# Malin Head Offshore Wind Farm

# Foreshore Licence Application for Site Investigation Works

*Schedule of Works*

## Document Control

| Revision | Date | Authored: | Checked: | Approved: |
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| 00 | 29/06/2022 | [redacted] | | |
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# 1 Introduction

Malin Array Limited proposes to investigate the feasibility of developing an offshore wind farm, Malin Head Offshore Wind Farm, off the coast of county Donegal.

Malin Array Limited has prepared this report in support of an application for a Foreshore Licence under Section 3 of the Foreshore Act 1933, as amended, to carry out site investigation activities to determine the suitability of the Foreshore Licence Application Area for the development of an offshore wind farm.

Malin Array Limited intends to undertake a survey campaign at the proposed Foreshore Licence Application Area to inform the location and design of the proposed offshore wind farm and cable route to shore.

## 1.1 Foreshore License Application Area

The Foreshore License Application Area is situated off the coast of county Donegal (Figure 1-1).

Malin Array Limited acknowledges that it is only possible at this time to obtain a Site Investigation Licence for that area situated within the 12nm boundary. Malin Array Limited is not proposing at this time to undertake any intrusive surveys outside the 12nm limit regulated under the Foreshore Act 1933, as amended.

This Foreshore Licence Application seeks consent to conduct site investigation activities within the 12nm boundary to establish the potential for offshore wind farm development off the coast of counties Donegal. If the Foreshore Licence Application Area investigation activities, together with desktop studies and stakeholder engagement, indicates the feasibility of developing a wind farm, the project will be progressed at that point in accordance with the National Marine Planning Framework and other relevant legislation including the new consenting regime for offshore renewable energy being legislated for through the Maritime Area Planning Act 2021 (MAPA).

The Foreshore Licence Application Area covers a total area of 835.25 km$^2$. The Foreshore Licence Application Area is comprised of the Offshore Wind Farm (OWF) Area within the 12nm boundary (610.03 km$^2$) and the Offshore Export Cable Corridor (OECC) Area (225.22 km$^2$). The western boundary of the OWF area within the 12nm boundary is adjoined by the 12nm boundary.

The Foreshore Licence Application Area, OWF Area within the 12nm boundary and OECC Area are shown in Figure 1-1.

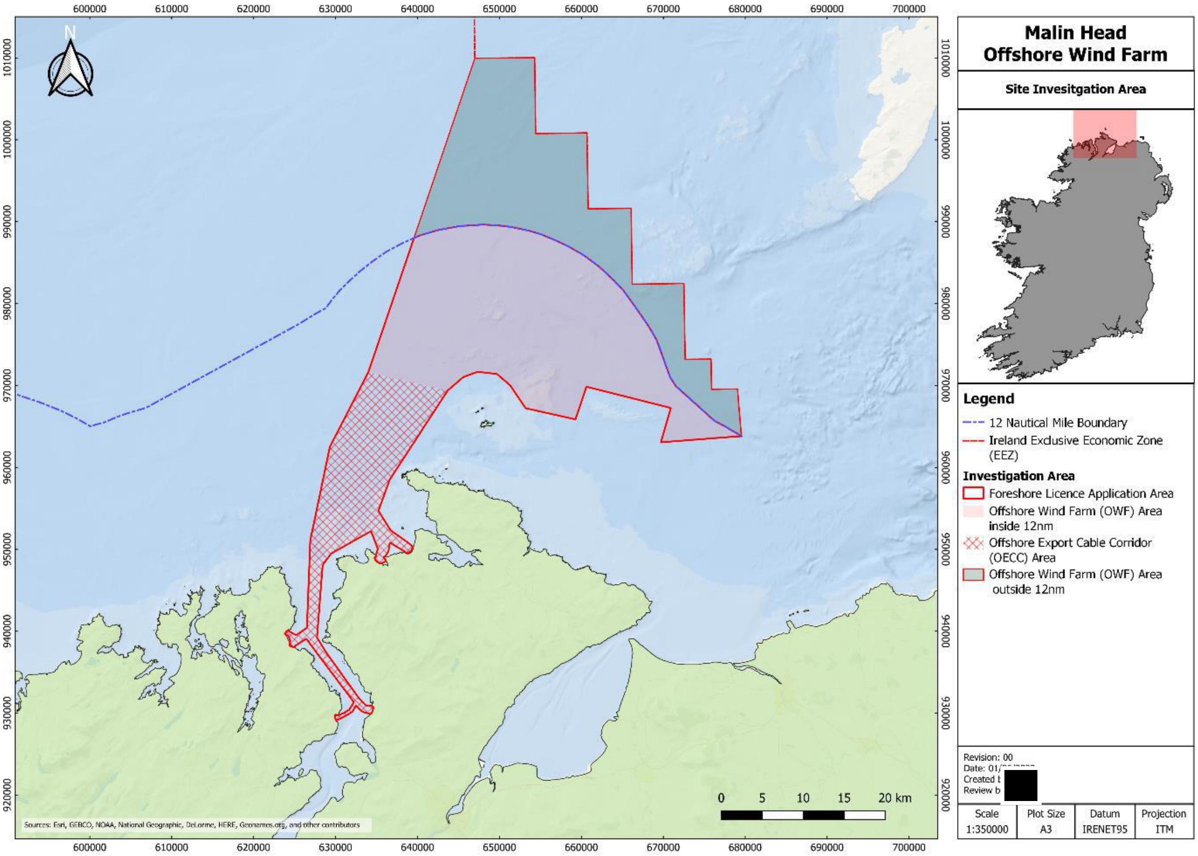


***Figure 1-1: Malin Head Offshore Wind Farm. Note Foreshore Licence Application Area is all within 12 nm.***

***Table 1-1: Foreshore Licence Application Area Coordinates***

| Point No. | WGS84 / UTM zone 29N EPSG:32629 | | WGS84 Geographic EPSG:4326 | | IRENET95 / Irish Transverse Mercator EPSG:2157 | |
|---|---|---|---|---|---|---|
| | X | Y | Longitude | Latitude | X | Y |
| 0 | 597075.82 | 6108946.18 | -7.47792 | 55.11769 | 633305.78 | 930158.67 |
| 1 | 596458.94 | 6109467.33 | -7.48742 | 55.12250 | 632696.36 | 930688.66 |
| 2 | 596235.57 | 6109718.05 | -7.49083 | 55.12479 | 632476.57 | 930942.59 |
| 3 | 595831.56 | 6108965.00 | -7.49742 | 55.11810 | 632061.77 | 930195.30 |
| 4 | 595033.06 | 6108453.51 | -7.51011 | 55.11366 | 631255.93 | 929695.24 |
| 5 | 594291.03 | 6108068.32 | -7.52186 | 55.11034 | 630508.37 | 929320.67 |
| 6 | 594082.51 | 6107963.30 | -7.52516 | 55.10944 | 630298.34 | 929218.63 |
| 7 | 593978.90 | 6107915.84 | -7.52680 | 55.10903 | 630194.05 | 929172.65 |
| 8 | 593861.86 | 6107854.53 | -7.52866 | 55.10851 | 630076.13 | 929113.01 |
| 9 | 593770.78 | 6108011.23 | -7.53003 | 55.10993 | 629987.29 | 929271.03 |
| 10 | 593697.14 | 6108301.23 | -7.53109 | 55.11255 | 629917.80 | 929562.09 |
| 11 | 593743.00 | 6108586.68 | -7.53028 | 55.11511 | 629967.75 | 929846.89 |
| 12 | 593898.58 | 6108501.09 | -7.52787 | 55.11431 | 630122.11 | 929759.06 |

| Point No. | WGS84 / UTM zone 29N EPSG:32629 | | WGS84 Geographic EPSG:4326 | | IRENET95 / Irish Transverse Mercator EPSG:2157 | |
|---|---|---|---|---|---|---|
| | X | Y | Longitude | Latitude | X | Y |
| 13 | 594068.13 | 6108466.09 | -7.52522 | 55.11396 | 630291.16 | 929721.64 |
| 14 | 594864.11 | 6108838.36 | -7.51262 | 55.11715 | 631092.49 | 930082.52 |
| 15 | 595417.02 | 6109187.04 | -7.50384 | 55.12018 | 631650.40 | 930423.29 |
| 16 | 595987.81 | 6110114.61 | -7.49458 | 55.12840 | 632234.48 | 931342.70 |
| 17 | 591723.57 | 6115605.93 | -7.55966 | 55.17854 | 628048.83 | 936895.22 |
| 18 | 590077.44 | 6117778.82 | -7.58481 | 55.19836 | 626433.80 | 939091.76 |
| 19 | 588680.59 | 6116869.79 | -7.60703 | 55.19045 | 625023.88 | 938202.73 |
| 20 | 588621.75 | 6116700.02 | -7.60801 | 55.18893 | 624962.60 | 938033.80 |
| 21 | 588529.54 | 6116707.68 | -7.60945 | 55.18902 | 624870.51 | 938042.78 |
| 22 | 588417.84 | 6116760.40 | -7.61119 | 55.18951 | 624759.56 | 938097.10 |
| 23 | 588190.96 | 6116821.97 | -7.61473 | 55.19011 | 624533.55 | 938161.92 |
| 24 | 588098.19 | 6116875.14 | -7.61617 | 55.19060 | 624441.54 | 938216.42 |
| 25 | 588027.99 | 6116945.12 | -7.61726 | 55.19124 | 624372.34 | 938287.41 |
| 26 | 588002.66 | 6116975.06 | -7.61764 | 55.19151 | 624347.44 | 938317.72 |
| 27 | 588012.53 | 6117021.62 | -7.61747 | 55.19193 | 624357.98 | 938364.13 |
| 28 | 588092.13 | 6117098.32 | -7.61620 | 55.19261 | 624438.68 | 938439.70 |
| 29 | 588078.06 | 6117175.80 | -7.61640 | 55.19330 | 624425.72 | 938517.38 |
| 30 | 588017.41 | 6117271.65 | -7.61732 | 55.19418 | 624366.44 | 938614.11 |
| 31 | 588123.01 | 6117524.93 | -7.61558 | 55.19643 | 624475.67 | 938865.87 |
| 32 | 587818.94 | 6118175.46 | -7.62016 | 55.20233 | 624180.92 | 939520.78 |
| 33 | 587581.61 | 6118163.03 | -7.62389 | 55.20226 | 623943.41 | 939511.75 |
| 34 | 587477.82 | 6118283.66 | -7.62548 | 55.20336 | 623841.34 | 939633.88 |
| 35 | 587439.49 | 6118338.43 | -7.62607 | 55.20386 | 623803.80 | 939689.20 |
| 36 | 587453.09 | 6118388.34 | -7.62584 | 55.20431 | 623818.11 | 939738.91 |
| 37 | 587489.32 | 6118415.45 | -7.62526 | 55.20455 | 623854.74 | 939765.51 |
| 38 | 587511.46 | 6118442.85 | -7.62490 | 55.20479 | 623877.27 | 939792.59 |
| 39 | 587554.34 | 6118482.43 | -7.62422 | 55.20514 | 623920.72 | 939831.56 |
| 40 | 587572.09 | 6118527.68 | -7.62392 | 55.20554 | 623939.11 | 939876.55 |
| 41 | 587580.08 | 6118585.25 | -7.62378 | 55.20606 | 623947.93 | 939934.01 |
| 42 | 587589.91 | 6118644.40 | -7.62361 | 55.20658 | 623958.60 | 939993.02 |
| 43 | 587605.13 | 6118664.23 | -7.62336 | 55.20676 | 623974.12 | 940012.64 |
| 44 | 587633.92 | 6118664.27 | -7.62291 | 55.20676 | 624002.91 | 940012.27 |
| 45 | 587659.76 | 6118660.76 | -7.62251 | 55.20672 | 624028.69 | 940008.38 |
| 46 | 587693.60 | 6118683.89 | -7.62197 | 55.20692 | 624062.87 | 940031.02 |
| 47 | 587700.76 | 6118680.79 | -7.62186 | 55.20689 | 624069.98 | 940027.82 |
| 48 | 587746.91 | 6118693.16 | -7.62113 | 55.20699 | 624116.31 | 940039.54 |

