Alpine

Gardline

Survey Report for
Alpine Ocean Seismic Survey Inc. on behalf of Equinor US Wind, LLC

Project:
BOEM Lease Area OCS-A 0512 Geophysical Survey

Description:
Protected Species Observer Report

Vessel:
RV *Shearwater*

Survey Dates:
Mar-11-2018 to Apr-02-2018

Project Number:
11179

Lease Reference Number:
OCS-A 0512

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Final Rev1

REPORT AUTHORISATION AND DISTRIBUTION

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SERVICE WARRANTY

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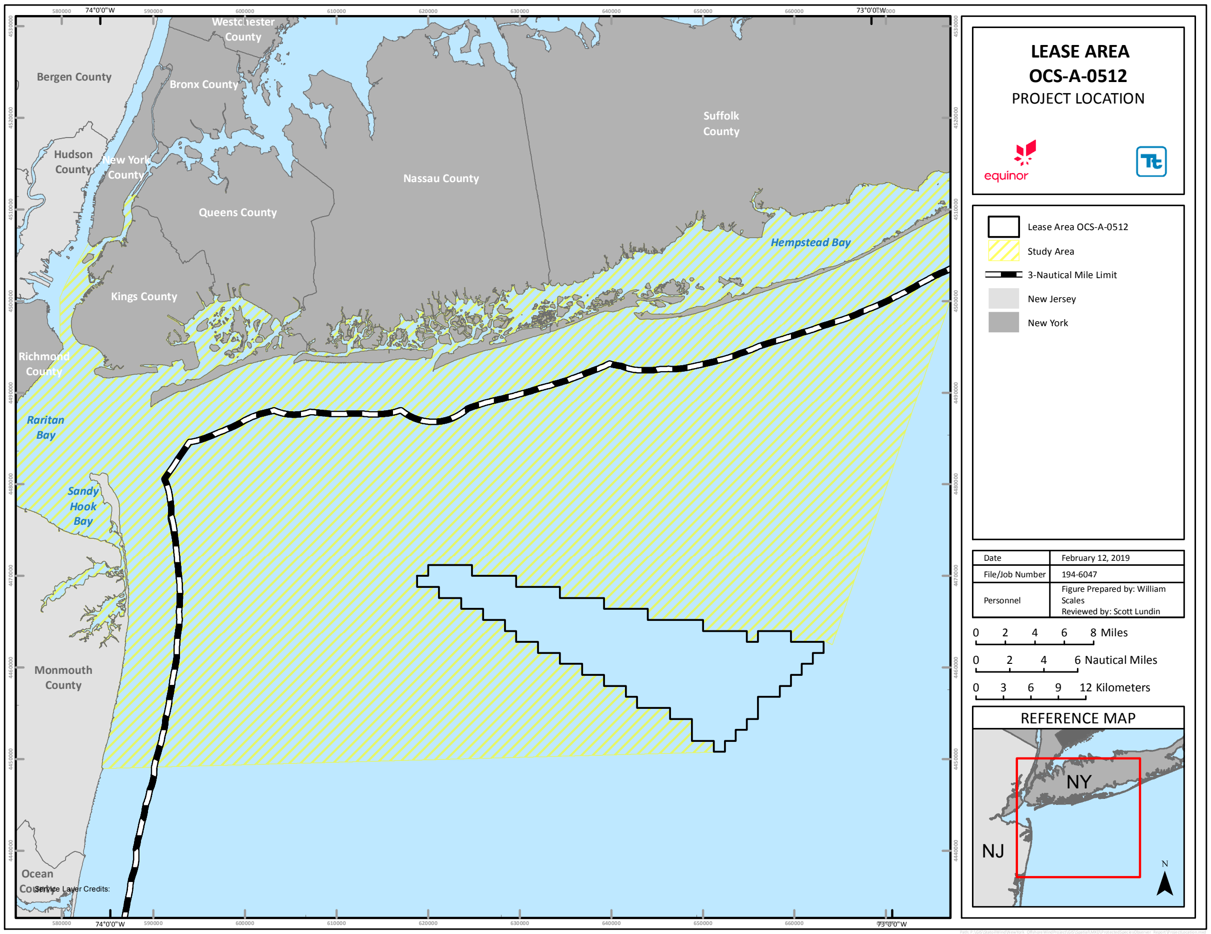
LOCATION MAP



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GLOSSARY OF TERMS AND ABBREVIATIONS

BOEM	Bureau for Ocean Energy Management
DMA	Dynamic Management Area
EZ	Exclusion Zone
FVS	Field Verification Survey
HRG	High Resolution Geophysical
IHA	Incidental Harassment Authorization
JNCC	Joint Nature Conservation Committee
kHz	Kilohertz
Lease	Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf OCS-A 0512
MBES	Multi-beam Echosounder
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OCS	Outer Continental Shelf
PAM(S)	Passive Acoustic Monitoring (System)
PSMP	Protected Species Mitigation Protocol
PSO	Protected Species Observer
RV	Research Vessel
SAP	Site Assessment Plan
SBES	Single-beam Echosounder (Low-frequency setting)
SBP	Sub-bottom Profiler
SMA	Seasonal Management Area
SSS	Side Scan Sonar
UHRS	Ultra-High Resolution Seismic (single channel)
USBL	Ultra-short Baseline
UTC	Coordinated Universal Time

1 INTRODUCTION

The following Protected Species Observer (PSO) Report has been developed by Gardline Limited for Alpine Ocean Seismic Survey Inc. (Alpine) on behalf of Equinor Wind US, LLC (Equinor)[1]. This report is being submitted in accordance with the requirements of Equinor Site Assessment Plan (SAP) for the BOEM Lease Area Outer Continental Shelf (OCS) -A 0512 geophysical survey.

The BOEM Lease Area OCS-A 0512 survey was conducted by Alpine on behalf of Equinor using two vessels; the research vessel (RV) *Shearwater* and the RV *Ocean Researcher.* The current report provides a summary of all PSO activities executed onboard the RV *Shearwater* during the BOEM Lease Area OCS-A 0512 survey. For the purposes of reporting, the survey activities conducted by the RV *Shearwater* shall hereafter be referred to as the “survey”. A separate suite of PSO Reports shall be issued to cover the survey activities conducted by the RV *Ocean Researcher*.

In accordance with Equinor’s Commercial Lease of Submerged Lands for Renewable Energy Development on the OCS-A 0512 (Lease), Addendum C, Stipulation 4.5.5, the current report provides a summary of survey activities, all PSO and incident reports, and an estimate of the number of listed marine mammals and sea turtles (hereafter ‘protected species’) observed and/or taken[2] during these survey activities*.* The report also contains detailed analysis and interpretation of the sound source verification data collected by the RV *Shearwater* prior to high resolution geophysical (HRG) operations.

As per the Lease, this report is being submitted 90 days post-commencement of the HRG survey activities on the RV *Shearwater*.

[1] Statoil Wind US, LLC changed its name to Equinor Wind US, LLC in May 2018
[2] The Endangered Species Act (1973) makes it unlawful for a person to take a listed animal without a permit. “Take” is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct”.

2 OVERVIEW OF HRG SURVEY ACTIVITIES

The HRG survey was conducted by Alpine onboard the RV *Shearwater* in accordance with the BOEM-approved Survey Plan (and the Alternative Monitoring Plan contained therein). Survey activities onboard the RV *Shearwater* were conducted between Mar-11-2018 and Apr-02-2018 within the boundaries of the Equinor Wind US Lease Area and possible cable route area (see Location Map), offshore New York.

From Mar-18-2018 to Mar-19-2018, the RV *Shearwater* conducted an acoustic source field verification survey (FVS), after having completed equipment calibration. It was a requirement of the Lease to undertake a FVS in support of survey operations, to verify that the default exclusion zone (EZ) proposed in the Lease encompassed the Level A harassment zone for the specified survey equipment. A detailed report of the FVS methodology and results are provided in Appendix A.

Survey operations were conducted throughout the project period on a 24-hour basis. Operations commenced with equipment calibration prior to the FVS and, following completion of the FVS and acceptance of the results by BOEM, survey data acquisition was conducted. The survey comprised gridded survey lines at a spacing of approximately 98ft by 1640ft (30m by 500m) and covered the 180m-wide cable route corridor. The RV *Shearwater* was equipped with a suite of HRG equipment including a single-beam echosounder (SBES; low frequency setting), multi-beam echosounder (MBES), side scan sonar (SSS), gradiometer, shallow penetration sub-bottom profiler (SBP; chirp), and an ultra-short baseline (USBL) system, which was used for positioning. The purpose of the survey was to acquire HRG data that will support the evaluation of shallow hazards, geological conditions, and marine archaeological resources prior to the construction of an offshore windfarm.

24-hour survey operations were conducted throughout the survey period. Table 2.1 provides the specifications of the suite of HRG equipment used onboard the vessel that required mitigating actions. These included a shallow penetration SBP (chirp), UHRS sparker, USBL beacon and SBES.

Table 2.1 Specifications of HRG survey equipment operating below 200kHz

Equipment	Sample Model type	Frequency (kHz)[1]
Shallow penetration SBP (chirp)	Teledyne Benthos CHRIP III	1-14
UHRS sparker	GeoMarine 1000J Sparker with 8-element Hydrophone Streamer	0.05-5
USBL	Sonardyne Scout Pro USBL Acoustic Positioning System	19-34
SBES	Odom Echotrac CVM Dual Frequency Single Beam Echosounder (low-frequency setting)	21-25

1 Frequencies obtained in the field.

3 SUMMARY OF MITIGATION AND MONITORING METHODS

In accordance with Addendum C of the Lease, BOEM requires Lessors to implement mitigation and monitoring to avoid and/or minimize potential impacts to protected species during survey activities. Mitigation measures covered vessel strike avoidance, the reduction of risk of disturbance and injury from geophysical survey operations, and reporting requirements. Further to the mitigation measures stipulated in the Lease, BOEM granted Equinor a limited waiver (Appendix B) to modify Lease Stipulation 4.4.6.8 regarding shutdown for non-delphinoid cetaceans and sea turtles and 4.4.6.9 regarding power-down for delphinoid cetaceans and pinnipeds, which was incorporated into the survey. Equinor have also applied to modify Lease Stipulation 4.4.6.1 (Appendix B), but this modification is still under review and therefore was not implemented during the survey period covered by this report. A summary of the mitigation measures implemented during the survey, including the modified requirements outlined in the waiver, is provided below.

It should be noted that Equinor applied for an Incidental Harassment Authorization (IHA) from National Oceanographic and Atmospheric Administration’s (NOAAs) National Marine Fisheries Service (NMFS), prior to the commencement of the survey. The application for the IHA contained several proposed modifications to the mitigation measures outlined in the Lease. On Feb-14-2018, Equinor notified BOEM that they would be ready to commence the HRG survey prior to NMFS-issuance of the IHA, and received approval to commence the survey pre-IHA issuance. Operations were therefore conducted in accordance with the original Stipulations in the Lease, in addition to the revisions outlined in the waiver provided by BOEM to Equinor on Feb-27-2018 (Appendix B).

The required mitigation and monitoring measures were summarized for the survey in a Protected Species Monitoring Protocol (PSMP; Appendix C) produced by Gardline and approved by Equinor. The PSMP compiled the requirements across different documents into a single source in order to facilitate ease of understanding of the survey requirements, procedures and responsibilities of personnel onboard. All crew members and PSOs/passive acoustic monitoring system (PAMS) operators were briefed using this document prior to the commencement of survey operations to ensure thorough understanding of the survey requirements.

3.1 Vessel Strike Avoidance Measures

The HRG survey was required to comply with the vessel strike avoidance measures outlined in Lease Stipulation 4.2. The vessel operator and crew maintained a dedicated watch for all protected species at all times. A minimum of one PSO was on watch during transit, in addition to the 24-hour observation conducted during operations. This was to ensure that, in the event of an encounter, the vessel undertook the appropriate avoidance measures to ensure that the minimum separation distance for the relevant protected species groups (Appendix C) was adhered to in order to avoid vessel strike. The vessel was required to operate at speeds below 10 knots at all times, as stipulated by the Lease for all vessels operating from November 1 to April 30.

3.2 Mitigation Measures for HRG Survey Equipment

HRG survey equipment operating below 200 kilohertz (kHz) has the potential to cause acoustic harassment to protected species such as marine mammals and sea turtles. During the BOEM Lease Area OCS-A 0512 survey, certain pieces of HRG equipment were utilized that operated below 200kHz. These equipment were subject to mitigation methods comprising the maintenance of protected species exclusion zones, ramp-up procedures, and delay, shutdowns and power-down procedures in the event of encounters, as summarized below and explained in full in Appendix C.

An EZ was implemented around the HRG survey equipment. As stipulated in the Lease (4.4.6.1), the radius of the EZ was 500m for North Atlantic right whales, and 200m for all other marine mammals. Prior to the activation of the acoustic sources a 60 minute pre-survey clearance monitoring period was undertaken during which the mitigation personnel monitored the EZ and surrounding area. Should a protected species be encountered in their relevant EZ during the 60-minute monitoring period, then a delay of 60 minutes from the last detection in the EZ was implemented.

As outlined in Lease Stipulation 4.4.6.7, a ramp-up was implemented for all HRG equipment, where technically feasible. In summary, the ramp-up constituted the incremental increase of the sound level in steps not exceeding 6dB per 5 minute interval, over a period of no less than 20 minutes. The method for increasing the sound level of the chirp was to increase the power output, and for the sparker, to increase the firing rate. It was not feasible to a conduct ramp-up of the USBL or SBES, therefore these were turned on after the ramp-up of other equipment was complete, or, if running without the additional equipment, after the 60-minute pre-clearance monitoring period was complete.

A shutdown of active acoustic equipment was to be implemented should a non-delphinoid cetacean or sea turtle be sighted in their respective EZ whilst survey operations were underway. Once a shutdown occurred, restart of the acoustic equipment could commence with a ramp-up once protected species had not been observed in the EZ for the specified restart pre-clearance period expressed in the limited waiver (60 minutes for North Atlantic right whales and turtles; 30 minutes for large whale species, including beaked whales and *Kogia sp.*; 15 minutes for small cetaceans and seals).

A power-down of the acoustic equipment to the lowest possible output was implemented should a delphinoid cetacean or pinniped be sighted within the EZ and deemed to not be approaching the vessel voluntarily. The acoustic equipment could then be ramped up to operational levels once the EZ was clear of the animals or if the animals changed their behaviour to voluntary approach to bow-ride or chase the towed equipment. An amendment under the limited waiver also allowed for all equipment under full power to remain at full power if small cetaceans and seals observed were immediately seen voluntarily approaching the survey vessel.

Unplanned breaks in acoustic activity for less than 20 minutes could be followed by the activation of survey equipment at operational levels providing that the break period had been monitored continuously by the mitigation personnel. Should monitoring not have been conducted continuously, or the break was greater than 20 minutes, the activation of the acoustic sources must be preceded by a full 60 minute pre-clearance monitoring period and follow the ramp-up procedure.

3.3 Monitoring Methods

The mitigation team onboard the RV *Shearwater* comprised four NMFS-approved dual-role PSO/PAMS operators that provided monitoring for survey operations on a 24-hour basis. Two PSOs conducted visual watches during daylight hours whilst two team members, one PSO and one PAMS operator, covered night-time operations. HRG operations were only permitted to occur during night-time when both visual and acoustic monitoring could be conducted simultaneously.

Mitigation personnel rotated their roles in order to maintain vigilance at all times. Personnel were scheduled to conduct a maximum of four hours monitoring, followed by a minimum two-hour break. Different schedules were in place during FVS activities, operations and vessel strike avoidance, which were adhered to as strictly as was practically feasible. Each individual worked a maximum of 12 hours within each 24-hour period.

3.3.1 Visual Monitoring

Visual monitoring occurred from the highest available vantage point on the RV *Shearwater* (approximately 5.6m above sea level) to allow for 360º scanning. During daylight operations the PSOs conducted visual monitoring using the naked eye and supplemented by reticule binoculars (magnification x10). During night-time operations the PSO on watch used night-vision binoculars with an additional clip-on thermal imaging.

In order to establish the range of objects at sea, primarily protected species, reticule binoculars and a range-finder stick (Heinemann, 1981) were used. The PSOs were also equipped with bearing-finding equipment (angleboard) and a digital reflex stills camera with a 70mm to 300mm zoom lens.

The Joint Nature Conservation Committee's (JNCC) standardized recording forms were used by the PSOs to document all operations, effort and encounters (Appendix D). These forms encompassed all the required data elements for PSO reports as listed in Appendix B to Addendum C of the Lease. All times were recorded in UTC, as per the guidelines provided in the JNCC recording forms.

3.3.2 Passive Acoustic Monitoring

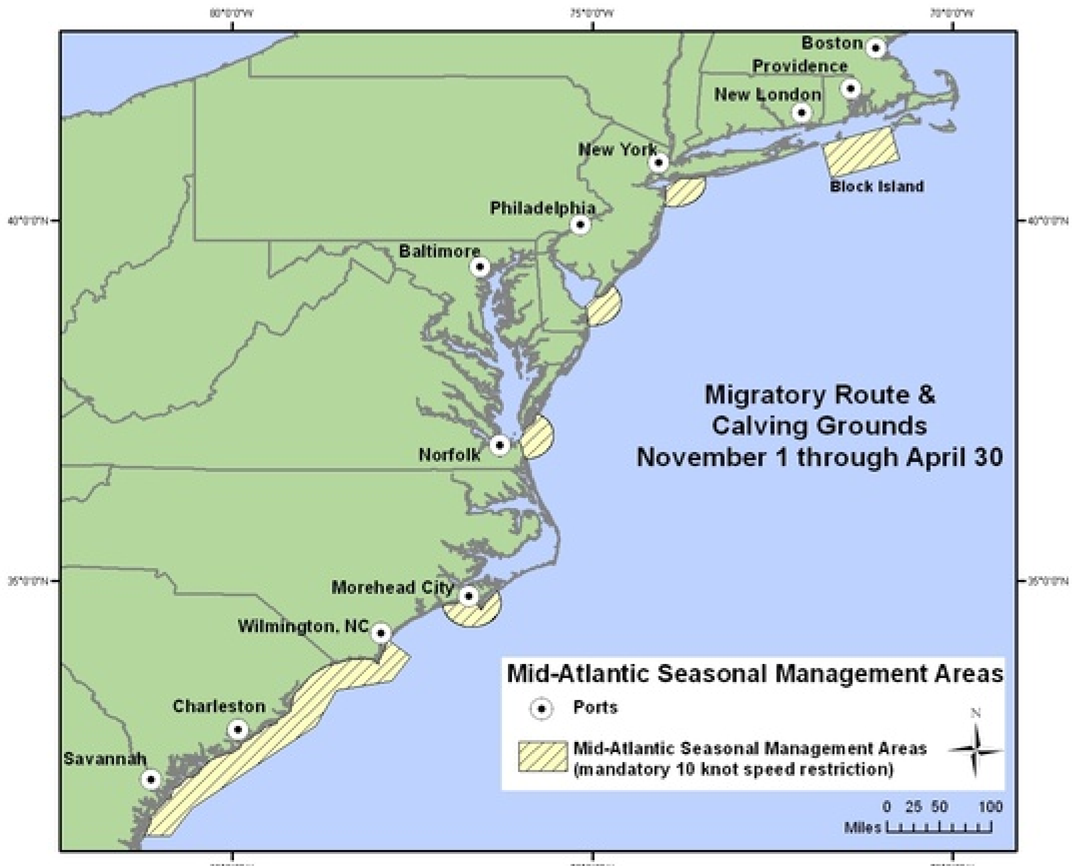
A PAMS was used by trained and experienced operators during the survey. The PAMS comprised a hydrophone array that was towed behind the vessel and connected to a data processing system, thereby allowing the operator to listen to and visualize the sounds following digitization by the computer system and display in PAMGuard (Version 1.15.03 CORE). While on watch, the PAMS operator monitored PAMGuard for any potential detection of cetaceans, with a focus on the minimum separation distances for avoiding vessel strike and the EZ around the acoustic sources. The PAMS operators completed the aforementioned JNCC forms in the same manner as the PSOs.

The PAMS utilized during the survey was a Gardline Mk 4.1 system. This system has been designed to detect and localize North Atlantic right whales in addition to a wide range of other cetacean species. The hydrophone array comprised of six hydrophones: three low frequency, with a frequency response of 10Hz to 70kHz and nominal sensitivity -190dB re 1V/µPA; and three broadband hydrophones, with a frequency response of 1kHz to 170kHz and nominal sensitivity -170dB re 1V/µPA. Further details of the system and operational procedures can be found in Appendix C.

3.4 North Atlantic Right Whale Monitoring

It was considered that encounters with North Atlantic right whale could occur during the survey due to the combination of season and location. The survey occurred in the vicinity of the Mid-Atlantic Seasonal Management Area (SMA; Figure 3.1) that operates from Nov-01 to Apr-30 to protect North Atlantic right whales along their migratory route, specifically around port or bay entrances. As stated in Lease Stipulation 4.4.6.5, the lead PSO monitored the NMFS North Atlantic Right Whale Reporting Systems (the Mandatory Ship Reporting system, the Whale Alert app and the Interactive North Atlantic Right Whale Sightings Map (available at https://www.nefsc.noaa.gov/psb/surveys/)) on a daily basis to monitor the presence of any North Atlantic right whales or the establishment of any Dynamic Management Areas (DMAs) in the survey area. This was to ensure that, in the event of NMFS establishing a DMA in the survey area, the vessel ceased all survey activities within 24 hours, as stated in Lease Stipulation 4.4.6.6.

Figure 3.1 North Atlantic right whale Mid-Atlantic SMA in effect from Nov-01-2018 to Apr-30-2018



4 RESULTS OF MONITORING

4.1 Monitoring Effort Summary

From Mar-11-2018 to Apr-02-2018 a total of 412 hours and 26 minutes of dedicated marine animal monitoring was carried out by the mitigation personnel onboard the RV *Shearwater* (where simultaneous visual and acoustic monitoring is counted separately; Table 4.1). The PSOs conducted a total of 309 hours and 5 minutes of dedicated marine animal observation, including a total of 17 hours of visual pre-clearance monitoring. The PAMS operators conducted a total of 103 hours and 21 minutes of dedicated acoustic monitoring, including a total of nine hours of acoustic pre-clearance monitoring.
Each pre-clearance monitoring period was recorded as precisely an hour long, in accordance with the lease Stipulation, although it should be noted that the mitigation personnel were on continuous dedicated monitoring duties throughout operations.

Table 4.1 Summary of monitoring effort

Monitoring Effort	Visual monitoring effort	Acoustic monitoring effort	Total combined monitoring
Total (hh:mm)	309:05	103:21	412:26
Total pre-shoot monitoring (hh:mm)	17:00	9:00	26:00
Average pre-shoot monitoring duration (min)	60	60	60

4.1.1 Weather Conditions During Monitoring Effort

Weather conditions recorded during all monitoring effort were predominantly good. Sea state was mostly slight (66%) with occasional choppy periods (27%; Figure 4.1). Swell height was predominantly low (<2m; 95%) with intermittent periods of medium swell (2m to 4m; 5%). Beaufort wind force ranged from a Force 1 to a Force 8 but was most frequently a Force 3 to Force 4 (28% and 29% respectively; Figure 4.2). Wind was recorded predominantly from a northwesterly direction (Figure 4.3). Visibility was mostly good (>5km) however it was also frequently recorded as poor (<1km; Figure 4.4) due to the restricted range of visual monitoring at night-time.

Figure 4.1 Sea state recorded during monitoring

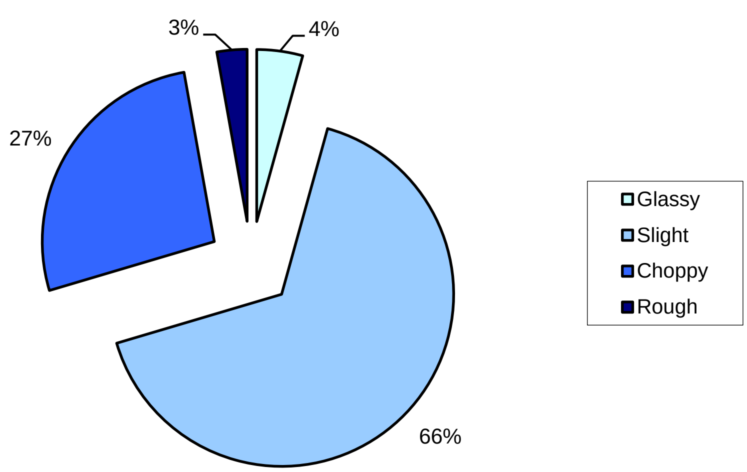


Figure 4.2 Beaufort wind force recorded during monitoring

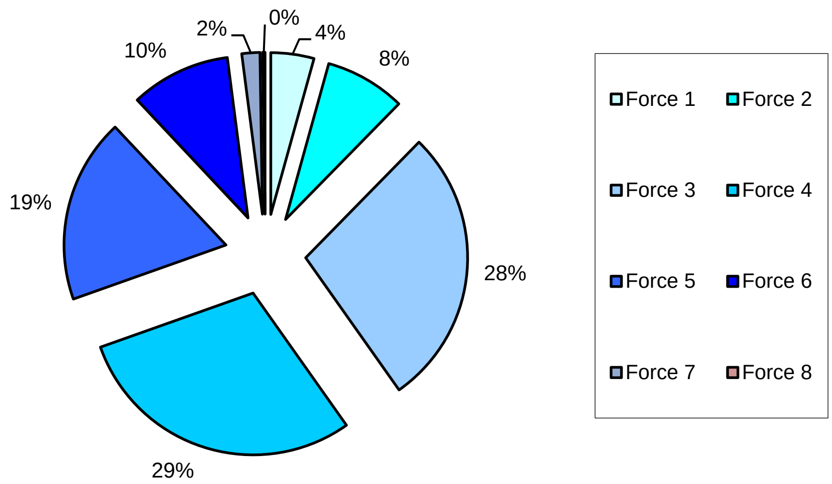


Figure 4.3 Wind direction recorded during monitoring

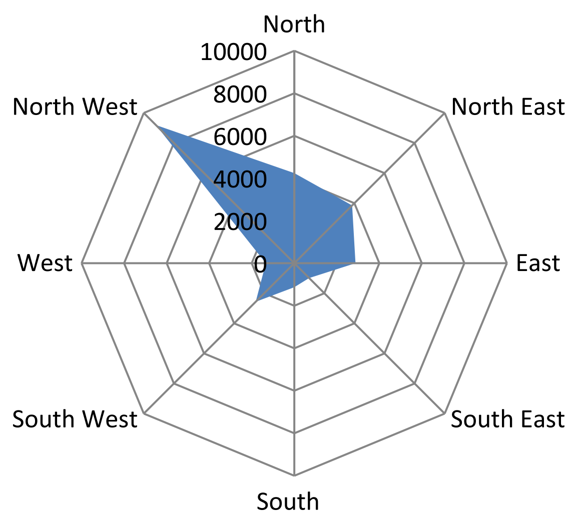
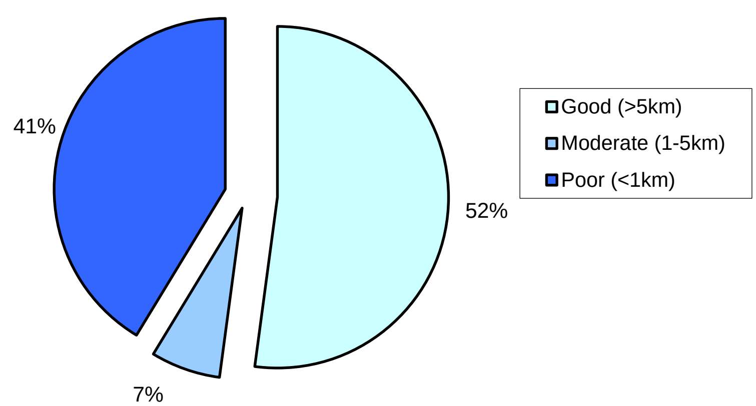


Figure 4.4 Visibility recorded during marine animal monitoring



Weather conditions recorded during the critical pre-clearance monitoring periods (n=17) were also predominantly good. Sea state during pre-clearance monitoring was mostly slight (82%) with one record each of glassy, choppy and rough conditions. During all bar one period, swell was low and there was no precipitation recorded. There was no glare recorded during 71% of pre-clearance periods; the glare present during the remainder of periods was estimated to obscure 10% to 20% of the ocean's surface. Beaufort wind force during pre-clearance monitoring periods ranged from Force 1 to Force 6 but was most frequently a Force 4 (35%). Visibility was most commonly recorded as poor (53%) or good (41%) during pre-clearance periods. However, it should be noted that this poor visibility was only recorded during pre-clearance periods that occurred during the hours of darkness, when acoustic monitoring was also conducted concurrently.

It could be considered that weather conditions for monitoring purposes were poor if any of the following conditions were met: Beaufort wind Force >6; rough sea state; or large swell. These conditions were recorded during 6% (17 hours and 56 minutes) of monitoring effort (where conditions during simultaneous visual and acoustic effort are counted once). Such conditions were recorded during one pre-clearance search period, attributable to a rough sea state.

4.2 North Atlantic Right Whale Monitoring

During the survey the lead PSO monitored the aforementioned NMFS North Atlantic Right Whale Reporting Systems on a daily basis. No North Atlantic right whales were sighted or DMAs established in the HRG survey area whilst the operations were ongoing from Mar-11-2018 to Apr-02-2018.

4.3 Protected Species Encounters and Estimated Take

There were no encounters with live, dead or injured protected species throughout the duration of activities on the RV *Shearwater*, from Mar-11-2018 to Apr-02-2018. As there were no animals encountered during project activities, it is considered that no protected species were "taken" as a result of survey operations.

4.4 Protected Species Mitigation

In accordance with the mitigation measures stipulated in the Lease, the mitigation personnel conducted dedicated watches and acoustic monitoring during all survey operations. Visual monitoring was conducted during all transits to and from site. There were no delays to ramp-up procedures nor power-downs or shutdowns of equipment required due to protected species encounters. In addition there were no incidences where vessel strike avoidance measures had to be undertaken during the survey. During survey activities vessel speed was maintained at an average of 3.5 knots, with a maximum of 7.7 knots recorded, in accordance with the maximum vessel speed of 10 knots stated in the Lease.

5 DISCUSSION

5.1 Effectiveness of Mitigation Methods

In order to minimize the impacts on marine mammals and sea turtles, the HRG survey was run in accordance with dedicated protected species mitigation measures. During the survey pre-clearance monitoring periods and ramp-ups were conducted, and no delays, power-downs or shutdowns were required. The measures implemented during the survey are considered to have successfully achieved a high standard of mitigation suitable for the project. The success relied on the use of experienced and dedicated observers, who were available to provide both acoustic and visual monitoring for protected species on a 24-hour basis, and able to communicate effectively with the survey crew and each other.

The area offshore New York has been identified as an area of common occurrence for up to 15 marine protected species, including baleen whales, large toothed whales, dolphins, seals and turtles (NYSERDA, 2017). Within this area, the majority of species are predicted to be concentrated around the continental shelf break and slope (NYSERDA, 2017). The coastal continental shelf waters are primarily used by baleen whales, including North Atlantic right whales, fin whales and humpback whales, for feeding and migration (NYSERDA, 2017). The spatio-temporal distribution of these baleen whales overlaps with the present survey activities (NYSERDA, 2017). It was therefore anticipated that encounters were possible during the survey, either with species of known seasonal occurrence in the area, or of highly mobile species. Despite this, there were no sightings or detections of protected species during the survey.

5.2 Effectiveness of Detection Methods

Using a number of detection methods in conjunction with each other increases the effectiveness of detection of all animals in the area. All methods available (daylight visual, night-time visual, and acoustic) have some limitations, however using a combination of methods provides a complementary approach.

5.2.1 Daylight Observer Effectiveness

There are several factors that may have influenced the detection of marine animals within the survey area. Weather can affect the ability to detect marine animals in a number of ways, with increasing sea state, wind force and decreasing visibility reducing the detection probability of marine animals (Forney, 2000) particularly those with inconspicuous surfacing behaviour (Palka, 1996). During survey activities weather conditions were predominantly good; visibility was good for the majority of monitoring time, with a low swell and slight sea state. However, weather may still have impacted the ability to detect marine mammals, particularly during the rare periods of poor conditions. One such marine mammal that may have been harder to detect is the harbour porpoise, which is known for its elusive nature and inconspicuous surfacing behaviour (Shirihai & Jarrett, 2006).

5.2.2 PAMS Effectiveness

The acoustic detection of marine mammals is generally not as restricted by the weather as visual observations, although the hydrophones' range is occasionally reduced during poor weather conditions, due to increased levels of background noise. The main limitation with PAMS is that the animal must be vocalising in order to be detected. For some species, particularly baleen whales, vocal activity may vary

with season, location, behaviour and gender (Mellinger *et al.*, 2007; Boisseau *et al.*, 2008). Some species of cetacean are notoriously difficult to monitor acoustically, for example the beaked whales (Barlow & Gisner, 2006). Despite this, many species of cetacean are audible for a greater proportion of time than they are visible at the surface (Gordon *et al.*, 2003). In general, PAMS has the advantage of being able to detect elusive or small mammals, like the harbour porpoise, that can often be missed by observers during unfavourable weather conditions and the hours of darkness (O'Brien, 2009).

5.2.3 Night-vision Effectiveness

No night-time observations were made during the current survey, therefore no comparison can be made between the effectiveness of the night-time detection methods used. However, the observers reported that the night vision binoculars were very effective at monitoring within the limits of the 500m EZ. During previous surveys conducted by Gardline, they have proved effective at detecting animals both at close distances and up to 750m from the vessel; therefore it is considered that the devices provided an appropriate level of mitigation during the night-time operations of the survey.

The effectiveness was greatest when environmental conditions allowed for maximum availability of background light, such as when close to coastal lights or when the moon phase was full with little cloud cover. Their effectiveness could be limited by certain environmental conditions, such as periods of heavy fog or precipitation. This being said, on no occasion did the environmental conditions prevent the effective monitoring of the EZ using the night-vision devices.

