare victim for transport to medical facility by decontamination, as necessary • Do not allow any person to eat or smoke until decontamination has taken place • Do not allow any person to re-enter an area affected by hazardous material
Fire	• Notify co-workers, and commence evacuation as necessary • Assure that the emergency number has been called • Attempt to extinguish fire **if**: • The fire can be put out with one extinguisher, and • You can fight the fire with your back to an escape route or exit, and • The correct extinguisher is available, and • You possess the necessary training.
Severe Storm	• Secure your area • Move to a safe location • Tune radio to weather station for local conditions • Be prepared to evacuate

10. Fuel or Hazardous Material Spills

Upon a release of a fuel or hazardous material, personnel should take precautions for personal safety, and if possible contain the spill with onsite equipment, to the extent that the responder's training capability allows. If necessary, the SSHO will evacuate all non- response personnel and visitors to the refuge area. Fuels or hazardous materials must be properly containerized, labeled, and handled. Clean-up materials will be disposed of at an approved disposal facility. The HDR PM will notify the client if the spill is greater than the reportable quantity.

11. Communication/Remote Site Safety

The following actions will be taken by all survey staff while the vessel is away from shore:

- Inform the shore based observer by phone that you are departing and your vessel's planned activities for the day – which boat you will be on and which area you will be monitoring.
- Ensure VHF radios are available and in working order.
- Notify the shore based observer by phone once the vessel has returned to shore.
- If the shore based observer follower does not hear from you within thirty minutes of the agreed upon return to shore time, shore based observer will attempt to contact the vessel via VHF radio. If unable to make contact, the remaining vessels will be dispatched to search for the vessel in the pre-determined area of operation. If the search for the vessel is unsuccessful, the shore based observer shall notify the local Coast Guard (see contacts page) and request that they contact the vessel on VHF channel 16 to check on their safety and status before beginning an all-out search for the missing vessel. At this point, the shore based observer should notify the PjM and keep them informed as to the status of the missing vessel.

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12. Prevention of Alcohol and Drug Abuse

Plan for prevention of alcohol and drug abuse (Defense Federal Acquisition Regulation Supplement (DFARS) Subpart 252.223-7004)

HDR believes that alcohol or drug abuse is an illness requiring medical treatment. If you feel you may have an alcohol or drug-related problem, we encourage you to seek advice and help from your private physician or an agency with special licensing to provide treatment for chemical dependencies. Information related to substance abuse and treatment is available through the Human Resources Department.

Individuals, who use, possess, dispense, or distribute drugs at any HDR workplace may be subject to disciplinary action, up to and including discharge. The inappropriate use of prescription drugs is also prohibited. "Workplace" includes, but is not limited to, HDR offices, the physical work site, training sessions, business travel, conferences, work related social gatherings, etc. Any drugs confiscated will be turned over to law enforcement officials.

Individuals working under client contracts specifically calling for drug screening will, as a condition of working on those projects, be subject to baseline, periodic and perhaps random drug testing. HDR reserves the right to require a drug test as part of an accident investigation.

All individuals employed at HDR are required to abide by the terms of this policy statement. *Any employee who violates this prohibition shall be subject to disciplinary action. Such disciplinary action shall include any number of the following:*

- Discharge from his or her duties under the Federal contract
- Requiring participation in a substance abuse assistance or rehabilitation program
- Placement on "probation" of employment with HDR
- Termination of employment with HDR
- Any other action HDR deems necessary.

As a condition of employment, all employees must abide by the terms of the above statement and must notify the Human Resources Office of HDR of any criminal drug statue conviction arising from conduct in this workplace no later than five days after such conviction.

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13. Training and Records Retention

Prior to initiating site activities, the HDR SSHO will conduct a safety and health "Kick-off" or "Tail-gate" meeting. At this time, pertinent HDR procedures and this HASP will be discussed in detail with special attention being given to site physical hazards, PPE, emergency procedures, etc. Upon completion of this meeting and briefing, all routine field personnel in all areas, including subcontractors, will be required to read and sign the acceptance sheet of this HASP. Applicable field forms/documents can be found in Attachment A.

The HDR PjM and SSHO will maintain on site a copy of the certifications certifying that all HDR personnel have satisfied the minimum training requirements. Supporting documentation and certificates will remain on file with the HDR FPM/SSHO. Field work will not be allowed to take place in the absence of adequate documentation.

Additional site-specific training covering new site hazards, procedures, and contents left out of the approved HASP will be modified and added by the HDR HSM/PjM/SSHO for all on-site employees, prior to the commencement of any work not outline in this HASP, and also for visitors new to the project. The HDR SSHO will be responsible for maintaining a list on-site of training records and expiration dates of applicable training for all project personnel. The following will be completed by the onsite HDR SSHO before project starts:

- HSM Boating and Water Safety, to be discussed onsite by the SSHO
- A complete review of this HASP.
- Review of staffs safety training

A pre-job safety meeting will be held before the vessel departs on its initial survey on the first day of the fieldwork to review:

- Use of PFD
- A review of vessel safety features
- Site specific construction danger areas and protocols associated with working in or transiting through those areas.

An HDR Float Plan (see **Appendix A**) will be filed with the Monitoring Coordinator/ SSHO or a designated Point of Contact for each day's operations, and an Inspection Check List For Chartering Class III-IV (see **Appendix B**) shall be completed and submitted by HDR's Vessel Safety Ops Manager Michael Richlen to the PjM at the beginning of the project.

Records of all training will be maintained in the project files and in the HDR Connects system.

14. Accidents, Reports, and Recordkeeping

14.1 When to Report an Accident

If an accident occurs at any project location where an HDR employee is present (office, work site, hotel or vessel);

The first obligation of co-workers is to assist the victim and obtain medical assistance.

If the victim is an HDR employee, following the release of the victim to the medical authorities, the HDR employee(s) knowledgeable about the accident (this may be the injured employee, if able to do so) must notify the following HDR contacts immediately:

If a non-life threatening injury occurs at any project location where an HDR employee is present immediately call: INCIDENT INTERVENTION @ 1 (888) 449-7787

14.2 Incident Intervention

In the event of an accident or incident the HDR PM will be notified immediately. It will be the responsibility of the HDR PM/SSHO to investigate any accident and complete the HDR Accident form (see Attachment A), as appropriate. The HDR PM/SSHO will assist in these duties as appropriate.

All accidents, no matter how big or small and including near misses are to be reported to the HDR HSM within 24 hours.

The reporting procedure will be as follows:

- Following an injury accident involving any employee or subcontractor at the jobsite, the HDR PM will be notified immediately.
- The HDR FPM/SSHO will then complete an HDR Accident and Incident Report Form (Attachment A). The form will be forwarded to the client within 7 days of the incident. The form will also be provided to HDR Project HSM.

14.3 Accident and Incident Report Form

A current Accident and Incident Report Form and Accident Reporting Instructions, can be accessed at http://hdronline/ec/healthandsafety/Pages/AccidentNearMissReporting.aspx This form also includes the “Return to Work Form”.

If you are not able to complete the information online, you may access the form in the Appendix. The form should be completed and submitted as quickly as possible **and** e-mailed to:

Daniel Sciarro, HDR HSM
daniel.sciarro@hdrinc.com

14.4 Accident Investigation

Following notification that an accident or injury has occurred, The HSM will initiate a formal accident investigation. Those onsite, including witnesses will be interviewed and may be asked to assist in the investigation. A formal accident report will be provided to the PM upon completion of the investigation.

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A

Health and Safety Forms

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DAILY SAFETY MEETING

Date:________________________________ Time: ____________________________

SUMMARY OF WORK CONDUCTED AND PLANNED:

SPECIFIC HEALTH AND SAFETY ISSUES DISCUSSED:

ATTENDEES:

Name (print)	Signature	Name (print)	Signature

MEETING CONDUCTED BY:

Name (printed) **Signature**

Name (printed) **Signature**

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Employee Self-Audit-#7 Part 1

(Field Visit Checklist)

Project Manager, please fill out this form during project start-up and provide a copy to each employee on the H&S Field Staff (page 2). Rerum original pages 1&2 to your section's Admin for filing.

Project Manager's Name & Office —————————————————— ______________

Project Name & Number ————————————————————— ______________

GENERAL- *before field visit*

- O Review the HDR Project Safety Forrn!Guide for this project (PM will provide copy).
- O Know what Personal Protective Equipment (PPE) is required and acquire them. (H&S Pro #21) (Hard Hats, Safety Glasses, Traffic Vests, Steel Toe Boots, etc.)
- O Acquire any special equipment if necessary. (Respiratory Protection (H&S Pro #9) and/or Air Monitoring (H&S Pro #25))
- O Check to see if a first aid kit is in the vehicle, if not, check one out from the front desk.
- O Check the location of the nearest medical facility from the project location.
- O Will work include overnight travel? (HDR Safety Memo: Travel Safety Guidelines and someone receives copy of itinerary)

MISCELLANEOUS- *during or afterfield visit*

- All accidents require the completion of an AccidenUlncident Report. (See your OSC)
- Complete a Potential Unsafe Conditions Report for all potentially (serious) unsafe conditions. (See your OSC)

DOES YOUR PROJECT ASSIGNMENT INCLUDE THE FOLLOWING?

PROJECT SPECIFIC TASKS	YES	NO	Not sure? Resear ch
Electrical -*I.ockout/Tagout* (H&S Pro #4 & #7)	D	D	D
Demolition (H&S Pro #22)	D	D	D
Drill Rigs (H&S Pro #37)	D	D	D
Excavation (H&S Pro #5)	D	D	D
Work in Elevated Areas (H&S Pro #12)	D	D	D
Noise (Hearing Conservation) (H&S Pro #26)	D	D	D
Permit-Required Confined Spaces (H&S Pro #1)	D	D	D
Portable Ladders (H&S Pro #2)	D	D	D
Work at a Remote Site (H&S Pro #38)	D	D	D
Work on or around a Drill Rig (H&S Pro #37)	D	D	D
Work on Aerial Lifts (H&S Pro #36)	D	D	D
Bridge Inspection (H&S Pro #15)	D	D	D
Work on or around a Railroad (H&S Pro #14)	D	D	D
Work in or around Traffic (H&S Pro #17)	D	D	D
OTHER??	D	D	D

COULD EMPLOYEES BE EXPOSED TO THE FOLLOWING ON YOUR PROJECT?

ENVIRONMENTAL HAZARDS	YES	NO	Not sure? Research
Biological Hazards (H&S Pro #34) (snakes, spiders, mites, insects, noxious plants, bacteria, fungi, etc)	D	D	D
Cold Temperab.lres (H&S Pro #29)	D	D	D
High Temperab.lres/Humidity (H&S Pro #28)	D	D	D
CHEMICAL HAZARDS			
Asbestos (H&S Pro #10)	D	D	D
Bloodbome Pathogens (H&S Pro #8)	D	D	D
Hazardous Waste (H&S Pro #20)	D	D	D
Lead/Lead-Based Paint (H&S Pro #11)	D	D	D
OTHER??	D	D	D

Any questions concerning Health & Safety on your project, please feel free to contact:

- Office Safety Coordinators (OSC): Kevin Ashby at 602.522.7726 or Kurt Watzek at 602.522.4327
- Regional Health & Safety Coordinator: Brad Kruger at 402.399.1267

Employee Self-Audit-#7 Part 1

(Field Visit Employee Lit't)

Project Manager ,please provide each employee a copy of the completed self-audit on page 1 of this document and a completed copy of the Project Safety Form/Guide. Return original pages 1&2 to your section's Admin for filing.

Project Manager's Name & Number ______________ ____________

Project Name & Number ____________________ ____________

Employees expected to complete field work on project:

	Name	Home Office **if** Different from this one
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		

All listed staff were provided a completed copy of page 1of this document (Field Visit Checklist) and a completed copy of the Project Safety Form!Guide.

______________________________ ____________

Project Manager Signature Date

HDR FLOAT PLAN

Date:___/___/___ Submitted By: ____________________

Vessel Name: ________________ Engine type/manufacturer: ________________

Fuel capacity (hours): ____

Vessel Description:

Hull Material: ______________________________ Color: __________________

Manufacturer ____

Registration #: ________________________ Length: ______________________

Width: ______________________________ Draft: ______________________

Vessel Operator:

Name/Phone : ________________________ Experience Level: ______________

Health ____

Tow Vehicle:

Make _______________ Model ____________________ Color ___________

Plate # _______________ Location Parked: _______________________________

Itinerary:

Depart From:	Time:	Arrive at destination:	Time:	Arrival:

Destination/route:*	Purpose for trip:*	Weather condition by shore:	How Far out are you going?

Upon Return, vessel operator will check in with:

Float Plan Follower (via phone call or text message)

Persons Aboard:

Name	Age	Swim	Medical Conditions	Emergency Contact #

Equipment Checklist:

# PFDs:		**Medical Kit:**		**Flashlight:**		**Emergency contact List:**	
# Flares:		**Fire Extinguisher:**		**Anchor:**		**Paddles or oars:**	

Cell Phone # ______________________
Proper scale charts corrected, reviewed & aboard? _______
Radio Type: VHF/CB/other

*Attach complete description of work to be accomplished waypoints w/ estimated times of arrival and departure and a coms. Schedule and contact w/ shore based personnel. Refer to HDR Small Boat Operations Manual for Coms. Procedures.

INCIDENT REPORT

Fill this form out hardcopy only if you do not have access to HDR's online reporting system.

Employee Name

Location

(Select General Location of Incident)
- Active Mine Site
- Client Office
- Field or Construction Site
- HDR Office
- Parking Lot or Roadway
- Other ______________________

Circle one of the choices on the right and complete applicable questions

MINE

Enter MSHA Mine ID Number *(If Applicable)*

CLIENT OFFICE

Enter Name of Client *(If Applicable)*

FIELD/CONST SITE

Enter Name of Project *(If Applicable)*

Enter Project Number

Enter Name of Project Manager

Enter Name of Client *(If Applicable)*

OTHER

Enter Location details

ro;; ;

Indicate state or province where incident occurred

Date & Time

Date & Time (include A.M. or P.M.)

!:J!m!e *Office*

Home office of employee involved in incident

Operating Company

Circle One
- Architecture
- Canada
- CCC
- Constructors
- Corporate
- Engineering
- EOC
- HydroPower (DTA)
- United Kinl!!dom

Ine dent Type

Circle One
- YES, illness or impairment occurred
  Complete *Attachments 1 & 2*
- NO injury, illness or impairment, but potential for such existed
  Complete *Attachment 2*

INCIDENT REPORT

Attachment 1	
Witnesses *(HDR employees)*	
Witnesses *(non-HDR employees)*	
Did the incident occur within working hours? *(Circle One)*	YES NO (Occurred during break; before or after shift)
Work Impact *(Circle One)*	No Missed Time or Restricted Duties One or More Full Work Days Missed One or More Partial Work Days Missed Restricted Duties
If one or more full/partial work days are missed, or you have restricted duties, please specify the dates (do not include the day of the incident, but do count holidays and weekends)	Dates Missed ____ Restricted Dates ____
Medical Treatment needed *(Circle One)*	No Medical Treatment Needed *(Go to Attachment 2)* First Aid Given at Work Site *(Go to Attachment 2)* Medical Treatment Away From Work Site *£Go to Next questionl*
Medical Treatment Away From Work Site:	Provider Name: Facility Name: Facility Address:
Treatment Type (Circle all that Apply)	Emergency Room Visit Overnight Hospitalization Physical Therapy MRI/X-Ray/CT Scan Stitches/Glue Hard Splint/Brace Soft Splint/Brace Other
Splint or Brace Details *(Circle all that Apply)*	Ankle Knee Wrist Other
Prognosis *(Describe Doctor's orders)*	
Medical Follow-Up Dates *(If Any)*	
Medication *(Circle One)*	No Medication Needed Over the Counter Medication (OTC) at OTC Strength Prescription for OTC Medicine at Prescription Strength Prescription for Prescription Strength Prescription Written But Not Filled
Have you filed a Workers' Compensation Claim with your HR Representative? *(Circle One)*	YES NO

INCIDENT REPORT

Attachment 2

Describe Incident	
Enter detailed description of incident and where it happened *If more room is needed, attach additional documents to this Report* ***when returning***	
Hand Laceration	
Was incident related to hand laceration?	**YES** **NO**
If **YES,** were Cut-Resistant Gloves Worn?	**YES** **NO**
Causative Factors	
What circumstances contributed to the incident? *If more room is needed, attach additional documents to this Report* ***when returning***	
Suggestions for Prevention	
What changes may prevent the circumstances from reoccurring? *If more room is needed, attach additional documents to this Report when returning*	

When you are finished with this report, enter it into HDR's online reporting system or give it to our local OSC for entry.

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PROJECT KICK-OFF HEALTH AND SAFETY MEETING DOCUMENTATION FORM

Project Name/Number:

____________________________________ Task:____________________________

______________________ Date: ____ Work Area/location:

____

REVIEW TOPICS (CHECK OFF LIST AS COMPLETED):

- D Review Job Hazard Analysis (JHA) forms for the day's work
- D Discuss relevant safety protocols
- D Discuss emergency procedures and equipment (satellite phone, whistles, horns, etc.)
- D Identify/bring specific safety gear
- D Identify necessary medications and individual crew member's medical situations/precautions (if staff is willing to share with crew)
- D Is everyone comfortable with daily plan of action, safety, and any other issues/concerns?

TEAM MEMBER SIGNATURES:

By signing below I certify that I have read and understand the contents of the project-specific health and safety plan.

FIELD CREW LEADER'S SIGNATURE:

Signature:____________________________________ Date: __________________

NOTES/COMMENTS:

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WORKER/VISITOR REVIEW AND ACKNOWLEDGEMENT
OF THE SITE HEALTH AND SAFETY PLAN

Project Name: ______________________________

Job No.: ______________________________

Project Location: ______________________________

Client/Contract No.: ______________________________

I have been briefed on and understand the requirements of the Site Health and Safety Plan for the above site. By signing below, I acknowledge and agree to follow the Site Health and Safety Plan for this project.

Date	Name (Printed)	Company	Signature

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B

Inspection Checklist for Chartering Class III SRV Vessels

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INSPECTION CHECK LIST
FOR CHARTERING CLASS III-SRV VESSELS

Vessel Name: ____________________

Owner: ____________________

Address and Contact Information: ____________________

Operator: ____________________

Address and Contact Information: ____________________

Licenses held: ____________________

Vessel Type and General Description: ____________________

Length Overall: ____________________

Displacement: ____________________

Tonnage [GT/GRT/NT] : ____________________

Draft: ____________________

Radio Call Sign: ____________________

Number of Passengers/Scientists that can be carried: ____________________

Dates of planned charter: ____________________

Area of operations: ____________________

Type of operations or activities planned: ____________________

Number in planned science party: ____________________

Bridge and Navigation Equipment:

Communications Equipment:

Documentation:

Life Saving Equipment:

Exterior Decks and Equipment:

Fire Fighting Equipment:

Engineering:

Structural:

Miscellaneous:

C

Vessel Description

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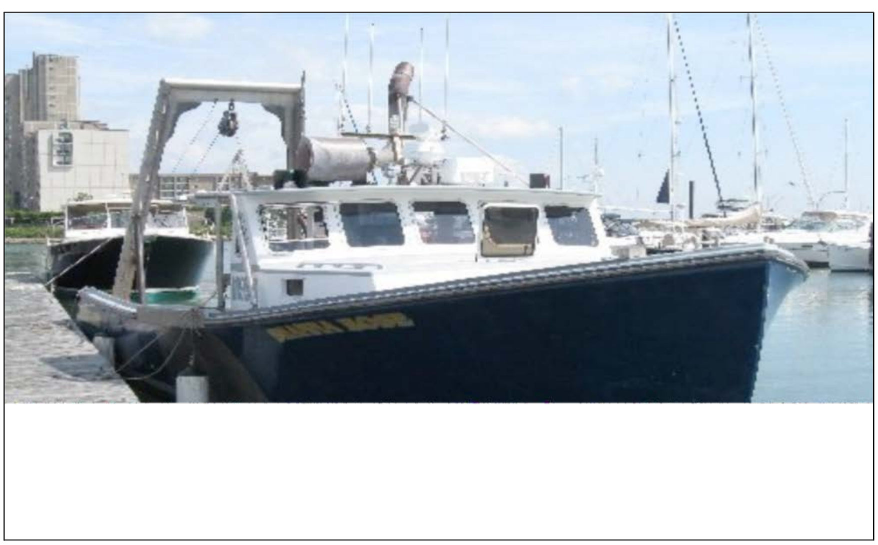
Willard Marine *Whale Research.* The Willard Marine Sea Force 730 LE is a 23 foot hybrid foam/air collar vessel with twin outboard Mercury 200HP engines. The research vessel has an open deck and covered console as well as an onboard navigation system, depth sounder, EPIRB, and additional USCG approve safety equipment.

R/V McMaster Sportcraft –URI owned, length 30' R/V McMaster is a 30' Sportcraft owned by URI It has an A-frame and a windlass that can be used for various sampling and deployment and retrieval of instruments. URI always uses ~600-700 lbs as our safe working weight for the A-frame. It was repowered with an inboard Mercruiser engine 5 years ago and has all required electronic equipment

Hula Dog. The Hula Dog is a 27’ long center console vessel manufactured by “Shamrock”. The vessel is equipped with start of the art radar, global positioning, sonar, and communications systems.

Shanna Rose. Shanna Rose is a 42' with a 14.6’ wide beam equipped with Lugger/Northern Light Turbo-Charged engine. It is equipped with state of the art electronics, VHF radios, EPIRB, and safety equipment for Coastal Navigation



D

Activity Hazard Analysis

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ACTIVITY HAZARD ANALYSIS

ACTIVITY HAZARD ANALYSIS **Vessel based monitoring**	**Name of Task:** **Real-Time Opportunity for Development of Environmental Observations (RODEO)**	**AHA No.:** 01	**Date:** **July 29, 2015**

Job Steps **Areas of Operation** ***Field Exploration Onshore***	**Potential Hazards**	**Health and Safety Controls**
• Drive to the marina • Crew to load gear and board small vessel at dock • Transit from marina WTG construction site offshore • Observe environmental conditions and record construction activities • Perform acoustic measurements • deteriorate, crew will transit boat back to marina	1. Vehicle Safety 2. Trips/Falls 3. Electrical Equipment Hazards 4. Over-water work 5. Pinching and Crushing 6. Rigging 7. Hypothermia 8. Heat Disorders 9. High Winds and Rain and/or Storms 10. Grounding (Bottoming out)	1. Seat belts will be worn at all times when driving and rules of the road will be obeyed while engaged in company business. 2. Caution will be exercised to prevent slips on rain-slick surfaces, stepping on sharp objects, etc. Work will not be performed on elevated platforms without fall protection PPE. Check soles of boots and shoes for wear. Footwear should have soles that provide good traction. 3. Personnel should assume all electrical equipment is live with current and caution should be taken to avoid any contact with electrical equipment. Electrical dangers can include short-circuit arcing faults and shock or electrocution. 4. All personnel on a boat, barge, and on the docks will be required to wear a Personal Flotation Device (Type V minimum). 5. Care will be taken by field employees when working with boats coming in and out of wharves to prevent pinching or crushing of body parts during operation. 6. Personnel will dress appropriately and regulate body temperature to avoid cold stress. 7. Heat Disorder precautions are discussed above. Personnel will dress appropriately. 8. In the case of extreme weather, vessel operations may cease or be delayed. 9. Follow protocols in the HASP

Equipment to be Used	Training Requirements	PPE Requirements
• GPS and navigator • Depth sounder / fish finder • Marine and VHF radio • Satellite telephone • EPIRB • Camera equipment with laser mount • Laser range finders • iPad for focal follows • Pool net to collect samples from water • Life jackets • Personal gear – hats, gloves, sunglasses, etc. • Water and food for the day	• HDR General Safety Awareness • HDR Safe Driving • HDR Disaster Communication • HDR Heat Stress • HDR Cold Stress	• All required PPE is listed in the HASP

ACTIVITY HAZARD ANALYSIS Onshore based monitoring	Name of Task: Real-Time Opportunity for Development of Environmental Observations (RODEO)	AHA No.: 01	Date: July 29, 2015

Job Steps Areas of Operation *Field Exploration Onshore*	Potential Hazards	Health and Safety Controls
• Drive to the observation site • Crew to unload gear • Observe environmental conditions and record construction activities • Perform acoustic measurements • If weather deteriorates, crew will transit boat back to marina	1. Vehicle Safety 2. Trips/Falls 3. Electrical Equipment Hazards 4. Pinching and Crushing 5. Hypothermia 6. Heat Disorders 7. High Winds and Rain and/or Storms	8. Seat belts will be worn at all times when driving and rules of the road will be obeyed while engaged in company business. 9. Caution will be exercised to prevent slips on rain-slick surfaces, stepping on sharp objects, etc. Work will not be performed on elevated platforms without fall protection PPE. Check soles of boots and shoes for wear. Footwear should have soles that provide good traction. 10. Personnel will dress appropriately and regulate body temperature to avoid cold stress. 11. Heat Disorder precautions are discussed above. Personnel will dress appropriately. 12. In the case of extreme weather, crew operations may cease or be delayed. 13. Follow protocols in the HASP
Equipment to be Used	**Training Requirements**	**PPE Requirements**
• GPS • Camera equipment with laser mount • Personal gear – hats, gloves, sunglasses, etc. • Water and food for the day	• HDR General Safety Awareness • HDR Safe Driving • HDR Disaster Communication • HDR Heat Stress • HDR Cold Stress	• All required PPE is listed in the HASP

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Appendix B: Visual Monitoring Data

During visual monitoring over 1,400 photographs were taken from the onshore and offshore monitoring stations. These photographs illustrate the types of activities that occurred during the construction. They were provided to BOEM on a DVD and are available upon request. **Tables B-1** and **B-2** provide a key to the photo logs. **Table B-3** summarizes meteorological data recorded during the monitoring

Table B-1. Onshore Photo Log Key and Field Observation Summary

Date/Timestamp	Observations Notes	Photo Frames ID
08/04/2016 15:04:26	Test	
08/07/2016 10:24:56	Initial observations of work area. Work has not started yet. Plan is to place one blade on wind turbine #2. Fred Olsen Wind carrier vessel the *Brave Tern* is positioned next to WTG2. A smaller lift boat is adjacent to *Brave Tern* acting as a supply ship with turbine blades.	1006-1009
08/07/2016 10:48:42	Blade is being lifted and attached to the nacelle.	1010-1020
08/07/2016 11:01:31	Crane is still holding on to the blade.	1021-1029
08/07/2016 11:08:22	Crane still holding on to the blade	1030-1031
08/07/2016 11:17:12	No noticeable noise from construction site. Crane is still holding the blade.	1032-1035
08/07/2016 11:41:28	Blade is still being held by the crane.	1036-1039
08/07/2016 11:49:56	Turbine is being rotated. Crane is still holding on to the blade.	1040-1044
08/07/2016 12:06:48	Turbine has rotated the blade down to get ready to install the second blade.	1045-1048
08/07/2016 12:26:02	Crane has begun to lift the second blade.	1049-1052
08/07/2016 12:32:44	Correction on last note: Crane has set hook on the deck. It is not picking up the other blade	
08/07/2016 12:40:54	Turbine has rotated to face east.	1053-1057
08/07/2016 13:02:05	Lift boat is positioned at WTG3 with towers on deck. Has lowered itself into the water	1058-1059
08/07/2016 13:02:26	No activity. Crane has not picked up the second blade yet	1060-1061
08/07/2016 13:26:38	Crane is lifting up the hook used to grab the blade	1062-1064
08/07/2016 13:44:57	Crane has moved the transport cradle to the second blade. Preparing to lift blade.	1065-1066
08/07/2016 14:05:18	Second blade is being put into position to install.	1067-1083
08/07/2016 14:35:56	Second blade is being installed into the nacelle	1084-1087
08/07/2016 15:00:11	Continuing to install the second blade into the nacelle at WTG2.	1088-1090
08/07/2016 15:24:02	Not finished installed the second blade yet.	1091-1092
08/07/2016 15:34:46	Still installing the second blade. Large shipping vessel is passing behind the turbines in the distance	1093-1094
08/07/2016 15:46:03	Second blade installed.	1095
08/08/2016 09:37:21	Start of day. Construction will occur on WTG 3. Transition decks for WTG 4 and WTG 5.	1096-1097
08/08/2016 09:40:24	200mm shot of Lift Boat *Brave Tern* and smaller supply lift boat at WTG 3. Neither lift boat is elevated.	1098-1099
08/08/2016 09:40:59	Deepwater Wind's *Atlantic Pioneer* at WTG 1 dropping/picking up workers	1100-1101
08/08/2016 10:31:51	Construction is scheduled to start at 12 so there has been no activity seen in the last hour. Completed WTG 1 and WTG 2 are visible.	1102-1105
08/08/2016 11:21:33	Still no activity at the construction site.	1106-1108
08/08/2016 11:28:03	Deepwater Wind indicates that construction will start at 1:30pm	
08/08/2016 11:55:40	Lift Boat *Brave Tern* is starting to raise up to get into	1109-1113

Date/Timestamp	Observations Notes	Photo Frames ID
	position.	
08/08/2016 12:06:17	Small Lift boat is also lifting up now	1114-1115
08/08/2016 12:40:20	Crane is now lifting	1116-1117
08/08/2016 13:05:33	Crane still moving into position	1118-1120
08/08/2016 14:00:21	Crane rotated to small lift boat but did not lift any pieces	1121-1124
08/08/2016 14:48:15	Crane is moving cage to smaller barge	1125-1129
08/08/2016 15:20:31	Crane has moved sling to hook up to WTG3 tower. Sailboat passing close to L/B *Brave Tern*.	1130-1135
08/08/2016 16:08:42	Crane lifting section of tower and putting it into place on the platform	1136-1157
08/08/2016 16:48:39	*Atlantic Pioneer* approaching the platform	1158-1162
08/08/2016 17:00:07	End of day. Crane still attached to first section of tower.	1163-1164
08/09/2016 09:20:36	WTG1 and WTG2 are fully assembled. Construction has started at WTG3. The nacelle was placed on tower overnight.	1165-1169
08/09/2016 10:28:25	Crane still attached to nacelle. No clear progress can be seen from the lighthouse	1170-1172
08/09/2016 11:09:38	Crane has detached from nacelle	1173-1176
08/09/2016 11:32:17	Crane has let go of nacelle and has moved to pick up the cradle for the blades	1177-1179
08/09/2016 12:01:37	Crane moved the cradle to the blade. It has not lifted the crane yet	1180-1190
08/09/2016 12:36:30	Blade has not left the small lift boat. They are still connecting the cradle to the blade.	1191-1194
08/09/2016 13:26:25	Started lifting the first blade for WTG 3	1195-1196
08/09/2016 13:35:06	Blade being lifted into place	1197-1213
08/09/2016 13:35:21	Blade is being mated to the nacelle	1214-1215
08/09/2016 13:36:12	200mm shot of crane holding the blade in place	1216-1217
08/09/2016 14:26:42	Crane still holding onto the blade	1218-1221
08/09/2016 14:47:07	Turbine is rotating. Crane is still attached to the blade	1222-1226
08/09/2016 15:28:11	Cradle is being released from blade	1227-1229
08/09/2016 15:28:28	*Atlantic Pioneer* at WTG 1	1230
08/09/2016 15:28:53	Cradle is being put down on large barge deck. Nacelle is being rotated	1231-1234
08/09/2016 15:50:05	Crane moving to lift up crate	1235-1236
08/09/2016 16:28:24	Crane has moved cradle to second blade	1237-1238
08/09/2016 16:45:04	Started to lift the second blade	1239-1248
08/09/2016 16:49:41	Moving the second blade into place	1249-1262
08/09/2016 16:58:29	Second blade is being put into place	1263-1270
08/09/2016 17:23:42	70mm photo of WTG 3 being built. 200mm shot of second blade attached to the nacelle	1271-1274
08/09/2016 17:49:29	End of day. Cradle is still holding on to blade #2 at WTG 3	1275-1277
08/10/2016 08:07:49	WTG 3 has been completed. The second and third blade were installed overnight. L/B *Brave Tern* is transiting to WTG 4. Foggy conditions.	1278-1282
08/10/2016 09:05:02	Lift boat *Brave Tern* has moved into position at WTG 4. Photos taken from the lighthouse porch due to rain.	1283-1285