| Point No. | WGS84 / UTM zone 29N EPSG:32629 | | WGS84 Geographic EPSG:4326 | | IRENET95 / Irish Transverse Mercator EPSG:2157 | |
|---|---|---|---|---|---|---|
| | X | Y | Longitude | Latitude | X | Y |
| 49 | 587766.52 | 6118719.31 | -7.62081 | 55.20723 | 624136.29 | 940065.41 |
| 50 | 587776.85 | 6118712.96 | -7.62065 | 55.20717 | 624146.54 | 940058.90 |
| 51 | 587803.69 | 6118722.55 | -7.62023 | 55.20725 | 624173.52 | 940068.11 |
| 52 | 587808.60 | 6118740.30 | -7.62014 | 55.20741 | 624178.68 | 940085.79 |
| 53 | 587804.84 | 6118777.93 | -7.62019 | 55.20775 | 624175.46 | 940123.48 |
| 54 | 587844.36 | 6118804.38 | -7.61956 | 55.20798 | 624215.36 | 940149.35 |
| 55 | 587864.50 | 6118840.46 | -7.61923 | 55.20830 | 624236.01 | 940185.15 |
| 56 | 587867.80 | 6118857.36 | -7.61918 | 55.20845 | 624239.56 | 940202.00 |
| 57 | 587884.33 | 6118856.64 | -7.61892 | 55.20844 | 624256.08 | 940201.05 |
| 58 | 587888.57 | 6118836.94 | -7.61886 | 55.20826 | 624260.03 | 940181.29 |
| 59 | 587882.94 | 6118813.13 | -7.61895 | 55.20805 | 624254.06 | 940157.55 |
| 60 | 587938.83 | 6118711.45 | -7.61811 | 55.20713 | 624308.50 | 940055.08 |
| 61 | 588002.94 | 6118629.33 | -7.61712 | 55.20638 | 624371.44 | 939972.03 |
| 62 | 588813.39 | 6118201.73 | -7.60453 | 55.20239 | 625175.78 | 939532.80 |
| 63 | 590118.78 | 6119111.94 | -7.58373 | 55.21033 | 626494.25 | 940424.32 |
| 64 | 590376.82 | 6129784.60 | -7.57625 | 55.30616 | 626905.39 | 951093.56 |
| 65 | 592597.22 | 6141222.80 | -7.53751 | 55.40849 | 629290.11 | 962500.15 |
| 66 | 597159.53 | 6150399.55 | -7.46227 | 55.49004 | 633984.45 | 971611.46 |
| 67 | 602498.30 | 6166859.24 | -7.37171 | 55.63679 | 639560.26 | 987994.47 |
| 68 | 642834.02 | 6143257.98 | -6.74358 | 55.41471 | 679555.32 | 963813.28 |
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| 72 | 623807.49 | 6149027.55 | -7.04138 | 55.47170 | 660612.52 | 969856.18 |
| 73 | 622530.79 | 6145021.87 | -7.06333 | 55.43605 | 659278.27 | 965868.96 |
| 74 | 616424.65 | 6146298.57 | -7.15925 | 55.44900 | 653190.59 | 967233.42 |
| 75 | 614496.82 | 6149056.65 | -7.18857 | 55.47423 | 651302.45 | 970019.19 |
| 76 | 612870.47 | 6150421.17 | -7.21374 | 55.48686 | 649695.75 | 971407.09 |
| 77 | 610516.40 | 6150656.14 | -7.25088 | 55.48951 | 647345.07 | 971675.92 |
| 78 | 608769.17 | 6149993.32 | -7.27878 | 55.48395 | 645588.32 | 971038.24 |
| 79 | 606887.64 | 6148323.88 | -7.30918 | 55.46937 | 643682.78 | 969395.86 |
| 80 | 599963.49 | 6137339.41 | -7.42260 | 55.37217 | 636600.72 | 958510.85 |
| 81 | 598642.20 | 6133523.44 | -7.44478 | 55.33816 | 635224.61 | 954713.81 |
| 82 | 600162.80 | 6131164.94 | -7.42166 | 55.31666 | 636711.36 | 952333.46 |
| 83 | 602299.21 | 6129689.26 | -7.38855 | 55.30297 | 638826.62 | 950827.10 |
| 84 | 602902.87 | 6129213.54 | -7.37922 | 55.29857 | 639423.45 | 950342.71 |

| Point No. | WGS84 / UTM zone 29N EPSG:32629 | | WGS84 Geographic EPSG:4326 | | IRENET95 / Irish Transverse Mercator EPSG:2157 | |
|---|---|---|---|---|---|---|
| | X | Y | Longitude | Latitude | X | Y |
| 85 | 602841.72 | 6129006.73 | -7.38026 | 55.29673 | 639359.33 | 950136.78 |
| 86 | 602720.45 | 6128728.10 | -7.38227 | 55.29425 | 639234.06 | 949859.89 |
| 87 | 602578.97 | 6128572.18 | -7.38455 | 55.29288 | 639090.34 | 949706.00 |
| 88 | 602421.61 | 6128487.01 | -7.38706 | 55.29214 | 638931.76 | 949623.08 |
| 89 | 602239.71 | 6128401.83 | -7.38995 | 55.29142 | 638748.63 | 949540.51 |
| 90 | 602086.68 | 6128406.16 | -7.39236 | 55.29149 | 638595.66 | 949547.04 |
| 91 | 602017.38 | 6128446.58 | -7.39344 | 55.29187 | 638526.94 | 949588.46 |
| 92 | 601987.06 | 6128550.53 | -7.39388 | 55.29281 | 638498.12 | 949692.84 |
| 93 | 601880.23 | 6128621.27 | -7.39553 | 55.29346 | 638392.30 | 949765.11 |
| 94 | 600350.05 | 6129499.03 | -7.41931 | 55.30166 | 636874.70 | 950664.84 |
| 95 | 600082.36 | 6129652.58 | -7.42347 | 55.30310 | 636609.22 | 950822.23 |
| 96 | 599938.67 | 6128611.50 | -7.42610 | 55.29377 | 636450.58 | 949783.20 |
| 97 | 599655.55 | 6128125.35 | -7.43073 | 55.28946 | 636160.48 | 949301.12 |
| 98 | 599641.72 | 6128074.65 | -7.43097 | 55.28901 | 636145.92 | 949250.61 |
| 99 | 599618.67 | 6128042.38 | -7.43134 | 55.28873 | 636122.41 | 949218.68 |
| 100 | 599572.58 | 6128010.12 | -7.43208 | 55.28844 | 636075.86 | 949187.07 |
| 101 | 599544.92 | 6127968.63 | -7.43253 | 55.28808 | 636047.60 | 949145.98 |
| 102 | 599540.31 | 6127964.02 | -7.43260 | 55.28804 | 636042.93 | 949141.44 |
| 103 | 599517.26 | 6127973.24 | -7.43296 | 55.28812 | 636020.01 | 949150.99 |
| 104 | 599392.81 | 6127876.45 | -7.43495 | 55.28728 | 635894.17 | 949055.98 |
| 105 | 599378.98 | 6127844.18 | -7.43518 | 55.28699 | 635879.88 | 949023.91 |
| 106 | 599392.81 | 6127811.91 | -7.43498 | 55.28670 | 635893.24 | 948991.44 |
| 107 | 599415.86 | 6127784.26 | -7.43462 | 55.28645 | 635915.89 | 948963.45 |
| 108 | 599420.47 | 6127761.21 | -7.43456 | 55.28624 | 635920.17 | 948940.34 |
| 109 | 599429.69 | 6127728.94 | -7.43443 | 55.28595 | 635928.93 | 948907.94 |
| 110 | 599443.51 | 6127687.46 | -7.43422 | 55.28557 | 635942.16 | 948866.26 |
| 111 | 599438.90 | 6127655.19 | -7.43431 | 55.28528 | 635937.09 | 948834.06 |
| 112 | 599485.00 | 6127678.24 | -7.43357 | 55.28548 | 635983.51 | 948856.44 |
| 113 | 599508.05 | 6127715.11 | -7.43320 | 55.28581 | 636007.09 | 948892.99 |
| 114 | 599535.70 | 6127696.68 | -7.43277 | 55.28564 | 636034.48 | 948874.15 |
| 115 | 599581.80 | 6127576.83 | -7.43209 | 55.28455 | 636078.86 | 948753.65 |
| 116 | 599614.06 | 6127498.47 | -7.43161 | 55.28384 | 636110.00 | 948674.82 |
| 117 | 599627.89 | 6127438.55 | -7.43141 | 55.28330 | 636122.97 | 948614.70 |
| 118 | 599687.81 | 6127406.28 | -7.43048 | 55.28300 | 636182.43 | 948581.57 |
| 119 | 599604.84 | 6127350.97 | -7.43180 | 55.28252 | 636098.66 | 948527.45 |
| 120 | 599485.00 | 6127295.66 | -7.43371 | 55.28204 | 635978.02 | 948473.86 |