6 BIBLIOGRAPHY

Barlow, J. & Gisner, R., 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management*, 7(3), pp.239-49.

Boisseau, O., Gillespie, D., Leaper, R. & Moscrop, A., 2008. Blue (Balaenoptera musculus) and fin (B. physalus) whale vocalisations measure from northern latitudes of the Atlantic Ocean. *Journal of Cetacean Research and Management*, 10 (1), pp.23-30.

Forney, K.A., 2000. Environmental models of cetacean abundance: reducing uncertainty in population trends. *Conservation Biology*, 14(5), pp.1271-86.

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M., Swift, R. & Thompson, D., 2003. A review of the effects of seismic surveys on marine mammals. *Marine Technology Society Journal*, 37(4), pp.16-24.

Heinemann, D., 1981. A range finder for pelagic bird censusing. *Journal of Wildlife Management*, 2(45), pp.489-93.

Mellinger, D.K., Stafford, K.M., Moore, S.E., Dziak, R.P. & Matsumoto, H., 2007. An overview of fixed passive acoustic observation methods for cetaceans. *Oceanography*, 20(4), pp.36-45.

NYSERDA, 2017. *New York State Offshore Wind Master Plan Marine Mammals and Sea Turtles Study. NYSERDA Report 17-25L*. New York: New York State Energy Reseach and Development Authority Ecology and Environment Engineering, P.C.

O'Brien, J., 2009. Passive acoustic monitoring of the harbour porpoise (Phocoena phocoena) in Irish waters. In: Muc Mhara – Ireland's smallest whale. In Berrow, S.D. & B, D., eds. *Proceedings of the 2nd Irish Whale and Dolphin Group International Whale Conference*. Killiney, 2009.

Palka, D., 1996. Effects of Beaufort sea state on the sightability of harbor porpoises in the Gulf of Maine. *Report of the International Whaling Commission*, 46, pp.575-82.

Shirihai, H. & Jarrett, B., 2006. *Whales, Dolphins and Seals: A field guide to the marine mammals of the world*. London: A&C Black Publishers.

APPENDICES

APPENDIX A ACOUSTIC SOURCE FIELD VERIFICATION REPORT

Survey Report for
Alpine Ocean Seismic Survey Inc. on behalf of Statoil US Wind LLC

Project:
Empire Wind High Resolution Geophysical Survey

Description:
Acoustic Source Field Verification Report

Vessel:
RV *Shearwater*

Survey Date:
Mar-18-2018 to Mar-20-2018

Project Number:
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EXECUTIVE SUMMARY

This report presents the results obtained during underwater noise monitoring for the field verification survey (FVS) at the New York Empire State Offshore Wind Farm during a high resolution geophysical (HRG) survey.

HRG equipment operating below 200kHz and vessel noise measurements were performed on Mar-18-2018 and Mar-19-2018, prior to the HRG survey, using seabed mounted Autonomous Recording Units (ARUs) and the associated hydrophones.

The FVS comprised a total of six transects run along a pre-determined route: two transects for the ultra-high resolution seismic(UHRS) sparker (one for each power setting, at 400J and 600J), one for sub-bottom profiler (SBP; chirp, one for single-beam echosounder (SBES), one for ultra-short baseline (USBL) and one for vessel noise.

As per National Oceanic and Atmospheric Administration (NOAA; 2016) guidelines, zero to peak sound pressure level (SPL_{peak}) and frequency-weighted cumulative sound exposure level ($cSEL_{24h}$) should be calculated for each functional hearing group over a 24-hour period. Based on acoustic thresholds from this guidance, none of the HRG sources were predicted to cause auditory injury to marine mammals beyond the planned 200m EZ. Table 1.1 summarises the measured source levels of each piece of HRG equipment and the RV *Shearwater* during the FVS.

Table 1.1 Predicted source levels of HRG equipment operating below 200kHz and the vessel RV *Shearwater* measured during the FVS

Equipment	Primary Mooring			Secondary Mooring		
	Source Level (SPLpeak dB re 1µPa.m)	Source Level (SPLrms 90% dB re 1µPa.m)	Source Level (SEL dB re 1µPa2s.m)	Source Level (SPLpeak dB re 1µPa.m)	Source Level (SPLrms 90% dB re 1µPa.m)	Source Level (SEL dB re 1µPa2s.m)
UHRS Geo-Source sparker (400J)	206.0	182.7	168.1	208.3	184.6	170.2
UHRS Geo-Source sparker (600J)	208.8	190.0	174.9	210.4	191.5	176.9
Teledyne SBP (chirp)	204.3	184.6	166.0	206.3	186.4	168.6
Odom SBES	174.1	155.8	144.7	175.8	157.5	146.4
Sonardyne USBL	198.6	173.0	167.3	198.7	172.2	167.3
RV Shearwater	183.4	168.0	167.4	186.3	170.0	169.4

Overall, the measurements made during this FVS did not result in injury beyond the EZ according to the metrics stipulated in the lease requirement. There was no indication sound produced by the HRG equipment will exceed the provided noise thresholds within the EZ.

SERVICE WARRANTY

USE OF THIS REPORT

This report has been prepared with due care and diligence and with the skill reasonably expected of a reputable contractor experienced in the types of work carried out under the contract and as such the findings in this report are based on an interpretation of data which is a matter of opinion on which professionals may differ and unless clearly stated is not a recommendation of any course of action.

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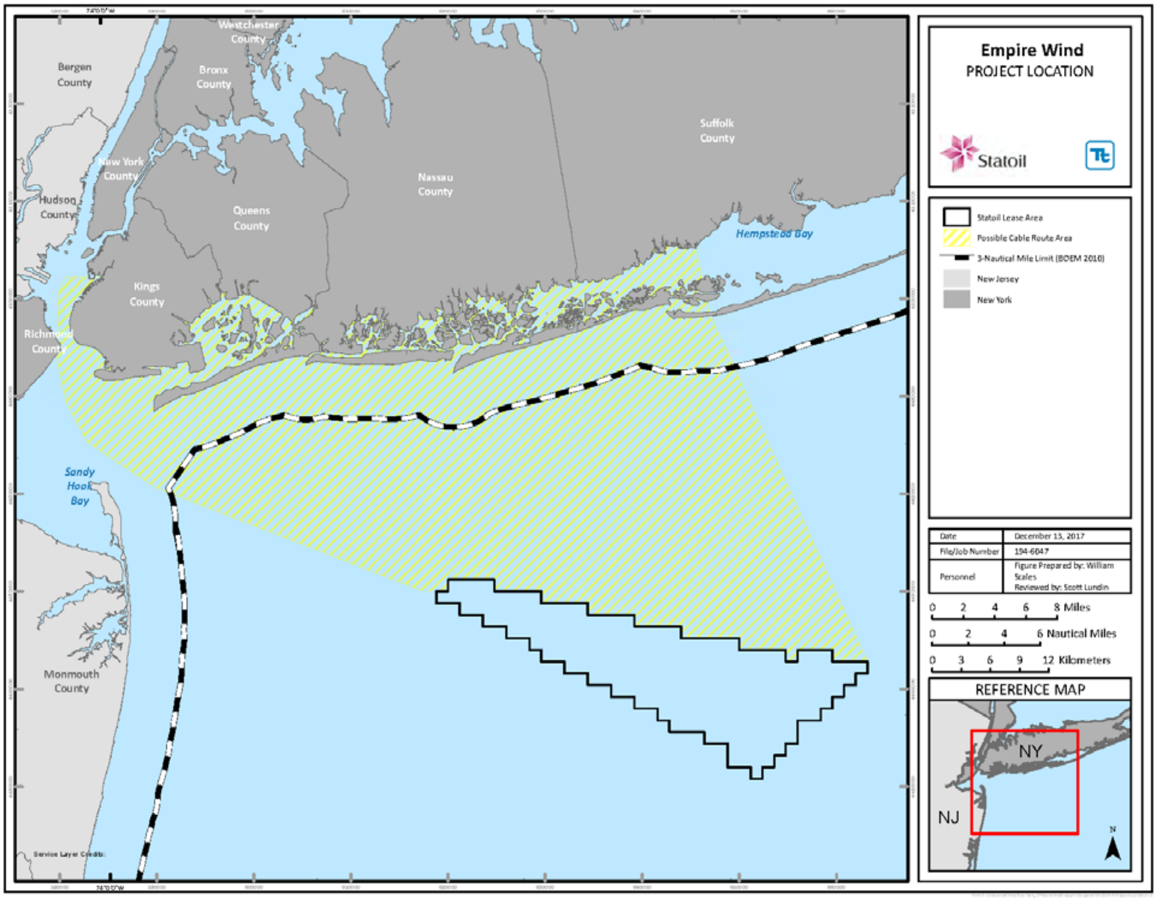
LOCATION MAP



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GLOSSARY OF TERMS AND ABBREVIATIONS

ARU	Autonomous Recording Unit
BOEM	Bureau of Ocean Energy Management
CPA	Closest Point of Approach
cSEL	Cumulative Sound Exposure Level over a 1-second period
$cSEL_{24\,h}$	Cumulative Sound Exposure Level over a 24-hour period
dB	Decibel: a logarithmic unit expressing the ratio of a quantity, a_1, relative to a reference value, a_0, according to the formula: $10 \cdot \log_{10}\left(\frac{a_1}{a_0}\right)$
EZ	Exclusion Zone
FVS	Field Verification Survey
HRG	High Resolution Geophysical
kHz	Kilohertz
Lease	Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf OCS-A 0512
m/s	Meters Per Second
ms	Millisecond
MMPA	Marine Mammal Protection Act
NOAA	National Oceanic and Atmospheric Administration
OWF	Offshore Wind Farm
Pa	Pascal
PPS	Pulse Power Supply
pps	Pulse Per Second
PSD	Power Spectral Density
PSMP	Protected Species Monitoring Plan
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
RL	Received Level
rms	Root Mean Square
rpm	Revolutions per Minute
RV	Research Vessel
SBES	Single-Beam Echosounder (Low-frequency setting)
SBP	Sub-Bottom Profiler
SEL	Sound Exposure Level
$SEL_{24\,h}$	Sound Exposure Level over 24-hour period
SL	Source Level
SoW	Scope of Work
SPL	Sound Pressure Level
SPL_{rms}	Sound Pressure Level (root mean square)
SPL_{peak}	Sound Pressure Level (zero-to-peak)
SVP	Sound Speed (Velocity) Profile
TL	Transmission Loss
TTS	Temporary Threshold Shift
USBL	Ultra-Short Base Line
UHRS	Ultra-High Resolution Seismic

1 INTRODUCTION

1.1 Project Overview and Objectives

Gardline Limited (Gardline) carried out a geophysical survey for for Alpine Ocean Seismic Survey Inc. (Alpine) on behalf of Statoil US Wind LLC (Statoil) on board the Research Vessel (RV) *Shearwater*. The objective of the geophysical survey was to provide information to support the submission of a Site Assessment Plan (SAP) Survey Plan by Statoil to advance the development of an offshore wind project, under the Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf (OCS-A 0512; Lease).

The geophysical survey was conducted across the planned New York (NY) Empire Wind site area within the area of the Lease. The survey site is located approximately 20km south of Long Island, NY (see Location Map), with a water depth ranging between 10m and 25m.

1.2 Scope of Work

Gardline provided an acoustic source field verification survey (FVS hereafter) prior to the commencement of the geophysical survey for the Empire State offshore wind farm (OWF), in accordance with the conditions of the Lease, Addendum C.

The aim of the FVS was to confirm the acoustic sound levels emitted from all high resolution geophysical (HRG) survey equipment operating below 200kHz, in order to authenticate that sound pressure levels fall within the predicted ranges, thereby confirming that the exclusion zones (EZs) are suitable. In accordance with the Marine Mammal Protection Act (MMPA), EZs implemented for equipment that is likely to cause disturbance to protected species need to be defined so that acoustic related injury and disturbance to marine mammals, turtles and other protected species susceptible to acoustic equipment is minimised. These thresholds have previously been modelled based on existing data collected for different marine mammals (NOAA, 2016), however they require confirmation of their suitability through a FVS.

The shallow geophysical survey equipment to be used during the survey includes Ultra High Resolution Seismic (UHRS) sparker, shallow sub-bottom profiler (SBP; chirp), single-beam echosounder (SBES), and ultra-short baseline (USBL) beacons which are used to characterize the sediments and layers just below the seabed. This equipment produce sound predominantly at frequency under 200kHz, with source levels between 200dB re 1 μPa^2 m^2 and 230dB re 1 μPa^2 m^2 (Richardson *et al.*, 1995). The operating frequencies of this equipment can be found in Table 1.1.

Table 1.1 HRG survey equipment operating below 200kHz.

Equipment	Sample Model type	Frequency (kHz)[1]
UHRS sparker	GeoMarine 1000J Sparker with 8-element Hydrophone Streamer	0.05-5
Shallow penetration SBP (chirp)	Teledyne Benthos CHRIP III	1-14
SBES	Odom Echotrac CVM Dual Frequency Single-Beam Echosounder (low-frequency setting)	21-25
USBL	Sonardyne Scout Pro USBL Acoustic Positioning System	19-34

[1] Frequencies observed in the field.

1.3 Lease Requirements

The HRG equipment was regulated under Addendum C of the Lease. Stipulation 4.4.6.2 states:

The Lessee must submit to the Lessor the results of field verification to verify the exclusion zone for the HRG survey equipment operating below 200 kHz. If no applicable data are available the Lessee must conduct field verification of the exclusion zone for HRG survey equipment operating below 200 kHz. As part of such field verification, the lessee must take acoustic measurements at a minimum two reference locations and in a manner that is sufficient to establish the following: source level (Peak, SEL and RMS sound levels at 1 meter), pattern of spreading loss and the sound exposure distance for ear injury for each marine mammal hearing group, sea turtles, and fish. The distance to the 166, 160, and 150 dB RMS behavioural thresholds (Level B harassment) must also be reported. The first location must be at a distance of 200m from the sound source, and the second location must be as close to the sound source as technically feasible The Lessee must take these sound measurements at the reference locations at two depths (i.e., a depth at mid-water and a depth at approximately 1 meter (3.28 ft) above the seafloor). The Lessee must report the field verification results to the Lessor in the applicable survey plan(s), unless otherwise authorised by the Lessor.

2 METHODOLOGY

In order to accomplish the requirements of the Lease, as outlined in Section 1.3, a monitoring specification was developed by Gardline. The methodology was approved by the Bureau of Ocean Energy Management (BOEM) prior to the start of the survey which was undertaken on the RV *Shearwater*. Vessel specifications can be found in Appendix A.

The monitoring methodology was designed to provide characterisation of the acoustic source levels and an assessment of the variation in noise level with respect to slant distance from HRG equipment. This would allow the size of the exclusion zone to be verified based on predictive measurements.

The field verification activities were to be undertaken a minimum of one day prior to the start of the survey. The FVS results for National Oceanographic and Atmospheric Administration (NOAA) marine mammal harassment zones, as well as NOAA's (2016) injurious isopleths for cetaceans, phocid and otariid pinnipeds were submitted to BOEM within 24 hours of receipt of field data. This report reviews and analyses these data, along with the results of the transects run.

2.1 Fieldwork Methodology

To establish the impact of underwater noise generated by individual HRG sound sources produced during the geophysical survey for the NY Empire State OWF, a sound source FVS was conducted.

Autonomous recording units (ARUs) were deployed at a specific location within the survey site and six pre-determined transect survey lines were run for each HRG equipment test over seabed mounted ARUs, in order to reduce variation with changing variables. Each piece of equipment was tested separately and setup with the same parameters that would be used under normal survey conditions.

Deployment, recovery and maintenance of the survey equipment was conducted by a Gardline marine acoustician and acoustic scientist onboard the vessel. The working proximity of the survey vessel to the mooring, particularly whilst operating towed acoustic equipment, was at the discretion of the vessel Master. The detailed methodology is given in the following sections.

2.1.1 Fixed Point Measurements

As outlined in Stipulation 4.4.6.2 (Section 1.3), two reference locations are required. At each reference location, measurements must be taken at two depths within the lease area to determine the source level (SL) of each acoustic source. Therefore, a sail-past method (Figure 2.1), with ARUs moorings (Figure 2.2) deployed at mid-water column and approximately 1m above seafloor, was developed to provide data acquisition at multiple reference locations at required water depth.

Two hydrophones were housed in each ARU, which were attached to a mooring line secured by a bottom anchor. An acoustic release was also attached with the riser line to allow an alternative method of equipment recovery in the case if the two moorings detaching due to the breakage of the ground line. Separate ARU configurations were connected by a 150m leaded line and bottom anchors were attached with a high visibility marker buoy on the sea surface. The primary mooring was required for initial analysis and the secondary mooring (200m offset) was deployed to make a more robust dataset for detailed analysis. The coordinates of the moorings are shown in Table 2.1.

Figure 2.1 Field verification line plan for each HRG equipment used during the NY Empire State OWF survey

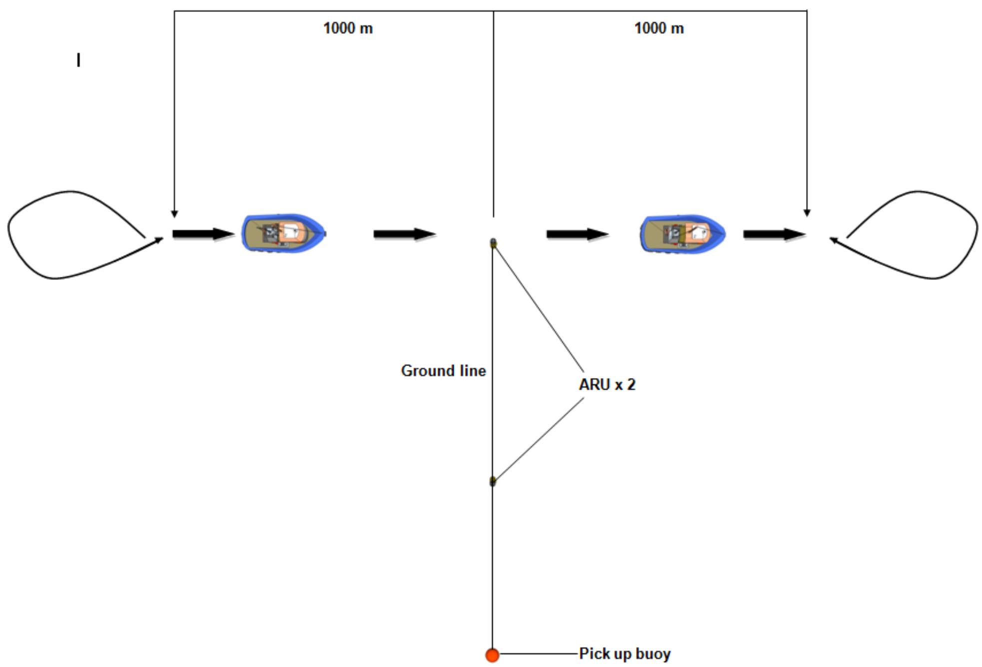


Figure 2.2 Mooring configuration for FVS

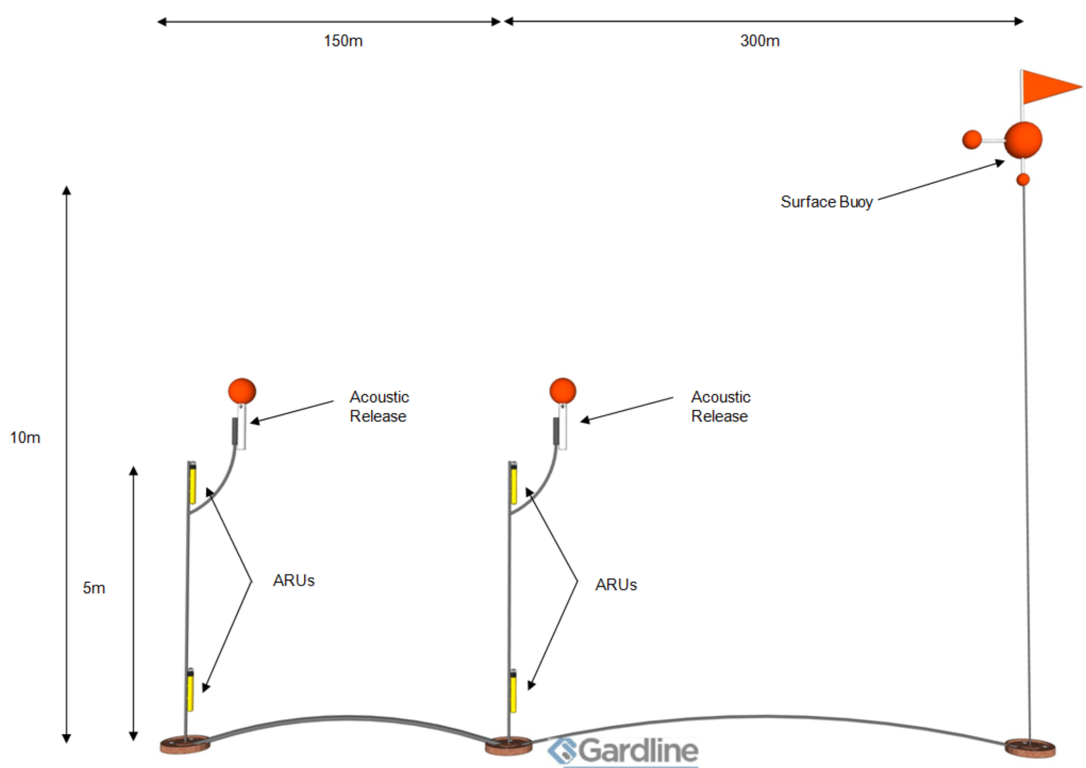


Table 2.1 Coordinates of recording stations

Mooring	Coordinate (WGS 1984)	
	Latitude	Longitude
Primary	40°31.361'N	73°52.950'W
Secondary	40°31.288'N	73°52.948'W

2.1.2 Verification Survey Procedures

Once the static configuration was deployed, the RV *Shearwater* conducted the FVS by running the pre-determined transects.

The field verification method used was based on a modified version of the sail-past method (ISO 17208 1, 2016). This method comprised running a verification line past two groups of fixed acoustic recorders, from 1km before to 1km after the recorder position, and turning to repeat in the reciprocal heading. The return line was used as a backup in case the original line data quality was poor due to unforeseen circumstances such as inconsistent output from acoustic source or failure of the device. The aim was to create a more reliable and robust data set. The first set of the ARU would be placed as close as technically feasible to the acoustic source, in order to capture all possible data including the source level. However, due to the shallow water conditions (~10m) and towed distance of survey equipment, the vessel would not sail directly above the ARU mooring in order to avoid potential entanglement. An offset distance (agreed by marine acoustic scientist and survey crew) of between 20m to 30m was implemented for all FVS lines to ensure the safety of the operations.

The designed survey lines (Table 2.2) provided a continuous transect of acoustic data, with the range extending up to 1km from the source, sufficient to determine the effectiveness of the proposed EZ in the Protected Species Mitigation Protocol (PSMP; Gardline Limited, 2018). Survey lines were intentionally repeated for different HRG equipment to ensure consistency of data. The method reduced the need for line turns and provided a continuous transect of acoustic data extending over a wide spatial area whilst minimizing the amount of unnecessary noise being introduced into the marine environment. Water depth during the FVS varied between 10m and 13m.

Table 2.2 FVS line locations

Acoustic Source	Start of Line Coordinate (WGS 84)		End of Line Coordinate (WGS 84)	
UHRS Geo-Source sparker (400J)	40°31.380'N	73°53.720'W	40°31.360'N	73°52.160'W
UHRS Geo-Source sparker (600J)	40°31.380'N	73°53.720'W	40°31.360'N	73°52.160'W
Teledyne SBP (chirp)	40°31.370'N	73°52.100'W	40°31.390'N	73°53.700'W
Odom SBES	40°31.380'N	73°53.720'W	40°31.370'N	73°52.140'W
Sonardyne Scout Pro USBL	40°31.380'N	73°52.130'W	40°31.360'N	73°52.130'W
RV *Shearwater*	40°31.370'N	73°52.130'W	40°31.380'N	73°53.700'W

To determine the SL of HRG equipment using this method, separate verification lines were performed for each acoustic source operating under 200kHz. During the survey, the "ping/firing intervals" on lines and the ship speed that best corresponded with the HRG survey activities were maintained. By measuring the sound levels at various ranges and two water depths, the EZ for the HRG survey equipment could be confirmed. The measured sound levels at the proposed distances allowed for the calculation of the apparent peak source levels and distances (Table 2.3).

Table 2.3 The effect of measured sound levels at the proposed distances from the acoustic source

Effect of acoustic source	Proposed acoustic threshold
Marine Mammal PTS / TTS isopleths	Table 2.7
Cetacean and Pacific walrus Level B harassment zone	160dB re 1µPa SPLrms
Marine turtle injurious zone	207dB re 1µPa SPLrms
Atlantic sturgeon behavioural disturbance	150dB re 1µPa SPLrms
Physiological effects on fish	187dB re 1µPa2·s cSEL
Impulsive injury threshold for fish (all sizes)	206dB re 1µPa SPLpeak

In order to fulfil the lease requirements, analyses were undertaken according to NOAA's (2016) guidelines. This included the calculation of sound pressure level (SPL_{rms} & SPL_{peak}), sound exposure level (SEL) and $cSEL_{24\,h}$ isopleths for auditory injury for low frequency (LF) cetaceans, medium frequency (MF) cetaceans, high frequency (HF) cetaceans, phocid pinnipeds in water and otariid pinnipeds in water.

A total of six FVS lines were completed: one for each of the USBL, SBES and SBP, and two for the UHRS sparker at both 400J and 600J. Details of the equipment used can be found in Table 1.1. In addition, a line was also completed without acoustic equipment firing in order to assess the continuous vessel noise presence in the survey area.

2.2 Data Sampling Equipment

Acoustic sampling equipment was selected according to the expected general characteristic of the acoustic sources, with a frequency range from 0.05kHz to 35kHz for HRG equipment, and peak frequency from 0.08kHz to 0.25kHz for vessel noise (El-Hawary, 2000). This two channel configuration for data acquisition, combined with a simultaneous sampling rate of 96kHz with a 16-bit resolution, providing a measured bandwidth from 0.002kHz to 48kHz, is sufficient to capture the full spectrum of all HRG equipment output signals. The ARUs used were manufactured by Wildlife Acoustics, models Song Meter SM2M and SM3M (Table 2.4), both equipped with a HiSPL hydrophone and an Ultrasonic hydrophone (Table 2.4).

Table 2.4 Specifications of ARUs

Model	SM3M Submersible	SM2M Submersible[1]
Height (cm)	90.9	79.4
Diameter (cm)	16.8	16.5
Buoyancy	5.5kg with no batteries 1.5kg fully populated with batteries	5.5kg with no batteries 1.5kg fully populated with batteries
Audio Sample Rate (kHz)	4-384	4-96 (up to 384kHz with the addition of computer daughter card)
Frequency Range (kHz)	0.002-192	0.002-48 (up to 192kHz with the addition of computer daughter card)
Storage Media	Up to four SD Cards (Card capacity 32–256GB)	Up to four SD Cards (Card capacity 32-256GB)
Depth Rating (m)	150	150

[1] Back up unit

Table 2.5 Specifications of hydrophones

Hydrophone Type	HiSPL	Ultrasonic
Frequency Range (kHz)	0.002-48	0.002-192
Sampling Rate	96	384
Mean Sensitivity (dB re 1µPa)	-240	-165

High sound pressure level (SPL) hydrophones with lower sensitivity were used alongside the Ultrasonic hydrophones because they are capable of recording high intensity sounds when the equipment is operating at very close range, as well as the full frequency range of the acoustic sources being tested, thus allowing for the contingency of clipped data being collected by the Ultrasonic hydrophones.

To ensure the accuracy of the hydrophone measurements, a calibration tone at 0.25kHz was recorded for each hydrophone before the data acquisition period using a handheld pistonphone. This produces a calibration signal that could be used to determine each hydrophone's sensitivity. The pistonphone used to calibrate all hydrophones, including the backup ARU, was a 42AC (high pressure, class 1) pistonphone manufactured by G.R.A.S. Sound & Vibration. The device is quoted to calibrate sound sources up to 134dB re 20µPa (equivalent to 196dB re 1µPa underwater) at a reference frequency of 0.25kHz, and has an accuracy of ±0.14dB. The pistonphone complies with ANSI SI.40 (1984) & IEC 60942 (1997) standards and it is calibrated to accredited ISO 17025 standard, a calibration certificate can be supplied upon request. Full ARU calibration results obtained from the FVS can be found in Appendix B.

2.2.1 Sound Velocity Profile Measurements

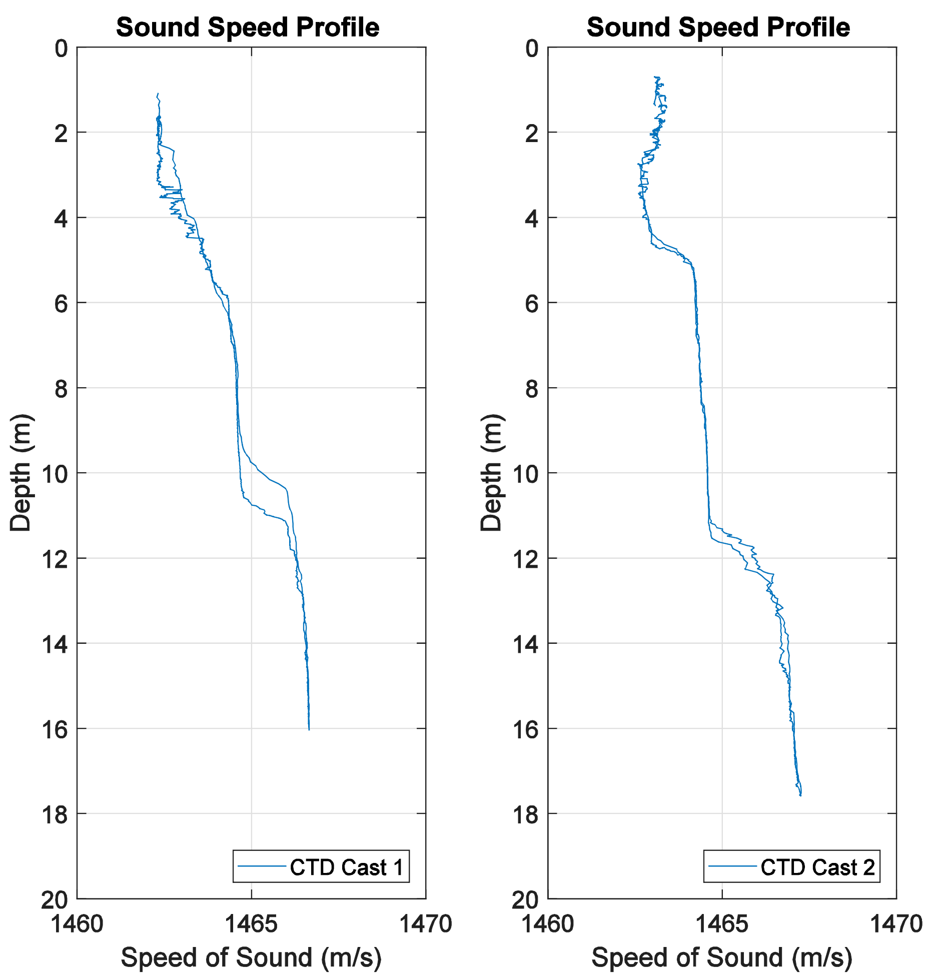
The largest variation of the speed of sound in water occurs with changes in water depth. A plot of propagation speed as a function of depth is known as the sound speed (velocity) profile (SVP) and is a fundamental tool for predicting the propagation of sound in the ocean. The sound speed was fundamentally derived from the measured seawater conductivity, temperature and pressure. An SVP that shows large depth dependence or variation can have significance influence on the measurement. For best practice, SVPs should always accompany the acoustic survey for comparison purposes and future reference. Sound velocity measurements were therefore taken during deployment and recovery of the FVS equipment.

An SVP probe was configured to take at least one measurement point per one meter depth while descending. The probe was lowered to the seabed during the deployment to ensure sufficient oceanographic information to establish the SVP of the area. The equipment used in this case was a calibrated AML Oceanographic MVP30 SVP probe (Table 2.6). The SVP of the survey area is illustrated in Figure 2.3.