Date/Timestamp	Observations Notes	Photo Frames ID
08/10/2016 09:55:19	Lift Boat *Brave Tern* has started lifting itself up. Smaller lift boat with tower section adjacent to WTG 4	1286-1288
08/10/2016 10:56:53	Lift boat have remained in the same position for the last hour. They are not fully elevated.	1289-1291
08/10/2016 11:57:47	LB *Brave Tern* has lifted itself into position. Small lift boat is preparing to lift itself up.	1292-1295
08/10/2016 12:17:10	Small lift boat is lifting itself up	1296-1299
08/10/2016 13:25:23	Both lift boats have lifted up. No activity with the crane.	1300-1302
08/10/2016 14:17:49	Lift boats have remained in the same positions for the last hour	1303-1304
08/10/2016 15:20:38	*Atlantic Pioneer* going out to WTG 3. Lift boat still in same positions they were an hour ago. No construction has occurred today.	1305-1308
08/11/2016 08:17:35	Start of day, fog makes it hard to see construction site. Both of the smaller lift boats are on site. One has the blades and other lift boat has the towers. No sections for WTG 4 were put up last night.	1309-1312
08/11/2016 08:35:24	Crane is moving	1313-1314
08/11/2016 09:06:32	Still poor visibility, However it looks like the crane is moving equipment around the *Brave Tern*.	1315-1317
08/11/2016 09:38:09	Crane is moving gear from the turbine platform to the L/B *Brave Tern*	1318-1319
08/11/2016 10:16:59	Crane is still moving equipment from the turbine platform to the barge.	1320-1321
08/11/2016 10:31:40	Moved onshore monitoring observation to porch at Southeast Lighthouse. Thunder heard in the distance.	
08/11/2016 11:01:52	Construction has stopped. Rain has started	1322-1324
08/11/2016 11:26:37	Heard on radio that workers from Deepwater wind were descending WTG 2 and were talking to the crew tender to get picked up. Workers were working inside WTGs.	
08/11/2016 11:46:55	Fog is starting to move in again. Light rain has started. Moved monitoring location to the porch because of rain.	1325-1326
08/11/2016 12:13:11	Crane has brought straps over to section of the tower to lift it up	1327-1329
08/11/2016 12:23:42	Straps are in place. They are about to lift tower for WTG 4	1330-1332
08/11/2016 13:10:48	Crane is moving tower section to platform. Photos are not very clear due to fog.	1333-1336
08/11/2016 14:07:08	Fog is still thick. Hard to see much in the 200mm picture	1337-1338
08/11/2016 14:52:32	Crane has moved hook to the small barge.	1339-1340
08/11/2016 15:05:20	Crane is moving to hook up to tower section. Photos are still not clear due to fog	1341-1342
08/11/2016 16:02:39	*Atlantic Pioneer* has dropped people off. crane has moved over the large barge	1343-1344
08/11/2016 16:24:18	Fog has moved back in. The barge can't even be seen now	
08/11/2016 17:07:14	Still can't see the wind turbines or construction site due to fog	1345-1346
08/12/2016 08:24:28	WTG 4 first section of tower is on, no progress overnight. Preparing to lift 2nd section.	1347

Date/Timestamp	Observations Notes	Photo Frames ID
08/12/2016 08:29:24	200mm WTG 4 preparing to lift 2nd section of tower.	1348
08/12/2016 08:30:09	WTG 1	1349
08/12/2016 08:30:29	WTG 2	1350
08/12/2016 08:30:45	WTG 3	1351
08/12/2016 08:30:58	WTG 4 with L/B *Brave Tern*	1352
08/12/2016 09:21:07	WTG 4 unhooked from second section of tower	1354
08/12/2016 09:49:22	WTG 4 no activity	1355-1357
08/12/2016 10:19:25	WTG 4 no activity visible.	
08/12/2016 10:36:42	200mm WTG 4 no activity	1358
08/12/2016 10:37:09	70mm WTG 4 no activity	1359
08/12/2016 10:37:32	70mm WTG 1	1360
08/12/2016 10:37:52	70mm WTG 2	1361
08/12/2016 10:38:29	70mm WTG 3	1362
08/12/2016 10:39:05	70mm WTG 4	1363
08/12/2016 10:39:30	70mm WTG 5	1364
08/12/2016 11:58:10	WTG4 no action	1365-1366
08/12/2016 11:58:31	WTG 1	1367
08/12/2016 11:58:47	WTG 2	1368
08/12/2016 11:59:01	WTG 3	1369
08/12/2016 11:59:19	WTG 4	1370
08/12/2016 11:59:33	WTG 5	1371
08/13/2016 08:33:14	Called Bryan Wilson, Deepwater Wind Project Manager, and was informed there is no construction today because it is too windy.	
08/13/2016 08:33:24	Fog is too heavy to see construction site	
08/13/2016 08:40:59	Upon arrival its foggy and can't see turbines	
08/13/2016 09:16:49	Turbines 2 and 3. Brave Term has put up second section of tower at WTG4. .	1372
08/13/2016 09:17:33	*Brave Tern* at turbine 4	1373
08/13/2016 09:17:51	Turbine 1, 2 and 3 still in same positions. No activity from tender vessel.	1374
08/13/2016 10:01:53	Crane putting straps on deck.	1375-1377
08/13/2016 10:52:58	Small lift boat in same positions. Crane is moving on *Brave Tern*, possibly moving equipment.	1378
08/13/2016 10:53:42	No activity at WTG 1, 2, and 3.	1379
08/13/2016 11:57:10	L/B *Brave Tern* in same position for last hour with no activity.	1380
08/13/2016 11:57:58	No activity at WTG 1, 2, and 3.	1381
08/13/2016 12:47:26	*Atlantic Pioneer* dropped crew off at WTG4.	1382-1383
08/13/2016 13:05:57	*Atlantic Pioneer* dropping crew off at WTG 1.	1384
08/13/2016 13:57:56	70mm WTG 4 no activity.	1385
08/13/2016 13:58:20	WTG 4 200mm.	1386
08/13/2016 13:58:53	WTG 1	1387
08/13/2016 13:59:07	WTG 2	1388
08/13/2016 13:59:24	WTG 3	1389
08/13/2016 13:59:38	WTG 4	1390

Date/Timestamp	Observations Notes	Photo Frames ID
08/13/2016 13:59:55	WTG 5	1391
08/13/2016 14:37:15	*Atlantic Pioneer* dropped off worker at WTG 2.	1392
08/13/2016 14:38:09	WTG 1	1393
08/13/2016 14:38:31	WTG 3	1394
08/13/2016 14:38:54	WTG 4 no activity, next step is to move Lift Boat *Caitlin* but we think they are waiting on calm seas, in order to bring in L/B *Paul* with tower and blades.	1395
08/13/2016 14:40:23	WTG 5 just platform, no installation started.	1396
08/13/2016 16:01:39	WTG 1	1397
08/13/2016 16:01:52	WTG 3	1398
08/13/2016 16:02:04	WTG 4	1399
08/13/2016 16:10:13	Brian Wilson just informed monitoring team that they are done for the day, can't do anything else until they re-supply small lift barges and are waiting on calm conditions.	
08/14/2016 09:49:14	Turbines 1, 2 and 3. Heavy fog, little to no visibility. Fog horn going off every 30 seconds.	1401
08/14/2016 10:36:11	*Brave Tern* at Turbine 4. Lifting of harness possibly to get nacelle. Moderate / heavy fog obstructing view.	1402
08/14/2016 11:08:02	Turbines 1, 2 and 3. Moderate to heavy fog.	1403
08/14/2016 11:13:29	*Brave Tern* at turbine 4. Crane moved towards nacelle but resumed original position. No further movement.	1404
08/14/2016 11:33:11	*Brave Tern*'s crane has moved towards nacelle.	1405
08/14/2016 11:34:17	*Brave Tern*. Crane hovering harness.	1406
08/14/2016 11:36:19	*Brave Tern*. Crane moved back, obstructing harness view.	1407
08/14/2016 11:55:25	*Brave Tern*. No further movement from prior photo. Fishing vessel passing.	1408
08/14/2016 12:00:19	*Brave Tern*, crane has moved left, harness back in view.	1409
08/14/2016 12:07:45	WTGs 1, 2 and 3. Fog is lifting.	1410
08/14/2016 12:11:23	*Brave Tern*. Harness being lowered to nacelle.	1411
08/14/2016 12:23:21	*Brave Tern*, harness obtaining nacelle,	1412
08/14/2016 12:29:51	*Brave Tern*. Harness hooked on nacelle.	1413
08/14/2016 12:58:37	L/B *Paul* is in front of WTG 4.	
08/14/2016 13:28:12	WTG 1, 2 and 3. No activity.	1414
08/14/2016 13:29:02	L/B *Brave Tern* and L/B *Paul*. Harness still attached to nacelle but no further activity.	1415
08/14/2016 13:47:04	Started to pick up nacelle with crane.	1416
08/14/2016 13:57:35	Crane started to move towards tower with nacelle.	1417
08/14/2016 14:21:02	Bringing nacelle back over towards *Brave Tern*.	1418
08/14/2016 14:55:41	Per Bryan Wilson, they started to attach nacelle but called all stop because too windy. They are going to wait for wind to die down.	
08/14/2016 14:59:34	WTG 1	1419
08/14/2016 14:59:52	WTG 2	1420
08/14/2016 15:00:09	WTG 3	1421
08/14/2016 15:00:28	WTG 4	1422
08/14/2016 15:01:00	WTG 5	1423

Date/Timestamp	Observations Notes	Photo Frames ID
08/14/2016 15:02:57	WTG 4 just set nacelle back on deck.	1424
08/14/2016 15:37:25	200mm WTG 4. Per Brian it is too windy and they are not doing anything else today.	1425
08/14/2016 15:38:26	WTG 1-3	1426
08/15/2016 08:14:08	WTG 4 DW attached nacelle overnight.	1440
08/15/2016 08:14:50	WTG 4 L/B *Brave Tern* with transport cradle preparing to install first blade.	1427-1428
08/15/2016 08:15:55	WTG 1 70mm	1429
08/15/2016 08:16:34	WTG 1 200mm	1430
08/15/2016 08:17:24	WTG 2 70mm	1431
08/15/2016 08:17:41	WTG 2 200mm	1432
08/15/2016 08:18:28	WTG 3 70mm	1433
08/15/2016 08:18:59	WTG 3 200mm	1434
08/15/2016 08:20:31	WTG 4 70mm L/B *Brave Tern* and L/B *Paul*	1435
08/15/2016 08:21:02	WTG 4 200mm L/B *Brave Tern* L/B *Paul*	1436
08/15/2016 08:22:25	WTG 5 L/B *Caitlin*	1437-1439
08/15/2016 08:41:57	WTG 4 *Brave Tern* crane has moved towards turbine with harness ready to pick up blade.	1440
08/15/2016 09:27:26	WTG 4 crane moving cradle back towards *Brave Tern*.	1441
08/15/2016 09:28:35	WTG 4 crane moving to pick up blade.	1442-1444
08/15/2016 09:32:46	WTG 4 crane cradle in position to attach to blade.	1445
08/15/2016 09:45:27	WTG 4 Crane cradle attached to blade.	1446
08/15/2016 09:59:41	WTG 4 cradle has lifted blade.	1453-1458
08/15/2016 10:11:19	WTG 4 crane attaching blade to turbine.	1459-1464
08/15/2016 10:24:24	WTG 1, 2 and 3	1447
08/15/2016 10:24:42	WTG 1 200 mm	1448
08/15/2016 10:25:11	WTG 2 70 mm	1449
08/15/2016 10:25:40	WTG 2 200mm	1450
08/15/2016 10:25:57	WTG 3 70mm	1451
08/15/2016 10:26:17	WTG 3 200mm	1452
08/15/2016 10:59:14	WTG 4 crane positioning first blade.	1466-1473
08/15/2016 11:24:29	WTG 4 blade still in position with harness attached.	1474
08/15/2016 11:34:55	WTG 4 harness being removed from blade 1.	1475-1478
08/15/2016 11:45:30	WTG 4 blade 1 repositioning.	1479
08/15/2016 12:13:33	WTG 4 crane lowering harness to blades on L/B *Paul*.	1480
08/15/2016 12:16:37	WTG 1, 2 and 3, 70mm	1481
08/15/2016 12:20:08	WTG 1 200mm	1482
08/15/2016 12:20:46	WTG 2 200mm	1483
08/15/2016 12:21:03	WTG 3 200mm	1484
08/15/2016 12:21:20	WTG 5 L/B *Caitlin*	1485
08/15/2016 12:21:42	WTG 4 crane moved back towards *Brave Tern*.	1486
08/15/2016 12:50:33	WTG 4 crane lowering cradle to obtain second blade.	1487-1490
08/15/2016 13:02:17	WTG 4 cradle lifting blade 2.	1491-1495
08/15/2016 13:14:35	WTG 4 attachment of second blade.	1496-1499
08/15/2016 13:53:25	WTG 4 blade 2 being rotated to lock in place.	1500-1502

Date/Timestamp	Observations Notes	Photo Frames ID
08/15/2016 14:29:41	WTG 4 cradle released and turbine rotated	1503-1504
08/15/2016 14:47:51	WTG 4 cradle back on deck of *Brave Tern*.	1505
08/15/2016 16:02:25	WTG 1, 2 and 3 70mm.	1506
08/15/2016 16:03:04	WTG 1 200mm	1507
08/15/2016 16:03:25	WTG 2 200mm	1508
08/15/2016 16:03:59	WTG 3 200mm	1509
08/15/2016 16:04:39	WTG 3, *Brave Tern* and L/B *Caitlin*	1510
08/15/2016 16:44:52	WTG 5, L/B *Paul*	1511
08/15/2016 16:45:00	WTG 4, cradle on deck	1512
08/15/2016 16:45:56	WTG 1, 2 and 3 70mm	1513
08/15/2016 16:46:24	WTG 1, 200mm	1514
08/15/2016 16:46:42	WTG 2, 200mm	1515
08/15/2016 16:47:03	WTG 3, 200mm	1516
08/15/2016 16:47:23	WTG 3, WTG 4 L/B *Brave Tern* L/B *Caitlin*, and WTG 5 L/B *Paul*, 70mm.	1517
08/15/2016 16:48:43	WTG 4, L/B *Brave Tern* , L/B *Caitlin* , 200mm.	1518
08/15/2016 16:49:22	WTG 5, L/B *Paul*, 200mm	1519
08/16/2016 08:34:54	WTG 1, 2 and 3. 70mm. Hazy conditions. Third blade at WTG 4 installed over night.	1520
08/16/2016 08:35:33	WTG 3, 4 and 5. L/B *Brave Tern*, L/B *Paul* at WTG 5. 70mm.	1521
08/16/2016 08:37:55	WTG1, 200mm	1522
08/16/2016 08:38:12	WTG 2, 200mm	1523
08/16/2016 08:38:44	WTG 3, 200mm	1524
08/16/2016 08:39:14	WTG 4, 200mm. Third blade installed over night	1525
08/16/2016 08:39:47	WTG 5, 200mm. L/B *Brave Tern* and L/B *Caitlin*. Getting ready to install first section of tower.	1526
08/16/2016 09:36:19	WTG 1, 2 and 3. 70mm. No activity	1527
08/16/2016 09:36:47	WTG 3, 4 and 5	1528
08/16/2016 09:37:22	WTG 1, 200mm	1529
08/16/2016 09:37:37	WTG 2, 200mm	1530
08/16/2016 09:38:24	WTG 3, 200mm	1531
08/16/2016 09:38:54	WTG 4, 200mm	1532
08/16/2016 09:39:28	WTG 5, 200mm. *Brave Tern* slowly lifting platform. L/B *Caitlin* in front of *Brave Tern*.	1533
08/16/2016 10:18:33	Close up of Turbine 1 with *Atlantic Pioneer* approaching.	1534
08/16/2016 10:18:58	Close up of turbine 2.	1535
08/16/2016 10:19:11	Close up of turbine 3	1536
08/16/2016 10:19:25	Close up of turbine 4	1537
08/16/2016 10:19:39	Close up of turbine 5 platform with *Brave Tern* and Caitlyn. *Brave Tern* is still lifting itself.	1538

Table B-2. Offshore Photo Log Key and Field Observations Summary

Date/Timestamp	Observation Notes	Photo Frames ID
08/07/2016 11:29:51	WTG2 L/B *Brave Tern* placing second blade on WTG2 100mm. L/B *Paul* next to it with remaining blades.	3575
08/07/2016 11:31:19	WTG 2 400mm	3576-3578
08/07/2016 11:32:39	WTG 1 100mm	3579-3580
08/07/2016 11:33:19	WTG 1 400mm	3581
08/07/2016 11:33:38	WTG 3	3582-3584
08/07/2016 11:34:41	WTG 4. Recreational fishing vessel anchored nearby.	3585-3586
08/07/2016 11:35:09	WTG 5. Fishing tournament today. Popular stripe bass fishing area near WTG 5.	3587-3588
08/07/2016 11:35:41	All pictures above looking east, between Block Island and WTG	
08/07/2016 12:20:40	WTG 2- appears first blade installed, crane has released. Positioning crane to pick up 2nd blade	3589-3591
08/07/2016 12:24:50	Cradle was placed back on deck, not picking up second blade. Close-up photo of deck of L/B *Brave Tern* and L/B *Paul*	3592
08/07/2016 12:30:56	No support vessels in area, fishing boats located to south of WTG 5	
08/07/2016 12:38:04	Hook still on deck of crane WTG 2	3593
08/07/2016 12:38:40	WTG 2 worker on top of nacelle	3594-3597
08/07/2016 12:47:48	WTG 2 the top of nacelle just spun 180deg, now the platform side is facing Block Island vice the blade side	3598
08/07/2016 12:54:35	WTG 3 L/B *Caitlin* lowered itself in water	3600
08/07/2016 13:10:38	Yellow attachment on crane is called transport cradle, used to attach blades.	
08/07/2016 13:11:53	WTG 2	3593
08/07/2016 13:13:48	WTG 2 nacelle. Workers visible.	3594-3697
08/07/2016 13:16:21	WTG 3	3600
08/07/2016 13:16:38	WTG 2 nacelle	3601
08/07/2016 13:17:05	L/B *Brave Tern* WTG 2 facing west towards Block Island	3602-3605
08/07/2016 13:17:50	Close-up of nacelles on deck of L/B *Brave Tern*	3606
08/07/2016 13:18:18	L/B *Paul* close-up with blades on deck.	3607
08/07/2016 13:36:40	WTG 2 lift cradle on second blade preparing to lift	3608-3609
08/07/2016 13:37:21	WTG 3 LB	3610
08/07/2016 13:37:57	WTG 4 and WTG 5	3611
08/07/2016 13:38:21	WTG 1	3612
08/07/2016 14:15:53	WTG 2 installing second blade	3613-3623
08/07/2016 14:29:59	WTG 2 second blade will be rotated 90 degrees once connected to lock in	3624-3626
08/07/2016 14:50:47	L/B *Paul* next to WTG2	3627
08/07/2016 14:51:07	Still connecting second blade	3628
08/07/2016 14:52:39	So far spent 1.5hrs getting 2nd blade connected. Last bit seems to take awhile	
08/07/2016 15:03:06	Almost complete with 2nd blade	3629

Date/Timestamp	Observation Notes	Photo Frames ID
08/07/2016 15:04:17	Bryan Wilson informed us they will take 4hr break after this so we will head back in. State holiday and concern ferry will book up	
08/07/2016 15:29:55	WTG 2 2nd blade attached , sounded like they used air drill to pull it tight	3630-3640
08/07/2016 15:33:15	WTG 3	3641
08/07/2016 15:33:39	WTG 4-5	3642
08/07/2016 15:35:53	Took 2hrs to Hook connect blade, overnight the guys worked inside turbine but no heavy lifting.	
08/08/2016 10:12:13	WTG 3 L/B *Brave Tern* preparing to install nacelle/tower	3644
08/08/2016 10:15:08	L/B *Caitlin* with tower sections next to WTG 3	3645
08/08/2016 10:15:42	WTG 1	3646
08/08/2016 10:15:59	WTG 2	3647
08/08/2016 10:16:16	WTG 4	3648
08/08/2016 10:16:32	WTG 5	3649
08/08/2016 10:23:37	Arrived onsite at 0900, set up time lapse shot at SE Lighthouse	
08/08/2016 10:34:41	WTG3 close up of L/B *Brave Tern*	3650-3552
08/08/2016 10:35:24	Great shot of WTG 3, WTG 2, WTG 1 in the same frame	3653-3654
08/08/2016 10:36:01	WTG 4 and WTG 5 in same frame	3655
08/08/2016 10:38:17	Not much activity, Bryan says tower I install will start around 12	
08/08/2016 10:46:48	BITs cable visible on WTG 4	3656
08/08/2016 10:55:47	16 fishing vessels located SW of WTG 5. No support vessel onsite	3657-3659
08/08/2016 10:59:09	WTG 3 L/B *Caitlin*, L/B *Brave Tern*, and 2 fishing vessels located SE	3660
08/08/2016 11:11:34	Commercial fishing vessel Nancy Beth passing by WTG 3. 500 yards east	3661
08/08/2016 11:33:34	Bryan Wilson informed no activity until 1300 so we came back in to pick up Walter of Blue Land Media to capture B-roll.	
08/08/2016 12:36:47	WTG 1 *Atlantic Pioneer* dropping off crew at WTG 1.	3662-3664
08/08/2016 12:37:45	L/B Tern starting to elevate.	
08/08/2016 12:57:03	WTG 2 and WTG 1 in same frame	3665
08/08/2016 12:57:27	WTG 3, 4, 5 in same frame	3666-3668
08/08/2016 12:58:25	WTG 3 L/B *Caitlin* and L/B *Brave Tern*	3669-3671
08/08/2016 12:59:47	GE Nacelles on deck of L/B *Brave Tern* close up	3672-3673
08/08/2016 13:00:21	L/B *Caitlin*	3674
08/08/2016 13:15:47	Walter captured footage of Tim taking measurements	
08/08/2016 13:27:20	WTG 3, crane just placed cradle on deck	3675
08/08/2016 13:59:22	n4107457 w31772	3676
08/08/2016 14:00:09	L/B *Brave Tern*	3676
08/08/2016 14:00:52	WTG 4 and Lindsey E with Deepwater staff	3678
08/08/2016 14:02:13	Lindsey E	3680
08/08/2016 14:02:38	*Atlantic Pioneer* - crew tender	3681

Date/Timestamp	Observation Notes	Photo Frames ID
08/08/2016 14:39:45	WTG 3 moved cradle to L/B *Caitlin*	3684-3685
08/08/2016 14:40:29	Workers on WTG 3 preparing for tower install	3686-3689
08/08/2016 14:59:53	WTG 3 workers preparing for tower	3690-3691
08/08/2016 15:00:19	Turbines on L/B *Brave Tern* deck	3692
08/08/2016 15:00:48	WTG 3 L/B *Caitlin*	3693-3694
08/08/2016 15:01:31	WTG 3	3695
08/08/2016 16:08:10	WTG 3 shots of lifting first tower section from L/B *Caitlin* and installing at WTG 3. Took about 1hr 15 minutes	3696-3721
08/08/2016 16:32:09	WTG 1 *Atlantic Pioneer* picking up crew from turbine	3722
08/08/2016 16:33:18	WTG 2	3723
08/08/2016 16:33:36	WTG 4	3724
08/08/2016 16:33:55	WTG 5	3725
08/08/2016 16:51:13	*Atlantic Pioneer* dropping off crew	3726-3728
08/08/2016 16:51:45	Releasing straps on top of first section	3729-3730
08/08/2016 16:52:16	*Atlantic Pioneer*, crew boarding WTG 3	3731
08/09/2016 10:10:41	Upon arrival, tower was complete and nacelle placed on top overnight.	3732-3735
08/09/2016 10:11:17	WTG 2	3736
08/09/2016 10:11:35	WTG 1	3737
08/09/2016 10:11:57	WTG 4 Lindsey E with film crew working for Deepwater Wind	3738
08/09/2016 10:12:41	WTG 5 approx 13 fishing vessels located to SW of turbine	3739
08/09/2016 10:13:45	Coast guard approached us today	
08/09/2016 10:21:05	Fishing boats SW of WTG 5	3740-3741
08/09/2016 10:21:31	Coast guard patrolling near WTG 5	3742
08/09/2016 10:31:48	Lindsey E flying drone over WTG 3	2743-3746
08/09/2016 10:40:41	WTG 3 L/B *Paul* with 3 blades	3747
08/09/2016 10:41:29	Nacelle WTG 3	3748-3749
08/09/2016 10:42:15	WTG 3 base/tower	3750
08/09/2016 10:43:21	WTG 2 and WTG 1	3751
08/09/2016 10:43:54	Good shot L/B *Paul* with 3 blades	3752-3753
08/09/2016 10:44:25	Vertical shot of tower WTG 3	3754-3755
08/09/2016 11:09:34	WTG 3 the nacelle was released from transport cradle and put back on deck	3758-3759
08/09/2016 11:42:21	Placed lift cradle on deck, made some adjustments and now getting blade	
08/09/2016 12:36:01	Placed transport cradle on blade WTG3. They started process to pick up blade at 12:30	3760-3772
08/09/2016 13:17:41	Turned nacelle 180 degrees	3773-3774
08/09/2016 13:18:03	WTG 2 and WTG 1	3775
08/09/2016 14:01:52	Starting to lift 1st blade from L/B *Paul*	
08/09/2016 14:14:18	WTG 3 lift of 1st blade to nacelle. Has taken them around 2 hours from getting transport cradle in blade and attaching	3776-3786
08/09/2016 14:15:40	WTG 2 and WTG 1 , Lindsey E	3787
08/09/2016 14:16:15	WTG 4 and fishing vessel	3788

Date/Timestamp	Observation Notes	Photo Frames ID
08/09/2016 14:16:37	WTG 5	3789
08/09/2016 14:41:00	WTG 3 first blade	3790-3791
08/09/2016 14:41:28	Worker standing on nacelle	3792-3795
08/09/2016 15:00:21	The blade was horizontal with ocean. They are now slowly rotating nacelle down and perpendicular with ocean.	3797
08/09/2016 15:11:38	WTG 3 blade 1 still working on it.	3798-3799
08/09/2016 15:22:11	WTG 1 transport cradle. Started blade install at 12:30 and finished 3:30.	3800-3801
08/09/2016 15:24:39	Worker on top of nacelle	3802
08/09/2016 16:50:06	Monitoring team had to change boat captains, Matt's neck was hurting. Arrived just in time to see 2nd blade lifted.	
08/09/2016 16:50:30	Lifting 2nd blade onto WTG 3	3803-3805
08/09/2016 17:01:13	WTG 3 installing second blade	3806-3810
08/09/2016 17:11:03	L/B *Paul* with 1 blade left on deck	3811
08/09/2016 17:20:00	WTG 3 blade 2 connected to tower	3812-3813
08/09/2016 17:27:17	WTG 3 2nd blade, about 700m away	3813
08/09/2016 17:54:42	L/B *Paul*	3815
08/09/2016 18:08:28	Leaving to catch ferry. Transport cradle was still attached to blade.	
08/10/2016 10:00:31	Unable to leave port at planned start of 0800. Thunder and lightning.	
08/10/2016 10:02:11	L/B *Brave Tern* and L/B *Caitlin* at WTG4. They are elevated approx 4 ft above sea level	
08/10/2016 10:03:24	No activity at any other WTGs. Sea state is rough, no other boats on water except did see *Atlantic Pioneer* headed back in	
08/10/2016 10:05:24	WTG 1	3816
08/10/2016 10:05:45	WTG 2	3817
08/10/2016 10:06:07	WTG 3	3818
08/10/2016 10:06:20	WTG 4 L/B *Brave Tern* and L/B *Caitlin*	3819-3821
08/10/2016 10:07:21	WTG 5	3822-3823
08/10/2016 10:17:24	Calling for 15-20 mph gusts through Wednesday	
08/10/2016 11:05:55	WTG 1	3824
08/10/2016 11:06:21	WTG 2	3825
08/10/2016 11:06:42	WTG 3	3826
08/10/2016 11:07:11	WTG 4 L/B *Brave Tern*, L/B *Caitlin* , no activity	3827-3828
08/10/2016 11:07:56	WTG 4 L/B *Caitlin*	3829
08/10/2016 11:08:20	WTG 5	3830
08/10/2016 12:00:04	WTG 4 L/B *Brave Tern* just raised up and is now even with platform. L/B Caitlyn is still on not raised.	3831-3840
08/10/2016 12:02:09	Crane still on deck.	
08/10/2016 12:04:06	Platform not connected	3841
08/10/2016 12:06:24	L/B *Caitlin* just started elevating.	3842
08/10/2016 12:07:15	Tim, Subacoustech, is seasick going in to drop him off	
08/10/2016 12:18:38	L/B *Caitlin* finished raising up, took 13 minutes	3843-3848

Date/Timestamp	Observation Notes	Photo Frames ID
08/10/2016 15:18:13	Sea states got worse and started to rain. Captain checked and radar indicates mores rain coming and expected to get worse	
08/11/2016 09:00:00	Start	3881-3889
08/11/2016 09:12:19	WTG 4 L/B *Brave Tern* no install yet, they did install the walkway	3849
08/11/2016 09:13:57	WTG 4 and 5	3850
08/11/2016 09:15:55	L/B *Paul* south of WTG 4 with 3 blades and top section of tower	3851-3852
08/11/2016 09:16:42	L/B *Brave Tern* and *Caitlin*	3853
08/11/2016 09:17:37	*Atlantic Pioneer* preparing to transfer crew to WTG 4	3854-3855
08/11/2016 09:18:07	WTG 2 and WTG 1	3856
08/11/2016 09:18:25	WTG 3	3857
08/11/2016 09:18:55	WTG 5	3858
08/11/2016 09:19:14	Workers on L/B *Caitlin*	3859-3860
08/11/2016 09:19:37	*Atlantic Pioneer* on WTG 4	3861-3863
08/11/2016 09:20:42	L/B *Paul*	3864-3865
08/11/2016 09:34:35	*Atlantic Pioneer* dropped crew at WTG 3	
08/11/2016 09:35:36	Crane lowered next to WTG 4	3866-3868
08/11/2016 10:27:53	No activity	3869-3871
08/11/2016 10:36:16	WTG 1	3872
08/11/2016 10:36:34	WTG 2	3873
08/11/2016 10:36:51	WTG 3	3874
08/11/2016 10:37:06	WTG 5	3875
08/11/2016 11:14:02	Heard thunder, storm cell moving through so we headed into harbor while it passed.	
08/11/2016 11:15:18	No construction activity has occurred.	
08/11/2016 12:36:49	Back onsite, storm passed	
08/11/2016 12:37:22	WTG 4 crane is connected to first section of tower	3876-3878
08/11/2016 12:41:04	No activity at the other WTGs	
08/11/2016 12:59:10	Crane hooked up, still no movement	
08/11/2016 13:02:29	WTG 4, lifted first tower section couple of feet off deck of L/B *Caitlin*.	3880
08/11/2016 13:16:40	Set first tower section down. Note time	
08/11/2016 13:29:02	Workers entering door to inside of bottom tower section at WTG 4	3890-3891
08/11/2016 13:42:53	Crane still attached but now there is slack in line	
08/11/2016 13:52:28	WTG 4 crane still attached to first tower section	3892-3893
08/11/2016 13:53:00	L/B *Paul* with blades	3894
08/11/2016 13:53:25	WTG 5	3895
08/11/2016 13:53:52	Worker on WTG 3	3896
08/11/2016 13:54:14	WTG 2 and WTG 1	3897
08/11/2016 14:20:29	WTG 4 worker on top of first tower section	3898
08/11/2016 14:22:17	WTG 4 crane still connected	3899-3900
08/11/2016 14:37:27	*Atlantic Pioneer* at WTG 2 picking up crew	3901