| Point No. | WGS84 / UTM zone 29N EPSG:32629 | | WGS84 Geographic EPSG:4326 | | IRENET95 / Irish Transverse Mercator EPSG:2157 | |
|---|---|---|---|---|---|---|
| | X | Y | Longitude | Latitude | X | Y |
| 121 | 599342.11 | 6127217.30 | -7.43598 | 55.28137 | 635834.00 | 948397.55 |
| 122 | 599213.04 | 6127171.20 | -7.43803 | 55.28098 | 635704.28 | 948353.30 |
| 123 | 599079.37 | 6127143.54 | -7.44015 | 55.28076 | 635570.21 | 948327.56 |
| 124 | 598904.21 | 6127148.15 | -7.44290 | 55.28084 | 635395.11 | 948334.69 |
| 125 | 598765.93 | 6127203.47 | -7.44506 | 55.28136 | 635257.62 | 948391.98 |
| 126 | 598540.06 | 6127327.92 | -7.44857 | 55.28252 | 635033.54 | 948519.68 |
| 127 | 598406.39 | 6127438.55 | -7.45063 | 55.28355 | 634901.45 | 948632.23 |
| 128 | 598323.42 | 6127544.57 | -7.45190 | 55.28451 | 634820.00 | 948739.44 |
| 129 | 598281.94 | 6127655.19 | -7.45252 | 55.28552 | 634780.10 | 948850.66 |
| 130 | 598254.28 | 6127756.60 | -7.45292 | 55.28643 | 634753.90 | 948952.47 |
| 131 | 598272.72 | 6127839.57 | -7.45260 | 55.28717 | 634773.53 | 949035.17 |
| 132 | 598309.59 | 6127890.27 | -7.45200 | 55.28762 | 634811.13 | 949085.35 |
| 133 | 598337.25 | 6127936.37 | -7.45155 | 55.28803 | 634839.45 | 949131.05 |
| 134 | 598406.39 | 6127927.15 | -7.45046 | 55.28793 | 634908.46 | 949120.83 |
| 135 | 598420.22 | 6128139.18 | -7.45017 | 55.28984 | 634925.33 | 949332.67 |
| 136 | 598633.94 | 6128875.93 | -7.44655 | 55.29641 | 635149.63 | 950066.36 |
| 137 | 598490.01 | 6129236.40 | -7.44869 | 55.29968 | 635010.88 | 950428.90 |
| 138 | 597776.51 | 6131023.33 | -7.45930 | 55.31587 | 634323.02 | 952226.10 |
| 139 | 592952.91 | 6128224.70 | -7.53620 | 55.29167 | 629459.16 | 949496.65 |
| 140 | 591930.15 | 6126811.13 | -7.55277 | 55.27916 | 628416.09 | 948097.73 |
| 141 | 591368.08 | 6117934.50 | -7.56449 | 55.19952 | 627726.71 | 939228.94 |
| 142 | 592499.44 | 6116163.69 | -7.54730 | 55.18341 | 628832.71 | 937441.87 |
| 143 | 596653.38 | 6110529.83 | -7.48401 | 55.13200 | 632906.01 | 931748.39 |
| 144 | 597461.59 | 6109741.93 | -7.47160 | 55.12477 | 633702.95 | 930948.90 |
| 145 | 597785.65 | 6109678.90 | -7.46655 | 55.12414 | 634026.12 | 930881.23 |
| 146 | 598179.66 | 6109737.37 | -7.46035 | 55.12458 | 634420.97 | 930934.06 |
| 147 | 598372.67 | 6109489.93 | -7.45741 | 55.12232 | 634610.44 | 930683.85 |
| 148 | 598299.33 | 6109134.16 | -7.45868 | 55.11914 | 634532.00 | 930329.13 |
| 149 | 598205.88 | 6108923.37 | -7.46022 | 55.11727 | 634435.53 | 930119.67 |
| 150 | 598067.14 | 6108702.93 | -7.46247 | 55.11531 | 634293.63 | 929901.21 |

# 2 Site Investigation Schedule of Works

## 2.1 Summary of Proposed Surveys

The objective of the proposed Malin Head Offshore Wind Farm survey campaign is to determine environmental conditions, the seafloor and subsurface geological characteristics within the Foreshore Licence Application Area. The proposed programme of site investigations to be undertaken within the Foreshore Licence Application Area is summarised in Table 2-1 below and discussed in more detail in Sections 3 to 5.

Two types of site investigation activities will be undertaken; remote sensing activities which typically do not contact the seabed and direct sampling activities which do. Indicative locations for direct sampling site Investigation activities are shown in Figure 2-1.

All efforts will be made to follow survey recommendations outlined in the Guidance on Marine Baseline Ecological Assessments & Monitoring Activities for Offshore Renewable Energy Projects Part 1 and 2 (DCCAE, April 2018), where the specific timeframes are indicated for the survey provision.

***Table 2-1 Proposed programme of site investigations***

| Survey | Methods | Purpose | Sampling Effort |
|---|---|---|---|
| **Hydrographical and Geophysical** | Multibeam Echosounder (MBES) | MBES is a system for collecting detailed topographical data of the seabed. Typical equipment includes the Kongsberg EM3002D multi-beam system with mounting system including AML SV Smart Probe, Kongsberg EM 2040 or similar. For these surveys the equipment will operate at a typical central frequency of 200 - 400kHz (700kHz optional) with sound pressure levels in the range of 200-228dB re1µPa @1m. | MBES may be undertaken across the Foreshore Licence Application Area to a suitable percentage coverage. |
| | Side Scan Sonar (SSS) | SSS surveys are used to determine sediment characteristics and seabed features. The EdgeTech 4200 may be taken as an indicate example of an SSS device and for these surveys will have a potential operating frequency range of approximately 230/540kHz in the offshore area and 540/850kHz in the shallower nearshore area with sound pressure levels of 228dB re1µPa @1m. | SSS may be undertaken across the Foreshore Licence Application Area to a suitable percentage coverage. |
| | Magnetometer | A magnetometer is used to identify magnetic anomalies and hazard mapping for metal obstructions, shipwrecks and unexploded ordnance on the surface and in the shallow sub-surface. The Geometrics G-882 can be taken as an indicative equipment example, it is a passive device (i.e. it does not emit any sound waves into the marine environment). | It may be undertaken across the Foreshore Licence Application Area to a suitable percentage coverage. |

| Survey | Methods | Purpose | Sampling Effort |
|---|---|---|---|
| | Sub-bottom Profiling (SBP) | SBP is used to develop an image of the subsurface, identifying different strata encountered in the shallow sediments. The Innomar SES-2000 Medium is an indicative example of a parametric system with a primary and secondary frequency range of 85-115kHz and 2-22kHz, respectively, and sound pressure levels of up to 247 dB (typically operated at <200dB) re1µPa @ 1m, which would be used in both nearshore and offshore areas. The Applied Acoustics AA301 is an indicative example of a boomer, with sound pressure levels in the range of 208-215dB re1µPa @ 1m which would be used in the nearshore shallower area. The applied Acoustics Duraspark 400 is an indicative example of a sparker system used in sub-bottom profiling, with sound pressures in the range of 204-216dB re1µPa @1m. | SBP may be undertaken across the Foreshore Licence Application Area to a suitable percentage coverage. |
| **Geotechnical** | Boreholes | Boreholes may be up to 80m deep within the OWF area; however, within the OECC area they will likely be around 20m deep. All drilling equipment used will follow the ISO and API technical specifications for drilling equipment. | Up to 60 no. boreholes will be required within the Foreshore Licence Application Area. |
| | Cone Penetration Tests (CPT) | CPTs are a method for testing in situ soil parameters. CPTs can be performed as either Seabed CPTs or downhole in boreholes. | Up to 105 no. CPTs will be required covering both the preliminary and interim campaign within the Foreshore Licence Application Area.<br><br>The spacing interval will be determined by the variability and level of understanding of the shallow geology. |
| | Vibrocore / Gravity Corer | Vibrocore and Gravity Corer are methods of collecting un-consolidated seabed samples. | Up to 150 no. sample locations will be required for either vibrocore or gravity sampling with a target depth of 6m BSF within the Foreshore Licence Application Area. |
| **Metocean** | Floating LiDAR | Up to 2 floating LiDAR buoys will be deployed to measure the wind resource within the OWF Area. Deployment of this buoy will include anchor points on the seafloor. LiDAR may be deployed for a period of between 12 to 24 months. | Up to 2 floating LiDAR buoys may be deployed |
| | Acoustic Doppler Current Profiler (ADCP) | Up to 5 ADCPs may be used to examine wave and current conditions in the Foreshore Licence Application Area. This equipment is installed on the seabed and anchored with a suitable mooring structure. It is generally a short-term deployment used to gather seasonal data (e.g. winter storm data) however may be deployed for longer. | Up to 5 ADCPs may be used to examine wave and current conditions in the Foreshore Licence Application Area. |

| Survey | Methods | Purpose | Sampling Effort |
| --- | --- | --- | --- |
| | Wave Buoy | Up to 3 wave rider buoys may be deployed to measure wave heights and direction to feed into the detailed design of the project within the OWF area. They will be moored to the seabed by a suitably sized mooring structure | Up to 3 Waverider buoys may be deployed to measure wave heights and direction to feed into the detailed design of the project within the array investigation area. |
| **Ecology** | Bird Survey | Identify bird species distribution and behaviour within the Foreshore Licence Application Area. This does not require a licence under the Foreshore Act 1933, as amended and is included for information only. | Bird survey may be undertaken across the Foreshore Licence Application Area |
| | Fisheries Survey | Identify fish species distribution within the Foreshore Licence Application Area. Exact details of monitoring required will be determined through engagement with the relevant authorities such as SFPA, the Marine Institute and through local knowledge where appropriate. | Fisheries survey may be undertaken across the Foreshore Licence Application Area |
| | Benthic Ecology (subtidal benthic survey, intertidal habitat walkover survey) | This survey is designed to identify the expected benthic communities and habitats at the site.<br>This may consist of the intertidal Phase I walkover survey of the OECC Area and landfalls of the cable with identification of the main habitats present (in the form of biotope mapping).<br>In the intertidal area features of conservation importance will be identified by means of intertidal habitat mapping with core/quadrat sampling and hard substrate quadrat sampling where appropriate.<br>Subtidal sample locations may be subject to drop down video in advance of sampling. | There will be up to 150 no. subtidal sampling locations within the Foreshore Licence Application Area and multiple samples will be taken at each location. |
| | Marine Mammal Acoustic Monitoring (CPODs) | Marine mammal acoustic monitoring using CPODs deployed on the seabed. SoundTrap hydrophones may be deployed alongside the CPODs for periods throughout the monitoring campaign. | Either 4 permanent sites will be selected, or the 4 sites will be relocated every 3 months during battery change. The CPOD locations are subject to archaeological survey results. |
| **Archaeological** | Underwater Archaeology | Identification and assessment of metallic and other targets recorded during the marine geophysical surveys. | Underwater Archaeology survey may be undertaken across the Foreshore Licence Application Area |