Table 2.6 Specification of AML Oceanographic MVP30 SVP

Sensor	Sound velocity	Pressure
Range	1375–1625m/s	100–500dBar
Precision (+/-)	0.006m/s	0.03% FS
Accuracy (+/-)	0.025m/s	0.05% FS
Resolution	0.001m/s	0.02% FS
Response time	20ms	10ms

Figure 2.3 Sound speed profile obtained during the FVS operation



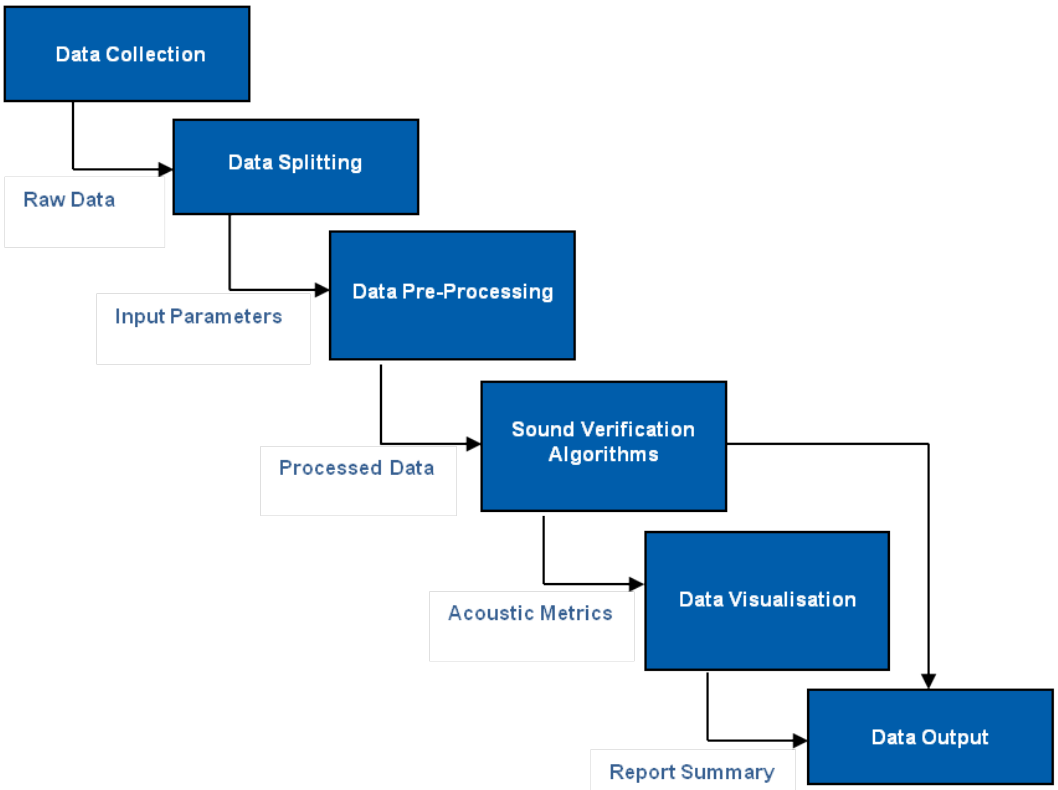
2.3 Data Analysis Methodology

2.3.1 Field Verification Survey

A proprietary algorithm was created to process the FVS dataset. The analysis workflow of the FVS dataset is illustrated in Figure 2.4. Once raw acoustic data was retrieved from the ARUs, initial

processing was conducted to identify the acoustic information according to the survey navigation and operation data. This will ensure the data associated with a specific type of equipment to be extracted with synchronised metadata between the moving vessel and the mooring. Next, the FVS data will be extracted and reduced from the continuous raw dataset into smaller segments containing recording from each FVS line for organisation and efficient computations. Any signal contamination considered to cause inaccurate calculation would be removed.

Figure 2.4 Data processing and analysis workflow for FVS



Signal processing techniques were used to isolate geophysical equipment acoustic information based on its operating frequency and the pulse detection threshold. The acoustic pulse will be identified from the pre-processed data and underwater noise calculations will be conducted to determine the acoustic levels. These measurements will be expressed in metrics most commonly used to describe underwater sound including SPL_{rms}, SPL_{peak} and SEL. Details of acoustic metrics are described in Appendix C. In addition, frequency weighted cumulative sound exposure level (cSEL) was also estimated in order to describe the cumulative impact which considers the peak pressure and the duration of the sound exposure. The exposure duration was normalised to 24 hours, as per the recommendations advised by NOAA (2016). The $cSEL_{24\,h}$ calculation (see Appendix C; C.7) assumes the source and receptor were stationary relative to each other for 24 hours and, hence, assumes no flee response. It should be noted that the pulse duration of each acoustic pulse is estimated from the cumulative energy function. The time window containing 90% of central pulse energy (see Appendix C; C.7) is considered best practise for estimating the average pulse duration ($T_{90\%}$) of field data. This approach was used throughout the analysis in this report except for the continuous noise generated from the research vessel. A constant

time window of 1 second was used for vessel noise based on BOEM (2016) for continuous noise analysis.

Once processed, the data were used to generate a noise profile for the FVS line. The rate of attenuation over distance (or transmission loss) was determined from this information. This allowed the received sound field to be estimated relative to the ARU position within the survey area. Next, the NOAA underwater sound threshold guidance detailed in BOEM (2016) was used as the basis for impact range assessment, in which conservative noise criteria is specified for the occurrence of behavioural response and injury for marine wildlife. The acoustic isopleth was calculated according to the noise criteria for marine mammals and fish including Atlantic sturgeon, by estimating the distance to the conservative thresholds proposed by NOAA. In order to verify the EZ for survey equipment operating below 200kHz, comparisons were made between field measurement and proposed EZ, detailed in the PSMP (Gardline Limited, 2018). This ensured the field equipment satisfied the requirement under the MMPA and BOEM requirement for underwater noise.

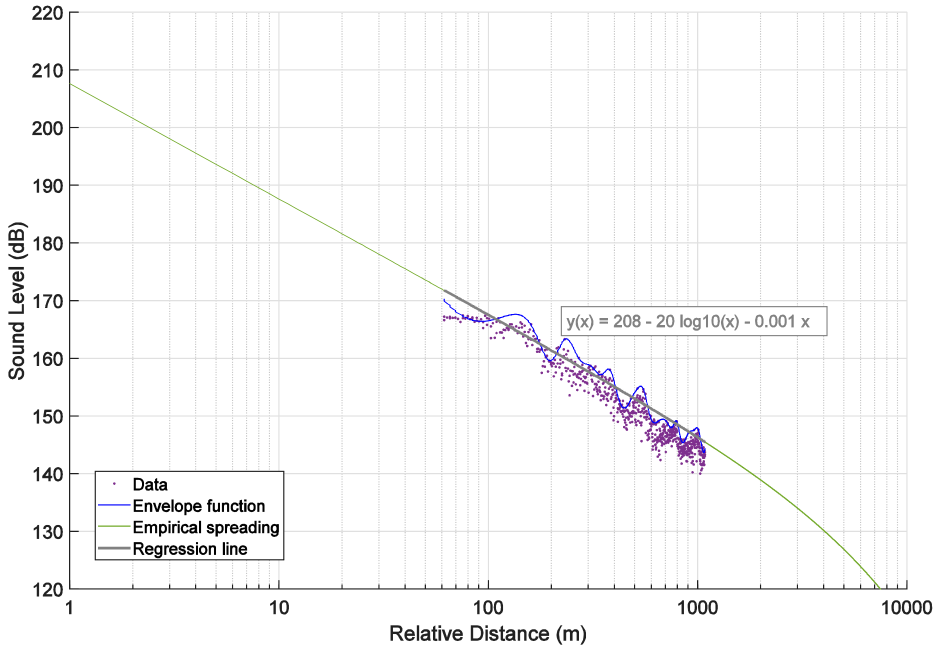
2.3.2 Source Level

In order to predict the source level, the propagation loss must be obtained from the field measurement by forming an empirical propagation loss curve in the form of:

$$RL = SL - n\log_{10}(r) + \alpha \cdot r$$

This empirical formula estimates the propagation trends of the geophysical equipment in the acoustic environment. This formula is generated by linear regression algorithms applied to passive sonar equation (see Appendix C; C.9) based on the statistical relationship of the acoustic metrics and its energy dissipation in the water column. This technique provides a best fit or a regression line, which derives a linear relationship that can be used to predict unknown values outside the measurement range. Under the given condition, the empirical formula can be used to predict the RL at any point within the sound field, transmission loss coefficient and the absorption coefficient (Figure 2.5).

Figure 2.5 Example of SL prediction using field measurement.



The source level is determined by finding the linear intercept (i.e. at reference distance=1 m) using this regression prediction based on the field observation. In order to reflect the worst case scenario, the algorithm estimates the regression line based on the envelope function of the dataset thereby giving the highest measured level for the HRG equipment. The source level can be calculated for any acoustic metrics calculated within the field verification algorithms, which included SPL, un-weighted SEL and frequency weighted SEL/cSEL.

2.3.3 Frequency-weighted SEL

Frequency-weighting relates the acoustic signal to the hearing ability of the species under consideration. Each weighting function is derived from available data describing the hearing response of and the effect of noise on marine mammal. The result weighting function is illustrated in Figure 2.6. The advantage of using a weighted signal containing multiple frequency components is that it removes energy contributions outside the animal hearing bands from the overall exposure estimate. Hence, if the frequencies produced by a sound source lie outside of a species most sensitive hearing range, the sounds at these frequencies will require a higher sound pressure level to result in a similar threshold shift.

The frequency weighting functions were computed according to methodology as described in Finneran (2016) and NOAA (2016). Marine mammals are divided into six species groups and for this analysis included LF, MF and HF cetaceans, sirenians, phocids in water and otariids in water. For each group, numeric thresholds for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) were clearly defined for the identification of the impact isopleths. Frequency dependent weighting values are added to the analysed SEL values in 1/3 octave bands at the corresponding frequencies to better estimate the sound exposure for different animal groups. As recommended, frequency-weighting is only

applied to SEL values, and relate to corresponding thresholds that differ from those outlined in BOEM (2016). The PTS and TTS thresholds used in this report are detailed in Table 2.7.

Figure 2.6 NOAA weighting functions for marine mammals

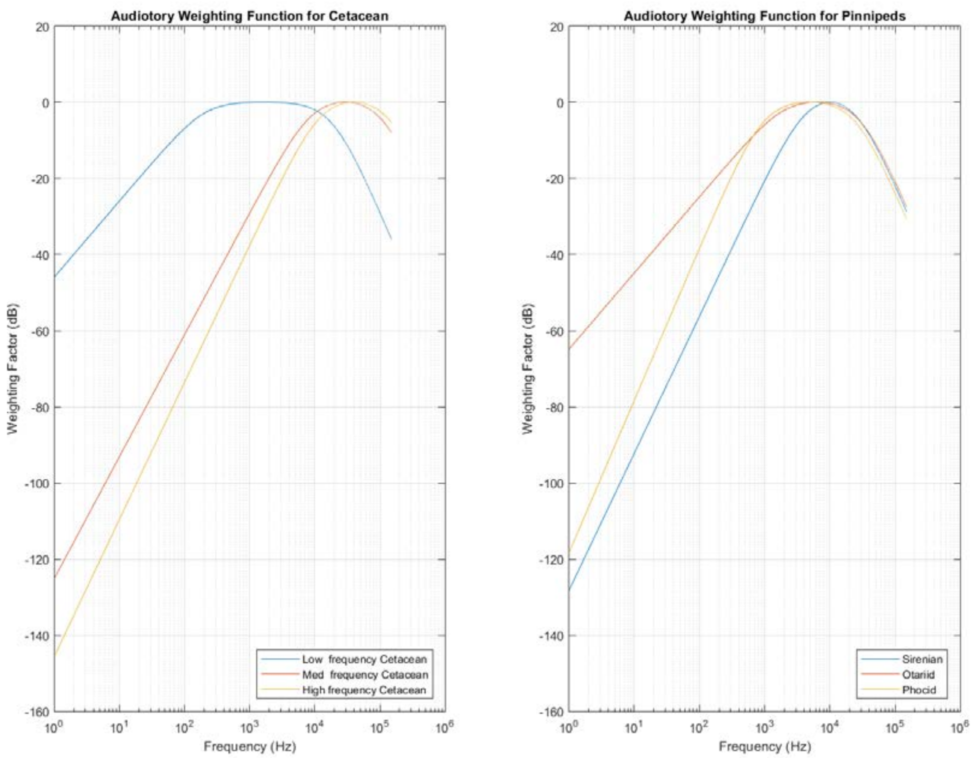


Table 2.7 Summary of PTS and TTS thresholds BOEM (2016)

Animal Group	PTS threshold		TTS threshold	
	SEL (weighted) dB re 1µPa2 24h	SPLpeak (un-weighted) dB re 1µPa2	SEL (weighted) dB re 1µPa2 24h	SPLpeak (un-weighted) dB re 1µPa2
LF cetacean	183	219	168	213
MF cetacean	185	230	170	224
HF cetacean	155	202	140	196
Sirenian	190	226	175	220
Otariid pinnipeds	203	232	188	226
Phocid pinnipeds	185	218	170	212

3 RESULTS

This section presents the results of the sound source field verification analysis in terms of the acoustic received levels and source levels in respect to the slant range from the acoustic source. The received levels presented in this section represent broadband, un-weighted frequency responses. This report presents data acquired from all ARU's deployed over the whole duration of the FVS. Note that the results in this final report may differ slightly to the preliminary results produced in the initial FVS report for the field verification of the EZ, due to parameters optimisation and removal of anomalies during post processing. This does not have significance to the overall outcome of the original FVS report.

3.1 Source Predictions

Monitored source levels in terms of SPL_{peak}, $SPL_{rms\ 90\%}$ and SEL were obtained for each piece of HRG equipment operating under 200kHz individually, Table 3.1 shows the SL predicted based on data acquired during the FVS. The measured sound level for each piece of HRG equipment was found to be within the maximum acceptable variation thresholds provided by BOEM. In general, data acquired from both moorings shows consistent results, with SL variation of less than 3dB in SPL_{peak}, SPL_{rms} and SEL. This variability is expected from field measurement typically acquired from marine environment where the changing depth, sampling conditions can influence the received levels.

Table 3.1 Estimated source levels of HRG equipment during NY Empire Wind FVS

Equipment	Primary Mooring			Secondary Mooring		
	Source Level (SPLpeak dB re 1µPa.m)	Source Level (SPLrms 90% dB re 1µPa.m)	Source Level (SEL re dB 1µPa^2.m^2.s)	Source Level (SPLpeak dB re 1µPa.m)	Source Level (SPLrms 90%dB re 1µPa.m)	Source Level (SEL re dB 1µPa^2.m^2.s)
UHRS Geo-Source sparker (400J)	206.0	182.7	168.1	208.3	184.6	170.2
UHRS Geo-Source sparker (600J)	208.8	190.0	174.9	210.4	191.5	176.9
Teledyne SBP (chirp)	204.3	184.6	166.0	206.3	186.4	168.6
Odom SBES	174.1	155.8	144.7	175.8	157.5	146.4
Sonardyne USBL	198.6	173.0	167.3	198.7	172.2	167.3
RV Shearwater	183.4	168.0	167.4	186.3	170.0	169.4

3.2 Equipment Sound Characterisation

This section details the acoustic characteristics of the HRG equipment that are intended to be used during the NY Empire Wind OWF geophysical survey. All results presented in the below section are unfiltered and represent the raw form of the original acoustic signals.

3.2.1 UHRS Geo-Source Sparker

The UHRS sparker source was tested at two different energy levels during the FVS: 400J and 600J. Due to the shallow water at the OWF site, the maximum power intended to be used is expected to be less than 600J for the UHRS sparker.

Each UHRS sparker pulse consists of a series of three to five acoustic pulses (multipath reflections) created by the electrodes discharging an electrical impulse in the seawater. The time series and the spectrogram are shown in Figure 3.1 and Figure 3.2 for 400J and 600J, respectively. The UHRS sparker pulse has a central frequency from 0.5 kHz to 1.25kHz, with the trailing frequency extending to 48kHz at closest point of approach (CPA). Signals generated by the UHRS sparker at higher energy produced noticeably higher SPL by approximately 2dB to 3dB in the low frequency regions.

The UHRS sparker has a higher firing rate when configured in a lower output, resulting in a higher number of pulses fired for the FVS lines. The pulse firing rate was measured at 2.0 pulses per second (pps), with 2109 pulses detected during the 400J line. The pulse firing rate was measured at 1.4pps with 1460 pulses detected during the 600J line.

Figure 3.1 Example time series of the measured signal from the UHRS Geo-Source sparker operating at 400J at CPA (top). Spectrogram of the same signal showing the frequency response in the time domain (bottom)

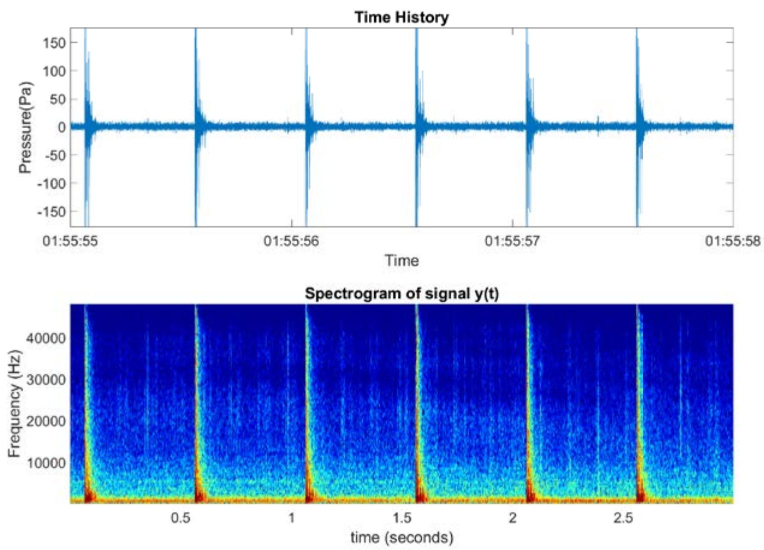
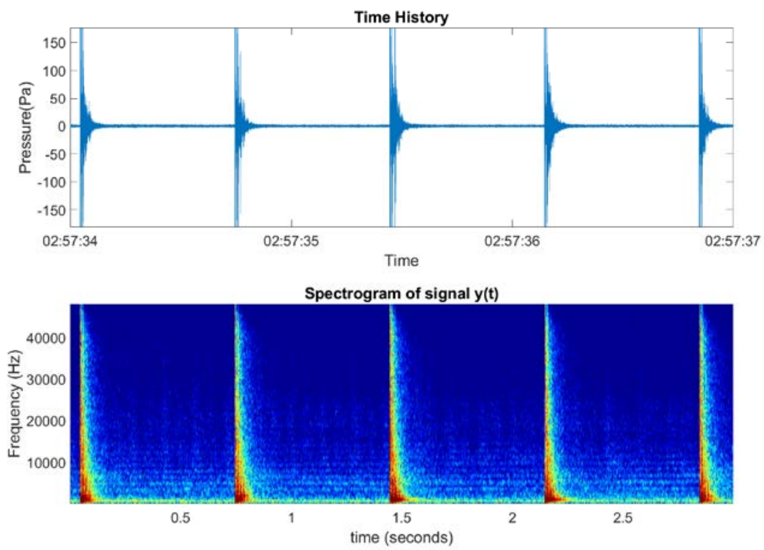


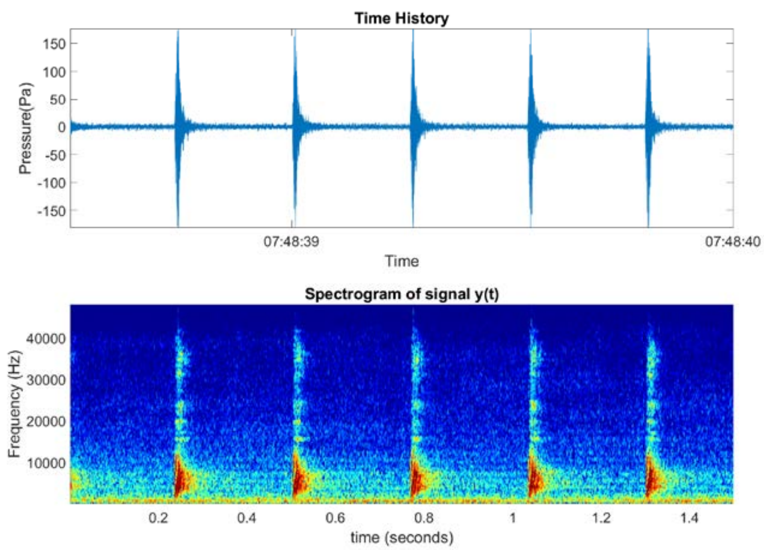
Figure 3.2 Example time series of the measured signal from the UHRS Geo-Source sparker operating at 600J (top). Spectrogram of the same signal showing the frequency response in the time domain (bottom)



3.2.2 Teledyne Shallow SBP (Chirp)

The shallow SBP produces an impulsive medium frequency broadband signal, with a frequency range from 2kHz to 12kHz with a distinctive, rapid up sweep signal, also known as a chirp signal. The peak frequency centred between 4kHz and 8kHz. The noticeable harmonic components were also detected at 22kHz and 32kHz. The time series and the spectrogram are shown in Figure 3.3. The profiler has a pulse-firing rate at approximately 3.8pps and a total of 5515 pulses were detected during the FVS line.

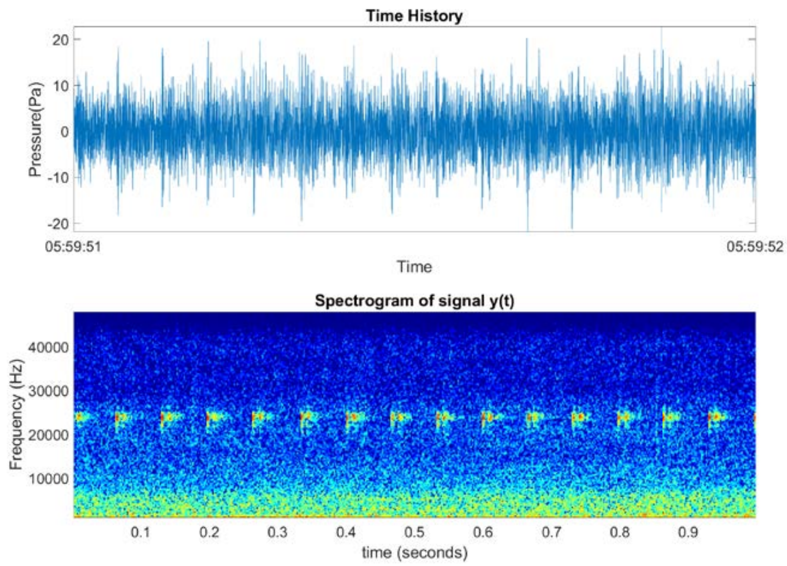
Figure 3.3 Example time series of the measured signal from shallow SBP near CPA (top). Spectrogram of the same signal showing the frequency response in the time domain (bottom)



3.2.3 Single-Beam Echosounder

The shallow SBES produces impulsive narrow-band signal at high frequency, with a frequency range from 23kHz to 25kHz, with peaks centred 24kHz. The time series and the spectrogram are shown in Figure 3.4. The profiler has a pulse-firing rate at approximately 15.6pps and a total of 6877 pulses were detected during the FVS line.

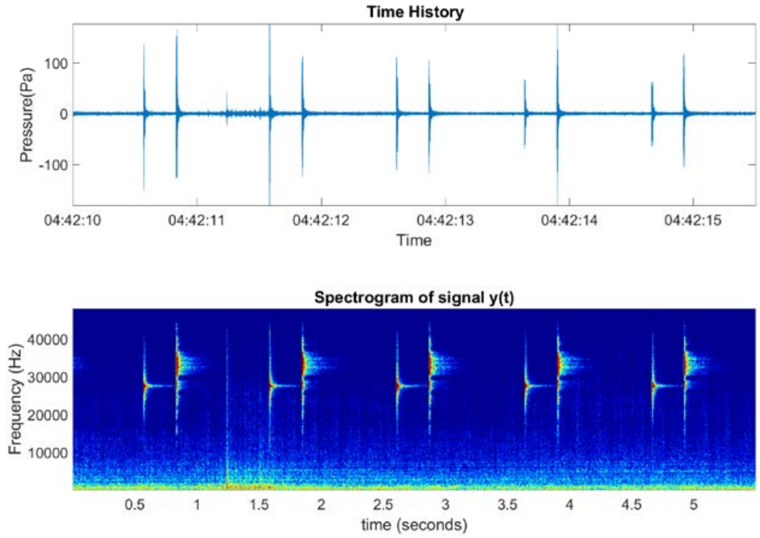
Figure 3.4 Example time series of the measured signal from shallow SBP near CPA (top). Spectrogram of the same signal showing the frequency response in the time domain (bottom)



3.2.4 USBL Beacon

A USBL produces a dual, wide-band high frequency impulse, with peak frequency ranging from 25kHz to 35kHz. Acoustic energy was clearly detected extending to 15kHz to 40kHz. The time series and the spectrogram are shown in Figure 3.5. The source has a pulse firing rate of 1.0pps and a total of 1252 pulses were detected during the FVS line.

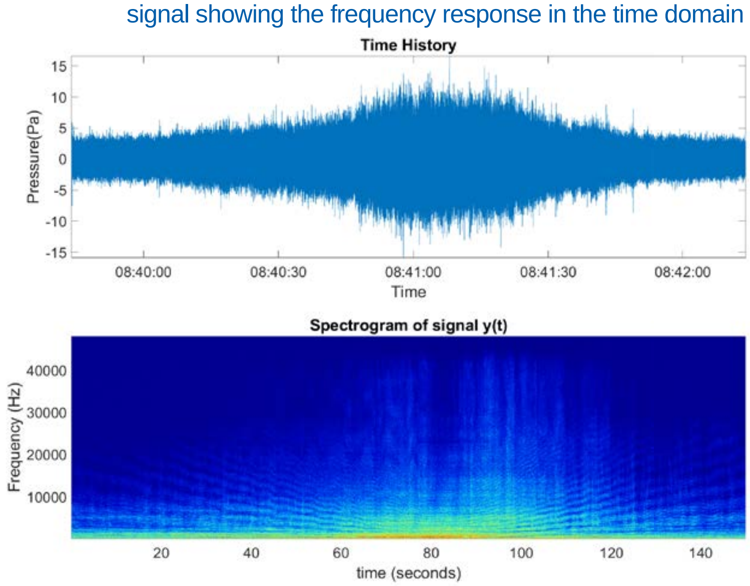
Figure 3.5 Example time series of the measured signal from a USBL beacon near CPA (top). Spectrogram of the same signal showing the frequency response in the time domain (bottom)



3.2.5 RV *Shearwater* Vessel Noise

A FVS line without any HRG equipment was completed in order to assess the acoustic impact of RV *Shearwater*. The data was subjected to field verification of EZ in order to determine the sound isopleths according to BOEM requirement. The vessel produces sound in a wide range of frequencies, with peak frequency generally below 1kHz. Low level acoustic energy was observed up to 40kHz when vessel noise is measured around CPA. The vessel noise has tonal components focusing below 10 kHz, most of these sub 10kHz tonal components only detectable within the first 200m. The time series and the spectrogram is shown in Figure 3.6. The computation of the SPL_{rms} of vessel's continuous noise was based on a 1-second time window.

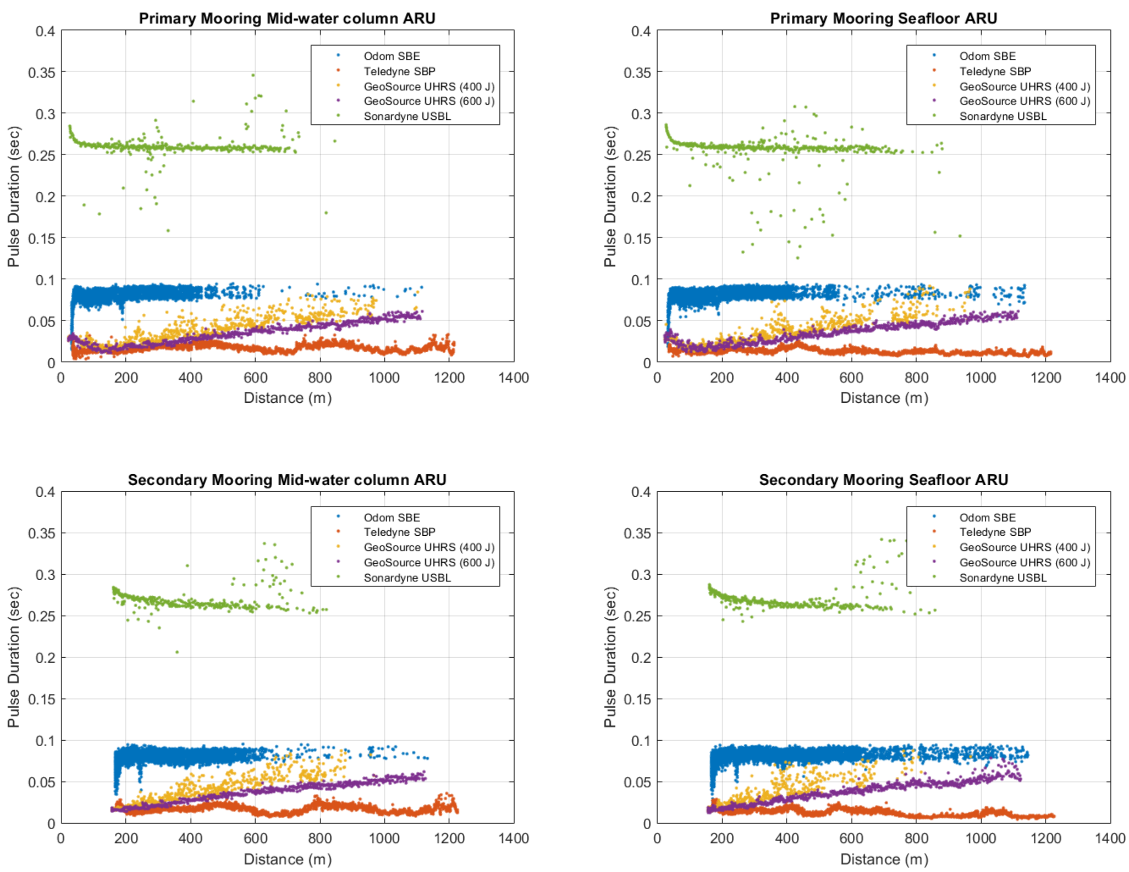
Figure 3.6 Example time series of the measured signal from RV *Shearwater* (top). Spectrogram of the same signal showing the frequency response in the time domain (bottom)



3.3 Measured Pulse Duration $T_{90\%}$

The measured pulse length of the HRG equipment sound, a crucial parameter for determining the exposure time is detailed in Figure 3.7. The methodology of calculation for this parameter and its usage is detailed in Section 2.3.1 and Appendix C.

Figure 3.7 Measured pulse duration of HRG impulsive signal on the primary mooring



3.4 BOEM and Un-weighted NOAA Isopleths

The distance to the 207, 190, 180, 166, 160, and 150dB re 1µPa $SPL_{rms\ 90\%}$ isopleths for each piece of HRG equipment were found to be within the maximum acceptable distance variations provided by NOAA (2016; Table 3.2). The 206dB re 1µPa SPL_{peak} and 187dB re 1µPa^2·s cSEL for each piece of HRG equipment were also found to be within the maximum acceptable variation thresholds provided by NOAA (2016; Table 3.2). Please note 0m indicates that no injury was predicted for the given noise profile from the HRG equipment.

The distance to the 219, 230, 202, 226, 218, and 232dB re 1µPa SPL_{peak} PTS and 213, 224, 196, 220, 212, and 226dB re 1µPa SPL_{peak} TTS isopleths for each piece of HRG equipment were also found to be within the maximum acceptable distance variations provided by NOAA (2016; Table 3.3).

Figure 3.8 to Figure 3.19 illustrate the sound profiles of each piece of HRG equipment in respect to the slant distance from the receiver located at the primary and secondary mooring, respectively.