Date/Timestamp	Observation Notes	Photo Frames ID
08/11/2016 14:43:16	Just let go first section moved tower cap to L/B *Caitlin*	3902-3904
08/11/2016 14:59:44	Release tower cap.	
08/11/2016 15:13:14	*Atlantic Pioneer* picking up crew from WTG 3	3907
08/11/2016 15:35:51	Moving small crane on deck of L/B *Caitlin*.	3911
08/11/2016 15:36:16	*Atlantic Pioneer* at WTG 4	3912-3915
08/11/2016 16:26:37	L/B *Paul*	3916
08/11/2016 16:27:06	WTG 4- only work today was setting first section of tower	3917-
08/11/2016 16:27:34	WTG 1-3	3918
08/11/2016 16:27:50	WTG 5	3919
08/11/2016 16:46:07	Guy exercising on top of helicopter pad	3920-3925
08/11/2016 17:02:47	Still no action	
08/11/2016 17:19:02	No activity	
08/11/2016 17:56:46	No activity, guy still jogging on deck	
08/12/2016 08:50:17	Tension in straps. getting ready to install second section	3927/3932
08/12/2016 08:51:21	WTG 1 still stationary. does not look like crews are out working on it	3928
08/12/2016 08:51:33	WTG 2 still stationary. does not look like crews are out working on it	3929
08/12/2016 08:51:53	WTG 3 still stationary. does not look like crews are out working on it	3930-3931
08/12/2016 09:04:32	L/B with turbine blades on standby until the second section is installed	3933
08/12/2016 09:05:32	*Brave Tern* and WTG 4 with first tower section installed. Getting ready to install second tower section	3934/3935
08/12/2016 09:23:39	Straps have been removed from second tower section and are being placed down on *Brave Tern* deck	3936-3937
08/12/2016 09:35:44	Crane has brought the straps to the first section on the turbine platform	3938-3943
08/12/2016 10:05:06	Crane has not moved since bringing the straps over to the first section. Straps have just been hovering over the section	3944-3945
08/12/2016 11:25:58	Crane in same position. No activity	3946-3948
08/12/2016 11:26:34	No activity at WTG 1 and 2	3949
08/12/2016 11:26:59	No activity at WTG 3	3950
08/12/2016 12:20:45	Still no activity at *Brave Tern*	3951-3952
08/12/2016 12:21:17	WTG 1 has had no activity	3953
08/12/2016 12:21:37	WTG 2 has had no activity	3954
08/12/2016 12:22:03	WTG 3 has had no activity	3955-3956
08/12/2016 12:22:48	Second lift boat still on standby with blades and top section	3957
08/12/2016 13:36:17	No activity from the crane. everything has been stationary for last hour	3958-3960
08/12/2016 14:04:18	Crane has moved to bring the straps to the deck.	
08/12/2016 14:04:34	Crane is being lowered to the deck.	
08/12/2016 20:52:01	Spoke with DWW, too windy today. So ended survey. No construction today	
08/13/2016 09:20:49	Trained Tracy at SE lighthouse with Tim	
08/13/2016 09:21:29	WTG 4 Bryan Wilson told us they put 2nd section of tower	

Date/Timestamp	Observation Notes	Photo Frames ID
	on at dawn	
08/13/2016 09:54:48	L/B *Paul* with third tower section and blades	3967
08/13/2016 09:55:12	L/B *Caitlin*, all materials offloaded. we think next step is to lower into water and pull in L/B *Paul*	3968-3970
08/13/2016 09:57:57	WTG 4 L/B *Brave Tern* no action upon arrival.	
08/13/2016 09:58:08	WTG 1-3	3972
08/13/2016 09:58:26	WTG 3	3973
08/13/2016 09:58:44	WTG 5	3974
08/13/2016 10:01:12	WTG 4 worker on top of second tower section	3976-3977
08/13/2016 10:45:04	WTG 1-2	3978
08/13/2016 10:46:12	WTG 3 Lindsey e conducting sightseeing tour	3979
08/13/2016 10:46:58	WTG 4 *Brave Tern*	3980
08/13/2016 10:47:23	L/B *Caitlin* and L/B *Paul*	3981
08/13/2016 10:47:44	WTG 5	3982
08/13/2016 10:48:01	WTG 4	3982
08/13/2016 11:17:24	Came in to switch captains. No activity so far.	
08/14/2016 10:11:58	The third section of the tower has been installed. Crane is no longer attached to it. Crane is lowering straps to the deck. Nacelle is next to go on. Foggy conditions make visual monitoring difficult.	3984/3985/3990
08/14/2016 10:12:33	WTG 1 has had no activity	3986
08/14/2016 10:12:43	WTG 2 has had no activity	3987
08/14/2016 10:12:55	WTG 3 has had no activity	3988
08/14/2016 10:13:19	*Atlantic Pioneer* is located between WTG 1 and 2	3989
08/14/2016 10:30:13	Crane lifting harness, possibly for nacelle	3991
08/14/2016 10:30:32	Worker prepping the nacelle	3992
08/14/2016 11:01:16	Crane has lifted up nacelle harness and had moved towards the nacelle. It is now moving the harness back to where it was picked up from the deck	3993-3997
08/14/2016 11:27:08	Crane has spun in a full circle with the harness.	3998-4003
08/14/2016 11:28:13	Sailboat coming within 500yds of L/B *Brave Tern*	4004-4005
08/14/2016 12:00:32	Crane moving harness	4006-4009
08/14/2016 12:11:35	Nacelle is being hooked up	4010-4017
08/14/2016 12:58:42	No activity at WTG 1	4018
08/14/2016 12:58:54	No activity at WTG 2	4019
08/14/2016 12:59:06	No activity at WTG 3	4020
08/14/2016 13:44:28	Nacelle being lifted	4021-4033
08/14/2016 14:19:12	Moving nacelle back to *Brave Tern*. Nacelle is never placed back on the deck	4034-4038
08/14/2016 15:17:43	Nacelle back on deck. Headed back in to harbor due to increasing winds and seas	
08/15/2016 09:10:12	Installed the nacelle overnight. Preparing to install blades	
08/15/2016 09:14:41	WTG 4 L/B *Brave Tern* transport cradle picking up blade.	4045-4046
08/15/2016 09:15:37	WTG 4 L/B *Paul*	4047
08/15/2016 09:16:01	WTG 5 L/B *Caitlin*	4048-4049

Date/Timestamp	Observation Notes	Photo Frames ID
08/15/2016 09:26:30	WTG 4 L/B *Paul*	4050
08/15/2016 09:27:07	WTG 4 transport cradle	4051-4053
08/15/2016 09:27:50	WTG 4 nacelle	4054
08/15/2016 09:28:19	WTG 4 L/B *Brave Tern*	4055
08/15/2016 09:28:40	WTG 5 L/B *Caitlin* with tower section 1 and 2 on deck	4056
08/15/2016 09:30:52	WTG 3 close-up of nacelle and blades	4057
08/15/2016 09:31:17	WTG 3	4058
08/15/2016 09:31:47	WTG 2	4059
08/15/2016 09:32:02	WTG 1	4060
08/15/2016 09:33:46	WTG 4 just attached transport cradle to first blade	4061
08/15/2016 09:36:28	Per VHF there is a survey vessel onsite. It is surveying the cable route for Durocher.	4062
08/15/2016 09:38:16	*Atlantic Pioneer* approaching WTG 4 to drop off 1 crew member	4073
08/15/2016 09:57:46	Just started lifting first blade	4064-4067
08/15/2016 10:23:12	Blade is touching nacelle	4074
08/15/2016 10:41:29	Blade 1 attached	
08/15/2016 10:42:07	Harley charter boat next WTG 4 with DW staff	4075
08/15/2016 10:42:47	WTG 4 close up , blade 1 attached	4076-4077
08/15/2016 10:44:55	survey vessel under WTG4	4078
08/15/2016 12:23:09	walkway between L/B *Brave Tern* and L/B *Paul*	4084
08/15/2016 12:24:09	WTG 4 first blade installed	4085-4086
08/15/2016 12:24:37	WTG 4 *Atlantic Pioneer* with VIPs from DW. no construction occurring	4087
08/15/2016 12:26:01	WTG 5 with L/B *Caitlin* and 2 tower section	4089
08/15/2016 12:26:58	WTG 1	4090
08/15/2016 12:27:15	WTG 2	4091
08/15/2016 12:27:30	WTG 3	4092
08/15/2016 12:29:28	*Atlantic Pioneer*	4093-4094
08/15/2016 12:37:11	*Atlantic Pioneer* next to WTG 3	4095
08/15/2016 12:42:13	Picking up transport cradle off deck , going for blade 2	4096-4097
08/15/2016 12:47:52	Attaching transport cradle with blade #2	4096
08/15/2016 12:53:24	Worker inside of blade 2 on the deck of L/B *Paul*.	4100-4101
08/15/2016 12:57:41	Helicopter tours near WTGs.	4102-4108
08/15/2016 12:58:28	Worker inside blade 2	4109
08/15/2016 12:58:51	Helicopter	4110
08/15/2016 13:07:27	Lifting blade 2, going for nacelle	4111-4112
08/15/2016 13:12:52	Close to having second blade attached.	4113
08/15/2016 13:15:59	Blade 2 is attached WTG 4	4114
08/15/2016 13:54:06	Started to rotate 2 blade to lock it in place on nacelle	4114-4115
08/15/2016 14:08:30	Still turning blade 2 to lock in	4116-4118
08/15/2016 14:23:54	Released cradle from blade 2	4119-4120
08/15/2016 14:31:12	WTG 1 and 2	4121
08/15/2016 14:31:37	WTG 3	4122

Date/Timestamp	Observation Notes	Photo Frames ID
08/15/2016 14:31:55	WTG 5	4123
08/15/2016 14:32:30	WTG 4 workers on top of nacelle removing blue cover preparing for 3 blade install	4124-4127
08/15/2016 14:38:20	Transport cradle back on deck	4128
08/15/2016 15:42:56	WTG 5 Lindsey e passing with DW staff	4129
08/15/2016 15:43:38	WTG 4 waiting on hem to pick up 3rd blade crane still on deck	4130
08/15/2016 15:44:20	WTG 1-3	4131-4132
08/15/2016 15:59:18	Lindsey E and *Atlantic Pioneer* at WTG 4	4133
08/15/2016 16:00:05	*Atlantic Pioneer* dropping off crew at WTG 4	4134-4135
08/15/2016 16:09:36	*Atlantic Pioneer* leaving WTG 4	
08/15/2016 16:19:22	*Atlantic Pioneer* now at WTG 1	
08/15/2016 16:52:51	Team learned they are not lifting 3rd blade until 10:00pm. Ended survey	
08/16/2016 08:15:32	Installed 3rd blade on WTG 4 overnight	
08/16/2016 08:16:11	L/B *Brave Tern* is transitioning to WTG 5	4139
08/16/2016 08:16:32	WTG 1	4136-4138
08/16/2016 08:19:30	WTG 2	4140-4142
08/16/2016 08:28:13	WTG 3	4143-4144
08/16/2016 08:28:31	*Atlantic Pioneer* dropping staff off at WTG 3	4145-4146
08/16/2016 08:34:41	WTG 4	4147-4148
08/16/2016 08:35:40	*Atlantic Pioneer* approaching *Brave Tern*	4149, 4151
08/16/2016 08:36:41	NOAA boat in background	4150
08/16/2016 08:41:56	L/B *Brave Tern* and L/B *Caitlin* on WTG 5. Neither vessel is elevated.	4152-4154
08/16/2016 08:43:02	2 fishing vessels located near WTG 5	4155
08/16/2016 08:47:54	WTG 5, *Brave Tern*, and Caitlyn. Sounds like he is jacking up	4156-4159
08/16/2016 08:52:22	WTG 1-5 in one frame	4160-4162
08/16/2016 08:57:02	L/B *Brave Tern* is lifting itself up. bow thrusters are out of the water	4163
08/16/2016 08:58:36	L/B *Brave Tern* and Caitlyn	4164
08/16/2016 08:58:50	L/B Caitlyn	4165
08/16/2016 08:59:03	Close ups of L/B *Brave Tern*	4166-4169
08/16/2016 09:06:12	WTG 4 with Lindsey E vessel	4171
08/16/2016 09:07:13	Close up of Lindsey E next to WTG 4	4172
08/16/2016 09:07:39	Close up of nacelle of WTG 4	4173
08/16/2016 09:08:00	WTG 4	4174
08/16/2016 09:10:50	WTG 3	4175-4176
08/16/2016 09:11:05	WTG 3 nacelle	4177
08/16/2016 09:14:09	WTG 2	4178-4179
08/16/2016 09:14:44	WTG 2 nacelle	4180
08/16/2016 09:14:58	*Atlantic Pioneer* dropping off at WTG 1	4181
08/16/2016 09:18:11	WTG 1 with *Atlantic Pioneer*	4182-4183
08/16/2016 09:18:31	Close up of the nacelle	4184

Date/Timestamp	Observation Notes	Photo Frames ID
08/16/2016 09:18:49	*Atlantic Pioneer* next to WTG 1	4185
08/16/2016 09:23:20	Buoy the says no mooring and European phone number	4186-4187
08/16/2016 09:30:07	WTG 1 through 5	4188-4194
08/16/2016 10:05:25	Tracy and Pete taking photos from the lighthouse	4195-4200
08/16/2016 10:17:00	L/B *Brave Tern* not lifting anymore.	
08/16/2016 10:19:29	Finished monitoring 2 complete turbines with 3 blades on WTG4	

Table B-3. Meteorological Data Recorded During Visual Monitoring

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
08/07/2016 10:19:30	Sunny	S	2	0	77	66
08/07/2016 11:07:24	Sunny	S	2	0	78	62
08/07/2016 11:50:47	Sunny	S	2	5	78	58
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/07/2016 14:06:01	Sunny	S	2	25	78	59
08/08/2016 09:41:48	Sunny	NNE	2	0	72	74
08/08/2016 11:10:59	Sunny	NNE	2	0	73	67

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
08/08/2016 12:52:30	Sunny	S	2	50	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/08/2016 14:01:36	Cloudy	S	2	75	75	61
08/09/2016 09:27:46	Sunny	E	2	0	73	81
08/09/2016 12:34:45	Sunny	E	2	0	79	50
08/09/2016 14:27:17	Sunny	S	2	25	77	56
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/09/2016 17:07:55	Sunny	S	2	50	76	77
08/10/2016 08:08:47	Light Rain	SSW	3	100	73	
08/10/2016 11:58:24	Cloudy	S	4	100	73	93
08/10/2016 11:58:24	Cloudy	S	4	100	73	93
08/10/2016 11:58:24	Cloudy	S	4	100	73	93
08/10/2016 11:58:24	Cloudy	S	4	100	73	93
08/10/2016 11:58:24	Cloudy	S	4	100	73	93
08/10/2016 11:58:24	Cloudy	S	4	100	73	93
08/10/2016 11:58:24	Cloudy	S	4	100	73	93
08/10/2016 11:58:24	Cloudy	S	4	100	73	93
08/11/2016 08:19:02	Hazy/Foggy	SE	2	100	74	100
08/11/2016 10:31:48	Cloudy	S	2	100	75	98
08/11/2016 11:43:39	Light Rain	S	3	100	73	98

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
08/11/2016 12:24:14	Cloudy	S	3	100	74	99
08/11/2016 14:35:03	Cloudy	S	2	100	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/11/2016 16:03:12	Sunny	S	2	30	76	97
08/12/2016 09:30:19	Hazy/Foggy	SW			78	84
08/12/2016 10:18:19	Hazy/Foggy	SW		60	79	83
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^{o}F)	Humidity (%)
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/12/2016 12:01:16	Hazy/Foggy	SW		40	80	84
08/13/2016 08:33:47	Hazy/Foggy	W	2	75	77	95
08/13/2016 13:52:50	Sunny	SW	3		83	79
08/13/2016 14:42:00	Sunny	S	3	75	78	95
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/13/2016 16:05:29	Hazy/Foggy	SW	2	75	84	79
08/14/2016 10:04:15	Hazy/Foggy	SW	2		82	85
08/14/2016 11:09:33	Hazy/Foggy	SW	2		84	80
08/14/2016 12:08:51	Hazy/Foggy	SW	2		85	75
08/14/2016 13:30:25	Hazy/Foggy	SW	2		87	70
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/14/2016 14:57:07	Hazy/Foggy	SW	3	5	85	74
08/15/2016 08:24:59	Sunny	NW	2	25	76	71
08/15/2016 10:38:44	Sunny	NW	1	25	79	60

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^{o}F)	Humidity (%)
08/15/2016 11:47:46	Sunny	W	1	0	81	60
08/15/2016 13:47:31	Sunny	SW	2	25	85	55
08/15/2016 15:24:27	Sunny	W	2	0	86	55
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/15/2016 16:36:45	Sunny	SW	2	0	84	61
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91
08/16/2016 08:42:01	Hazy/Foggy	E	1	35	76	91

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
06/19/2017 17:48:39	Hazy/Foggy					
06/19/2017 17:48:39	Hazy/Foggy					
06/19/2017 17:48:39	Hazy/Foggy					
06/19/2017 17:48:39	Hazy/Foggy					
06/19/2017 17:48:39	Hazy/Foggy					
06/19/2017 17:48:39	Hazy/Foggy					
06/19/2017 17:48:39	Hazy/Foggy					
06/19/2017 14:44:39	Hazy/Foggy	SW	5	90	70	88
06/19/2017 17:49:37	Hazy/Foggy	SW	6	90	66	100
06/19/2017 21:25:55	Light Rain	SW	6	100	66	100
06/20/2017 08:36:01	Light Rain	SW	4	100	64	100
06/20/2017 11:38:34	Hazy/Foggy	SW	4	100	65	100
06/20/2017 15:29:00	Sunny	SW	5	50	70	84
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/20/2017 21:59:44	Cloudy	SW		40	65	90
06/21/2017 08:48:44	Hazy	WSW	3	80	67	90
06/21/2017 11:35:51	Hazy	SW	4	50	74	73
06/21/2017 17:31:17	Hazy/Foggy	SW	5	40	70	88
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^{o}F)	Humidity (%)
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90
06/21/2017 21:33:13		WSW		40	66	90

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
06/22/2017 09:23:29	Sunny	NEW	2	20	70	58
06/22/2017 13:54:59	Sunny	SW	3	20	75	49
06/22/2017 18:25:49	Sunny	SW	3	30	71	54
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84
06/22/2017 21:28:09		SSW		50	67	84

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
06/23/2017 08:57:53	Hazy	SW	3	10	71	86
06/23/2017 12:20:59	Hazy/Foggy	SSW	3	60	73	86
06/23/2017 18:16:32	Cloudy	SSW	5	80	69	86
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97

Date/Time	General Weather	Wind Direction	Beaufort Sea State	% Cloud Cover	Temperature (^oF)	Humidity (%)
06/23/2017 22:29:47	Hazy/Foggy	SSW	5	90	67	97

Appendix C: Airborne Noise Assessment Equations and Terminology

ISO 9613-2:1996 states that airborne environmental sound propagation over substantial distance tends to follow a basic equation where the noise level at a receiver position is affected by the level of sound at source, a directivity correction relating to any changes in noise emission is dependent on the direction from the source and the attenuation with distance, which is a combination of multiple factors. As piling is effectively an ‘omnidirectional’ sound source—that is, it radiates noise equally in all directions—directivity at source can be discounted. Discounting factors that will also not have an effect offshore (e.g., screening effects), the equation for estimation of sound level at a receiver becomes:

$$RL = SL - N \log_{10} R - \alpha R$$

where, RL is the sound level at the receiver, SL is the sound level at the source location, R is the range or distance from the source, N is a coefficient relating to the rate of geometric sound attenuation dependent on a number of factors, and α is the atmospheric absorption coefficient.

Source Level (SL)

Critical to the calculation of the sound level at a receiver is the sound level at source. Previous offshore impact piling noise underwater monitoring has shown that the source level is primarily related to the diameter of the pile and how hard the pile is struck (the blow energy of the hammer in use). While other factors will also have an effect on the sound produced (e.g. material type and thickness, properties of the ground and properties of the pile), the source sound emission can be described adequately by the diameter of the pile and blow energy. As the pile size and hammer used for the installation of foundations at the BIWF remained the same, the source level is likely to change only by the energy used in each strike.

It should be noted that for the purposes of this study, the source level is defined as a theoretical sound level at 1 m (3.3 ft) from the sound source. This assumes that the source itself is effectively a point source, as it will appear at the distances at which the measurements were taken.

N Coefficient

Also known as geometric spreading, the value of N defines how quickly the sound at source reduces over distance and is primarily related to how the sound ‘spreads out’. However, this value changes with the shape of the source (i.e., if the source is a ‘point,’ a ‘line’ or an ‘area’), how far the receiver is from the source, weather conditions, changes in the atmosphere, reflective surfaces and others. Typically a simple assumption of a sound spreading spherically from the source in ideal conditions provides a value of N of 20, and real world conditions lead to variations around this value depending on the exact situation. For example, downwind conditions might be expected to lead to slower attenuation of sound and a slightly lower value of N, but upwind the sound will attenuate more quickly and the value of N will be greater.

Depending on the value of N, the real reduction in sound tends to vary between 3 and 6 dB per doubling of distance from the sound source.

Absorption Coefficient, α

While the N coefficient causes a reduction in the sound level with every doubling of distance, the absorption coefficient (α) applies a small reduction with every unit of distance, because of absorption in the medium in which the sound is travelling. The consequence of this is that the overall attenuation of sound is controlled by N when near the sound source, and α becomes more significant at a greater distance.

Like N, the value of α depends on many factors, including the frequency of the sound and the environmental conditions, such as air temperature and humidity. Detailed tables showing the values of α under a variety of environmental conditions can be found in ISO 9613-1:1993 Acoustics - Attenuation of sound during propagation outdoors, and for the purposes of this study, are considered to be a known quantity.

This analysis is designed to estimate an appropriate value for N and α coefficients based on the measured airborne sound levels. It is acknowledged that other factors will have an impact on the attenuation of sound, such as scattering by the water surface, weather conditions (e.g., clouds/fog) or variations in temperature with altitude, but analysis to this level of detail is beyond the scope of this study.

Sound Metrics

LAeq,t – the A-weighted, Equivalent Average Sound Pressure Level (or Energy-Averaged Sound Level). It indicates the decibel level of a constant sound source that would have the same total acoustical energy over the same time interval as the actual time-varying sound condition being measured or estimated. Leq values must be associated with an explicit or implicit averaging time “t” in order to have practical meaning.

LAFmax,t – the A-weighted Maximum Sound Pressure Level measured with a fast 125 millisecond time constant and associated with an averaging time “t.”

LA90,t – the A-weighted Sound Pressure Level Sound exceeded for 90 percent of the measurement period “t.”

LCPeak – the C-weighted, largest absolute value of the instantaneous sound pressure.

A Weighting – a weighting applied to received sound pressure level spectra designed to filter out the lower and higher frequencies that the average person cannot hear.

C Weighting – similar to A-weighting, C-weighting filters less of the lower frequencies of received sound pressure levels.

Spherical and Cylindrical Spreading

This relates to the manner in which the sound spreads from the source, and depends on the distance from the source and the shape of the source. Assuming the source appears to be a single point, at certain distances the sound behaves as if it is spreading out in an approximately spherical shape, and this leads to a theoretical reduction of 6 dB per doubling of distance. In other situations, the sound can spread in a cylindrical shape, leading to a theoretical reduction of 3 dB per doubling of distance. In practice, the conditions are rarely this well-defined.

In this situation, the noise spreading tends to be approximately spherical near to the sound source then transitions to a more cylindrical pattern at a greater distance.

Appendix D: Airborne Noise Monitoring Report

See Chapter 6 of the attached report for a discussion of airborne noise monitoring conducted during the installation of the tower sections on the WTG foundations.

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Measurement of airborne noise during construction of the Block Island Wind Farm, Rhode Island

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13 May 2019

Subacoustech Environmental Report No. E494R0302

Document No.	*Date*	*Written*	*Approved*	*Distribution*
E494R0301	*10/30/2018*	*T Mason*		*HDR/BOEM*
E494R0302	*05/13/2019*	*T Mason*		*HDR/BOEM*

This report is a controlled document. The report documentation page lists the version number, record of changes, referencing information, abstract and other documentation details.

Executive Summary

As part of the Real-time Opportunity for Development of Environmental Observations (RODEO) program, Subacoustech Environmental Limited, under the team headed by HDR Inc., undertook a series of airborne noise measurements during the installation of the foundations and turbine tower for the Block Island Wind Farm (BIWF).

Few measurements of noise propagation over water from offshore construction exist, with most attention paid to propagation over land, or under water. The BIWF development provided an excellent opportunity to collect data to study the noise generated at source and the attenuation of impulsive airborne noise over long distances offshore.

Five jacket-type frame foundation structures were placed and fixed off the coast of Block Island, Rhode Island over August, September and October 2015. This involved situating the frames by crane on the seabed and inserting long metal piles into the frame, which were then driven by impact piling – striking the top of the piles with a specialised piling hammer – to fix the frame in place. This process generates high noise levels both above and below the sea surface. The noise produced during piling was measured under a series of environmental conditions over ten separate piling events on five days. Noise measurement stations were situated at three locations on land surrounding BIWF, and also a mobile measurement station on a survey vessel, which moved on transects on different orientations and ranges from the pile under installation. The three coastal locations were the nearest point of land to the wind farm on Block Island, the Block Island Southeast Light, approximately three miles to the northwest; Balls Point North, on the east coast of Block Island, approximately seven miles north-northeast of BIWF; and at Point Judith, 17 miles to the north of BIWF and the nearest point on the mainland.

The turbine towers, nacelle and blades were installed in August 2016. At this time, airborne noise was sampled on a survey vessel around the lifting machinery, on transects relative to the direction of the wind.

The results of measurements of the airborne noise emission and its propagation during piling and tower construction have been analysed. In general, wind speeds, humidity, temperature and sea states were reasonably consistent over the measurement periods, although the wind direction was changeable. The measurements demonstrate variations depending on the environmental conditions, with the main difference in noise propagation caused by changes in the wind direction relative to the direction of travel on the measurement transects.

The propagation of noise from the piling over water changes from a roughly spherical to cylindrical spreading pattern at a distance, but the location of this transition point is hard to identify. No measurements were possible closer than 500 yards from piling activities for safety reasons, limiting more detailed examination of this aspect. The source of the noise was significantly above the water surface and no access to the installation vessel was possible. It is reasonable to assume that there is no single transition ‘point’ from spherical to cylindrical spreading and the change will be progressive over a range. This range will be dependent on environmental factors, particularly the wind direction. However, based on the information available the transition is estimated to occur around 800 m from the pile.

Based on extrapolations from piling measurements at a distance, a sound pressure level of approximately 127 dB $L_{Aeq,1s}$ re 20 µPa is estimated at 1 m from the pile, treating the piling as an effective point source where the receiver is in the acoustic far-field. Due to the shortage of measurements within the 500 yard (460 m) exclusion zone around the piling there is significant uncertainty in this figure.

A value for the geometric spreading loss was estimated for different relative wind directions within the cylindrical spreading zone. Measurements over long distance clearly demonstrated higher noise levels under downwind conditions than when the wind was against the direction of travel.

One short opportunity was available to sample noise propagation over water in flat calm conditions and measurements were taken between 710 m and 10 km from the source. Analysis of the results suggest that even a modest increase sea state will have an effect on the propagation of airborne noise over water.

Noise from piling was always clearly audible at the Southeast Light, three miles away, and sometimes audible at Balls Point North at seven miles under good conditions. Piling noise was never audible at Point Judith; although background noise levels were substantially raised by wave noise on the shore at Point Judith, no noise could be heard in breaks in wave noise nor would it be expected to be audible at this distance based on the audibility at sea.

During lifting and installation of the tower, nacelle and blades, noise was only audible from the crane machinery on the barge. The machinery was detectable out to beyond 2 km under ideal downwind conditions but was effectively inaudible at 750 m upwind. Machinery noise was a continuous low frequency machinery ‘whir’ and quickly lost in the background noise from the water movement.

The noise propagation over the water largely followed the same attenuation as during piling, with the apparent change from spherical to closer to cylindrical spreading at approximately the same point as was found during piling. The noise level at the barge was estimated to be 105 to 108 dB $L_{Aeq,1min}$ re 20 µPa.

While substantial data was acquired during piling for the foundations at Block Island Wind Farm, only a small number of repeated transects were possible, and all under identical environmental conditions (i.e. daytime, summer, clear, dry, similar temperature and humidity). Further investigations for offshore piling noise would ideally be under different conditions and it is likely that these would be available in a different location or time of year. The greatest data gaps exist for airborne noise measurements at close range (less than 500 yards, or 460 m) and at a greater range, particularly in excess of 8,000 m. Additionally, it was not possible to take samples of the noise level as it propagates long range over land, and so it would be useful to attempt to identify any changes in the propagation in the transition from water to land.

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1 Introduction

The Bureau of Ocean Energy Management (BOEM) seeks to investigate the environmental impacts associated with the construction and operation of offshore wind farms. The Block Island Wind Farm (BIWF), situated off the coast of Rhode Island, is the first of its kind to be constructed in United States waters and provided an opportunity to directly observe and measure a variety of potential stressors on the local environment. The Real-time Opportunity for Development of Environmental Observations (RODEO) program was set up by BOEM to enable this.

Activities associated with the construction and operation of an offshore wind farm will necessarily generate noise. This noise will be produced from many sources, including those associated with the transportation of construction equipment and materials, the operation of construction equipment and the operation of the completed offshore wind turbines. As part of the RODEO program, Subacoustech Environmental Limited, as part of the team led by HDR Inc., planned and executed a survey around the construction site to measure the noise emitted both in the air and underwater.

This report has been prepared by Subacoustech Environmental Ltd for HDR, Inc. It presents the methodology and results of the airborne environmental noise survey undertaken during the installation of the foundation piles and turbine towers for the BIWF offshore wind turbines in 2015 and 2016.

1.1 Study overview and site description

The Block Island Wind Farm is situated approximately three miles (approximately five kilometers) off the southeast coast of Block Island, and south of Point Judith, Rhode Island. The wind farm is comprised of five offshore wind turbines, each of a 6 MW output.

Table 1-1 shows the coordinates of the five turbines.

Turbine designation	North (degrees)	West (degrees)
WTG 1	41° 7’ 32.596”	71° 30’ 27.230”
WTG 2	41° 7’ 11.770”	71° 30’ 50.208”
WTG 3	41° 6’ 53.060”	71° 31’ 16.183”
WTG 4	41° 6’ 36.710”	71° 31’ 44.810”
WTG 5	41° 6’ 23.050”	71° 32’ 15.540”

Table 1-1 Block Island Wind Farm turbine coordinates

The primary focus of this study was to observe and measure the levels of airborne noise produced during installation of foundations, the lift of the turbine towers and the fitting of blades. Airborne noise levels were sampled using a sound level meter (SLM) attached to a survey vessel offshore and a series of SLMs on Block Island and the mainland. The SLM on the vessel allowed noise levels to be captured in a mobile position in relative vicinity of the construction machinery, while the SLMs on land captured sound levels at fixed positions at greater distance.