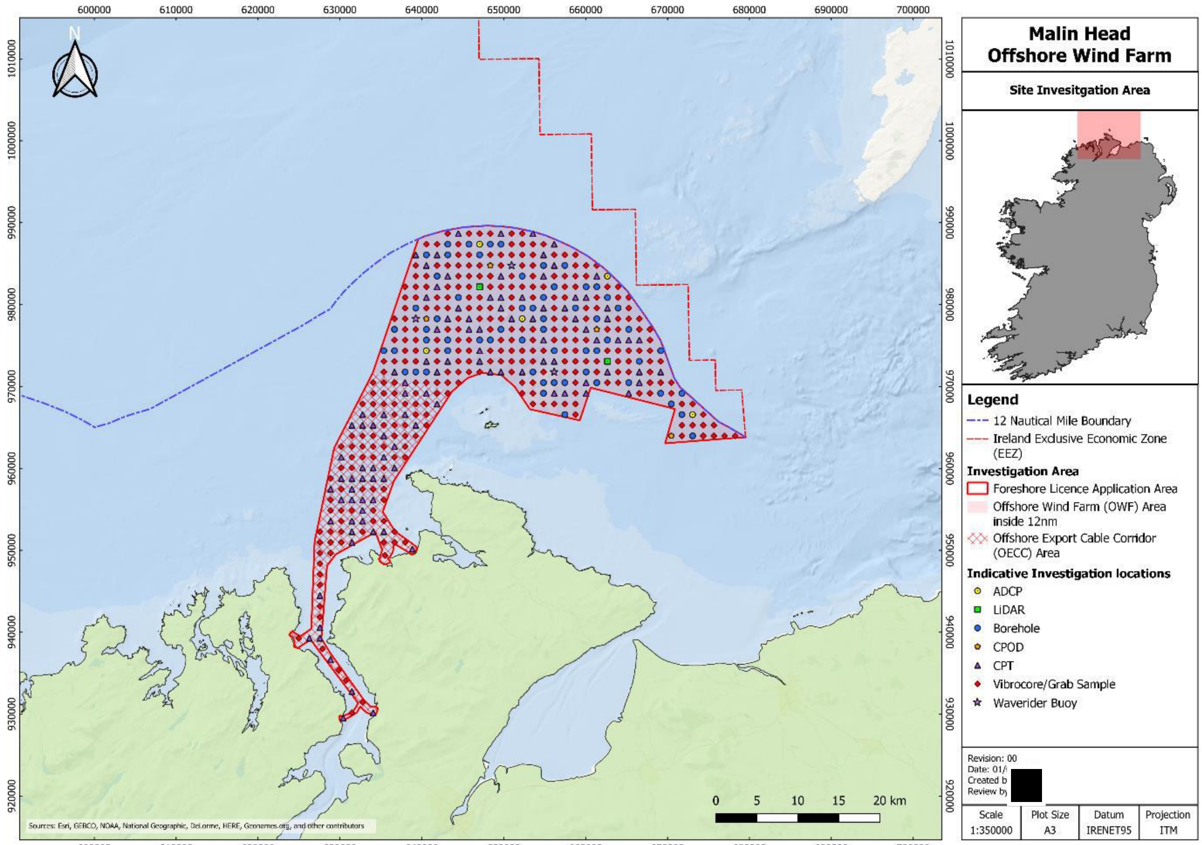


***Figure 2-1: Indicative Direct Sampling Site Investigation Locations***

# 3 Remote Sensing Site Investigation Activities

## 3.1 Geophysical Survey

The proposed geophysical survey programme involves a multi-disciplinary approach that is designed to acquire a full suite of data which includes a multibeam echosounder, side scan sonar, magnetometer, sub-bottom profiler, and a seismic survey which is also a form of sub-bottom profiling using a higher energy source (only if sufficient depth data cannot be obtained using a device such as the Innomar). The collected data will be used to better understand the water depths, topography and relief and structure of the seabed and the subsurface structure, in particular the sub-surface stratigraphy, determining sediment strata and the elevation of competent bedrock. The process is non-physically intrusive and at no point will the equipment used make contact with the seafloor. The exact equipment to be used will be confirmed following a tender process to procure the site investigation contractor. However, the operating frequencies outlined in Table 3-1 represent the operating frequencies employed in site investigations for offshore wind.

The objectives of the geophysical survey shall be:

- To obtain up to date high-resolution water depth measurements across the site;
- To obtain information on the seabed surface (type, texture, variability, etc.) and in particular, to identify any seabed features that may be of interest to the overall project;
- Identify any shallow geohazards and man-made hazards (including but not limited to outcropping, boulders, shallow gas, wrecks, debris etc.);
- Determine the stratigraphy across the site and quantify the variability in the lateral and vertical extents to depths of up to approximately 50m below seabed, if necessary;
- Identify the presence of bedrock should it exist within the top 50m;
- Identify any magnetic anomalies;
- Identify marine habitat areas as the basis for benthic survey to be carried out;
- Identify sensitive marine habitats which will need to be avoided during geotechnical and environmental sampling.

### 3.1.1 Multibeam Echosounder (MBES)

A Multibeam Echosounder (MBES) system will be used to provide detailed bathymetric mapping throughout the Foreshore Licence Application Area.

The MBES system will be hull mounted. The exact equipment used will be confirmed following the appointment of a survey contractor. The R2 Sonic 2024 or the Kongsberg EM2040 may be taken as a typical example (Figure 3-1). Typical operating frequencies for offshore wind are in the regions of 400kHz and can be up to 700kHz.

MBES is non-intrusive therefore does not interact with the seabed. MBES may be undertaken across the Foreshore Licence Application Area to a suitable percentage coverage.

***Figure 3-1: Multibeam Echosounder (EM2040)***

### 3.1.2 Side Scan Sonar (SSS)

Side Scan Sonar (SSS) is a towed sensor which is typically towed behind the vessel on an armoured tow cable, although some models can be pole mounted on the side of the vessel. SSS will be a dual frequency hydrographic sonar used to produce seabed imagery. A Side Scan Sonar (SSS) system will be used to provide detailed imagery of the seabed throughout the Foreshore Licence Application Area which will aid with seafloor sediment/bedrock and geomorphology mapping as well as for identifying any shallow geohazards.

Side scan systems are available from a number of manufacturers. These units vary in size, working and technical characteristics and acquisition configuration (towed or vessel mounted). Presently, dual frequency digital systems are available in the market which allows more survey flexibility; some systems can acquire and record both frequencies swaths independently and simultaneously. Using these systems, operator may use a higher frequency to produce sharper images and narrow swath or use the lower frequencies to obtain wider seabed coverage at lower resolutions. The exact equipment used will be confirmed following the appointment of a survey contractor. The typical operating frequency range for offshore wind purposes is between 300 to 900 kHz however a frequency as low as 200kHz may be used in shallower water.

The system will be adequate to the depth range of the study area and the seabed discrimination level required. The design of transects will consider the geographic and depth extent of the study area, seabed coverage ratio, overlap coverage desired, priority areas to survey, prevailing winds and currents, etc. Often, the complete coverage of the seabed is the ultimate goal of an acoustic survey design, to enable the creation of full mosaics. In these cases, theoretically, parallel transects should be run to produce swath overlapping of, at least, 50%. When complete coverage is not necessary to define seabed boundaries, consecutive swaths overlapping 20 to 30% can be adequate. However, in some cases, transect spacing of at least 75% of the swath width can provide reasonable overlapping to compensate any loss of resolution at the outer range limits. This is very dependable on weather conditions and the survey will be planned accordingly by an experienced sonar operator.

SSS is non-intrusive therefore does not interact with the seabed. SSS may be undertaken across the Foreshore Licence Application Area to a suitable percentage coverage.


***Figure 3-2: Example of a Towable Side Scan Sonar Data Device (EdgeTech)***

### 3.1.3 Magnetometer

A magnetometer is a passive device that is towed behind a survey vessel. It is used to detect ferrous objects on the surface or in the subsurface. Magnetometer surveys are widely used prior to intrusive works to highlight any obstruction or potential risk such as existing infrastructure, shipwrecks and unexploded ordnance.

The vessel will tow a submerged pod (Magnetometer). The exact equipment used will be confirmed following the appointment of a survey contractor. The marine magnetometer will be of the Caesium Vapour type and capable of recording variations in magnetic field strength during survey to an accuracy of ±0.5nT.

A Magnetometer is non-intrusive therefore does not interact with the seabed. It may be undertaken across the Foreshore Licence Application Area to a suitable percentage coverage and the parameters of the survey may be determined by the requirements of the Underwater Archaeology Unit of the National Monuments Service. Their requirements are set out in Table 3-1.

***Table 3-1: Underwater Archaeology Unit Requirements for Magnetometer Survey***

| Survey Type | Requirements for Archaeological Purposes |
|---|---|
| **Side Scan Sonar** | • Operational frequency of 410/500kHz.<br>• 50m survey line spacing<br>• 100% site coverage (overlap of areas may be required) |
| **Magnetometer** | • Proton or caesium magnetometer<br>• 50m side spacing |

***Figure 3-3: Magnetometer Example (Geometrics)***

### 3.1.4 Sub-Bottom Profiling (SBP)

Shallow Sub-Bottom Profiling aims to create a 2-D image of the subsurface up to potential depths of approximately 10-50 m below seabed, depending on the geological conditions encountered and the choice of system used. Different types of SBP are available including chirp, pinger, boomer, sparker and parametric chirp systems. The most appropriate system will be decided depending on the seabed, anticipated geological environment and the objectives of the survey.

A Sub-Bottom Profiling (SBP) system may be used to determine the stratigraphy across the site and quantify the variability in the lateral and vertical extents to a depth of at least 50m below seabed.

A parametric system (Innomar) combined with a sparker system such as the Applied Acoustics Duraspark 400 are most likely to be used for offshore wind data acquisition purposes.

The Applied Acoustics AA301 Boomer may be taken as an indicative example of a boomer source and would have an expected operating frequency of approximately 3 kHz with peak sound pressure levels of 210dB re1µPa at 1 metre range. The Duraspark 400 may be taken as an example of a typical sparker system used for offshore wind data acquisition purposes, with peak sound pressure levels in the range of 221dB and an operation frequency of 2kHz.

This survey is non-intrusive therefore does not interact with the seabed. It may be undertaken across the Foreshore Licence Application Area to a suitable percentage coverage.


***Figure 3-4: Example of Boomer Sub-Bottom Profiler***


***Figure 3-5: Example of Pinger Sub-Bottom Profiler***

***Figure 3-6: Example of Sparker sub-bottom profiler***

## 3.2 Seabed Imagery

Various underwater camera systems may be used for underwater imagery inspections to provide high quality video and stills data.