Table 3.2 Summary of impact range of HRG sources to the maximum available thresholds according to lease requirement

Acoustic thresholds for impact isopleths	EZ in Place for HRG Surveys (m)	Sound Level Isopleth (m)											
		Primary mooring						Secondary mooring					
		UHRS (400J)	UHRS (600J)	SBP	SBE	USBL	Vessel	UHRS (400J)	UHRS (600J)	SBP	SBE	USBL	Vessel
207dB re 1µPa $SPL_{rms\ 90\%}$ threshold of injury for marine turtles	500	0	0	0	0	0	0	0	0	0	0	0	0
166dB re 1µPa $SPL_{rms\ 90\%}$ behavioural effects threshold for marine turtles	500	7	16	9	0	2	1	9	19	11	0	2	2
160dB re 1µPa $SPL_{rms90\%}$ Level B harassment	500	14	32	17	1	4	2	17	37	21	0	4	4
150dB re 1µPa $SPL_{rms\ 90\%}$ behavioural effects threshold for Atlantic sturgeon	NA*	43	101	54	3	14	7	54	119	66	2	13	12
187dB re 1µPa^2·24h cSEL physiological effects on fish	NA*	0	0	0	0	0	0	0	0	0	0	0	0
206dB re 1µPa SPL_{peak} impulsive injury threshold for fish (all sizes)	NA*	1	2	0	0	0	0	2	2	1	0	0	0

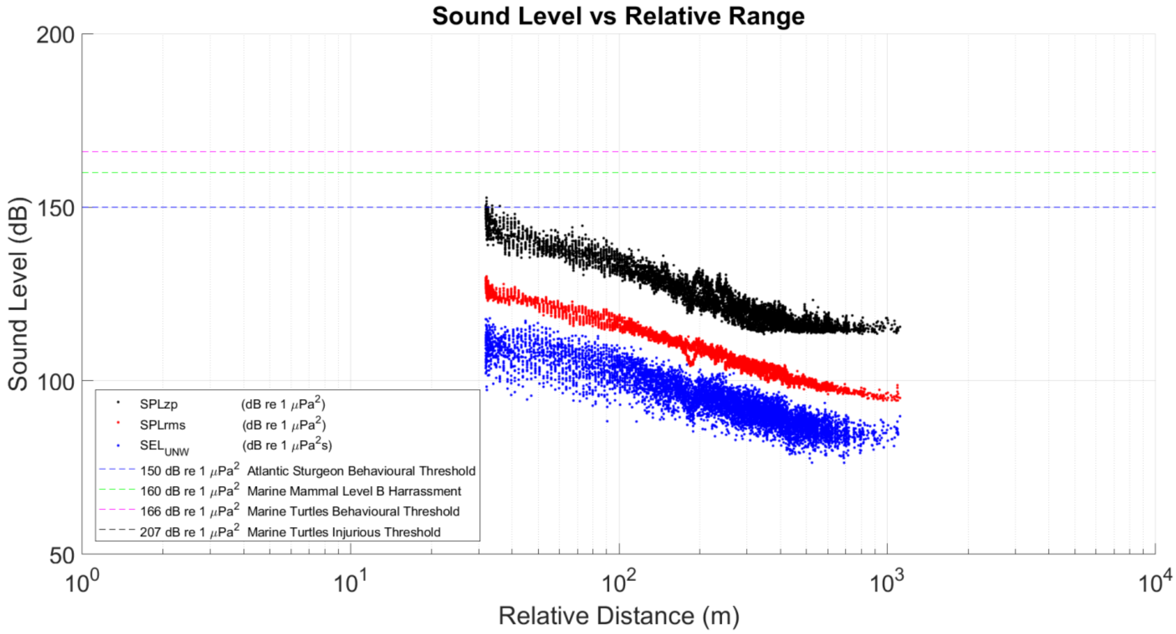
* No mitigation action was implemented in the PSMP

Table 3.3 Summary of impact range of HRG sources according SPL_{peak} provided by NOAA (2016)

Acoustic thresholds for impact isopleths	EZ in place for HRG surveys (m)	Sound Level Isopleth (m)											
		Primary Mooring						Secondary Mooring					
		UHRS (400J)	UHRS (600J)	SBP	SBE	USBL	Vessel	UHRS (400J)	UHRS (600J)	SBP	SBES	USBL	Vessel
PTS onset													
219dB re 1µPa SPL_{peak} for LF cetaceans	200* 500	0	0	0	0	0	0	0	0	0	0	0	0
230dB re 1µPa SPL_{peak} for MF cetaceans		0	0	0	0	0	0	0	0	0	0	0	0
202dB re 1 µPa SPL_{peak} for HF cetaceans		2	2	1	0	0	0	2	3	2	0	0	0
226dB re 1 µPa SPL_{peak} for sirenians	500	0	0	0	0	0	0	0	0	0	0	0	0
218dB re 1 µPa SPL_{peak} for phocid pinnipeds		0	0	0	0	0	0	0	0	0	0	0	0
232dB re 1 µPa SPL_{peak} for otariid pinnipeds		0	0	0	0	0	0	0	0	0	0	0	0
TTS onset													
213dB re 1µPa SPL_{peak} for LF cetaceans	200* 400	0	0	0	0	0	0	0	0	0	0	0	0
224dB re 1µPa SPL_{peak} for MF cetaceans		0	0	0	0	0	0	0	0	0	0	0	0
196dB re 1 µPa SPL_{peak} for HF cetaceans		3	4	3	0	1	0	4	5	3	0	1	0
220dB re 1 µPa SPL_{peak} for sirenians	500	0	0	0	0	0	0	0	0	0	0	0	0
212dB re 1 µPa SPL_{peak} for phocid pinnipeds		0	0	0	0	0	0	0	0	0	0	0	0
226dB re 1 µPa SPL_{peak} for otariid pinnipeds		0	0	0	0	0	0	0	0	0	0	0	0

*EZ for North Atlantic right whale

Figure 3.8 Measured SPL_{peak}, SPL_{rms} and un-weighted SEL of Odom SBES recorded at mid-water column (top) and approximately 1m above seafloor (bottom) at primary mooring



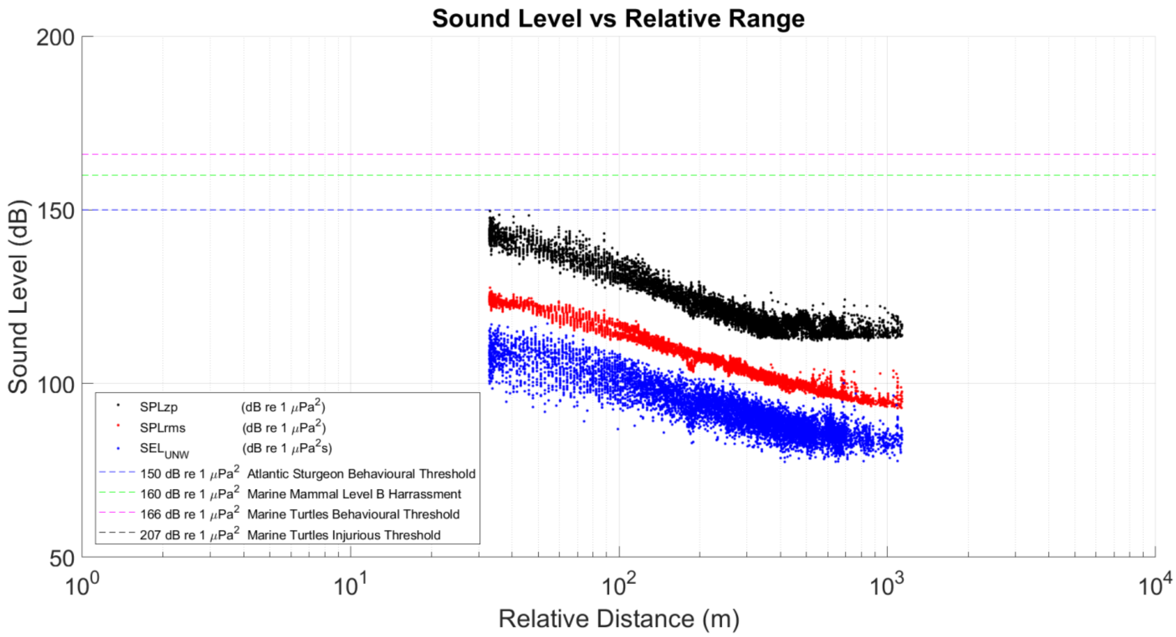
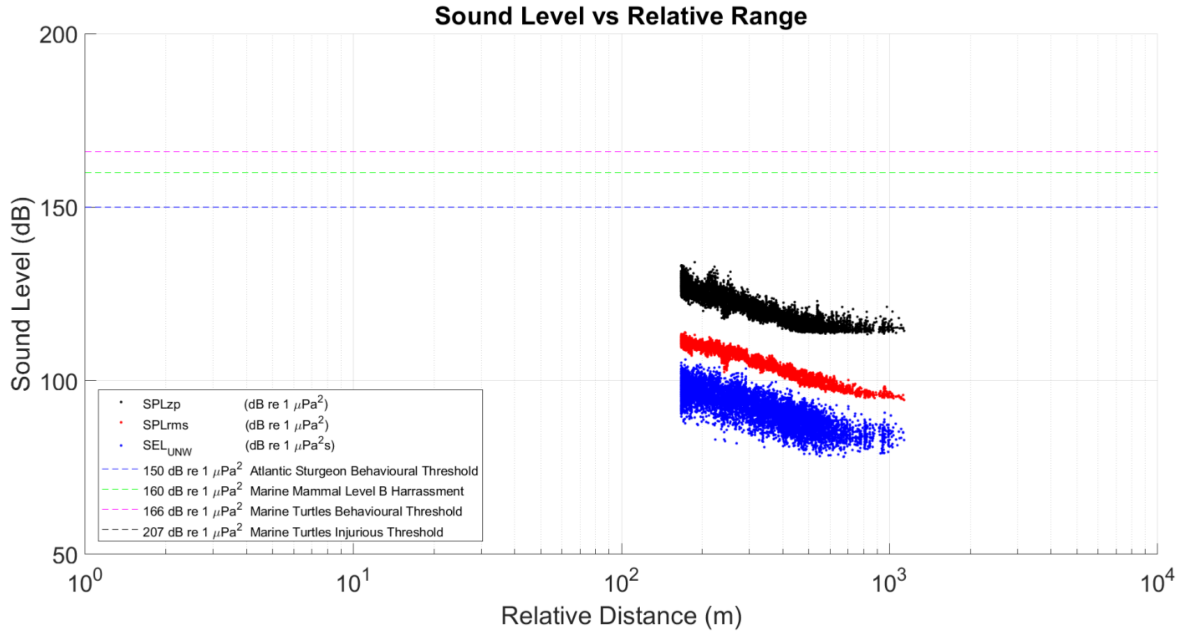


Figure 3.9 Measured SPL_{peak}, SPL_{rms} and un-weighted SEL of Odom SBES at mid-water column (top) and approximately 1m above seafloor (bottom) at secondary mooring



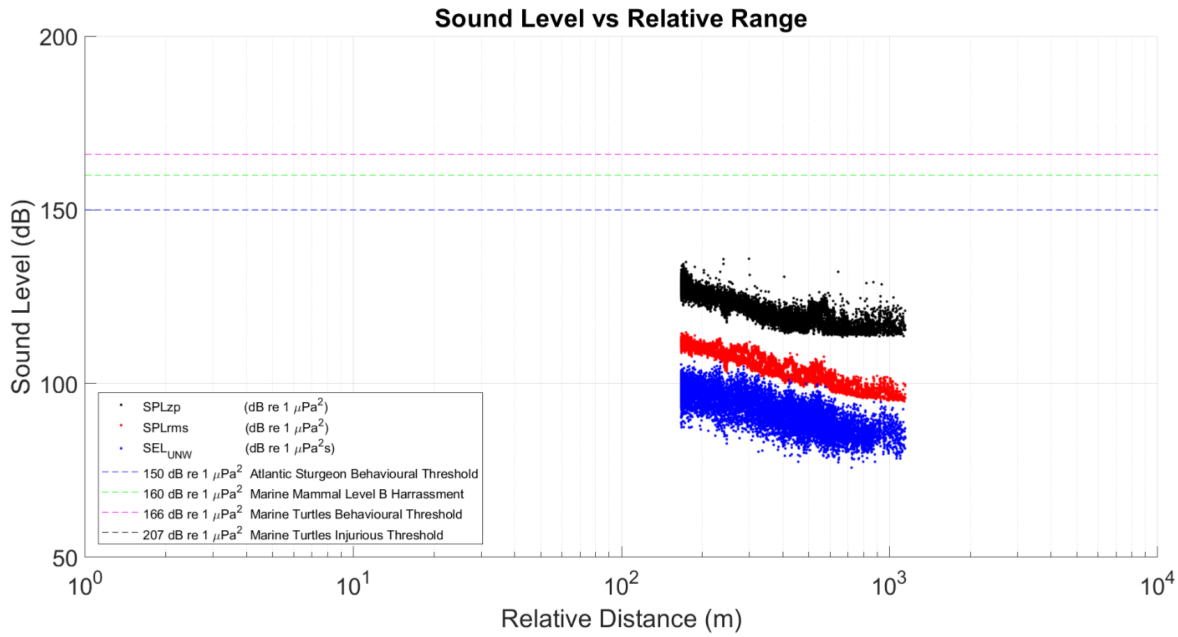
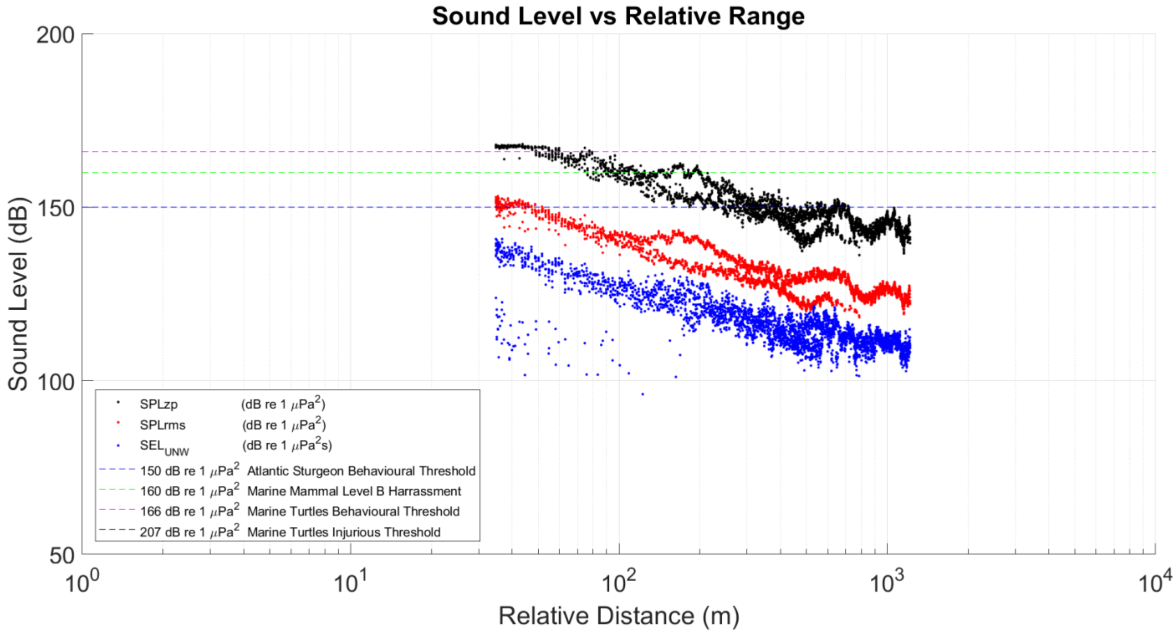


Figure 3.10 Measured SPL_{peak}, SPL_{rms} and un-weighted SEL of Teledyne SBP recorded at mid-water column (top) and approximately 1m above seafloor (bottom) at primary mooring.



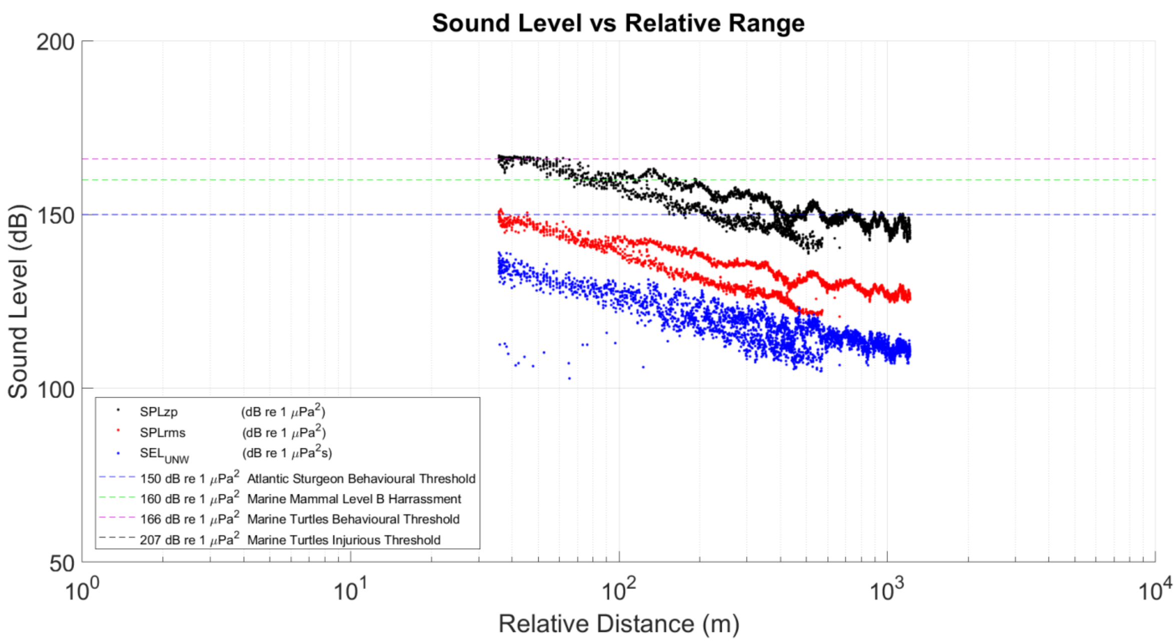
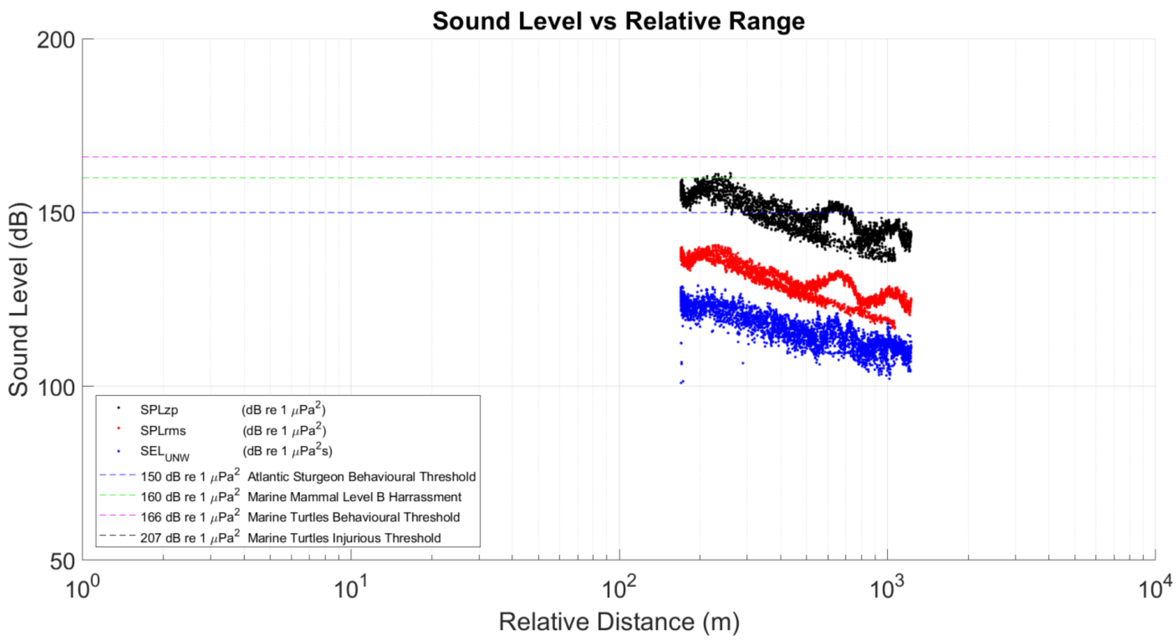


Figure 3.11 Measured SPL_{peak}, SPL_{rms} and un-weighted SEL of Teledyne SBP recorded at mid-water column (top) and approximately 1m above seafloor (bottom) at secondary mooring.



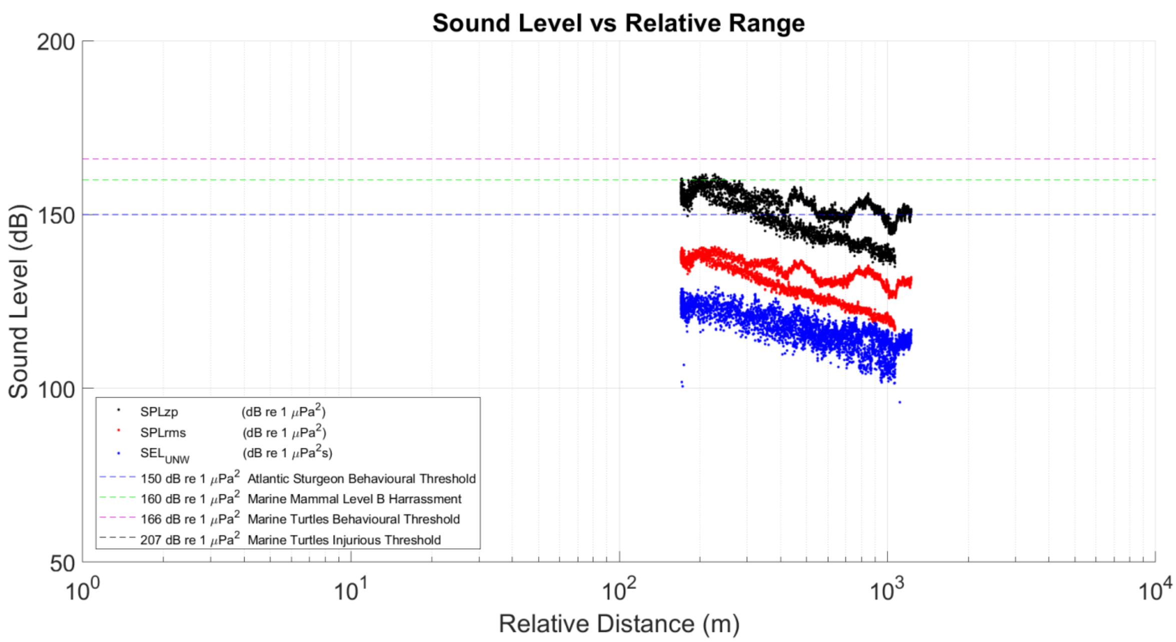
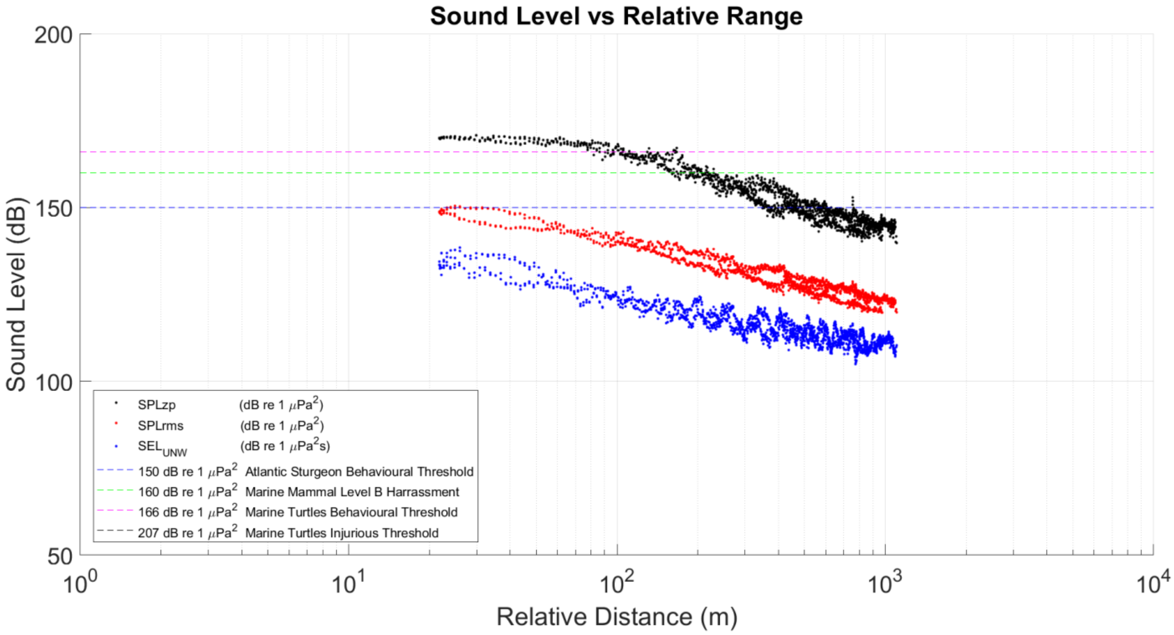


Figure 3.12 Measured SPL_{peak}, SPL_{rms} and un-weighted SEL of UHRS Geo-Source sparker source operating at 400J recorded at mid-water column (top) and approximately 1m above seafloor (bottom) at primary mooring



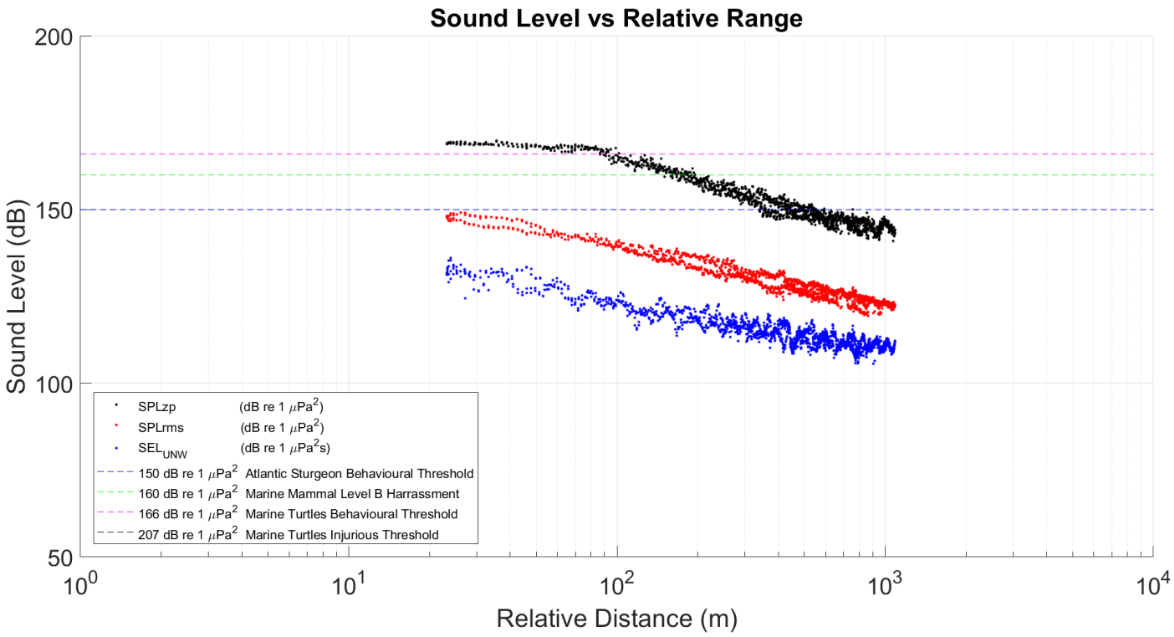
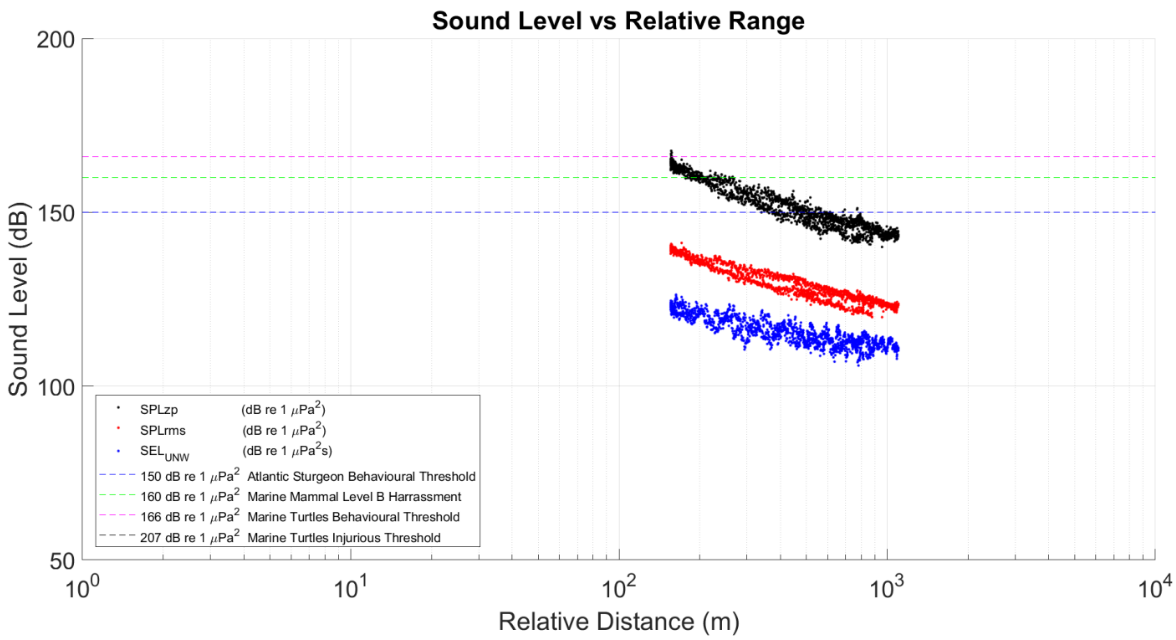


Figure 3.13 Measured SPL_{peak}, SPL_{rms} and un-weighted SEL of UHRS Geo-Source sparker source operating at 400J recorded at mid-water column (top) and approximately 1m above seafloor (bottom) at secondary mooring



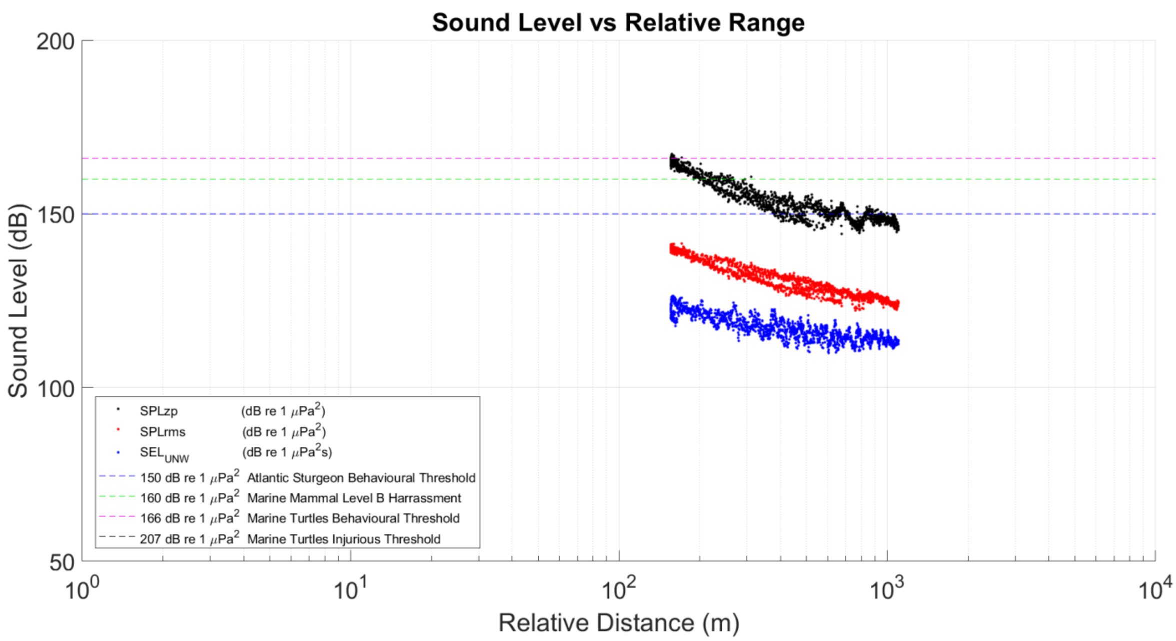


Figure 3.14 Measured SPL_{peak}, SPL_{rms} and un-weighted SEL of UHRS Geo-Source sparker source operating at 600J recorded at mid-water column (top) and approximately 1m above seafloor (bottom) at primary mooring

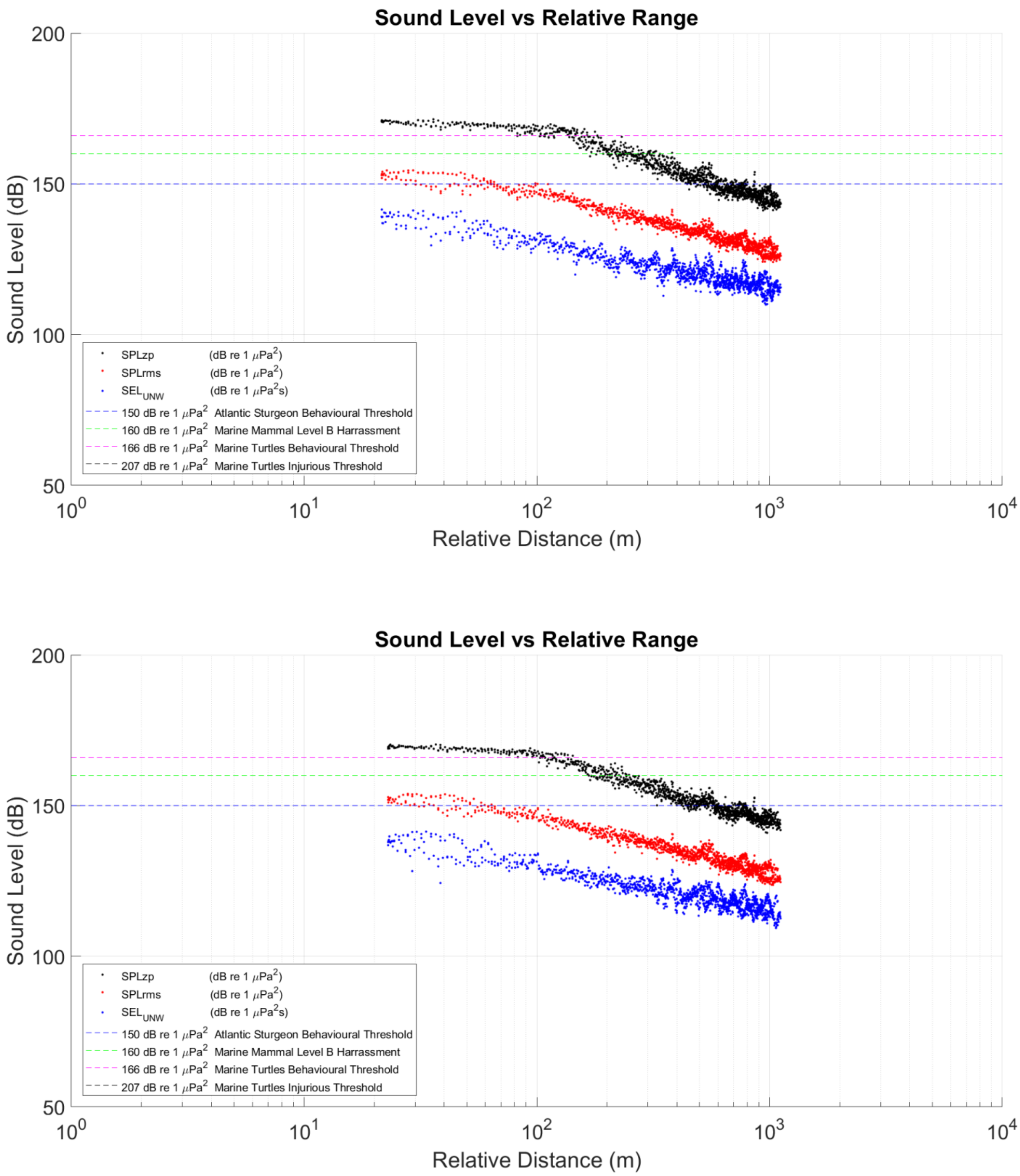
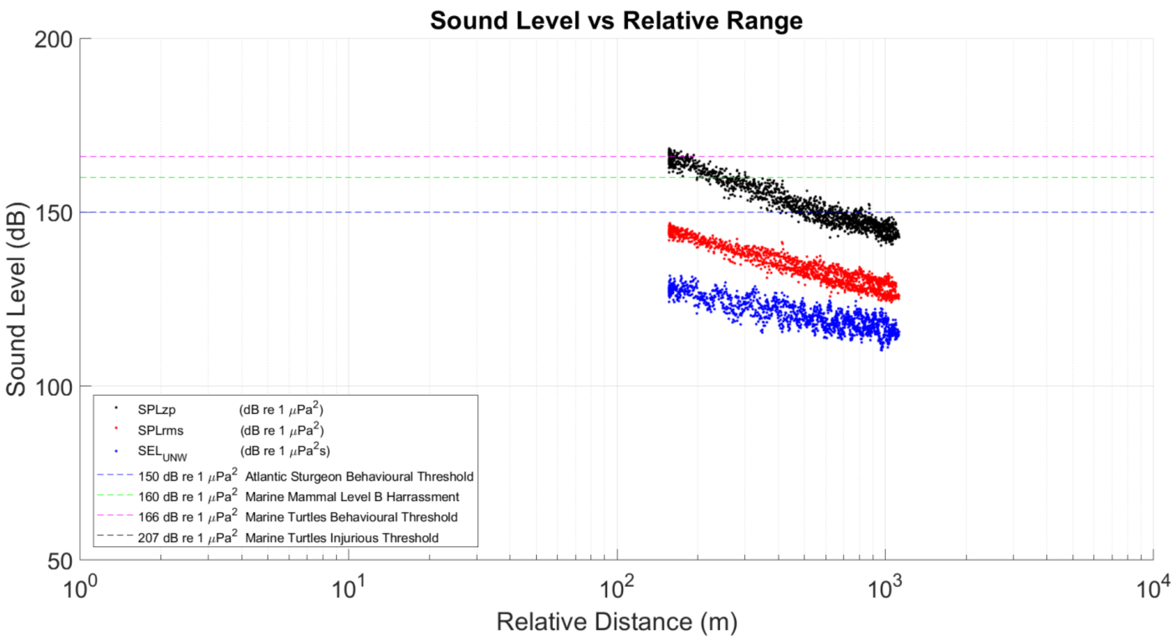