1.2 Construction machinery and foundation design

In common with the turbine foundation installation in 2015, a jack-up installation vessel was used to lift and install the turbine towers. The Fred.Olsen Windcarrier “Brave Tern” was designed for use in the offshore wind industry and carries an 800 tonne crane. The turbine towers were lifted into position on the jacket frames in three sections, followed by a nacelle and three blades.

The tower under construction can be seen in Figure 1-1.

Figure 1-1 Jacket with four driven piles under construction

1.3 Scope of work

This report describes the results obtained from the airborne noise monitoring surveys for the installation of the foundations, tower, nacelle and blades. In summary, this report covers:

- Description of the methodology used to carry out the noise monitoring (Section 2)
- Measured background noise in and around the wind farm site (Section 3)
- Levels of noise measured during impact piling operations (Section 4)
- Interpretation of the levels of noise propagation and attenuation during construction, including the effect of wind direction (Section 5)
- Levels of noise measured around the vessels constructing the tower and turbines (Section 6)
- Conclusions (Section 7)

2 Methodology

This section presents the methodology for the airborne noise surveys on and around Block Island. The equipment used is detailed, along with descriptions of the survey locations.

2.1 Terminology

This section provides an overview of acoustic terminology.

A-weighting	Adjustment to the noise level based on the variable sensitivity of human hearing at different frequencies.
C-weighting	Similar to A-weighting, but with the adjustment changed to be more appropriate for human hearing sensitivity at high noise volumes.
dB	Decibel
Hz	Hertz, measure of sound frequency
kHz	Kilohertz, 1000 Hertz
L_{Aeq}	Notional steady-state sound level containing the equivalent energy as the fluctuating sound level over an equivalent period of time, A-weighted.
L_{AFmax}	Maximum noise level occurring over the sample period, A-weighted, Fast time weighting.
L_{A10}	The statistical noise level exceeded for 10% of the sample time, A-weighted. Typically used to capture short event noises, such as a vehicle pass-by.
L_{A50}	The statistical noise level exceeded for 50% of the sample time, A-weighted.
L_{A90}	The statistical noise level exceeded for 90% of the sample time, A-weighted. Typically used to define the background noise level.
L_{Cpeak}	The peak instantaneous noise level, C-weighted. Often used to define high, impulsive noise levels such as gunshots.
µPa	microPascal, measure of sound pressure.
Octave-band	Contraction of octave-band centre frequency, figure identifying the range of sound frequencies under consideration over an octave (doubling in frequency) defined by its centre-point, e.g. the 1000 Hz (1 kHz) octave band contains noise energy at all frequencies from 707 to 1414 Hz.
One-third (⅓) octave	Contraction of one-third (⅓) octave-band center frequency, figure identifying the range of sound frequencies under consideration over one-third of an octave defined by its centre-point, e.g. the 1000 Hz one-third octave band contains sound energy between 891 Hz and 1112 Hz.

Table 2-1 Summary of acoustic terminology

2.2 Measurement equipment

Three Larson Davis model 831 sound level meters (SLMs) were utilised in the monitoring during piling.

- LD 831 serial number 01152. Used offshore.
- LD 831 serial number 03417. Used at Point Judith on the Rhode Island mainland and Balls Point North, Block Island.
- LD 831 serial number 03605. Used at the Southeast Lighthouse on Block Island.

Calibration certification for the equipment is provided in Appendix A, for the complete frequency range of the SLMs, and confirmed before and after measurements using a field calibrator at 1000 Hz.

All noise measurements are presented as decibels re 20 µPa.

No monitor was used at Point Judith during the tower construction operation.

2.3 Measurement procedure

A series of airborne sound monitoring stations were set up both onshore and offshore to sample the noise produced during the construction of the offshore windfarm foundations, primarily by piling, and the construction of the turbine towers and blades. All SLMs were calibrated with a field calibration device and clocks synchronized. Environmental and meteorological conditions were noted, including air temperature, wind speed and direction, precipitation, humidity, cloud cover, sea state and any other significant environmental features (e.g. fog).

2.3.1 Offshore measurement procedure

Airborne sound monitoring equipment was set up on the survey vessel *R/V McMaster*, operated by the University of Rhode Island, shown in Figure 2-1. A microphone and a high performance windscreen was fixed to a steel frame over the top of the vessel wheelhouse and connected to a sound level meter with a 5 m extension lead. The microphone was fixed to the top of the wheelhouse on the vessel (see Figure 2-2).

Figure 2-1 URI survey boat, R/V McMaster, used as the survey vessel for all transect measurements

Figure 2-2 McMaster deck showing microphone positioning and high performance windscreen (jack-up barge for piling in background)

The survey vessel's engines and other equipment which might have caused acoustic interference with the measurements were turned off and the boat was allowed to drift while measurements were taken.

The surveyors took measurements on a series of transects centred on the noise source, either piling or construction machinery. The transects were chosen either to coincide with one of the onshore monitoring stations (often heading northwest towards the Southeast Light, see Section 2.3.3) or coincident with a particular wind direction. The vessel was also used simultaneously for taking underwater noise measurements for a separate study, and so the transects sometimes focused on directions pertinent to underwater conditions. A key element of the scope of work was to sample a range of conditions, especially transects under different wind directions relative to the transect direction.

Transects began at the edge of the offshore safety exclusion zone, 500 yards (460 m) from the piling location, and continued out until the vessel reached land or an impassable region of water, piling ended or piling noise was no longer audible or detectable. In practice the measurements typically continued beyond the range of audibility in air as the sound was detectable in water to a much greater distance.

At intervals starting at around 500 m and doubling in distance (500 m, 1 km, 2 km, 4 km, etc.) sound data was acquired on the computer, together with details of the boat's position and other relevant information. The boat's position was recorded on the computer system by sending the output from a GPS receiver to a USB port on the computer, which was logged with the acoustic data. This was used to determine the range to the piling from the survey vessel.

In general, airborne noise measurements were taken continuously during a piling event and so captured all noise during that period, including voices on the vessel and engine noise as the vessel moved. These spurious noises have been highlighted on figures.

A summary of the measurement details and conditions during piling is given in Table 2-2.

Tran-sect ID	Date	Turbine foundation	Direction	Ranges	Time	Wind direction	Wind speed
1	18-Aug-15	WTG2	Northwest	450 - 700 m	15:53 - 16:11	SW	3-4.5 m/s
2	03-Sep-15	WTG2	Northwest	550 m - 4.85 km	09:56 - 10:20	WSW	3-3.5 m/s
3	03-Sep-15	WTG2	East	640 m – 12.0 km	11:14 - 15:11	WSW-S	3 m/s
4	17-Sep-15	WTG5	Northwest	470 m - 5.32 km	12:42 - 13:35	SW	3 m/s
5	17-Sep-15	WTG5	Northwest	590 m – 5.32 km	15:20 – 15:53	W	4 m/s
6	17-Sep-15	WTG5	Northwest	420 m – 5.32 km	16:39 – 17:21	W	3 m/s
7	18-Sep-15	WTG3	Southeast	730 m – 6.0 km	13.09 – 13:49	SW	2 m/s
8	18-Sep-15	WTG3	Southeast	500 m – 6.42 km	14:22 – 15:07	NW	3 m/s
9	19-Sep-15	WTG1	North	710 m – 10.5 km	08:37 – 08:55	NE	Calm
10	19-Sep-15	WTG1	North	3.9 km – 6.2 km	15:29 – 15:52	S	2 m/s

Table 2-2 Summary of underwater noise measurements of piling undertaken

2.3.2 Onshore Sound Monitoring

SLMs were fixed to tripods facing the direction of the site, and windscreens were fitted at all times. Wind speed, pressure, air temperature and relative humidity was taken at 3 m above sea level while offshore and at the measurement locations at the top of the cliffs on Block Island, approximately 80 m above sea level, 1.2 meters above ground level. There was no precipitation over the duration of the survey.

The onshore measurement locations were selected to be close to the coast, with nothing blocking line of site to the BIWF site and minimal propagation over land. It was attempted to acquire a location with a minimum of influence from other noise sources, primarily the presence of members of the public on foot and road noise. Account was taken of the prevailing wind direction, southeast during the summer months.

Airborne noise levels were captured at three locations surrounding the BIWF site, representing a spread of distances to the site.

2.3.3 Southeast Light, Mohegan Bluffs, southeast Block Island

Noise measurements were undertaken at the Southeast Light for the majority of piling events. This location is approximately five kilometres (three miles) from the BIWF site. The SLM was situated on the south of the lighthouse land near the edge of the cliff, as far as possible from the public, with line of sight to the BIWF offshore site. Background noise was dominated by rustling foliage and distant waves, sporadic voices from members of the public and occasional light aircraft.

Figure 2-3 Photograph taken from the Southeast Light measurement location, showing the BIWF construction barge (circled) on the horizon

2.3.4 Balls Point North, northeast Block Island

The measurement location at Balls Point North was on the edge of a quiet footpath at the top of the cliff overlooking the site. This is approximately 11 kilometers (approximately seven miles) from the site. The background noise here was dominated by vegetation rustling in the wind and wave noise, and occasional light aircraft and vessels passing.

Figure 2-4 Onshore noise measurement location at Balls Point North, showing barge (circled) on the horizon.

2.3.5 Near Point Judith Lighthouse, Point Judith, Rhode Island mainland

The measurement location at Point Judith, on the Rhode Island mainland, was approximately 27 kilometers (17 miles) north of the BIWF site, on the coast. It was selected as an accessible position near the coast, as far as possible from the sea, without too much noise propagation over land, but which was unlikely to be disturbed by members of the public. The background noise was dominated by intermittent wave noise on the beach, which was impossible to avoid near to sea level.

Figure 2-5 Onshore measurement location near Point Judith Lighthouse. SLM was situated on the section of clear ground behind the large rock.

3 Background noise measurements

3.1 Introduction

Background noise readings were taken in all locations over periods outside of piling, in locations identical to those used during the measurements of construction noise. Although construction machinery was in position at all times, the activities being undertaken and the distances between the measurement location and the machinery were such that no appreciable noise from it could be detected or was audible outside of piling.

The background noise in each measurement location was dominated by specific sources in each case:

- Location 1 (mobile), at sea: waves and wave slap on the vessel. Vessel entirely shut down during measurements.
- Location 2, SE Light, Block Island: distant waves, rustling vegetation, members of the public, occasional vessel pass, light aircraft.
- Location 3, Balls Point North, Block Island: distant waves, occasional vessel pass.
- Location 4, Point Judith, RI mainland: wave noise on the shore.

3.2 Location 1 (mobile), background noise levels offshore

Background noise levels were sampled on the vessel outside of piling events. The background noise was typically caused by the movement of the seas and some wave slap to the side of the vessel. Background noise levels under typical offshore conditions during the August and September 2015 surveys are shown below.

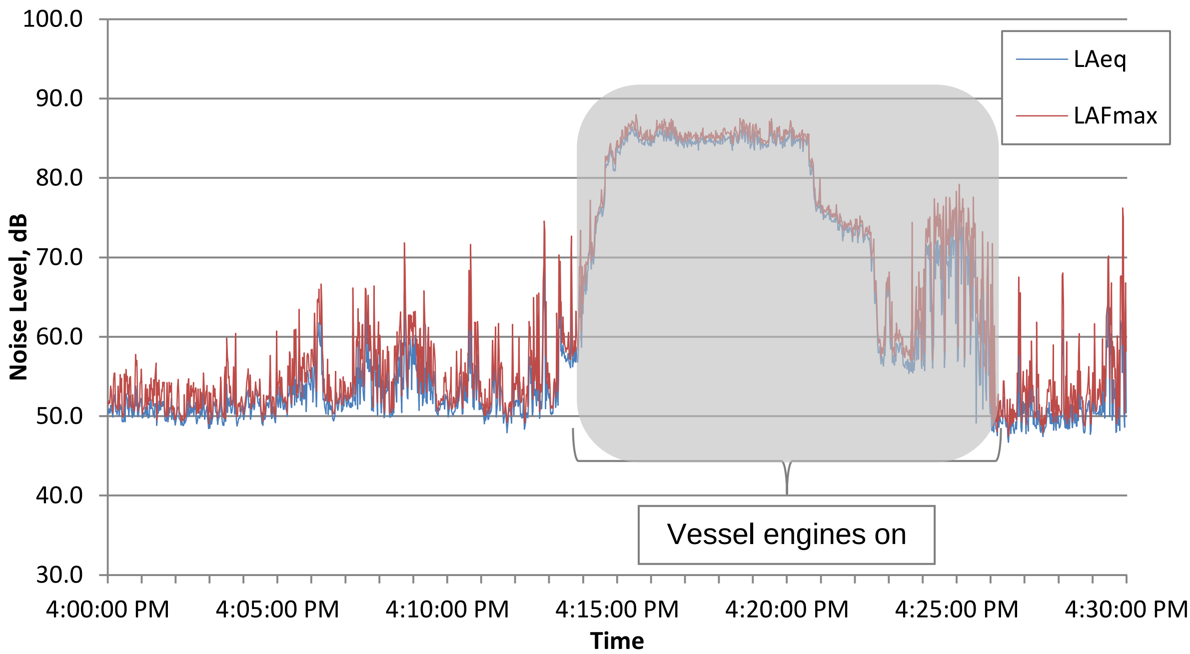

Figure 3-1 Typical sample background noise level measured offshore, August 25, 2015

Wind speed 2-3 m/s southwest, seas ~0.5 m.

	$L_{Aeq,10mins}$	L_{AFmax}	$L_{A90,10mins}$
16:00-16:10	53.3 dB	n/a	49.8 dB

Table 3-1 Summary of background noise level sample offshore (excluding engines)

Background noise levels offshore were entirely dependent on the sea state and the orientation of the vessel to the waves. As the vessel had to be shut down for the duration of the measurement period the orientation was somewhat out of the control of the personnel on board. However, the sea state was fairly consistent throughout most of the surveys. There was also some influence from small creaks on the vessel and occasional radio transmissions, therefore the L_{Aeq} should be considered indicative and a valid L_{AFmax} cannot be stated.

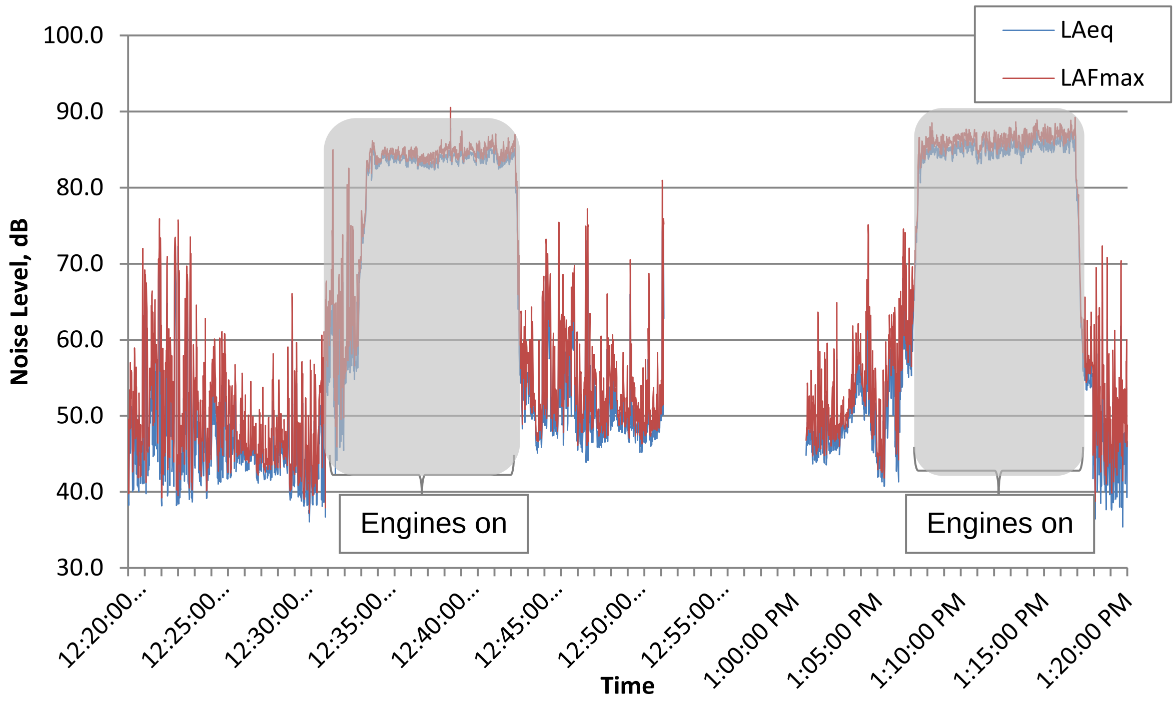

Figure 3-2 Comparative background noise level measured offshore, calm, September 19, 2015

Wind calm, sea calm to <0.5 m.

	$L_{Aeq,15mins}$	L_{AFmax}	$L_{A90,15mins}$
12:20-12:30, 12:45-12:50	56.6 dB	n/a	42.5 dB

Table 3-2 Summary of background noise level sampled offshore (excluding engines)

Figure 3-2 shows noise levels measured on September 19 when the wind and wave conditions were extremely calm and the sea, especially early in the sample, was glassy. The L_{A90} is around 7 dB lower than under the slightly choppy conditions normally present during the survey. As previously, influence from small vessel noises and radio transmissions cannot be excluded from the noise levels calculated.

3.3 Location 2, Southeast Light

A short-term indicative snapshot of background noise levels measured at the Southeast Light is shown below.

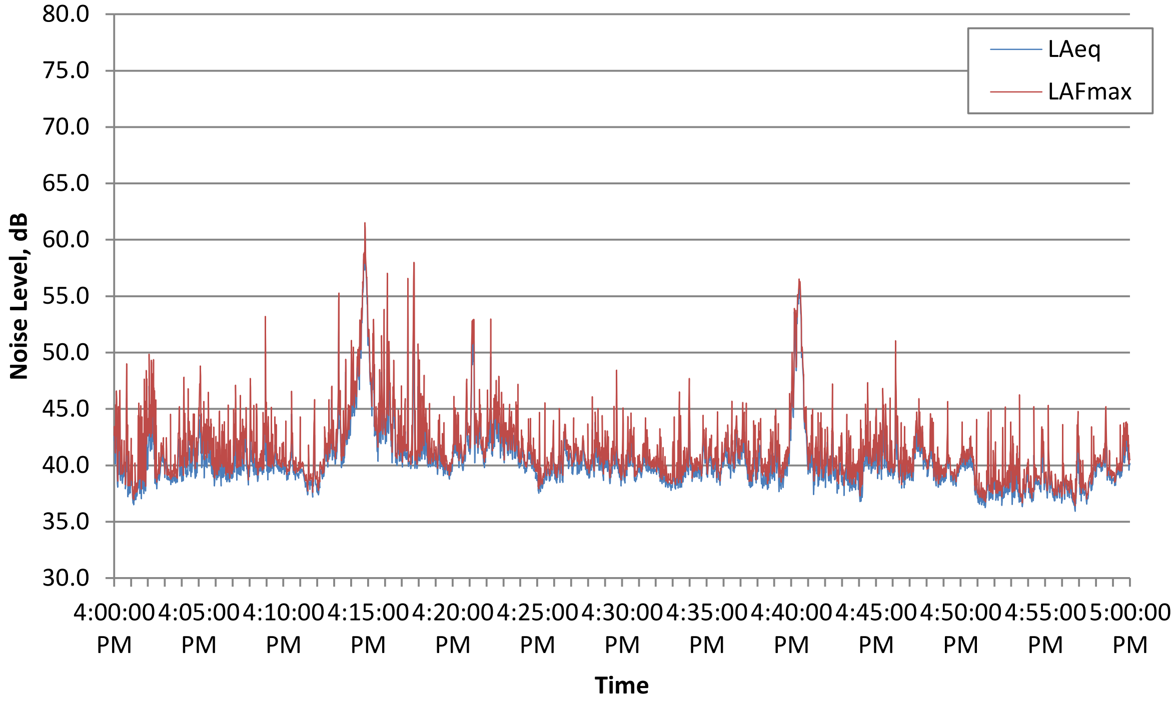

Figure 3-3 Typical sample background noise level measured at the Southeast Light, August 9, 2015

Average wind speed 9 m/s, northeast.

	$L_{Aeq,30mins}$	L_{AFmax}	$L_{A90,30mins}$
16:00 – 16:30	43.3 dB	61.5 dB	38.6 dB
16:30 – 17:00	41.1 dB	56.5 dB	37.5 dB

Table 3-3 Summary of background noise level sample at the Southeast Light, August 9, 2015

Noise levels were affected by members of the public talking and occasional light aircraft passes (for example see 16:15 in Figure 3-3 above).

A longer-term background noise survey was undertaken in January 2016, which sampled noise levels over day and night periods in the winter and at higher wind speeds, representative of more optimum wind turbine conditions. Note: due to the longer timescales, Figure 3-4 uses a 5-minute sample periods, as opposed to the 1-second sample periods used elsewhere.

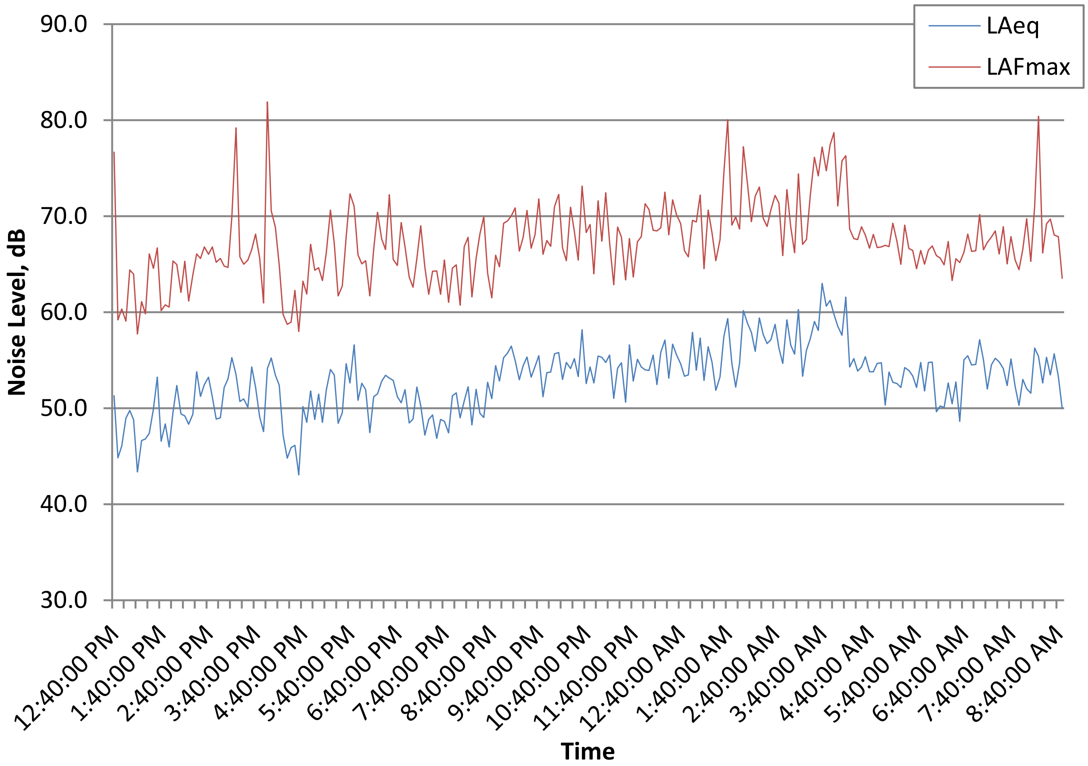

Figure 3-4 Sample background noise level measured at the Southeast Light, January 18-19, 2016

Wind speed range 6-12 m/s, northwest. The microphone was sheltered from strong winds in the shadow of the shed overlooking the sea. Noise levels were caused by wind in bare winter trees and correlated well with wind speed (shown in Figure 3-5 below).

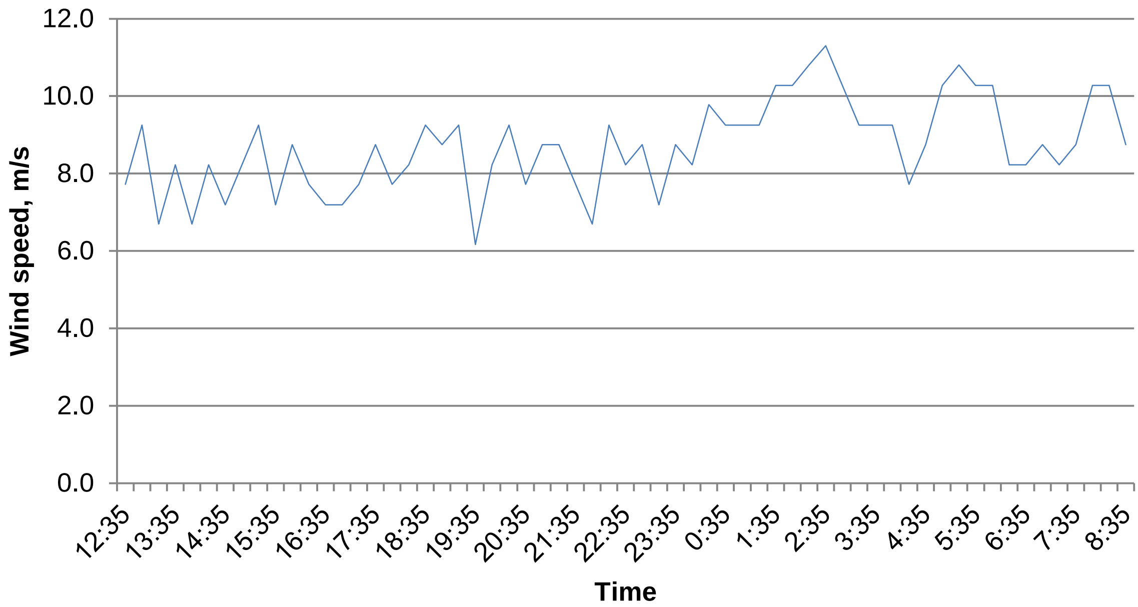

Figure 3-5 Wind speeds on Block Island, historic data from wunderground.com, Block Island Airport weather station, January 18-19, 2016

Note: wind speed data is not available with the same resolution as the noise data.

3.4 Location 3, Balls Point North

Background noise levels sampled at Balls Point North are shown in Figure 3-6 below. Problems with the SLM download mean that manual measurements must be used and thus this dataset uses a lower resolution to the other datasets. Note also that the noise levels recorded were L_{Cpeak} rather than L_{Amax} and not directly comparable with one another.

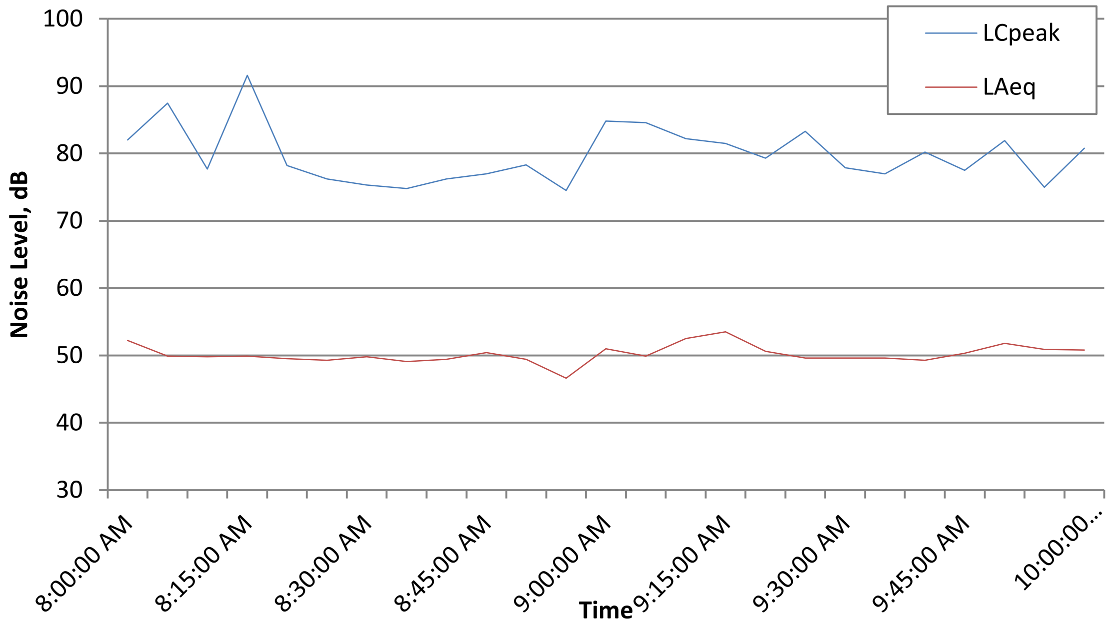

Figure 3-6 Typical sample background noise level measured at Balls Point North, August 13, 2015

	$L_{Aeq,30mins}$	$L_{Cpeak,30mins}$	$L_{A90,30mins}$
08:00 – 08:30	50.2 dB	91.6 dB	45.8 dB
08:30 – 09:00	49.3 dB	78.3 dB	45.5 dB
09:00 – 09:30	51.4 dB	84.8 dB	46.4 dB
09:30 – 10:00	50.3 dB	81.9 dB	46.0 dB

Table 3-4 Summary of background noise level sample at Balls Point North, August 9, 2015

Noise levels were caused by passing vessels, wave noise and rustling vegetation.

3.5 Location 4, Point Judith

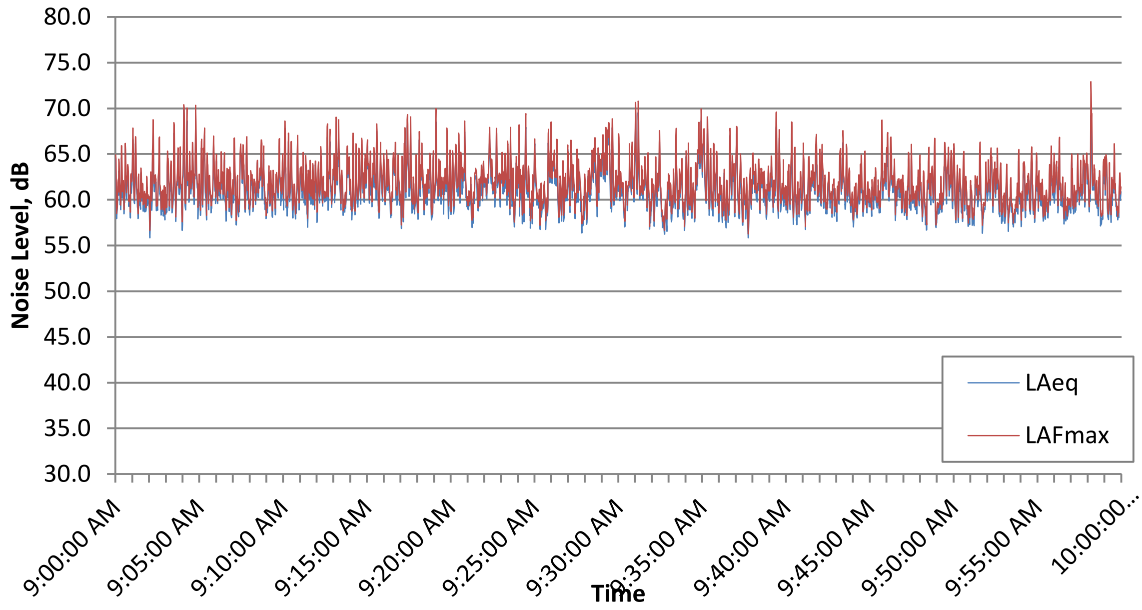

Figure 3-7 Typical sample background noise level measured at Point Judith, August 30, 2015

	$L_{Aeq,30mins}$	L_{AFmax}	$L_{A90,30mins}$
09:00 – 09:30	62.0 dB	70.4 dB	58.7 dB
09:30 – 10:00	61.3 dB	72.9 dB	58.2 dB

Table 3-5 Summary of background noise level sample at Point Judith, August 30, 2015

Noise levels are dominated by wave noise on the pebbly shore at Point Judith, which is continuous and reliable.