### 3.2.1 Drop camera systems

The SeaSpyder Telemetry system is a typical underwater camera system and is designed for operation in water depths up to 1000m utilising standard coaxial sonar umbilicals. This system is one of the most commonly used camera systems for underwater video inspections. The system as standard offers simultaneous uninterrupted recording of low latency live video footage along with high resolution stills photography, along with interfacing to a wide range of sensors and dataloggers. The stills camera is fitted with a high quality 18 mega pixel digital SLR Camera offering full control of all photographic parameters including manual focus, shutter speed and aperture. The stills camera is housed within a robust 1000m rated aluminium enclosure along with an internal IP video camera. All data are transferred directly to the surface unit for live interpretation; this includes video, stills photos, serial sensor data and ethernet data such as an imaging sonar.

### 3.2.2 ROV camera systems

Remotely Operated Vehicles (ROVs) are unoccupied, highly manoeuvrable vehicles controlled by qualified personnel onboard of the ship or platform from which it was deployed. ROVs are to assist in a variety of industries including Search and Rescue, Military, Recreation and Discovery, Aquaculture, Marine Biology, Oil, Gas, Offshore Energy, Shipping and Submerged Infrastructure.

ROV manoeuvrability and real-time visualisation (through stills and video) means that operators can use them effectively to investigate the seabed with greater control of observations than would be achieved with towed or drop-down video camera frame.

There are several classes of ROV, examples are provided in in Table 3-2.

*Table 3-2: Examples of the of Remote Operated Vehicles (ROV)*

| Classification of ROV | Description |
| --- | --- |
| Light Work Class ROV | A Light Work Class ROV is used in activities such as cleaning, drilling; various survey works. It can be also used during inspections for reparation works. Additionally, they can be equipped in for example laser scanners or specialized inspection devices and sensors. They can operate at depths of 3,000m (Cappoci, R. at al, 2017). |
| Surveyor Interceptor ROV (SROV) | The Surveyor Interceptor ROV (SROV) is new generation survey support ROV developed by Reach Subsea AS and MMT. It was designed for pipeline inspection and seabed surveys to provide improved, accurate data at higher speed as being towed by the ship in speeds up to 6 knots. This result in substantially better inspection quality with production of high quality and density data at a lower cost per km.<br>The SROV is very stable and equipped with state-of-the-art sensors with respect to geophysical instrumentation as well as sounding equipment, such as dual swath and ping Multi Beam Echo Sounder in order to keep density at higher speeds. The data is obtained live and can be quality controlled with respect to quality and coverage in real time. The SROV was initially designed for pipeline inspections however has also proven its excellence in geophysical surveys and ecological visual inspections. More information on the technical specifications can be found at https://www.mmt.se/innovations/srov/ |

# 4 Direct Sampling Site Investigation Activities

## 4.1 Geotechnical survey

Typically, individual geotechnical site investigation locations correspond to key structure locations. However, the positioning of individual geotechnical site investigation locations also needs to take into consideration environmental constraints such as the position of sensitive habitats or archaeological features. The purpose of the geotechnical survey is to evaluate physical properties of the superficial seabed sediments and/or bedrock formations. These methodologies will ensure that a comprehensive understanding of the subsurface is achieved to a suitable depth, below which, the existence of weaker formations will not influence the safety or performance of a wind turbine and its support structure. The scheduled geotechnical sampling may comprise of:

- 60 no. boreholes
- 105 no. seabed CPTs
- 150 no. core samples acquired by vibrocore or gravity corer

### 4.1.1 Downhole Sampling

The geotechnical survey will be undertaken across a range of water depths and will be performed by a geotechnical drilling rig mobilised on board a jack-up barge or a Dynamic Positioning (DP) controlled drillship. This scope of work shall comprise of sampling boreholes and CPT boreholes that may be co-located. This shall provide in situ soil properties and recover soil samples or rock cores for the full depth range of interest.

It is envisaged that seabed sampling and CPT may have limited penetration along some sections of the export cable route due to shallow outcropping of till or bedrock. In such a situation it may be recommended that a limited number of locations along the export cable route are completed by geotechnical drilling vessel.

For the landfall boreholes, a jack-up barge shall be fully equipped with a rotary drilling rig capable of deploying various sampling and coring methods. An example of which is presented in Figure 4-1. Coring through rock will require a large diameter system such as the Geobore S. The jack-up will also be able to deploy downhole CPT equipment in a borehole adjacent to the sampling borehole. All equipment shall be deployed downhole and all thrust shall be top loaded.

Generally, all jack-ups shall be maintained and operated in accordance with SNAME TR5-5A/. Sampling methodologies shall be in accordance with BS EN ISO 22475 and CPT testing in accordance with ISO 22476.

During drilling, borehole wall integrity will be maintained using drilling mud mixed with sea water. This drilling fluid is comprised of biodegradable miscible guar gum. This drilling mud and any drill risings will disperse into the water column. During fieldworks, the retrieved samples and cores shall be logged, and the CPT data processed and interpreted, to produce borehole and CPT logs that includes interpreted stratigraphy. An example of the combined borehole logs is presented in Figure 4-2.


***Figure 4-1: Example of a drill rig mobilised on a jack-up (Comacchio MC1200)***

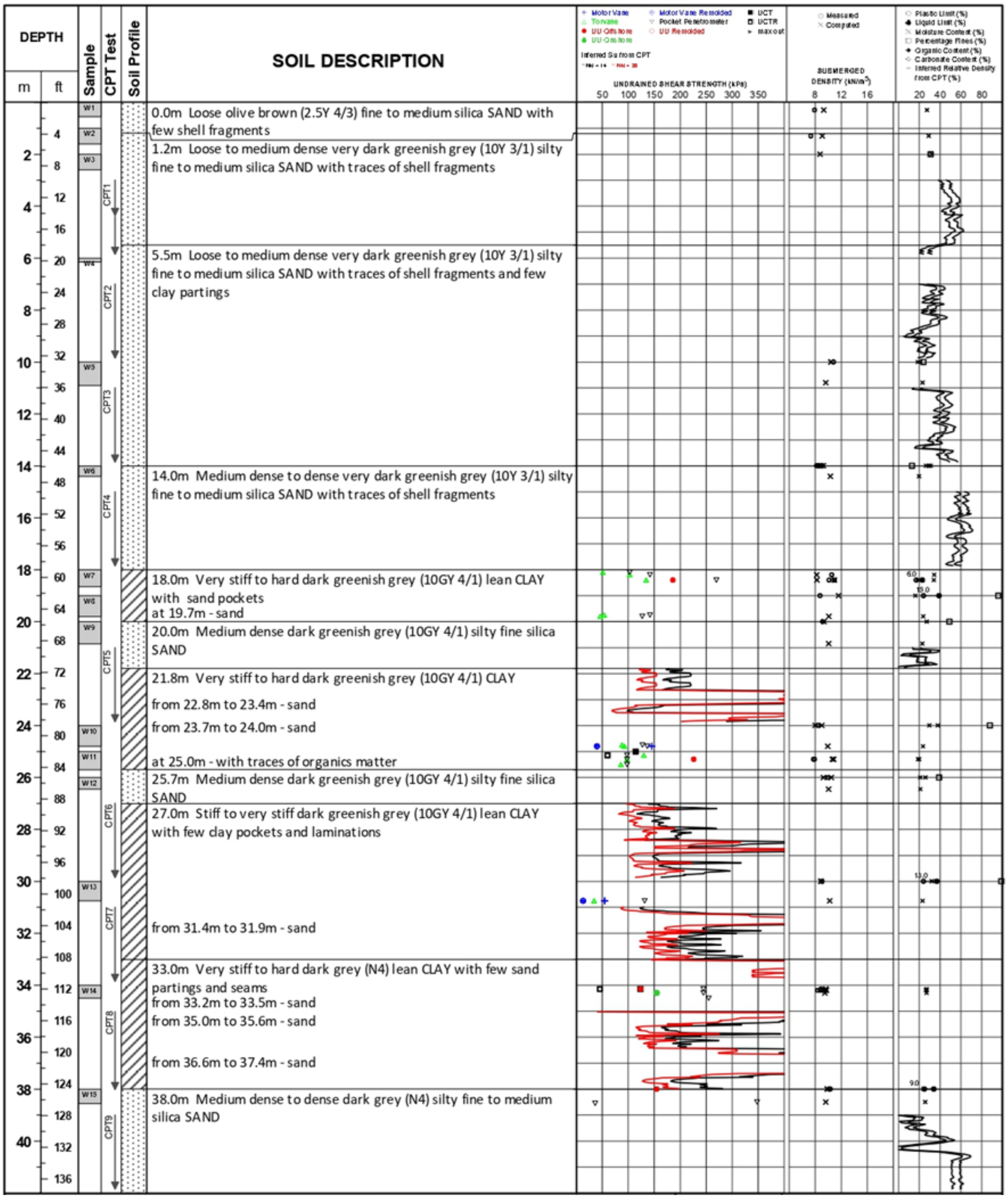


***Figure 4-2: Example of a typical borehole log***

## 4.1.2 Cone Penetration Tests (CPT)

The Cone Penetration Test (CPT) is a geotechnical test used to measure in situ properties of soil. The CPT is one of the most commonly employed site investigation techniques for offshore projects worldwide. CPT is performed by pushing an instrumented and calibrated steel cone into the ground at a constant rate. During testing, the resistance on the cone tip and sleeve are measured, as well as pore water pressure. These results can be used to derive soil parameters and interpret soil behaviour.

There are two broad categories of CPT testing methods as discussed below:

**Down-borehole CPT**

Downhole CPT: Downhole CPTs may be deployed using traditional offshore rotary heave compensated drilling rig or drilling rigs mobilised on to jack-up barges. The CPT test start depth may be at seabed or any depth below. The CPT tool is deployed by wireline through the drill string, which then in turn latches within the drill bit. The CPT test starts, and the cone advances out through the drill bit and into virgin soil. The test stroke length is typically 3m. The CPT tool is recovered to deck, and the borehole is advanced by drilling to the depth corresponding to the end of test depth. A drill string is then used to drill out the hole at the CPT location. Downhole CPT test only experiences friction along the CPT sounds rod length. By contrast, the seabed CPT experiences friction along the entire length of the CPT rod, which may be up to 40m in length, which may cause refusal. The downhole CPT test is quick, but the cumulative time associated with deploying and recovering the tool, drilling and adding pipe, means that a comparative target depth takes longer compared to seabed CPT. However, downhole CPT may provide CPT data to greater depths, primarily limited by the length of pipe available.