Figure 3.15 Measured SPL_{peak}, SPL_{rms} and un-weighted SEL of UHRS Geo-Source sparker source operating at 600J recorded at mid-water column (top) and approximately 1m above seafloor (bottom) at secondary mooring



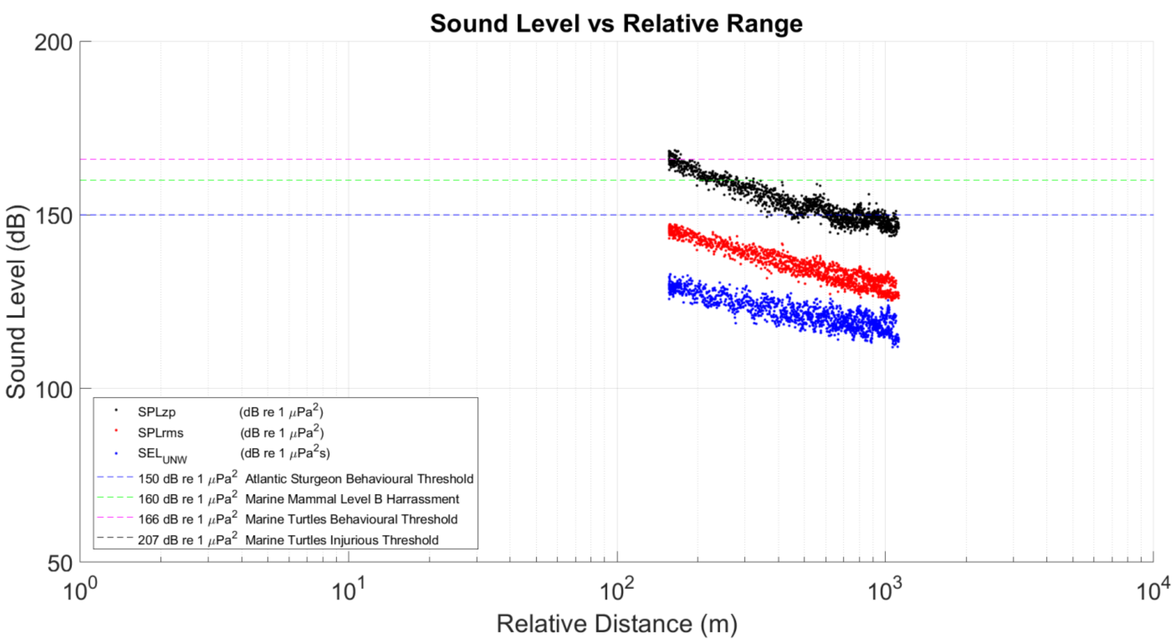


Figure 3.16 Measured SPL_{peak}, SPL_{rms} and un-weighted SEL of Sonardyne USBL beacon recorded at mid-water column (top) and approximately 1m above seafloor (bottom) at primary mooring

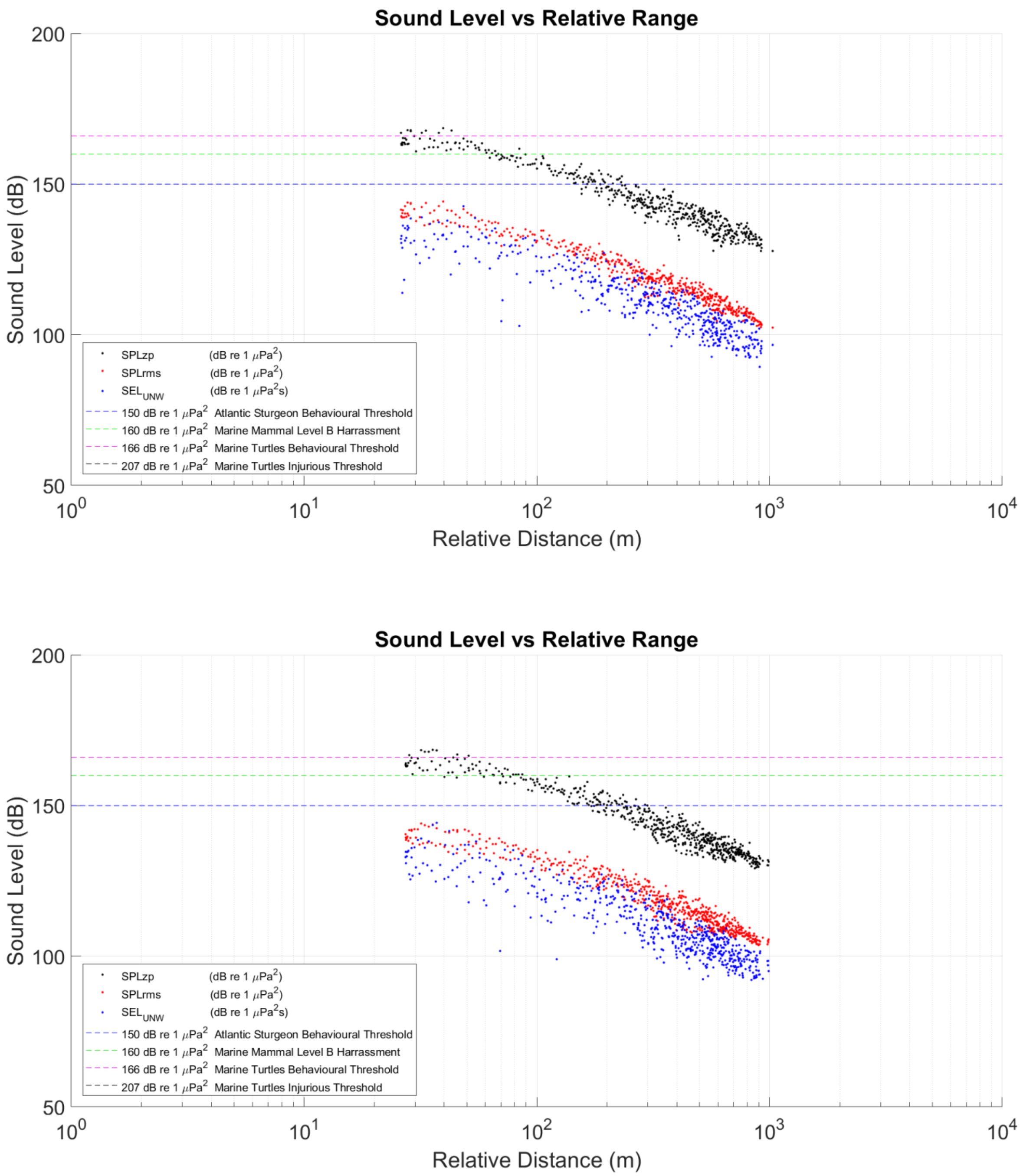
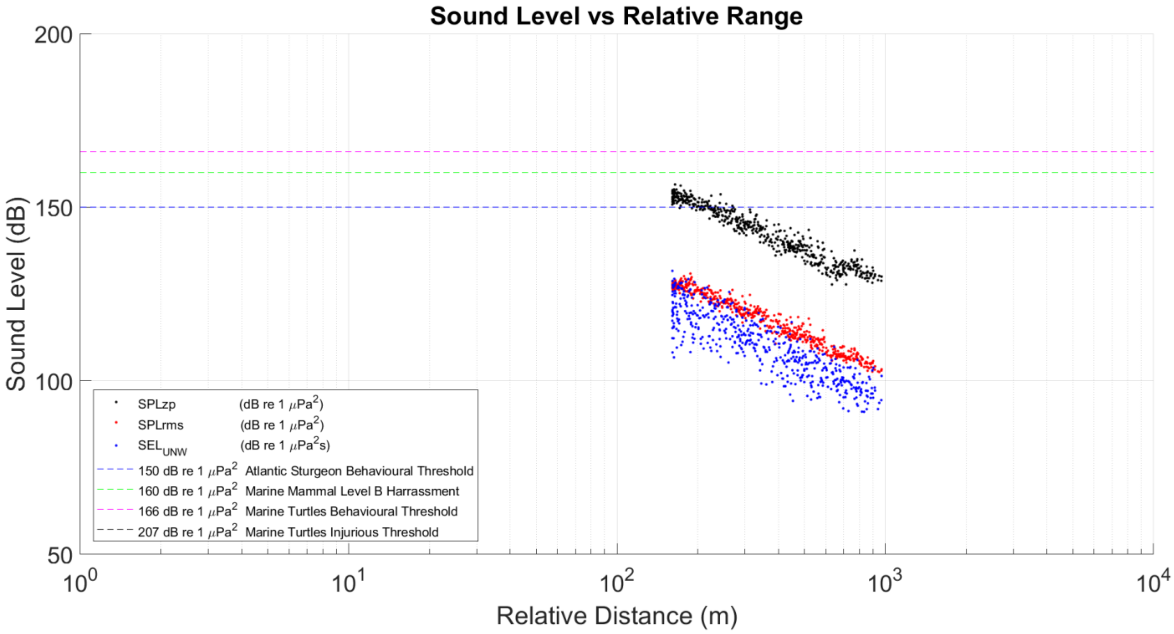


Figure 3.17 Measured SPL_{peak}, SPL_{rms} and un-weighted SELof Sonardyne USBL beacon recorded at mid-water column (top) and approximately 1m above seafloor (bottom) at secondary mooring



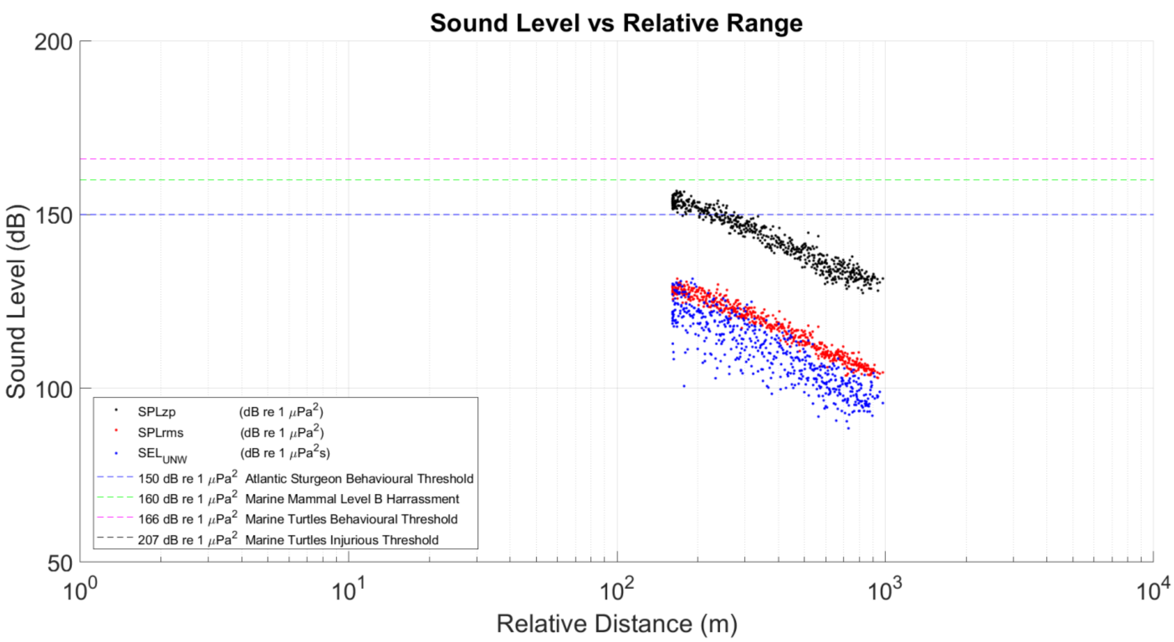
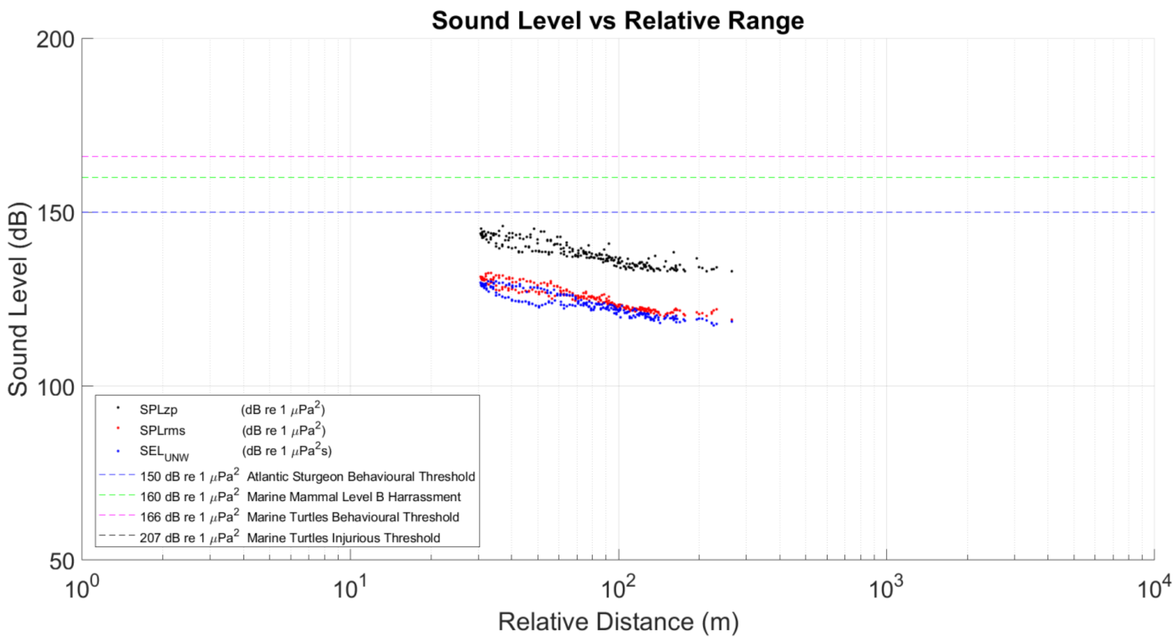


Figure 3.18 Measured SPL_{peak}, SPL_{rms} and un-weighted SEL of vessel noise generated by RV Shearwater recorded at mid-water column (top) and approximately 1m above seafloor (bottom) at primary mooring



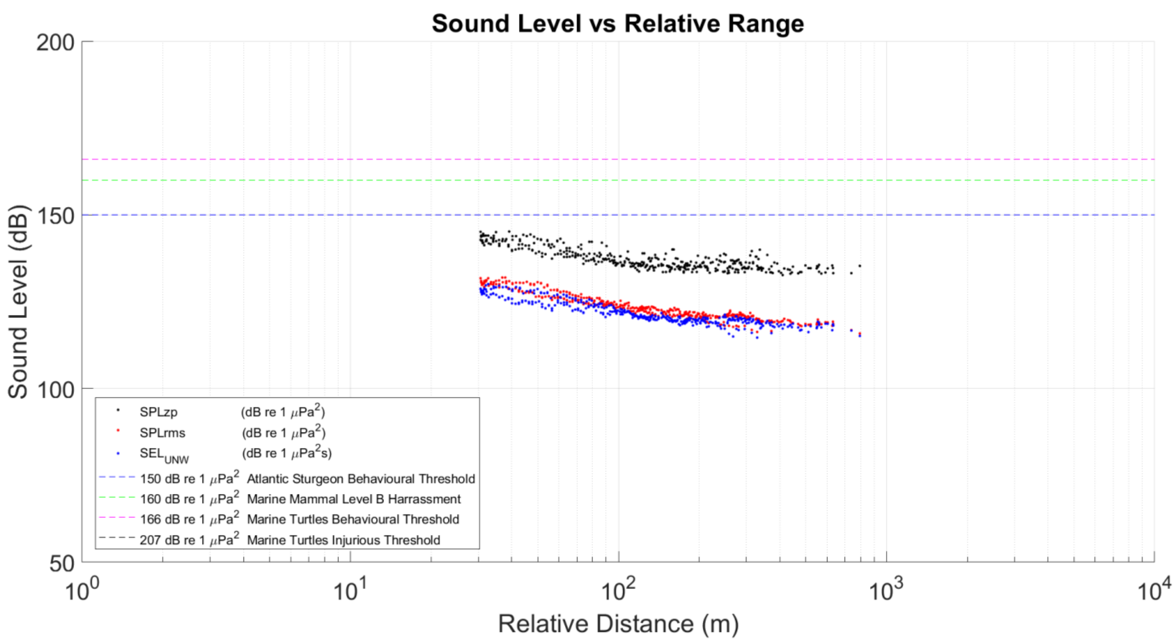
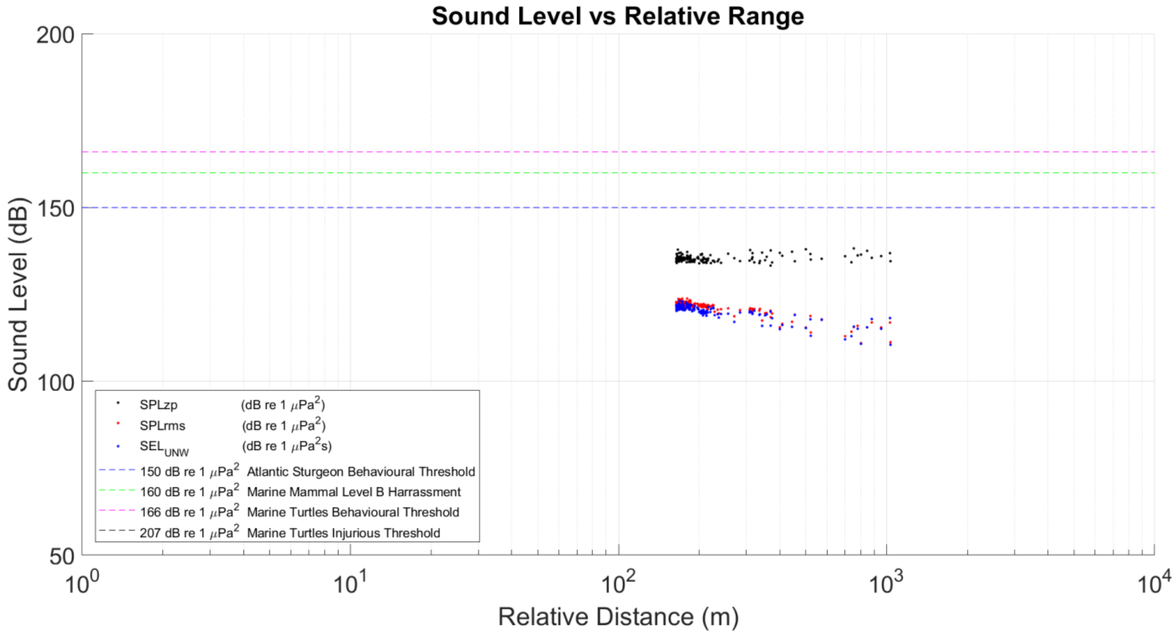
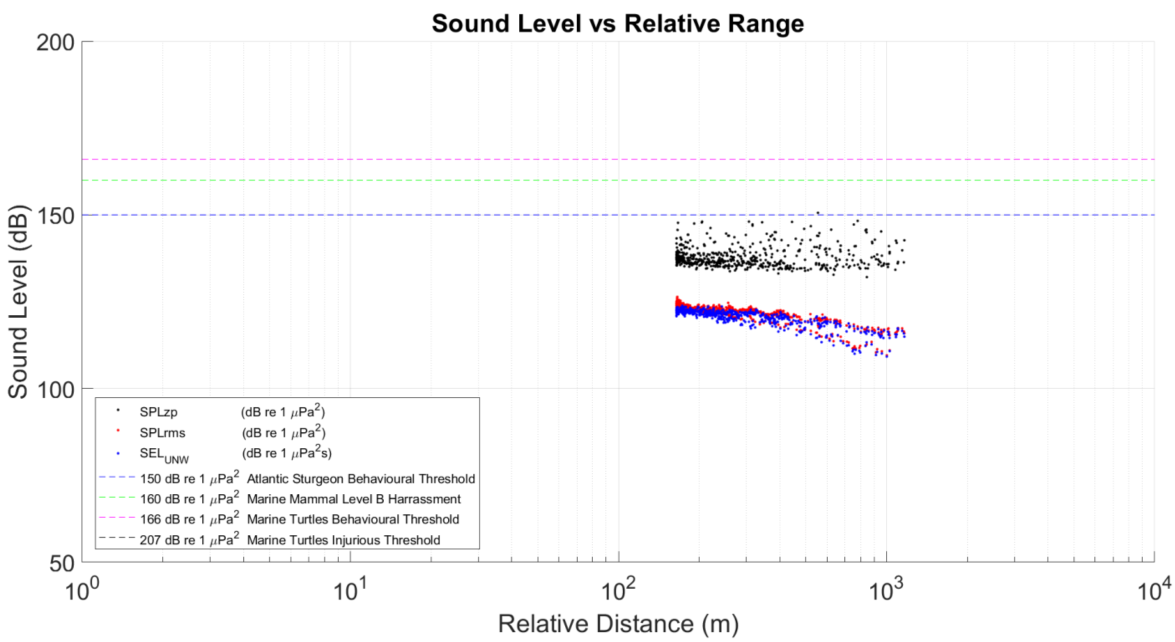


Figure 3.19 Measured SPL_{peak}, SPL_{rms} and un-weighted SEL of vessel noise generated by RV Shearwater recorded at mid-water column (top) and approximately 1m above seafloor (bottom) at secondary mooring.





3.5 NOAA (2016) Frequency-Weighted Isopleths

This section presents results of the FVS weighted according to the frequency response of different functional hearing groups (LF, MF and HF cetaceans, sirenians, phocids in water and otariids in water). The details of the weighting functions applied are described in Section 2.3.3. Derivations of weighting functions and its usage can be found in NOAA (2016).

The distance to the $cSEL_{24\,h}$ PTS onset and $cSEL_{24\,h}$ TTS onset impact isopleths for impulsive sound for each piece of HRG equipment were found to be within the maximum acceptable distance variations provided by NOAA (2016; Table 3.4). Please note, no non-impulsive isopleths were calculated due to the impulsive nature of HRG sound.

Figure 3.20 to Figure 3.25 display the sound profiles for all individual pieces of HRG equipment, all HRG in operation and the RV *Shearwater* weighted by functional hearing group (as per NOAA, 2016) in respect to the relative distance from the acoustic receiver.

Table 3.4 Summary of impact range of HRG sources according to $cSEL_{24\ h}$ (impulsive sounds) provided by NOAA (2016)

Acoustic thresholds for impact isopleths	EZ in place for HRG surveys (m)	Sound Level Isopleth (m)											
		Primary Mooring						Secondary Mooring					
		UHRS (400J)	UHRS (600J)	SBP	SBES	USBL	Vessel	UHRS (400J)	UHRS (600J)	SBP	SBES	USBL	Vessel
PTS onset													
183dB re 1µPa^2·24h cSEL for LF cetaceans	200* 500	0	0	0	0	0	0	0	0	0	0	0	0
185dB re 1µPa^2·24h cSEL for MF cetaceans		0	0	0	0	0	0	0	0	0	0	0	0
155dB re 1µPa^2·24h cSEL for HF cetaceans		0	0	0	0	0	0	0	0	0	0	0	0
190dB re 1µPa^2·24h cSEL for sirenians	500	0	0	0	0	0	0	0	0	0	0	0	0
185dB re 1µPa^2·24h cSEL for phocid pinnipeds		0	0	0	0	0	0	0	0	0	0	0	0
203dB re 1µPa^2·24h cSEL for otariid pinnipeds		0	0	0	0	0	0	0	0	0	0	0	0
TTS onset													
168dB re 1µPa^2·24h cSEL for low frequency cetaceans	200* 500	0	0	0	0	0	0	0	0	0	0	0	0
170dB re 1µPa^2·24h cSEL for MF cetaceans		0	0	0	0	0	0	0	0	0	0	0	0
140dB re 1µPa^2·24h cSEL for HF cetaceans		0	0	0	2	3	0	0	0	0	3	4	0
175dB re 1µPa^2·24h cSEL for sirenians	500	0	0	0	0	0	0	0	0	0	0	0	0
170dB re 1µPa^2·24h cSEL for phocid pinnipeds		0	0	0	0	0	0	0	0	0	0	0	0
188dB re 1µPa^2·24h cSEL for otariid pinnipeds		0	0	0	0	0	0	0	0	0	0	0	0

*EZ for North Atlantic right whale

Figure 3.20 Measured frequency weighted $cSEL_{24\,h}$ of Odom SBES. Cetacean functional groups at primary mooring (top left). Pinniped and sirenian functional groups at primary mooring (top right). Cetacean functional groups at secondary mooring (bottom left). Pinniped and sirenian functional groups at secondary mooring (bottom right)

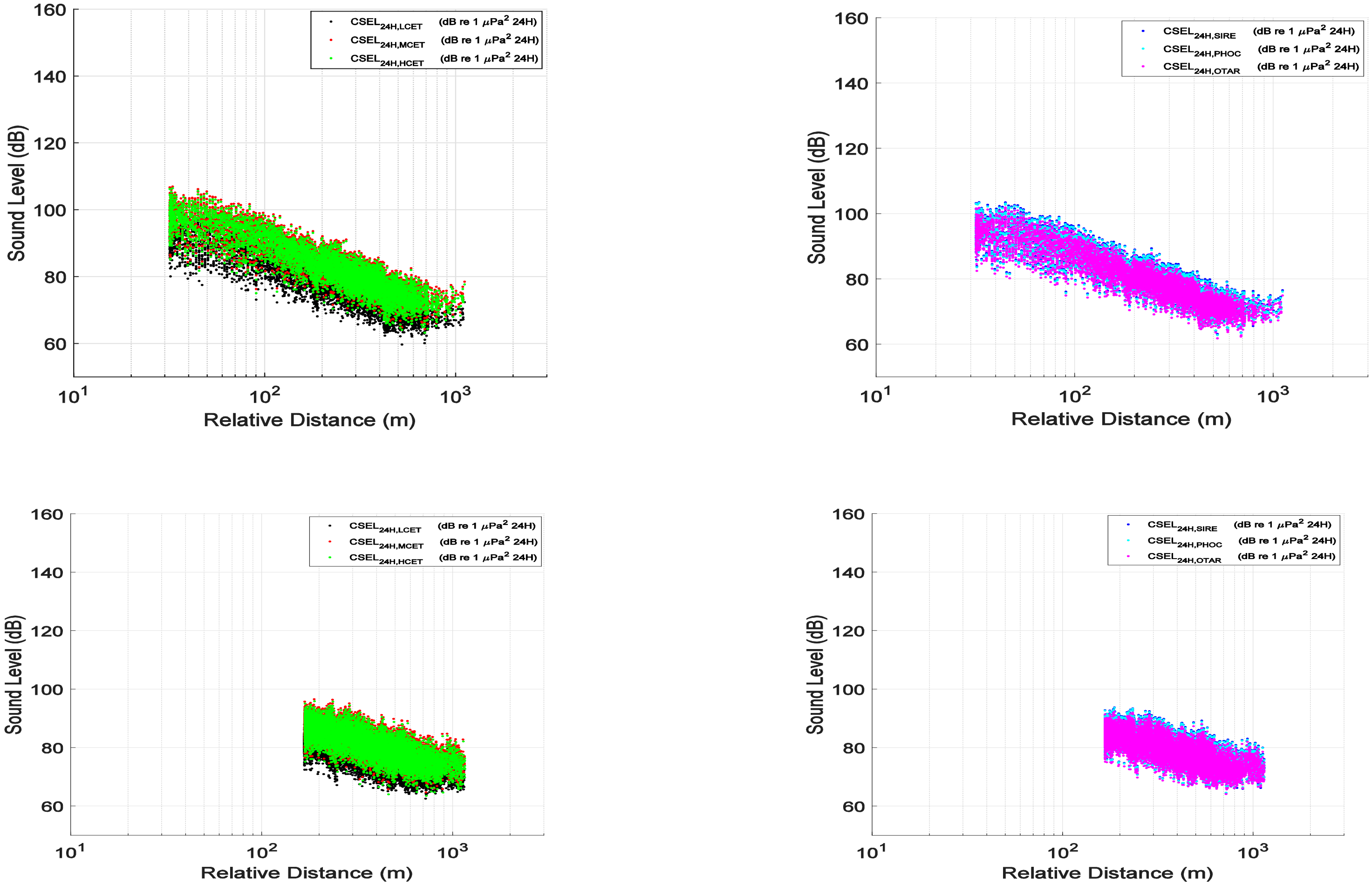


Figure 3.21 Measured frequency weighted $cSEL_{24\,h}$ of Teledyne SBP. Cetacean functional groups at primary mooring (top left). Pinniped and sirenian functional groups at primary mooring (top right). Cetacean functional groups at secondary mooring (bottom left). Pinniped and sirenian functional groups at secondary mooring (bottom right)

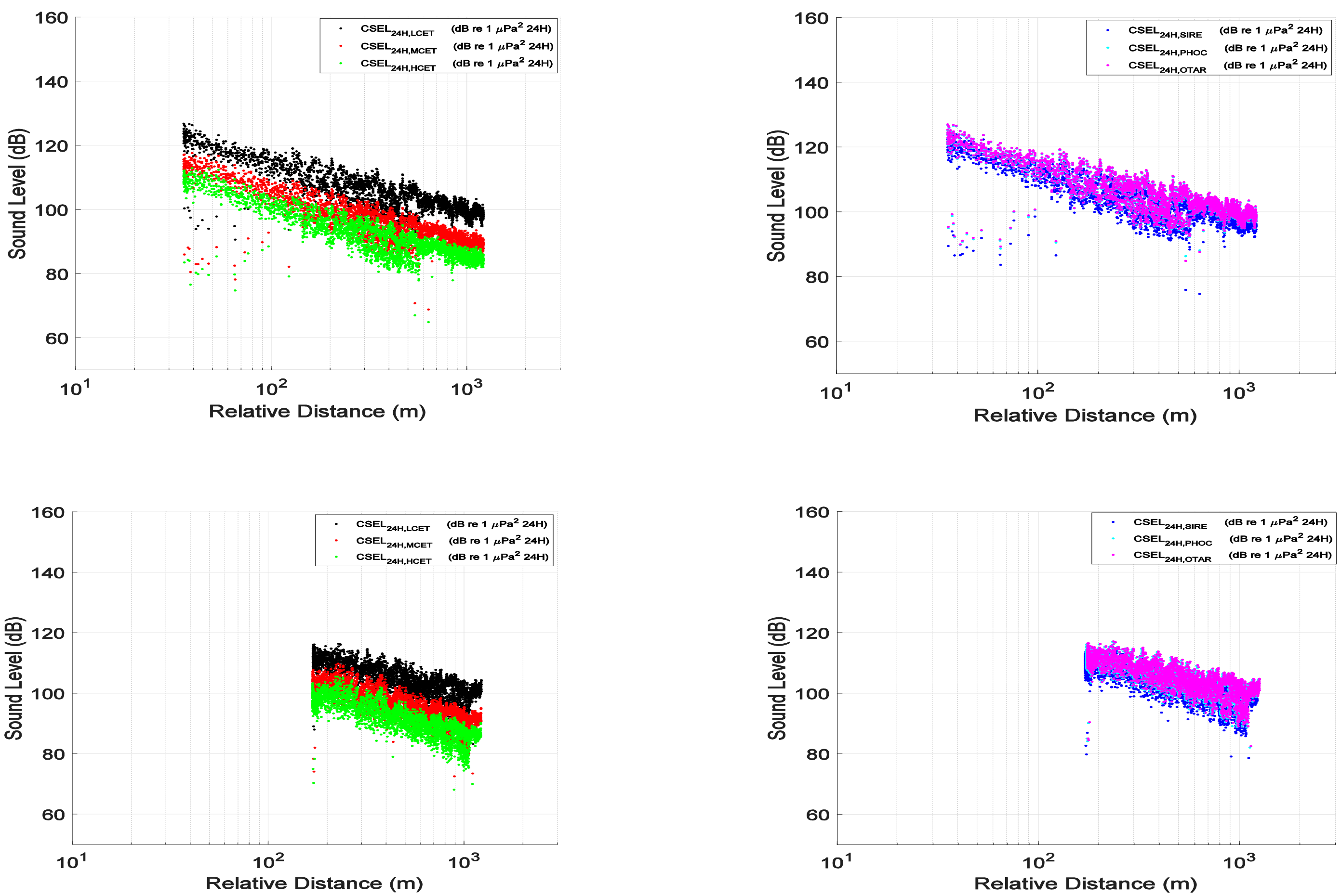


Figure 3.22 Measured frequency weighted $cSEL_{24\,h}$ of UHRS Sparker operating at 400J. Cetacean functional groups at primary mooring (top left). Pinniped and sirenian functional groups at primary mooring (top right). Cetacean functional groups at secondary mooring (bottom left). Pinniped and sirenian functional groups at secondary mooring (bottom right)