4 Piling noise measurement results

Measurements were taken offshore on the SLM set up on the *R/V McMaster* during all of the piling events.

Measurements were taken at the Southeast Light on Block Island during all piling events, with the exception of September 19th, where the monitor moved to Balls Point North. The results below show the results of the airborne noise measurements taken offshore alongside time histories taken at the Southeast Light, as the noise levels were reliably audible here and remained at a consistent location, unlike the measurements taken offshore. Measurements were taken at Point Judith on August 18th and September 3rd. At no time during construction was piling audible and as such the noise measurements have only been reproduced in this report in Section 4.1.

The noise levels measured are variable strike-to-strike, and so a 30-second sample is provided of clear, continuous piling noise where it was unaffected by any other spurious noise source (for example public voices nearby, light aircraft overhead, bangs on the vessel). The 1-second $L_{Aeq,}$ L_{AFmax} and L_{Cpeak} value given was selected from the higher levels sampled of the pile strikes over a measurement period, typically the second highest measured within the period to avoid the risk of spurious spikes. As coastal measurement periods were much longer than those on the vessel, since the vessel had to move between locations and sometimes over significant distances, the measurement period chosen on the coast was selected to coincide with measurements taken offshore. This somewhat selective technique was deemed necessary to obtain the best quality comparable results due to the frequent presence of non-piling noise sources during the busy holiday period in which the works took place.

4.1 WTG2 – 18 August 2015

Piling work began at WTG2. A very brief piling event took place to begin to install the first corner pile before an element of the piling equipment failed and piling ceased. This event was captured on the SLMs offshore and at the Southeast Light on Block Island.

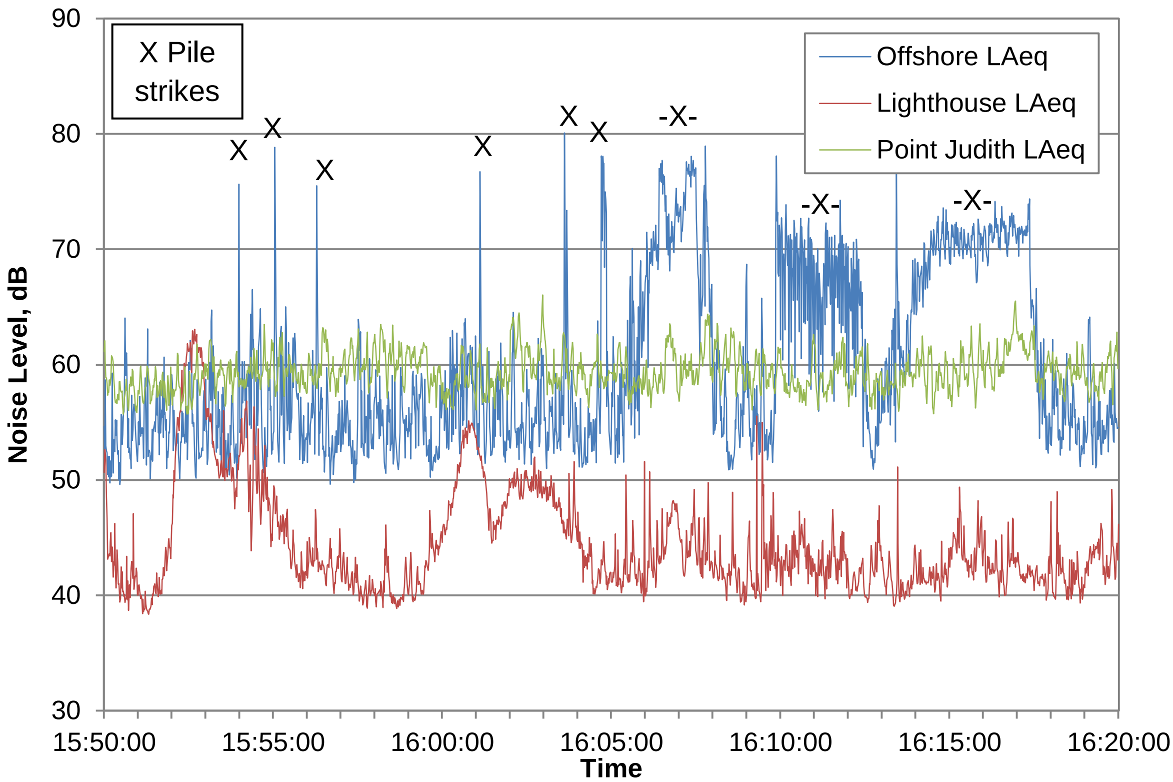

Figure 4-1 1s time history over the piling period, August 18, 2015

Figure 4-1 shows the time history over the piling period, which marks the pile strikes offshore, the variability of noise onshore at the Southeast Light and the noise levels at Point Judith.

Three initial pile strikes can be seen clearly at around 15:55, with a few sporadically before continuous piling for three distinct periods over the next 20 minutes. Piling can be detected in the Southeast Light time history and was clearly audible, although it is lost in frequent recreational light aircraft flybys (e.g. 15:53, 16:01). The noise level remains relatively high at Point Judith due to wave noise.

Although the noise appears somewhat continuous from the above Point Judith time history, of course there were periods between waves when the ambient noise was effectively, temporarily, ‘quiet’ and pile strikes would be more audible. Subjectively, pile strikes were never audible at any time at Point Judith. This is as expected based on offshore samples taken at locations closer than Point Judith. For this reason measurements at Point Judith have been omitted in the rest of the main report.

4.2 WTG2 – 03 September 2015

Airborne noise measurements took place during the second stage of pile driving for the foundation WTG2 which took place on 3 September 2015. The jacket foundation had previously been set and the first stage of pile driving had occurred. Three of the four second stage piles were sampled.

Throughout the driving of the second pile, measurements were carried out along an eastern transect between 640 m and 4.05 km. The second piling event began at 11:14 and ceased at 11:35.

In between the second and third piles being driven the survey vessel moved out to 7.6 km to continue measurements along the east transect. On commencement of piling for the third pile, measurements were taken between 7.6 km and 20 km.

The survey vessel continued to a distance of 30 km in between the third and fourth piles being driven for underwater measurements. The noise was inaudible in air at 20 km, and so no further measurements were taken at greater distances.

Measurements were taken onshore, at the Southeast Light and Point Judith. As previously, no noise from the piling was detected at Point Judith either subjectively or on the SLM at any time.

4.2.1 Pile 1 Northwest Transect

Figure 4-2 shows the time history data captured by the monitor onboard the survey vessel. The graph clearly displays four blocks which correspond to vessel operation; the SLM was not shut down during these periods and so these represent engine noise.

The figure shows the comparison between three common noise metrics that are used in environmental noise assessments. The time average is 1 second, equivalent to the 'slow' weighting for the L_{Aeq} metric.

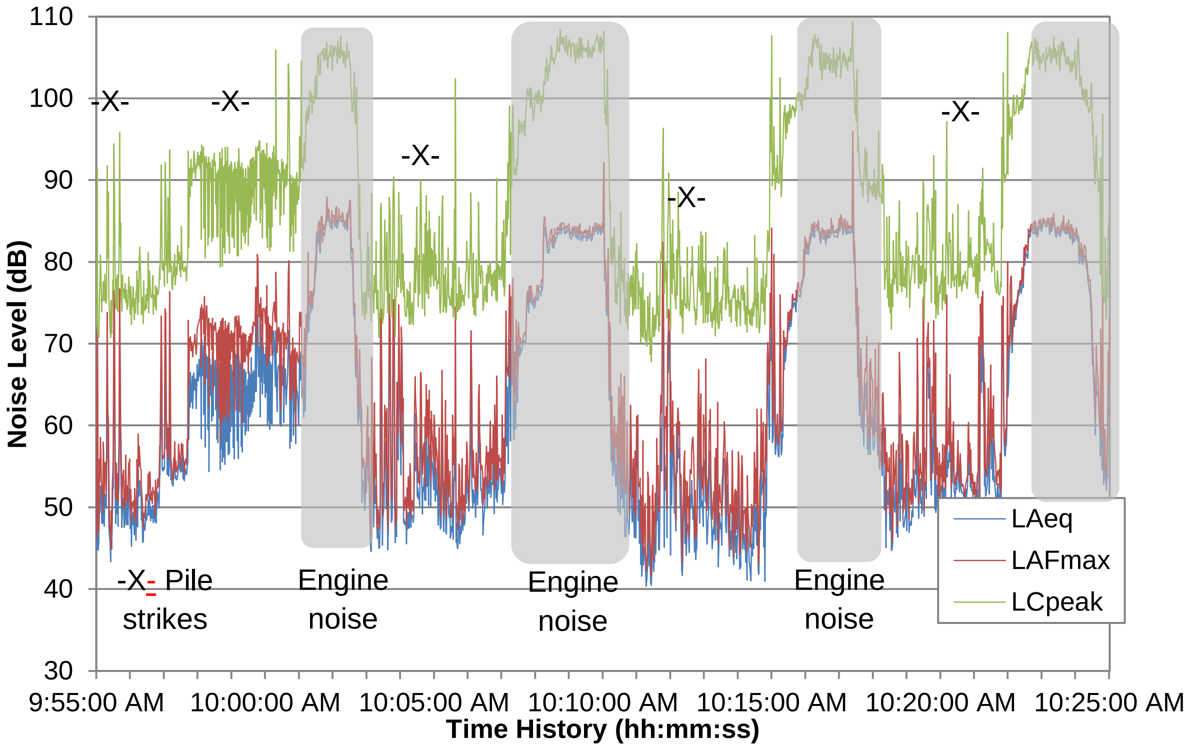

Figure 4-2 Time history plot of noise levels recorded offshore from WTG2 on 03 September 2015

Between vessel engine operation periods, Figure 4-2 shows a progressive reduction in noise levels clearly within the L_{Cpeak} trace as the vessel moves further from the noise source. The exception to this is the final measurement period around 10:20 at approximately 3,000 m, where the noise levels increase with no obvious explanation. This may be due to environmental conditions, such as a brief undocumented lull in wind or change in wind direction. No similar increase was observed in the underwater noise measurements at the same time, and no increase was noted on the time history for the Southeast Light (Figure 4-3). A similar, apparently spurious, increase was also noted on the east transect at around 4,000 m. This is discussed further in Section 4.2.2.

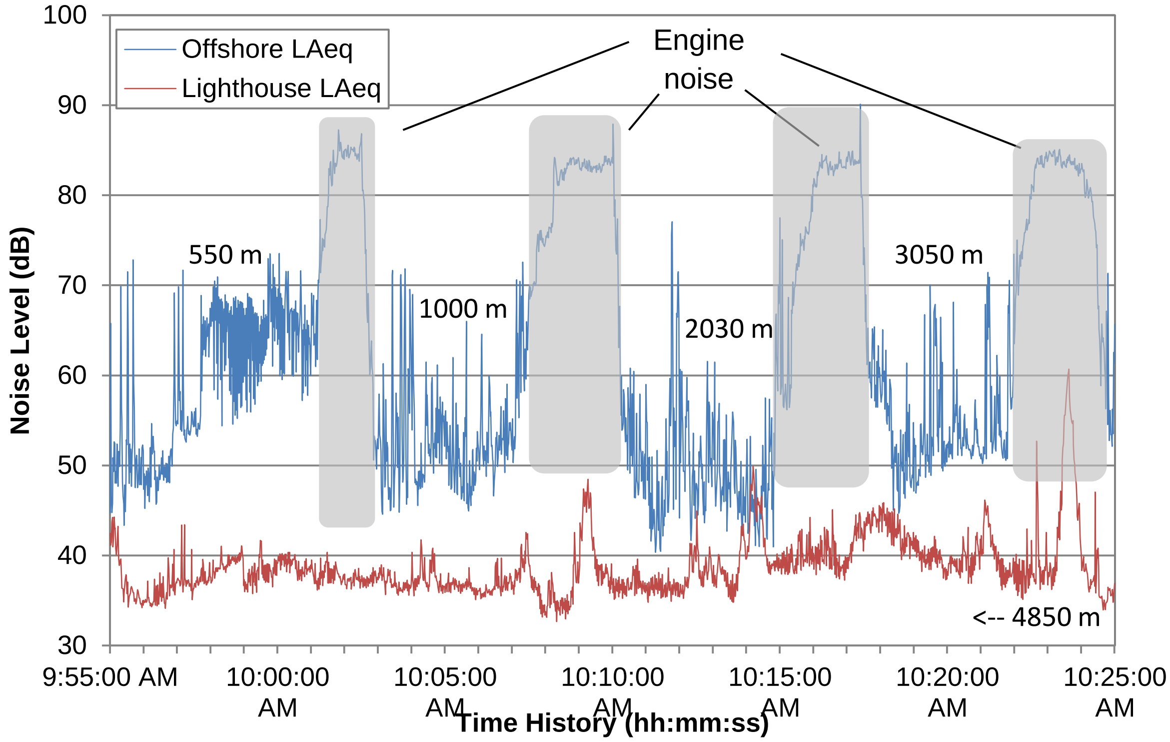

Figure 4-3 Comparative time history plot of noise levels recorded offshore and on the coast on an northwest transect, 03 September 2015, including range from piling

Figure 4-3 shows the same offshore time history as Figure 4-2 alongside the time history recorded at the Southeast Light. The transect was to the northwest and so the vessel was travelling towards the lighthouse.

4.2.2 Pile 2 and 3 East Transect

Measurements were taken along an east transect for two piling events. Figure 4-4 presents a summary of the data captured along the east transect. Noise events of pile strikes were recorded up to 12 km from the piling.

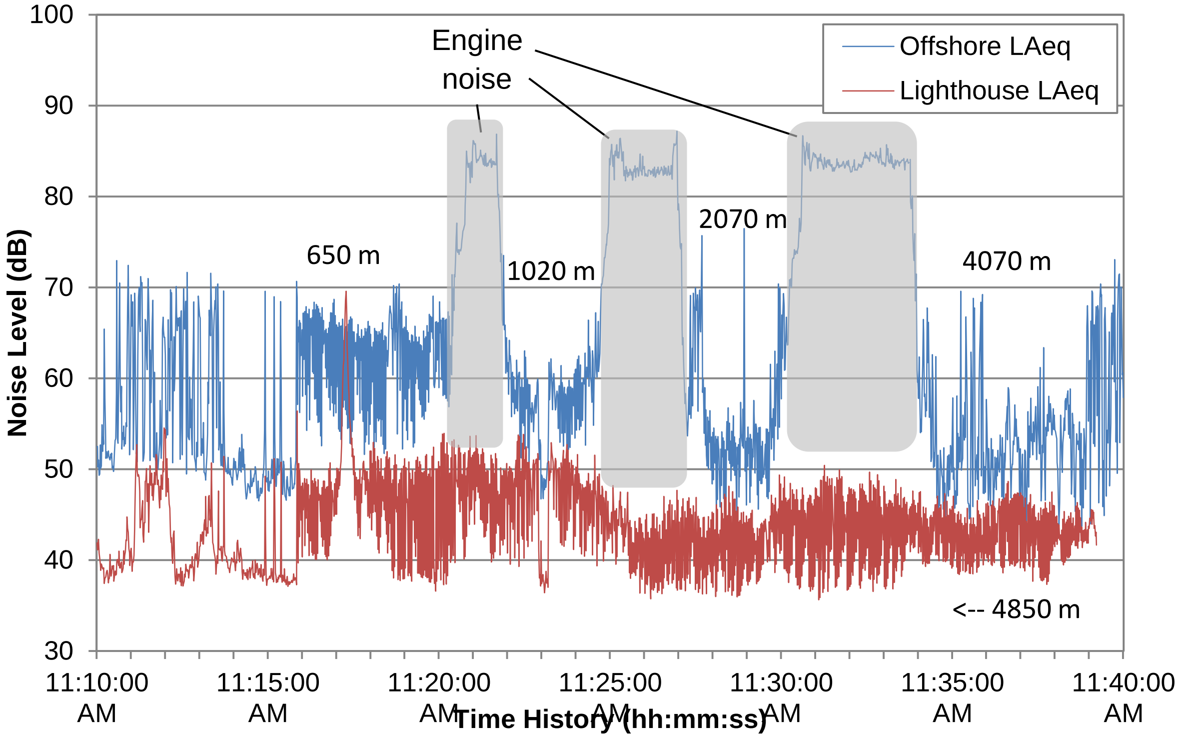

Figure 4-4 Time history plot of noise levels recorded offshore and on the coast on an east transect, 03 September 2015, including range from piling

As in Section 4.2.1, the offshore time history shows a progressive reduction over time, and therefore distance, around the periods of transit and high engine noise. There is also a clear reduction in the noise level received at the fixed lighthouse location at around 11:25, which cannot be explained.

In common with the measurements earlier in the day in Section 4.2.1, there is an unexpected increase in the noise level at around 11:35, 4.0 km from the piling. As the distances were similar but on different transects, it is possible that the increase is caused by atmospheric temperature variations, which can lead to a focussing of sound over a particular range. This cannot be confirmed.

4.3 WTG5 – 17 September 2015

Noise measurements were undertaken on 17 September 2015 offshore, at the Southeast Light and Point Judith. The pile driving was carried out on WTG5 foundation. The jacket structure of the foundation had been placed and the first stage of the four piles had been placed into the jacket.

4.3.1 Pile 2 – Northwest transect

Figure 4-5 shows a comparative time history of the airborne noise levels sampled offshore and at the Southeast Light. The survey vessel was on a heading directly towards the lighthouse.

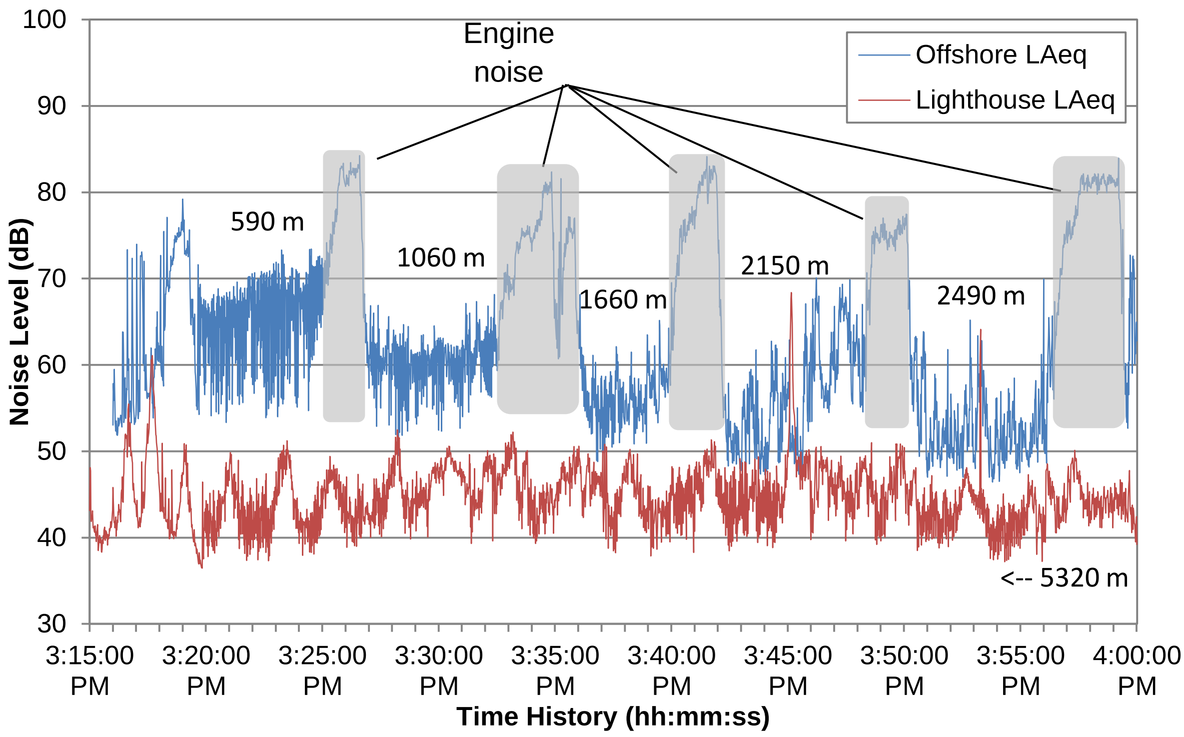

Figure 4-5 Time history plot of noise levels recorded offshore and on the coast on an northwest transect, 17 September 2015, including range from piling

The time history shows the initial soft start clearly at the beginning of the offshore trace, but is lost in the background noise onshore. After periods of engine noise with transiting of the survey vessel, progressive reductions in the noise level with time and distance are visible, although there is an increase around 15:47: piling noise was only just audible at this location and so this increase is due to other spurious factors most likely caused by talking on the vessel – underwater noise monitoring was also being conducted at this time – or other external source.

4.3.2 Pile 3 – Northwest transect

Figure 4-6 shows the comparative time histories between the offshore SLM taken on a northwest transect and the lighthouse. Five periods of vessel engine operation are clearly identifiable. The lighthouse monitor was started one minute late.

The offshore noise levels decrease as expected after each transit until 17:35, where the vessel returns to 750 m, the same distance as at 16:50-16:55.

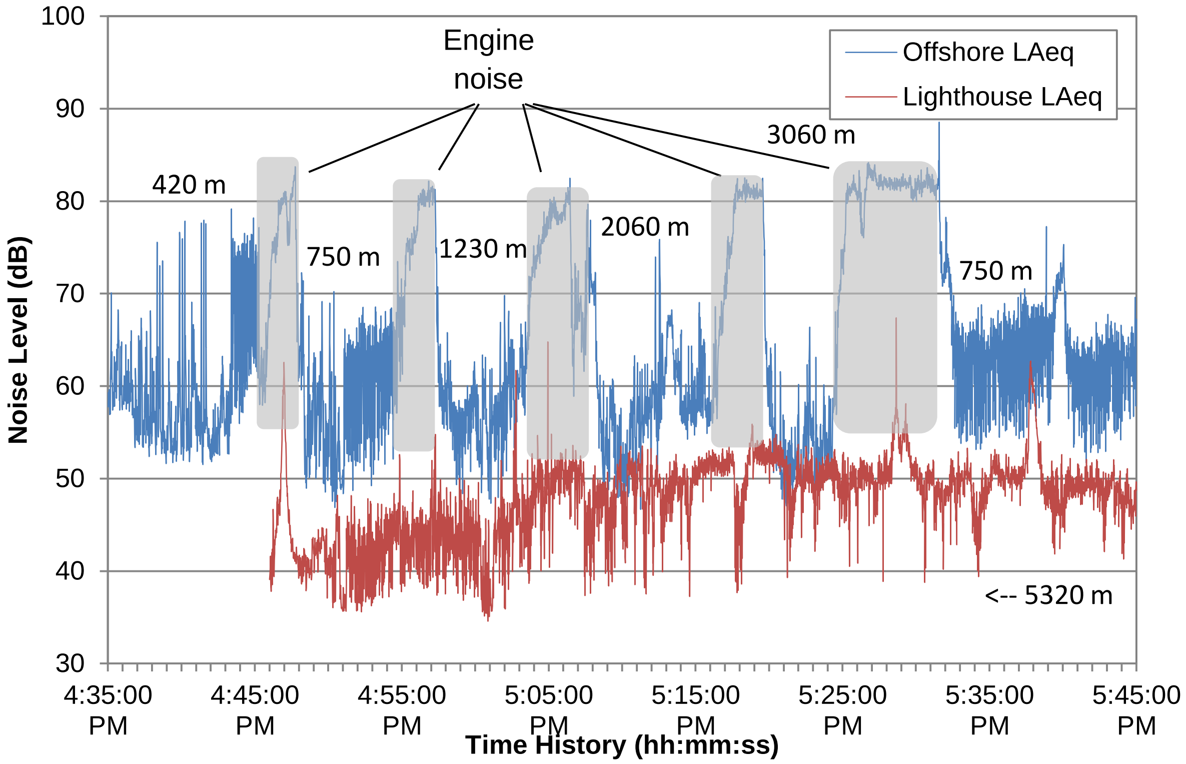

Figure 4-6 Time history plot of noise levels recorded offshore and on the coast on a northwest transect, 17 September 2015, including range from piling

The lighthouse time history shows a clear increase in the received noise level in the early stages of piling. This is also seen in the underwater fixed monitor and matches the ramp-up (i.e. progressive increase) in blow energy over the piling event. Energies increased from approximately 100 kJ to 170 kJ at 17:04 and from 170 kJ to 250 kJ at 17:18.

4.4 WTG3 – 18 September 2015

Noise measurements took place during the second stage of pile driving for the foundation WTG3 which took place on 18 September 2015. The jacket foundation had previously been set and the first stage of pile driving had occurred.

4.4.1 Pile 1 – Southeast transect

Airborne noise transect measurements were carried out during the pile driving along a transect to the southeast from WTG3, out into deeper waters. Three ranges were sampled offshore: 730 m, 3.1 km and 6.0 km. The offshore SLM was started slightly late due to time taken to reach the correct position.

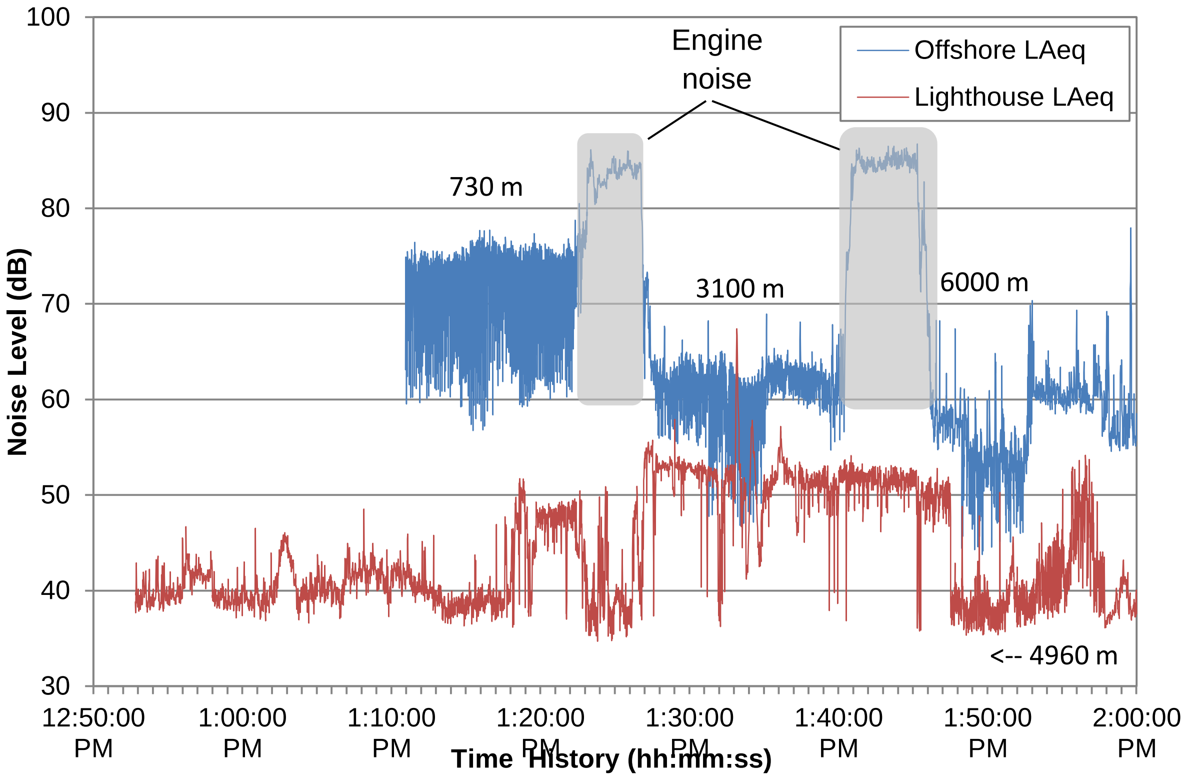

Figure 4-7 Comparative time history plot of sound level meters on September 18 2015, including range from piling

A sudden drop in the noise level at the lighthouse can be observed at 13:47:30, and a few seconds later offshore due to the additional distance the sound has to travel. It appears to also be replicated in the fixed underwater noise monitor, and so would indicate a reduction in the noise level at source, possibly because of hitting a section of soft ground, rather than any external factor. The piling log shows no significant variation in blow energy at this time.

4.4.2 Pile 2 – Southeast transect

The second piling event sampled on September 18 is shown below. The transect was southeasterly, as per Figure 4-7 above, although moving towards the pile, starting at 6.4 km and moving to just under 500 m just after 15:00.

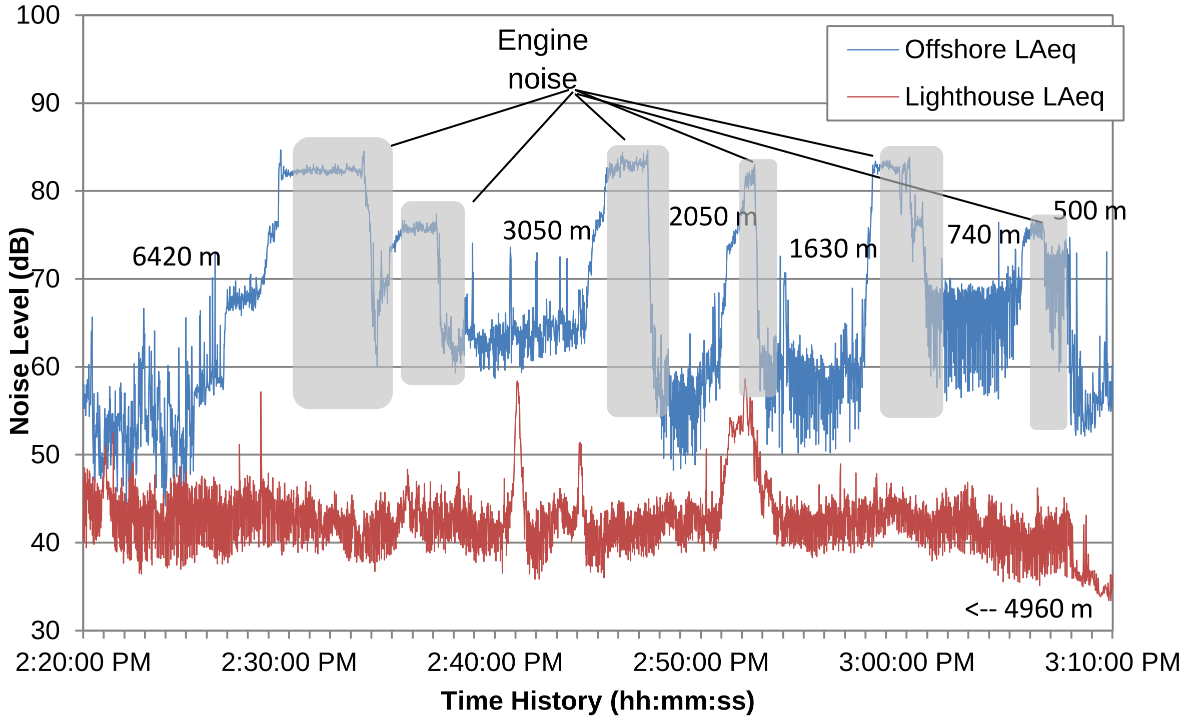

Figure 4-8 Time history plot of sound level meters on September 18th 2015, including range from piling

The piling noise levels follow the expected trend, becoming progressively louder after each vessel transit as the vessel moves closer to the piling with time. One notable exception is the period around 14:40 where the vessel was at 3.0 km. At this distance, the measured noise levels were at least 5 dB higher than the trend suggests, which can be seen clearly as the outlier in Figure 5-1. There is no clear explanation for this, although it does seem to follow a pattern of unexpectedly high noise levels around the 3.0 km to 4.0 km range, identified previously in Section 4.2.