**Seabed CPT**

Seabed CPTs involve mobilizing a self-contained and automated CPT test unit housed within a seabed frame. This frame is typically kept on the deck of a dynamically positioned vessel and may be deployed using a dedicated Launch and Recovery System (LARS) – such as an A-frame – or in the case of larger CPT unit, through a moonpool (as illustrated in Figure 4-3). The vessel will hold station over the target position and deploy the CPT unit. The CPT is connected to the vessel via an umbilical, which acts as a lift wire and data transfer umbilical. Depending on the CPT unit, the CPT rods may need to be built up overboard prior to deployment through the water column. Once on seafloor, the cone is pushed into the seabed until it reaches refusal. Refusal is defined as the point where one of the following criteria are met: target penetration depth is reached, maximum system thrust is reached, excessive load on the tip or the sleeve, or excessive cone inclination occurs, or a combination of these. The objective of the survey will typically define the size and configuration of the CPT unit. A lightweight CPT unit with maximum penetration depth of 10m, may weigh about 5 tonnes and are frequently used for the export cable route survey. For deep seabed CPT testing, with target penetration depths of 20 to 40m, the seabed unit will weight in the order of 20 to 25 tonnes. The test typically takes 2 to 5 minutes, depending on the target penetration depth, however total time taken to be deployed and recovered may be in order of one to two hours. If at each location the technical requirements of the project are met, the CPT unit is lifted back on to the vessel and the vessel moves on to the next location. If target depth is not achieved, then the CPT unit may “bump-over” – which is where the unit is lifted a small distance of seafloor and moves horizontally so another test can be completed.

***Figure 4-3: Example of a Block Push Seabed CPT System (Fugro Seacalf)***

### 4.1.3 Sampling and Coring

Sampling or coring equipment provide a means to recover samples to deck to allow for logging and testing offshore, and onward testing at onshore laboratories.

As for CPT testing, sampling may be conducted via dedicated seabed units or downhole. Coring is generally only achieved downhole. Downhole samplers include the push and piston samplers for soils, and coring equipment for rock.

**Downhole sampling and coring:** The wireline push or piston sampler is lowered into the drill string where it latches into the Bottom Hole Assembly (BHA). The attached sample tube is then pushed into the ground ahead of the drill bit to sample the soil. Before the push commences, the piston is located at the bottom of the sample tube preventing any ingress of drill cuttings and travels up the tube as it penetrates the ground minimising sample disturbance and maximising recovery. When the piston is not fitted the push sampler head has a hole which allows water to escape whilst penetrating the ground. After the test has completed the hole is then covered by a ball and held in place using a spring this is to prevent losing the sample when recovering the tool. Sample tubes (or Shelby tubes) are typically 1m in length with various wall thicknesses and internal diameters. Generally, the thinner walled tubes are used for soft cohesive material, and thicker walls for granular material. Depending on various factors, high quality, undisturbed samples may be recovered.

Rock core samples are recovered by either using the main drill string or using piggy-back drill rig. For the former, a double tube barrel is dropped into and latched into the BHA. This set up comprises two concentric steel tubes joined in such way to permit the rotation of the out tuber without causing rotation of the inner tube. Within the inner tube is a liner that can be recovered without the need to recover the entire BHA and drill string. Piggy-back coring is achieved when a separate rig with smaller diameter drill string it deployed through the main drill string. In both cases, the drill bit is advanced, and a core of rock is recovered within the liner. When the core is recovered to deck it is logged, tested and prepared for onward testing at an onshore laboratory. Typical core diameters can range from 70mm up to 100mm, though larger is possible.

**Seabed Samplers:** Vibrocoring is a method for retrieving samples of up 6m in length from mudline. Penetration into the soil is afforded by the reciprocal motion of the motor at the top of the barrel. High frequency, low amplitude vibration that is transferred from the vibrocore head down through the attached barrel. This vibration energy allows the core barrel to penetrate the sediments under self-weight. The core barrel is fitted with a plastic liner, core catcher and cutting shoe. The vibrocore rig is similar to that seen in Figure 4-4. Once coring is started, the core barrel will penetrate to the target depth or refusal. Samples will be recovered in the plastic liner, split into 1m lengths, processed, sealed appropriately for onward freight to an onshore laboratory. Vibrocore is best suited to non-cohesive soils (e.g. gravel or sand) as samples recovered are considered disturbed. Vibrocore samples are typically 50 – 100mm and a have a maximum diameter of 110mm.

Gravity or piston core (self-weight penetration sampler) is performed where cohesive soil is expected. The sampler is comprised of an outer barrel with PVC inner barrel, and a cutting show. The sampler may be fitted with a piston which effectively reduces the resistance to the soil entering the liner and may result in a superior quality sample. The sampler penetrates the seabed under its own weight. Upon refusal or at target depth, the sampler is recovered on deck where the sample is split, typically into 1m lengths, logged and tested in the offshore laboratory. The typical diameter of the liner is in the region of 60mm with a typical maximum diameter of 120mm.

The exact equipment to be used will be confirmed following a tender process to procure the site investigation contractor. Indicative locations are shown in Figure 2-1 however final individual site investigation locations will depend on the geophysical survey locations. Some locations may need to be avoided due to environmental reasons including sensitive archaeological features or unsuitable substrate types.

***Figure 4-4: Example of a Crane Deployed Vibrocore System***

### 4.1.4 Grab samplers

Grab samplers recover samples from approximately the top 0.2 - 0.5m of seafloor. These samples may be used to classify the seabed, or for chemical and biological analyses. These samples are generally deployed overboard using a crane from a vessel.

There are various grab sampler types to include but not limited to Van Veen, Hamon and Day Grab samplers. Generally, some variants may come either as single or double, and in a variety of different sizes.

Geotechnical Grab sampling: A grab sampler with dimensions of a 0.5x0.5x0.5m is recommended, though multiple attempts with smaller samples is possible. The aim of this sampling is to recover sufficient seabed material for onshore classification testing for ground truthing of the seafloor seismic interpretation. The grab sample locations may be co-located with other seabed sampling.

Grab samplers generally comprises of steel buckets that are deployed open and which trigger shut when the sampler is in contact with the seafloor. As the buckets close, sediment and biological material are retained inside the sampler. The grab sampler is then recovered to deck and place on a trestle or table. The retained material is then visually inspected for acceptance and then transferred to adequate container or on to a designated mat for further offshore processing and logging.

There are various grab sampler types to include but not limited to:

Single Van Veen Grab: It is ideal for the collection of sediment samples for biological and environmental sampling. In a range of sizes ($0.025m^2$, $0.1m^2$, $0.2m^2$, $0.3m^2$) each model has a marine grade stainless steel bucket with hinged access flaps on the top allowing sub sampling of the collected sediment before it is emptied from the grab. The bucket is operated with a pair of stainless-steel lever arms that increase the tension to secure the sample securely in the grab as it is retrieved to the surface. Additional lead weights can be added to the back of the bucket to improve stability in strong currents and to the lever arms to increase the equipment's ability to perform in harder conditions. More information on the technical specifications can be found at: https://www.cms-geotech.co.uk/single-van-veen-grabs

***Figure 4-5: Single Van Veen Grab (OSIL)***

Double Van Veen Grab: The Double Van Veen Grab allows collection of two 0.1m2 samples at the same. This equipment is frequently used to carry out comparable sampling, for example where biological and chemical samples are required on the same sampling location. The connection of two samplers into one is also time and cost-effective solution for the surveys where large number of sampling locations are planned with repetition of sediment sampling on the same location or when larger depths are considered. More information on the technical specifications can be found at https://www.cms-geotech.co.uk/double-van-veen-grab-.

***Figure 4-6: Double Van Veen Grab Sampler (OSIL)***

Mini and Standard Hamon Grabs (0.1m$^2$ and 0.2 m$^2$ respectively): These grabs are particularly used for the collection of samples generally from coarse (sand and gravel) sediment substrates and used for benthic macrofauna and particle size measurement. The grab is relatively simple to operate in almost any water depth.

A 0.1m² sample area is a standard practice used in many benthic sampling applications. The Hamon Grab is a box shaped sampling scoop mounted in a triangular frame. Upon contact with the seabed, tensioned wires are released, which causes the sampling bucket to pivot through 90º pushing seabed sediment into the bucket. On completion of its travel the open end of the bucket comes against a rubber sealed steel plate which stops the sediment escaping during recovery. 0.1m² Hamon Grab refers to 0.1m² area of seabed sampled. The depth of scoop penetration is up to 20cm. On recovery the grab is landed onto a rectangular base from where access can be gained to the inside of the bucket via an inspection window. Whilst in the stand the grab sample can then be easily emptied into a sampling container located under the bucket. More information on the technical specifications can be found at https://www.cms-geotech.co.uk/standard-hamon-grabs-

***Figure 4-7: Hamon Grab (CMS – Geotech Ltd)***

Day Grabs (single and double): The Single Day Grab is built from two stainless steel bucket sections combined within a stainless-steel frame that level to the seabed when it is deployed. When frame is in contact with the seabed, the latch plates on the buckets unlock and they are released. A typical 0.1 $m^2$ operational Day Grab weights between 60-165 kg (sediment sample weight not included), where additional weights can be added to the frame as required. Insufficient weight can lead to the frame being pushed upwards as the buckets are drawn into the sediment, reducing the effective bite depth. The sampler has sturdy design, simple mechanism and ability to access the undisturbed surface of the sample. It not designed for work on hard, coarse, substrata. More information on the technical specifications can be found at https://www.cms-geotech.co.uk/siingle-day-grab and https://www.kc-denmark.dk/products/sediment-samplers/day-grab-/day-grab-1000-cm%C2%B2.aspx)

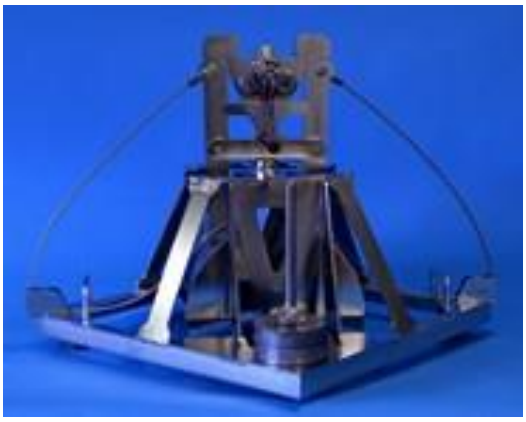

***Figure 4-8: Day Grab (KC Denmark A/S)***

Generally, any grab sampling will be carried out by deploying sampling gear from the vessel, as per standard operation procedure for deck works involving this kind of equipment taking into account the technical specification of the grab in use. Various grabs will be available for the benthic survey provision to ensure adequate sampling equipment for various sediment types.

## 4.2 Metocean Site Investigations

The metocean site investigations, using the equipment outlined in this section, are necessary to evaluate the wind, wave and current conditions across the Foreshore Licence Application Area. These site investigation activities will involve the mobilisation of buoys and bottom profilers to collect data over periods varying from hours up to 12 months although floating LiDARs may be deployed for up to 24 months. The longest deployment in any one location would be for a floating LiDAR which is generally used to record wind data. The proposed metocean survey equipment include floating LiDAR, Waverider buoys and Acoustic Doppler Current Profilers (ADCP).