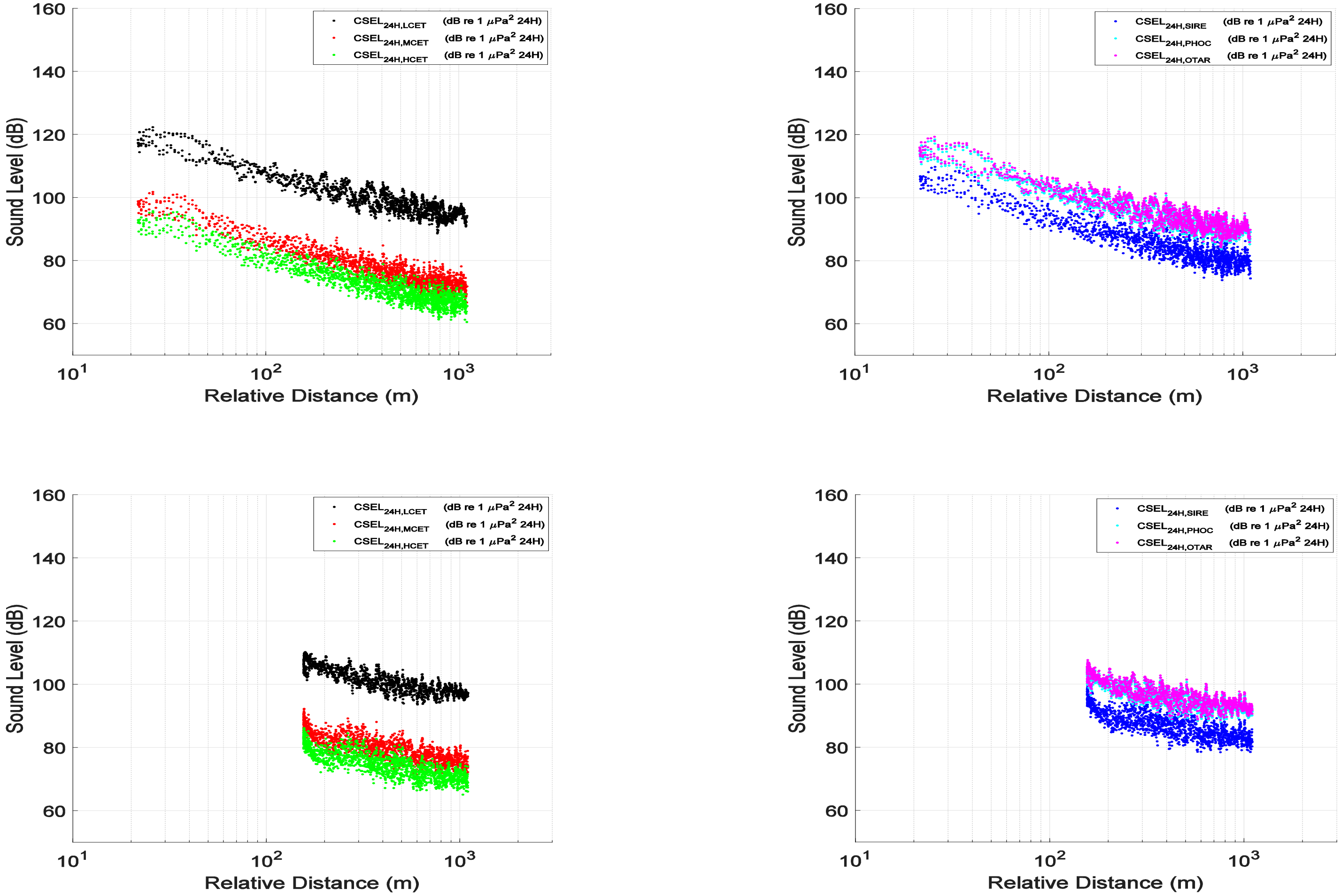


Figure 3.23 Measured frequency weighted $cSEL_{24\,h}$ of UHRS Sparker operating at 600J. Cetacean functional groups at primary mooring (top left). Pinniped and sirenian functional groups at primary mooring (top right). Cetacean functional groups at secondary mooring (bottom left). Pinniped and sirenian functional groups at secondary mooring (bottom right)

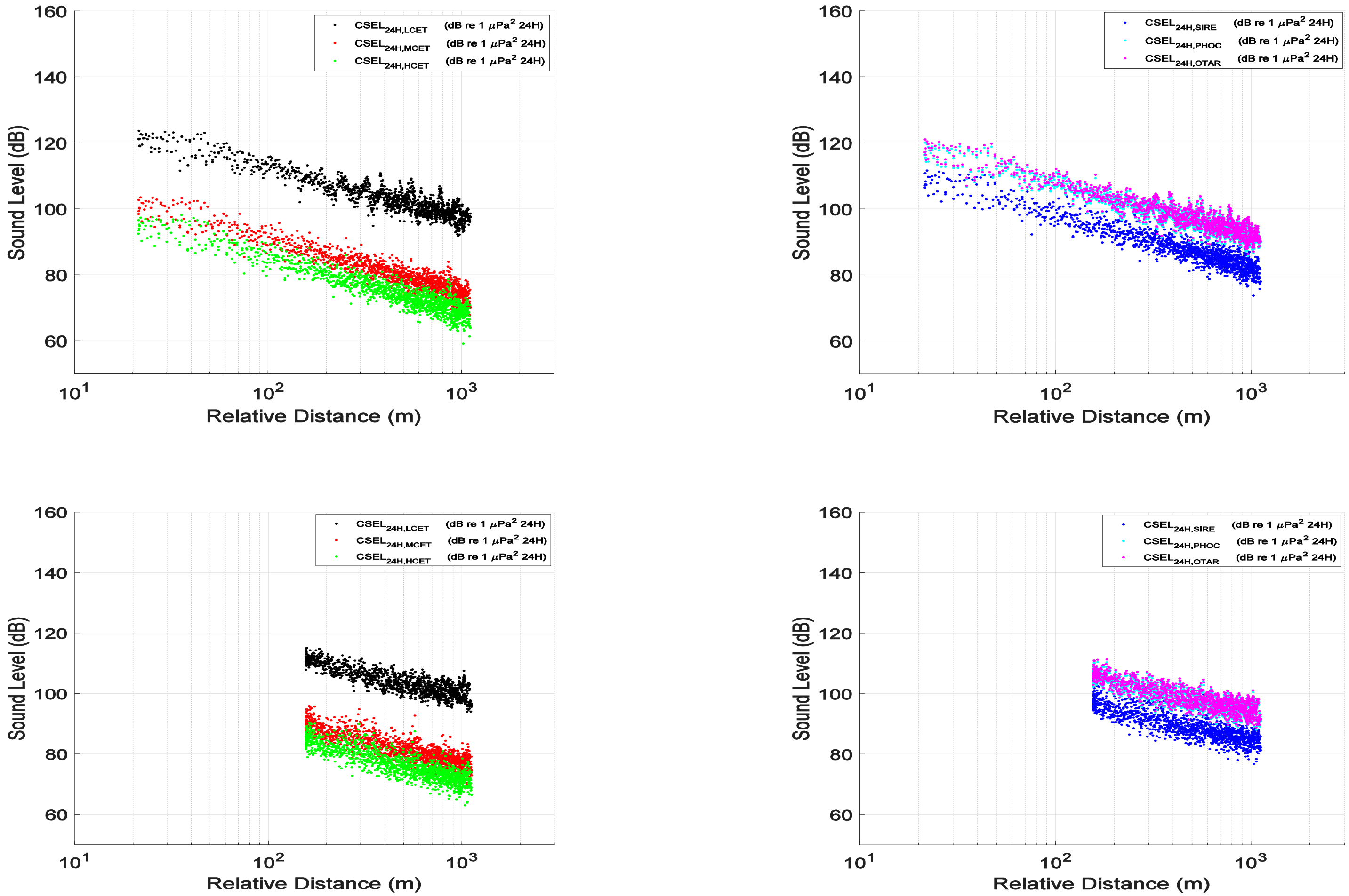


Figure 3.24 Measured frequency weighted $cSEL_{24\,h}$ of Sonardyne USBL. Cetacean functional groups at primary mooring (top left). Pinniped and sirenian functional groups at primary mooring (top right). Cetacean functional groups at secondary mooring (bottom left). Pinniped and sirenian functional groups at secondary mooring (bottom right)

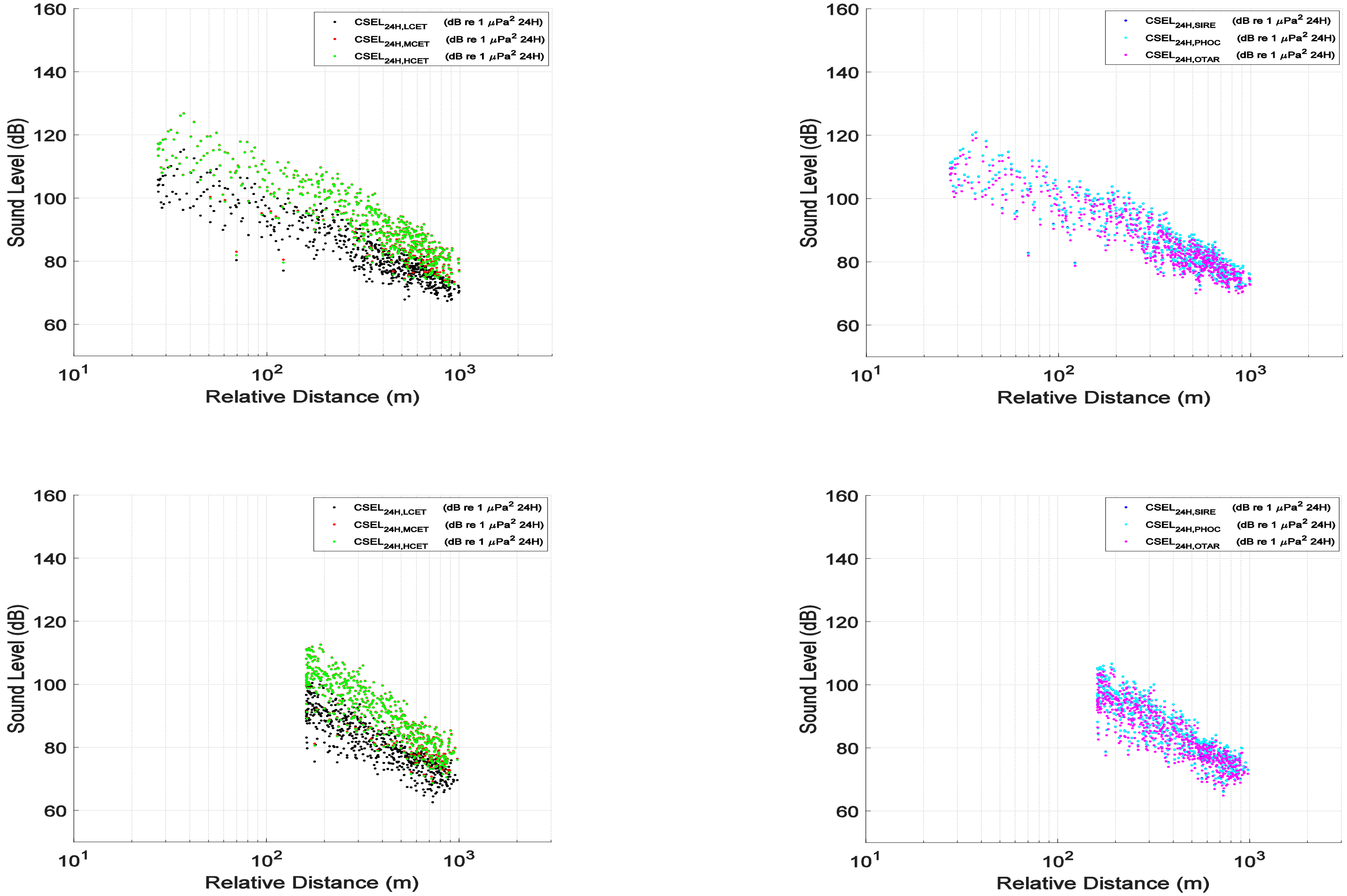
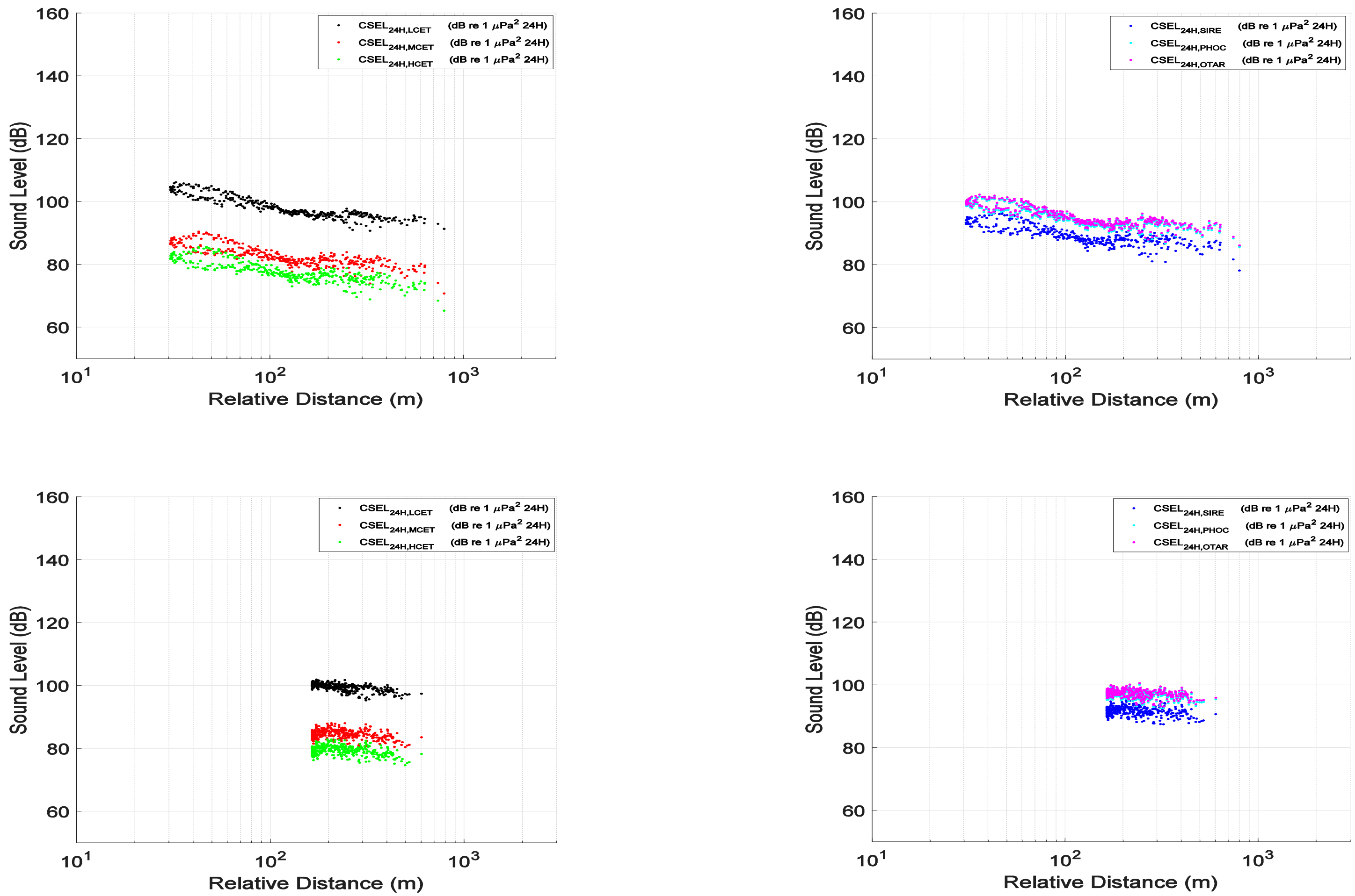


Figure 3.25 Measured frequency weighted $cSEL_{24\,h}$ of RV *Shearwater* vessel noise. Cetacean functional groups at primary mooring (top left). Pinniped and sirenian functional groups at primary mooring (top right). Cetacean functional groups at secondary mooring (bottom left). Pinniped and sirenian functional groups at secondary mooring (bottom right)



4 CONCLUSION

The aim of this study was to determine the SL of each acoustic source operating under 200kHz. The analysis of equipment operating under 200kHz included predictions of the apparent source levels and isopleths distances to criteria specified in:

- The Lease requirements, including the threshold of injury for marine turtles, fisheries, and marine mammals.
- NOAA (2016), including PTS and TTS onset based on SPL_{peak} and $cSEL_{24\,h}$ for three cetacean, sirenians and two pinniped species groups.

In compliance with the Lease requirements, the SPL_{peak}, SPL_{rms} and SEL source level for each piece of HRG equipment was determined. The distance to the 207, 190, 180, 160 and 150dB re 1µPa SPL_{rms}, 206dB re 1µPa SPL_{peak} and 187dB re1µ Pa^2 s cSEL isopleths for each piece of HRG equipment were found to be within the maximum acceptable distance variations required by BOEM.

Further analysis were conducted in accordance with NOAA (2016) guidelines incorporated SPL_{peak} and frequency-weighted $cSEL_{24\,h}$. Based on SPL_{peak} and $cSEL_{24h}$ PTS and TTS thresholds, no injury would occur within the planned 200m EZ.

This provides supporting evidence that the mitigation used during the geophysical survey was adequate. There was no indication sound produced by the HRG equipment will exceed the provided noise thresholds within the EZ.

5 BIBLIOGRAPHY

ANSI SI.40, 1984. *American national standard specification for acoustical Calibrator*. [Online] Acoustical Society of America, New York.

BIPM, 2006. *SI Brochure: The International System of Units (SI)*. [Online] Bureau International des Poids et Mesures (BIPM) Available at: https://www.bipm.org/en/publications/si-brochure/section2-2.html. Paris.

BOEM, 2016. *Ocean Noise Strategy Roadmap*. [Online] NOAA: http://cetsound.noaa.gov/ons [Accessed Sep 2016].

Carey, W.M., 2006. Sound sources and levels in the ocean. *IEEE Journal of Oceanic Engineering*, 31(1), pp.61-75.

El-Hawary, F., 2000. The Ocean Engineering Handbook. Boca Raton: CRC Press. pp.47-50.

Finneran, J.J., 2016. *Auditory Weighting Functions and TTS/PTS Exposure Functions for Marine Mammals Exposed to Underwater Noise. Technical Report 3026*. San Diego, CA.

Gardline Limited, 2018. *Protected Species Mitigation Protocol – NY Empire Wind – Geophysical Screening Survey*. Great Yarmouth.

IEC 60942, 1997. *International Electrotechnical Commision Standard, Electroacoustics – Sound*. [Online].

ISO 17208 1, 2016. Underwater acoustics -- Quantities and procedures for description and measurement of underwater sound from ships -- Part 1: Requirements for precision measurements in deep water used for comparison purposes. p.20.

Kaye, G.W. & Laby, T.H., 2004. *Tables of Physical and Chemical Constants*. [Online] Available at: http://www.kayelaby.npl.co.uk/ [Accessed Oct 2016].

Kinsler, L.E., Frey, A.R., Coppens, A.B. & Sanders, J.V., 1982. *Fundamentals of Acoustics*. 3rd ed. New York: Wiley.

NOAA, 2016. *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing*. [Online] http://www.nmfs.noaa.gov/ [Accessed Nov 2017].

Richardson, W.J., Greene Jr., C.R., Malme, C.I. & Thompson, D.H., 1995. Marine Mammals and Noise. San Diego, USA: Academic Press. p.576.

Theobald, P., Lepper, P., S., R. & Hazelwood, D., 2009. Cumulative Noise Exposure Assessment for Marine Mammals using Sound Exposure Level as a Metric. In *Proceedings of the 3rd International Conference Underwater Acoustic Measurement: Technologies & Results (UAM2009), 21 - 26 June 2009, Nafplion, Greece.*, 2009. National Physical Laboratory.

TNO, 2011. *Standard for measurement and monitoring of underwater noise, Part I: physical quantities and their units*. TNO Report TNO-DV 2011 C235. Author: Ainslie, M. A.

Urick, R.J., 1983. *Principles of Underwater Sound*. 1st ed. New York: Peninsula Publishing.

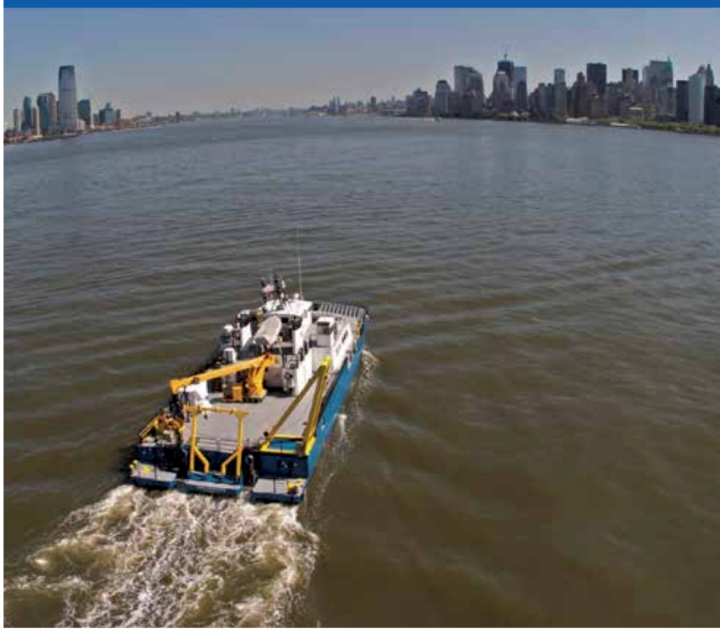
APPENDICES

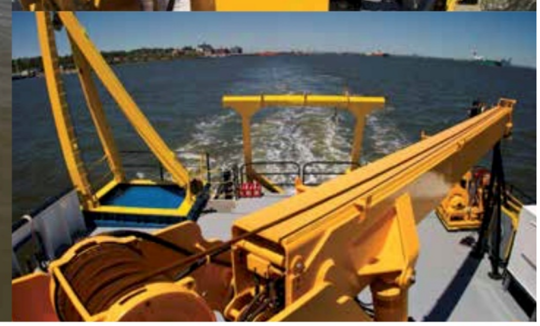
APPENDIX A VESSEL SPECIFICATION

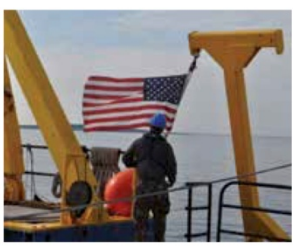
Alpine
A GARDLINE COMPANY

R/V Shearwater
Multi-role Survey Vessel

R/V Shearwater – Multi-role Survey Vessel







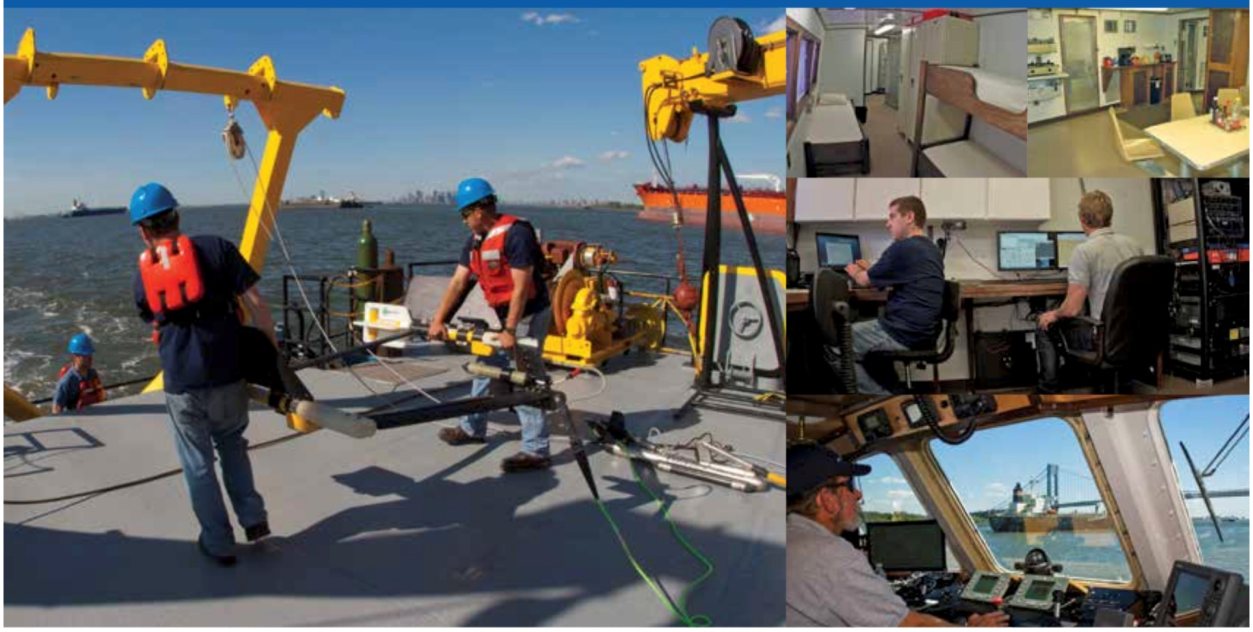
R/V Shearwater combines superior stability and maneuverability with state-of-the art research facilities to provide a flexible, multipurpose platform for marine surveying. The vessel fills the gap between small coastal and large offshore survey platforms providing a cost effective solution for many applications. In addition, the Shearwater allows for a single vessel to complete different tasks, such as geophysical, environmental, and geotechnical surveys, thereby affording our clients the opportunity to save both time and money.

The Shearwater is designed to be flexible enabling it to provide efficient and effective configurations for the completion of its missions. The 110' x 39' aluminium trimaran boasts a hydraulic azimuth drive propulsion system which is fuel efficient while providing superior positioning and line-keeping performance (handling is further enhanced by a 100 HP Bow Thruster). In most instances, this allows the vessel to hold station without resorting to anchoring. The Shearwater also features a large back deck, two equipment moon-pools, a crane, hydraulic stern A-frame, fixed starboard A-frame, dedicated equipment winches, laboratory and office space with onboard data processing capabilities, and accommodation for up to 20 people on a 24-hour basis.

A professional crew, with extensive experience in offshore survey and construction operations, allows clients to take advantage of the full list of impressive capabilities the Shearwater can bring to a project.

R/V SHEARWATER HAS BEEN DESIGNED TO SUPPORT THE FOLLOWING KEY AREAS:

/ Offshore Structure Surveys (Wind, Oil & Gas, Hydrokinetic)
/ Cable and Pipeline Route Surveys
/ Marine Aggregate and Mineral Surveys
/ Environmental Surveys
/ Oceanographic Instrument Deployment and Recovery
/ Port and Breakwater Development Surveys
/ ROV, AUV and Diver Support
/ Offshore Construction Support and Monitoring Surveys



Vessel Details

- **Name:** Shearwater
- **Type:** Multi-Role Survey
- **Year of Build:** 1981
- **Reconfigured, Refit and Repowered:** 2011

Dimensions

- **Length:** 110'
- **Beam:** 39'
- **Draft:** 9'
- **GRT:** 198
- **NRT:** 175
- **Aft Deck:** 1175 sq. ft with separate stern rescue deck

Accommodation

- **Berths:** 20 including crew
- **Survey Lab:** 127 sq ft
- **Processing Office:** 72 sq ft

Propulsion and Machinery

- **Main Engines:** 2 x 526 HP John Deere Model 6125AFM
- **Propulsion:** 2 x Hydraulically driven "Z" Drives (raise/lower/tilt with 360 degree steering)
- **Bow Thruster:** Thrustmaster 100 HP
- **Generators:** 2 x John Deere Model 6081AFM/Marathon (Magna Plus) 135 Kw

Capacities

- **Desalination System:** Up to 900 gallons/day
- **Fresh Water Storage:** 5000 gallons
- **Fuel Storage:** 13800 gallons
- **Septic:** Zero discharge with 2000 gallon holding tank
- **Endurance:** 21 days

Fuel Consumption

- **Survey 24hrs:** 300 gallons/day
- **Steaming:** 500-600 gallons/day
- **Standby at Sea:** 70-100 gallons/day

Navigation

- **Radar:** Furuno 1944C/NT, Furuno 1935
- **Charting System:** Garmin 5208 GPS with Chart Plot
- **Auto Pilot:** COMNAV
- **Echosounders:** Furuno FCV 620 – color in each hull
- **AIS:** Furuno FA 150
- **Navtex:** Furuno NX700
- **Survey GPS, Heading and IMU:** Applanix POS MV
- **Acoustic Positioning:** Moon Pool mounted USBL

Communication

- **VHF:** 2 x Icom IC-M504
- **SSB:** SEA 245 HF/SSB
- **SART:** Sevenstar Electronics S.701
- **Satellite (Phone/Data):** Intellian v80G VSAT

Equipment Handling

- **Equipment Moon Pools:** Port and Starboard 3 foot diameter moon pools
- **Hydraulic Stern A-Frame:** 2 Ton Capacity. Can operate as two separate davits
- **Fixed Starboard A-Frame:** 5 Ton Capacity
- **Crane:** 14 Ton Maximum Capacity, 5 Ton w/ single part line, 2 Ton at 40' Extension.
- **Geotechnical Winch:** 5 Ton Capacity
- **Survey Equipment Winch:** 2500m (11mm diam.) Capacity

Survey Capabilities

Hydrography and Geophysics

- Multibeam and Single Beam Echosounders
- Side Scan Sonars
- Subbottom Profilers
- Boomers
- Sparkers
- Mini Air Gun
- Multi-Channel Streamers
- Magnetometers and Gradiometers

Benthic and Oceanographic

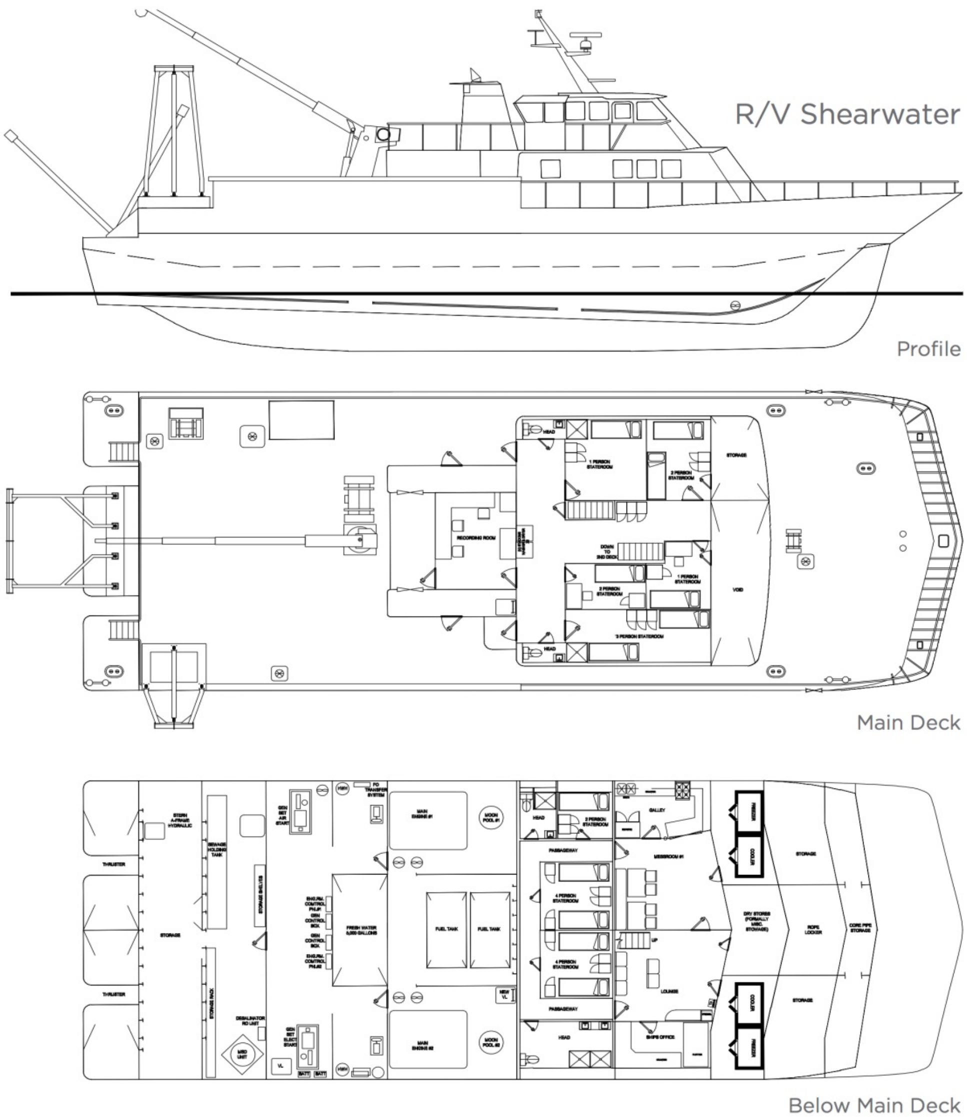
- CTD and SVPs
- Water Sampling Systems
- Turbidity Monitoring Systems
- Benthic Grabs
- Box Corers
- Drop Down Cameras

Geotechnical

- 10 to 30' Pneumatic and Electric Vibracores
- Mini-CPTs
- Piston Corers
- Drop Corers
- Grab Samplers

Other

- Deployment and Retrieval of Inspection Class ROVs and Compact AUVs
- Dive Platform Capable
- Permanently Installed Networked Server



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APPENDIX B HYDROPHONE CALIBRATION

Table B. 1 Pistonphone calibration of ARU hydrophones

Ultrasonic Hydrophone						
Serial Number	Date	Start time	End time	Barometer Reading (dB)	Barometer Reading (hPa)	Sensitivity (dB 1V/µPa)
MWAR0005 681689	17-Mar-18	19:52:30	19:53:30	-0.07	1004	-166.3
MWAR0006 681839	17-Mar-18	19:24:00	19:25:00	-0.07	1004	-166.2
MWAR0007 681698	17-Mar-18	19:41:00	19:42:00	-0.07	1004	-166.0
MWAR0008 681840	17-Mar-18	19:13:30	19:14:30	-0.07	1004	-165.0
HiSPL Hydrophone						
Serial Number	Date	Start time	End time	Barometer Reading (dB)	Barometer Reading (hPa)	Sensitivity (dB 1V/µPa)
MWAR0005 681836	17-Mar-18	19:54:00	19:55:00	-0.07	1004	-240.6
MWAR0006 681835	17-Mar-18	19:25:30	19:26:30	-0.07	1004	-238.5
MWAR0007 681833	17-Mar-18	19:38:00	19:39:00	-0.07	1004	-241.9
MWAR0008 681825	17-Mar-18	19:12:00	19:13:00	-0.07	1004	-237.6

APPENDIX C BASICS OF UNDERWATER ACOUSTICS METRICS AND ACOUSTIC MODEL

This section outlines some of the relevant concepts in underwater acoustics and provides context to the parameters required by BOEM as mentioned throughout this report.