4.5 WTG1 – 19 September 2015

Airborne noise measurements were taken offshore on a northerly transect towards Point Judith. The offshore transect was chosen so the vessel travelled past the Balls Point North monitoring location for corroboration. Pile driving for the first stage of the WTG1 foundation was carried out on 19 September 2015.

4.5.1 Pile 1 – North transect

Piling began at 8:30. Measurements were taken starting at 710 m from WTG1. The piling resumed on pile 1 at 12:25 and measurements were taken from the survey vessel at 12.4 km. The survey vessel then continued on the north transect in order to take measurements further out for the second pile. Pile strikes were recorded out to 24 km during the second pile being driven.

Piling was faintly audible on the survey vessel out to 6 km and also at Balls Point North, but only during the first piling event. The wind during this period was very calm and the water was still. Beyond this the winds picked up and piling was not generally audible on the coast. This may be in part due to slightly increased background noise caused by the wind in the vegetation.

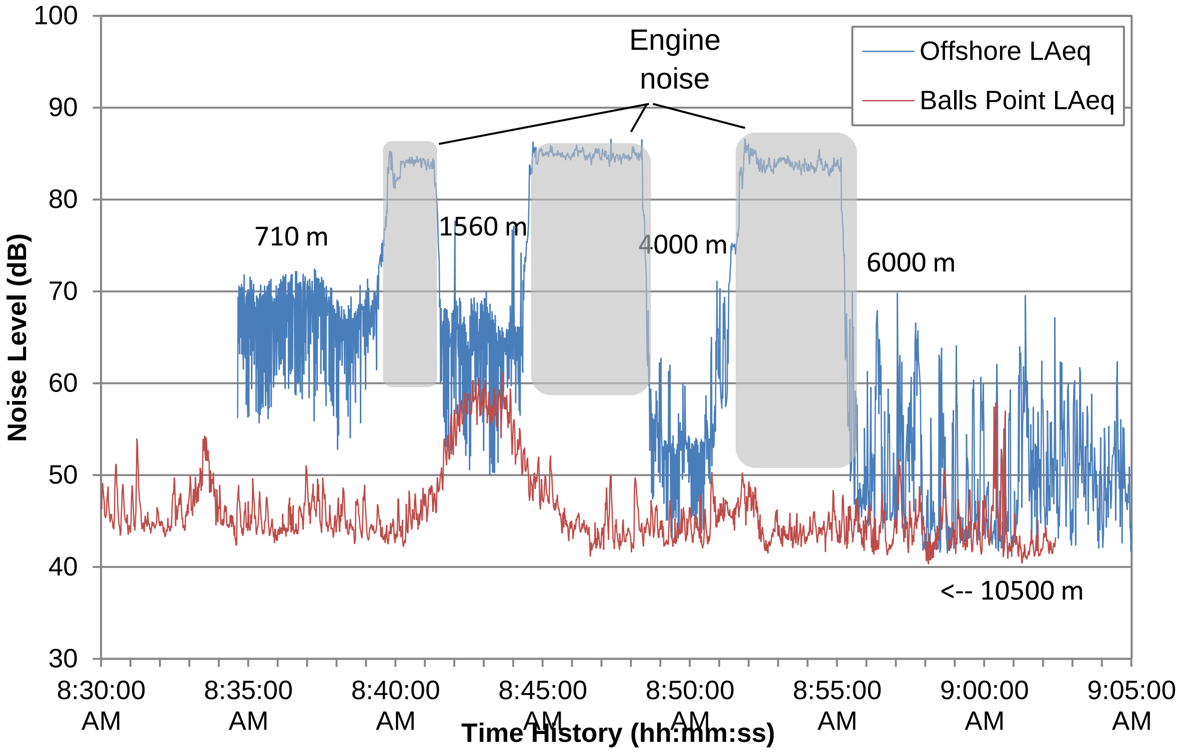

Figure 4-9 Comparative time history plot between SLM on the survey vessel and at Balls Point North on 19 September 2015, including range from piling

The offshore SLM was started slightly late. The large hump in the Balls Point North time history in Figure 4-9 was caused by a passing vessel close to the coast. At this time the survey vessel was nearly 10 km from the Balls Point North location. Piling finished very shortly after vessel stop at 08:55 and noise fluctuations after this were mostly due to speech on board the vessel and radio communications.

4.5.2 Pile 2 – North transect

Figure 4-10 below shows the same transect as in Figure 4-9 above, but at approximately 6.2 km before the vessel transit at 15:45, and 3.9 km after, moving towards the piling. Piling was clearly audible at both ranges. The winds had increased to approximately 2 m/s south, and the transect was therefore directly downwind.

Pile strikes can be observed in blocks up to 15:35, although they continue after this. Piling stops at 15:53, shortly after the vessel reaches 3.9 km and the strikes can be seen only briefly after the vessel engine noise between 15:45 and 15:49.

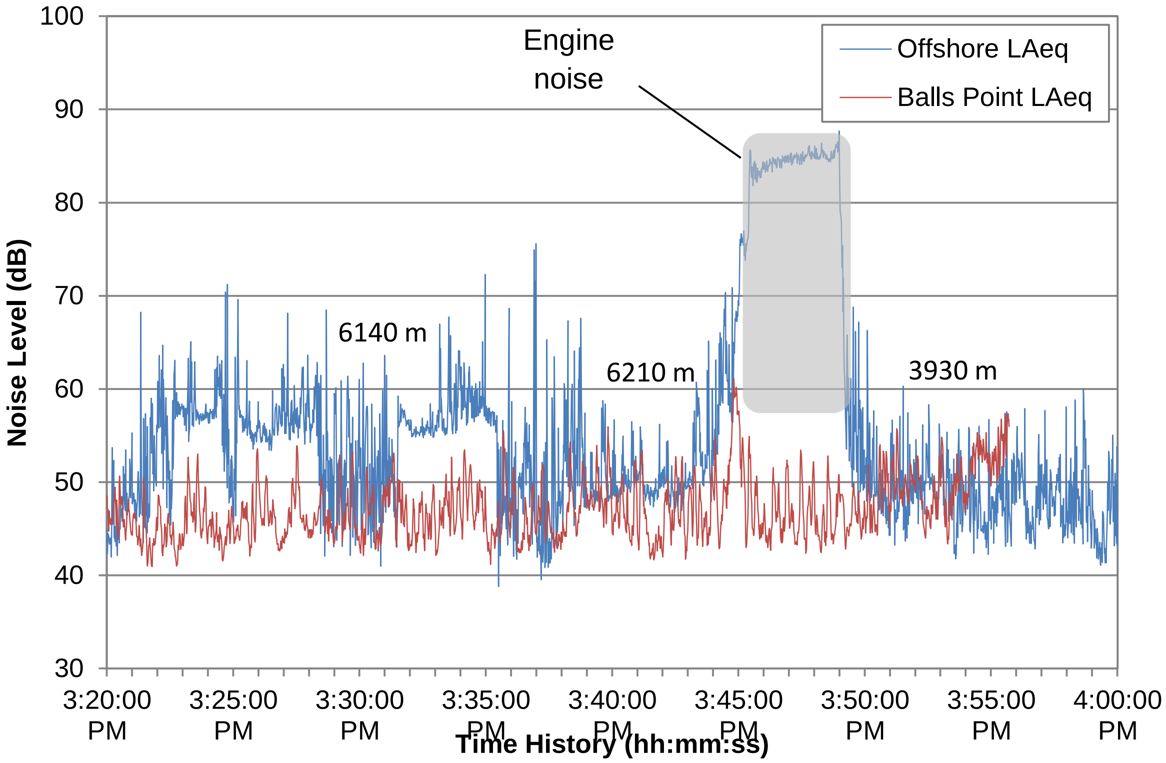

Figure 4-10 Comparative time history plot between SLM on the survey vessel and at Balls Point North on 19 September 2015, including range from piling

The pile strikes are indistinguishable from the background noise on the Balls Point North plot.

4.6 Discussion

In general the L_{Amax} was around 4.8 ±2 dB higher than the $L_{Aeq,1s}$ within approximately 1600 m, and closer to 3.9 ±3 dB beyond approximately 1600 m. Longer term $L_{Aeq,30s}$ readings vary relative to the short-term values according to the piling strike rate; the more rapid the strike rate, the more impulses occur within the thirty second period and consequently the time-averaged $L_{Aeq,30s}$ will be higher.

5 Interpretation of results – piling measurements

5.1 Introduction

The airborne noise levels have been analysed to attempt to calculate the attenuation of airborne noise over water, taking into account the measurements taken on the survey vessel and at the onshore locations.

ISO 9613-2:1996 states that airborne environmental noise propagation over substantial distance tends to follow a basic equation where the noise level at a receiver position is affected by the level of noise at source, a directivity correction relating to any changes in noise emission dependent on the direction from the source and the attenuation with distance, which is a combination of multiple factors. As piling is effectively an 'omnidirectional' noise source, that is it radiates noise equally in all directions, directivity can be discounted. Discounting also factors that will not have an effect offshore (e.g. screening effects) and the equation for estimation of noise level at a receiver becomes:

$$RL = SL - N\log_{10} R - \alpha R$$

where RL is the noise level at the receiver, SL is the noise level at the source location, R is the range or distance from the source, N is a coefficient relating to the rate of geometric sound attenuation dependent on a number of factors, and α is the atmospheric absorption coefficient.

The primary purpose of this study is to observe the airborne noise emissions caused by impact piling during installation of the Block Island Wind Farm foundations. This analysis is designed to estimate an appropriate value for N coefficients based on the measured airborne noise levels as they propagate from piling over water, primarily as a function of wind speed and wind direction, relative to the direction of travel. This will help to predict received noise levels under similar situations in the future. It is acknowledged that other factors will have an impact on the attenuation of noise, such as scattering by the water surface, weather conditions (e.g. cloud/fog) or variations in temperature with altitude, but analysis to this level of detail is beyond the scope of this study.

The analysed data below will be split into the following groups: where data was taken downwind, crosswind and upwind of the piling and also during flat calm conditions. Noise data sampled offshore has been combined with measurements onshore, primarily at the Southeast Light.

5.2 Factors affecting noise propagation in air

5.2.1 Source level

Critical to the calculation of the noise level at a receiver is the noise level at its source. Subacoustech Environmental's previous measurements of offshore impact piling noise underwater has found that the source level is primarily related to the diameter of the pile and how hard the pile is struck (the blow energy of the hammer in use). While other factors will have an effect on the noise produced (e.g. material type and thickness, properties of the ground and properties of the pile), the source noise emission can be described adequately by the diameter of the pile and blow energy.

As the pile size used for the foundations at the BIWF is the same, the source level is likely to change only by the energy used in each strike.

It should be noted that for the purposes of this study, the source level is defined as a theoretical sound level at 1 m from the noise source. This assumes that the source itself is effectively a point source, as it will appear at the distances at which the measurements were taken.

5.2.2 N coefficient

Also known as geometric spreading, the value of N defines how quickly the noise at source reduces over distance and is primarily related to how the noise 'spreads out'. However, this value changes with the shape of the source (i.e. if the source is a 'point', a 'line' or an 'area'), how far the receiver is from the source, weather conditions, changes in the atmosphere, reflective surfaces and others. Typically a simple assumption of a sound spreading spherically from the source in ideal conditions provides a value of N of 20, and real world conditions lead to variations around this value depending on the exact situation. For example, downwind conditions might be expected to lead to slower attenuation of noise and a slightly lower value of N, but upwind the sound will attenuate more quickly and the value of N will be greater.

Depending on the value of N, the real reduction in noise tends to vary between 3 and 6 dB per doubling of distance from the noise source.

5.2.3 Absorption coefficient, α

While the N coefficient causes a reduction in the noise level with every doubling of distance, the absorption coefficient (α) applies a small reduction with every unit of distance, due to absorption in the medium in which the noise is travelling. The consequence of this is that the overall attenuation of noise is controlled by N when near the noise source, and α becomes more significant at a greater distance.

Like N, the value of α depends on a large number of factors, including the frequency of the noise and the environmental conditions, such as temperature and humidity, where the noise travels through air. Detailed tables showing the values of α under a variety of environmental conditions can be found in ISO 9613-1:1993 *Acoustics - Attenuation of sound during propagation outdoors* and for the purposes of this study are considered to be a known quantity.

5.3 Analysed data – wind direction

The airborne noise data sampled during the piling for the BIWF, ten piling events, have been sorted in respect of the wind direction under which they were taken. Where events occurred under the same wind direction, the various distances at which noise level samples were taken were combined to provide a level vs. range plot including measurements taken at the coast.

It should be noted that the sea state, wind speed, temperature, pressure and humidity remained fairly consistent throughout measurements in each group. For more information on conditions at the time of survey, see Table 2-2.

All analysis assumes there are two values of the N coefficient: one which exists close to the piling and one at a greater distance. Due to safety reasons, as the number of measurements close to the pile (nearfield) were insufficient to empirically establish a trend in the measurements, spherical spreading (i.e. N = 20) was assumed. The limited nearfield data also makes it difficult to determine the transition point between the nearfield and far-field spreading zones. The best fits to the data were achieved where a range of 800 m was used as the transition point in the analysis; that is, the calculations assumed spherical spreading (N = 20) at ranges of 800 meters or less. This is similar to the conclusion reached by Boué (2007) in a report to the Swedish Energy Agency for Vindforsk, which identifies a transition point of 700 m, based on data from a noise measurement programme in the Baltic Sea.

Analysis initially consisted of applying a line of best fit using a sum-of-squares technique to the 1-second L_{Aeq} ($L_{Aeq,1s}$) data. The $L_{Aeq,1s}$ rather than the 30-second average was used in the analysis as it is independent of piling strike rate, which was variable. Changing the strike rate would affect the longer-term average, despite the source level remaining unchanged.

Coefficients of N (>800 m) and the source noise level were then altered manually until data (at 200 m intervals) most closely matched the line of best fit. The effect of blow energy on the apparent source noise level is considered in section 5.5 but in general the same source level fitted the data throughout. There were two exceptions: measurements taken under slightly upwind conditions (wind at 67.5°) and under calm conditions. These are described in the relevant sections below.

The range axes are all on a logarithmic scale.

5.3.1 Receiver downwind of the piling

Two piling events took place with measurements taken under a downwind transect: one on September 18th and one on September 19th. The level vs. range plot, with reference to 1 m, is shown in Figure 5-1 below.

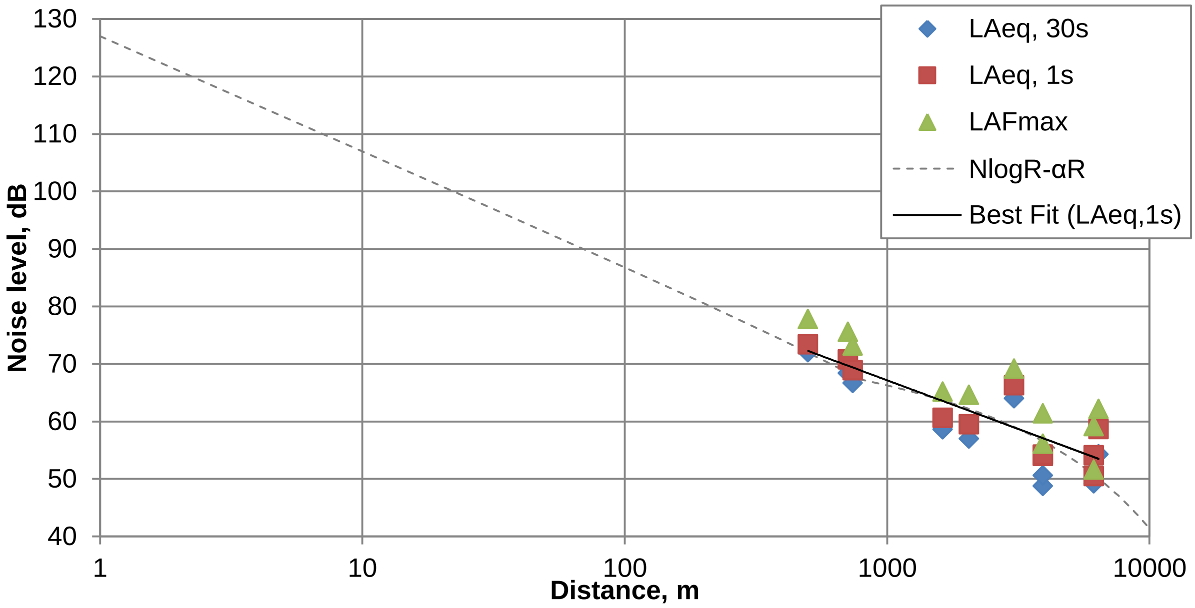

Figure 5-1 Level vs range plot for winds at 180° (downwind) to the direction of travel

Receiver Level [R>800m]: N = 6, α = 0.0021

The source noise level was calculated to be 127 dB $L_{Aeq,1s}$, a figure remarkably close to the estimate reported in “In-Air Acoustic Report” prepared by TetraTech EC, Inc. for Deepwater Wind of “129 dBA”. The ‘tail’ at the end of the NlogR-αR points represents a greater influence of the absorption coefficient, α, over large ranges.

5.3.2 Receiver crosswind of the piling

Data in the 90° crosswind analysis was extracted from samples taken on three piling events, which occurred on September 3rd, 17th and 18th.

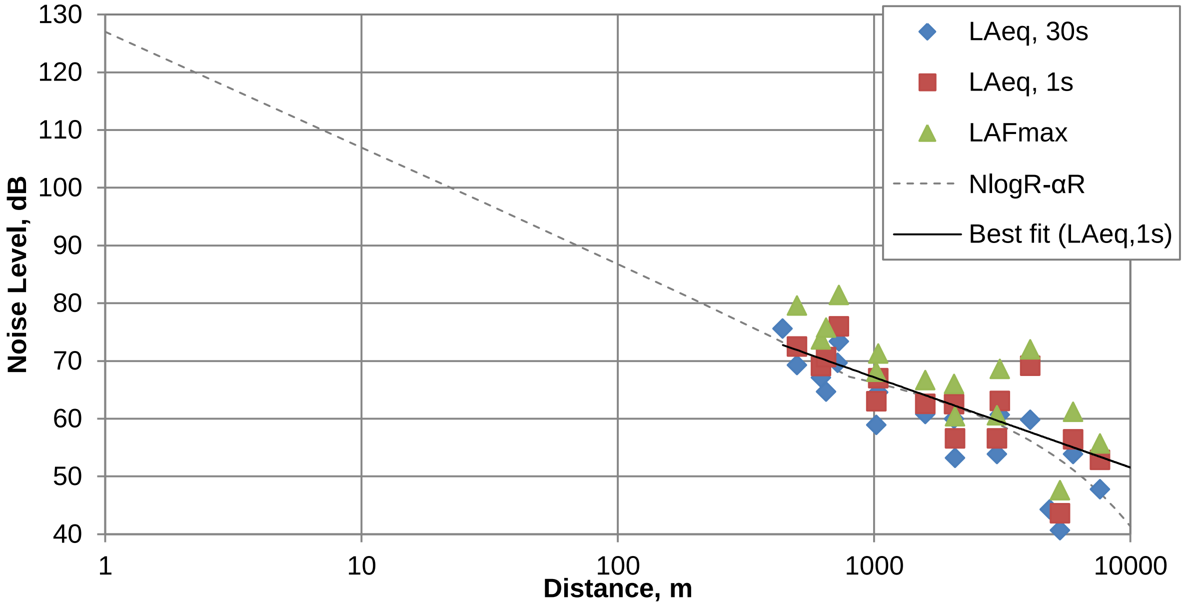

Figure 5-2 Level vs range plot for winds at 90° to the direction of travel

Receiver Level [R>800m]: N = 6, α = 0.0021

There is a lower correlation between the line of best fit and samples beyond 3000 m; all samples were included in the best fit calculation. Although the line of best fit is best matched by N = 6 for ranges in excess of 800 m, values of up to N = 12 show a progressive steepening of the curve which remains visually within the trend, especially if the sample at 4.1 km is considered a spurious outlier. It is suggested that there is likely to be greater variation in sound in crosswinds than under an entirely upwind or downwind condition and that a slightly higher value of N than downwind would be reasonable, especially in light of the analysis for the 67.5° winds noted in Section 5.3.3 below.

The source level remains at 127 dB $L_{Aeq,1s}$.

5.3.3 Receiver upwind of the piling

Most measurements were taken during events under winds with an upwind component.

There were two piling events where the wind was at 45° to the transect, both on September 17th, and data combined show an excellent correlation to the line of best fit between 400 m and 5 km.

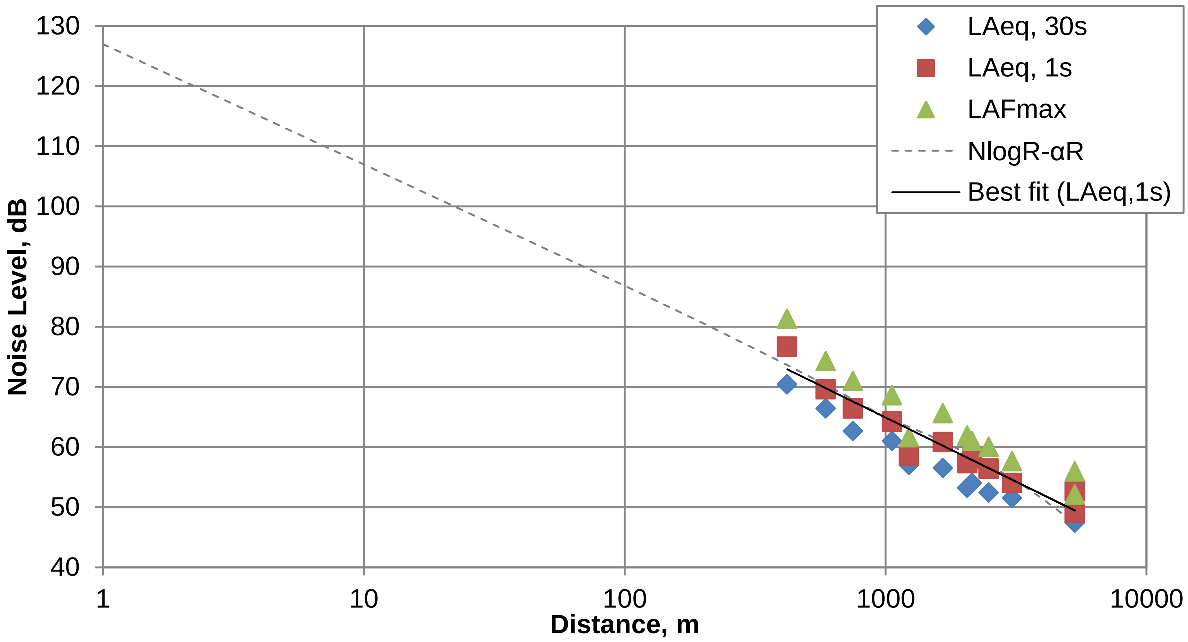

Figure 5-3 Level vs range plot for winds at 45° to the direction of travel

Receiver Level [R>800m]: N = 12, α = 0.0021

The NlogR-αR points fit the line well at N=12, i.e. a slightly faster attenuation with distance than the standard N=10 for cylindrical spreading. This is to be expected, as the adverse winds lead to greater reductions in noise. The absorption coefficient remains as previously at 0.0021 and the source noise level at 127 dB $L_{Aeq,1s}$.

The wind direction at 67.5°, or just beyond crosswind conditions, was only sampled briefly over one event and four points on September 3rd. However the line of best fit remains at N=12 for R>800m.

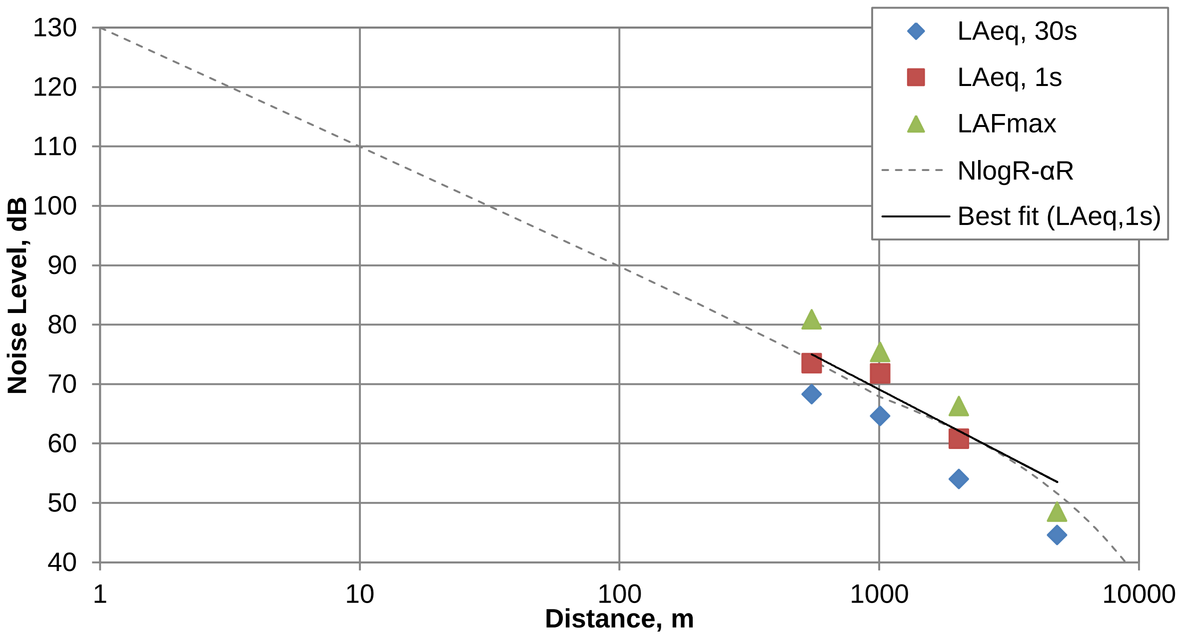

Figure 5-4 Level vs range plot for winds at 67.5° to the direction of travel

Receiver Level [R>800m]: N = 12, α = 0.0021

It is worth noting that for the event when the wind is at 67.5° from the direction of travel, the standard N=20 (R<800m) and α coefficients only fitted the data when the source level was increased by 3 dB to 130 dB $L_{Aeq,1s}$. The data would also fit if the source level remained constant and the value of N in the nearfield range reduced to 19, although it seems more plausible that environmental conditions remain consistent and there was an increase in the overall noise output during this event. Piling logs do not show a notably high blow energy at this time (energy was 60 kJ to 100 kJ over this period, which is representative of most sampled periods) and so the apparently higher source noise level may be as a result of the relatively low number of measurements taken over this wind condition.

5.3.4 Calm wind and seas

On the final day of measurement, the wind dropped completely with flat calm seas. Only one short transect was possible under these conditions.

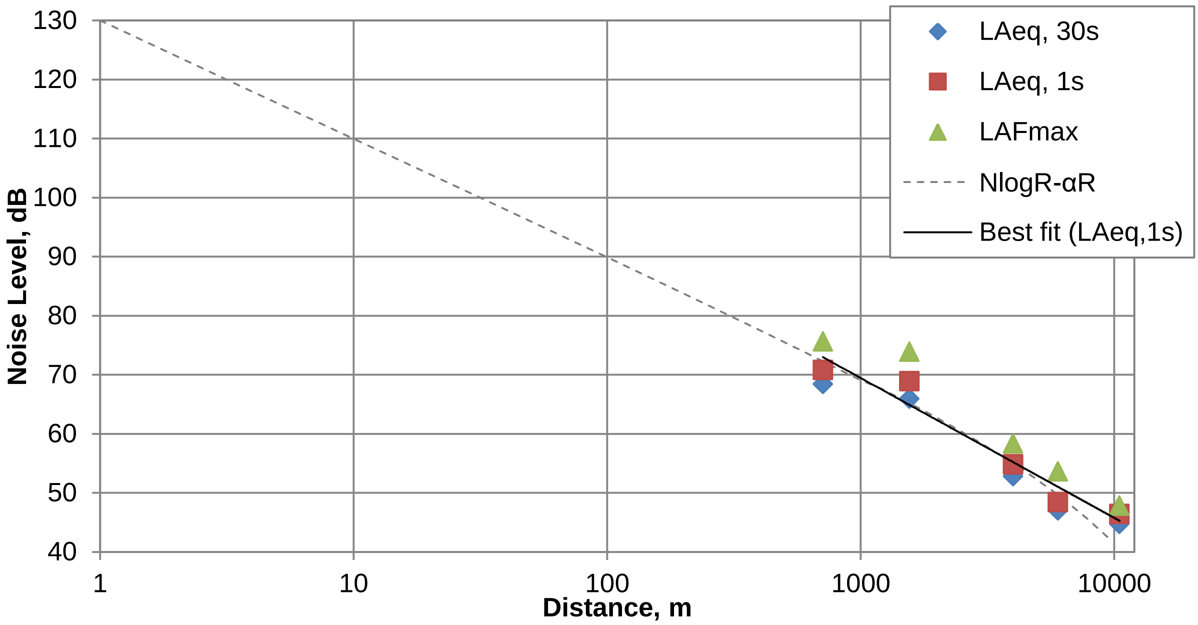

Figure 5-5 Level vs range plot for calm winds and seas

Receiver Level [R>800m]: N = 19, α = 0.001

Under entirely calm conditions, the propagation of sound in the far-field behaved somewhat differently to all other wind and sea states. There appears to be no significant transition from spherical (N=20) to cylindrical (N≈10) spreading, with the data sampled between 700 m and 10 km fitting N=19. All other conditions have much slower attenuations with N=12 or less in the far-field. This may be due to flat seas scattering sound less and reflecting more to the atmosphere.

The measurements under calm conditions also required a lower attenuation coefficient (α) of 0.00063, instead of 0.0021 dB/m to keep the trendline from deviating from the measured noise levels.

The standard N=20 and α coefficients only fitted the data when the source level was increased by 3 dB to 130 dB $L_{Aeq,1s}$, as with the results where the wind is at 67.5° from the direction of travel,. An investigation of the piling logs showed that there was an increase in the blow energy at the time when the two shortest range measurements (710 m and 1.6 km) where taken, representing a near doubling in energy for this short period. A higher source noise level was also noted in the concurrent underwater noise measurements compared to other piling events on the same day.

A doubling of blow energy could reasonably represent a 3 dB increase in the source noise level, and so applying a reduction of 3 dB to the first two data points reduces the line of best fit to a source level of 127 dB $L_{Aeq,1s}$, in consensus with the other wind condition trends, but the high N=19 remains. To best fit the data, an absorption coefficient of α = 0.00063 dB/m, considerably lower than most other conditions and equivalent to the ISO 9613 air absorption at 200 Hz, is required.

5.4 Analysed data – frequency analysis

All pile strikes will have a frequency 'signature', which will be dependent on numerous factors including pile material and dimensions, position, type and force of strike, seabed properties, and numerous others. For future analyses, the most useful frequency data will be that taken close to the pile, as any distance between source and receiver will be a function of the environment in which the sound travels, and this will affect every frequency band slightly differently, high frequencies generally being attenuated more quickly than low frequencies.