### 4.2.1 Floating LiDAR

Offshore wind farms require at least 12 months of measured wind data to allow for an understanding of the wind conditions and an accurate assessment of the generating capacity within any site selected for development. Typically, 12 months data would be collected at a suitable location within an OWF area. If there is sufficient time to move the LiDAR to another location within the OWF area to gather further data, the opportunity to move it would typically be taken as any additional data would increase the accuracy of the dataset over the entire OWF area. Two locations have been included in this Foreshore Licence Application for LiDAR deployment within the OWF area. This may comprise of one floating LiDAR moved after 12 months or it may comprise 2 floating LiDARs deployed at the same time, depending on time constraints.

Exact specifications of the floating LiDAR equipment, the associated mooring arrangement and installation vessel will become available following award of the tender contract. An installation vessel will be required for the launch and recovery of this equipment, the details of which will become available on award of the tender contract. The same type of vessel used for the installation will be required to service the floating LiDAR.

A typical floating LiDAR deployment involves the LiDAR unit being mounted on a buoy which is moored using a mooring chain and concrete anchor (e.g. Seawatch Buoy). The device provides measurements across the entire potential rotor diameter and beyond and can be configured to measure up to 10 different heights from 12.5 to 300 metres above the sea surface.

The buoy will be moored to the seabed for a duration of 12 to 24 months (12 months in a single location) and will be powered by solar panels, batteries and micro wind turbine generators.

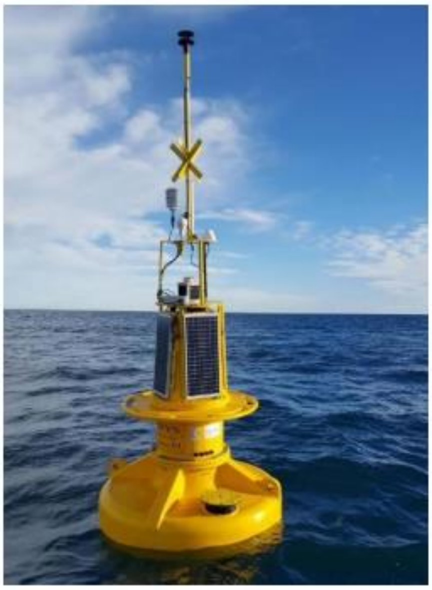

***Figure 4-9: Typical Floating LiDAR (AXYS Technologies)***

### 4.2.2 Waverider Buoys

These buoys are used to track wave data, which is updated hourly online and processed onshore, providing vital information for marine users. Each wave rider buoy is anchored to the sea floor. The buoys are specially designed to follow the movement at the sea surface. The anchoring system includes a length of rubber chord that is capable of stretching up to three times its length. The flexibility of the mooring allows the wave rider to follow the fluctuating water surface. Fluctuations in the surface water are measured by either an accelerometer mounted inside the wave rider buoy or by a GPS unit which is converted to radio signals that are transmitted to a receiver station onshore. The electronics and the navigation light are powered for up to twelve months by a bank of dry cell batteries mounted around the inside of the hull. Figure 4-10 shows a typical wave rider buoy by Datawell BV which also measures surface current.

***Figure 4-10: Directional Waverider 4 with Acoustic Current Meter (Datawell BV)***

### 4.2.3 Acoustic Doppler Current Profiler (ADCP)

It is proposed that up to 5 ADCPs will be deployed on the seabed. The purpose of the ADCP is to determine the principal tidal current regime of the Foreshore Licence Application Area. Exact details of any ADCP and deployment location within the Foreshore Licence Application Area will not be available until a contract has been awarded. The following points provide a brief overview of an ADCP system, illustrated in Figure 4-11.

- The ADCP is expected to sit within a stainless-steel frame;
- Dimensions of a typical ADCP are a 1.8m base with 0.6m height off the seabed;
- The total weight of the frame and ADCP will be in the order of 300kg;
- The ADCP and stainless-steel mooring frame will be attached to a ground line, a clump weight (approx. 150kg) and to an acoustic release system carrying a rope retrieval system. This will ensure that all equipment is recovered from the seabed after the monitoring period (minimum period of 30 days)

***Figure 4-11: Acoustic Doppler Current Profiler (ADCP) (Wikipedia)***

## 4.3 Ecological Site Investigations

The purpose of the ecological site investigation activities is to collect baseline data that will primarily be used to inform the Environmental Impact Assessment Report (EIAR), by describing the environmental conditions within the Foreshore Licence Application Area, and subsequently developing appropriate mitigation measures for any potential environmental impacts. The ecological scope of work proposed for the Foreshore Licence Application Area includes the following:

- Fisheries surveys;
- Subtidal benthic surveys;
- Intertidal benthic surveys;
- Marine mammal survey including static acoustic monitoring which will be achieved by utilising CPODS deployed on the seabed. Soundtraps may be deployed with the CPODs

### 4.3.1 Fisheries Survey

A fisheries survey will be carried out to determine the species and their distribution within the Foreshore Licence Application Area. The Sea Fisheries Protection Authority will be consulted regarding the exact nature of the survey, survey design and survey methods to be applied. In addition, consultation with the local fishing industry will be undertaken in advance of any survey effort and survey design will take into consideration fish spawning and fishing seasons. The aim of the survey is to maximise the accuracy and value of the information to the ongoing design of the project and to feed into engagement with fishing communities. The information will also feed into the EIAR. Engagement with the relevant stakeholders will commence in the coming months on this matter.

### 4.3.2 Subtidal Benthic Survey (grab sampling and seabed imagery)

The aim of the proposed benthic survey is to map the distribution and extent of marine benthic biological communities and habitats in the Foreshore Licence Application Area. This will be comprised of an epibenthic video and still photographs inspection (by a drop down or remote operated vehicle (ROV) camera system as described in Section 3.2) followed by a benthic sampling programme undertaken using a suitable grab sampler to collect benthic macrofaunal and physio-chemical data (Section 4.1.4). The sampling locations will be selected to sample different representative habitats; geophysical data will be used where available to stratify and target sampling.

The resulting information (i.e. from seabed imagery and grab samples) will inform an assessment of the taxa, communities and habitats present and will be used as ground-truthing data and overlaid on available geophysical data to accurately map biotopes and delineate protected habitat features (e.g. biogenic and rocky reefs).

This information can then be used to undertake Annex I habitat assessments for any Annex I features present within the Foreshore Licence Application Area using feature appropriate guidance (i.e. for biogenic or stony Annex I reef).

Where grab sampling is not possible, sufficient coverage of video (e.g. transect of length >150 m) and number of stills (e.g. n >30) will be taken from the sample location to identify habitats and habitat boundaries (video) and to identify and enumerate taxa present (stills) in order to characterise the habitats and epifaunal communities present.

Van Veen/Day Grab/ Double van Veen will be used in 'softer' sediments (e.g. mud, fine sand) for quantitative benthic macrofaunal sample collection for analysis and for physio–chemical analysis.

Physio–chemical analysis would include the following standard parameters unless specified differently by the client or regulator:

- Particle size analysis
- Sediment organic matter and carbon analysis
- Major trace element analysis
- Hydrocarbon analysis

If the grab sampler cannot gather a sufficient sample of 5 cm minimum depth due to nature of sediment (e.g. coarser sands and gravels), then a mini-Hamon grab will be used to collect benthic macrofaunal collection and particle size analysis (PSA). In this case the minimum sample retention should be a 5l volume.

Three grab samples will be retrieved for benthic fauna analysis and sub-sampled for particle size analysis. An additional grab sample will be collected for chemical analysis. This will ensure sufficient data are collected for quantitative analysis of benthic fauna and physio–chemical analysis and that benthic fauna data can be used with their associated PSA results.

To minimise repetition of benthic sampling approaches, it is proposed to use double van Veen grab/double Day grab, where suitable (i.e. in water depths >100 m). This will provide two samples for each grab therefore minimising the number of deployments needed to obtain the required four samples.

All retrieved and accepted samples will be processed on deck. Benthic fauna samples will be sieved through a 1mm mesh sieve or a 0.5mm mesh sieve if required. Photographic records will be taken (following retrieval of the grab sampler and sieve residue following processing through the mesh sieve). The faunal residue will be transferred to properly labelled sealable wide neck containers and preserved in buffered 10% w/v formaldehyde solution (or 96% ethanol if required) for subsequent transport and analysis at a specialist benthic fauna analysis laboratory. The laboratory will ideally have NMBAQC applied protocols in place and be a participant in the NMBAQC invertebrate scheme. The containers with the biological samples will be kept in a well-ventilated area at all times due to the high toxicity of the preserving medium used.

### 4.3.3 Ecological Intertidal Survey

An intertidal survey (walkover survey) will be carried out at the landfall for the windfarm export cable once locations suitable for cable landing have been refined. A series of locations will be also sampled in areas of both soft sediment and hard substrates to allow a detailed biotope mapping at these landing locations. The area surveyed could be up to 500m wide.

The intertidal surveys will be undertaken during spring tides in line with guidance in the Marine Monitoring Handbook (Davies et al., 2001). During the walkover survey, biotopes will be identified according to the European Nature Information System (EUNIS) classification. Where possible, boundaries of biotopes will be tracked using a handheld GPS device and recorded using a suitable software package.

Various locations will be sampled by quadrat with dimensions of a 0.04 $m^2$ (0.2 m x 0.2 m), to identify the benthic macrofauna at the potential landfall locations.

### 4.3.4 Marine Mammal Acoustic Monitoring

It is proposed that the site investigations may involve the use of Continuous Porpoise Detectors (CPOD) which would be installed for the purpose of acoustic monitoring of marine mammal activity within the Foreshore Licence Application Area.   Up to two CPODs would be deployed at any one time across the site.

A sound trap may be deployed alongside one of the CPODs for various durations throughout the monitoring campaign to obtain background noise measurements. The CPODs will be recovered approximately every three months to download data and change batteries. Upon each three-month recovery, they would likely be relocated based on a 4x4 km survey grid across the site so that over the 18 to 24 month monitoring period, CPODs may be deployed at a total of 32 locations across the site Location. The exact locations where the CPODs will be deployed has not yet been determined. The currents in parts of the site may make some areas unsuitable for deployment.

### 4.3.5 Archaeological Survey

The proposed archaeological survey will comprise of identification and assessment of metallic and other targets recorded during the geophysical survey where magnetometer data will be acquired for further archaeological assessment.

This will follow the baseline assessment that includes documentary and cartographic searches using several sources in order to locate all known cultural heritage assets within the Foreshore Licence Application Area, and to identify the archaeological potential of the area. The baseline assessment will be carried out in line with industry best practice and any relevant offshore renewables and underwater archaeological guidance.

Survey specifications will need to consider archaeological data acquisition to enable professional archaeological interpretation and analysis of data. The data collected will be used to support the archaeological assessment.

All archaeological work will be carried out by a suitably qualified archaeologist to determine the location of all known archaeological features in advance of the intrusive geotechnical and environmental survey.