C.1 Underwater Noise Metrics

It is very important to state correct acoustic metrics in a clear and unambiguous way. There are guidance documents available such as the *Standard for measurement and monitoring of underwater noise* (TNO, 2011), which provide a detailed review of the metrics to measure and assess the impact of underwater noise in the marine environment. A brief overview is included to assist the reader.

Sound results from the propagation of a mechanical disturbance in a compressible medium, which causes associated fluctuations in pressure and density due to particle motion.

Water is denser and less compressible than air therefore sound propagates faster in water than in air: sound speed on average in water is ~1521 metres per second (m/s) while in air is ~344m/s, and absorption is generally less. The sound waves are thereby propagated from the sound source at the speed of sound (Urick, 1983).

C.2 Sound Pressure

Underwater sound can be described as a pressure wave travelling through the water. The low absorption in water (Kinsler *et al.*, 1982; Kaye & Laby, 2004) allows sound to travel large distances in the ocean, particularly low frequency sound. A number of quantities may be used to describe a sound wave, but the most common is sound pressure.

The sound pressure can be described as the difference between instantaneous total pressure and pressure that would exist in the absence of sound ("equilibrium" pressure). This quantity is in effect the quantity that is being represented when a sound pressure waveform is plotted. The unit of sound pressure is the Pascal (Pa), which is equivalent to a Newton per meter squared, or N/m^2, as defined by the International System of Units (S.I.; BIPM, 2006).

C.3 Sound Levels

In acoustics, it is common to express sound levels in decibels (dB) relative to a fixed reference pressure value, for which 1μPa is used for measurements made underwater. Decibel is a logarithmic unit and is used to represent power ratio between measurement and the specified reference value. It is useful for expressing the relative level to the reference level. For example, a 3dB increase represents a doubling of the total acoustic energy while a 10dB represents a 10 times increase of the total sound energy.

C.4 Sound Pressure Level – Root Mean Square (SPL_{rms})

The most common convention in underwater acoustics for expressing SPL is for it to be expressed as a root mean square (rms) value. The rms value is a time-averaged pressure value, which allows the SPL to be related to the time-averaged acoustic power (the original use of the decibel notation is for expressing power ratios; Carey, 2006).

The convention in acoustics for expressing SPL_{rms} is calculated by the expression:

$$SPL_{rms} = 20 \cdot \log \left[\frac{P_{rms}}{P_0} \right]$$

where P_{rms} is the rms sound pressure and P_0 is the reference pressure of 1µPa.

C.5 Sound Pressure Level - Peak-to-peak ($SPL_{peak\text{-}peak}$)

For a pulse waveform, or sound of impulsive nature, peak-to-peak sound level or zero-to-peak sound level is commonly used.

For a specific pulse, the peak-to-peak pressure, $P_{pk\text{-}pk}$, is calculated from the pressure, p, by the expression:

$$P_{peak-peak} = max(p) - min(p)$$

where max(p) and min(p) are the peak positive and peak negative pressures in the waveform, respectively.

Since the peak negative pressure has a negative value, the peak-to-peak pressure is equivalent to the sum of the magnitudes of the peak positive and peak negative pressures. The value is expressed as the peak-to-peak pressure level in dB re 1µPa. This is calculated from:

$$SPL_{peak-peak} = 20 \cdot \log \left[\frac{P_{pk-pk}}{P_0} \right]$$

where P_0 is the reference pressure of 1µPa.

C.6 Sound Pressure Level - Zero-to-peak (SPL_{peak})

The maximum absolute sound pressure during a stated time interval is referred to as the SPL_{peak}. A peak sound pressure may arise from a positive or negative sound pressure.

For a symmetric waveform, the zero-to-peak amplitude is half the value of the peak-to-peak amplitude. However, usually the waveforms encountered in measurements sometimes exhibit significant asymmetry, and so the zero-to-peak values have been more commonly used as well:

$$SPL_{peak} = 20 \cdot \log \left[\frac{P_{pk}}{P_0} \right]$$

where P_{pk} maximum absolute sound pressure and P_0 is the reference pressure of 1µPa.

C.7 Sound Exposure Level (SEL)

The SEL is a measure of the total noise energy produced by a single acoustic event. The SEL for a single pulse is calculated by integrating the square of the pressure waveform over the duration of the pulse. "*The duration of the pulse, $T_{90\%}$, is defined as the region of the waveform containing the central 90% of the energy of the pulse. The calculation is given by:*

$$E_{90} = \int_{t_5}^{t_{95}} P^2\,(t)\,dt$$

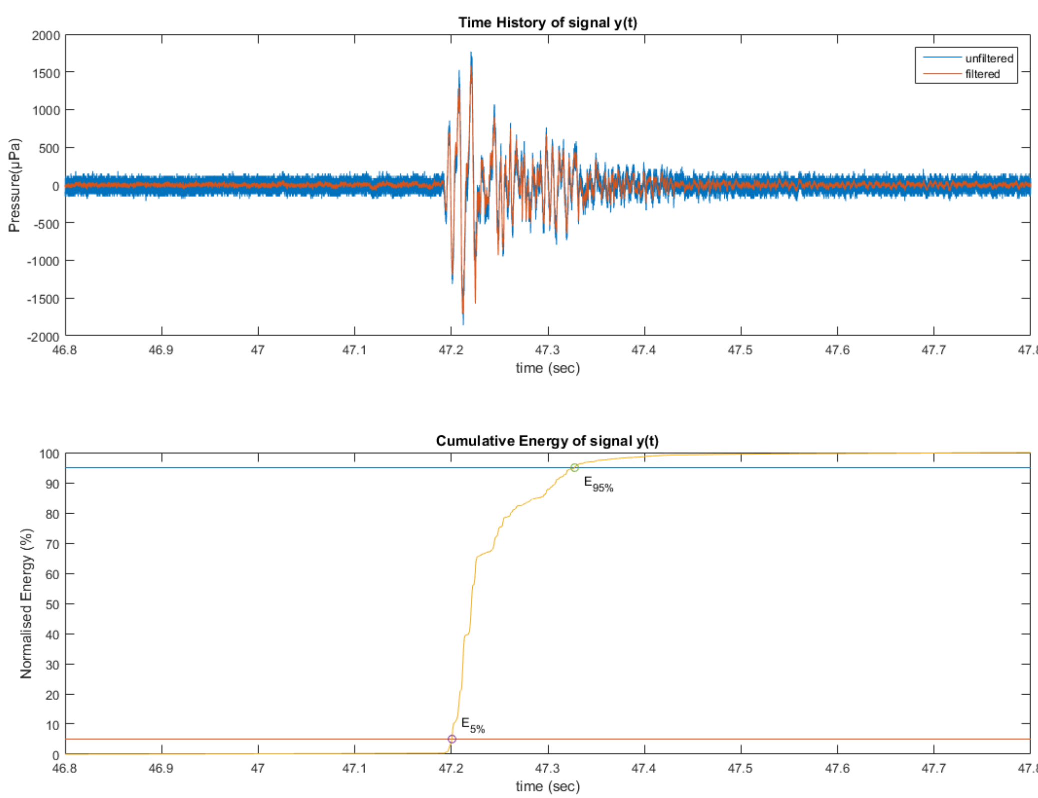
The value is then expressed in dB re 1µPa^{2}·s and is calculated from:

$$SEL = 10 \cdot \log\left[\frac{E_{90}}{E_0}\right]$$

where E_0 is the reference value of 1µPa^{2}·s" (Theobald *et al.*, 2009).

Note that the definition uses the central 90% of the energy in the pulse. This is because it can be difficult to determine the exact start of the pulse when the waveform contains random noise. The original signal maybe optimised using a band-pass filter to enhance the signal to noise ratio of the impulse signal (Figure C.1) by eliminating the white noise in the signal, in order to obtain a more accurate prediction of the exposure time window.

Figure C.1 A typical waveform generated impulsive source (top). Cumulative energy curve for predicting the pulse duration (bottom)



C.8 Cumulative Sound Exposure Level (cSEL)

The addition of the SEL for each impulsive noise event can be calculated for the entire exposure duration. The cSEL is used to describe not only the peak sound pressure but also the duration of the exposure to the noise exposure, allowing a total noise dose to be considered (Theobald *et al.*, 2009). The exposure level can be normalised to the daily exposure of an animal. Thus, the sound exposure level is given by:

$$SEL_{24\,h} = 10 \cdot \log_{10}\left\{\frac{1}{86400}\int_{t_5}^{t_{95}}\left(\frac{p(t)}{p_0}\right)^2 dt\right\}$$

This expression can be further simplified to:

$$SEL_{24\,h} = SEL - 10 \cdot \log_{10}(86400)$$

By definition the cumulative sound exposure level (cSEL), normalised to 24-hour dosage, is provided by the following:

$$cSEL_{24\,h} = \sum_{i=1}^{n} SEL_{24\,h,\,i}$$

Note SEL_{24h} and $cSEL_{24h}$ have unit of *dB re1μPa²·24h or dB re 1μPa²·day.*

If individual pulses are considered similar, the normalised sound exposure is given by:

$$cSEL_{24\,h} = SEL_{24\,h} + 10 \cdot \log(\mathrm{n})$$

where n represents the total number of pulses.

C.9 Underwater Acoustic Model

The basic approach to the acoustic model adopted in air-borne acoustics is also valid in the underwater environment:

- a source (characterised by the source level),
- a sound transmission medium (which will be influenced by boundary conditions and environmental conditions),
- a receiver (characterised by the received level).

C.10 Source Level (SL)

SL is a metric used in underwater acoustics to describe the source output amplitude. The decibel units for this quantity may be written as dB re $1\mu Pa^2 \cdot m^2$. It should be noted that SL is an idealised acoustic far-field parameter and is not necessarily equal to the acoustic pressure or received level measured at a distance of 1m from the source. It may be considered as the SPL that would exist at a range of 1m from the acoustic centre of an equivalent simple source, which radiates the same acoustic power into the medium as the source in question.

In general, SL may be given by:

$$SL = RL + TL$$

where RL is the received level in the acoustic far-field and TL is the transmission loss.

C.11 Transmission Loss (TL)

TL is the term used to describe the reduction of the sound level as a function of distance from an acoustic source. The mechanisms by which the sound intensity reduces are primarily geometrical spreading, sound absorption in the water and losses into the seabed or other boundaries. It is normal for TL to be stated as a positive number in dB representing the loss for the total range between the reference distance (1m for SL) and the receiver location.

In general terms, the TL is given by:

$$TL = n \cdot \log_{10}(r) + \alpha \cdot r$$

where r is the range from the source, n is the spreading coefficient due to geometric spreading, and α is the absorption loss (expressed in dB·km^{-1}) of acoustic energy.

The accurate estimation of the TL requires a precise model for the propagation of the sound and its interaction with the seabed and sea surface. Alternatively, the TL can be estimated through spatial sampling from the field measurement.

C.12 Received Level (RL)

The RL is the acoustic pressure which arrives at any acoustic receptor (for example, marine fauna or hydrophone) which is exposed to a sound. RL is typically expressed in sound pressure level (SPL) and sound exposure level (SEL) and can be very useful as it is directly related to the acoustic source level and the transmission loss in the medium, such that

$$RL = SL - TL$$

where SL is the acoustic source level and TL is the transmission loss. Note that TL can be frequency dependent, which can be estimated from field measurement or through acoustic modelling.

APPENDIX B WAIVER GRANTED BY BOEM ON FEB-27-2018

On Tue, Feb 27, 2018 at 6:21 PM, Bennett, James <james.bennett@boem.gov> wrote:

Ms. Keiser,

On November 17, 2017, Statoil Wind US LLC (Statoil) submitted a High Resolution Geophysical (HRG) and Geotechnical Survey Plan for the BOEM Lease area OCS-A 0512 survey area, which included a request to modify certain lease Stipulations and to begin surveys prior to receiving its incidental harassment authorization (IHA) from the National Marine Fisheries Service (NMFS), which you estimate will be received on or around March 15, 2018. BOEM requested additional information from Statoil in order to properly consider this request and received the latest revised plan on February 12, 2018. The proposed modifications are dependent upon NMFS' concurrence that they are consistent with the scope of the April 10, 2013 biological opinion (BiOp) under the Endangered Species Act (ESA). **NMFS is currently reviewing the proposed modifications, and if NMFS concurs, BOEM will grant your requests as described below.**

1) Lease Stipulations modification request:

Pursuant to Addendum C, Stipulation 4.4.6.3 of your lease, the default exclusion and monitoring zones under lease Stipulation 4.4.6.1 are modified as follows:

Exclusion Zones

- 500 meter (m) for North Atlantic right whales (NARWs) (same as the monitoring zone below)
- 100 m for large whales other than NARWs, including beaked whales and *Kogia*, and for harbor porpoises
- 50 m for pinnipeds and delphinids (except harbor porpoises) and sea turtles

Monitoring Zones

- 500 m for NARWs
- 200 m for all other marine mammals

BOEM is also granting Statoil a limited waiver to modify lease Stipulation 4.4.6.9 to allow for all equipment under full power to remain at full power if small cetaceans and seals voluntarily approach the survey vessel. While the initial pre-survey clearance period remains 60 minutes for all protected species, the post shutdown clearance periods in lease Stipulation 4.4.6.8 are modified to the following:

- Sea turtles – 60 minutes
- Large whales, including beaked whales and Kogia – 30 minutes
- Small cetaceans and seals – 15 minutes

The lease modifications described above are dependent upon NMFS' concurrence that these modifications are consistent with the scope of the April 10, 2013 biological opinion (BiOp) under the Endangered Species Act (ESA).

2) Pre-IHA issuance survey start request:
On January 30, 2018, and supplemented on February 14, 2018, Statoil notified BOEM that its survey contractor would be ready to begin its HRG surveys on March 1, 2018, prior to NMFS-issuance of an IHA. Given the cost and schedule implications of delaying its survey activities, Statoil requests authorization to proceed as scheduled on March 1. Statoil intends to implement a 500 m monitoring zone and a 200 m exclusion zone until the IHA is issued, and asserts that this will be 100% effective at avoiding Level A and B take. Statoil contends that existing empirical sound source data supports this assertion, and provided justification describing why existing empirical sound source data is applicable to this survey.

During review of this request, BOEM also considered recently published sound source data (Crocker and Fratantonio, 2016). In both instances, the data show that the 500 m monitoring and 200 m exclusion zones are sufficiently protective. Together with the above-mentioned measures and the short period of survey time affected (approximately two weeks), BOEM finds that the likelihood of protected species being taken is low. Please note that upon receipt of the IHA, Statoil must abide by the more protective measures if there are any differences between the Stipulations in this waiver request and the IHA.

Upon NMFS's concurrence with BOEM's BiOp consistency determination, BOEM approves Statoil's request to start their HRG survey on March 1, 2018 with the following condition: any shut-down of HRG survey equipment due to an ESA-listed marine mammal or sea turtle must be reported to BOEM within 24 hours to renewable_reporting@boem.gov.

BOEM will notify Statoil as soon as we are in receipt of NMFS' correspondence regarding the requests outlined above. Please feel free to reach out to me or Luke Feinberg, the New York Project Coordinator, should you have any questions.

Jim

James F. Bennett
Chief, Office of Renewable Energy Programs
Bureau of Ocean Energy Management
United States Department of the Interior
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APPENDIX C PROTECTED SPECIES MITIGATION PROTOCOL

Client
Statoil US Wind LLC

Projects
NY Empire Wind

Description
Protected Species Mitigation Protocol
-RV Shearwater

Date
14 March 2018

Status
Revision 3

SERVICE WARRANTY

USE OF THIS DOCUMENT

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GLOSSARY

BOEM	Bureau for Ocean Energy Management
COTI	Clip on thermal imaging
DMAs	Dynamic Management Areas
ESA	Endangered Species Act
EZ	Exclusion Zone
FLIDAR	Floating Light and Detection Ranging Buoy
HRG	High Resolution Geophysical
IHA	Incidental Harassment Authorisation
IMO	International Maritime Organisation
JNCC	Joint Nature Conservation Committee
Lease	Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf (OCS-A 0512)
MBES	Multi-beam echo sounder
MMPA	Marine Mammal Protection Act
MSRS	Mandatory Ship Recording System
MV	Motor Vessel
nm	Nautical mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PAM	Passive Acoustic Monitoring
PAMS	Passive Acoustic Monitoring System
PSMP	Protected Species Mitigation Protocol
PSO	Protected Species Observer
SBES	Single Beam Echo Sounder
SBP	Sub-bottom profiler
SSS	Side scan sonar
UHRS	Ultra high resolution seismic
USBL	Ultra-short baseline
SMA	Seasonal Management Areas

1. INTRODUCTION

Please note that this is a working document and may be subject to change.

1.1 Project Background

As a part of the development of the Empire Wind project, New York, Statoil plans to conduct a High Resolution Geophysical (HRG) survey of the entire Lease Area and one or more export cable route corridors (Figure 1.1). The purpose of such survey is to gain better understanding of the Lease Area and inform overall project design and engineering as well as site selection for deployment of buoys.

The HRG survey will be undertaken on a 24-hour basis utilising two platforms – *RV Ocean Researcher* and *RV Shearwater*. This PSMP relates to the survey that will be carried out on the RV Shearwater.

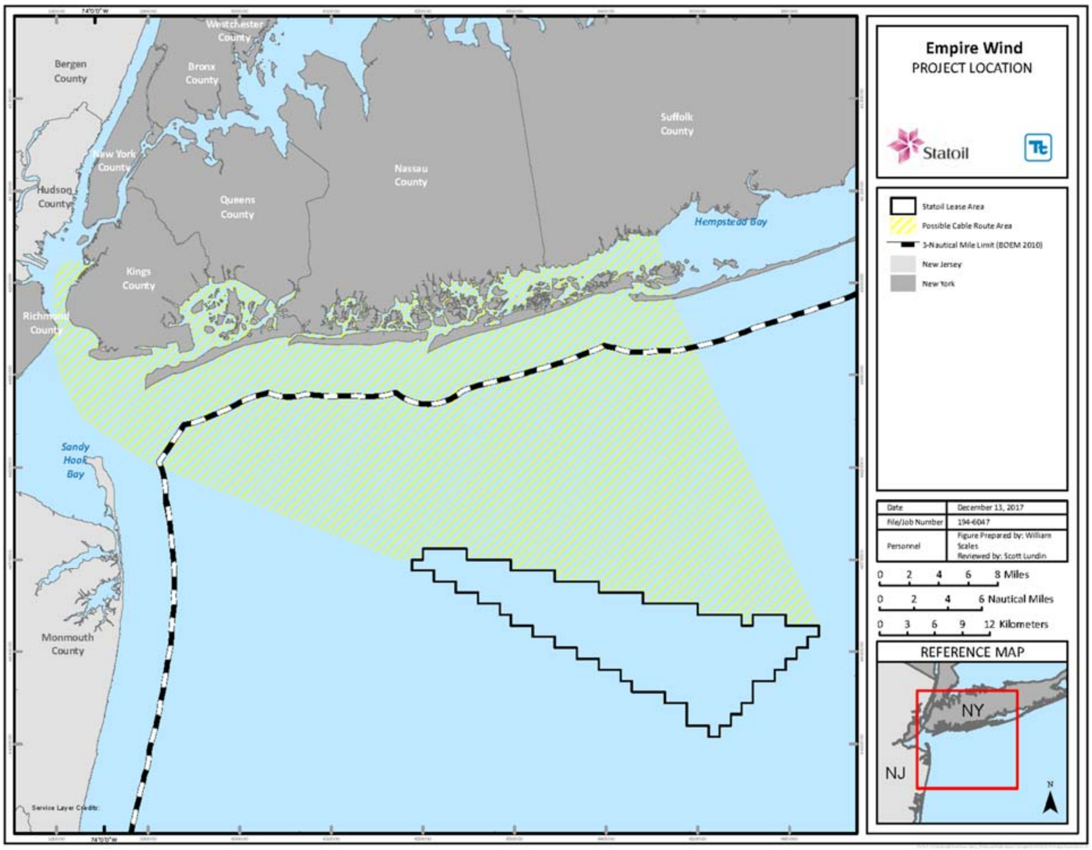
More specifically, the *MV Shearwater* will carry out the following:

- Field Verification Test (one transect consisting of two lines run in opposite directions will be run to test each piece of survey equipment operating at <200kHz, equipment with operating frequency over 200kHz shall not be tested, plus one transect over the array for vessel only noise and another transect for all the equipment running concurrently)
- MARA HRG lines at two Flidar locations (21 main lines and 3 cross lines), and one combined Flidar/Metocean Location (21 main lines and 5 cross lines, 600m x 2300m area)
- One line through lease area connecting Flidar and Metocean area
- Environmental camera & grab operations at each of the Flidar and Metocean locations (5 total locations). Each location will include 3 camera drops and 3 grab samples, depending upon seabed (geophysical review of data) additional grabs can be performed.
- MARA HRG lines along ECRs

The equipment types required to complete the geophysical survey will consist of multi-beam echo sounder (MBES), side scan sonar (SSS), ultra short baseline (USBL), and shallow and medium penetration sub-bottom profilers (SBPs; specifically a pinger and sparker [ultra-high resolution seismic; UHRS]). The equipment will be configured to achieve the following objectives:

- Determination of site bathymetry and elevations;
- Detection of local variations in the regional magnetic field from geological strata and potential ferrous objects on and below the seabed;
- Seabed sediment classification and identification of natural and man-made features;
- Mapping near and deep surface stratigraphy.

Figure 1.1 Location map NY Empire Wind lease area



1.2 Background on HRG Surveys

The HRG survey will be carried out across the planned NY Empire Wind site area within the area of the Commercial Lease of Submerged Lands and Renewable Energy Development on the Outer Continental Shelf (OCS-A 0512). The shallow geophysical survey equipment to be used during the survey includes SBP, S-UHRS, MBES, SSS, and USBL which are used to characterize the sediments and layers just below the seabed. Several of these equipment produce sound predominantly between 0.4 and 30kHz with source levels between 200 and 230dB re 1 μPa^2 m^2 (Richardson *et al*., 1995).

Anthropogenic sounds impact marine mammals in a variety of ways from direct injury (physiological and auditory effects) and behavioural responses, to perceptual and indirect effects (Southall *et al*., 2007; Gotz *et al*., 2009). The operating frequency of proposed equipment is generally above the hearing range of marine mammals; however, such equipment has the capability of generating sounds within the functional hearing range of marine mammals. Therefore, such sources may be detectable over distances of several hundred metres, and although below harmful levels, these anthropogenic sounds could potentially affect the behaviour of marine mammals within close proximity (Deng *et al*., 2014).

Sea turtles are another group potentially impacted by acoustic activity although their hearing sensitivity falls in the low frequency range (<1kHz; Bartol *et al*., 1999). Strong site fidelity to nesting

sites, specific feeding grounds and migratory routes (Broderick *et al*., 2007) could result in sea turtles being unable to avoid particular areas and consequently acoustic activity.

1.3 Background on Vessel Strikes

There is increasing evidence that collisions between vessels and cetaceans (whales, dolphins and porpoises) are occurring more frequently than previously thought, and in some cases, may pose a significant conservation threat, particularly for geographically isolated and endangered populations (Knowlton & Kraus, 2001; Dolman *et al.,* 2006; Van Waerebeek *et al*., 2007). Several variables can result in a collision becoming more likely, and influence the kind of injuries inflicted or whether the collision is fatal. These variables include vessel speed, with speeds above 11 knots more likely to result in a fatality (Vanderlaan & Taggart, 2007), the type and size of vessel, visibility, species, and condition and behaviour of individuals (Dolman *et al*., 2006). In the north-west Atlantic, the North Atlantic right whale (*Eubalaena glacialis*) is particularly vulnerable to vessel strikes (Knowlton & Kraus, 2001). A number of mitigation measures have been implemented in order to reduce the number of vessel strikes offshore of the north east coast of the USA (NOAA, 2008; Laist *et al*., 2014).

1.4 Marine Mammals and Sea Turtles in the Area

In total, 33 species of cetacean have been recorded off the north east USA coast, occupying habitats from coastal waters to offshore, pelagic environments (NEFSC, 2015a). All species of cetacean are listed under the US Marine Mammal Protection Act (MMPA) (1972). Further to this, several species of cetaceans are listed as *Endangered* or *Threatened* under the Endangered Species Act (ESA). Species listed under ESA occurring within the region include blue whale (*Balaenoptera musculus*), humpback whale (*Megaptera novaeangliae*), fin whale (*B. physalus*), sei whale (*B. borealis*), sperm whale (*Physeter macrocephalus*), and the North Atlantic right whale (*Eubalaena glacialis)*. Of particular concern is the status of the North Atlantic right whale, whose population size dropped down to 430[1] individuals after high number of fatalities and no new calves recorded in 2017.

In addition to cetaceans, two species of pinniped are commonly recorded within the region, the grey seal (*Halichoerus grypus*) and the harbour seal (*Phoca vitulina concolor*). Harbour seals are found in near shore waters year round off Maine and seasonally off southern New England to New Jersey (Waring *et al*., 2013). Grey seals range from New York to Labrador, with three established breeding colonies off Maine and Massachusetts. Summer surveys indicate seals have the potential to be distributed coast-wide along New England and Maine (Waring *et al*., 2013).

All species of sea turtle are listed on the ESA. Off the north eastern USA, five species are recorded; green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*; NEFSC, 2015b).

1.5 Purpose of the Protocol

The current document describes the proposed Protected Species Mitigation Protocol (PSMP) for use during the HRS at the Empire Wind site commencing in March 2018. The PSMP outlines the

[1] The last official count indicated minimum 444 individuals in 2009 (Waring *et al*., 2013), but numbers since declined further.

monitoring and mitigation requirements for minimising the impacts on marine mammals and sea turtles during the project and is based on the mitigation requirements stipulated in the Lease (OCS-A-0512) and the High Resolution Geophysical and Geotechnical Survey Plan (which includes Alternative Monitoring Plan).

Please note, the survey/s will begin prior to receiving its Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS), which is estimated to be issued around the end of March 2018. The survey shall be conducted in accordance with the measures stipulated in the Lease (OCS-A-0512) until the IHA is granted. An updated version of the PSMP will be issued taking in consideration new stipulations outlined in the IHA.

2. MONITORING METHODS

The *MV Shearwater* observation team will be comprised of four PSO/PAMS Operators. The team will provide 24-hour monitoring during the survey. Two PSOs will conduct visual watched during daylight hours while two team members, one PSO and one PAMS Operator, will cover night time operations conducting both visual and acoustic monitoring.

Observers will alternate their roles in order to maintain vigilance at all times. Personnel shall conduct a maximum of four hours monitoring on any single discipline (visual or acoustic), and then take a minimum of two hour break. Observers shall work a maximum of 12 hours with a minimum of 12 hours rest period within each 24-hour period.

2.1 Visual Monitoring

Visual methods using trained and experienced PSOs are likely to be effective for all species of marine mammal and sea turtles during daylight hours, good visibility and calm (Beaufort sea state <4) weather conditions. Visual methods using night-vision binoculars with additional thermal imagery clip on, both are likely to aid the detection of all species during the hours of darkness.

2.1.1 Daylight operations

While on watch, the PSOs will search 360° around the vessel focusing on the Exclusion Zone (EZ; see Section 3.3) around the acoustic source. PSOs will scan with the naked eye and use binoculars to focus on points of interest where required. PSOs will use a bespoke version of the Joint Nature Conservation Committee (JNCC) forms, which will document all the required information in 'Operations', 'Effort' and 'Sightings' tabs (See attached PSO forms).

During daylight hours, two PSOs will be conducing visual watches . The PSOs will have access to reticule binoculars which will be used to determine the distance to any marine mammals or turtles sighted. Additionally, PSOs shall construct range-finder sticks (see Heinemann, 1981) for measuring distances. Range-finder sticks are a useful tool to validate an observer's judgement of distance to an animal, and therefore whether they have been detected within the EZ. Essentially, distances can be calculated using trigonometry principles, taking into account the height of the observation platform and how far away in relation to the horizon the animal(s) appear. In order to use a range-finder stick, the top of the range-finder should be aligned with the horizon and distances to animal(s) can be read from the scale. Note, the method only works if the view of the horizon is unobstructed. As a minimum, distance bands relating to the EZ and distances relating to separation distances for vessel strike avoidance should be marked on the stick for use in determining the distance of sighted animals.

In summary the PSOs will be equipped with:

- 1 x binoculars (8x or 10x magnification),
- 1 x stills camera with 70-300 mm lens (effective 112-480 mm due to 1.6x digital magnification),
- marine mammal and sea turtle identification guides,
- bearing finding equipment (angleboard),
- reticule binoculars,
- range-finder stick, and
- standardised recording forms.

2.1.2 Night-time operations

Visual observations shall continue during the hours of darkness, with one PSO onboard *MV Shearwater*.

PSOs on duty at night will be required to operate the night-vision binoculars (PVS-7 Generation 3 Pinnacle night vision goggles) with additional clip on thermal imagery (COTI) technology throughout operations scan the EZ. Watches will be conducted from a platform with no visual barriers in order to reduce the potential for reflectivity from bridge windows. While on watch the PSO will search 360° around the vessel, with a focus on the minimum separation distances for vessel strike avoidance and the EZ around the acoustic source. The PSO team will the use of the night vision binoculars . Standardised data recording forms as mentioned previously will be completed during all night-time operations (See attached PSO forms).

In accordance with the Alternative Monitoring Plan described in the Survey Plan, geophysical operations at night shall only occur whilst both visual watches and acoustic monitoring are conducted (see 2.2 below).

2.1.3 Poor weather conditions

During poor weather conditions in daylight hours (e.g. heavy rain, high sea states, fog), the PSO/s on watch will continue observations. In addition, the PAMS Operator on call will deploy the PAMS until conditions improve. The re-occurrence of periods of poor visibility during the day will be monitored onboard to ensure rest periods are not interrupted for prolonged periods.

2.2 Acoustic Monitoring

PAM by trained and experienced operators is likely to be effective for detecting vocalising cetacean species during periods of poor weather conditions and low visibility including night time.

A towed hydrophone array will be deployed behind the vessel and connected to a data processing system, thereby allowing the operator to both listen to and visualise the sounds via a computer. While on watch, the PAMS Operator shall monitor the system for any potential detection of cetaceans with a focus on the minimum separation distances for avoiding vessel strikes and the EZ around the acoustic source. When possible the PAMS Operator shall confirm species and range of any detection with the visual observer on watch. The same standardised data recording forms as mentioned previously shall be completed during all acoustic monitoring (See attached PSO forms).

2.2.1 Passive Acoustic Monitoring System

A towed Gardline Mk 4.1 system (with backup Mk 4) will be installed on the vessels. The system has been designed with the need to detect and localise North Atlantic right whales and a wide range of other cetacean species. The hydrophone array will be comprised of six hydrophones: three low frequency, with a frequency response of 10Hz to 70kHz and nominal sensitivity -190dB re 1V/μPA; and three broadband hydrophones, with a frequency response of 1kHz to 170kHz and nominal sensitivity -170dB re 1V/μPA (Table 2.1).