While detailed analysis of sound propagation in individual frequency bands will provide detailed and accurate data for that specific band, it is considered more useful to analyse the data as a whole, particularly as almost all criteria used in environmental noise assessments are denoted in A-weighted decibels. However, 1/3 octave band spectra have been acquired and can be reanalysed at a later date.

Below is a sample of the spectra under an upwind and downwind condition, and under calm conditions.

5.4.1 Frequency spectra downwind

Taken on a southeast transect, with northwesterly winds at 3 m/s.

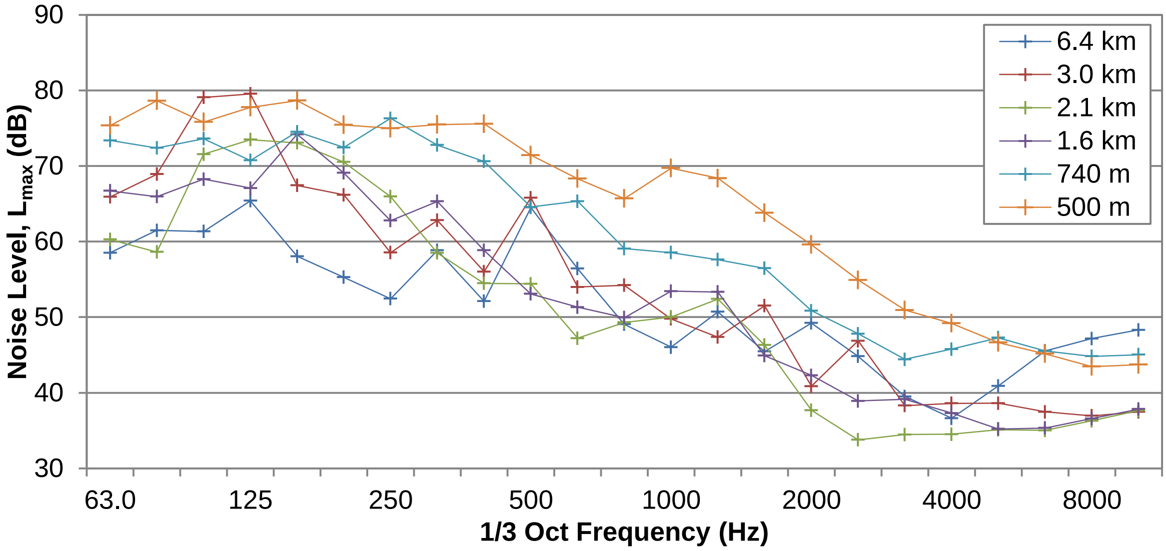

Figure 5-6 1/3 octave band L_{max} spectra taken under downwind conditions on September 18th 2015

Most of the energy in the strikes is at low frequency and primarily below 400 Hz, although the spectra are clearly broadband in nature.

5.4.2 Frequency spectra upwind

The spectra were taken on a westerly transect, with a northwesterly wind (i.e. taken on 45° upwind conditions).

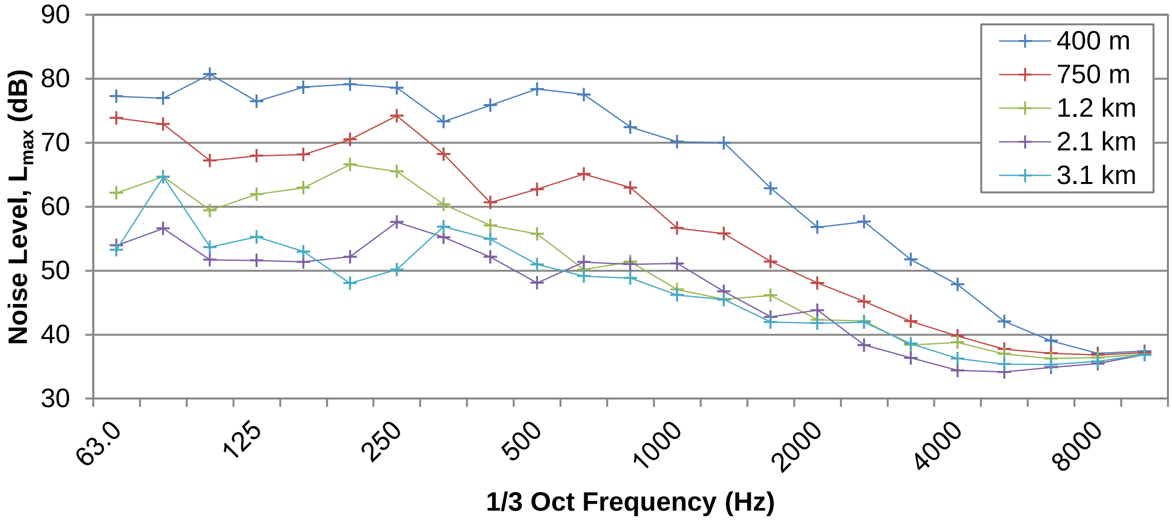

Figure 5-7 1/3 octave band L_{max} spectra taken under upwind conditions on September 17th 2015

A sample was taken closer to the piling here than on the downwind sample in Figure 5-6, and it showed a spectrum at 400 m reaching the 630 Hz 1/3 octave band before any significant drop in energy occurs. After little more than 1 km most of the energy in frequency bands over 630 Hz has been lost. It is interesting to note the consistency between Figure 5-6 and Figure 5-7 where the spectrum at 740/750 m both start to drop off above 250 Hz.

5.4.3 Frequency spectra, calm winds

Taken on a northerly transect.

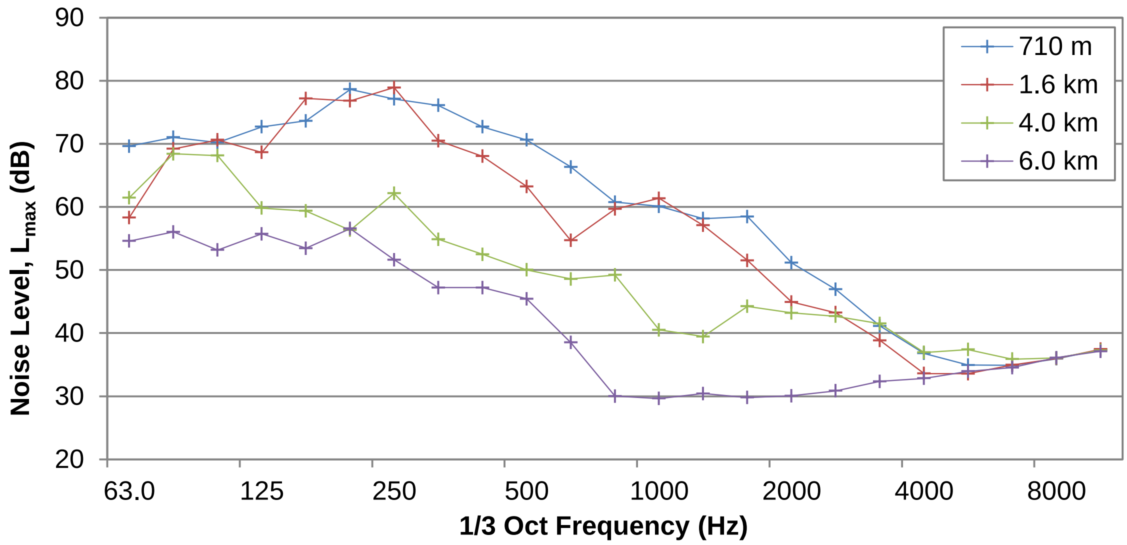

Figure 5-8 1/3 octave band L_{max} spectra taken under upwind conditions on September 19th 2015

Though there are fewer positions on Figure 5-8, this demonstrates clear reductions in all frequencies below 6300 Hz band, suggesting that little energy is produced by piling above this frequency, or it attenuates so quickly that little arrives at 710 m. However, data reproduced in Figure 5-6 indicates that higher frequencies are present closer to the pile.

5.5 Analysed data – piling blow energy and source noise level

The airborne source noise level of the piling has been calculated based on a 20 logR + αR spreading attenuation. An absorption coefficient of α = 2.1 has been set based on the typical results and analysis in Section 5.3. Only airborne noise levels measured at 750 m or less from the pile have been included in the analysis to reduce the influence of wind and other more far-field factors.

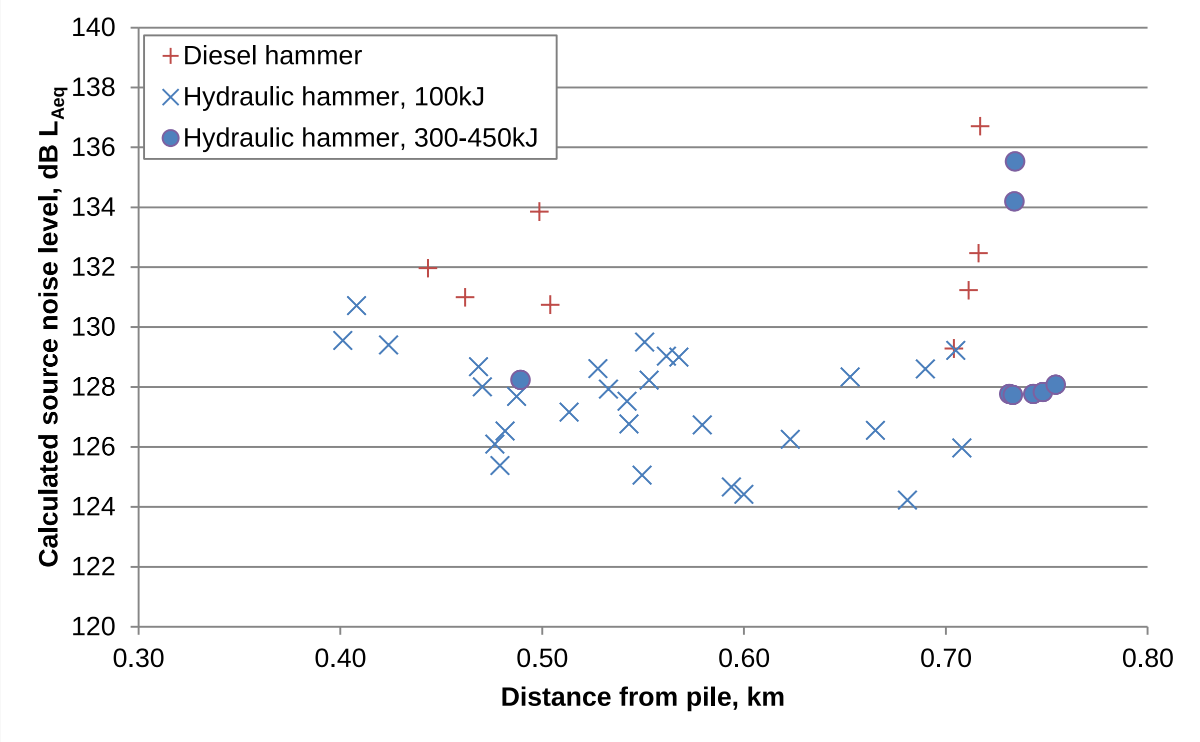

Figure 5-9 Scatter chart of calculated source noise levels from the diesel and hydraulic piling hammer

Figure 5-9 shows the results of the analysis by the distance from piling. Results are broken down in the chart by hammer type: the Menck hydraulic hammer in blue (September 3 and 17, the last two at 710 m on Sep 19) and the Bauer-Pileco D280-22 diesel hammer in red (Aug 18). The piling logs for the Bauer-Pileco hammer did not include energy-per-blow data. However, the hammer's technical specifications state energy per blow of 485-933 kJ, which is significantly greater than that used with the Menck, logged between 60 and 500 kJ. (Bauer-Pileco data from http://www.bauerpileco.com/en/products/hammers/diesel_hammers/d280-22, last downloaded February 22, 2016.)

The diesel hammer clearly demonstrates higher calculated source noise levels, typically being above 130 dB $L_{Aeq,1s}$. The hydraulic hammer typically produces noise levels lower than 130 dB $L_{Aeq,1s}$. Results show little correlation with distance suggesting that the simple 20 logR + αR propagation loss produces reasonable results over this range. That the small collection of closest three measurements (~400 m) is also among the highest, however, is noted; also that these three samples occurred during soft start on September 17th at around 16:40. Slightly higher noise levels during soft start were also noted in the underwater measurements, despite lower blow energies.

It is possible that there are three 'bands' within the blue x results at 124-126 dB, 126-128 dB and 128-130 dB, with a gentle decline with range. The data points that make up these 'bands' are scattered and do not follow a particular day, time or wind direction. The gentle decline may however reflect a slightly higher value of α may in fact be more appropriate and investigations with the least-squares line of best fit shows α = 0.009 provides the 'flattest' trend. This corresponds with a 1/3 octave band centre frequency of 1600 Hz, which is much higher than where most of the energy is contained in the signal, even at close range (see section 5.4), and so this seems unlikely to be the explanation.

All results denoted with a blue x occurred with a blow energy of approximately 100 kJ. The blue spots denoted energies of 300 or 450 kJ, and the two results between 134 and 136 dB $L_{Aeq,1s}$ are at the higher 450 kJ energy. It is notable that the results at 300 kJ did not appear to be significantly louder than those at the typical lower 100 kJ, where the 450 kJ stood clearly out. The block of blue spot results in excess of 700 m at approximately 128 dB $L_{Aeq,1s}$ were all taken under downwind conditions and so wind is unlikely to have caused any lowering effect.

The Menck hydraulic hammer produced an arithmetic average source level of 127.4 dB $L_{Aeq,1s}$ and the diesel hammer averaged 132.2 dB $L_{Aeq,1s}$. In the absence of any explanation for the variation in noise emission with the same hammer under the same energy, there appears to be a 'natural' source noise level spread of ±3 dB across each hammer type.

5.6 Discussion

The data acquired during the surveys generally follows the expected trend for far-field noise propagation, with a transition from spherical to cylindrical spreading, and more rapid attenuation with distance in upwind conditions. The following table provides a summary of the coefficients that best fit the measured data under different wind conditions. Note that 0° denotes upwind conditions, 180° denotes downwind conditions and the transition between nearfield and far-field is 800 m.

Wind bearing	Nearfield N value	Far-field N value	Absorption coefficient, α
45°	20	12	0.0021
67.5°	20	12	0.0021
90°	20	6	0.0021
180°	20	6	0.0021
Calm	20	19	0.0010

Table 5-1 Summary of noise attenuation coefficients under different wind and sea conditions

The data fits the theory well, with greater than cylindrical spreading (N=10) under upwind conditions and lower than cylindrical spreading downwind. Also, perhaps surprisingly, the data under crosswinds (90°) shows a better agreement with the line of best fit where N is equivalent to that of downwind spreading. However, correlation with the line of best fit under crosswinds is weaker than with the upwind or downwind conditions and so the confidence in this conclusion is somewhat lower.

Noise levels normalized by distance from piling measured showed that the diesel hammer was louder than the hydraulic hammer by an average of 5 dB, which agrees with subjective observations by the surveyor at the Southeast Light. The average calculated source noise level for the diesel hammer was 132 dB $L_{Aeq,1s}$ at 1 m, compared with the hydraulic hammer at 127 dB $L_{Aeq,1s}$ at 1 m based on measurements between 400 and 750 m. There was no clear correlation between source noise level and blow energy for the hydraulic hammer at blow energies 300 kJ and under. However, an average source noise level of 135 dB $L_{Aeq,1s}$ at 1 m was calculated where the blow energy increased to 450 kJ. No blow energy data for the diesel hammer during use was available but generic specifications for it show its minimum blow energy was similar to the maximum used for the hydraulic hammer.

To simplify the assessment, only an overall A-weighted value for the received noise levels and a single-figure value of α has been used, rather than the more robust technique of breaking down the individual frequency components of the measured noise levels. It is acknowledged that a much deeper analysis of the data would provide more accurate conclusions as the value of α would no longer be a selection. However, this simplified approach has produced a generally good agreement with the measured results across a long range.

This study primarily utilises A-weighted metrics, in keeping with international standards for the assessment of airborne environmental noise. The A-weighting of sound is designed to correct for the sensitivity of human hearing. The effect of this is to reduce the significance of sound frequencies progressively below and above 2000 Hz, as this is the frequency of peak hearing sensitivity. This avoids any undue emphasis on very low (and very high) frequencies to which humans are not sensitive. The analysis of the frequency data for the samples of piling noise show that the majority of the energy in the received noise levels at a distance are dominated by low frequencies.

The consequence of this is that the A-weighting effectively attenuates some of the energy in the received noise levels and this is a consequence of the standards used across the majority of environmental noise assessments. Despite this, the fact that the data does appear to follow the theory suggests that the A-weighting does not eliminate the useful information.

For future studies, it may be worth investigating the data in terms of a criterion that takes better account of low frequency characteristics, such as the C-weighting, an unweighted metric or investigation of a single frequency band. However, this may be of limited use when it comes to comparison with environmental criteria and it is recommended that the A-weighting continue to be the primary metric in the airborne data analysis.

6 Tower lift operations

Noise measurements were taken in the vicinity of the Fred.Olsen Brave Tern and its partner the L/B Caitlin during lifting operations for installation of tower sections, followed by fitting of the nacelle and blades. The measurements were taken over nine days between August 7 and 15, 2016 inclusive. Simultaneous measurements were also taken at the Southeast Light, in the same location as used during the measurements of foundation installation piling. At no point during the lifting operations was construction noise offshore audible or detectible. Detailed analysis will focus on the measurements sampled offshore.

Measurements on the vessel were conducted with specific attention paid to wind conditions. As wind conditions were critical to the measurements undertaken during foundation piling, so they were fundamental to the measurements taken during turbine lifting operations. Distances from the barges were measured using a laser range-finder up to 1,000 m and calculated using GPS co-ordinates relative to the turbine location beyond this.

For each set of measurements described below, analysis has been undertaken in the same manner as during piling, to identify the source level and geometric spreading loss coefficient. A transition point at 800 m between spherical spreading (N=20) and another attenuation coefficient to be determined, dependent on wind direction, was used.

Note: as low frequency noise from the barges dominates the operating noise and measurements were taken over a maximum of 3 km, no atmospheric absorption element has been included as this would have an effect of less than 1 dB.

6.1 Measurements during lifting: Brave Tern

The most useful datasets available to sample the noise from the operational lifting equipment were taken on downwind transects. The vessel was located downwind on the edge of the exclusion zone around the Brave Tern and awaited commencement of the lifting operation. When the operation started, the vessel's engines were switched off and the vessel naturally drifted away from the barge until the lifting operation finished or the machinery was inaudible.

6.1.1 Transect 1, downwind

Figure 6-1 below shows the measured time history on the first day. The left side of the chart between 12:00 and 13:00 is effective ambient noise; two small vessels passing at 12:15 and 12:55 caused temporary increases in the background noise level of the order of 4 dB $L_{A90,1min}$. The average background noise level was 46 dB $L_{A90,1hr}$.

The right side of the graph shows a downwind transect during the lifting of one of the turbine blades. A klaxon on the Brave Tern was activated at approximately 13:50 and the drift transect was undertaken shortly afterwards. This was a short transect, from 500 m to 850 m. The machinery is a continuous, low-level hum, relative to the background noise offshore.

In this time the noise level dropped from 55 dB $L_{Aeq,1min}$ to 50 dB $L_{Aeq,1min}$ with a clear but gentle reduction in noise over the drifting period.

Although the L_{Aeq} metric is typically used for the reporting of operational noise, here the L_{Aeq} to describe the relatively low-level continuous noise from the barges is susceptible to contamination by the ambient noise, primarily movement of water and wave slap on the side of the vessel. The statistical L_{A50} metric may be better to identify the continuous noise, which represents the noise level exceeded for 50% of the time the sample is taken and is less sensitive to sudden increases in noise level, unlike the L_{Aeq}. Using this metric, the noise level drops from 54 dB $L_{A50,1min}$ at 500 m to 49 dB $L_{A50,1min}$ at 850 m.

It can be seen that for this sample, although the L_{A50} 'smooths out' spurious signals (see the spike in the L_{Aeq} at 14:15, which was caused by an unexpected vessel radio transmission), the reduction using the two metrics is the same.

The calculated source level has been presented in the standard L_{Aeq} metric. This has been calculated based on the L_{A50} value plus 1 dB, which was found to be the average difference between the measured L_{Aeq} and L_{A50} when noise from the Brave Tern was dominant and uncontaminated by extraneous noise, close to the barge.

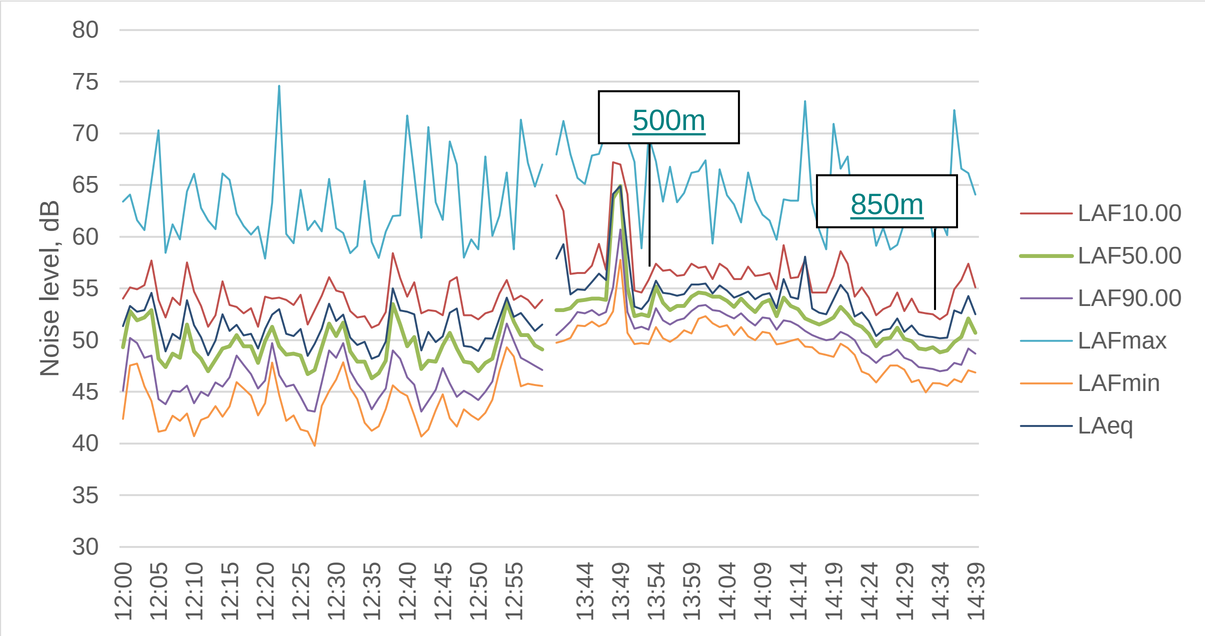

Figure 6-1 Noise measurements taken on August 7th 2016 at WTG2, including blade lift

Receiver Level [R>800m]: SL = 108 dB L_{Aeq}, N = 6

6.1.2 Transect 2: downwind

The chart in Figure 6-2 shows a downwind drift with few contaminating events on August 8. The benefit of the L_{A50} metric can be seen better on this transect, where radio communications significantly influenced the L_{Aeq} noise level at 10:31 and the ambient noise, primarily the action of waves, keeps the L_{Aeq} at around 50 dB, but the L_{A50} falls 5 dB further.

The noise level at the start of the drift, at 250 m from the Brave Tern, was 56 dB L_{A50} and at the end of the drift, at 1,150 m, the noise level had fallen to 46 dB L_{A50}.

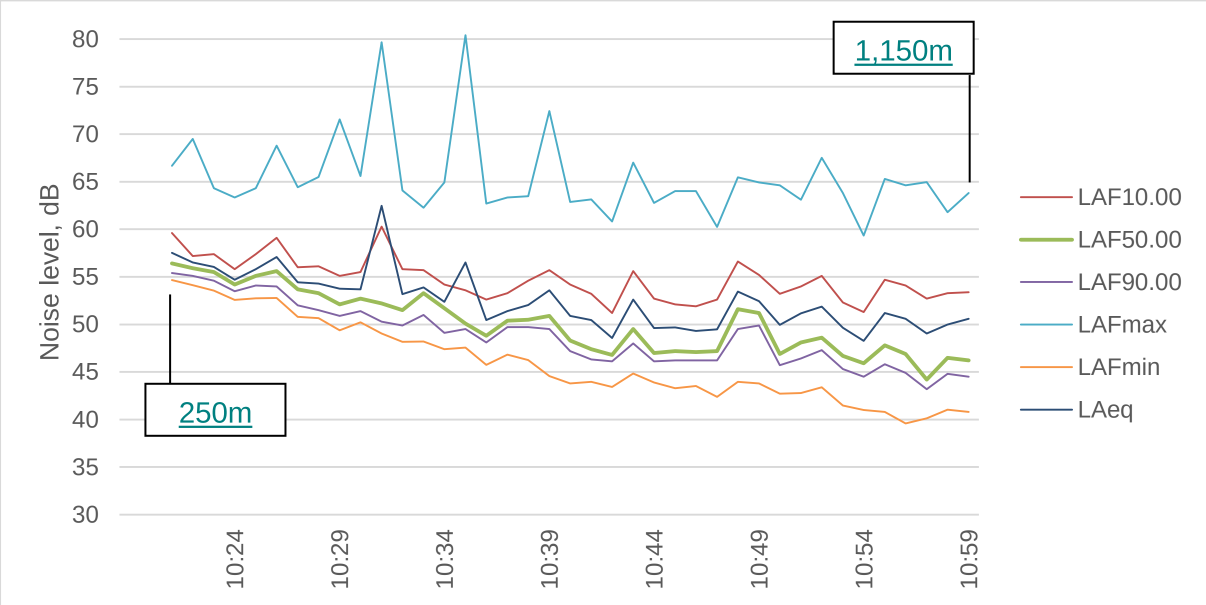

Figure 6-2 Noise measurements taken on August 8th 2016 downwind transect at WTG3, including tower lift

Receiver Level [R>800m]: SL = 105 dB L_{Aeq}, N = 6

This was the closest position where a noise sample was taken under ideal conditions and the gentle downward slope of the noise levels in Figure 6-2 illustrate this. With the combination of relative vicinity to the Brave Tern and conditions, this was considered the best position to determine a source level. Making the same assumption as during piling of a propagation loss of 20 log(r) in the 'nearfield', an estimated source level of 106 dB $L_{Aeq,1m}$ was calculated.

6.1.3 Transect 3: upwind

Comparative measurements were taken upwind of the Brave Tern, to identify the limits of audibility and noise propagation over water under these conditions.

Figure 6-3 shows an upwind transect, beginning the drift at 450 m and ending at 1,050 m. The sudden increases at the start and the end of the transect was caused by engine noise from the survey vessel. A small increase in noise can be seen over the course of the transect, despite moving further from the vessel. The increase was caused by an increase in ambient noise; the wind speed had increased from 1.5 m/s in the morning to 4 m/s by this time.

The Brave Tern was barely audible at the closest position, up to approximately 500 m but was lost in ambient noise beyond this.

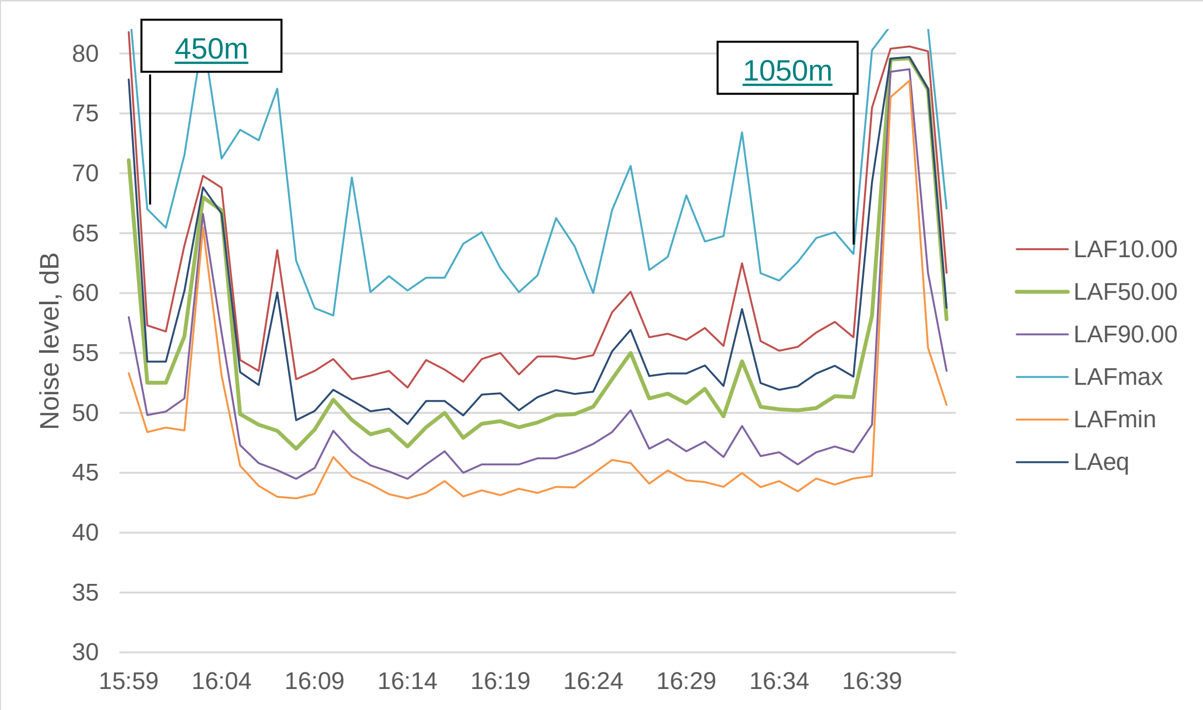

Figure 6-3 Noise measurements taken on August 8th 2016 upwind transect at WTG3, including tower lift and survey vessel engine noise

No attenuation coefficient could be identified under these conditions and at this range, with any noise from the Brave Tern rapidly lost in the background.

6.1.4 Transect 4: calm

Wind conditions on August 9 were very calm and measurements were taken in the vicinity of the Brave Tern with little influence from any extraneous noise, particularly any wave noise. The drift began at 650 m from the Brave Tern and ended at 1350 m, and noise from the barge was clear at all times in the absence of significant wind or wave action.

There was a little trend downward in the noise detected from the Brave Tern over this 50 minute period. A doubling in the distance led to, at most, a 3 dB reduction in the noise. This small effect may be because of light, variable winds higher above the water causing fluctuations, or small changes in the noise output from the engines.