# 5 Survey Vessels

Different marine vessels will be required for efficient deployment, execution, and recovery of the various site investigation activity equipment and methods. It is envisaged that different vessels may be required for the geotechnical, geophysical, ecological and metocean stages of the survey.

Geotechnical survey vessels are typically 55-90m in length and have an endurance of up to 28 days. Their port of mobilisation will depend on previous work but may be Irish, UK, or another European location.

Geophysical survey vessels are typically between 15m and 60m in length and have an endurance of up to 14 days. These vessels are likely to use a local port for mobilisation and replenishment. The exact vessels to be used, will be confirmed following a tender process to procure the survey contractor. All vessels will be fit for purpose, certified, and capable of safely undertaking all required survey work. The vessels will conform to the following minimum requirements as appropriate:

- Station-keeping and sea keeping capabilities required by the specified work at the proposed time of year; the appointed contractor may provide supplemental tug assistance if such assistance benefits the operation;
- Endurance (e.g. fuel, water, stores, etc.) to undertake the required survey works;
- Staffing to allow all planned work to be carried out as a continuous operation (on a 24 hour per day basis for the offshore activities and on a 12 hour per day basis for the inshore activities);
- Equipment and spares with necessary tools for all specified works;
- Appropriate accommodation and messing facilities on board;
- Adequate soil laboratory testing facility.

The survey contractor and vessels will comply with international and national statute as appropriate. A non-exhaustive list of examples includes:

- Sea Pollution Act 1991 which transposes into Irish statute the requirements of the International Convention for the Prevention of Marine Pollution from Ships (MARPOL 73/78)
- Sea Pollution (Amendment) Act, 1999 - which gives effect to the International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990 (OPRC).
- S.I. No. 372/2012 - Sea Pollution (Prevention of Pollution by Garbage from Ships) Regulations 2012.
- S.I. No. 492/2012 - Sea Pollution (Prevention of Pollution by Sewage from Ships) (Amendment) Regulations 2012
- S.I. No. 507/2012 - Merchant Shipping (Collision Regulations) (Ships and Water-Craft on the Water) Order 2012.

# 6 Noise Sources from Survey Works

The ranges of noise frequency and sound pressure associated with all the surveys outlined in previous sections is summarised in Table 6-1below. It should be noted that while equipment may have the ability to operate at lower frequencies (below 200kHz) the frequencies required to return the data necessary for offshore wind development generally operate at the higher end of the frequency range. For example, equipment for multi-beam echo sounder may be capable of operating at 200kHz however the typical frequency for offshore wind purposes is 400kHz.

In addition, while the exact equipment will not be known until after the procurement process there is some equipment and frequencies that would not be used for offshore wind data acquisition such as the EM122 which may be used for Multi-Beam Echo Sounder which can operate at 12 kHz. This would never be used as it does not serve the needs of offshore wind development data acquisition. The equipment described in Table 2-1 (Refer to Section 2.1) represents typical equipment, frequencies and intensity levels for offshore wind data gathering purposes.

***Table 6-1: Survey Sound Pressure Levels***

| Noise Source | Frequency (kHz) | Sound Pressure Level (dB re 1µPa @ 1m) |
|---|---|---|
| Shipping Noise | 0.050 – 0.300 | 160 – 175 |
| Multi-beam echo sounder | 200 – 700 | 200 – 228 |
| Side scan sonar – Dual Frequency | 230/540 or 540/850 | 228 |
| Sub-bottom profiler (SBP) | 85 – 115 / 2 – 22 | 247 |
| Sparker system (SBP) | 2 – 16 | 204 – 216 |
| Boomer system (SBP) | 2.5 | 208 – 215 |
| Geotechnical drilling (Rotary) | 0.002 – 50 | 160 |

# 7 Timeline for Site Investigations

The intention is to begin survey activities as soon as feasible following license award, with a staged programme of investigations, capitalising on suitable weather windows over this time period. This phased approach will progress the overall development towards detailed design stage. The exact mobilisation dates will not be known until the process of procuring a contractor is complete.

Typical duration and footprint of proposed Site Investigation activities is described in Table 7-1below.

***Table 7-1: Typical Time Required for Individual Site Investigation Activities***

| Activity | Typical Time Period Required for Activity | Total Number of SI Locations | Total Time for Site Investigations | Footprint Affected per SI | Footprint Affected per SI (km²) | Total Footprint per SI (km²) | Area Directly Affected as % of Total Foreshore Licence Application Area |
|---|---|---|---|---|---|---|---|
| Hydrographical and Geophysical | 8-10 weeks (weather dependent) | N/A | 8-10 weeks. The survey area and in particular the potential cable routes will be refined prior to undertaking the geophysical survey to minimise the time on site. | N/A | N/A | N/A | N/A |
| Borehole | 24 - 36 hours in any one location | 60 | Up to 90 days in total hours for actual boreholes across all campaigns. Boreholes will be split between campaigns with a preliminary campaign typically taking up to 8 weeks and an interim campaign typically taking up to 16 weeks. | $8m^2$ | 0.000008 | 0.00048 | 0.0000575% |
| CPT | 30 minutes - 3 hours in any one location | 105 | Maximum 14 days of actual SI time over all campaigns but is part of same campaign as Boreholes so approximately 8 weeks for a preliminary campaign and 16 weeks for an interim campaign. Some locations will be co-located with borehole locations. | $8m^2$ | 0.000008 | 0.00084 | 0.0001006% |
| Gravity Corer | 45 minutes - 2 hours in any one location | 150 | Maximum 13 days of actual SI time but is part of same campaign as Boreholes so approximately 8 weeks for preliminary campaign and 16 weeks for the interim campaign | $1m^2$ | 0.000001 | 0.000150 | 0.0000179% |

| Activity | Typical Time Period Required for Activity | Total Number of SI Locations | Total Time for Site Investigations | Footprint Affected per SI | Footprint Affected per SI ($km^2$) | Total Footprint per SI ($km^2$) | Area Directly Affected as % of Total Foreshore Licence Application Area |
|---|---|---|---|---|---|---|---|
| Benthic Grab Sampling | Up to 3 hours in any one location | 150 | Maximum 19 days in actual SI hours however 5 to 6 weeks for the campaign to allow for SI Prep (drop down camera or ROV) and transit between locations | $1m^2$ | 0.000001 | 0.000150 | 0.0000179% |
| Floating LiDAR | 12 - 24 months in any one location (may be moved to a second location for a further 12 months if project development timeline allows) | 2 | 365 to 730 (12 - 24 months). Actual deployment will include 1 day to deploy and 1 day to retrieve | $1m^2$ | 0.000001 | 0.000002 | 0.00000023945% |
| ADCP | 4 weeks - 12 months in any one location | 5 | 1 - 12 months. Actual deployment will include 1 day to deploy and 1 day to retrieve. May be deployed at same time as LiDAR | $1m^2$ | 0.000001 | 0.000005 | 0.00000059862% |
| CPODs | Throughout site investigation campaign with battery change every 3 months | 4 | 365 to 730 (12 - 24 months). Actual deployment will include 1 day to deploy and 1 day to retrieve | $1m^2$ | 0.000001 | 0.000004 | 0.00000047890% |
| Wave Buoys | Throughout site investigation campaign | 3 | 365 to 730 (12 - 24 months). Actual deployment will include 1 day to deploy and 1 day to retrieve | $1m^2$ | 0.000001 | 0.000003 | 0.000000359174% |

## References


Berrow, S.D., Whooley, P., O'Connell, M. and Wall, D. 2010. Irish Cetacean Review (2000-2009). Irish Whale and Dolphin Group, 60pp.

Capocci, Romano; Dooly, Gerard; Omerdić, Edin; Coleman, Joseph; Newe, Thomas; Toal, Daniel. 2017. "Inspection-Class Remotely Operated Vehicles—A Review" J. Mar. Sci. Eng. 5, no. 1: 13. https://doi.org/10.3390/jmse5010013

Coggan, R|., Populus, J†., White, J‡., Sheehan, K‡., Fitzpatrick, F‡. and Piel, S†. (eds.) (2007). Review of Standards and Protocols for Seabed Habitat Mapping. MESH.

Crowe, O. 2005. Ireland's Wetlands and their Waterbirds: Status and Distribution. Birdwatch Ireland, Newcastle, Co. Wicklow.

Camphuysen, K. J., Fox, A. D., Leopold, M. F. and Petersen, I. K. (2004) Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the U.K.: a comparison of ship and aerial sampling methods for marine birds, and their applicability to offshore wind farm assessments, NIOZ report to COWRIE (BAM – 02-2002), Texel, 37pp

Day Grab – technical information: https://www.cms-geotech.co.uk/siingle-day-grab

Day Grab – technical information: https://www.kc-denmark.dk/products/sediment-samplers/day-grab-/day-grab-1000-cm%C2%B2.aspx

Davies J. 2001. Marine Monitoring Handbook. JNCC.

DAHG. 2014. Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters. January 2014. Prepared by the National Parks and Wildlife Service of the DAHG.

DEHLG, 2009. Appropriate Assessment of Plans and Projects in Ireland – Guidance for Planning Authorities (Department of Environment, Heritage and Local Government, 2010 revision).

Double van Veen Grab – technical information: https://www.cms-geotech.co.uk/double-van-veen-grab-.

EC Environment Directorate-General (2000) Managing Natura 2000 Sites: The Provision of Article 6 of the Habitats Directive 92/43/EEC

European Commission Environment Directorate-General (2001) Assessment of Plans and Projects Significantly Affecting Natura 2000 sites: Methodical Guidance on the Provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC

European Commission (2007) Guidance Document on Article 6(4) of the Habitats Directive 92/43/EEC

Hamon Grab – technical information: https://www.cms-geotech.co.uk/standard-hamon-grabs-

Mickle, M. F., Miehls, S. M., Johnson, N. S. and Higgs, D. M. (2009) Hearing capabilities and behavioural response of sea lamprey (Petromyzon marinus) to low-frequency sounds Canadian Journal of Fisheries and Aquatic Sciences Vol. 76 (9): 1541-1548

Parry, M.E.V. 2019. Guidance on Assigning Benthic Biotopes using EUNIS or the Marine Habitat Classification of Britain and Ireland (Revised 2019), JNCC Report No. 546, JNCC, Peterborough, ISSN 0963-8091

Popper, A. N., Dennis T.T. Plachta, Mann, D A., and Higgs, D. (2004) Response of clupeid fish to ultrasound: a review, ICES Journal of Marine Science, Volume 61, Issue 7, Pages 1057–1061.

Single van Veen Grab – technical information: https://www.cms-geotech.co.uk/single-van-veen-grabs

SROV: https://www.mmt.se/innovations/srov/

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene., C. R. Jr., 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(4): 411-521