Table 2.1 PAM System specifications

General		
Manufacturer	Gardline Ltd	Gardline Ltd
Model	MK4	MK4.1
Towed streamer section		
Length	N/A integrated into tow cable	N/A integrated into tow cable
Section diameter	14mm over cable, 24mm over mouldings	14mm over cable, 24mm over mouldings
Number of Hydrophones	6	6
Hydrophone type	Custom built by Gardline Environmental Limited 3 low frequency, 3 broadband	Custom built by Gardline Environmental Limited 3 low frequency, 3 broadband
Receive sensitivity (dB re 1 V/μPa)	-204	-204
Hydrophone separation	Hydrophone 1 to 2, 6.75m Hydrophone 2 to 3, 2.3m Hydrophone 3 to 4, 1.2m Hydrophone 4 to 5, 1.25m Hydrophone 5 to 6, 2.1m	Hydrophone 1 to 2, 10m Hydrophone 2 to 3, 4.5m Hydrophone 3 to 4, 0.5m Hydrophone 4 to 5, 0.5m Hydrophone 5 to 6, 4.5m
Preamplifiers	3 broadband, 3 low frequency	3 broadband, 3 low frequency
Preamplifier type	Sensor Technology SA-03	Sensor Technology SA-03
Depth sensor manufacturer	SensorTechnics	SensorTechnics
Tow cable		
Length	250 m	250 m
Diameter	14 mm	14 mm
Termination	37 pin CEEP Connectors	37 pin CEEP Connectors
Deck cable		
Length	100 m	100 m
Diameter	14 m	14 m
Termination	37 pin CEEP Connectors	37 pin CEEP Connectors

Monitoring will be achieved using the dedicated interface unit − MK 4.1 IU – in combination with a custom built computer with two monitors. The interface unit comprises DAQ cards and a studio-grade sound card. These are responsible for acquiring and converting the signal received by the broadband and low frequency hydrophones. The converted data will be processed by the software PAMGuard. PAMS Operators will monitor both the sound received by the hydrophones and the visual output of PAMGuard (spectrograms and click detectors). Operators will analyse these outputs to determine localisation and the species or species group of the vocalising marine mammals.

A dual frequency data model will be created specifically for this project, so that the real time detectability of vocalisations is increased. The audio signal will be enhanced for the desired frequency ranges, through the configuration of the sound card and the use of the appropriate filters in PAMGuard. Data sampled at the maximum sampling capability (500kHz sampling rate, at 16 bits) will be used to set up the click detectors, and classifiers will be put in place. All the raw data will be stored in an SQL database to allow for *a posteriori* analysis.

Primary acoustic monitoring periods will be during the hours of darkness however the PAMS Operators will be on call as necessary should visual observations become impaired during daylight hours. This will be monitored onboard to ensure rest periods are not interrupted for prolonged periods.

2.3 Calibration and Effectiveness

A standard technique will be employed to calibrate visual monitoring equipment, whenever adequate objects such as other vessels, navigation buoys, and fixed structures are available. The ship's radar will be used to measure "true" distances which will be compared to measurements taken using reticule binoculars and range-finder sticks. The distance measuring equipment will be calibrated against objects at a variety of ranges. It is likely that the number of objects situated within the EZ that are large enough to detect on radar will be low; therefore, this calibration will be carried out when the vessel is alongside as part of mobilisation activities. Measurements will be taken during different weather condition and calibration forms will be completed in order to allow comparison of equipment effectiveness in different weather conditions. It should be noted that during hours of darkness, it can only be assessed if an object at a known distance (from ship's radar measurement) is visible or not. Additional detail is provided in Appendix A.

Should deployment set-up allow, the PAMS shall be employed during daylight hours, to support system calibration. This will be monitored by the PSO team and survey crew and will be subject to ensuring that continual deployment does not present an operational/entanglement risk. At a minimum, the system will be deployed at dusk/dawn to correspond with PAMS operators shifts. Any data collected while the PAMS operators are off shift will not be monitored in real-time, but will be brought back to the office on completion of the survey where time periods coinciding with visual sightings will be analysed.

3. MONITORING PROCEDURES

3.1 Vessel Strike Avoidance

The HRG survey shall comply with the requirements for vessel strike avoidance as stipulated in the Lease OCS-A-0512. In order to avoid causing injury or death to marine mammals and sea turtles, the following measures shall be implemented. Only under extraordinary circumstances, when complying would put the safety of the vessel or crew at risk, will the mitigation measures not be implemented:

- PSOs and the vessel crew shall maintain a vigilant watch for marine mammals and sea turtles, and slow down or stop the vessel in order to avoid striking any sighted protected species.
- A minimum of one PSO shall be on watch during transit.
- Vessel speed shall be reduced to 10 knots or less when any large whale, any mother/calf pairs, whale or dolphin pods, or larger assemblages of non-delphinoid cetaceans are observed near (within 100 m) an underway vessel.
- Vessel shall operate at speeds of 10 knots or less from November 1 through April 30.
- Vessel speed shall be reduced to 10 knots or less when in any active Dynamic Management Areas[2] (DMAs) for North Atlantic right whales.
- If North Atlantic right whales are sighted, a minimum of 500m separation distance between the individual/s and the vessel shall be maintained.
- If a North Atlantic right whale is detected within 100−500m of the vessel, the vessel shall steer a course away at 10 knots or less until the 500m minimum separation distance has been established.
- If a North Atlantic right whale is detected in the vessels path or within 100m of the vessel, the vessel shall immediately reduce speed and shift the engine into neutral until the whale has moved beyond 100m (so long as this does not pose a risk to vessel and crew safety). Engines shall only be engaged once the individual/s are further than 100m from the vessel. The vessel shall then steer a course away from the whale at 10 knots or less until the 500m separation distance is achieved. If stationary, the vessel must not engage engines until animal/s have moved beyond 100m.
- If any non-delphinoid cetaceans (other than the North Atlantic right whale) are sighted, a minimum 100m distance shall be maintained between the individuals and the vessel.
- If any non-delphinoid cetaceans are detected within 100m of the vessel, the vessel speed shall be reduced and the engine shifted into neutral (so long as this does not pose a risk to vessel and crew safety). Engines shall only be engaged once the animal/s is more than 100m from the vessel. If stationary, the vessel must not engage engines until animal/s have moved out of the vessel’s path and beyond 100m.
- If delphinoid cetaceans, pinnipeds or sea turtles are detected, a distance of 50m between the vessel and the individual/s shall be maintained.
- If any delphinoid cetaceans are encountered within 50m, the vessel shall maintain a parallel course with the group, where possible, avoiding abrupt changes in direction and excessive speed. Any vessel underway shall reduce the speed to 10 knots or less when pods (including mother/calf pairs) or large assemblages of delphinoid cetaceans are

[2] DMAs refer to a temporary area designation by the NMFS, and consist of a circle around confirmed North Atlantic right whale sightings. The radius of this circle expands incrementally with the number of whales sighted and includes a buffer zone beyond the core area. The radius is based on 3nm per whale, adjusted for multiple animals so that a density of 0.04 per nm^2 is maintained. Buffer zones of up to 15nm are then added to this core area.

observed. Course and speed shall only be adjusted once the animal/s have moved more than 50m from the vessel or they have moved abeam.

- All vessels underway will not divert or alter course in order to approach any whale, delphinoid cetacean, or pinniped. Any vessel underway will avoid excessive speed or abrupt changes in direction to avoid injury to the sighted cetacean or pinniped.
- To avoid vessel strikes, the Early Warning System (a network of observers that disseminates right whale location information to mariners via the typical marine communication channels), Sighting Advisory System (sighting locations can be checked at http://www.nefsc.noaa.gov/psb/surveys/ or an email can be sent to mnfs.gar.rightwhale@noaa.gov to request sightings on-demand) and the Mandatory Ship Recording System (MSRS) notifying mariners of right whale presence will be monitored regularly between 1st November and 30th April.
- If the vessel enters the WHALESNORTH designated area for any reason the ship must report in using the MSRS. The vessel shall report its presence in the International Maritime Organisation (IMO) standard format if equipped with IMARSAT C or alternatively via email to rightwhale.msr@noaa.gov or via telex 48156090. Instructions for reporting are included in Appendix B.
- All sightings of North Atlantic right whales shall be reported to the NMFS on 866-755-6622. Sightings can also be reported to the US Coast Guard on VHF Channel 16.

The monitoring team will consult NMFS North Atlantic right whale reporting systems for the presence of North Atlantic right whales throughout survey operations (as outlined above). It is however worth noting that the proposed survey activities will occur outside of the SMA located off the coasts of New Jersey and New York.

3.2 Reporting Injured or Dead Protected Species

3.2.1 Reporting injured or dead protected species not associated with the vessel

PSOs will inform Statoil who shall subsequently report any sightings of dead or injured protected species (*e.g.* marine mammals or sea turtles) within **24-hours** if the death or injury has not been caused by the vessel.

Any sightings of dead, injured or entangled North Atlantic right whales shall be immediately reported to the US Coast Guard via VHF channel 16 (or via the Stranding Hotline).

If it is deemed that the injury or death of the animal is not caused by the vessel, the following information is needed when making the report together with any videos or photos:

- name of observer and contact information,
- date and time of sighting,
- location,
- where were you (*i.e.* vessel or land),
- number of protected species sighted,
- behavior observed,
- certainty of species ID,
- detailed description of the sighting, and
- details of the whale condition if injured, entangled or dead.

PSOs are provided with a standardized incident report form for reporting injured or dead protected species (Appendix C).

If the PSOs determine that the cause of death was not due to survey activities, no stoppage is required.

The Client Representative onboard the vessel shall be informed about any sightings of dead or injured protected species before any reports are made.

The subsequent form and any additional pertinent information shall be sent to Statoil for review. Upon review completion, Statoil shall submit the form to BOEM and NMFS within **24-hours**. Sightings shall be reported to BOEM and the NMFS via the Northeast Stranding Hotline (866-755-6622). Entangled animals are to be reported to the Marine Animal Entanglement Response Team (800-900-3622).

3.2.2 Reporting injured or dead protected species potentially associated with the vessel

If, in the unlikely event that the death or injury may have been caused by the vessel, including a significant behavioural reaction, PSOs shall inform Statoil who shall subsequently report any sightings of dead or injured protected species (*e.g.* marine mammals or sea turtles) **immediately**.

If it is deemed that the injury or death of the animal is caused by the vessel, or the death or injury cannot be determined but it is thought to be recent, additional information is required as well as those stated above:

- Description of the incident.
- Status of all sound sources used in the 24 hours preceding the incident.
- Description of all protected species observations in the 24 hours preceding the incident.

PSOs are provided with a standardized incident report form for reporting injured or dead protected species (Appendix C).

In the event that the injury or death has definitely been caused by the vessel all activities shall immediately be ceased. NMFS will review the circumstances of the event and steps will be put in place to minimise the recurrence of such an event in future. Activities will not resume until notified by NMFS.

In the event that the death or injury cannot be determined but it is thought to be recent, operations may still resume once NMFS have been informed and reviewed the circumstances of the incident. NMFS will work with Statoil to determine if modifications to activities are appropriate.

The Client Representative onboard the vessel shall be informed about any sightings of dead or injured protected species before any reports are made. If the PSOs cannot clearly determine that the death was not caused by survey activities then the PSOs shall consult with Statoil in order to review the available information and make a determination.

The point of contact will be the Statoil onboard Client Representative, or any other contact requested by the Client Representative onboard.

The subsequent form and any additional pertinent information shall be sent to Statoil for review. Upon review completion, Statoil shall submit the form to BOEM and NMFS **immediately**. Sightings shall be reported to BOEM and the NMFS via the Northeast Stranding Hotline (866-755-6622). Entangled animals are to be reported to the Marine Animal Entanglement Response Team (800-900-3622).

3.3 Marine Mammal and Sea Turtle Exclusion Zone

The exclusion zone (EZ) for marine mammals and sea turtles refers to the radius around the acoustic source in which mitigation procedures (delays and shut-downs) are implemented should a marine mammal or sea turtle be detected. The EZ will be continuously monitored by the mitigation personnel in order to implement the appropriate mitigation and vessel strike avoidance measures as required.

The following EZ[3] will apply:

- 500m for North Atlantic right whales;
- 200m for all other marine mammals.

The above distances represent the default EZs stipulated in the Lease (OCS-A-0512) which shall be in effect until the IHA is granted. Once the IHA has been granted, anticipated to be the end of March 2018, the mitigation measures listed therein shall be implemented with immediate effect and a revised PSMP will be issued.

[3] These zones will be verified in the field prior to the start of the survey programme. If new EZ are recommended based on the field verification tests, PSMP will be updated and observers as well as survey team informed.

3.4 60 Minute Pre-Survey Clearance Monitoring

The PSOs and PAMS Operators shall be notified by the Senior Survey Engineer on watch in advance of planned times for activation of acoustic equipment and shall conduct dedicated visual and acoustic monitoring for a minimum of 60 minutes prior to that. The PSOs will be positioned onboard the survey vessel at a suitable location that allows a 360° view of the EZ. Upon completion of a 60 minute pre-survey clearance monitoring period with no marine mammal and sea turtle sightings or detections within the EZ, the PSOs and PAMS Operator shall inform the survey crew that the acoustic source can commence firing.

3.5 Ramp-Up Procedure

A ramp-up of all acoustic survey equipment when technically feasible should occur at the start or restart of all survey activities. The ramp-up should begin with the power of the smallest acoustic source at its lowest output. The power output should be gradually increased and other acoustic sources added in a way such as the source level would increase in steps not exceeding 6 dB per 5 minute period, where technically feasible.

The ramp-up procedure will **not** be initiated during periods of inclement conditions if the EZ cannot be adequately monitored by the PSOs using the appropriate visual technology (e.g., reticulated binoculars, night vision equipment) and/or PAM for a minimum 60-minute period.

Only the SBP (pinger) and UHRS (sparker) can be ramped up incrementally. Again, the power levels of the UHRS cannot be changed easily so it is proposed that this equipment be ramped up at increasing intervals over the period of the ramp up. It is recommended that the ramp up continues for a period of 15 to 20 minutes. The ramp up procedure for these pieces of equipment when used together will be implemented as follows:

- Period 1, 0–5 minutes: Sparker 60 second shot interval, Pinger 30% power.
- Period 2, 5–10 minutes: Sparker 30 second shot interval, Pinger 60% power.
- Period 3, 10–15 minutes: Sparker 16 second shot interval, Pinger 80% power.
- Period 4, 15–20 minutes: Sparker 0.5 second shot interval, Pinger 100% power.

Actions for the sparker will remain the same as above when firing independently. However, the ramp up procedure for the SBP (pinger) when firing independently will be implemented as follows:

- Period 1, 0–5 minutes: Pinger 20% power.
- Period 2, 5–10 minutes: Pinger 40% power.
- Period 3, 10–15 minutes: Pinger 60% power.
- Period 4, 15–20 minutes: Pinger 80% power.
- After 20 minutes: Pinger 100% power.

The USBL cannot be ramped up, so instead, in all instances it will be turned on after the pinger and sparker are at full power. During periods when the USBL is being run without any SBP or UHRS equipment in use it will only be turned on as long as the exclusion zone is clear of marine mammals and sea turtles for the full pre-clearance monitoring period.

3.6 Delay Procedures

Should marine mammals or sea turtles be detected, either visually or acoustically, within the relevant EZ during the 60 minute pre-shoot monitoring period, the PSO or PAMS Operator shall immediately alert the Senior Survey Engineer on watch who shall ensure that a delay to the firing of acoustic equipment occurs. The location of the marine mammal or sea turtle within the EZ and the distance to the acoustic source, during daylight hours, shall be confirmed using a range-finder stick and reticule binoculars. Distance to any acoustic detections shall be determined using the appropriate software of the PAMS where possible.

Start up of operations using the ramp-up procedures may not begin until the 60 minute pre-clearance time period has elapsed with no further sightings.

The survey crew shall wait to receive the 'All Clear' from the PSO and PAMS Operator before the acoustic source commences firing.

If the PAMS detects a low frequency vocalization for which the range cannot be determined and the animal cannot be visually detected, a delay of 60 minutes to operations shall be implemented from the last detection as a precautionary measure.

3.7 Shut-Down Procedures

Once the acoustic equipment is active, should a non-delphinoid cetacean or sea turtle be sighted or acoustically detected within the relevant EZ, the PSO or PAMS Operator is required to inform the Senior Survey Engineer on watch, who will call for the immediate shut-down of the acoustic equipment. The survey crew must comply immediately with such a call; any disagreement shall only be discussed after shut-down.

A restart, with a ramp-up procedure, of the acoustic sources shall commence only after the following time periods have elapsed since marine animals were last seen or detected within the EZ:

- North Atlantic right whale and sea turtles: 60 minutes;
- Large whales, including beaked whales and *Kogia sp*: 30 minutes;

If a North Atlantic right whale vocalization is detected by the PAMS, but cannot be localised, HRG survey equipment will be immediately shut down. Ramp up procedures may only begin if the right whale is confirmed to be beyond the 500m EZ, or the vocalization has stopped for at least 60 minutes.

If low frequency vocalizations are detected by the PAMS but range cannot be determined and the animal cannot be detected visually, then a 60-minute shut-down shall be implemented from the last detection as a precautionary measure.

It is a requirement to notify BOEM within 24 hours of a shut down procedure being implemented for an endangered species. The Lead PSO onboard the vessel shall undertake this duty and notify BOEM via email to renewable_reporting@BOEM.gov.

3.8 Power Down Procedures

Once the acoustic equipment is active, should a delphinoid cetacean or pinniped be sighted or acoustically detected within the EZ, the PSO or PAMS Operator is required to inform the Senior

Survey Engineer on watch. If it is determined that the small cetaceans and seals are voluntarily approaching the survey vessel, then the equipment can remain at full power, in accordance with the waiver provided to Statoil by BOEM. However, should the small cetacean and seals be determined as not approaching the vessel, the Survey Engineer on watch will call for the immediate power down of the acoustic equipment to the lowest power output that is technically feasible. The survey crew must comply immediately with such a call; any disagreement shall only be discussed after shut-down.

The acoustic equipment can return to operational level following the aforementioned ramp-up procedures only after:

- The EZ is clear of delphinoid cetaceans and pinnipeds, or
- The PSO determines that, after 10 minutes of observation, the delphinoid cetacean and/or pinniped has changed behaviour and is voluntarily approaching the vessel or towed equipment to bow-ride or chase the equipment.

3.9 Breaks in Acoustic Activity

If a break in acoustic activity occurs (due to *e.g*. mechanical or electrical failure) for less than 20 minutes, operations can recommence at operational level as soon as practicable on condition that a PSO and PAMS Operator (when applicable) have been conducting continuous monitoring and no marine mammals or sea turtles have been detected within the relevant EZ during this time. If the observers were not monitoring continuously during the break then full pre-shoot monitoring and ramp-up must be undertaken. For a break of longer than 20 minutes, the acoustic operations may only be started after full ramp-up have been undertaken and continuous visual and/or acoustic monitoring has confirmed the absence of marine mammals and turtles in the EZ for the 60 minute pre-clearance period.

3.10 Dynamic Management Area Shut-Down Requirement

All HRG survey activities shall be stopped within 24-hours of NMFS establishing a DMA in the survey area. The geophysical survey shall only resume once the DMA has expired.

4. REPORTING

4.1 Daily Reporting

Daily Progress Reports issued by the Party Chief throughout the project will contain information specific to PSO/PAM activity such as:

- Number of visual sightings and acoustic detections of cetaceans, pinnipeds and sea turtles;
- Details of each sighting / detection, including (where possible) species group, number of animals, distance from the sound source, and behavioural observations;
- Details of mitigation action taken, where required.

4.2 Protected Species Reporting

Throughout the project, the PSOs /PAMS Operators will record information on survey operations and all dedicated visual and acoustic monitoring. There are no BOEM-specific recording forms at the present time, so Gardline would propose to use bespoke JNCC forms that will contain the following information as a minimum (as per Appendix B to Addendum C Lease OCS-A 0512):

- Vessel name;
- Observers' names and affiliations;
- Date and location of survey operations;
- Time and latitude/longitude when daily visual/acoustic survey began;
- Time and latitude/longitude when daily visual/acoustic survey ended;
- Environmental conditions during visual/acoustic surveys including:
  - Wind speed and direction,
  - Sea state,
  - Swell,
  - Visibility.
- Species (or identification to lowest possible taxonomic level):
  - Certainty of identification (sure, most likely, best guess),
  - Total number of animals,
  - Number of juveniles,
  - Time and location (i.e., distance from sound source) of observation,
  - Description (as many distinguishing features as possible of each individual seen, including length, shape, colour and pattern, scars or marks, shape and size of dorsal fin, shape of head, and blow characteristics),
  - Direction of animal's travel – related to the vessel (drawing preferably),
  - Reaction of the animal(s) to relevant sound source (if any) and behaviour − as explicit and detailed as possible: note any observed changes in behaviour (e.g., avoidance, approach) including bearing and direction of travel,
  - Activity of vessel when sighting occurred.

The proposed PSO-recording forms are attached.

All injured or dead protected species shall be reported to NMFS via the Greater Atlantic Region Stranding Hotline (866-755-6622) within 24-hours of the sighting. A standardised incident report shall be completed for each sighting (see section 3.2).

4.3 Final Reporting

4.3.1 Protected Species Monitoring Report

A Draft Protected Species Monitoring Report (unless otherwise required) will be submitted to Statoil within 4 weeks from demobilisation. The report will detail all visual and acoustic monitoring undertaken throughout the survey, all sightings recorded as well as an interpretation of the results and effectiveness of all monitoring tasks and the performance of, the PAM and Night Vision set-up employed during survey operations at night. Specifically, the effectiveness of the monitoring equipment should be assessed based on factors such as range accuracy and limitation, weather limitations, number of detections per unit effort, and operational complexity. A final report will be submitted 45 calendar days from demobilisation, subject to receipt of comments.

5. REFERENCES

BARTOL, S.M., MUSICK, J.A. AND LENHARDT, M.L. 1999. Auditory evoked potentials of the loggerhead sea turtle (*Caretta carretta*). *Copeia*, 3:836-840.

BRODERICK, A.C., COYNE, M.S., FULLER, W.J., GLEN, F. AND GODLEY, B.J. 2007. Fidelity and over-wintering of sea turtles. *Proceedings of the Royal Society B*, 274: 1533-1538.

DENG, Z.D., SOUTHALL, N.L., CARLSON, T.J., XU, J., MARTINEZ, J.J., WEILAND, M.A. AND INGRAHAM, J.M. 2014. 200 kHz commercial sonar systems generate lower frequency side lobes audible to some marine mammals. *PLoS One*, 9(4): e95315.

DOLMAN, S., WILLIAMS-GREY, V., ASMUTIS-SILVIA, R. AND ISAAC, S. 2006. *Vessel collisions and cetaceans: what happens when they don't miss the boat.* WDCS, Chippenham, Wiltshire, UK.

GOTZ, T., HASTIE, G., HATCH, L.T., RAUSTEIN, O., SOUTHALL, B.L. AND TASKER, M. 2009. Overview of the impacts of anthropogenic sound in the marine environment. OSPAR Commission Biodiversity Series. Publication Number 441/2009. OSPAR Commission, UK.

HEINEMANN, D. 1981. A range finder for pelagic bird censusing. *Journal of Wildlife Management*, 45 (2): 489-293.

KNOWLTON, A.R. AND KRAUS, S.D. 2001. Mortality and serious injury of northern right whales (*Eubalaena gracialis*) in the western North Atlantic Ocean. *Journal of Cetacean Research and Management,* (Special Issue) 2: 193-208.

LAIST, D.W., KNOWLTON, A.R. AND PENDLETON, D. 2014. Effectiveness of mandatory vessel speed limits for protecting North Atlantic right whales. *Endangered Species Research*, 23: 133-147.

NATIONAL OCEANIC AND ATMOSPHERIC ASSOCIATION (NOAA). 2008. Vessel Strike Avoidance Measures and Reporting for Mariners. NOAA Fisheries Service, South East Region. Florida, USA.

NEFSC (NORTHEAST FISHERIES SCIENCE CENTRE). 2015a. *Ecology of the Northeast U.S. Continental Shelf. Whales and dolphins*. NESFC, NOAA. Accessed on 30th April 2015 from www.nefsc.noaa.gov/ecosys/ecology/ProtectedSpecies/Cetaceans.

NEFSC (NORTHEAST FISHERIES SCIENCE CENTRE). 2015b. *Ecology of the Northeast U.S. Continental Shelf. Protected Species*. NESFC, NOAA. Accessed on 30th April 2015 from www.nefsc.noaa.gov/ecosys/ecology/ProtectedSpecies/index.

RICHARDSON, W.J., GREENE, JR., C.R., MALME, C.I. AND THOMPSON, D.H. 1995. *Marine Mammals and Noise*. Academic Press, San Diego, USA.

SOUTHALL, B.L., BOWLES, A.E., ELLISON, W.T., FINNERAN, J.J., GENTRY, R.L., GREENE, JR., C.R., KASTAK, D., KETTEN, D.R., MILLER, J.H., NACHTIGALL, P.E., RICHARDSON, W.J., THOMAS, J.A. AND TYACK, P.L. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals*, 33 (7).

VANDERLAAN, A.S.M. AND TAGGART, C.T. 2007. Vessel collisions with whales: the probability of lethal injury based on vessel speed. *Marine Mammal Science*, 23 (1): 144-156.

VAN WAEREBEEK, K., BAKER, A.N., FÉLIZ, F., GEDAMKE, J., IÑIGUEZ, M., SANION, G.P., SECCHI, E., SUTARIA, D., VAN HELDEN, A. AND WANG, Y. 2007. Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, an initial assessment. *Latin American Journal of Aquatic Mammals*, 6 (1): 43-69.

WARING, G.T., JOSEPHINE, E., MAZE-FOLEY, K., ROSEL, P.E. (EDS.) 2013. *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2012*. NOAA Technical Memo NMFS NE 223; 419 pp. Available from National Marine Fisheries Service, Massachusetts or online at www.nesfc.noaa.gov/nefsc/publications.

APPENDICES

APPENDIX A CALIBRATION INSTRUCTIONS FOR DISTANCE ESTIMATIONS

All observers should calibrate their monitoring equipment for distance estimation (i.e. range-finder stick, reticule binoculars, night-vision binoculars (with COTI)) throughout the survey, where possible**.**

For reticule binoculars and range finder sticks this includes carrying out the following procedure:

- For visual distance estimating equipment, measure the height of the observer deck and account for any changes in height (i.e. make new range-finder stick; recalculate distances for reticule binoculars).
- Take note of the observer, the height of platform and the height of eye of the observer;
- Measurements should be taken at least once per week throughout the project.
- The observer should estimate distance of a stationary object using firstly the range finder stick and secondly the reticule binoculars.
- The measurement should be taken where the object touches the water surface when there is a clear view of the horizon.
- If for any reason measurement of both pieces of equipment is not possible at the same time please state why.
- A range of objects at a number of distances should be taken. This includes measurements within 500m where possible.
- Where possible PSOs will take measurements in a range of weather conditions each week providing that Beaufort sea state is <4.
- If any of the observers recorded a distance that is significantly different than the one provided by the onboard system, then he/she needs to measure his/her height and arm length again in order to correct the error.
- This should all be recorded on the associated excel spreadsheet (Table A1).

Table A1 Example of calibration spreadsheet for reticule binoculars and range finder sticks

Date	Name of Observer	Number of Reticules from the horizon	Reticule Binoculars Distance (m)	Range Finder Distance (m)	Distance provided by the system onboard (m)	Sea state (Beaufort Scale)	Swell (m)	Height of Platform (m)
01/07/16	PSO 1	2	358	300	320	3	1	6.1

Reticule binoculars and range finder sticks cannot be used to prove the effectiveness of night vision devices as the horizon will not be observed. In order to test the effectiveness of this equipment at night, the distance of various stationary objects at a known distance should be checked on the ships radar where possible and filled into an associated spreadsheet stating whether or not that object was visible to the observer (Table A2). Effort should be made where possible to take measurements in a range of weather conditions.

Table A2 Example of calibration spreadsheet for reticule binoculars and range finder sticks

Date	Name of Observer	Distance provided by the system onboard	Sea state (Beaufort Scale)	Swell (m)	Object type	Object in view (y/n)	Height of Platform (m)
01/07/2016	PSO 1	400	2	1	Buoy	Y	6.2

APPENDIX B RIGHT WHALE MANDATORY SHIP REPORTING SYSTEM

Right Whale Mandatory Ship Reporting System

All commercial ships of 300 gross tons and greater are required to report in when they enter either of two designated right whale reporting areas along the U.S. East Coast. All ships equipped with INMARSAT C must report in IMO standard format as provided in the table below. For further information on reporting procedures please consult 33 CFR Part 169, the Coast Pilot, or the Mandatory Ship Reporting (MSR) System web site at:
http://www.nmfs.noaa.gov/prot_res/PR2/Conservation_and_Recovery_Program/msr/msrhome.html

Mandatory Reporting Requirements: (Report to: rightwhale.msr@noaa.gov or Telex: 48156090)

Paragraph	Function	Information Required
System Name	Area Identifier	Reporting system area name (WHALESNORTH).
M	INMARSAT Number	9-digit vessel INMARSAT number.
A	Ship	Vessel name and call sign.
B	Date, time, and month of report	6-digit group giving day of month and time, single letter indicating time zone, and three letters indicating month.
E	True course	3-digit number indicating true course.
F	Speed in knots and tenths	3-digit group indicating knots and tenths.
H	Date, time, and point of entry into system	Date and time expressed as in (B) and latitude and longitude expressed as a four digit group giving latitude, the letter N indicating north, followed by a / , a five digit group giving longitude, and the letter W indicating west.
I	Destination and ETA	Name of port and arrival time expressed as in (B).
L	Route information and speed	Route information should be reported as direct rhumbline to port (RL) and intended speed or a series of way points (WP). Vessels reporting waypoints should include latitude and longitude, expressed as in (H), and intended speed between waypoints. For vessels transiting within a traffic separation scheme (TSS), give only the WP on entry and departure of TSS.

WHALESNORTH BOUNDARY

The area coordinates (NAD 83) are as follows: from a point on Cape Ann, Massachusetts at 42°39'N, 70°37'W; then northeast to 42°45'N, 70°13'W; then southeast to 42°10'N, 68°31'W; then south to 41°00'N, 68°31'W; then west to 41°00'N, 69°17'W; then northwest to 42°05'N, 70°02'W, then west to 42°04'N, 70°10'W; and then along the Massachusetts shoreline of Cape Cod Bay and Massachusetts Bay back to the point on Cape Ann at 42°39'N, 70°37'W.

WHALESNORTH (operates year round)

NOAA Chart #13009

EXAMPLE REPORT:
Please follow the format exactly as outlined below.

WHALESNORTH//
M/487654321//
A/CALYPSO/NRUS//
B/031401Z APR//
E/345//
F/15.5//
H/031410Z APR/4104N/06918W//
I/BOSTON/032345Z APR//
L/WP/4104N/06918W/15.5//
L/WP/4210N/06952W/15.5//
L/WP/4230N/07006W/15.5//

*Vessels not equipped with INMARSAT C should still report via alternate satellite communications equipment to rightwhale.msr@noaa.gov or Telex: 48156090.

*Vessels unable to use satellite communications equipment should contact the U.S. Coast Guard Communication Area Master Station, Chesapeake, VA via published voice frequencies on 2182 kHz, 4125 kHz, 6215 kHz, 8291 kHz, 12290 kHz, 16420 kHz 24 hours per day or by phone at 1-800-742-8519 ext. 0.

WARNING
DO NOT INCLUDE ADDITIONAL MESSAGES OR CHARACTERS IN YOUR REPORT. FAILURE TO FOLLOW THE EXACT FORMAT WILL CAUSE THE MSR COMPUTER SYSTEM TO REJECT YOUR REPORT.

Update 11/2008

OMB Control #1625-0103

APPENDIX C INCIDENT REPORT FORM: PROTECTED SPECIES INJURY OR MORTALITY

INCIDENT REPORT: PROTECTED SPECIES INJURY OR MORTALITY

Photographs and/or video footage should be taken of all injured or dead animals, if possible

Observer's full name and/or Reporter's full name: ______________________

Date and Time animal observed: ______________________

Date and Time animal/samples collected: ______________________

Location of Incident (Latitude/Longitude): ______________________

Species Identification (closest taxonomic level possible): ______________________

Photograph/Video footage collected: YES / NO

If Yes, was the data provided to NMFS? YES/ NO

Name of vessel, vessel speed at the times of incident, and activity ongoing at the time of observation (e.g. transit, survey, pile driving): ______________________

Environmental conditions at time of observation (i.e. Beaufort sea state, cloud cover, wind speed, glare):

____

Water temperature (°C) and depth at site of observation: ______________________

Describe location of animal and events leading up to, including, and after, the incident: ______________________

Status of all sound-source use in the 24 hours preceding the incident: ______________________

Describe all marine mammal, sea turtle, and sturgeon observations in the 24 hours preceding the incident:

____

Marine Mammal Information:

Injuries observed: ______________________

Condition/description of animal: ______________________

Other remarks: ______________________

Date and time of incident reported to NMFS Stranding Hotline: ______________________

Sturgeon Information:

Fork length (or total length): ______________________________ Weight: ___________________________________

Condition of specimen/description of animal:____

____

Fish Decomposed: NO SLIGHTLY MODERATELY SEVERLY

Fish tagged: YES / NO *Please record all tag numbers. Tag #:* ____

Photograph taken: YES / NO

(Please label *species, date, geographic site* and *vessel name* when transmitting photo)

Genetics sample taken: YES / NO

Genetics sample transmitted to: ____________________ on (mm/dd/yyyy) _________________________________

____

Sea Turtle Species Information (*Please designate cm/m or inches*):

Weight (kg or lbs): ______________________________

Sex (circle): MALE FEMALE UNKNOWN How was sex determined? ____________________

Straight carapace length: ____________________ Straight carapace width: ________________________

Curved carapace length: ____________________ Curved carapace width: ________________________

Plastron length: ____________________________ Plastron width: _________________________________

Tail length: ________________________________ Head width: ____________________________________

Condition of specimen/description of animal: ____

____

Existing Flipper Tag Information: ____

Left: _______________ Right: _______________

PIT Tag #: ____________________________________

Miscellaneous:

Genetic biopsy taken: YES / NO

Photos taken: YES / NO

Turtle Release Information

Date: ___________________ Time: ____________________

Latitude: ________________ Longitude: ________________

State: __________________ County: ___________________

Remarks: (note if turtle was involved with tar or oil, gear or debris entanglement, wounds or mutilations, propeller damage, papillomas, old tag locations, etc.):

____

____

____

APPENDIX D COMPLETED PSO RECORDING FORMS

The completed PSO forms can be found in the Excel document entitled:
11179_Equinor_OCS-A 0512_Shearwater_PSOPAMforms