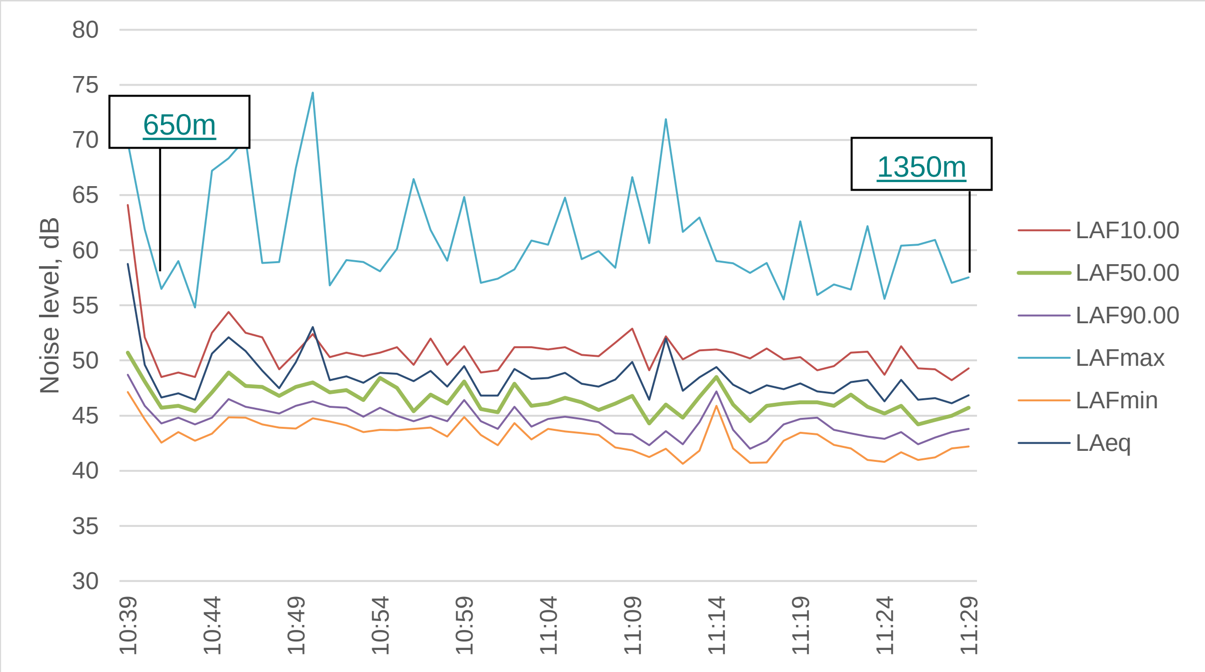

Figure 6-4 Noise measurements taken on August 9th 2016, calm to downwind conditions, at WTG3, including blade lift

Receiver Level [R>800m]: SL = 106 dB L_{Aeq}, N = 12

These calm conditions provided a good opportunity to present the frequency spectrum from the Brave Tern in the absence of wind or wave noise. Figure 6-5 shows the 1/3 octave centre-frequency band spectrum measured at 750 m, when the engine noise was clear. It is dominated by low frequency tonal noise with a peak at 40 Hz.

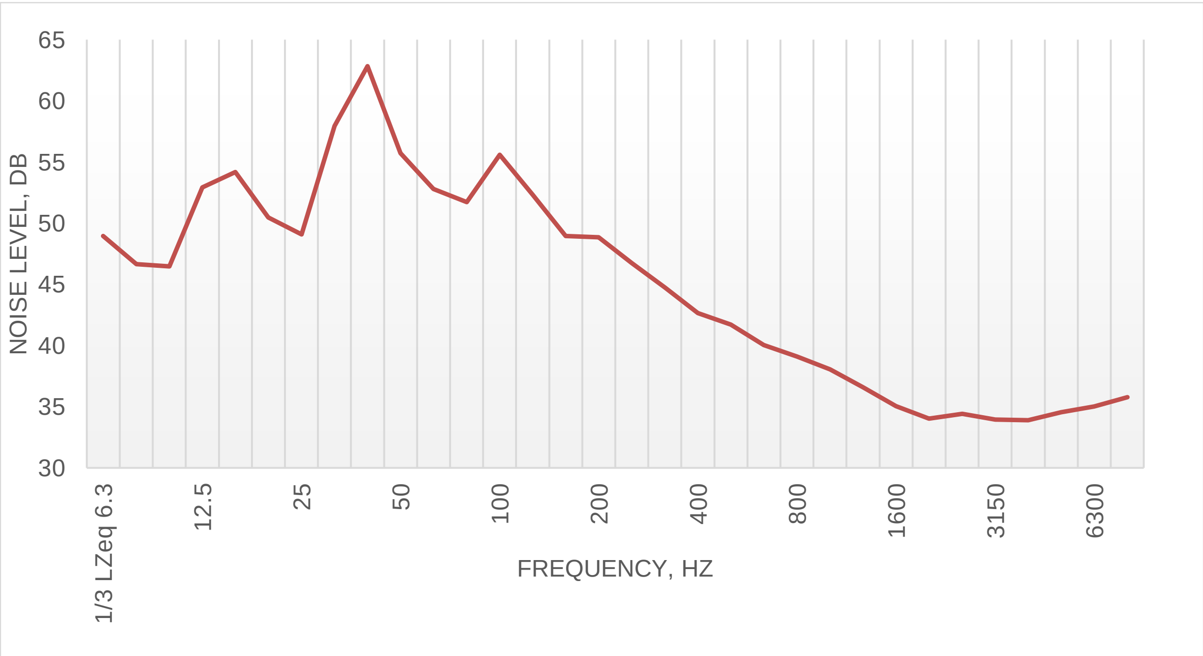

Figure 6-5 Noise frequency spectrum taken on August 9th 2016 calm conditions at WTG3

The fit of N for the calm wind conditions (N=12) is somewhat lower than during piling (see section 5.3.4), where N=19 was estimated. This is likely to be due to the noise from the Brave Tern being very close to the level of background noise, especially as a result of the impact of the A-weighting, which reduces the influence of low frequencies and which is significant at 40 Hz. A closer inspection of the data to identify the geometric absorption coefficient at 40 Hz was undertaken on the data on August 9 and this is shown in Figure 6-6.

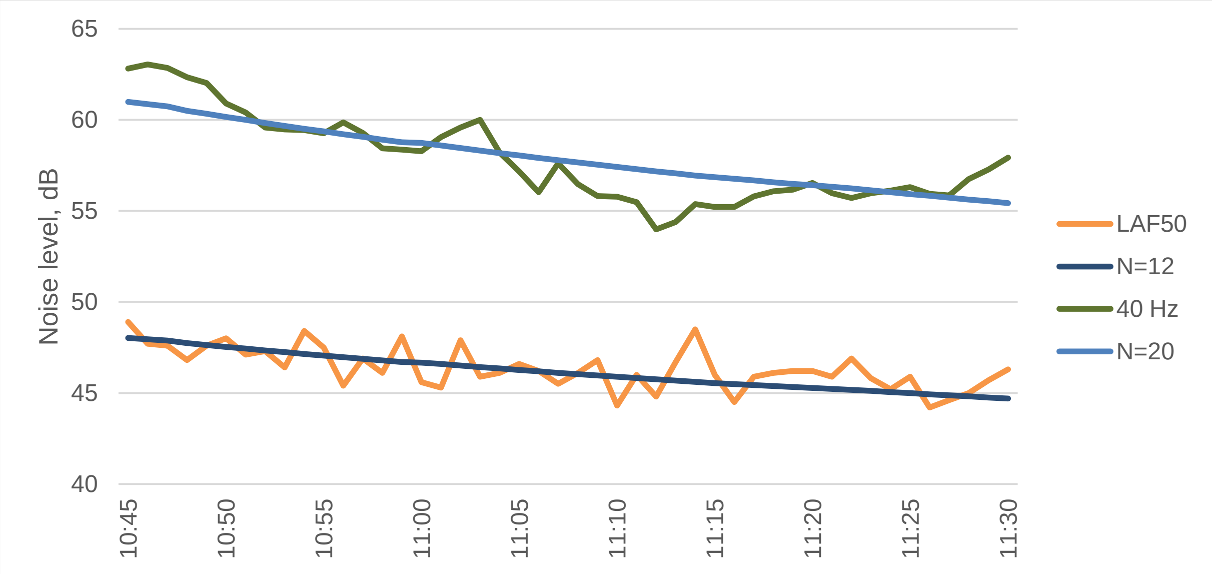

Figure 6-6 Transects with fits to L_{A50} and 40 Hz L_{eq} on August 9th 2016 calm conditions at WTG3.

There is much greater separation between the time-history for the 40 Hz 1/3 octave band centre frequency and the background noise and this shows a much more rapid attenuation. In fact a 'fit' of much greater than N=20 seems appropriate, with the 40 Hz band possibly reaching close to the background at around 11:10 (although it was still subjectively audible at this position). This does suggest that if the noise was better separated from the background (i.e. it was louder) then the fit to the L_{A50} would be greater than N=12, and closer to the value identified in calm conditions during piling.

6.1.5 Transect 5: downwind

An extended length downwind transect was possible on August 15 from 600 m at its closest point at the start of the transect to 2,750 m at 10:30. This is shown in Figure 6-7. The seas were relatively quiet with good periods without any contribution to the extraneous noise, so the Brave Tern was audible at all times.

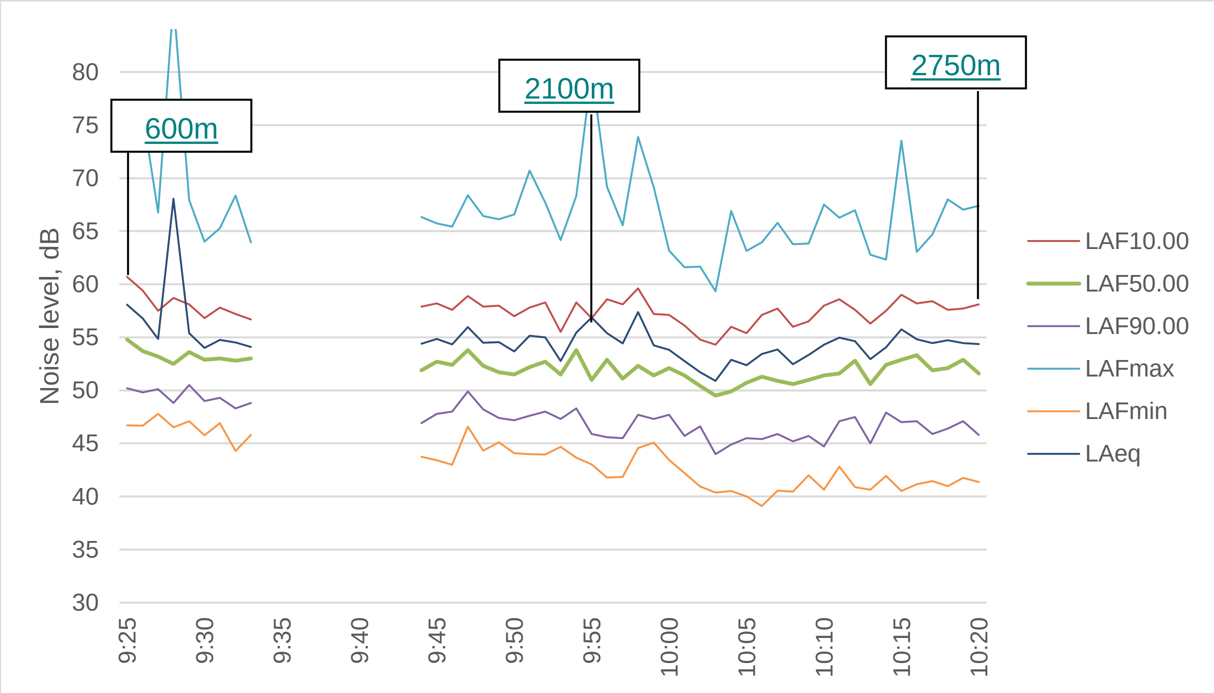

Figure 6-7 Long distance drift downwind of WTG4 during blade lift. Note: spurious noise from a passing vessel and helicopter between 9.33 and 9.44 has been removed. August 15, 2016.

Receiver Level [R>800m]: SL = 112 dB L_{Aeq}, N = 6

While crane movements were continuous in the period above, the crane only began lifting a blade at 09:56. At the time there was no subjective increase in the noise at this time and no change can be seen in the measurements in Figure 6-7 (or the following Figure 6-8).

A reduction of approximately 5 dB can be seen between 09:25 and 10:05, from 600 m to 2.1 km. After this time there is no significant further reduction in the measured overall noise level, due to the influence of background noise from the water movement.

The tonality of the noise from the Brave Tern was identified in the spectrum in Figure 6-5 above. The ambient noise in general is fairly broadband so to focus on the audibility of the noise, the peak frequency (40 Hz) was isolated and placed alongside two frequencies outside of the noise from the machinery (25 Hz and 100 Hz). This is shown in Figure 6-8.

The 40 Hz tone is nearly 10 dB above the surrounding frequency bands when close to the Brave Tern and so clearly audible. Between 2,000 m and 2,750 m any attenuation in the noise with distance is minimal and the level of the tone is similar to the ambient noise, although as it remains slightly elevated it is still audible.

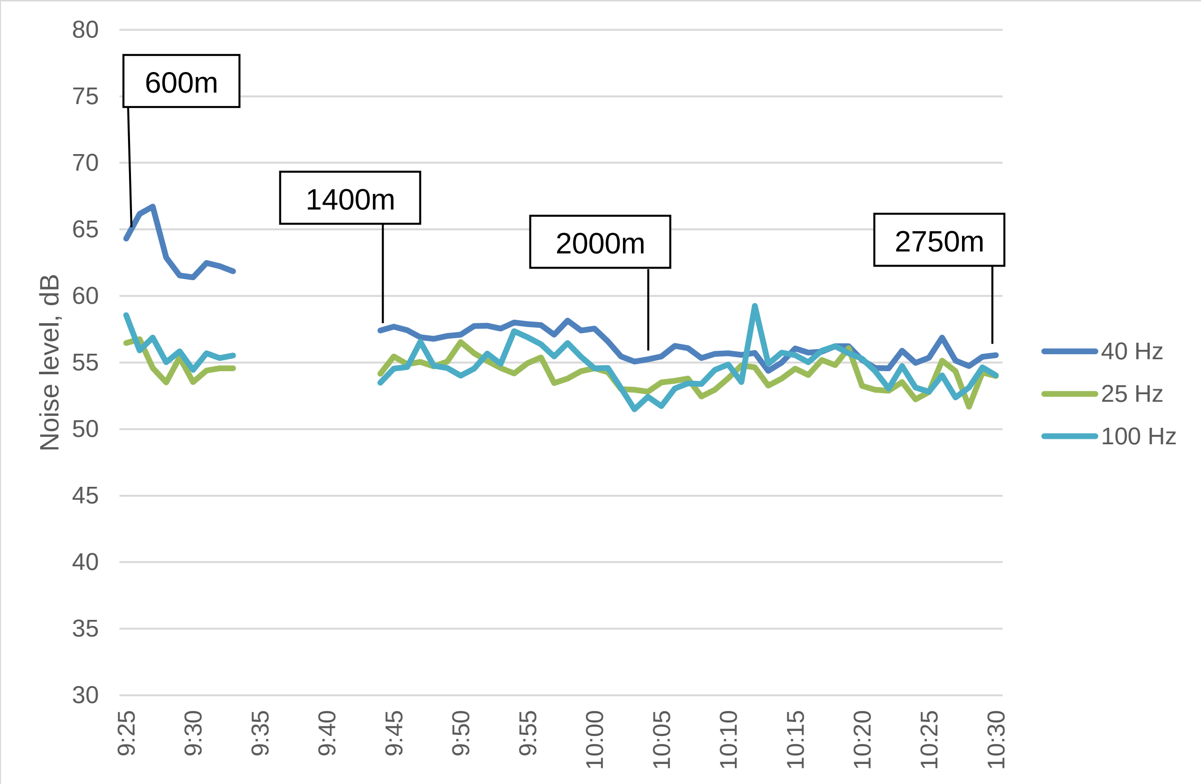

Figure 6-8 1/3 octave band time history. Drift on August 15 between 600 m and 2,750 m. Note: spurious noise from a passing vessel and helicopter between 9.33 and 9.44 has been removed.

This represents the greatest distance measured during the survey at which the noise was detectable, although due to the variation (or lack thereof) after 10:00 in Figure 6-7 the noise from the Brave Tern cannot be discerned when looking at the overall A-weighted noise levels.

6.2 Measurements around barge: L/B Caitlin

The L/B Caitlin was positioned adjacent to the Brave Tern for storage of turbine and tower parts prior to lifting in position. It remained static while the lifting operations were underway and produced a continuous noise from its engines.

On August 15, a continuous westerly 3 m/s breeze was blowing and this provided an opportunity to sample the noise levels in all orientations to the noise source relative to the wind direction. Table 6-1 shows these collated noise levels.

Time	Distance	L_{AF10} dB	L_{AF50} dB	L_{AF90} dB	L_{AFmax} dB	L_{AFmin} dB	L_{Aeq} dB	Wind
13:42	n/a	54.7	47.9	44.7	71.6	42.2	54.9	*Background*
15:05	510 m	54.7	48.9	45.5	78.6	42.8	57.4	Upwind (W)
14:56	520 m	54.3	51.6	49.7	57.3	47.6	52.1	Crosswind (S)
15:32	510 m	55.6	52.3	50.9	62.1	49.9	53.4	Crosswind (S)
15:11	510 m	53.2	50.6	47.8	57.0	45.2	51.0	Crosswind (N)
15:13	510 m	55.6	49.7	46.8	61.2	44.4	51.9	Crosswind (N)
15:21	400 m	57.3	55.0	53.0	61.4	51.6	55.5	Downwind (E)
15:51	340 m	82.9	59.5	53.0	84.6	51.2	78.1	Downwind (E)

Table 6-1 Noise levels sampled around L/B Caitlin, collated by relative wind direction

Noise from L/B Caitlin engines at the sampled distances was clearly audible downwind, not audible upwind and could occasionally be detected subjectively in crosswinds. The variation in noise levels shown in Table 6-1 reflect this, although there may also be a directionality to the noise from the engines which cannot be identified at the distance of the survey vessel. It should be noted that the survey vessel was slightly closer to L/B Caitlin in the downwind sample at 15:21. Given spherical noise spreading at this range, if the noise was sampled at 510 m as at the other positions, this could lead to a 2 dB reduction in the 400 m sample.

The L_{A90} noise metric, which is often used for measurement of background noise and susceptible to continuous noise sources but not infrequent, impulsive noises, may be the most reliable for identifying the noise from L/B Caitlin. As there was no impulsive noise produced by L/B Caitlin, the high L_{Amax} noise level on the upwind and one downwind sample (15:51) indicate some contamination of the noise, which leads to spurious increases in the noise level of other metrics, especially the L_{Aeq} and L_{A10}. If the noise continues for a long enough period, the L_{A50} will also be affected.

However, as the noise levels upwind and crosswind were found to be inaudible or barely audible respectively, direct comparison between the different conditions would be inappropriate. Assuming L/B Caitlin is acting as an effective point source, as it will appear at a distance, the source noise level is approximately 107.5 dB $L_{Aeq,1min}$, based on the lower level measured downwind.

6.3 Discussion and summary for measurements during tower lift

Measurements taken around the Brave Tern and L/B Caitlin during the tower lift phase of the construction operation have shown that the noise emanates primarily from the barge engines, and thus produces a continuous hum.

In the same way as airborne noise measurements during the piling phase, the direction of the wind during the lifting works is critical. Around the Brave Tern, upwind, the noise levels during crane operations were subjectively inaudible above background noise within 750 m (approximately half a mile). At this time background noise was approximately 45 dB L_{A90}. Downwind, the hum from the engines was still audible at nearly 3,000 m with background noise levels also at approximately 45 dB L_{A90}. The noise was reasonably tonal with a peak at 40 Hz and a noise level of 56 dB at 2,750 m at this 40 Hz 1/3 octave band and quickly dropped below the ambient noise outside this frequency band. Given favourable conditions, including wind and low background noise, this noise could plausibly be audible beyond this distance. However, at no time was noise from the Brave Tern detectible on Block Island during lifting operations either subjectively or in measurements, approximately five kilometres away. These measurements have not been presented.

In calm conditions, noise from the Brave Tern was still clearly audible at 1,350 m and is likely to be audible beyond this point. The noise appears to attenuate more slowly than during piling in calm winds, although this is likely to be partly due to the low frequency of this engine noise, compared to the much higher frequencies present in the piling noise.

Using the same assumption as during piling, that 'nearfield' sound propagation follows a 20 log(r) geometric spreading loss, the source level (at 1 m from the engine) for the Brave Tern is approximately 105 to 108 dB $L_{Aeq,1min}$. The same spreading coefficient was seen beyond the transition point as during piling, with N = 6 downwind and N = 12 in calm conditions. The value for N in calm conditions is likely to be higher in reality as the measured noise levels will be influenced by the ambient noise, as they were only marginally above the background. An investigation into the attenuation with range of the 40 Hz 1/3 octave band only showed a value of N = 20. A value of N could not be calculated under upwind conditions, over the limited audible range.

Similar calculations for the much L/B Caitlin show that the source level is 107.5 dB $L_{Aeq,1m}$, which suggests that the smaller barge is slightly louder. This may be correct or may be partly due to the difference in height of the two sources: the Brave Tern is a jack-up barge which was approximately 30 m above the surface of the water during measurements, whereas L/B Caitlin was on the water. The position of the engine outlet, the source of the noise, above the barge's deck may benefit from some shielding from the deck itself. However, as the deck and engine outlet will be at elevation during the operations, the measurements were appropriate.

The two lifting barges have therefore been measured and shown to produce similar noise levels under the measurement conditions. Upwind, any noise from the barges reduced to inaudibility within 750 m, with background noise levels at 45 dB L_{A90}. Downwind, the Brave Tern was just audible at 3,000 m, limited to noise in the 40 Hz ⅓ octave band.

7 Conclusions

Airborne noise levels have been sampled during the installation of the foundation piles for the Block Island Wind Farm in August and September 2015, and crane operations for lifting of the tower sections, nacelle and blades in August 2016. Measurement stations were located on three coastal locations facing BIWF and on a mobile survey vessel that transited on transects around the foundations during piling and tower construction.

A total of ten piling events were sampled, with a piling event consisting of a single period of pile driving of duration around 30 minutes. Pile strikes were typically 2-3 seconds apart. Conditions during the surveys were ideal for environmental noise measurement, sunny and dry, with temperatures around 25°C (77°F) and relative humidity 80% remaining fairly consistent day to day. Wind direction was variable but typically remained between 2 and 4 m/s. Seas were less than 1 m and usually between one and three feet. Completely calm conditions were present over one piling event. All measurements were undertaken in daylight hours.

Noise during piling was always audible at the closest coastal measurement station, five kilometers (three miles) from the offshore wind farm. At the furthest location, 27 kilometers (17 miles) from the piling, the noise was never audible. A further coastal location at eleven kilometres (seven miles) from the piling was visited for a short period and it was found that the piling was only intermittently audible under totally calm conditions and no longer audible shortly afterwards under light, downwind conditions.

The mobile measuring station on a survey vessel sampled noise levels at various distances from the piling, just under 500 m at the closest and 12 km at the furthest. No measurements were possible closer to the piling than this for safety reasons.

The measured noise levels were used to calculate the rate at which the sound attenuates over water. It was found that sound attenuated independently of any weather conditions in a spherical manner, i.e. 20 log(R) or a 6 dB attenuation per doubling of distance, up to approximately 800 m from the source, where R is the distance in meters from the pile. Beyond that point, the attenuation changed to a cylindrical character and wind direction was critical, with attenuations of 6 log(R) under downwind conditions and 12 log(R) under upwind conditions best fitting the measured data. An attenuation of 6 log(R) best fitted the crosswind condition line of best fit, although the received noise levels showed a much greater deviation from the line of best fit and so there is a consequently a lower confidence in this value.

The attenuation changed significantly under the brief calm condition, demonstrating approximately spherical spreading (~20 log(R)) in both the near and far-field. Measurements were possible up to 6 km from the foundation; only a single sample of this situation was possible.

Frequency spectra of the measurements showed that most of the energy in the received pulses was below the 630 Hz 1/3 octave band at distances up to 400 m from the piling, and below 250 Hz at distances beyond 2000 Hz.

The measurements during crane operations for turbine construction focused on the Brave Tern jack-up barge, which carried out all of the lifting. As previously, measurements were taken under downwind, upwind and calm conditions. The propagation of noise from the Brave Tern during the lifts is in line with that taken during piling downwind. Under other wind orientations, noise from the barge was quiet enough by 1 km to be significantly influenced by the ambient noise. No noise was audible beyond 500 m when upwind. No noise was detected on Block Island from crane operations under any wind conditions.

Future studies should attempt to investigate noise levels closer to the noise source to verify the initial spherical spreading assumption and improve confidence in the source noise levels. The source noise level will change with the equipment in use, so this is important bearing in mind the large variety of foundations currently in use or proposed for offshore wind turbines. This could be done either by vessel, where safe to do so, or by potentially setting up a sound level meter on the deck of the barge.

8 References

Boué M. 2007. *Long-range sound propagation over the sea with application to wind turbine noise*. Final report for the Swedish Energy Agency project 21597-3. TRITA-AVE 2007:22 ISSN 1651-7660

ISO 9613-1:1993 Acoustics - Attenuation of Sound during propagation outdoors: Part 1: Calculation of the absorption of Sound by the atmosphere. International Organization for Standardization.

ISO 9613-2:1993 Acoustics - Attenuation of Sound during propagation outdoors: Part 2: A general method of calculation. International Organization for Standardization.

Institute of Acoustics. 2013. A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise.

Institute of Acoustics. 2013. Supplementary guidance note 6: Noise propagation over water. For on-shore wind turbines.

Appendix A Calibration certificates

CERTIFICATE OF CALIBRATION

Issued by: **MTS Calibration Ltd**

Laboratory address: 17 Elvington Close, Billingham TS23 3YS, England

Telephone: +44 (0)1642 876 410

Please note delivery address below

UKAS CALIBRATION 0607

Date of Issue:	12 January 2015	Certificate Number:	23211U

Sound Level Meter Periodic Tests to BS EN 61672-3: 2006 Class 1

Client: PC Environmental Ltd.
Units 1/2 Claylands Road Industrial Estate
Bishop's Waltham
Southampton, SO32 1BH

Instrument Make:	Larson Davis	*Microphone Make:*	PCB
Instrument Model:	831	*Microphone Model:*	377B02
Serial Number:	1152	*Serial Number:*	103031
Preamplifier Make:	Larson Davis	*Calibrator Make:*	Larson Davis
Preamplifier Model:	PRM831	*Calibrator Model:*	CAL200
Serial Number:	0365	*Calibrator Serial Number:*	4418
		Calibrator Adaptor:	none
		Calibrator Certification Ref:	23214U

Other Accessories supplied:

MTS Calibration Ltd has obtained evidence which is generally available to the public that an independent testing organisation responsible for pattern approvals has demonstrated that this model of sound level meter has successfully completed the pattern evaluation tests of IEC 61672-2: 2003. This instrument, which was constructed to the requirements of BS EN 61672-1:2002 Class 1, has been tested using the procedures for periodic testing as specified in BS EN 61672-3: 2006.

The sound level meter submitted for testing has successfully completed the Class 1 periodic tests of IEC 61672-3: 2006 for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2: 2003, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1: 2002, the sound level meter submitted for testing conforms to the Class 1 requirements of IEC 61672-1: 2002

In conducting these measurements, it was necessary to use manufacturer's data. This was taken from the instruction manual of the instrument.	I831.01 Rev J

The instrument was within the above specification as received - no modifications were made

Ambient Temperature at Calibration (deg C)	22.9	Calibration check frequency (Hz)	1000.1
Ambient Pressure at Calibration (mPa)	996.25	Reference Sound Pressure Level (dBA)	114.0
Ambient Relative Humidity at Calibration (%)	36.6	Reference Level Range dB	Normal

Test Equipment:

Equipment	Manufacturer	Model	Serial No.	Traceability Ref.	Cal. Due
Condenser Microphone	Larson Davis	2541	4295	TE 102	Nov-15
Acoustic Calibrator 1kHz	Larson Davis	CAL200	9175	TE 208	Aug-15
Acoustic Calibrator	Brüel & Kjær	4226	2141963	TE 206	Sep-15
Signal Generator (set 2)	Agilent	33120A	MY40007806	TE 160	Aug-15
Real-Time Frequency Analyser (set 3)	Larson Davis	2900	0510	TE 165	Aug-15

Authorised signatory:

Date of Receipt:	7 January 2015		
Date of Periodic Test	12 January 2015	Page:	1
Date of Certificate:	12 January 2015	of:	12

Tony Sherris

MTS Calibration Ltd

The Grange Business Centre, Belasis Avenue, Billingham TS23 1LG

Telephone: 01642 876410 **Fax:** 01642 876411 **E-Mail:** dmarsh@slmcal.co.uk **or** tsherris@slmcal.co.uk

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2013-180305

Instrument Model 831, Serial Number 0003417, was calibrated on 03OCT2013. The instrument meets factory specifications per Procedure D0001.8310, ANSI S1.4-1983 (R 2006) Type 1; S1.4A-1985 ; S1.43-1997 Type 1; S1.11-2004 Octave Band Class 1; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class 1; 61252-2002.

New Instrument
Date Calibrated: 03OCT2013
Calibration due:

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Stanford Research Systems	DS360	61889	12 Months	30JAN2014	61889-013013

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 23 ° Centigrade

Relative Humidity: 31 %

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

Tested with PRM831-026043

Signed: Ron Harris
Technician: Ron Harris

Page 1 of 1

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2008 Certified

Calibration Certificate

Certificate Number **2014000714**

Customer:
Larson Davis, a division of PCB Piezotronics, Inc.
1681 West 820 North
Provo UT, 84601, US
716-684-0001

Model Number	831	***Procedure Number***	D0001.8378		
Serial Number	0003605	***Technician***	Ron Harris		
Test Results	**Pass**	***Calibration Date***	22 Apr 2014		
Initial Condition	As Manufactured	***Calibration Due***			
		Temperature	23.05	°C	± 0.01 °C
Description	Larson Davis Model 831	***Humidity***	50.7	%RH	± 0.5 %RH
		Static Pressure	85.4	kPa	± 0.03 kPa

Evaluation Method Tested electrically using PRM831 S/N 029415 and a 12.0 pF capacitor to simulate microphone capacitance. Data reported in dB re 20 μPa assuming a microphone sensitivity of 50.0 mV/Pa.

Compliance Standards Compliant to Manufacturer Specifications and the following standards:

IEC 60651:2001 Type 1	ANSI S1.4 (R2006) Type 1
IEC 60804:2000 Type 1	ANSI S1.11 (R2009) Class 1
IEC 61252:2002	ANSI S1.25 (R2007)
IEC 61260:2001 Class 1	ANSI S1.43 (R2007) Type 1
IEC 61672:2013 Class 1	

Larson Davis, a division of PCB Piezotronics, Inc. certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the SI through the National Institute of Standards and Technology (NIST), or other national measurement institutes.

The quality system is registered to ISO 9001:2008.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances will be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

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Standards Used

Description	Cal Date	Cal Due	Cal Standard
SRS DS360 Ultra Low Distortion Generator	07/10/2013	07/10/2014	006311
Hart Scientific 2626-H Temperature Probe	05/07/2013	05/07/2014	006767
Barometric Pressure Sensor	08/14/2013	08/14/2014	007130

Report documentation page

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Document No.	Draft	Date	Details of change
E494R0300	01	5 Nov 2018	Initial writing and internal review
E494R0302	-	13 May 2019	Final revision following comments

Originator's current report number	E494R0302
Originator's name and location	T Mason; Subacoustech Environmental Ltd.
Contract number and period covered	E494; July 2015 – May 2019
Sponsor's name and location	HDR
Report classification and caveats in use	Final
Date written	November 2015 – May 2019
Pagination	Cover + i + 54
References	
Report title	Measurement of airborne noise during construction of the Block Island Wind Farm, Rhode Island
Translation/Conference details (if translation, give foreign title/if part of a conference, give conference particulars)	
Title classification	Unclassified
Author(s)	T I Mason, A G Collett
Descriptors/keywords	
Abstract	
Abstract classification	Unclassified; Unlimited distribution

Appendix E: B-roll and Vignette

Appendix E is available as a separate digital file.

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The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation’s trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Bureau of Ocean Energy Management (BOEM)

The mission of the Bureau of Ocean Energy Management is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.

BOEM Environmental Studies Program

The mission of the Environmental Studies Program is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments. The proposal, selection, research, review, collaboration, production, and dissemination of each of BOEM’s Environmental Studies follows the DOI Code of Scientific and Scholarly Conduct, in support of a culture of scientific and professional integrity, as set out in the DOI Departmental Manual (305 DM 3).